WOOLSEY AND HILL FIRES

Watershed Emergency Response Team

Final Report

CA-VNC-091023 and CA-VNC-090993

December 14, 2018

California Department of Conservation
California Geological Survey

California Water Boards

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List of Acronyms

BAER	USFS Burned Area Emergency Response
BARC	Burned Area Reflectance Classification
CAL FIRE	California Department of Forestry and Fire Protection
Cal OES	California Office of Emergency Services
Caltrans	California Department of Transportation
CAM-17	California Administrative Manual Title-22 Metals
CEG	Certified Engineering Geologist
CFM	Certified Floodplain Manager
CGS	California Geological Survey
DOC	California Department of Conservation
DOI	Department of Interior
DWR	California Department of Water Resources
EAPs	Emergency Action Plans
EAS	Emergency Alert System
EHR	Erosion Hazard Rating
EPM	Emergency Protection Measure
ERMiT	Erosion Risk Management Tool
FEMA	Federal Emergency Management Agency
GIS	Geographic Information System
HOA	Homeowners Association
HUC	Hydrologic Unit Code
LACDPW	Los Angeles County Department of Public Works
LARWQCB	Los Angeles Regional Water Quality Control Board
LiDAR	Light Detection and Ranging
LVMWD	Las Virgenes Municipal Water District
NOAA	National Oceanographic and Atmospheric Administration
NPS	National Park Service
NRCS	Natural Resources Conservation Service
NWS	National Weather Service
PCH	Pacific Coast Highway
PE	Professional Engineer
PG	Professional Geologist
PH	Professional Hydrologist (AIH)
RCS	Rowe, Countryman, and Story
RPF	Registered Professional Forester
SBS	Soil Burn Severity
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USFS	United States Forest Service
USGS	United States Geological Survey
VARs	Values-at-Risk
VCWPD	Ventura County Watershed Protection District
VNC	Ventura County
WEA	Wireless Emergency Alerts
WERT	Watershed Emergency Response Team

State of California

Watershed Emergency Response Team (WERT)

WOOLSEY AND HILL FIRES – WERT ASSESMENT EXECUTIVE SUMMARY

CA-VNC-091023 and CA-VNC-090993 WERT Evaluation

Mission Statement: The California Watershed Emergency Response Team (WERT) helps communities prepare after wildfire by rapidly documenting and communicating post-fire risks to life and property posed by debris flow, flood, and rockfall hazards.

It should be noted that the findings included in this report are not intended to be fully comprehensive or conclusive, but rather to serve as a preliminary tool to assist Los Angeles and Ventura counties' Office of Emergency Services/Management, County Sheriffs, local first responders, Los Angeles and Ventura County Departments of Public Works, Ventura County Watershed Protection District, cities (e.g., Malibu, Agoura Hills, etc.), Caltrans, the California Governor's Office of Emergency Services, the United States Department of Agriculture Natural Resource Conservation Service, utility companies, and other responsible agencies in the development of more detailed post-fire emergency response plans. It is intended that the agencies identified above will use the information presented in this report as a preliminary guide to complete their own more detailed evaluations, and develop detailed emergency response plans and mitigations. This report should also be made available to residents, businesses, and property managers so that they may understand their proximity to hazard areas, and to guide their planning for precautionary measures as recommended and detailed in this document.

The Woolsey Fire started on November 8, 2018 in the Woolsey Canyon area south of Simi Valley in Ventura County, and burned a total of 96,949 acres (approximately 151.5 square miles) in Ventura and Los Angeles counties. A total of approximately 1,500 structures were destroyed and 341 structures were damaged, and 3 civilian fatalities were attributed to the fire. The Hill Fire also ignited on November 8th at Hill Canyon Road and Santa Rosa Road near the community of Camarillo in Ventura County. The fire burned 4,531 acres (approximately 7.1 square miles) in Ventura County. Four structures were destroyed and four structures were damaged.

Due to the large number of Values-at-Risk (VARs) in Los Angeles and Ventura counties, both burn areas were evaluated by an interagency WERT comprised of engineering geologists, civil engineers, hydrologists, foresters, and GIS specialists. The WERT rapidly evaluated post-fire watershed conditions, identified potential Values-at-Risk related to human life-safety and property, and evaluated the potential for increased post-fire flooding and debris flows. The team also recommended potential emergency protection measures to help reduce the risks to those values.

Summary of the WERT Key Findings

- The degree of fire-induced damage to soil is called “soil burn severity”, which is a primary influence on increased runoff generation and the occurrence of post-fire watershed hazards (e.g., debris flows and flooding). Moderate and high soil burn severity potentially create the most impacts.
- Fifty-seven percent of the Woolsey Fire burned at moderate (56%) to high (1%) soil burn severity. Only 22 percent of the Hill Fire burned at moderate soil burn severity, with 0 percent high, 52 percent low, and 26 percent unburned to very low.
- While VARs were identified in both fires, the relatively large proportion of moderate and high soil burn severity (57%), steep slopes, ample geomorphic evidence of recent debris flow processes, abundant unconsolidated debris in the source canyons, widespread occurrence of post-fire dry ravel, and likely rainfall intensities make the occurrence of post-fire watershed hazards in the Woolsey Fire most probable.
- USGS debris flow model results are presented in terms of “combined debris flow hazard”, which reflects both the likelihood of debris flow occurrence and the magnitude of potential debris volume. Basins with a high likelihood of debris flow occurrence and/or relatively high magnitude of debris production have a “high combined hazard”, whereas basins with a low likelihood of debris flow occurrence and/or a relatively low magnitude of debris production have a “low combined hazard.”
- The National Weather Service flash flood warning/watch threshold of 0.2 inches in 15-minutes (i.e., 0.8 in hr^{-1} or 20 mm hr^{-1} for the 15-minute duration) equates to a moderate combined hazard for the majority of the Woolsey Fire, and a low combined hazard for the majority of the Hill Fire (see Figure 20).
- A storm scenario of approximately 0.4 inches in 15-minutes (i.e., 1.6 in hr^{-1} or 40 mm hr^{-1}) equates to a high combined hazard for the majority of the Woolsey Fire, and a moderate combined hazard for the majority of the Hill Fire (see Figure 21). This storm scenario is highly probable within the next two years following the fire.
- Thirty-one sub-watersheds (i.e., pour points) were specifically analyzed for increased post-fire sediment-laden flood hazards, including sub-watersheds identified as having Values-at-Risk within identified FEMA 100-year flood zones, Los Angeles county floodplains, and USGS designated watch streams. Post-fire peak flows for 2-year return periods were estimated to increase between 110% and 390% over pre-fire flows. Post-fire peak flows for 10-year return periods were estimated to increase between 70% and 260% over pre-fire flows. Some of the largest flow increases for the 2-year recurrence interval event are predicted

to be for Seminole Hot Springs, Trancas Canyon, Puerco Canyon, Ramirez Canyon, and Arroyo Sequit.

- Two methods were used to predict debris yields for the 31 pour point watersheds. The Gartner et al. (2014) method predicts the largest debris yields for Arroyo Sequit, Zuma Canyon, Little Sycamore Canyon, Trancas Canyon, and Solstice Canyon for the 2-year storm. Gatwood et al. (2000) generally predicted lower sediment yields for the 2-year storm than Gartner et al. (2014).
- The ERMiT post-fire surface erosion model predicted an area-averaged post-fire sediment production rate for a 2-year recurrence storm event to be approximately 5.0 tons $acre^{-1}$and 3.0 tons $acre^{-1}$ for the Woolsey and Hill fires, respectively, or more than one order of magnitude greater than sediment production from unburned areas.

Identified Values-at-Risk and Hazards, and Emergency Conditions

The WERT identified Values-at-Risk (VARs) resulting from increased debris flow hazard, rockfall hazards, flood flows, and increased erosion and sediment delivery. A total of 410 VARs were identified. The WERT identified 247 VAR points, generally associated with individual structures and/or drainage structures, and 163 VAR polygons, generally associated with larger debris/alluvial fans, road segments, and flood-prone areas. Thirty-two (32) point VARs and 32 polygon VARs are classified as having a high hazard to life and safety. Fifty-three (53) point VARs and 56 polygon VARs are classified as having moderate hazard to life and safety. The remaining VARs are classified as having a relatively low hazard to life and safety, but this does not equate to an absence of risk.

Key areas of concern are:

- Flooding and debris flow impacts to public and residential access roads and highways, including, but not limited to U.S. Highway 101, the Pacific Coast Highway (SR 1), State Route 23, Yerba Buena Road, Kanan Road, Kanan-Dume Road, Mulholland Highway, Malibu Canyon Road, North Westlake Boulevard, Lindero Canyon Road, Carlile Road, Triunfo Canyon Road, Las Virgenes Road, and Bell Canyon Boulevard.
- Flooding and debris jams within designated FEMA 100-year flood zones, DWR awareness floodplains, Los Angeles County floodplains, and/or USGS modelled watch streams. Debris and flood flow impacts to residential communities, commercial structures, schools and other public infrastructure, and campgrounds and parks downstream of Big Sycamore Canyon, Little Sycamore Canyon, Arroyo Sequit drainage, Zuma Canyon, Trancas Canyon, Ramirez Canyon, Escondido Canyon, Latigo Canyon, Solstice Canyon, Malibu Canyon, Triunfo Canyon, Lobo Canyon, Las Virgenes Reservoir, Westlake Lake, Lindero Canyon,

Medea Creek, Palo Comado Canyon, Cheeseboro Canyon, Las Virgenes Canyon, East Las Virgenes Canyon, and Bell Canyon and near the outlet of unnamed burned basins with observed debris flow probability.

- Rockfall hazards downslope of steep rocky slopes and along steep canyon roads, particularly Yerba Buena Road, Mulholland Highway, Decker Canyon Road (SR 23), Kanan-Dume Road, Latigo Canyon Road, and Kanan Road.
- Debris flow and flood impacts to culverts, bridges, drainage basins, inlet structures and/or modified channels within and adjacent to Thousand Oaks, Lindero Canyon, Oak Park, Bell Canyon, Calabasas, Agoura Hills, Simi Hills, Westlake Village, Malibu, Malibou Lake, and southwestern Santa Monica Mountains and Pacific Coast Highway coastal communities.

General Recommendations

The WERT's objectives for the burned area were to quickly identify potential post-fire life-safety threats, including those from debris flows, flooding, rockfall, and erosion. General recommendations include:

- Utilize early warning systems available to homeowners, particularly those located in debris flow and flood-prone areas. The WERT recommends the use of county emergency alert notification systems (Alert LACo and VC Alert), as well as additional types of targeted emergency notifications offered by select municipalities affected by the burn areas (e.g., City of Malibu, Agoura Hills, etc.).
- Have Los Angeles County Public Works and Ventura County's Watershed Protection District assist in clearly communicating the high potential and high risk/consequences of post-fire watershed hazards to the agencies responsible for emergency planning and response (e.g., Los Angeles County Sheriff and Ventura County Office of Emergency Services).
- Increase the situational awareness of affected residents and the communities regarding the hazards and risks associated with living downstream/downslope of burned areas.
- Develop Emergency Action Plans (EAPs) for areas of concentrated hazards and for VARs with vulnerable populations (e.g., schools and assisted living facilities).
- Perform monitoring and maintenance of road drainage and storm drain infrastructure, particularly along the southern edge of the fire.
- Place temporary signage in areas of potential post-fire rockfall, debris flow, and flooding hazards.
- Utilize structure protection (sand bags, K-rails, Muscle Wall) where appropriate.
- Monitor and/or remove accumulated debris from within channels that are subject to post-fire flooding, where there is an elevated risk to life and property.

- We recommend more focused evaluations of debris flow/flood runout and inundation along the southern edge of the Woolsey Fire, particularly residential development within large canyons along the Santa Monica Coast Front (e.g., Trancas Canyon). In general, we suggest more focused investigations of geologic hazard(s) for VARs assigned a moderate to high life-safety hazard during the WERT evaluation.
- We recommend more focused evaluations of rockfall hazard within the burn areas, along steep walled canyon roads, and below steep rocky catchments.

1 INTRODUCTION

This report presents the results of a rapid evaluation of post-fire geologic and hydrologic hazards to life-safety and property (i.e., collectively known as “Values-at-Risk”) for private lands affected by the 2018 Woolsey and Hill fires in Los Angeles and Ventura counties, California (Figure 1). Wildfire can have profound effects on watershed processes. Loss of soil cover, alteration of soil structure, and enhancement of soil water repellency from burning can greatly increase runoff generation and the erosive power of overland flow, resulting in accelerated erosion of material from hillslopes. Increased runoff can also erode significant volumes of material stored within channels. A primary concern for burned watersheds is the increased potential for damaging flood flows and increased probability for debris flow occurrence. Other hazards include rockfall from steep slopes and hillslope erosion that can impact roadways, drainage features, and water supplies.

Debris flows are among the most hazardous consequences of rainfall on burned hillslopes. Debris flows pose a hazard distinct from other sediment-laden flows because of their unique destructive power. Debris flows can occur with little warning and can readily destroy and/or damage objects in their paths. Even small debris flows can strip vegetation, block drainage ways, damage structures, and endanger human life. Additionally, sediment delivery from debris flows can “bulk” the volume of flood flows, creating an even greater downstream flooding hazard (LACDPW, 2006; WEST, 2011). As winter approaches, it is critical that people who live in and downstream from large wildfires implement emergency protection measures (EPMs) where appropriate, remain alert of weather conditions, and be ready to evacuate if necessary during large and high intensity storms.

This document summarizes downslope/downstream Values-at-Risk (VARs), and makes specific and general recommendations to reduce life-safety and property exposure to post-fire hazards on private lands. VARs located on federal lands and areas within the Santa Monica National Recreation Area boundary were evaluated by the United States Department of Interior (DOI) Burned Area Emergency Response (BAER) Team. The WERT coordinated with the federal team to ensure consistency and reduce redundancy in hazard evaluation. Other WERT/BAER/USGS products associated with this report include GIS data in the form of shapefiles and raster files. Clear communication of life-safety and property hazards is an objective of the WERT process, and the use of this spatial data is a critical component for communicating these hazards in a planning and operational context. These data have been shared with federal, state, and local responsible agencies and distributed to a FEMA file sharing site for use by responsible agencies.

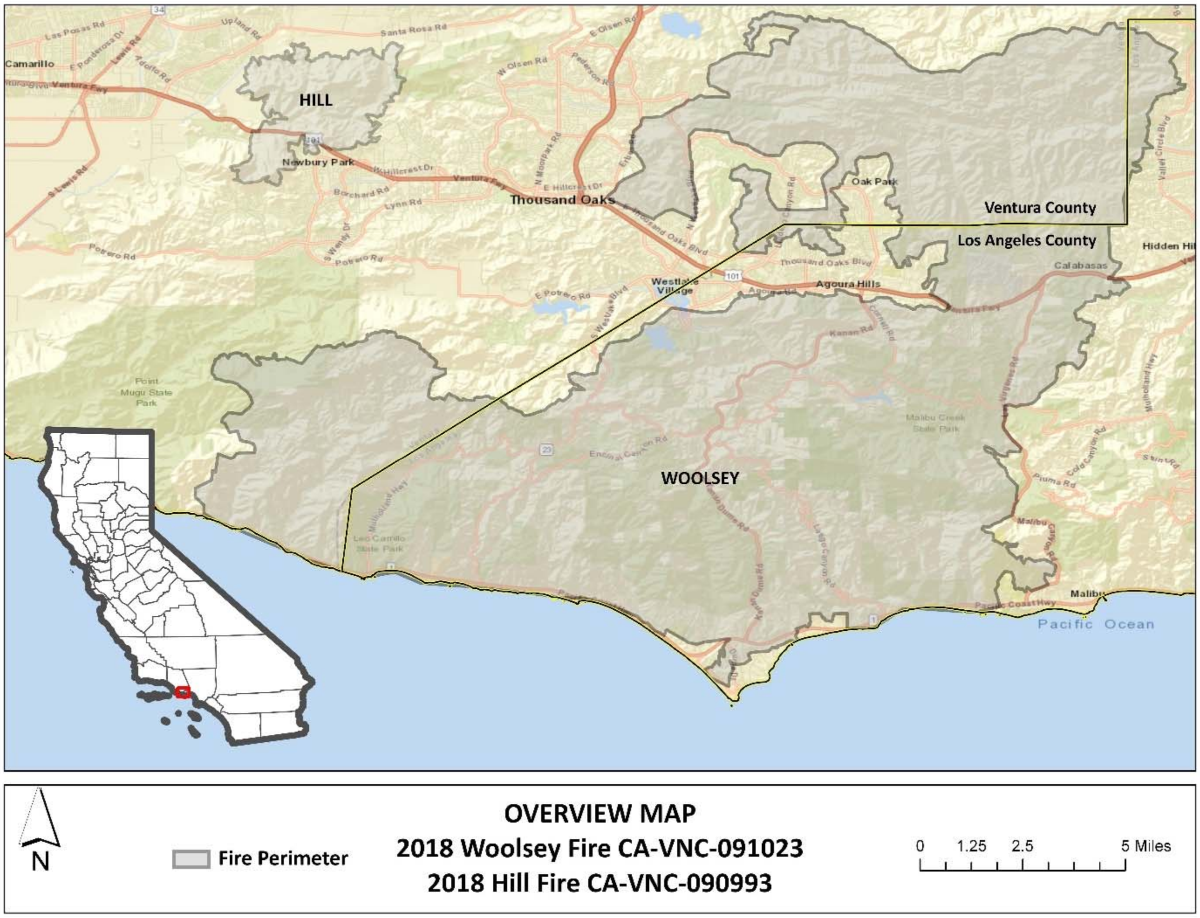


Figure 1. Overview map for the Woolsey and Hill fires.

Finally, the WERT's primary goal is to avoid and/or minimize risk to potential life-safety and property values from post-fire watershed hazards (Figure 2). A comprehensive evaluation of potential resource impacts following wildfire is beyond the scope of this document. However, the same tools used to determine hazard to life-safety and property values (i.e., model outputs; spatial data) can also be used to determine hazards to ecosystem services (e.g., water resources and aquatic habitat). We urge local government, responsible agencies, and private landowners to utilize the tools and data presented herein to aid in informed decision-making when seeking to minimize impacts to resource values (e.g., water quality).

1.1 OBJECTIVES

Primary objectives for the WERT are to conduct a rapid preliminary assessment to:

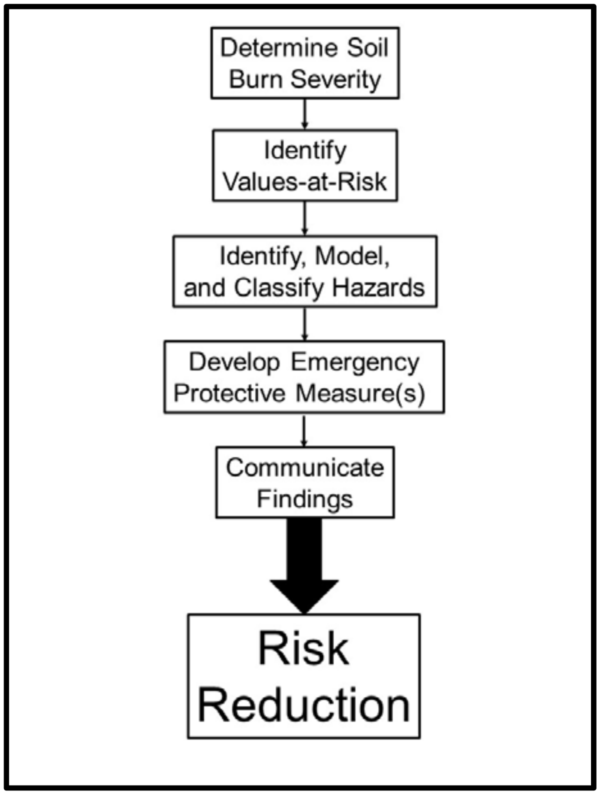


Figure 2. WERT objectives and goals.

- Identify types and locations of on-site and downstream threats to life-safety and property (i.e., Values-at-Risk) from rockfall, post-fire debris flows, flooding, erosion, road hazards, and other hazards that are elevated due to wildfire (Figure 3).
- Develop preliminary emergency protection measures needed to avoid or minimize life-safety and property threats.
- Communicate findings to responsible entities and affected parties.

1.2 BACKGROUND

The Woolsey Fire started on November 8, 2018 in the Woolsey Canyon area south of Simi Valley in Ventura County, and burned a total of 96,949 acres (approximately 151.5 square miles) in Ventura and Los Angeles counties (Figure 1). The fire was fully contained on November 21, 2018. A total of approximately 1,500 structures were destroyed and 341 structures were damaged. This fire had a major Presidential disaster declaration declared on November 12th. The Woolsey Fire caused three civilian fatalities, and three firefighter injuries were reported. The fire burned in both local and state responsibility areas (SRA), as well as contract county direct protection areas (i.e., Los Angeles and Ventura counties). The cause of the fire is under investigation.

The Hill Fire also ignited on November 8th at Hill Canyon Road and Santa Rosa Road near the community of Camarillo in Ventura County. The fire burned 4,531 acres (approximately 7.1 square miles) in Ventura County. The fire was fully contained on November 16, 2018. Four structures were destroyed and four structures were damaged. The fire burned in both local and state responsibility areas, as well as contract county direct protection areas (i.e., Ventura County). Like the Woolsey Fire, the cause of the Hill Fire is under investigation.

Due to the private and local agency land affected by the fire and the risk to life and safety, a WERT comprised of individuals with expertise in engineering geology, geomorphology, civil engineering, hydrology, forestry, and GIS was assembled for the Woolsey and Hill fires. WERT members and their qualifications are summarized in Table 1.

A post-fire soil burn severity assessment was conducted by soil scientists from the DOI BAER team and the WERT for the Woolsey Fire, and by the WERT for the Hill Fire. The USGS Debris Flow Model results were generated on November 22, 2018 for the Woolsey Fire and November 24, 2018 for the Hill Fire. WERT members identified VARs and performed hazard evaluations from November 22 through November 29, 2018 for both fires. Coordination with the DOI BAER team occurred throughout this timeframe.

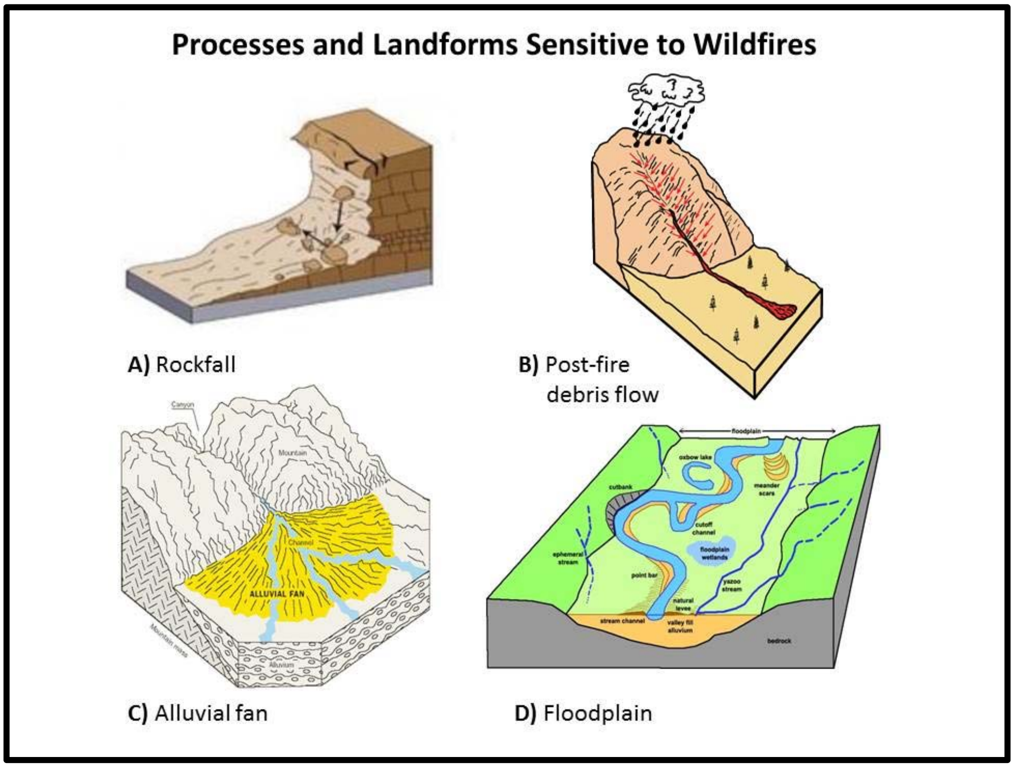


Figure 3. Physical processes and landforms associated with potential hazards in a post-fire setting.

Table 1. Woolsey-Hill Fires WERT members and qualifications.

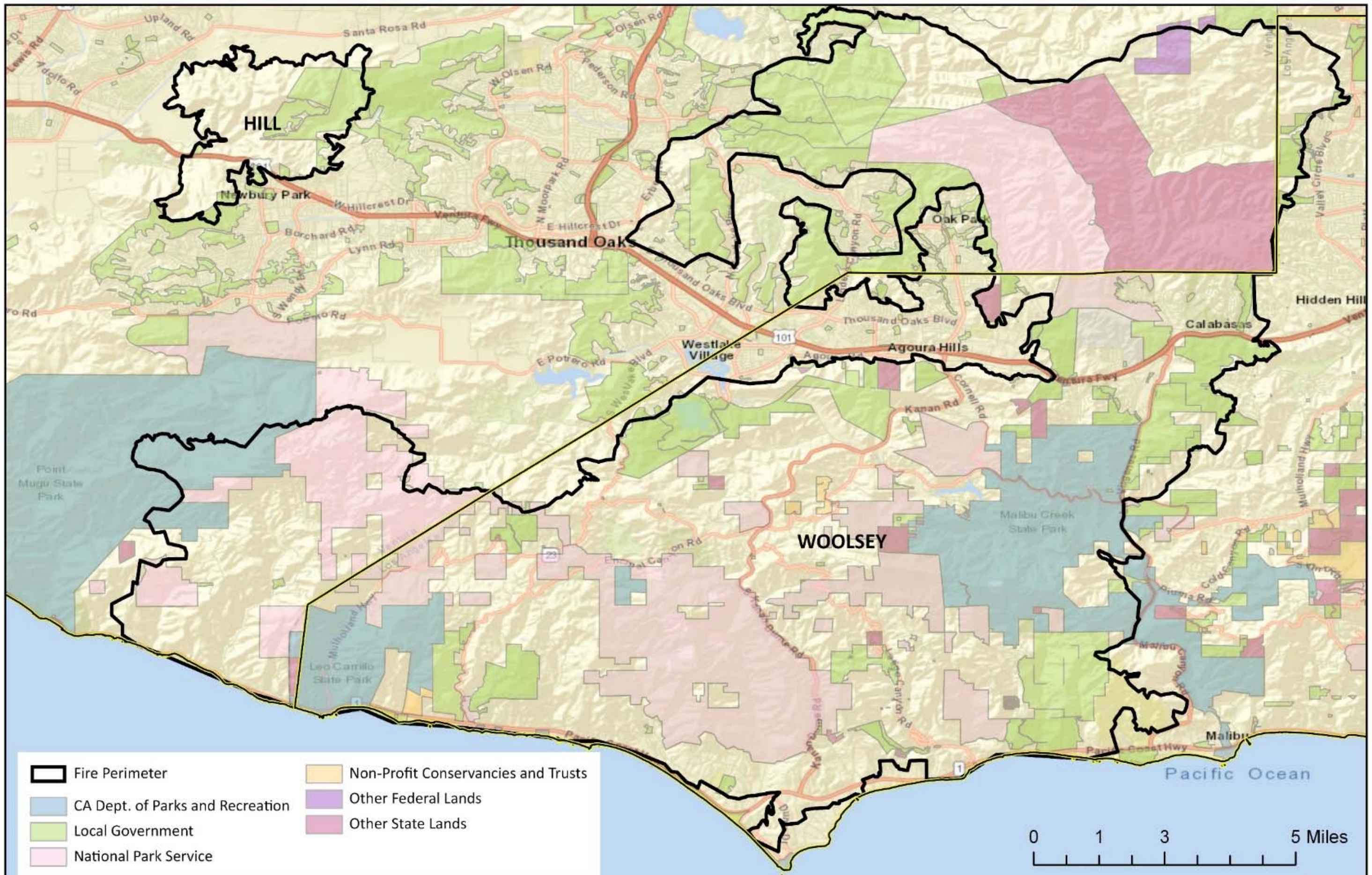
Name	Position	Agency	Expertise-Position
Pete Cafferata; PH 1676, RPF 2174	Team Leader	CAL FIRE	Hydrology/Forestry
John Oswald; PG 7219; CEG 2291	Co-Team Leader	CGS	Engineering Geology
Kevin Doherty; PG 7824; CEG 2666	Team Member	CGS	Engineering Geology
Drew Coe; RPF 2981	Team Member	CAL FIRE	Hydrology/Forestry
Mike Weil; PE 79917	Team Member	DWR	Civil Engineering
Shane Edmunds; PG 9308	Team Member	DWR	Engineering Geology
Mike DeFrisco; PG 8624; CEG 2574	Team Member	CGS	Engineering Geology
Cheryl Hayhurst; PG 8556; CEG 2639	Team Member	CGS	Engineering Geology
Paul Burgess; PG 9616	Team Member	CGS	Engineering Geology
Majd Nima; PG 8872	Team Member	LAWQCB	Water Quality/Geology
John Ramaley; RPF 2504	Team Member	CAL FIRE	Forestry
Kevin Conway; RPF 2888	Team Member	CAL FIRE	Forestry
Garin Hirata	Team Member	CAL FIRE	GIS Specialist
Adam Frese; RPF 2659	Team Liaison	CAL FIRE	Forestry
Nochella Funes; RPF 3057	Team Liaison	CAL FIRE	Forestry
Adjunct Team			
Pete Roffers; PG 9100	Adjunct Member	CGS	GIS/Geology
Sol McCrea; CFM 3527	Adjunct Member	CGS	GIS
Jeremy Lancaster; PG 7692; CEG 2379	Adjunct Member	CGS	Engineering Geology
Brian Swanson, PG 6494; CEG 2055	Adjunct Member	CGS	Engineering Geology
Francesca Rohr	Adjunct Member	CAL FIRE	GIS
Will Olsen	Adjunct Member	CAL FIRE	GIS/ Hydrology

Private land is the predominant ownership affected by the Woolsey Fire (46%), followed by federal ownership in the Santa Monica National Recreation Area (SMNRA) at 21% Table 2, Figure 4). Federal ownership is not blocked, but widely scattered throughout the SMNRA with state park, preserves, and private lands. The total SMNRA area is 153,785 acres, with National Park Service (NPS) ownership comprising 23,648 acres. Approximately 80 percent of the total area within the SMNRA perimeter burned in the Woolsey Fire. State Parks occupy 10,247 acres within the Woolsey Fire perimeter.

Land within the Hill Fire is made up of private (72%) and local government (28%) ownership.

Table 2. Proportion of the Woolsey Fire and Hill Fire burn areas by ownership group.

Woolsey Fire Ownership Group	Acres	Percent
CA Department of Parks and Recreation	10,247	10.6
Local Government	15,062	15.5
National Park Service	20,572	21.2
Non-Profit Conservancies and Trusts	222	0.2
Other Federal Lands	373	0.4
Other State Lands	6,221	6.4
Private	44,252	45.6
Total	96,949	100
Hill Fire Ownership Group	**Acres**	**Percent**
Local Government	1,220	28.0
Private	3,132	72.0
Total	4,352	100



OWNERSHIP
Woolsey Fire CA-VNC-091023
Hill Fire CA-VNC-090993

Hill_Ownership	Acres	Percentage
Local Government	1220	28
Private	3132	72
Total	4352	100

Woolsey_Ownership	Acres	Percentage
CA Dept. of Parks and Recreation	10247	10.6
Local Government	15062	15.5
National Park Service	20572	21.2
Non-Profit Conservancies and Trusts	222	0.2
Other Federal Lands	373	0.4
Other State Lands	6221	6.4
Private	44252	45.6
Total	96949	100

Figure 4. Woolsey and Hill fires ownership map.

2 PHYSICAL SETTING

2.1 TOPOGRAPHY, CLIMATE, AND VEGETATION

The topography within the Woolsey Fire burn area ranges from gentle to very steep with elevation ranging from sea level along the Pacific Coast Highway to 3,111 at Sandstone Peak in Ventura County in the west end of the fire. Refer to Figure 5 for a slope map that shows slope steepness distribution within the burned area. The upper portion of the watersheds are very steep and commonly contain cliffs and rock outcroppings, while the lower reaches near the ocean have generally gentler slopes. The canyons draining the Santa Monica Mountains in the Woolsey Fire area are typically steep and hold shallow alluvial deposits less than 30 feet in the stream valleys and terraces (PCR Services 2001). The steep, sloping mountain ranges throughout the burn area primarily drain into south flowing watercourses that discharge into the Pacific Ocean. The Hill Fire burn area terrain is gentler, with elevations ranging from approximately 1,810 near Conejo Mountain at the southwest edge of the fire to 130 feet in the northwest part of the fire near Pleasant Valley.

The burn areas have a southern California Mediterranean climate with mild, rainy winters and hot dry summers that are moderated by cold ocean currents offshore. Widely varying amounts of precipitation occur from year to year during the winter months. Precipitation throughout the burn areas occurs almost entirely as rain; snowfall is extremely rare. The average annual precipitation is variable, depending largely on elevation and location. In general, the coastal strip receives 12 to 16 inches of precipitation per year. Precipitation increases inland, and the highest locations near Malibu receive about 30 inches of precipitation in an average year. Most of the rest of the coastal mountains receive 20 to 27 inches annually (USDA-NRCS 2006). Over 90% of annual precipitation occurs from October through April (OSU PRISM site; http://prism.oregonstate.edu/explorer/).

For the Woolsey Fire, the 15-minute rainfall intensities for 1, 10, and 25-year recurrence intervals for the headwaters of Trancas Canyon within the burn area are 1.24, 2.30 and 2.78 inches hr^{-1}, respectively. At Zuma Beach these rainfall intensities are 0.73, 1.48, and 1.82 inches hr^{-1}, respectively. For the Hill Fire near the top of Conejo Mountain, the 15-minute rainfall intensities for 1, 10, and 25-year recurrence intervals are 0.81, 1.63, 1.97 inches hr^{-1}, respectively (NOAA Atlas 14 Point Precipitation Frequency Estimates for California; https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk=ca). The magnitude of precipitation intensity rates varies within the burn area due to orographic effects.

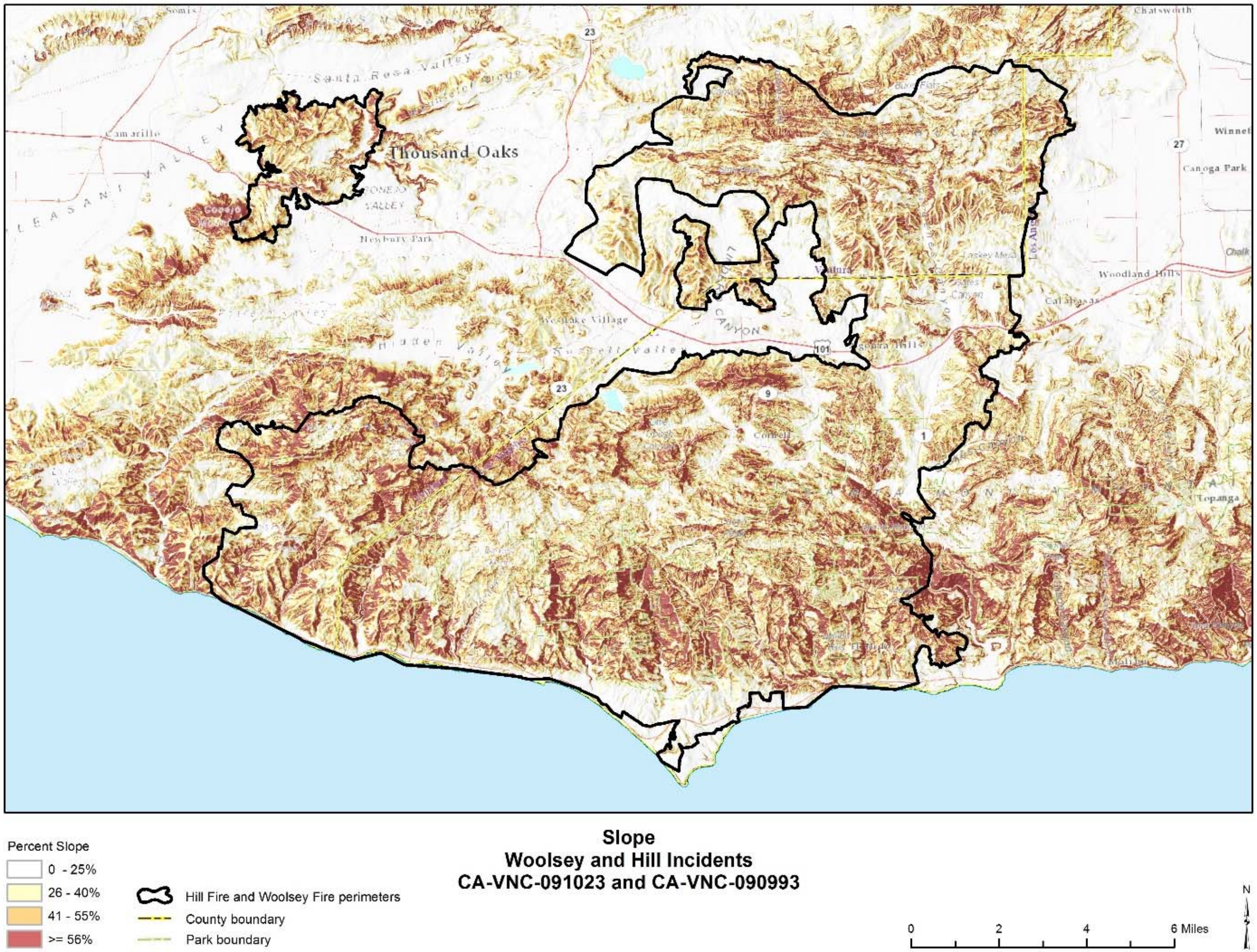


Figure 5. Slope map for the Woolsey and Hill fires.

Vegetation within the burn areas can be categorized into three community types: mixed northern chaparral, coastal sage scrub, and riparian. The dominant species within the mixed northern chaparral include laurel sumac, chamise, lilacs, mountain mahogany, and shrubby oaks. Coastal sage scrub species include buckwheats, sages, California coastal sage, and goldenbushes. Riparian species include alder, sycamore, willow, cottonwood, and oak. The dominant plant community is chaparral, which is particularly susceptible to fire because of its thick growth and high concentration of volatile oils.

2.2 REGIONAL FIRE HISTORY

Ninety percent of the Woolsey Fire area has burned in the last 50 years (1968 to 2018), and 41% has burned in the past 30 years (Figure 6). For the Hill Fire, 97% and 18% of the area has burned in the past 50 and 30 years, respectively. Major fires (>20,000 acres) in the local area include the 1970 Clampitt Fire (115,537 acres), 1982 Dayton Canyon Fire (43,097 acres), 1993 Green Meadows Fire (38,479 acres), 1970 Wright Fire (28,202 acres), 1978 Kanan Fire (25,589 acres), 2013 Springs Fire (24,060 acres), and 2005 Topanga Fire (23,396 acres).

Wildfire frequency within the Santa Monica National Recreation Area is displayed in Figure 7. The average fire return interval for the SMNRA is approximately 28 years, but some areas burn much more frequently than others. There are fire corridors that have burned multiple times due to high winds during Santa Ana events and common sources of ignitions. A few places in the Park have burned more than 10 times since 1925, which equates to a mean fire return interval of about 8 years.[1]

[1] https://www.nps.gov/samo/learn/management/firefrequency.htm

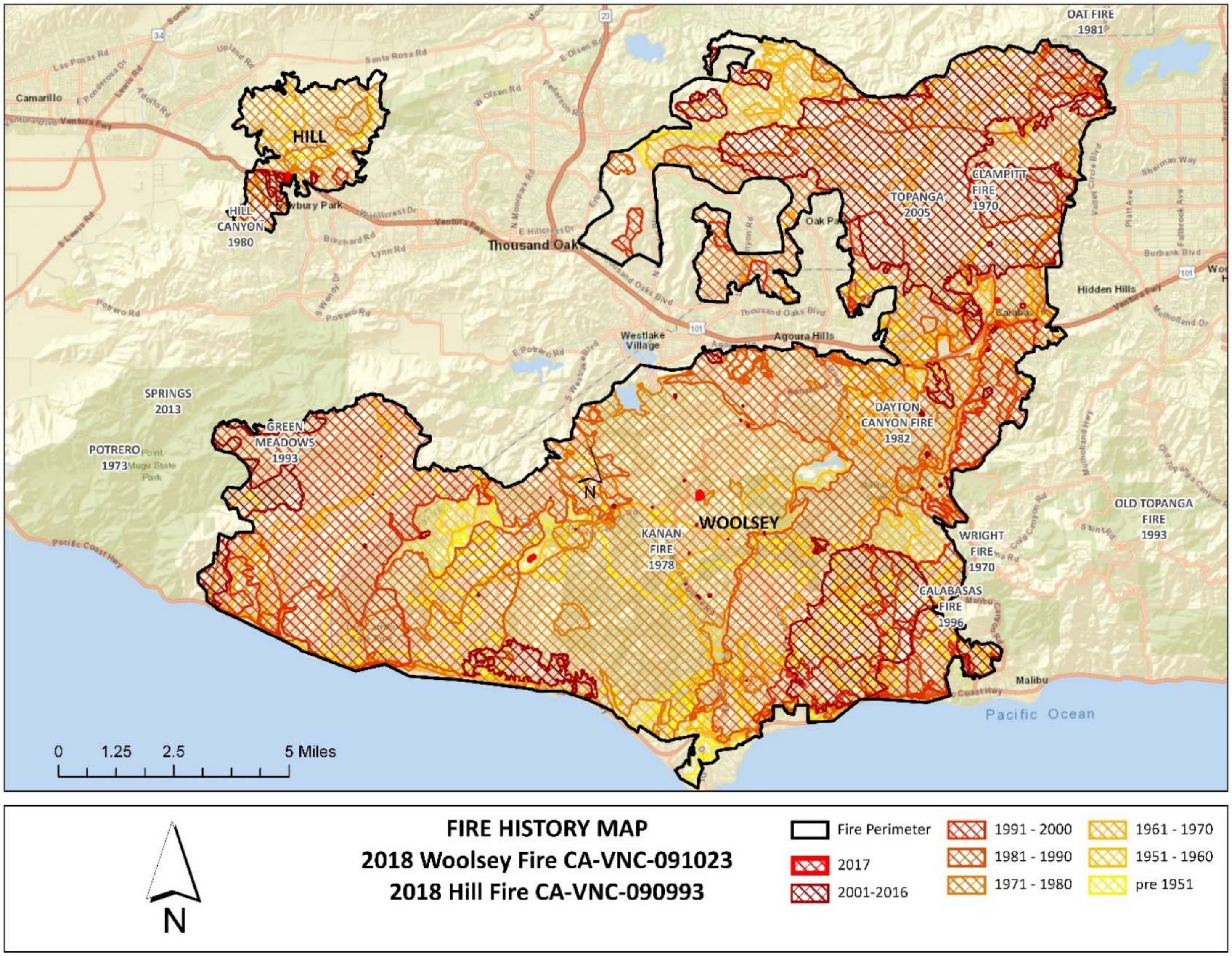


Figure 6. Fire history map for the Woolsey and Hill fires.

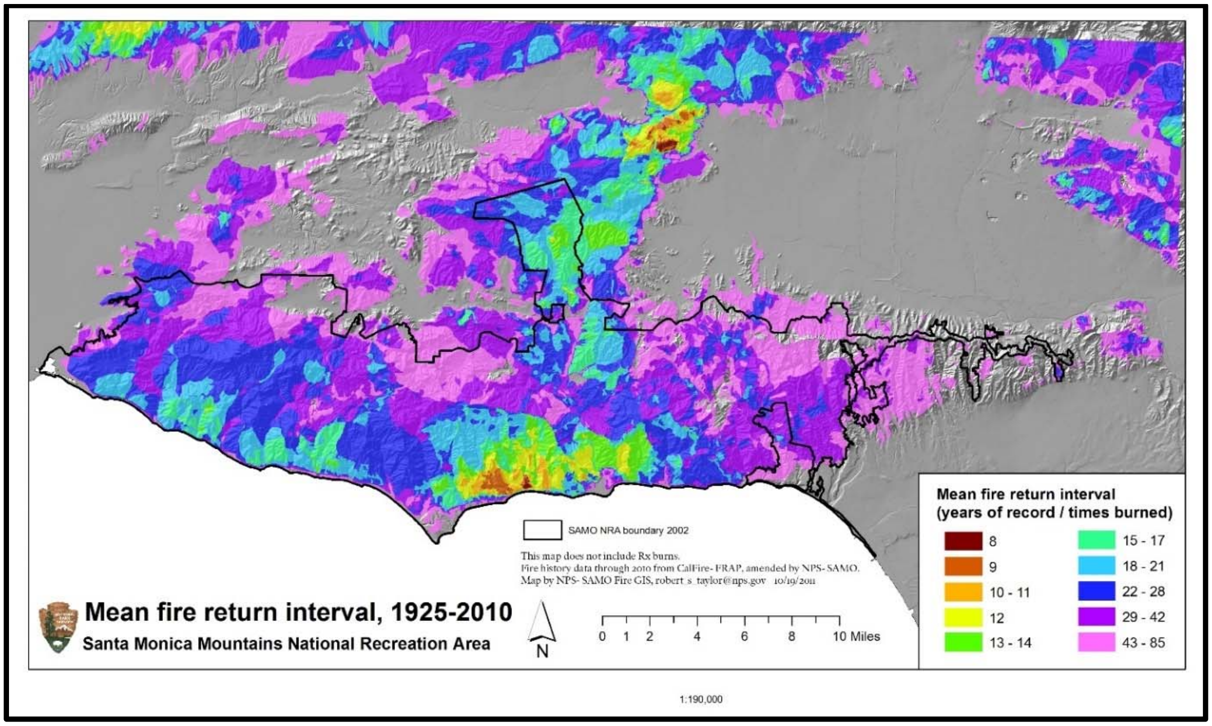


Figure 7. Regional mean fire return interval for the Santa Monica Mountains National Recreation Area, 1925-2010 (from NPS; see: https://www.nps.gov/samo/learn/management/firefrequency.htm)

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2.3 HYDROLOGY, FLOOD HISTORY, AND SEDIMENTATION

Rivers and streams in the Woolsey and Hill fire areas can be characterized as flashy, with high unit discharge rates during major storm events. Many of the streams in the fire areas are intermittent to ephemeral USGS blue-line channels, drying up in the mid-summer until the onset of the rainy season.

Historical records show that southern California has a history of periodic flooding on alluvial fans and downstream alluvial floodplains. Debris-laden flows on alluvial fans are often triggered by a series of storms following wildfires at higher elevations (i.e. the well documented southern California fire-flood sequence). Historical records show that major flooding can also be triggered by small isolated rain events, with or without recent wildfire events. Flooding on alluvial fans have caused major damage to structures not only on fans, but also on downstream alluvial floodplains (Schofield and Earp, 2007). Earp (2007) documented flooding events in 10 southern California counties, primarily from 1905 to 2005. She found that annual rainfall amounts do not necessarily correspond with flooding events. Major flood events in southern California occurred in 1825, 1862, 1885, 1916, 1938, 1969, 1978, 1998, and 2005, with great floods in 1938, 1969, and 1978. Detailed information on significant flood events for Los Angeles and Ventura counties is provided in Earp (2007).

No unregulated stream gaging stations with long term records are known to exist immediately in or adjacent to the Woolsey and Hill fire areas. The Topanga Creek near Topanga Beach, California USGS gaging station (No. 11104000) has a 49-year unregulated flow record that illustrates the magnitude of the 1938, 1969, and 1978 flood events in this part of Los Angeles County (Figure 8). Topanga Creek is located approximate 8 miles to the east of the Woolsey Fire perimeter.

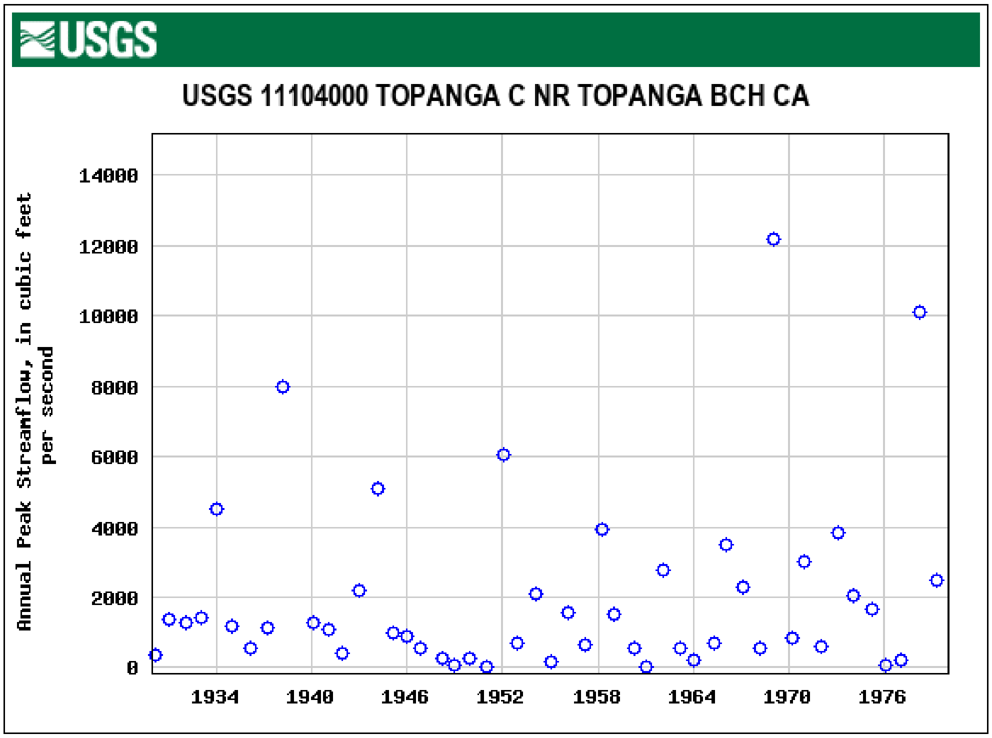

Figure 8. Annual peak flow record for USGS gaging station 11104000, Topanga Creek near Topanga Beach, California.

Several studies document decadal to millennial scale erosion rates for the Santa Monica Mountains area. The largest watershed with considerable area in the Woolsey Fire is the Malibu Creek watershed (109 mi^2). It has been estimated to produce approximately 150,000 cubic yards or 1,370 yd^3 mi^{-2} of sediment annually (U.S. Army Corps of Engineers 1994, cited in Capelli 1999). Stagel and Griggs (2006) estimate that Malibou Lake has a sand sedimentation rate of 6,000 m^3 yr^{-1} (7,848 yd^3 yr^{-1}). Meigs et al. (1999) estimated millennial scale denudation rates of approximately 1,700 yd^3 mi^{-2} yr^{-1} (0.5 mm yr^{-1}) in the Santa Monica Mountains.

An evaluation of pre-fire surface erosion hazard suggests the Woolsey and Hill fire burn areas have a mixture of low, moderate, high, and extreme erosion hazard (Figure 9), largely based on slope, with the highest concentration of erosion hazard in the southern portion of the Woolsey Fire. For the parts of the fire areas with digital soils data available, approximately 60% of the Wooley Fire has a high or extreme rating, while only about 20% of the Hill fire has a high or extreme rating.

No published unit area post-fire hillslope erosion rates (e.g., tons per acre) could be found for the Santa Monica Mountains area. However, post-fire hillslope erosion rates summarized for the western United States suggest that the burn area falls within the Pacific-Medium rainfall regime (Moody and Martin, 2009). Summarized post-fire sediment yields are listed in Table 3. (Moody and Martin, 2009).

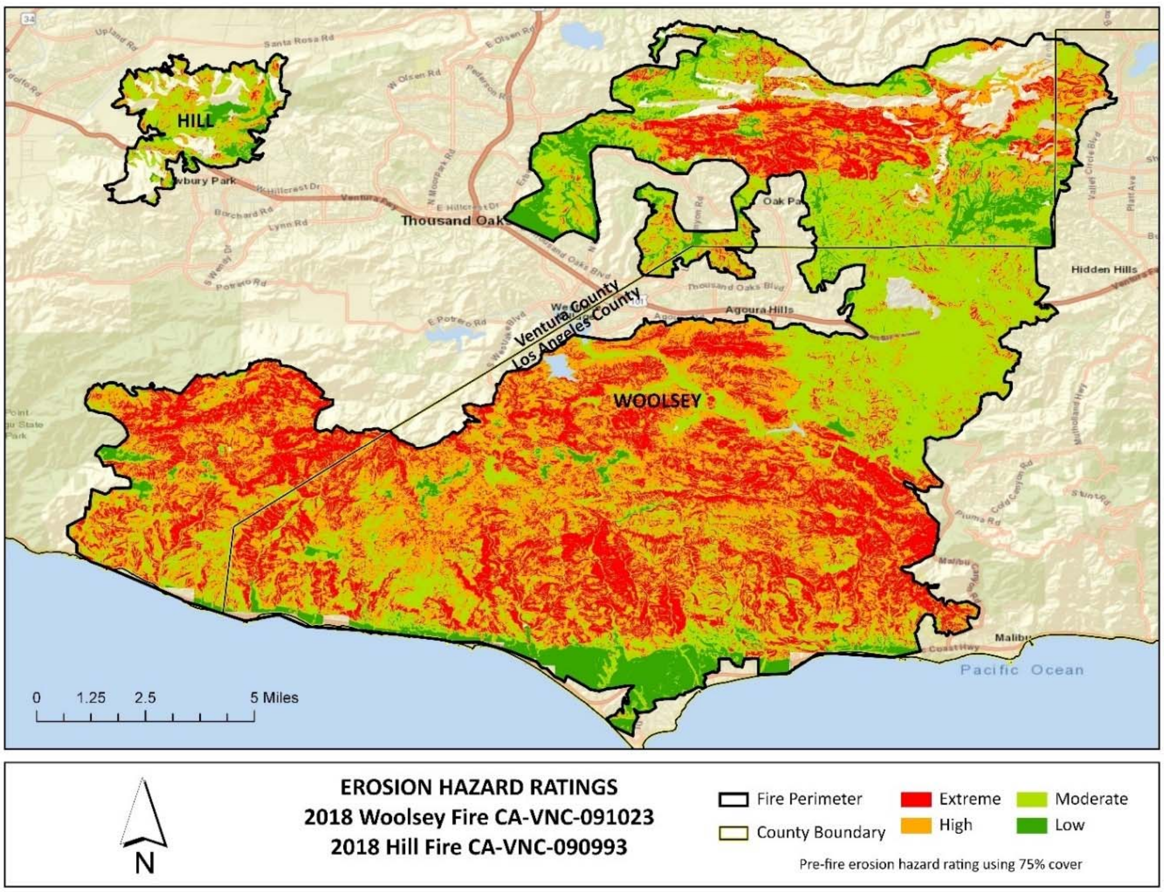

Figure 9. Pre-fire erosion hazard ratings for the Woolsey and Hill fire areas, using the State Board of Forestry and Fire Protection Technical Rule Addendum No. 1 methodology.

Table 3. Summary of post-fire sediment yield from the Pacific-Medium rainfall regime (Moody and Martin, 2009).

Sample Size	Annual Sediment Yield (tons per acre)			
	Minimum	Maximum	Median	Mean
17	0.01	221	14.4	43.7

2.4 SOILS

Soils in the watersheds comprising the Woolsey and Hill fires are derived from weathered sandstones, shale, igneous rock, and from alluvium derived from mixed sources, as well as marine and non-marine deposits (PCR Services, 2001).

Soil coverage was obtained from the Natural Resources Conservation Service (NRCS), which provides a detailed soil description and relevant soil information on all ownerships within the area. The soil surveys within the Woolsey Fire boundary consisted of 153 soil map units. However, the majority of these map units cover a small percentage of the burn area. Ten soil map units cover a total of 60% of the map units within the Woolsey Fire perimeter. Soil surveys within the Hill fire perimeter are composed of 23 map units. Four map units make up 93% of the fire area. The most prevalent map units for both fires are shown in Tables 4 and 5, and Figure 10.

Information about map units was obtained through the NRCS official series descriptions, which includes relevant soil information that is used to determine and examine the effects of fire impacts to the soil, the USDA-NRCS 2006 soil survey of the Santa Monica National Recreation Area, and the DOI BAER Woolsey Fire soil assessment report (Takenaka and Tripp 2018). General large-scale soil map units named for the major soils (USDA-NRCS 2006) that are known to be significant components in the Woolsey Fire area include:

- Cotharin-Talepop association characterized by shallow, steep and very steep, well-drained soils that formed in igneous volcanic rock on hills and mountains with slopes of 30 to 75 percent.
- Mipolomol-Topanga-Sapwi association, characterized by shallow and moderately deep, steep and very steep, well-drained soils that formed in shale, sandstone, and slate on hills and mountains.
- Chumash-Malibu-Boades association, characterized as very shallow to moderately deep, steep and very steep, well drained and moderately well drained soils derived from shale and sandstone on hills and mountains.
- Linne-Gaviota-Los Osos complex, characterized by very shallow and moderately deep, well drained soils derived from marine shale and sandstone on hills and mountains.
- Zumaridge-Rock outcrop-Kawenga association, characterized by shallow and deep, steep and very steep, well drained soils derived from sandstone, and rock outcrop on hills and mountains.

For the Hill Fire area, there are two main soil types.

- Hambright very rocky loam, 15 to 75 percent slopes, characterized by shallow, well drained soils formed in material weathered from basic igneous rocks. They are found on plateaus, basalt flows, and hillslopes.
- Igneous rock land, characterized by igneous rock land (50%), lithic xerorthents and similar soils (40%), and minor components (10%).

Extensive information about these soils can be found within the NRCS official series descriptions (see: https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx).

Table 4. Major soil map units found within the Woolsey Fire.

Map Unit	Soil Type	% Coverage
176	Cotharin-Talepop association, 15-50% slopes	12
120	Mipolomol-Topanga association, 30-75% slopes	9
100	Chumash-Boades-Malibu association, 30-75% slopes	9
330	Linne-Los Osos association, 15-65% slopes	6
170	Cotharin clay loam, 30-75% slopes	5
290	Topanga-Mipolomol-Sapwi association, 30-75 percent	4
175	Cotharin-Talepop association, 30-75% slopes	4
311	Gaviota-Rock outcrop association, 50-100%	4
171	Cotharian loam-Rock outcrop complex, very boulder, 30-75% slopes	4
300	Zumaridge-Kawenga association, 30-75% slopes	3
	Other soil types	40

Table 5. Major soil map units found within the Hill Fire.

Map Unit	Soil Type	% Coverage
HaG	Hambright very rocky loam, 15-75% slopes	55
IrG	Igneous rock land	29
GvF	Gilroy loam, 15-50%	7
1159	Topdeck loam	2
	Other soil types	7

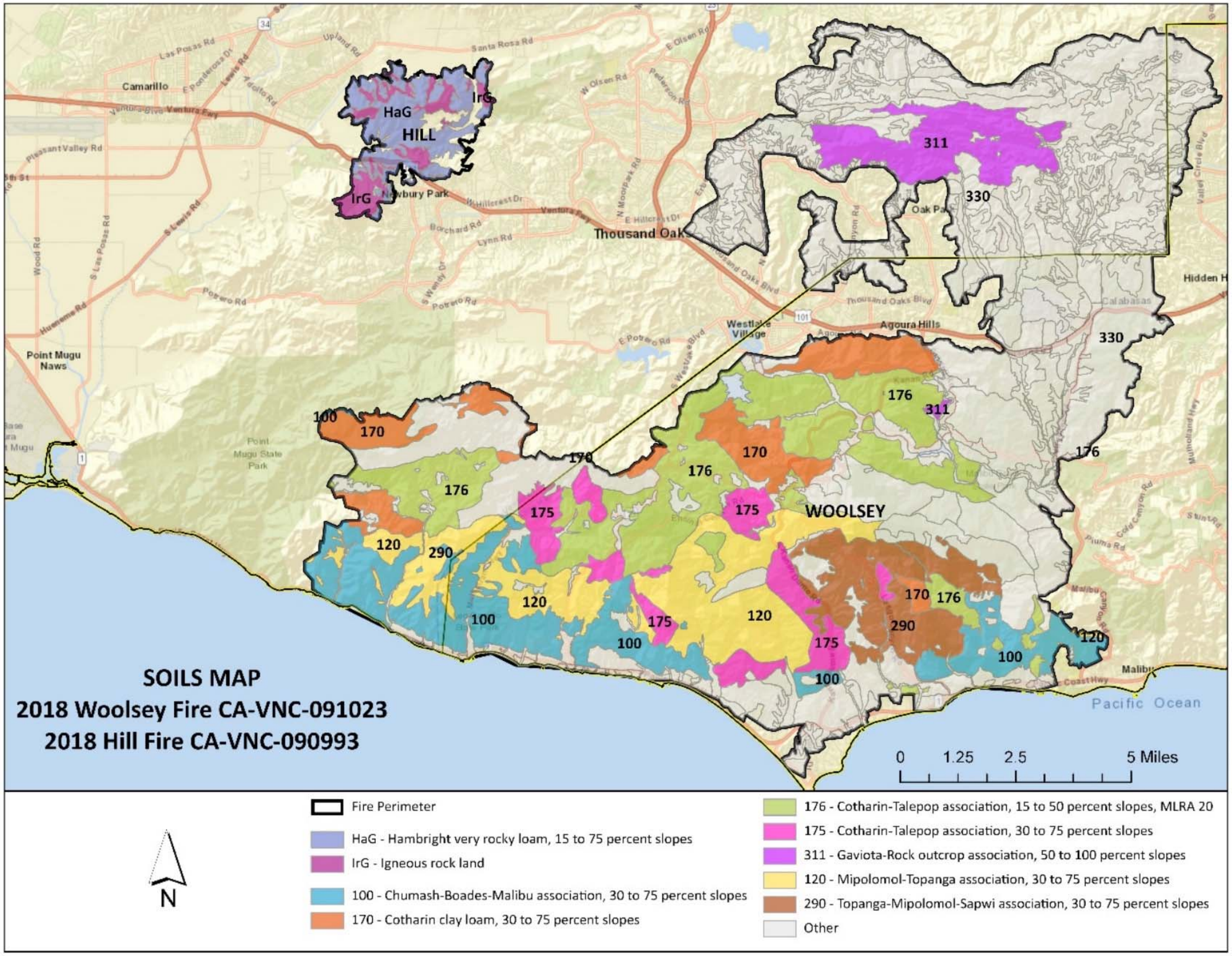

Figure 10. Soils map for the Woolsey and Hill fire area.

2.5 GEOLOGY

The Woolsey and Hill fires burned in the central and western Santa Monica Mountains, one of the ranges along the southern margin of the Transverse Ranges Geomorphic Province (CGS, 2002). The Transverse Ranges geomorphic province extends for about 300 miles (480 km) across southern California from the San Bernardino Mountains on the east to Point Conception on the west. It is comprised of a series of west-trending mountain ranges in contrast with the northwest-trending regional structure of coastal California to the north in the Coast Ranges, and to the south in the Peninsular Ranges. The geologic units exposed within the burn area are dominantly composed of weakly to moderately cemented sedimentary rocks and volcanic rocks, and their distribution is illustrated on the Geologic Map in Figure 11, based on mapping compiled by Campbell et al. (2014).

The geology of the Santa Monica Mountains is diverse, reflecting a long history of interplay between tectonic faulting and folding, volcanic activity, deposition in marine and non-marine basins, uplift, and erosion since Cretaceous time over 65 million years ago (e.g., Yerkes and Campbell, 1979; 1980). During late Cretaceous and Paleogene time, a vast area of oceanic crust of the Farallon plate in the Pacific Ocean was subducted to the east beneath the western margin of the North American continent. This led to the development of a continental arc-trench system, consisting of an outer accretionary wedge composed of the future metamorphic Franciscan Complex, a fore-arc basin that accumulated Great Valley Sequence-type deposits, and a continental igneous terrane with plutons intruding and metamorphosing the country rock (Atwater, 1970; Crouch and Suppe, 1993). Sediments comprising the Chatsworth, Simi Conglomerate, Santa Susana, Llajas, and Sespe Formations were deposited in the fore-arc basin during this time (e.g., Colburn, 1996).

As the East Pacific Rise spreading center between the Farallon and Pacific plates migrated eastward toward the subduction zone plate boundary, the Farallon plate began to break into smaller fragments, such as the Monterey microplate in southern California, which were eventually captured by the Pacific plate (e.g. Nicholson et al., 1994). As spreading along the East Pacific Rise ceased and the Monterey microplate began to move with Pacific plate motion, the block of continental crust overlying this partially subducted microplate was subjected to distributed basal right-lateral shear above the abandoned subduction zone and began to pull away from the continent, forming the incipient western Transverse Ranges block. This block then underwent substantial clockwise rotation around a northeastern pivot point that was trapped against a bend in the continent edge beginning in early Miocene time (e.g., Crouch, 1979; Kamerling and Luyendyk, 1979; Hornafius et al., 1986; Luyendyk, 1991).

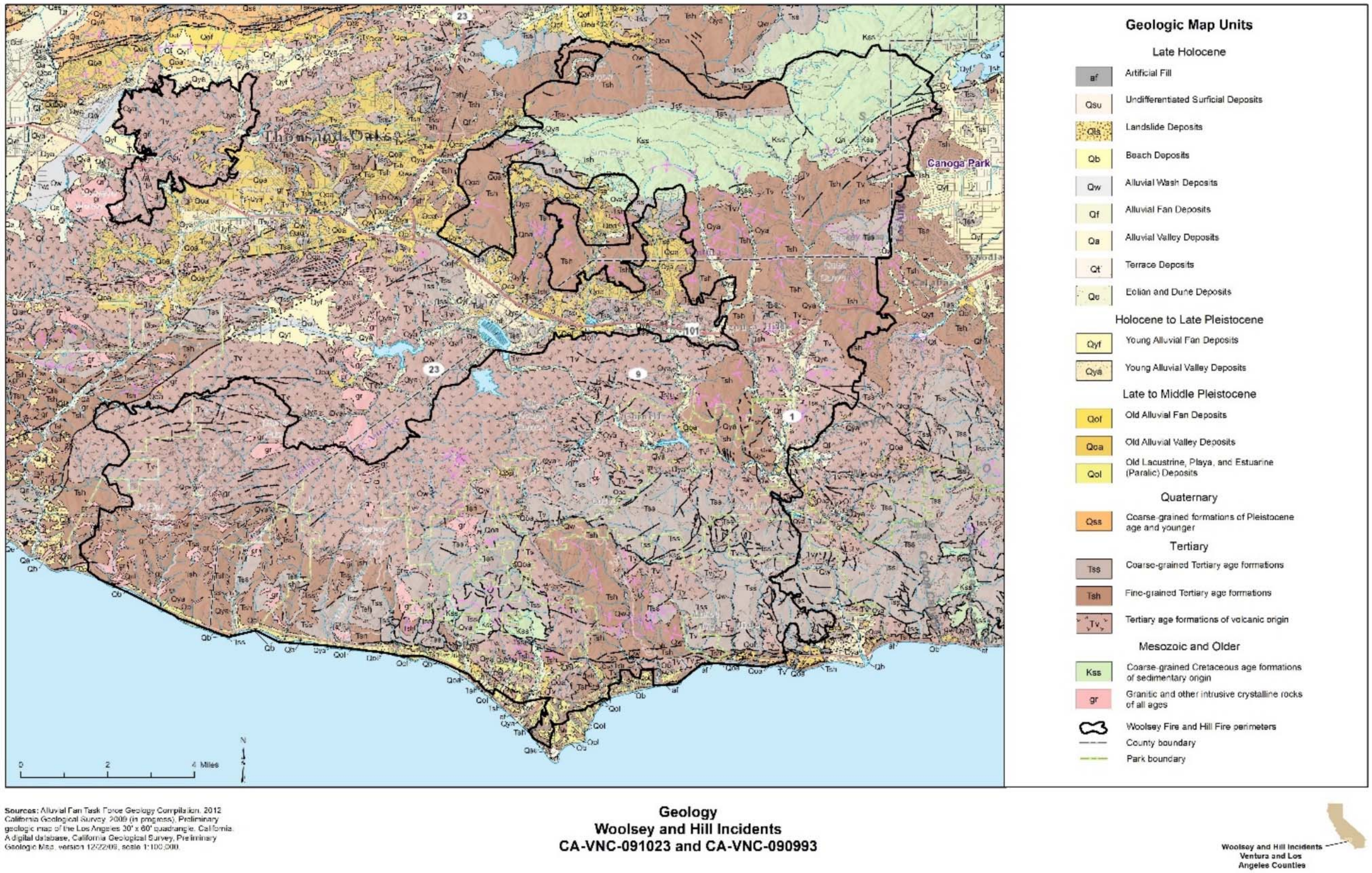

Figure 11. Geology map for the Woolsey and Hill fires.

Transtensional conditions developed south of the Transverse Ranges during this phase of plate boundary evolution, which resulted in unroofing of the Catalina Schist and development of marine depositional basins in the Inner California Continental Borderland and southwestern Santa Monica Mountain areas, where sediments of the Topanga Group and Trancas Formation accumulated concurrently with volcanism (i.e., Conejo and Zuma Volcanics, respectively); the basins subsequently widened and deepened during continued middle to late Miocene rifting, as recorded by sediments of the Monterey and Modelo Formations (e.g., Yeats, 1968; Crouch and Suppe, 1993; Dibblee and Ehrenspeck, 1993; Weigand and Savage, 1993; Nicholson et al., 1994; Ingersoll and Rumelhart, 1999). At about 5-6 Ma, the plate boundary in southern California shifted eastward from the San Gabriel Fault to the current trace of the San Andreas Fault as Baja California was captured by the Pacific plate. Transpressional conditions developed in the western Transverse Ranges due to its position between the northwest-migrating Peninsular Ranges block and the “Big Bend” in the San Andreas Fault (e.g., Atwater, 1998; Walls et al., 1998). The Santa Monica Mountains were uplifted during this most recent phase of deformation, separating Pliocene-Pleistocene deposition within the Los Angeles basin to the south from the Ventura basin to the north.

The southern boundary of the Transverse Ranges province in the Santa Monica Mountains is commonly defined along the offshore Anacapa-Santa Monica Fault, which separates diagnostic east-west-trending structures to the north from northwest-trending structures to the south (Campbell et al., 2014). Transpressional movement along this north-dipping fault system has been associated with regional uplift of the eastern Santa Monica Mountains. However, extensive post-middle Miocene, left-lateral movement (e.g., Yeats, 1968; Campbell et al., 1996; Walls et al., 1998; Fritsche et al., 2001) and/or extensional movement (e.g., Crouch and Suppe, 1993; Nicholson et al., 1994) along the Malibu Coast Fault has also juxtaposed two distinct geologic terranes along the southern margin of the Transverse Ranges (Treiman, 1994):

Santa Monica Slate and granodiorite basement overlain by Cretaceous to Miocene sedimentary and volcanic rocks to the north of the fault, and Glaucophane-bearing Catalina Schist basement overlain by Miocene and younger sedimentary and volcanic rocks to the south of the fault, a sequence which is commonly associated with the Peninsular Ranges province and western Los Angeles basin/continental borderland area.

During Pliocene time, the style of movement on the Malibu Coast Fault transitioned to include a significant component of north-side-up reverse slip as transpressional stresses associated with the formation of the “Big Bend” in the San Andreas Fault developed, which resulted in south-directed thrust faulting, intense folding of adjacent bedrock units, and associated uplift of the Santa Monica Mountains (Campbell et al., 1996). Pliocene deformation also produced local northwest-trending folds and associated cross faults in the Santa Monica Mountains, which overprint the older structures.

In the central Santa Monica Mountains, between Topanga Canyon and Point Dume, complex geologic relationships are interpreted by many workers to indicate the presence of three low angle, late middle Miocene, gravity-driven detachment/“thrust” faults, designated as the Tuna Canyon, Zuma, and Malibu Bowl Faults in ascending order (e.g., Campbell et al., 1966; Colburn, 1996). According to this model, much of the pre-Modelo-age, post-Cretaceous-age sections in the western Santa Monica Mountains are allochthonous and derived from areas miles to the northwest of their current position. Fritsche et al. (2001) suggested that the Malibu Bowl Fault may be the result of gravity sliding off the flank of a Conejo Volcanics-aged volcano, similar to slides found on the slopes of Hawaiian volcanoes. Mapping of the area by Dibblee (Dibblee, 1982, 1992, 1993; Dibblee and Ehrenspeck, 1990a, 1990b, 1993a, 1993b) questions the existence and/or magnitude of these faults and utilizes an alternate interpretation involving a combination of unconformities and steeply dipping faults rather than low-angle faulting to explain many of the complex geologic relationships.

Deep-seated landslides and surficial failures overprint many slopes in the Santa Monica Mountains within the burn areas. Landslides are shown on Figure 12 and attributed slides can be reviewed on-line at the California State-Wide Landslide Inventory Map (Link: https://maps.conservation.ca.gov/cgs/lsi/). These slides are most prevalent in geologically weak, fine-grained units such as the Santa Susana, Sespe, Danielson Member of the Vaqueros, portions of the Topanga, including weathered diabase intrusions, Trancas, and Modelo Formations. However, owing to common fracturing and deformation during past tectonic deformation, and Quaternary uplift of the range, landslides have occurred in most of the mapped formations. Landslides are relatively uncommon in the resistant sandstone beds of the Chatsworth Formation and Nicholson Member of the Vaqueros Formation, and in many of the Conejo Volcanic units; however, these units form resistant cliffs that are a source of boulders in drainages and a source of potential rockfall hazard. Geologic units exposed near the coast have been uplifted in Quaternary time (e.g., Birkeland, 1972) and been undercut by long-term wave activity, forming over-steepened bluffs, resulting in destabilization and the formation of landslides. Landslide movement has been a chronic problem along many sections of the Pacific Coast Highway, and heavy rainfall has also induced historic debris flows, landslides and flooding within and near the burn area (e.g., Roth, 1959; Keaton, 1979; Hollingsworth, 1984; Keene and Slosson, 1986; Ehlig and Steiner, 1992; URS, 1999; Weber et al., 1979; Weber, 1980; Campbell, 1980; Barrows et al., 1993).

Alluvial fans indicative of past debris flow events are present at many locations within and adjoining the burn areas. In the fall of 2014, significant debris flow events occurred

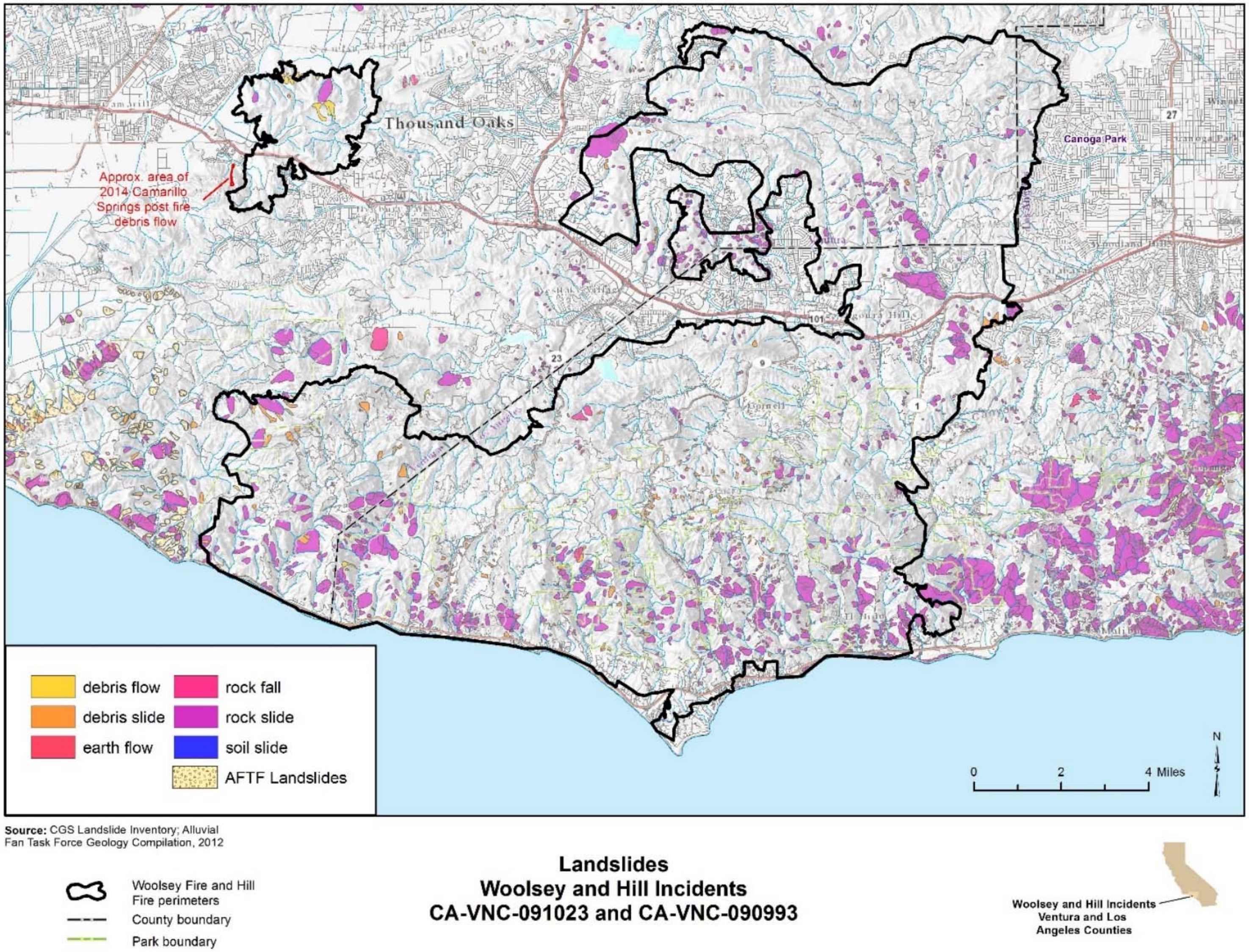

Figure 12. Woolsey and Hill fires landslide map.

as a result of intense rainfall in the 2013 Springs Fire burn area, which inundated houses in the Camarillo Springs area, just west of the Hill Fire, as well as inundating sections of the Pacific Coast Highway near the west margin of the Woolsey Fire near Point Mugu. A more detailed history of regional post-fire debris flow history is presented in the following section of this report.

The Santa Monica Mountains are within an area of moderate to high seismic activity and have been shaken by several historic earthquakes, including the 1971 6.6 M San Fernando Earthquake, 1973 5.8 M Point Mugu Earthquake, and the 1994 6.7 M Northridge Earthquake. These earthquakes have produced small landslides and may reduce rock strength, making subject geologic units more susceptible to future landslide and mobilization into debris flows. Seismic slope stability has been assessed for much of the burn area by CGS (e.g., McCrink et. al. 1997; Silva and Irvine, 2000, 2001a, 2001b; Silva and Wiegers, 2002).

2.5.1 Overview of Alluvial Fan Processes and Hazards

Alluvial fans were observed in and adjacent to the Woolsey and Hill fire burn areas. Many of the fan surfaces have been developed and are difficult to identify because of extensive grading for housing, commercial developments, and construction of roads. Several of these alluvial fans are the location of development because they generally provide low gradient slopes and enough elevation in the built environment to provide desirable views of the surrounding landscape.

Adjacent to the Santa Monica range front and facing the Pacific Ocean, alluvial fans are located at the mouths of smaller catchments that deliver to the coastal alluvial plain along the Pacific Coast Highway (Figure 13). Alluvial fans are generally absent at the larger canyons because they are usually more deeply incised in to the alluvial plain along the coast. Additionally, the larger canyons usually have low gradient channels approaching the coast promoting deposition of debris upstream of the coast. Alluvial fans and debris flow processes are also observed in the Lindero Canyon area of the Woolsey Fire, initiating in the steep catchments of the south facing slopes of Simi Peak, north facing slopes of the Santa Monica Mountains, and the western and eastern fire perimeter where the Santa Monica Mountains transition to the Oxnard and Los Angeles Basins.

The debris flow and flood processes that generate these landforms pose a significant hazard to life and property. These existing hazards are increased in the post-fire environment by removing vegetation cover and altering the characteristics of the exposed soils. These post-fire changes combine to increase the probability and volume of potential debris flows for a given rainfall event (e.g., Cannon et al., 2003). Alluvial fans are formed downstream of the mouth of drainages by divergent flow along distributary channels, forming a diagnostic “radial” fan-shaped landform (Figure 3 c),

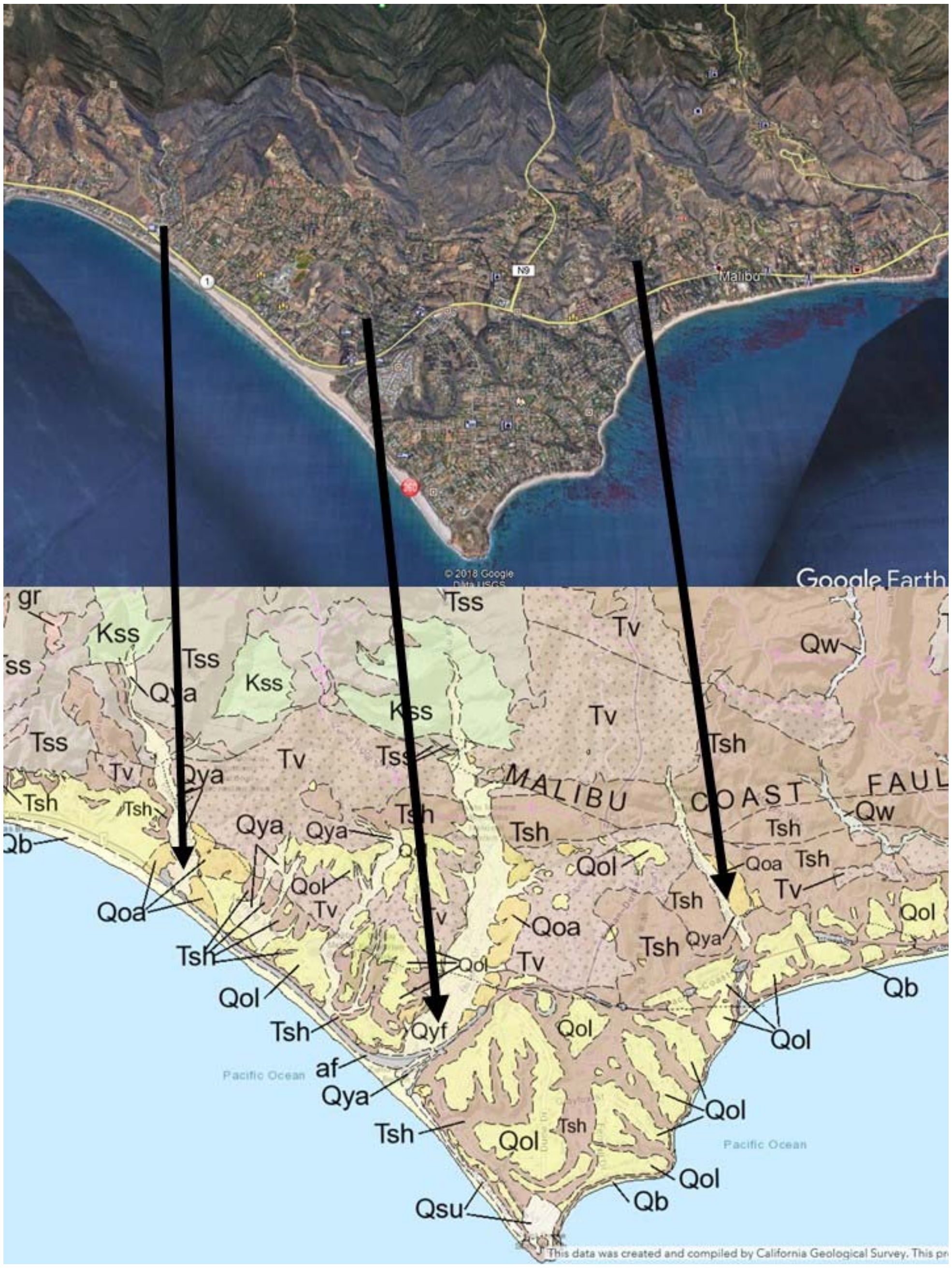

Figure 13. A Google Earth image and Quaternary surficial mapping for the community of Malibu. The presence of young alluvial fan deposits (Qyf) and young alluvial valley deposits (Qya) indicate heightened potential for post-fire debris flows.

see alluvial fan block diagram). Distributary channels form by a process of avulsion, where one channel becomes blocked by debris flow and flood deposition or bank failure and future flows are diverted into a new flow path. This phenomenon leads to complex and unpredictable flow patterns on fan surfaces that can extend far beyond established channels and hazard zones designated based on standard flood flow modeling (Lancaster et al., 2015; Bedrossian et al., 2012). Avulsion in the built environment is a serious hazard because once the flow leaves its channel roads can become efficient conveyance paths with little roughness that maintain or increase velocities. Many newer developments have open spaces in the form of parks and riparian corridors that contain the generally hardened flow channels emanating from catchments.

Evidence of alluvial fan activity includes:

1. Presence of recent debris flow and flood deposits observed on a fan surface.
2. Observation of deposits of angular clasts suspended in fine sediment typical of debris flows exposed in channel sidewalls and artificial cuts.
3. Record of mud and debris deposition following historic storm events based on written records or communication with local residents or officials.
4. Observations that constructed debris catchments or barriers have retained or deflected historic flows.

Conditions indicative of the likelihood and severity of debris flow and flood hazard include:

1. Recency and frequency of documented debris flow events.
2. Geologically young alluvial fan surfaces with limited channel incision.
3. Presence of multiple active and/or abandoned channels on the fan surface.
4. Steep gradient of source channel and fan surface.
5. Presence of cobbles and boulders in existing fan deposits, which is indicative of high debris flow energy and a source of potentially hazardous large debris.
6. Presence of woody debris in source channels, which can clog culverts.
7. Presence of channel bends; superelevation of debris flows at bends can cause overtopping of outer channel banks.
8. Manmade modifications to channels or adjacent fan surfaces such as culverts or bridges that reduce capacity and can divert flows beyond established channels.
9. Climate conducive to thunderstorms or other intense rainfall events.
10. Proximity of improvements to fan apex and channels.

Most of the mapped alluvial fans are the result of deposition by a combination of stream/flood flow and debris flow processes. Flow processes may transition from debris flow to hyperconcentrated flow to flood flow within a single flow event as energy dissipates on overbank and lower gradient surfaces, and sediment load drops out of the flow. Steep boulder-laden fans emanating from steep canyons are deposited primarily by debris flow processes and are more appropriately termed debris fans. Debris fans are generally more hazardous to life and property because of the large size of the transported debris and higher velocity of flows on the steep fan surfaces. Sediment content of the alluvial fans is variable from canyon to canyon, depending on the underlying bedrock lithology. Boulders up to and exceeding 3 feet in diameter are present in many of the channels and associated fan deposits on debris fans.

Field observations that support evidence for debris and flood flow hazards associated with the catchments include:

- Steep walls, commonly exceeding 60% gradient.
- Abundant ashy fine-grained sediment on the slopes.
- Extensive post-fire dry ravel on steeper slopes.
- Unconsolidated alluvial sediment deposits in the canyon bottoms containing boulder-size rocks.
- Vertical relief exceeding 2,000 feet.
- Moderate soil burn severities on most of the canyon slopes.

2.5.2 Regional Post-Fire Debris Flow History

The Santa Monica Mountains region has been subjected to many wildfires, with written documentation extending back to the Spanish Mission Period. Based on historic fire frequency analysis and mapping, several areas within the Santa Monica Mountains have burned more than ten times since 1925 (NPS, 2011). While Cannon et al. (2010) identified that frequent precipitation events, having a 50- to 100- percent annual-chance, may generate debris flows, these minimum threshold level storms typically produce smaller localized debris flows, mud flows, and hyperconcentrated flows that go undocumented. Thus, most historic records are dominated by larger post-fire debris flow and flood events and much less is known of smaller localized events.

The earliest documentation of a post-fire debris flow was in Arroyo Sequit following the 1930 Potrero Fire, near the western margin of the Woolsey burn perimeter (see Table 6). As urbanization occurred in the region, records of debris flow impacts to property and infrastructure have become more available. Some of the most noteworthy and large magnitude debris flow events occurred between 1993 and 1995 after the Green Meadows and Old Topanga fires in Ventura and Los Angeles counties, respectively. As discussed in Ainsworth and Doss (1995), post-fire debris flows in 1995 were of large magnitude:

> *In March of 1995 a storm hit the mountains dumping over 3 inches of rain in 2 hours upon the Topanga Canyon, Tuna Canyon, and Pena Canyon watersheds. The result of this storm was a debris flow which covered PCH with over 12 feet of mud and debris and closed the major route in and out of Malibu for over 3 days, as well as damaging or destroying several residences and associated structures.*

According to the Los Angeles Times (1995), about 100 houses were impacted in this event by mud and debris deposited in driveways and garages. Several days later, more than two dozen seaside homes were reported to be still filled with about three feet of mud.

After the Springs Fire burned the western portion of the Santa Monica Mountains in 2013, numerous debris flows occurred in several locations. A small development in the community of Camarillo Springs, built on a debris flow fan situated below Conejo Mountain (City of Camarillo), was inundated by several debris flows after about 0.60 inches of rain fell in 10 minutes (Sukup et al., 2016). The resulting debris flows inundated 16 homes (Keaton et al, 2014; Oakley et al., 2017). During the same storm, the Pacific Coast Highway was heavily impacted along a 9-mile stretch from Point Mugu to east of Deer Canyon in Ventura County. More than 12 debris flows issued from coastal draining canyons after receiving as much as 0.67 inches in 10 minutes (Sukup et al., 2016). In addition, numerous rockfalls were generated in the area. Examples of these debris flow events are shown in Figure 14.

Figure 14a-d: (a) Steeply sloping catchments on the northern margin of Conejo Peak showing channels eroded by debris flow movement on 12/12/2014; **(b)** Homes inundated by debris flows, with boulder fields up to the eves of the buildings. Primarily cobble- to boulder- size clasts are visible due to dewatering-related evacuation of fine-grained debris flow matrix; **(c)** Debris flow deposition on the Pacific Coast Highway at Mile Post 3.5 surges pushed K-rails fastened to the ground with steel K-rail pins into the ocean; **(d)** Debris flow deposition at Mile Post 3.5, view east.

Sparse documentation of debris flows exists in the Simi Hills area near the northern portion of the Woolsey burn area. Following the 2005 Topanga Fire in the area of Las Virgenes Canyon, the USGS monitored eight burned basins making observations after three storms. Precipitation data within the vicinity of the monitored basins were used to compare the burned watershed response. According to the USGS, debris flows were not observed, with rainfall totals ranging from 0.12 to 0.18 inches in 15 minutes (Staley et al., 2016).

During the research of historical imagery for this project, numerous debris flows were identified initiating on south facing slopes of the Simi Hills during the intense storms of 2016-2017. These debris flows were not from a recent burn area but highlight the natural propensity for debris flows within the burn area prior to impacts from fire. Many of these flows appeared to deposit into heavily vegetated canyons upslope of canyon mouths and residential development. One debris flow was observed impacting the debris basin upslope of a cul-de-sac located on the east end of Wembly Avenue, in the Lindero Canyon area of Ventura County. During fieldwork, crews observed a local HOA contractor digging out the plugged culvert one day prior to the heavy rains experienced on November 29, 2018. The deposit was about 6 feet deep at the culvert inlet and was comprised of silty sand with approximately 15 percent, 6 to 10-inch diameter sandstone clasts.

Table 6. Post-wildfire debris flow summary, Santa Monica Mountains area.

Storm Date	Fire Name (Year)	Event Trigger Time (LST)	Reference	Rainfall Rate	Event Type (# of events)	Affected Areas and Damages
1931-01-07	Potrero (1930)	Unknown	Eaton 1936; Cannon et al., 2010	1.28 inches in 3 hours	Debris flow (1)	Debris flows from Arroyo Sequit traveled to Pacific Ocean at velocities between 5 and 9 ft per second.
January 1968	Unknown	Unknown	Earp, 2007	N/A	Debris laden flooding (2)	Topanga Canyon and Malibu Creek: A tropical storm which dropped moderate amounts of rain in a short duration period caused flooding in Topanga Canyon and the Malibu Creek area. The watershed above had burned shortly before this rain event and although this wasn't a large amount of rain, the run-off was extremely high. This flood destroyed bridges in the Malibu Canyon area, flooded homes and led to the evacuation of over 500 people from the area when their homes were threatened.
1993-11-11	Old Topanga (1993)	Unknown	Los Angeles Times 12 November 1993	N/A	Debris flow (2)	Calabasas Area, Malibu Area (PCH): Mud and debris cleanup took six hours to remove.
1994	Green Meadows (1993)	Unknown	Irvine, 1994; Cannon et al., 2010	N/A	Debris flow (>7)	West of Malibu, (>3 debris flows) Arroyo Sequit Canyon; on Mullholland Highway and within the West Fork of Arroyo Sequit in the vicinity of Circle X Ranch. (>3 Debris flows) within Big Sycamore Canyon; (>1 Debris flow) within the Potrero Valley-Deer Ridge development; straw bale check dams failed during storms and debris entered backyards and homes; (1) Large debris flow in Big Rock Creek, as reported by Cannon at al, 2010.
January 1995	Old Topanga (1993)	Unknown	Ainsworth and Doss, 1995	N/A	Debris flow and flooding (3)	Las Flores Canyon, Carbon Canyon, and the Malibu/Cold Canyon watersheds. Several million dollars in damages

						including, flooding of the area surrounding Malibu City Hall; Closed the Pacific Coast Highway (PCH) in several locations for days,
March 1995	Old Topanga (1993)	Unknown	Ainsworth and Doss, 1995 Los Angeles,1995	3 inches in 2-hours (1.5 mm/hr)	Debris flow (3)	In March of 1995, a storm hit the mountains dropping over 3 inches of rain in 2 hours upon the Topanga Canyon, Tuna Canyon, and Pena Canyon watersheds. The result of this storm was a debris flow which covered PCH with over 12 feet of mud and debris and closed the major route in and out of Malibu for over 3 days, as well as damaging or destroying several residences and associated structures; (LA Times) About 100 houses had been impacted by mud piled up in driveways and garages. At least two dozen of those seaside homes were still filled with about three feet of sludge Sunday, but damage estimates were still unclear. Experts have estimated that the hillsides denuded by the 1993 fire need at least four more years of growth before they can absorb much rainfall, Maurice added. The heavier-than-usual runoff and the flooding it created are "absolutely and definitely fire-related," she said
2014-10-31	Springs (2013)	22:00 LST	CBS Los Angeles, 2014 ABC News, 2014	(.29-.51 in/hr)	Mud and debris flow (3)	Primarily mudflows at Camarillo Springs: Several homes with mud damage
2014-12-12	Springs (2013)	0210 LST	Sukup et al. 2016 Daily Mail 2014 Keaton et al., 2014	(0.6 in, in 10 minutes) (or 3.6 in/hr)	Debris flow (3)	Camarillo Springs: 16 homes damaged, 10 of which were considered destroyed

2014-12-12	Springs (2013)	0236 LST	Keaton et al., 2014 Sukup et al. 2016	(0.67 in, in 10 minutes) (or 4.0 in/hr)	Debris flow (>12)	Pacific Coast Highway: About a dozen debris flows occurred from Laguna Peak Access Road in the North to Deer Canyon in the south, that overtopped the debris storage basins and/or concrete K-rail barriers placed on the landward side of the highway; heavy equipment was required to clear the debris from the highway. Between established drainages, rockfall and sloughing of surficial material was pervasive along the entire 9-mile stretch.

2.5.3 Hazardous Materials

In the northern part of the Woolsey-Hill Fire burn area, there is one historic copper mine located on the south facing slope of Simi Peak at the northern edge of Russell Valley (Figure 15). The Ventura Mine is abandoned; the copper deposits were associated with copper-nickel mineralization of a gabbroic intrusion into turbiditic sandstone, conglomerate, and minor siltstone host rocks of the Chatsworth Formation. The mine was closed shortly after surveying and was likely not considered an economic deposit. Copper is listed as one of 17 potentially hazardous heavy metals listed in the California Administrative Manual, or CA Code of Regulations Title 22 and referred to as CAM17 metals. There are four other, non-CAM17 mine or diggings sites identified that are mostly associated with quartz, chalcedony, calcite, hematite, pyrite, marcasite, and melanophlogite. Figure 15 also shows the distribution of Cenozoic sedimentary rocks that have potential for locally elevated levels of cadmium, uranium, selenium and possibly other CAM17 metals. These hazardous minerals may be entrained with increased surface runoff and impair water quality downslope.

Based on our review of the California Department of Conservation's online well finder, there are numerous active or inactive and plugged oil or gas wells mapped within the Woolsey-Hill Fire burn area (Figure 15). There are four well locations identified as active or idle in the Woolsey fire burn area. One active/idle well is located at the top of Encinal Canyon and is located on a small ridge between low potential debris flow segments. It is unlikely that it would be affected by debris flow and flooding. A second active/idle well is located in the northeastern portion of the Woolsey fire burn area in El Escorpian Park. It is also located on a ridge between two low potential debris flow segments and is unlikely to be affected by debris flows and flooding. Two active/idle oil wells are located in Dayton Canyon in the northeastern perimeter of the Woolsey fire burn area. it appears unlikely that debris flows and/or flooding within the Dayton Canyon channel would have an adverse impact to the well because they appear to be located above the floodplain of the creek based on review of high resolution topography and available imagery. There are also numerous wells identified as buried within the Woolsey-Hill fire burn area. These wells are abandoned by plugging with concrete to separate production strata from aquifer strata. The casing is then cut off below the ground surface and buried. We do not expect these wells to be affected by debris flows and flooding. One well listed with an unknown status is located in the west central portion of the Hill Fire burn area. It appears to be located on a ridge, but local authorities should attempt to locate the well and assess if it is at risk from debris flow and flooding.

A geothermal well is identified adjacent to the dam impounding water in the Seminole Hot Springs area (Figure 15). Based on reports from interviews with locals by field crews there are no active geothermal wells in the area and it is likely the location of an exploratory well. The local population indicate intermittent discharge of hot water from this well and it does not appear to be currently active. The spring water is likely not hazardous from a mineralogical standpoint.

The Santa Susana Field Laboratory (SSFL), a former rocket engine test and nuclear research facility, is located within the Woolsey Fire burn area in the Simi Hills between Thousand Oaks and Simi Valley (Figure 15). This area drains primarily east to Bell Canyon, a tributary of the Los Angeles River and north to Callegaus Creek via Arroyo Simi. The 2,849-acre field laboratory was closed in 2006 and environmental cleanup of significant hazards associated with nuclear and metals testing are ongoing. It is currently the focus of a comprehensive environmental investigation conducted by Boeing, the United States Department of Energy (DOE), and the National Aeronautics and Space Administration (NASA). The SSFL site is regulated by several agencies, including the Los Angeles Regional Water Quality Control Board (Water Board) and the California Department of Toxic Substances Control (DTSC). The Water Board regulates cleanup activities on the site, and storm water discharge from the site is heavily controlled and tested. Based on the years of testing and control of the discharge of storm water from the site, we do not consider the site to be at significant risk from post-fire runoff. Topographic relief at the site is relatively low and there are no large catchments on the site that pose a significant hazard of debris flow generation.

For more information about the SSFL site see these weblinks:

- http://www.boeing.com/resources/boeingdotcom/principles/environment/pdf/Santa-Susana-stormwater-fact-sheet.pdf
- http://www.dtsc.ca.gov/SiteCleanup/Santa_Susana_Field_Lab/
- http://geotracker.waterboards.ca.gov/profile_report.asp?global_id=SL0611149778

Information regarding the hazardous minerals discussed above can be found at the California Office of Environmental Health Hazard Assessment (https://oehha.ca.gov/chemicals/).

The locations of potential mineralogical hazards, including existing mine and quarry locations and active and plugged gas and oil wells, are shown below in the Mineral Hazard Map (Figure 15).

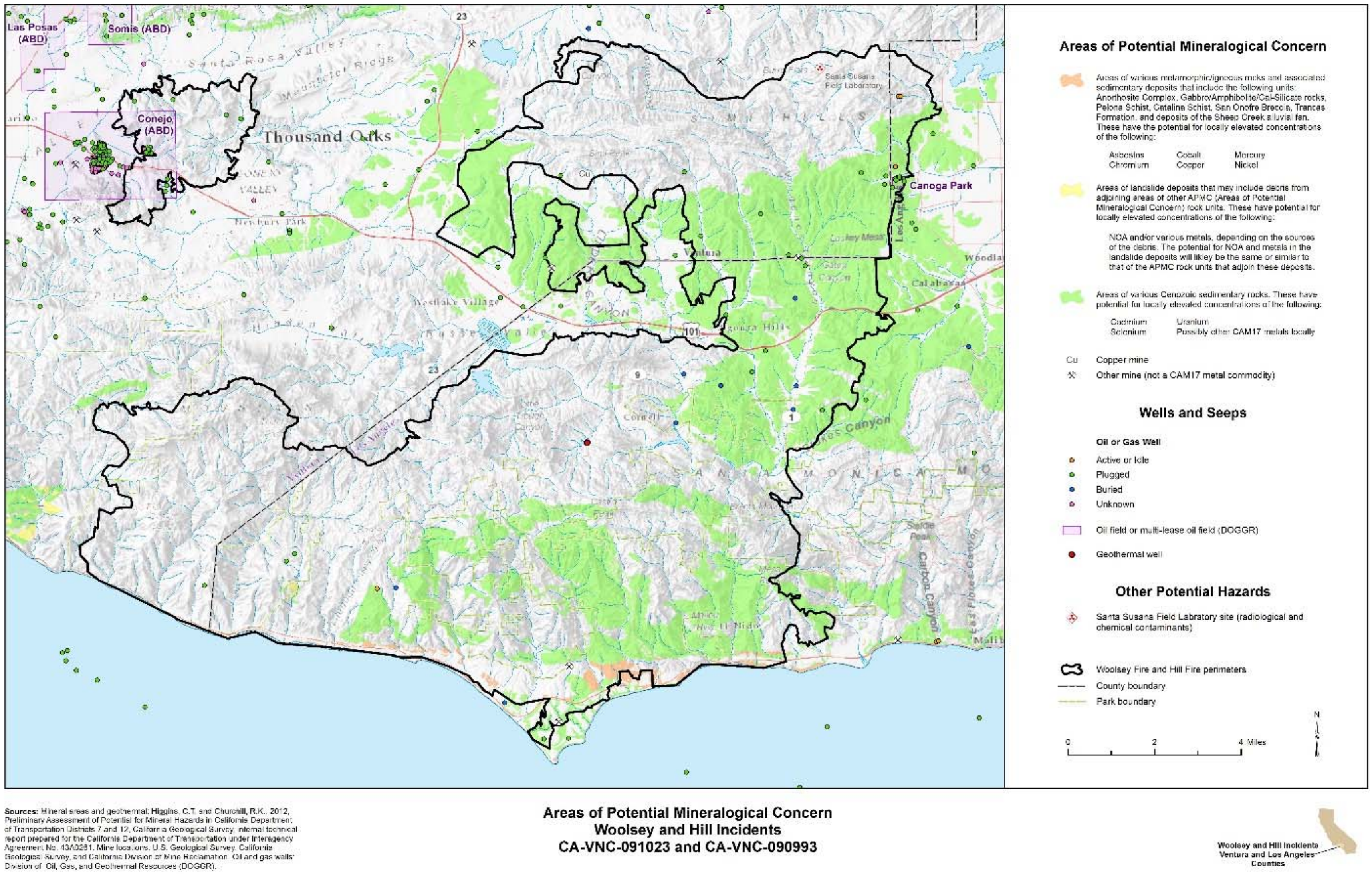

Figure 15. Areas of potential mineralogical concerns for the Woolsey and Hill fires.

2.6 DEVELOPMENT AND KEY INFRASTRUCTURE

The Hill Fire burned on primarily private, undeveloped land in Ventura County between the communities of Newbury Park and Camarillo. Agricultural fields flank the fire perimeter on the northern and western boundary. High density residential developments and commercial complexes border the southern and eastern boundaries. Wildwood Regional Park is adjacent to the northeastern fire boundary. Camarillo Springs Golf Course borders the southwestern fire perimeter.

The Woolsey Fire burned in both Ventura County and Los Angeles County, affecting residential areas that range from semi-permanent trailers to low density houses, scattered ranch properties, and large residential tracts, with associated roads and infrastructure. Additional affected areas include various regional and state parks, open space preserves, the Santa Monica National Recreational Area, and Pepperdine University. Many developments are located downslope of and within steep, burned canyons and were a primary focus of the WERT.

2.6.1 Transportation Corridors

U.S. Highway 101 provides a major transportation route through Ventura County and is located within the Hill Fire burn perimeter. It bisects the Woolsey Fire burn area extending from Ventura County in the west to Los Angeles County in the east. The section of Highway 101 within and adjacent to the Hill Fire burn area was evaluated by the WERT and identified as having a segment at risk of debris flow and rockfall.

Several additional highways and major transportation arteries traversing Ventura and Los Angeles counties intersect the Woolsey Fire burn perimeter. State Route 1 (Pacific Coast Highway or PCH between Dana Point and Oxnard) extends along the coast through the Woolsey Fire footprint from Ventura County in the west to Los Angeles County in the east. The PCH crosses numerous canyons draining south from burned source areas with sections downslope of steep burned slopes. East-west trending Mulholland Highway, and north-south trending Kanan Road/Kanan Dume Road and Las Virgenes Road/Malibu Canyon Road also function as major transportation routes within the burned area. These roads cross numerous steep, burned canyons and were evaluated by the WERT. Identified at-risk locations are described in the Observations and Recommendations section, and in Appendix C (VAR table).

2.6.2 Calabasas Landfill

The Calabasas Landfill is a waste disposal facility run by the County Sanitation Districts of Los Angeles County located in the northern portion of the Woolsey Fire. The site is the main landfill facility for the surrounding area in both Ventura and Los Angeles counties, including areas of Malibu, Thousand Oaks, Simi Valley, and Calabasas. The landfill is regulated by the Water Board and Cal Recycle under requirements of California Code of Regulations Title 27.

The Woolsey Fire perimeter encompasses the entire Calabasas Landfill site; however, the site was not evaluated during the VAR assessment by the WERT. This decision was made due to existing regulatory programs at the site which require stormwater runoff to be tested and meet certain standards prior to discharging from the site. The WERT assumes any post-fire increases in runoff or debris will be addressed through these existing programs.

For more information about the Calabasas Landfill see:
https://lacsd.org/solidwaste/swfacilities/landfills/calabasas/default.asp

For more information regarding the Calabasas Landfill regulatory programs see:
http://geotracker.waterboards.ca.gov/profile_report.asp?global_id=L10005926913
https://www2.calrecycle.ca.gov/SWFacilities/Directory/19-AA-0056/Detail/

2.6.3 Las Virgenes Municipal Water District

Las Virgenes Municipal Water District (LVMWD) provides potable water, wastewater treatment, recycled water and biosolids composting to more than 75,000 residents in the cities of Agoura Hills, Calabasas, Hidden Hills, Westlake Village, and unincorporated areas of western Los Angeles County.

Many of the facilities managed by the LVMWD fall within or downslope/downstream of the Woolsey burn area. The WERT evaluated several sewage lines managed by LVMWD, as well as a composting facility and the headquarters building along Los Virgenes Road. Identified at-risk locations are described in the Observations and Recommendations section, and Appendix C (VAR table).

3 METHODS

3.1 VALUES-AT-RISK ASSESSMENT

A fundamental step in the WERT process is the identification and characterization of Values-at-Risk (VARs). VARs are the values or resources at risk of damage or loss by post-wildfire geologic and/or hydrologic hazards (Calkin et al., 2007). Life-safety and property are the primary VARs evaluated during the WERT process. The WERT process relies on a combination of modeling and best professional judgement to guide hazard determination.

Potential VARs may be identified during the initial phases of reconnaissance and/or through consultation with local agency personnel and stakeholders. However, these

VARs may be found to have little risk associated with them following further evaluation and analysis.

3.2 OFFICE METHODS

To validate the satellite-derived Burned Area Reflectance Classification (BARC) map and to collect Values-at-Risk points and polygons, as well as associated information, a mobile mapping application was used. The application, an Esri product called "Collector for ArcGIS," allowed field observers to use mobile devices (tablets and smart phones) to view and use for reference several different information layers.[2] Layers produced in the office and loaded on these devices prior to field work included:

- Fire perimeter
- Ownership
- BARC (Burned Area Reflectance Classification) layer
- United States Geological Survey (USGS) debris flow model segments for a 24 mm hr^{-1} storm (0.94 in hr^{-1})
- Watershed boundaries (HUC-12)
- Federal Emergency Management Agency (FEMA) Special Flood Hazard Areas
- California Department of Water Resources (DWR) Awareness Floodplains
- LiDAR (1 m for Los Angeles County)
- LA County natural drainages
- LA County debris basins
- LA County culverts
- Hydrography
- Structures
- Roads
- Soils
- Geology (lithology and faults)
- Landslides
- Slope gradient
- Topographic hillshade
- Building footprints

The Collector mobile application was useful for navigation and it provided drop-down menus that allowed field observers to capture locations (as points or polygons), attributes, and georeferenced photos of the following features:

- Values-at-Risk

[2] http://doc.arcgis.com/en/collector/

- General observations

The data recorded in Collector was uploaded nightly to a secure cloud service (ArcGIS Online), allowing it to be quickly viewed by team members in different locations or downloaded into desktop GIS software for preparation of custom maps.

3.3 SAMPLING AND MODELING METHODS

3.3.1 Soil Burn Severity

The degree to which fire affects soil properties, along with other controlling factors, is important for predicting the potential for increased runoff and sedimentation (Keeley, 2009). Soil burn severity mapping reflects the spatial distribution of the fire's effects on the ground surface and soil conditions, and is needed to rapidly evaluate fire effects, identify potential Values-at-Risk, and prioritize field evaluation (Parsons et al., 2010). The Woolsey Fire BARC map was generated using Sentinel 2 satellite imagery from a November 15, 2018 flightpath, while the Hill Fire BARC map was generated using Sentinel 2 satellite imagery from a November 25, 2018 flightpath. The DOI BAER team and the WERT field verified the BARC map to create a final soil burn severity map for the Woolsey Fire (see photograph E-1). The WERT field verified the BARC map for the Hill Fire.

3.3.2 USGS Post-Fire Debris Flow Models

The WERT uses the USGS post-fire debris flow hazard suite of models (Staley et al., 2016; Gartner et al., 2014) as a screening tool for field evaluation and as a decision support tool for geologic hazard determination. The dataset used to develop the USGS models contains data specific to the Transverse and Peninsular Ranges of southern California. See https://landslides.usgs.gov/hazards/postfire_debrisflow/ for more information on these models.

The USGS model assessment uses the soil burn severity map as a primary input to estimate the likelihood and potential volume of debris flows for selected basins and streams in response to a design storm. The empirical models are based upon historical debris flow occurrence and magnitude data, storm rainfall conditions, topographic and soils information, and soil burn severity data from recently burned areas (Staley et al., 2016). Post-fire debris flow likelihood (Staley et al., 2016), volume (Gartner et al., 2014), and combined hazards are estimated at both the drainage basin scale and in a spatially distributed manner along the drainage network within each basin. These are described as **basin** and **segment**, respectively. The characteristics of basins and segments affected by the fire were calculated using a geographic information system (GIS) with a minimum area of 0.02 km^2 (approximately 5 ac) and a maximum area of 8.0 km^2 (1977 ac). Basins and segments with drainage areas greater than 8.0 km^2 were not explicitly modeled for debris flow probability, but were designated as **"**watch streams**"**, which may consist of a combination of flood and debris flow hazards.

For reporting purposes, we compare model outputs from a 15-minute rainfall intensity of 20 mm hr^{-1} (0.79 in hr^{-1}) and 40 mm hr^{-1} (1.57 in hr^{-1}). The 20 mm hr^{-1} storm closely reflects the threshold storm chosen by the National Weather Service to initiate flash flood watches and warnings.[3] The 40 mm hr^{-1} storm reflects approximately a 2-year 15-minute storm event calculated near the head of Zuma Canyon from the NOAA Atlas 14 website (https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html), and has a 75 percent chance of occurring within the next 2 years.

This report generally describes debris flow hazard in terms of an ordinally ranked "combined hazard", where:

Combined Debris Flow Hazard = Predicted Debris Flow Likelihood + Predicted Debris Flow Volume

According to the USGS:[4]

Debris-flow hazards from a given basin can be considered as the combination of both probability and volume. For example, in a given setting, the most hazardous basins will show both a high probability of occurrence and a large estimated volume of material. Slightly less hazardous would be basins that show a combination of either relatively low probabilities and larger volume estimates or high probabilities and smaller volume estimates. The lowest relative hazard would be for basins that show both low probabilities and the smallest volumes.

This concept is illustrated in Figure 16, which shows how the likelihood of a debris flow and the predicted debris flow volume are used to assign an ordinal combined hazard ranking of either low, moderate, or high. It is important to note that basins and/or segments may have a relatively high likelihood of debris flows, but that combined hazard may be low or moderate if the predicted volume is relatively low.

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[3] The NWS chose the Woolsey/Hill fires debris flow threshold from Cannon et al. (2008), Equation 3.

[4] https://www.usgs.gov/natural-hazards/landslide-hazards/science/scientific-background?qt-science_center_objects=0#qt-science_center_objects

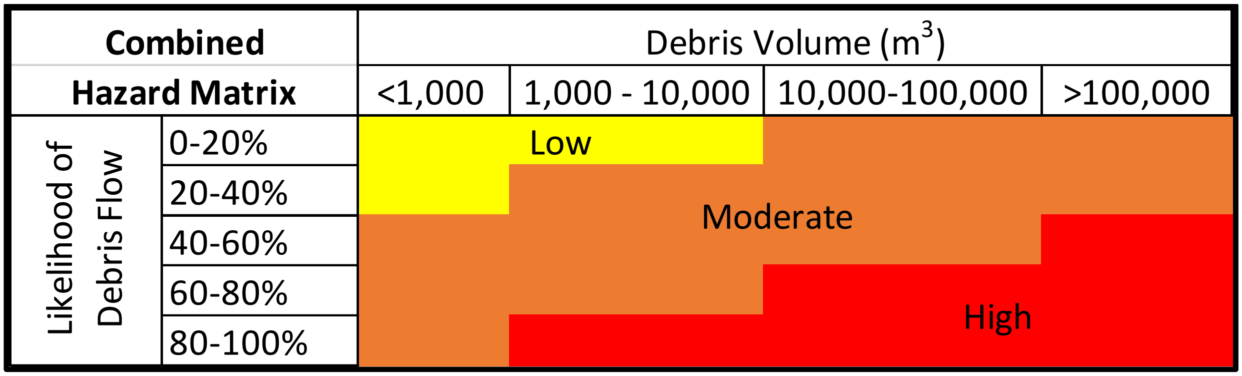

Figure 16. The combined debris flow hazard classification as a function of predicted debris flow probability and debris volume production. Colors in yellow, orange, and red represent a combined debris flow hazard of low, moderate, and high, respectively.

3.3.3 Flood Flow Predictions

Peak flows increase following wildfire as a result of reduced surface cover, loss of soil structure, and the formation of water repellent soils. The most intense peaks occur during intense, short duration rainfall events on severely burned watersheds with steep slopes (Neary et al., 2005). Estimated changes in post-fire peak flows were patterned after efforts that have been conducted for past federal BAER and state post-fire assessment work in southern California.

Research conducted in southern California indicates that post-fire peak flows can increase as much as 10 to 30-fold for low-magnitude storms and approximately 2 to 3 fold for larger magnitude storms (Rowe et al., 1949; Rowe et al. 1954; Moody and Martin, 2001), without an additional bulking factor. Kinoshita et al. (2014) reported that commonly used flood flow prediction methods have lower confidence with larger recurrence interval events (25- and 50-year); therefore, we analyzed pre- and post-fire flows using 2- and 10-year storm events.

To analyze projected peak flow changes affected by the burn area, 31 pour point watersheds (Figure 17) were selected at locations in basins with Values-at-Risk, upstream of existing debris basins, and upstream of alluvial fan formations. Pour points are watershed units used for flood flow and debris yield analyses. Pour points for watersheds are established to provide a better understanding of hydrological response for specific areas, especially those that are related to VARs from flooding and/or debris flows. Pour points represent a sampling of the fire and are not inclusive of all the Values-at-Risk (i.e., not all Values-at-Risk have an assigned pour point). Pour points that are closer to the burn area will yield greater post-fire flow increases than those further below the burn area.

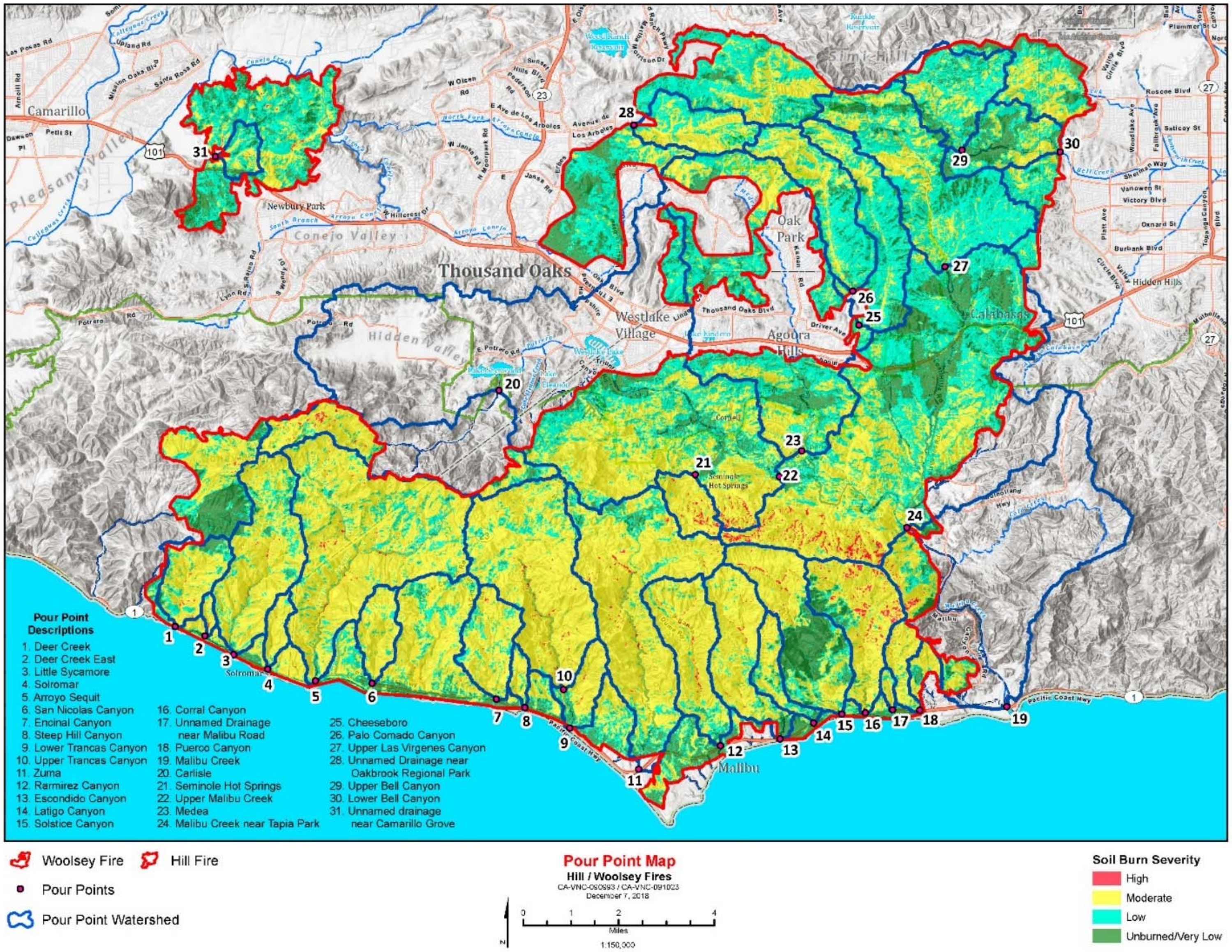

Figure 17. Woolsey and Hill fire pour point watersheds.

The Esri ArcMap software package was used for delineation of pour point watersheds.

Existing empirical data were utilized to predict relative changes in post-fire peak flows as a function of the proportion of the watershed area burned and time since fire. Rowe et al. (1954) provide curves to predict the ratio, or multiplier, of post-fire peak flow to pre-fire peak flow based on data from the Angeles storm zone in southern California (Figure 18).[5] These curves can be used to help predict absolute changes in post-fire peak flows when combined with appropriate hydrologic design procedures.

To determine the relative changes in peak flows following the Woolsey and Hill fires, the WERT utilized the 31 pour points to calculate the percentage increase in the 2-year and 10-year recurrence interval flood flows. The pour point watershed data for Woolsey and Hill fires located in Los Angeles and Ventura counties are displayed in Table 7.

In previous WERT post-fire hydrologic assessments for northern and central California wildfires, the high and moderate burn severity classes were combined to one assigned modifier and the low burn severity class was assigned a different or no modifier (Foltz et al. 2009). However, Rowe et al. (1954), does not make this distinction because their results are based on empirical data and assume fire as a lumped effect. Soil burn severity maps were not available when Rowe et al. (1954) conducted their research. Therefore, based on Figure 18, the peak runoff from high, moderate, and low soil burn severity areas in the Woolsey and Hill fires are assumed to increase by a factor of 3.3 and 2.4, relative to unburned areas, for the 2-year and 10-year recurrence intervals, respectively. Unburned areas were given a multiplier of 1.0 because runoff characteristics are unchanged from pre-fire conditions.

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[5] Rowe et al. (1949), an earlier version of the 1954 paper, has been used for several decades to predict changes in peak flows following wildfires in specific watersheds located in southern California (Kinoshita et al. 2014), but none of the tables in this document included areas burned by the Woolsey and Hill fires in the Angeles storm zone.

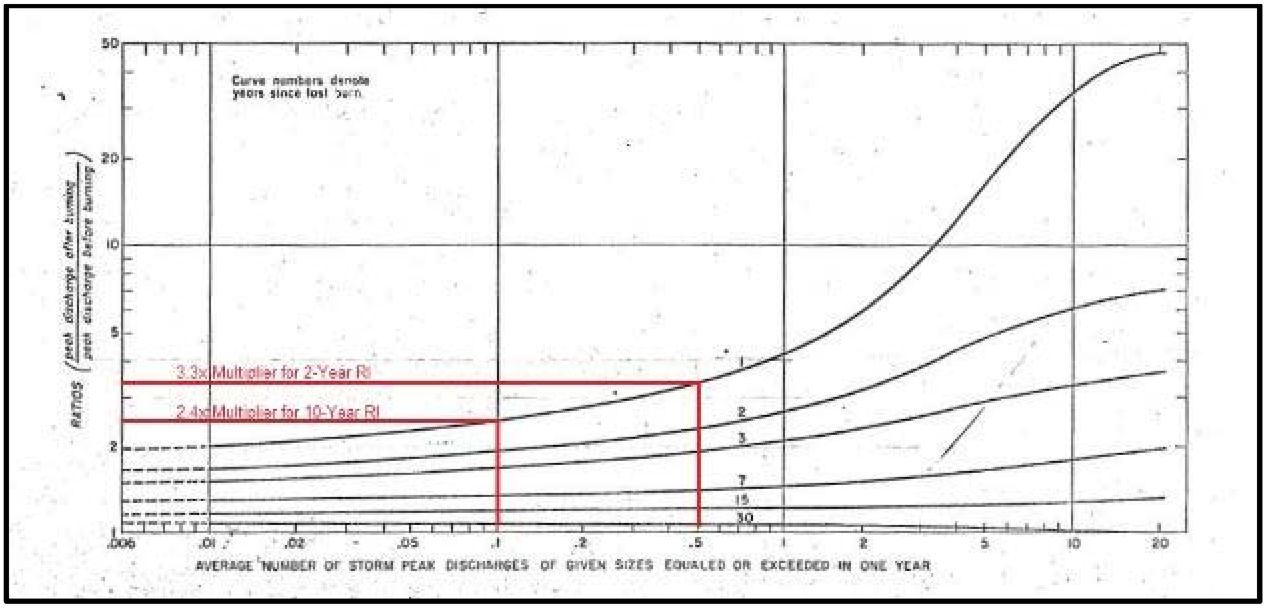

Figure 18. Modification of Figure 9 from Rowe, Countryman, and Storey (1954) showing the average effect of fire on peak discharge frequency classes and years following burning in the Angeles storm zone.

The curves from Rowe et al. (1954) do not reflect changes in clear water flow only, and there is some unspecified level of sediment bulking included in the post-fire flow predictions. As a conservative approach, we included an additional bulking factor in the analysis using the following equation:

$$BF = 1 + \%HighSBS*0.7 + \%ModerateSBS*0.5 + \%LowSBS*0.2$$

where BF is the bulking factor, %HighSBS is the percentage of the watershed with high soil burn severity (SBS), %ModerateSBS is the percentage of the watershed with moderate SBS, and %LowSBS is the percentage of the watershed with low SBS (WEST, 2011).

Bulking by sediment can be extremely important during the first few post-winter periods (LACDPW, 2006). For example, for the 2003 Cedar Fire in San Diego County, the federal BAER team estimated that in addition to projected increases in peak flows, flood flow volumes can increase an additional 2.1 times due to bulking (J. Frazier, USFS Stanislaus National Forest (retired), personal communication). This is considered to be a conservative estimate and it is more likely that bulking will increase flood flows another 30 to 70 percent during very infrequent, severe winter storm events.

3.3.4 Debris Yield Predictions

Debris yields were calculated for 31 pour point watersheds for the Woolsey and Hill fires using two different empirical methods. The first method (Gartner et al. 2014) was developed to predict post-fire debris flow and sediment-laden flood yield for watersheds draining the Transverse Ranges of southern California. The Gartner "emergency assessment model" represented by Equation 3 in the paper was developed for predicting volumes of sediment deposited by both debris flows and floods within two years of a fire, and is the method used by the USGS debris flow model (Staley et al., 2016, see Section 3.3.2 in this report). Gartner's model offers advantages over other methods in that it explicitly factors soil burn severity into the calculation of debris yield.

Gartner et al. (2014) Equation 3 is of the form:

$$(3)\ V = e^{(4.22 + 0.39 (\sqrt{i15}) + 0.36(\ln Bmh) + 0.13(\sqrt{R}))}$$

where:

V = Volume of sediment (m^3)
i15 = Peak rainfall intensity measured over a 15-minute period (mm hr^{-1})
Bmh = Watershed area burned at moderate and high soil burn severity (km^2)
R = Watershed relief (m)

The 2-year and 10-year recurrence interval 15-minute rainfall intensity was estimated using the NOAA Atlas 14-point precipitation frequency estimates website. Rainfall rates were selected at the top of watersheds (i.e., distal end of the channel network) using annual maximum time series. Watershed relief and the watershed area burned at moderate and high soil burn severity were extracted using GIS.

The second method used was the USACE Los Angeles District Method Equations 1 through 5 for calculating total debris yield (Gatwood et al., 2000). The USACE equations predict unit area debris yield, which includes a combination of hillslope and fluvial erosion. The specific equation varies by watershed size where:

USACE Equation 1 (0.1 to 3.0 mi^2) is of the form:

$$(1)\ Dy = 10^{0.65(\text{Log10 } P) + 0.62(\text{Log10 } RR) + 0.18(\text{Log10 } A) + 0.12(FF)}$$

USACE Equation 2 (3.0 to 10.0 mi^2) is of the form:

$$(2)\ Dy = 10^{0.85(\text{Log10 } Q) + 0.53(\text{Log10 } RR) + 0.04(\text{Log10 } A) + 0.22(FF)}$$

USACE Equation 3 (10.0 to 25.0 mi^2) is of the form:

$$(3)\ Dy = 10^{0.88(\text{Log10 } Q) + 0.48(\text{Log10 } RR) + 0.06(\text{Log10 } A) + 0.20(FF)}$$

USACE Equation 4 (25.0 to 50.0 mi^2) is of the form:

$$(4)\ Dy = 10^{0.94(Log10\ Q) + 0.32(Log10\ RR) + 0.14(Log10\ A) + 0.17(FF)}$$

USACE Equation 5 (50.0 to 200.0 mi^2) is of the form:

$$(5)\ Dy = 10^{1.02(Log10\ Q) + 0.0.23(Log10\ RR) + 0.16(Log10\ A) + 0.13(FF)}$$

where:

Dy = Unit Debris Yield ($yd^3\ mi^{-2}$)
P = Maximum 1-Hour Precipitation (inches; taken two places after the decimal point and multiplied by 100)
RR = Relief Ratio ($ft\ mi^{-1}$)
A = Drainage Area (acres)
FF = Fire Factor
Q = Unit Peak Runoff ($ft^3\ s^{-1}\ mi^{-2}$)

Precipitation (P) was selected by using the 2-year and 10-year, 1-hour rainfall magnitude (i.e., annual maximum time series) from NOAA Atlas 14-point precipitation frequency estimates website for each selected pour-point watershed at the distal end of the channel network. The P values selected exceeded the minimum criteria (≥0.3 in) required for use in the model. The USACE method is intended to estimate debris yield from runoff or precipitation events of greater than 5-year recurrence. Estimates below this generally display large errors (Gatwood et al., 2000). The 2-year and 10-year recurrence interval was chosen for this analysis to remain consistent with the flood modeling recurrence intervals; however, it should be noted that the 2-year recurrence debris yield could display larger errors than the 10-year recurrence debris yields. Unit Peak Runoff (Q), was obtained from USGS StreamStats. Relief Ratio (RR) was calculated by taking the difference in elevation between the highest point in the watershed and the lowest point in the watershed and dividing the difference by the stream length using a combination of the NOAA Atlas 14 web browser interface and ArcGIS Collector. A weighted fire factor was calculated based on the percentage of burned and unburned area within the pour point watershed. A value of 6.0 was given to the burned areas, and a value of 3.0 to the unburned areas to represent changed runoff conditions the first year after the fire and unchanged conditions, respectively.

3.3.5 Pre- and Post-Fire Erosion and Sedimentation Modeling

Post-fire erosion rates for the fire area were calculated for the 10- and 50-percent exceedance (10- and 2-year) probability using Batch ERMiT (Erosion Risk Management Tool) by USFS soil scientists Kellen Takenaka and Will Tripp working with the DOI BAER team (Takenaka and Tripp 2018). ERMiT is a web-based tool developed to predict surface erosion from pre- and post-fire hillslopes, and to evaluate the potential effectiveness of various erosion mitigation practices (Robichaud et al., 2011).[6] ERMiT requires input for climate parameters based on location, vegetation type (forest, range, chaparral), soil type (clay loam, silt loam, sandy loam, loam and rock content), topography (slope length and gradient), and soil burn severity class (low, moderate, high). This model provides probabilistic estimates of single-storm post-fire hillslope erosion by incorporating variability in rainfall characteristics, soil burn severity, and soil characteristics into each prediction (Robichaud et al., 2011). ERMiT only predicts rill and interrill erosion due to precipitation. Dry ravel can be the dominant erosion process in burned areas where slopes exceed the angle of repose (i.e., approximately 60 percent slope) (Lamb et al., 2011).

3.3.6 Field Observations of Values-at-Risk

The WERT conducted a site-specific evaluation of Values-at-Risk (VARs) within and immediately below the Woolsey and Hill fire areas. VAR and hazard determination relies on a combination of field observations, geomorphic interpretation, office review of available geologic and topographic data and aerial photography, debris flow and flood modeling, and empirical information based on conversations with local agencies and residents (see Appendices C and D).

Field observations for both the Woolsey and Hill fires VAR identification were conducted from November 22 to November 29, 2018. Four WERT engineering geologists observed the fire areas during a helicopter flight that took place on November 20th. Areas where there were concentrations of residential homes, schools, campgrounds, access roads, and public infrastructure received the greatest attention. Road-related features, such as culverts and bridges, were surveyed at major drainage crossings. **Some potential VARs could not be evaluated due to locked gates or general lack of access.**

The VARs evaluated by the WERT include possible loss of life and property due to an elevated potential for increased stream flows, hyperconcentrated flows, debris torrents, debris flows, rockfall, and associated slope movement as a result of the fire. VARs were evaluated using the USGS post-fire debris flow modeling data for the 24 mm hr^{-1} 15-minute rainfall intensity (probability, volumetric, and combined hazard), FEMA 100-year floodplain mapping, soil burn severity data, topography, aerial imagery, hillshade, slope, watershed boundaries (HUC-12),[7] DWR awareness floodplains, geology, Los Angeles County LiDAR (1 m), and roads. The WERT process utilizes a combined quantitative and qualitative approach for evaluating potential hazard to these values. Team members confirmed hazards based on site-specific observations and interpretation of

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[6] http://forest.moscowfsl.wsu.edu/fswepp/batch/bERMiT.html
[7] A HUC-12 watershed is typically 15,000 to 40,000 acres in size.

active geomorphic processes and landforms. When appropriate, team members noted preliminary or possible emergency protection measures.

Potential hazards to life-safety and property are qualitatively ranked either as low, moderate or high as part of the WERT process, as shown in the VAR summary table (Appendix C). Rankings consider a combination of the probability of potential post-fire impacts as well as the severity of the consequences. High value sites, such as housing tracks, schools, hospitals, and critical infrastructure are ranked conservatively where larger events with lower probability may result in substantial consequences.

4 MODELING RESULTS

4.1 SOIL BURN SEVERITY

The soil burn severity (SBS) for the Woolsey Fire area can be classified as:

- 14 percent unburned to very low SBS;
- 29 percent low SBS;
- 56 percent moderate SBS; and
- 1 percent high SBS.

The soil burn severity (SBS) for the Hill Fire area can be classified as:

- 26 percent unburned to very low SBS;
- 52 percent low SBS;
- 22 percent moderate SBS; and
- 0 percent high SBS.

Figure 19 is a map of SBS for both fires and shows the spatial pattern of SBS throughout the burn area. The map shows that the Woolsey Fire burn area is dominated by moderate SBS, while the Hill Fire is dominated by low SBS. Minor areas of high SBS for the Woolsey Fire are most common on the north facing slope near Castro Peak, along the Backbone Trail (crest of the Santa Monica Mountains).

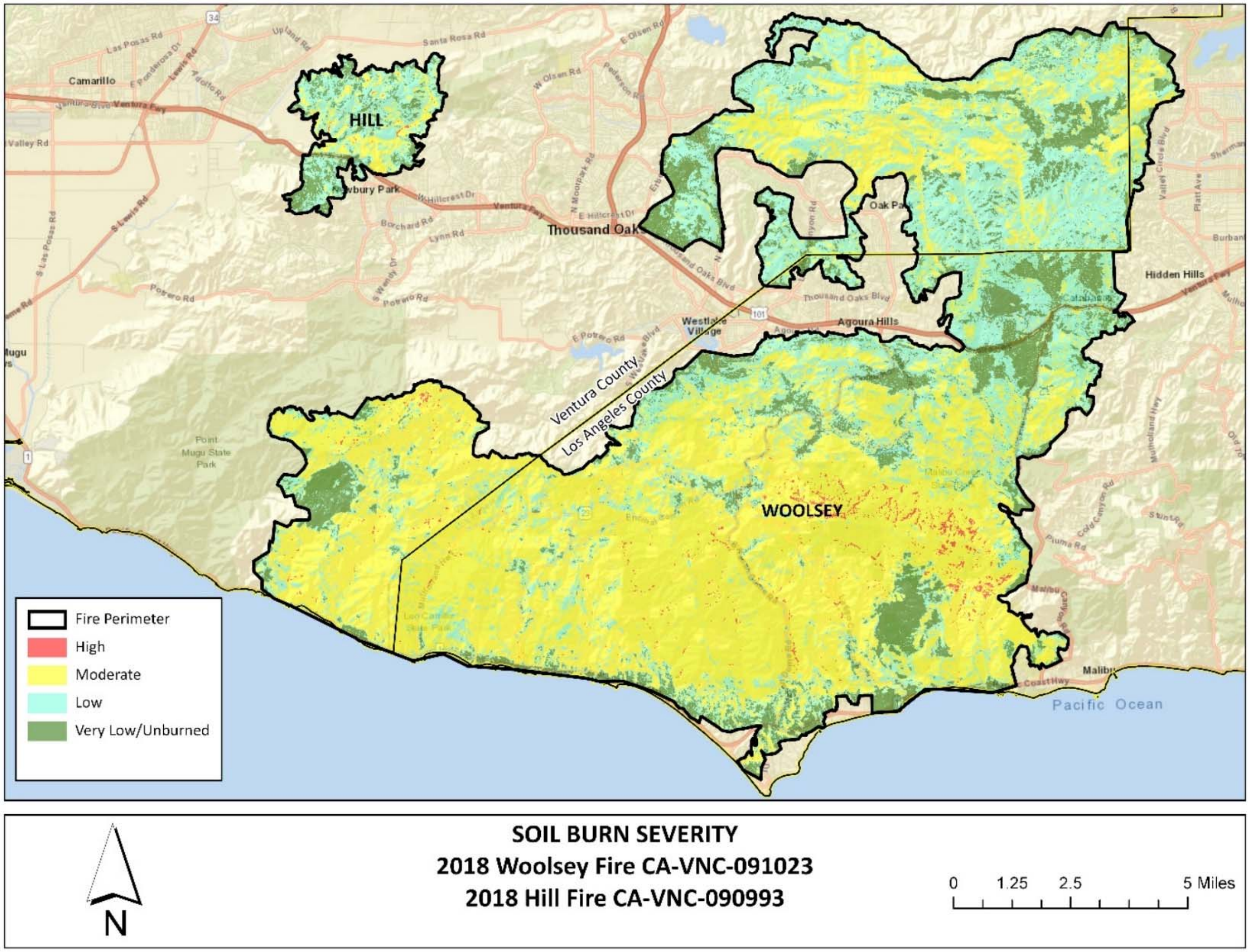

Figure 19. The soil burn severity map for the Woolsey and Hill fires.

4.2 USGS DEBRIS FLOW MODEL RESULTS

4.2.1 Woolsey Fire

The US Geological Survey (USGS) preliminary hazard assessment of the Woolsey Fire can be accessed at:
https://landslides.usgs.gov/hazards/postfire_debrisflow/detail.php?objectid=251

The assessment evaluated hazard for 864 distinct basins and 14,633 distinct stream segments within the Woolsey Fire. Figure 20 and Figure 21 show the spatial distribution of combined debris flow hazard for basins and stream segments affected by the Woolsey Fire for the 20 mm hr^{-1} and 40 mm hr^{-1} design storms, respectively.

Figure 22 and Figure 23 show the percentage of 15-minute basins and stream segments classified by combined debris flow hazard for the 20 mm hr^{-1} design storm (i.e., approximately 0.2 inches in 15 minutes) and 40 mm hr^{-1} design storm (i.e., approximately 0.4 inches in 15 minutes), respectively. Under the 15-min 20 mm hr^{-1} storm scenario, approximately 68 and 32 percent of basins are classified as having a low and moderate combined hazard, respectively, with none classified as having high combined hazard. Under the 15-min 40 mm hr^{-1} storm scenario, only 21 percent of basins are modeled as having low combined hazard, whereas 45 and 34 percent are modeled as having moderate and high combined hazard, respectively. Additional debris flow model outputs for the Woolsey Fire are displayed in Appendix B.

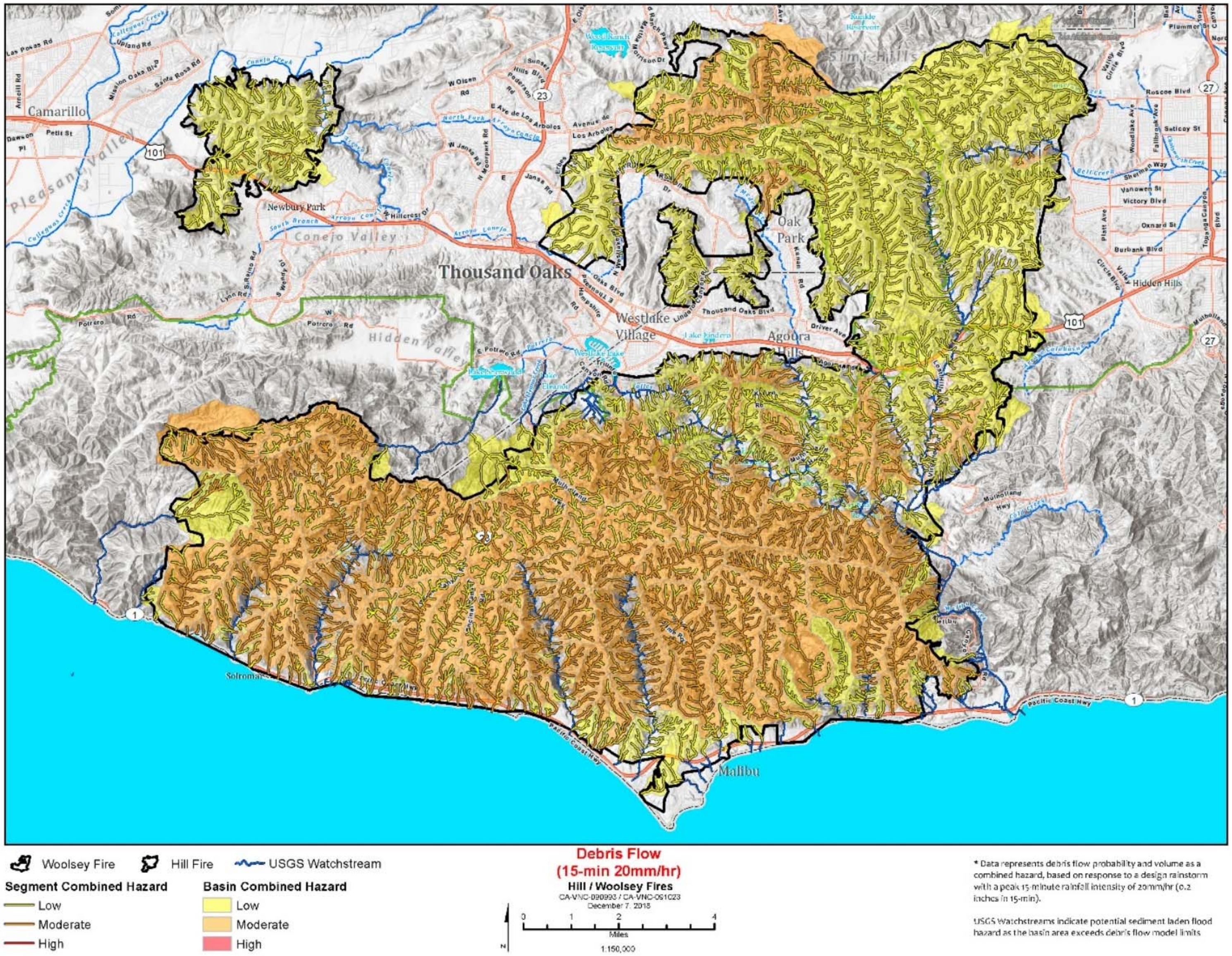

Figure 20. Combined debris flow hazard for the Woolsey and Hill fires for a 20 mm hr^{-1} 15-minute storm event. This event equates to a precipitation depth of approximately 0.2 inches in 15 minutes.

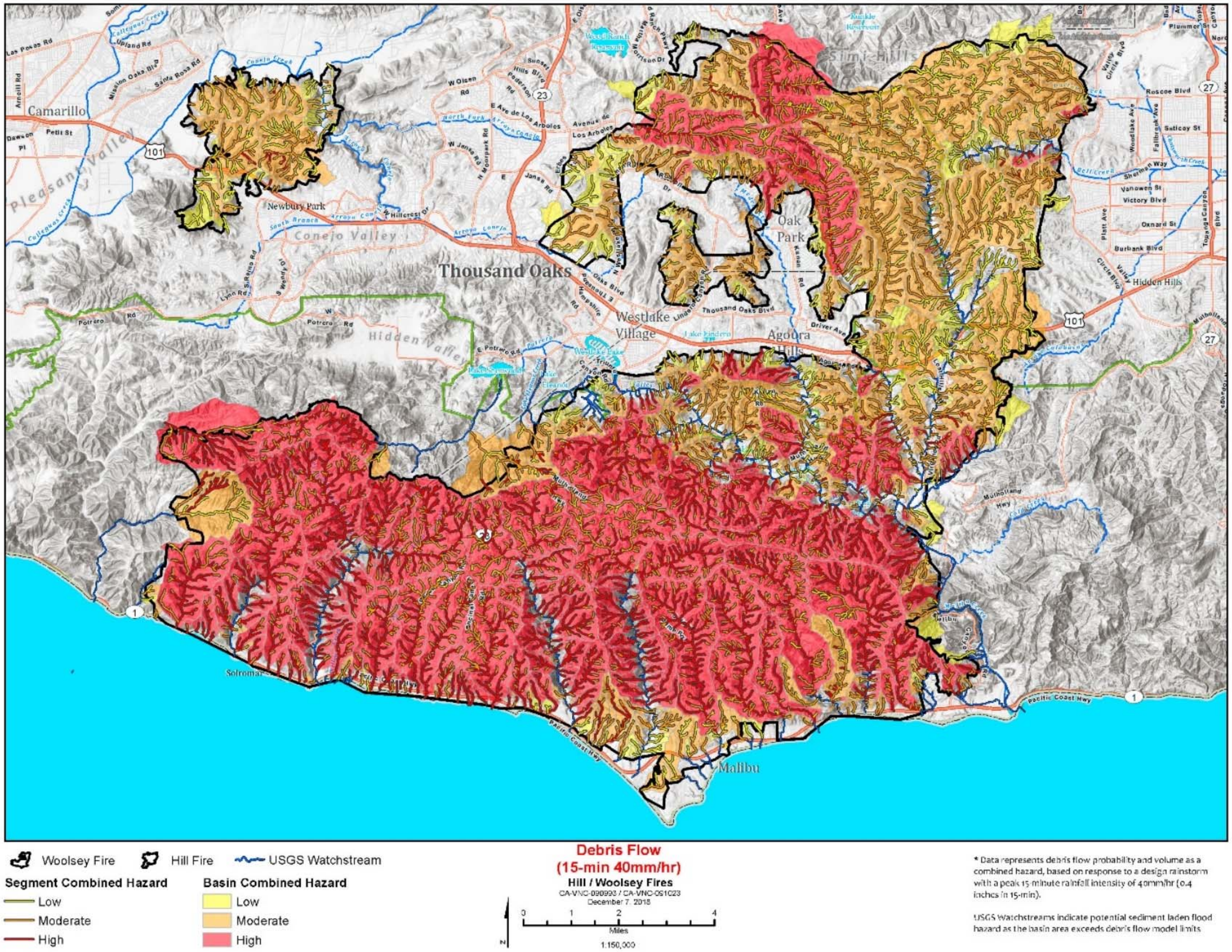

Figure 21. Combined debris flow hazard for the Woolsey and Hill fires for a 40 mm hr^{-1} storm event. This event equates to a precipitation depth of approximately 0.4 inches in 15 minutes.

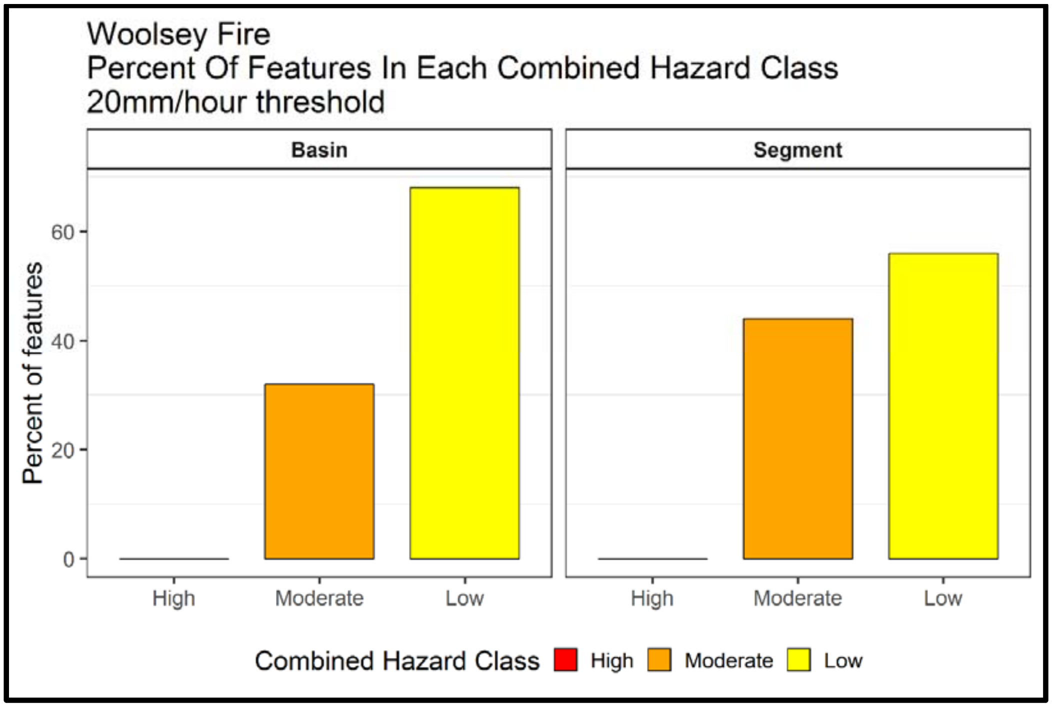

Figure 22. Percent of basins and stream segments in the Woolsey Fire by combined debris flow hazard class for the 15-minute 20 mm hr^{-1} storm. This event equates to a precipitation depth of approximately 0.2 inches in 15 minutes.

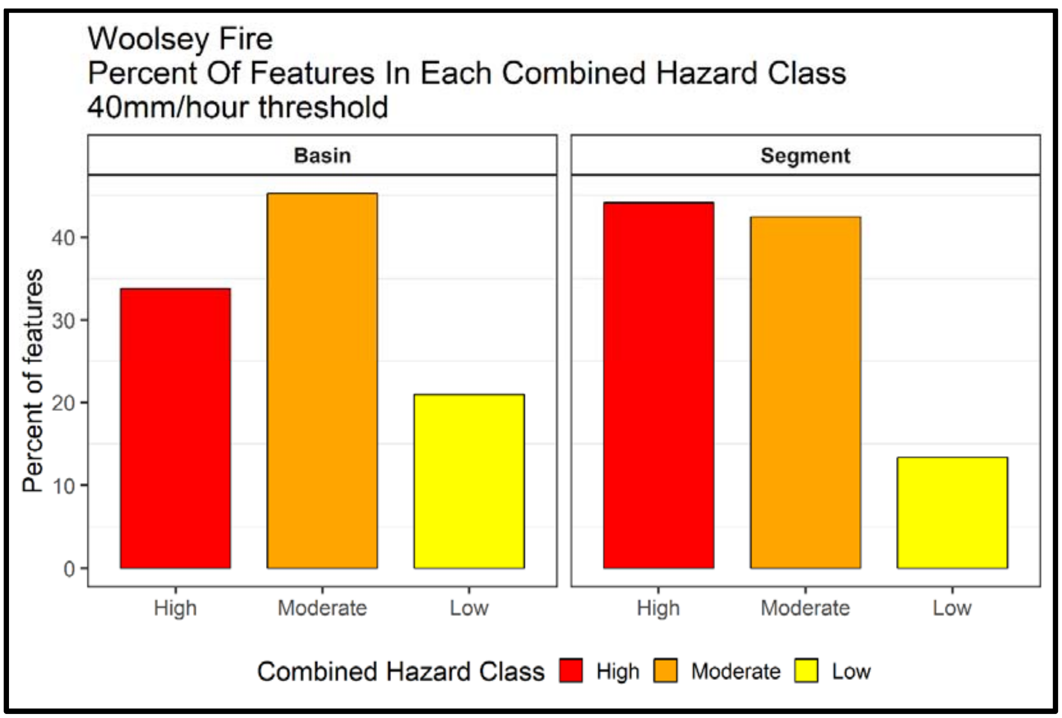

Figure 23. Percent of basins and stream segments in the Woolsey Fire by combined debris flow hazard class for the 15-minute 40 mm hr^{-1} storm. This design storm equates to a precipitation depth of approximately 0.4 inches in 15 minutes.

4.2.2 Hill Fire

The US Geological Survey (USGS) preliminary hazard assessment of the Hill Fire can be accessed at:
https://landslides.usgs.gov/hazards/postfire_debrisflow/detail.php?objectid=252

The assessment evaluated hazard for 34 distinct basins and 310 distinct stream segments within the Hill Fire. Figure 20 and Figure 21 show the spatial distribution of combined debris flow hazard for basins and stream segments affected by the Hill Fire for the 15-min 20 mm hr^{-1} and 40 mm hr^{-1} design storms, respectively.

Figure 24 and Figure 25 show the percentage of 15-min basins and stream segments classified by combined debris flow hazard for the 20 mm hr^{-1} design storm (i.e., approximately 0.2 inches in 15 minutes) and the 15-min 40 mm hr^{-1} design storm (i.e., approximately 0.4 inches in 15 minutes, respectively. Under the 15-min 20 mm hr^{-1} storm scenario, 100 percent of basins are classified as having a low combined hazard. Under the 15-min 40 mm hr^{-1} storm scenario, 56 percent of basins are modeled as having low combined hazard, whereas 44 percent are modeled as having a moderate combined hazard.

Additional debris flow model outputs for the Hill fire are displayed in Appendix B.

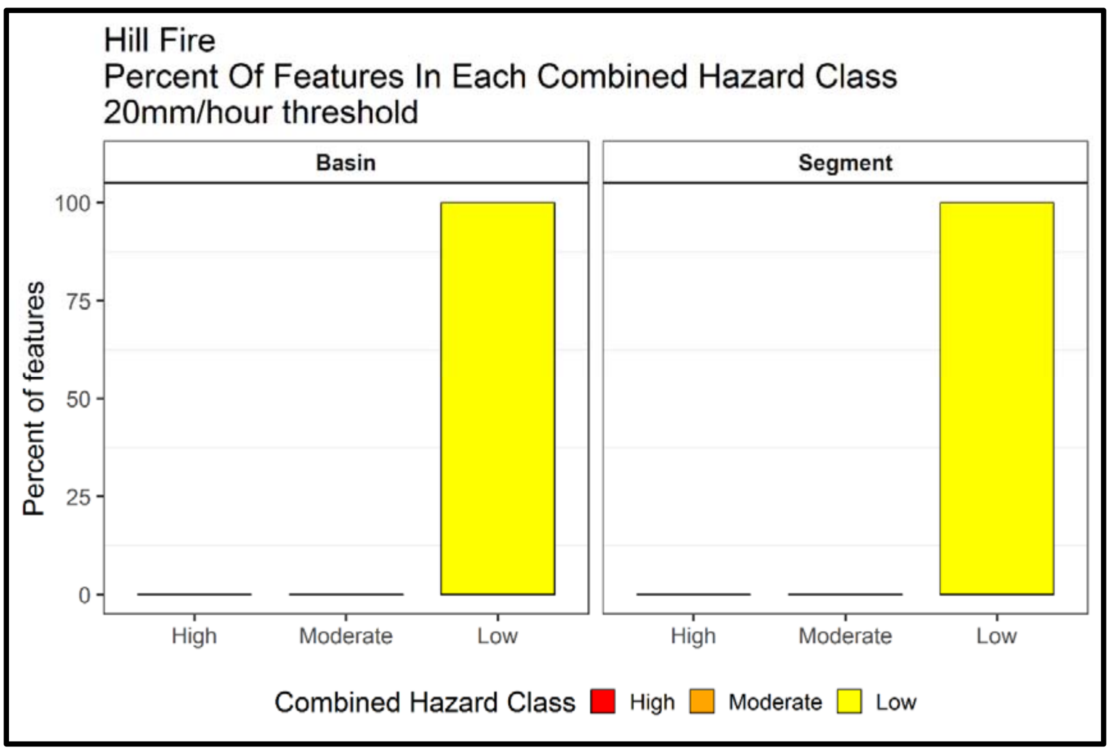

Figure 24. Percent of basins and stream segments by combined debris flow hazard class for the Hill Fire for the 15-minute 20 mm hr^{-1} storm. This design storm equates to a precipitation depth of approximately 0.2 inches in 15 minutes.

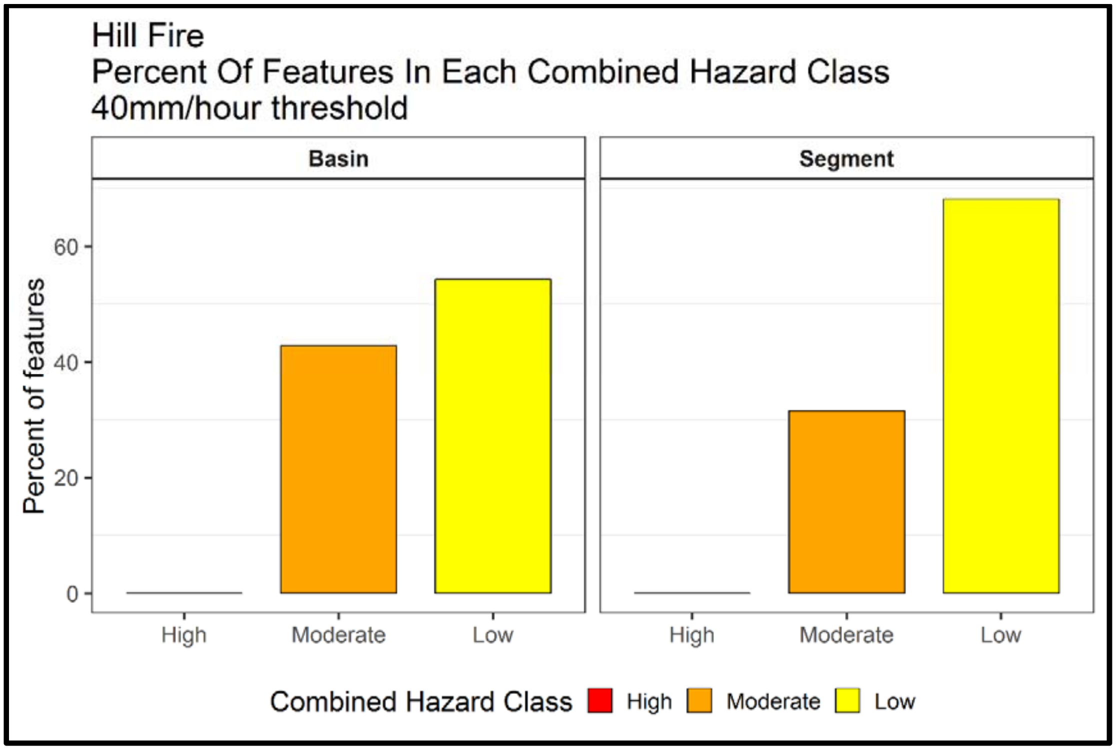

Figure 25. Percent of basins and stream segments in the Hill Fire by combined debris flow hazard class for the 15-minute 40 mm hr^{-1} storm. This design storm equates to a precipitation depth of approximately 0.4 inches in 15 minutes.

4.3 FLOOD MODELING RESULTS

Thirty-one pour point watersheds were established for the Woolsey and Hill fires to estimate potential post-fire peak flow increases to Values-at-Risk from flooding and sediment-laden flood hazard. Figure 26 shows that the pour point locations are concentrated along the Pacific Coast Highway near the Pacific Ocean and widely scattered throughout the remainder of the Woolsey Fire. Only one pour point watershed was selected for the Hill Fire due to its much smaller size and the limited number of drainages that can directly impact VARs. These pour points represent the highest potential for life-safety related flood hazard and/or debris flow impacts to Los Angeles and Ventura county residents. Most of the pour points are located close to the fire perimeter, yielding greater post fire flow increases than those far below the fire perimeter.

Due to modeling uncertainties, absolute changes in flow volumes or peak magnitude from the Woolsey and Hill fires are not provided; rather an estimate of peak flow response is displayed Table 7 to make a more informed determination on flood hazard. Relative increase of peak flows from one drainage basin to another was judged to be most important for this rapid assessment, not the estimated absolute values of the peak flows. Table 7 shows the drainage area of the pour point watersheds, the percentages in each soil burn severity category, and the bulked post-fire multiplier for 2-year and 10-year recurrence interval peak flows. Figure 26 displays the two-year bulked post-fire flow multipliers for the pour point watersheds.

Some pour point watersheds, such as the larger basins within the Malibu Creek watershed (i.e., pour points 19, 22, 23, 24) and the lower portion of Bell Canyon (i.e., pour point 30), drain urbanized areas and may have one or more water impoundments. For these pour points, uncertainty is high and the estimated post-fire flow multipliers are likely overestimating post-fire flow response.

Generation of post-fire flow multipliers for these watersheds indicate a mean 3.9- and 2.9-fold increase for bulked 2-year and 10-year recurrence interval flows, respectively.[8] Individual pour point watersheds with the highest modeling flood flow increases include Solromar, Upper and Lower Trancas, and Puerco Canyon. The flow multipliers for these watersheds are at 4.8 or 4.9 for 2-year recurrence interval events, and 3.5 or 3.6 for a 10-year event. These multipliers are most appropriately applied within the first two years following the fire, or until ground cover within the burn area is well established.

[8] Note that this is equal to increases of 290 percent and 190 percent, respectively.

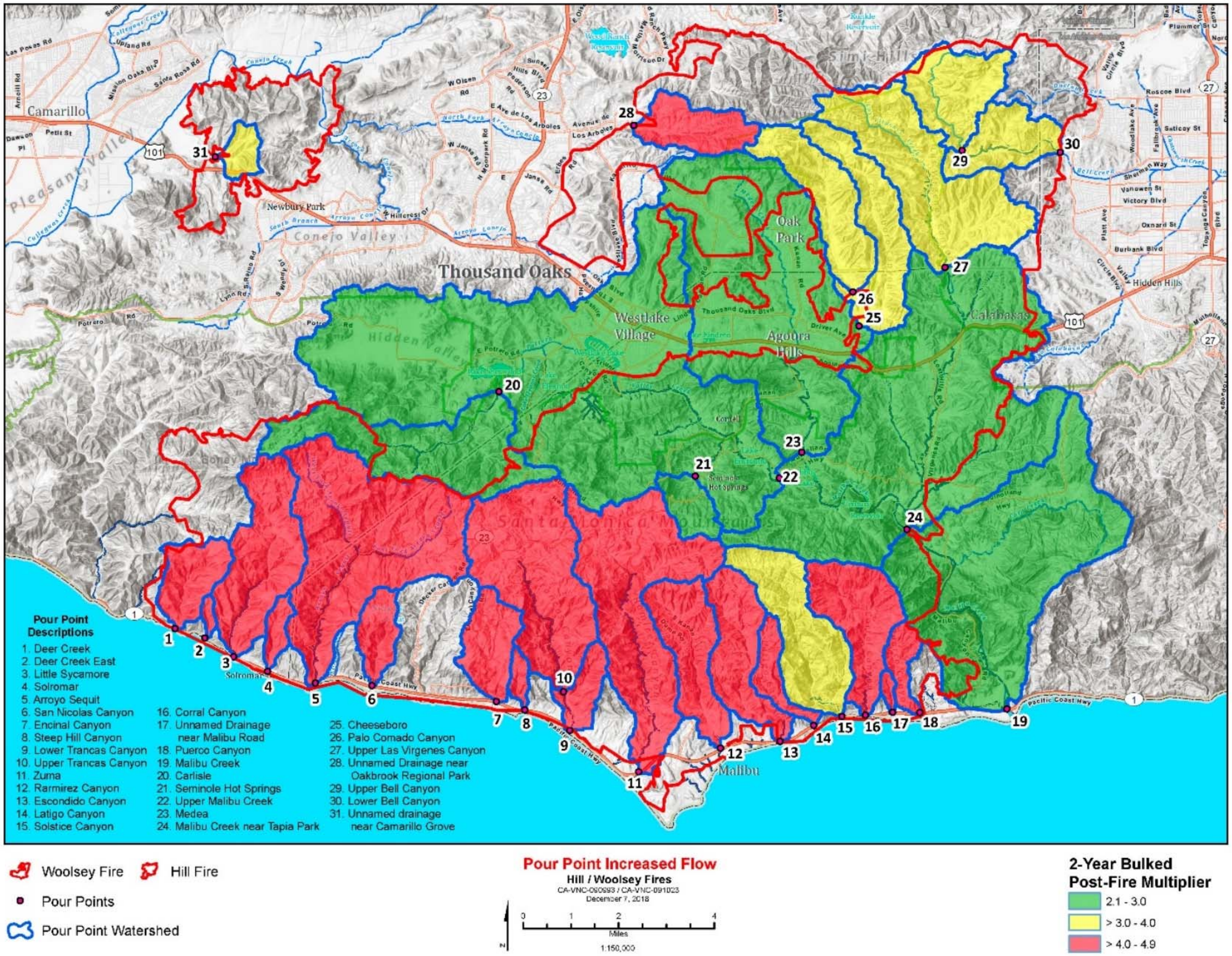

Figure 26. Map of pour point watersheds and the estimated bulked post-fire flow multipliers for the 2-year storm event.

Table 7. Estimated bulked post-fire flow multipliers for the pour point watersheds. Shaded rows reflect pour points that have a relatively high proportion of urbanization and may have one or more water impoundments. Post-fire flow multipliers are likely overestimated for shaded pour points.

Pour Point No.	Pour Point Watershed Name	Acres	Percent Burned	Low SBS (%)	Mod SBS (%)	High SBS (%)	2-Yr Bulked Post-Fire Multiplier	10-Yr Bulked Post -Fire Multiplier
1	Deer Creek	1227	86	17	68	1	4.1	3.0
2	Deer Creek East	122	99	12	86	1	4.8	3.5
3	Little Sycamore	3101	96	15	81	0	4.6	3.4
4	Solromar	378	99	8	92	0	4.9	3.6
5	Arroyo Sequit	6967	98	13	85	0	4.7	3.4
6	San Nicolas Canyon	829	99	10	90	0	4.9	3.5
7	Encinal Canyon	1322	99	17	82	0	4.7	3.4
8	Steep Hill Canyon	247	97	13	84	0	4.7	3.4
9	Lower Trancas Canyon	5544	98	10	88	1	4.8	3.5
10	Upper Trancas Canyon	4820	99	9	89	1	4.8	3.5
11	Zuma	5634	94	11	82	1	4.6	3.3
12	Ramirez Canyon	2094	97	11	85	1	4.7	3.4
13	Escondido Canyon	2077	94	9	84	1	4.6	3.3
14	Latigo Canyon	693	90	21	68	0	4.2	3.1
15	Solstice Canyon	2829	71	13	56	1	3.4	2.6
16	Corral Canyon	2276	91	8	78	6	4.5	3.3
17	Unnamed Drainage near Malibu Road	129	99	21	78	0	4.7	3.4
18	Puerco Canyon	570	98	8	90	1	4.8	3.5
19	Malibu Creek	70528	47	22	24	0	2.4	1.9
20	Carlisle	4128	33	6	27	1	2.1	1.7
21	Seminole Hot Springs	765	100	4	91	5	4.9	3.6
22	Upper Malibu Creek	25084	36	11	25	0	2.1	1.7
23	Medea	15763	56	34	22	0	2.7	2.1
24	Malibu Creek near Tapia Park	60663	53	26	27	1	2.7	2.1
25	Cheeseboro	4731	86	54	32	0	3.8	2.8
26	Palo Comado Canyon	2263	91	51	40	0	4.0	3.0
27	Upper Las Virgenes Canyon	4751	87	58	29	0	3.8	2.8
28	Unnamed Drainage near Oakbrook Regional Park	1397	95	39	56	0	4.3	3.2
29	Upper Bell Canyon	1981	79	52	27	0	3.5	2.6
30	Lower Bell Canyon	3536	71	45	26	0	3.2	2.4
31	Unnamed drainage near Camarillo Grove	468	82	50	32	0	3.6	2.7

4.4 DEBRIS YIELD RESULTS

The 2-year storm estimates of debris yield for the 31 pour points suggest that Gartner et al. (2014) generally predicted more debris yield than the Gatwood equations (Gatwood et al. 2000) for watersheds greater than 2.0 mi^2 (Figure 27). The estimates of debris yield were generally more similar between the two methods for the 10-year storm event (Figure 28, Table 8).

The 2-year estimates from Gartner et al. (2014) suggest that watersheds with the largest debris yield are Arroyo Sequit, Zuma Canyon, Little Sycamore Canyon, Trancas Canyon, and Solstice Canyon, respectively. These same watersheds also produce the highest debris yield using Gartner et al. (2000), although not in the same order. The same watersheds also generally produce the highest yields for the 10-year storms. The various pour points along Malibu Creek also produce large absolute debris yields. However, the results for the Malibu Creek watershed are highly uncertain due to the higher degree of urbanization and the presence of water impoundments.

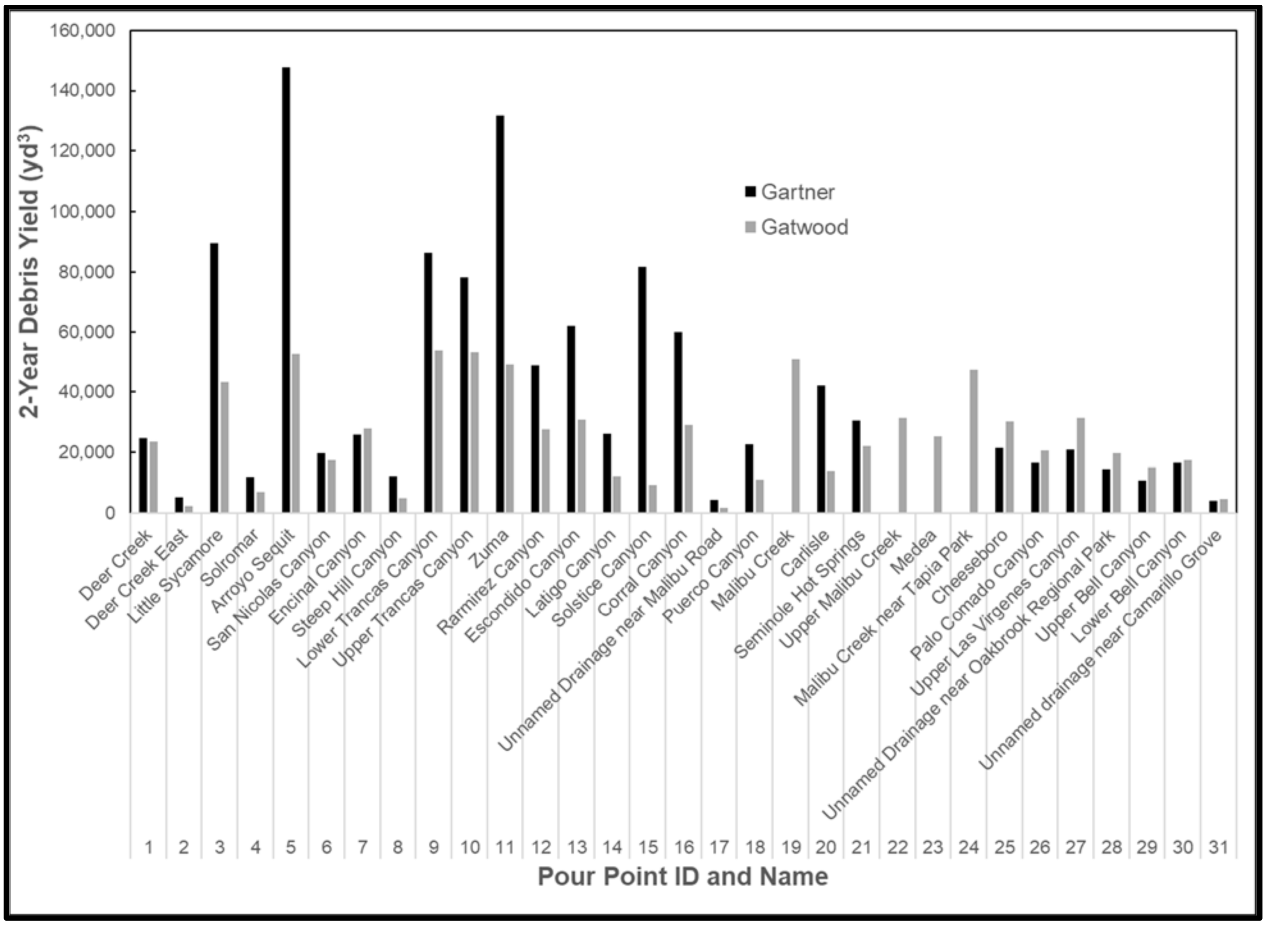

Figure 27. Two-year debris yield estimates for the Woolsey and Hill fire pour point watersheds**.**

Table 8. Estimated pour point debris yields for the 2-year and 10-year storm events. Shaded rows reflect pour points with high uncertainty due to the relatively high proportion of urbanization and may have one or more water impoundments.

Pour Point ID	Pour Point Name	Burn Area (mi^2)	Percent Burned	2-Year Debris Yield (yd^3)		10-Year Debris Yield (yd^3)	
				Gartner	Gatwood	Gartner	Gatwood
1	Deer Creek	1.9	86%	24,614	23,569	41,882	31,949
2	Deer Creek East	0.2	99%	5,353	2,248	9,293	3,097
3	Little Sycamore	4.8	96%	89,509	43,223	160,508	186,346
4	Solromar	0.6	99%	11,928	6,845	20,708	9,429
5	Arroyo Sequit	10.9	98%	147,738	52,696	402,370	263,018
6	San Nicolas Canyon	1.3	99%	19,906	17,480	36,760	24,634
7	Encinal Canyon	2.1	99%	25,878	28,055	49,271	39,684
8	Steep Hill Canyon	0.4	97%	12,253	4,949	23,181	7,072
9	Lower Trancas Canyon	8.7	98%	86,489	53,734	175,434	247,825
10	Upper Trancas Canyon	7.5	99%	78,245	53,203	158,713	243,987
11	Zuma	8.8	94%	131,789	49,173	302,275	227,784
12	Ramirez Canyon	3.3	97%	48,961	27,691	107,036	114,874
13	Escondido Canyon	3.2	94%	61,928	30,743	136,515	130,122
14	Latigo Canyon	1.1	90%	26,294	12,184	56,313	17,896
15	Solstice Canyon	4.4	71%	81,682	9,404	182,978	34,041
16	Corral Canyon	3.6	91%	59,925	29,034	129,670	122,335
17	Unnamed Drainage near Malibu Road	0.2	99%	4,473	1,782	8,692	2,571
18	Puerco Canyon	0.9	98%	22,786	11,065	46,370	15,732
19	Malibu Creek	110.2	47%		50,940		416,543
20	Carlisle	6.4	33%	42,205	13,869	85,299	63,534
21	Seminole Hot Springs	1.2	100%	30,602	22,200	71,036	32,624
22	Upper Malibu Creek	39.2	36%		31,286		194,338
23	Medea	24.6	56%		25,405		132,721
24	Malibu Creek near Tapia Park	94.8	53%		47,316		378,243
25	Cheeseboro	7.4	86%	21,394	30,337	44,155	134,698
26	Palo Comado Canyon	3.5	91%	16,664	20,540	34,393	85,338
27	Upper Las Virgenes Canyon	7.4	87%	21,012	31,287	43,461	138,913
28	Unnamed Drainage near Oakbrook Regional Park	2.2	95%	14,563	19,666	29,043	28,530
29	Upper Bell Canyon	3.1	79%	10,641	15,107	22,010	62,345
30	Lower Bell Canyon	5.5	71%	16,569	17,452	34,270	75,103
31	Unnamed drainage near Camarillo Grove	0.7	82%	4,187	4,673	7,884	6,830

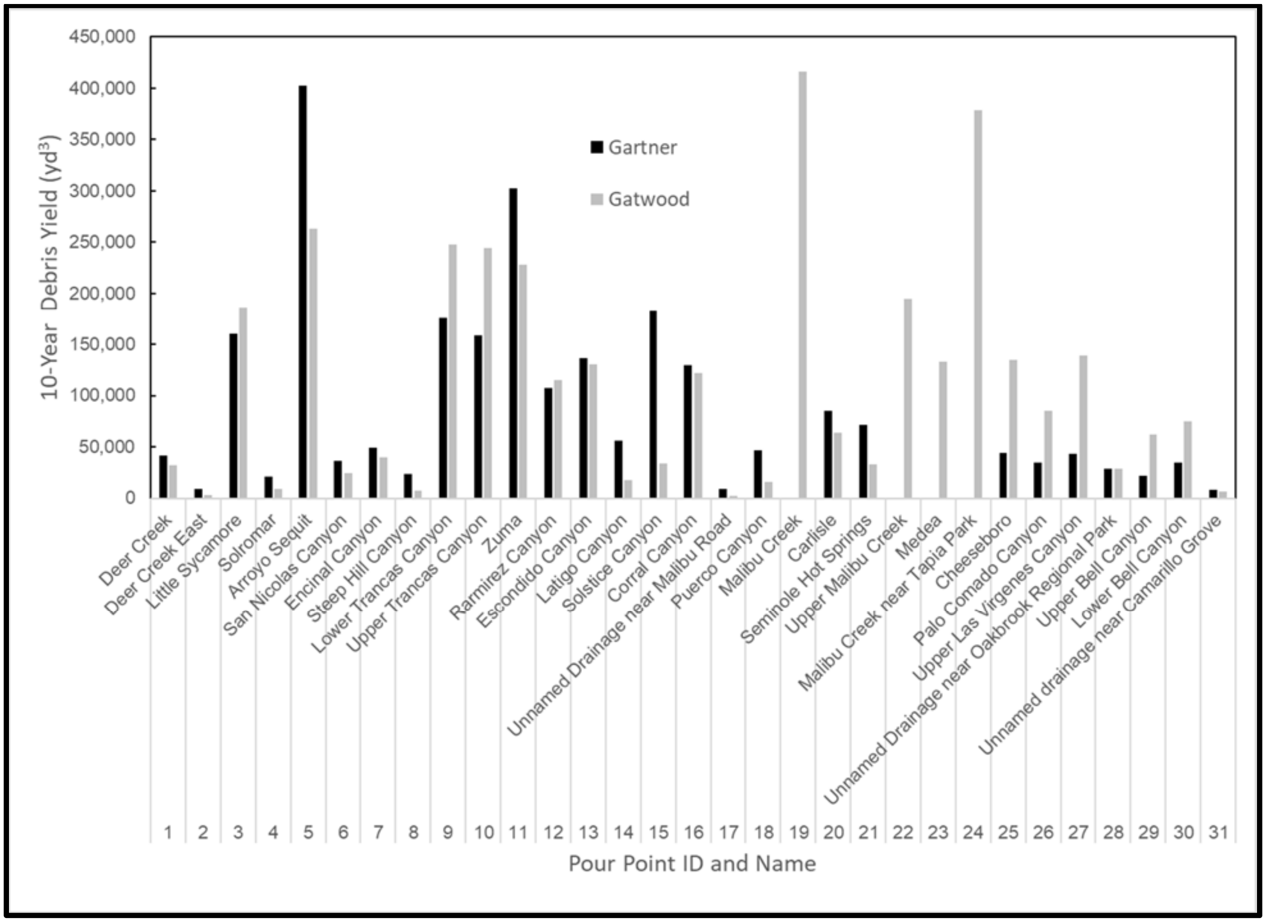

Figure 28. Estimated 10-year debris yields for the Woolsey and Hill fire pour point watersheds.

4.5 SURFACE EROSION MODELING RESULTS

For the Woolsey Fire, ERMiT predicts that surface erosion will increase by 24-fold for the 2-year storm, and a 10-fold increase for the 10-year storm. Figure 29 shows sediment production per unit area for the 50 percent probability storm event for the Woolsey Fire (i.e., 2-year storm). Table 9 summarizes fire-wide sediment production averages for unburned and burned areas for the 2- and 10-year storms for the Woolsey Fire; Table 10 does the same for the Hill Fire. On average, ERMiT predicts that surface erosion for the Hill Fire will increase by 15-fold for the 2-year storm, and a 10-fold increase for the 10-year storm. Figure 30 shows sediment production per unit area for the 50 percent probability storm event for the Hill Fire (i.e., 2-year storm). Empirical data from the 2003 Cedar Fire in San Diego County suggest post-fire erosion rates of approximately 10 to 20 tons $acre^{-1}$ yr^{-1} for granitic hillslope plots and small catchments in the Peninsular Ranges (Robichaud et al., 2013; Hubbert et al., 2012). This suggests that the 10-year ERMiT run predicts within the range of observed values for the general area.

The areas with the highest ERMiT model results for surface erosion correspond to basins with the highest debris flow probabilities. These basins also tend to contain a large percentage of slopes steeper than 60 percent which are most susceptible to dry ravel, providing significant sediment to bulk flood flows and contribute to large debris flows.

Table 9. Woolsey Fire spatially averaged ERMiT sediment production rates for unburned and burned hillslopes for the 2- and 10-year storm event.

2-YR STORM EVENT		**10-YR STORM EVENT**	
Unburned	**Burned**	**Unburned**	**Burned**
0.2 tons $acre^{-1}$	4.7 tons $acre^{-1}$	1.2 tons $acre^{-1}$	12.2 tons $acre^{-1}$

Table 10. Hill Fire spatially averaged ERMiT sedimentation rates for unburned and burned hillslopes for the 2- and 10-year storm event.

2-YR STORM EVENT		**10-YR STORM EVENT**	
Unburned	**Burned**	**Unburned**	**Burned**
0.2 tons $acre^{-1}$	3.0 tons $acre^{-1}$	0.8 tons $acre^{-1}$	7.7 tons $acre^{-1}$

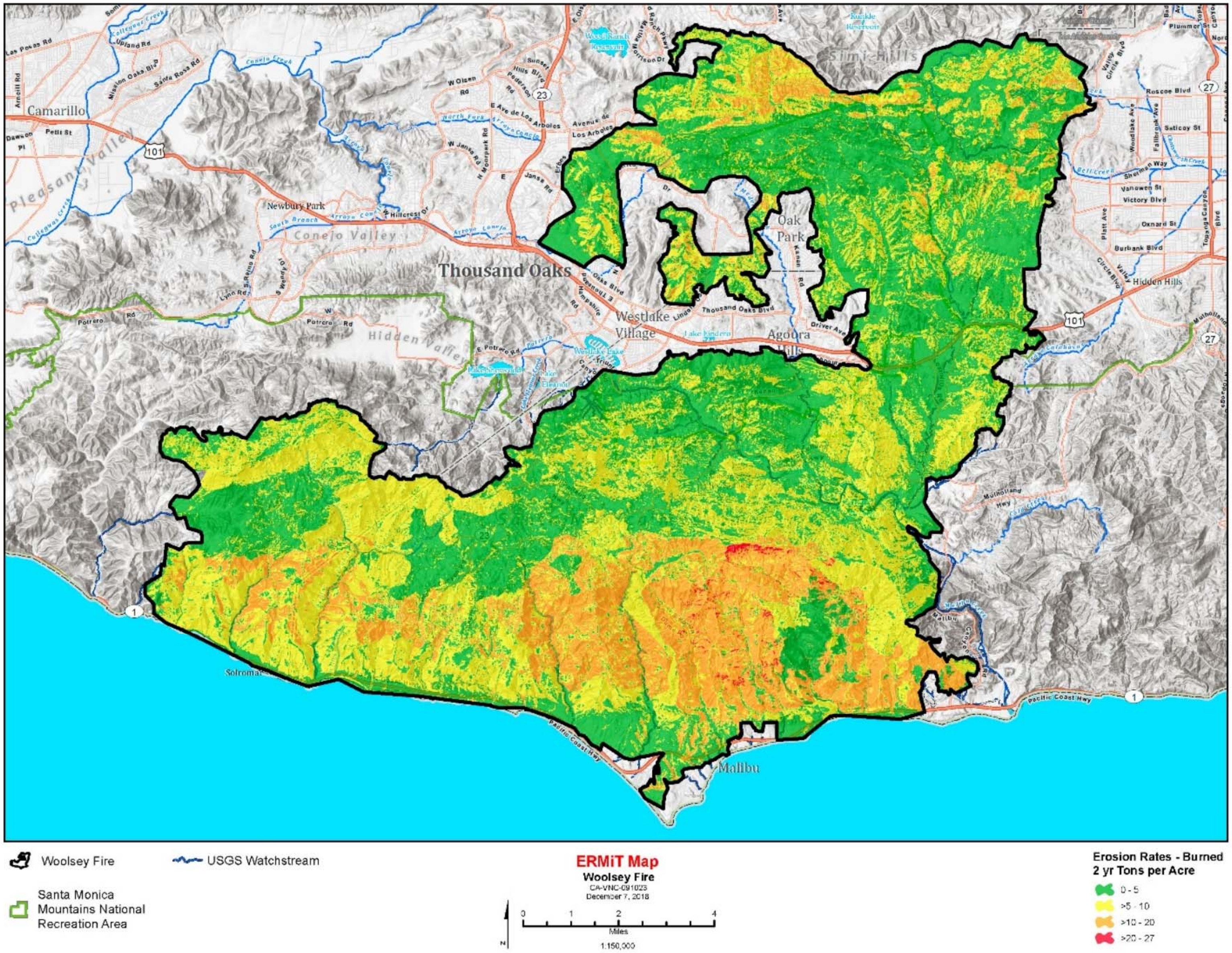

Figure 29. Woolsey Fire predicted range of hillslope sediment production values (tons acre^{-1}) for the 2-year storm.

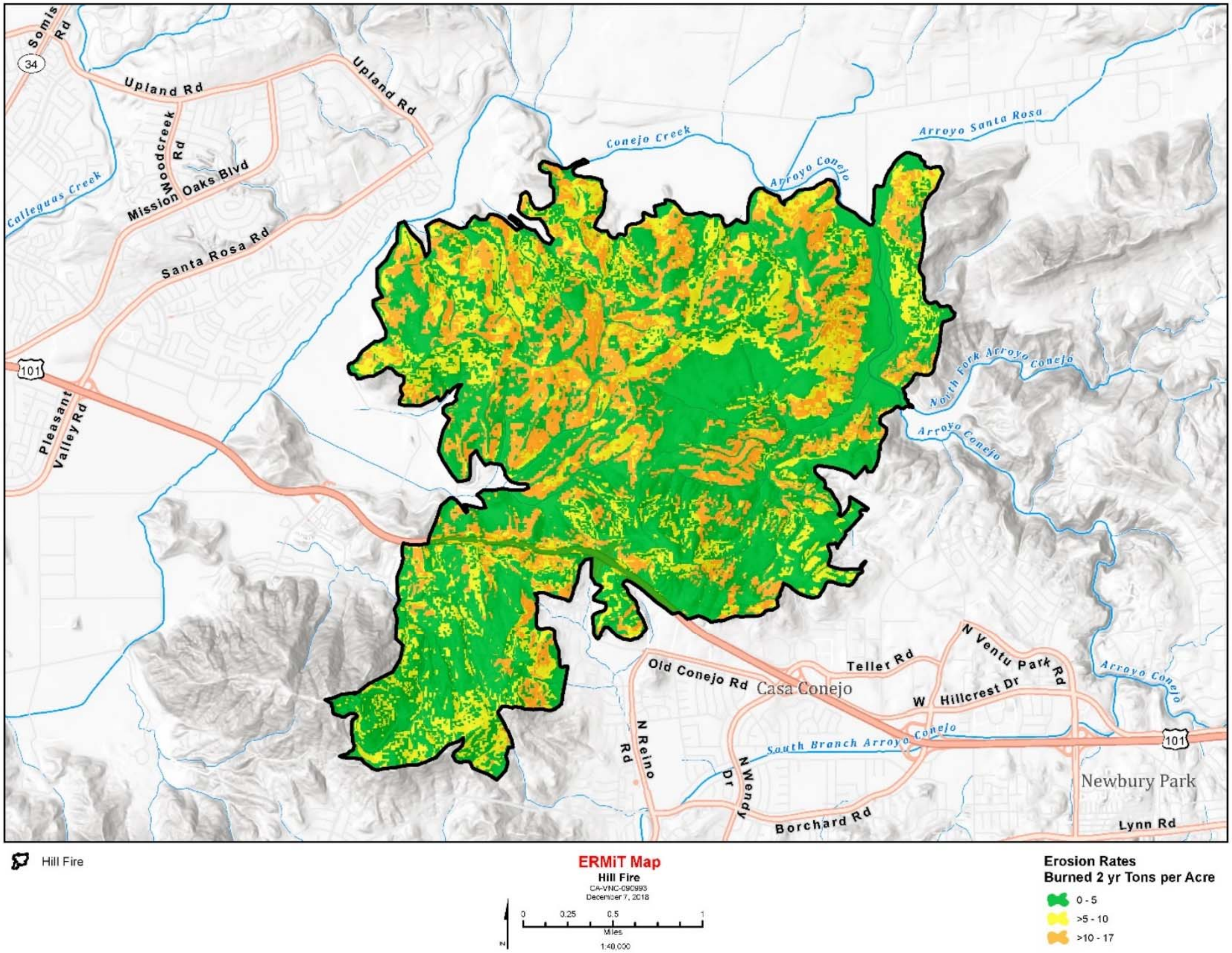

Figure 30. Hill Fire predicted range of hillslope sediment production values (tons acre^{-1}) for the 2-year storm.

5 EMERGENCY DETERMINATION—EXIGENCIES

A total of 410 VARs were identified within and downslope of the Woolsey and Hill fires. The WERT identified 247 VAR points, generally associated with individual structures and/or drainage structures, and 163 VAR polygons, generally associated with larger debris/alluvial fans and channels, residential developments and related infrastructure, road segments, and flood-prone areas. Thirty-two (32) point VARs and 32 polygon VARs are classified as having a high hazard to life and safety. Fifty-three (53) point VARs and 56 polygon VARs are classified as having moderate hazard to life and safety. The remaining VARs are classified as having a relatively low hazard to life and safety, but this does not equate to an absence of risk. For additional details on the inventoried VARs, see Section 6 below, the VAR summary table in Appendix C, maps showing VAR locations in Appendix D, and the VAR information sheets in Appendix F (separate document).

Key areas of concern are:

- Flooding and debris flow impacts to public and residential access roads and highways, including, but not limited to U.S. Highway 101, the Pacific Coast Highway (SR 1), State Route 23, Yerba Buena Road, Kanan Road, Kanan-Dume Road, Mulholland Highway, Malibu Canyon Road, North Westlake Boulevard, Lindero Canyon Road, Carlile Road, Triunfo Canyon Road, Las Virgenes Road, and Bell Canyon Boulevard.
- Flooding and debris jams within designated FEMA 100-year flood zones, DWR awareness floodplains, Los Angeles County floodplains, and/or USGS modelled watch streams. Debris and flood flow impacts to residential communities, commercial structures, schools and other public infrastructure, and campgrounds and parks downstream of Big Sycamore Canyon, Little Sycamore Canyon, Arroyo Sequit Drainage, Zuma Canyon, Trancas Canyon, Ramirez Canyon, Escondido Canyon, Latigo Canyon, Solstice Canyon, Malibu Canyon, Triunfo Canyon, Lobo Canyon, Las Virgenes Reservoir, Westlake Lake, Lindero Canyon, Medea Creek, Palo Comado Canyon, Cheeseboro Canyon, Las Virgenes Canyon, East Las Virgenes Canyon, Bell Canyon, and near the outlet of unnamed burned basins with observed debris flow probability.
- Rockfall hazards downslope of steep rocky slopes and along steep canyon roads, particularly Yerba Buena Road, Mulholland Highway, Decker Canyon Road (SR 23), Kanan-Dume Road, Latigo Canyon Road and Kanan Road.
- Debris flow and flood impacts to culverts, bridges, drainage basins, inlet structures and/or modified channels within and adjacent to Thousand Oaks, Lindero Canyon, Oak Park, Bell Canyon, Calabasas, Agoura Hills, Simi Hills, Westlake Village, Malibu, Malibou Lake, and southwestern Santa Monica Mountains and Pacific Coast Highway coastal communities.

6 OBSERVATIONS AND RECOMMENDATIONS

Potential Values-at-Risk (VARs) were grouped into 6 areas defined by HUC 10 watershed boundaries and U.S. Highway 101 (Figure 31). General observations and recommendations for each of these areas are provided below; more detailed observations are provided in the VAR summary table (Appendix C). However, this evaluation is not intended to be comprehensive and/or conclusive, and additional VARs may be identified through more detailed evaluation by responsible agencies. Several limitations include:

- Flood hazard mapping was either incomplete or non-existent in several areas.
- Lack of detailed elevation data (LiDAR) for Ventura County and hydrologic network information limited the team's ability to perform rapid hazard identification in parts of these fires.
- Hazards on alluvial fans could not be represented as single-points given the potential for avulsion and flow-path uncertainty. Alluvial fan VARs are generally presented as polygons.
- Not all roadway culverts are identified as individual VARs.
- Some potential VARs could not be evaluated due to lack of access.
- VAR evaluation was not conducted within all mapped flood hazard areas that are downstream of the burn perimeter. Risk of flooding in these areas was preexisting and is anticipated to be increased by post-fire runoff. As such, local agencies should consider these mapped hazard areas in addition to the VARs identified in this report.

It should be noted that the observations included in this report are not intended to be fully comprehensive and/or conclusive, but rather to serve as a preliminary tool to assist emergency responding agencies (e.g., Los Angeles and Ventura counties, local fire departments, Caltrans, Office of Emergency Services, Natural Resource Conservation Service, utility companies, and other responsible agencies) in the development of more detailed post-fire emergency response plans and assessments.

It is intended that the responsible agencies will use the information presented in this report as a preliminary guide to complete their own more detailed evaluations and develop detailed emergency response plans and mitigations. These agencies may identify additional VARs through their more detailed evaluations.

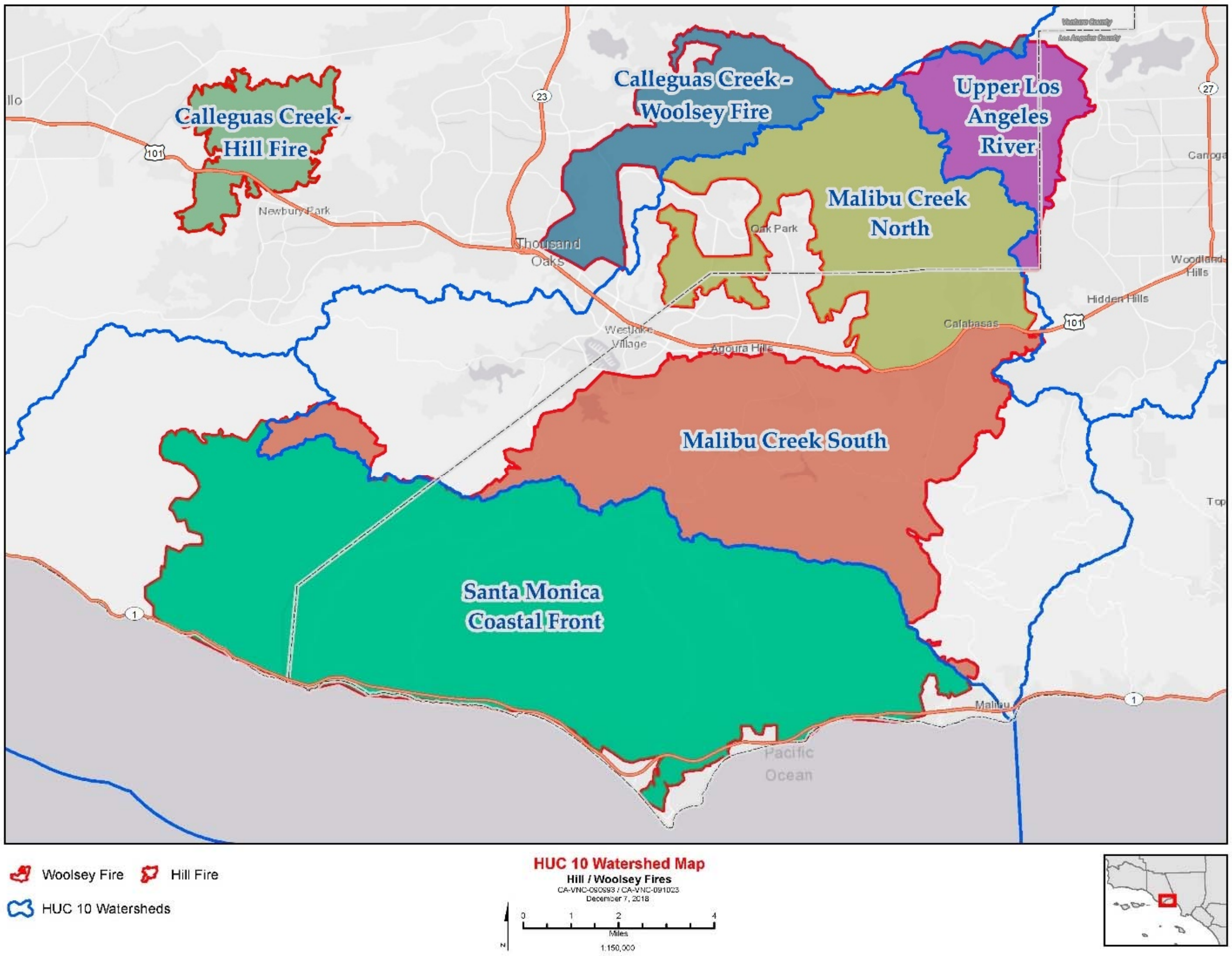

Figure 31. HUC 10 watershed boundaries and U.S. Highway 101 used to define six areas for more detailed descriptions of Values-at-Risk.

6.1 SANTA MONICA COASTAL FRONT

Observations

The burned area along the south and west-facing slopes within the western end of the Santa Monica Mountains between Malibu Canyon Road and Big Sycamore Canyon is a source of potential hazards to downstream residents and improvements. Debris basins and drainage improvements (culverts, diversion canals) have been constructed upslope of residential and commercial development in several areas, which may reduce the potential for downstream flooding or debris flows. Residences within the Santa Monica Coastal Front are accessed from the Pacific Coast Highway (SR 1) via Mulholland Highway, Kanan-Dume Road, Malibu Canyon Road, and numerous local side streets.

Regional geologic mapping (Campbell et al., 2014) characterizes the geologic units underlying the Santa Monica Coastal Front as Cretaceous-aged Tuna Canyon Formation, early Eocene to late Paleocene-aged Santa Susana Formation, early to middle Eocene-aged Llajas Formation, early Miocene, Oligocene and late Eocene-aged Sespe Formation, early Miocene-aged Vaqueros Formation, early to middle Miocene-aged Trancas Formation, early to middle Miocene-aged Zuma Volcanics, middle Miocene-aged Topanga Formation, middle Miocene-aged Conejo Volcanics, and middle to late Miocene-aged Monterey Shale. The sedimentary and volcanic bedrock is intruded by middle to late Miocene-aged diabase, basalt and andesite sills and dikes (Campbell et al., 2014). Quaternary-aged alluvial, wash, fan and terrace deposits are mapped along the toe of the west-facing slopes, downslope of canyon outlets and within elevated valleys. Many of the residential developments along the Pacific Coast Highway downslope of the Woosley burn area are constructed on graded pads underlain by alluvial fan on terrace deposits. The fan deposits are mapped by Campbell et al. (2014) as old; however, while alluvial features observed generally appeared incised, fans observed at the mouths of canyons along the Pacific Coast Highway still feed into this area and may be subject to inundation during significant rainfall events.

Unstable slope conditions are apparent in the burned areas upslope of the coast. Dry ravel and alluvium/colluvium, including cobble- to boulder-size rocks, were observed in steep drainages, along the steep canyon headwalls, and on side slopes above the residential areas (see photographs E-5 and E-6). These observations suggest the presence of preexisting rockfall and debris flow hazards. Recent small-scale shallow landslides were observed in steep headwalls and along steep streamside slopes, further confirming active hillslope processes and providing material to stream channels to be mobilized by subsequent debris flows. The east-west trending Malibu Coast fault is mapped by Jennings and Bryant (2010) as bisecting the southern portion of the Santa Monica Coastal Front burn area. The fault exhibits evidence of late Quaternary and Holocene (<11,000 years old) activity. In addition to storm events, landsliding and rockfall may also be triggered by strong ground shaking associated with earthquakes on nearby faults providing another source of material in channels to be mobilized during debris flow events.

USGS debris flow modeling on the slopes within the Santa Monica Coastal Front indicates that 199 of the 287 (69 percent) drainage basins exhibit debris flow probabilities at 40 percent or greater (using a threshold of a 15-minute duration at 24 mm hr^{-1} rainfall rate) within the burned portions of these drainages (https://landslides.usgs.gov/hazards/postfire_debrisflow/detail.php?objectid=251).

Many of the residential structures observed within and below the drainages upslope of the Pacific Coast Highway are built in low-lying areas within the delineated river floodplains and are prone to flooding. Debris and flood flows originating in channels above the low-lying areas can flow downslope through the communities and impact the low lying residential areas as sediment and debris laden floods. Drainage structures in the residential developments, including confined constructed channels and channel road crossings, can trigger in channel avulsion (i.e., the rapid shifting of channel location) and overbank flooding during storm events.

The lower portions of Zuma, Ramirez, Escondido, Trancas, Big Sycamore, and Little Sycamore canyons and Arroyo Sequit drainage are designated as Zone A-Special Flood Hazard Areas by the Federal Emergency Management Agency (FEMA). Residences and structures located within these areas, including Point Mugu State Park, Leo Carrillo State Park, Camp Hess Kramer, and residential developments along Paseo Canyon Drive, Bonsall Drive, Ramirez Canyon Drive, Via Escondido Drive and connecting side streets, are subject to inundation by the 1-percent annual exceedance probability flood event (i.e., a flood event that has a 1-percent chance of being equaled or exceeded each year or a 100-year flood). Additionally, low-lying areas within the lower reaches of Latigo and Solstice canyons are identified as designated floodplains by Los Angeles County. It is anticipated that the effects of the moderate to high burn severity in the watersheds that drain to the populated areas will increase the frequency and magnitude flooding, debris flows, and hyperconcentrated (mud) flows. The magnitude of the hillslope response will be increased by the post-fire changes to hydrology and soil properties.

Debris flows, rockfall and flooding may plug culverts and impact structures and infrastructure, potentially resulting in adverse impacts to adjacent residential structures and restricting residential access along the Pacific Coast Highway and connecting side streets. Two approximately 1,000 and 2,000-foot long constructed concrete diversion channel segments below the outlet of Trancas Canyon divert channel flows around residential developments along Paseo Canyon Drive. The constructed segments are separated by an approximately 1000-foot long stretch of natural channel. Alluvial and debris flow deposits and woody debris observed in the channel appear to have reduced channel capacity within the natural channel, potentially increasing the frequency of overbank flooding.

Rockfall hazards were noted above residences located below steep slopes and ridge-forming bedrock outcrops within the upper reaches of the Santa Monica Coastal Front burn area. Potential rockfall hazards are identified along stretches of Kanan-Dume Road, Latigo Canyon Road, Yerba Buena Road, Decker Canyon Road and Mulholland Highway, where perched rocks and boulders were observed above steep raveling road cut banks.

Residential communities and infrastructure observed downslope of the steep slopes and debris flow drainages were identified as Values-at-Risk. A total of 147 VARs were found within and downslope of the Santa Monica Coastal Front burn area, including polygons encompassing hundreds of individual structures. Forty-one of the VARs observed within and downslope of the Santa Monica Coastal Front burn area were determined to constitute a high risk to public safety, property or both, resulting from residential, commercial and recreational structures located at the base of potential rockfall slopes, the mouths of debris and flood flow-prone catchments, or within delineated floodplains (see photographs E-6 and E-11).

Recommendations

- Monitor areas along the Pacific Coast Highway, including but not limited to residential, commercial and recreational developments along Yerba Buena Road, Paseo Canyon Drive, Bonsall Drive, Ramirez Canyon Drive, Via Escondido Drive, and within Point Mugu and Leo Carrillo State Parks (VARs 101, 21, 154, 374, 219, 155, 161) subject to increased inundation during significant storm events.
- Consider installing diversion structures, including sand bags and/or concrete K-rails, along stream banks and around residences when high flood flows and debris flows are predicted along drainages.
- Utilize existing early warning systems, linked to up-to-date storm information. Consider evacuations of residential structures located within flood-prone areas, and at the base of steep canyons and steep side slopes that may be subject to debris flows, floods and/or rockfall hazards, including but not limited to structures along Yerba Buena Road, Paseo Canyon Drive, Bonsall Drive, Ramirez Canyon Drive, Via Escondido Drive, and within Point Mugu and Leo Carrillo State Parks (VARs 101, 21, 154, 374, 219, 155, 161).
- While preliminary mitigations can consist of early warnings, staying out of channels during storm events, road signage and warnings, removing large debris from channels, and staging of equipment to clear roadways, additional engineered mitigations can be designed and implemented by the appropriate professionals.
- Perform storm infrastructure monitoring and monitor road drainage infrastructure along highways and residential roads, including but not limited to the Pacific Coast Highway, Highway 23 (Encinal Canyon Road), Kanan-Dume Road and Mulholland Highway.
- Cleanout and monitor culverts and drainage structures prior to and during large rain events where they cross residential streets.
- Monitor and clean out debris basins, as needed (see photograph E-7).
- Consider installing signage and rock catchment structures where appropriate in areas prone to rockfall along Kanan-Dume Road, Latigo Canyon Road, Yerba Buena Road, Decker Canyon Road and Mulholland Highway.

- Consider constructing diversion structures where debris and flood flow channels may adversely impact residential development or restrict residential access roads where flooding is anticipated during predicted high intensity rain events. Site specific mitigations and containment and diversion structures should be designed by licensed professionals specializing in geotechnical engineering, soil erosion, and engineering geology.
- Provide Santa Monica Coastal Front burn area residents and commercial business owners with this VAR information so they may understand their proximity to hazard areas, and take appropriate actions—including evacuation when directed.
- Consider evaluating the channel capacity in the natural channel section of Trancas Canyon Creek along the residential subdivision on Paseo Canyon Drive to determine if removal of deposits within the channel could reduce flood hazards to the residences.
- Remove downed large woody debris and large dead trees from the channel of the natural section of Trancas Canyon Creek along the residential subdivision on Paseo Canyon Drive that have the potential to become trapped at the bridge accessing the residential development or become trapped in standing vegetation causing deposition further impacting channel capacity.

6.2 MALIBU CREEK-SOUTH

Observations

The Malibu Creek area is located in the central portion of the Woolsey Fire burn area and is characterized by moderate to steep slopes that drain into Malibu Creek. Medea Creek and Las Virgenes Creek flow to the southeast and to the Pacific Ocean through Malibu Canyon. Slopes within the Malibu Creek watershed are primarily burned at moderate soil burn severity, with some small areas of high soil burn severity on north-facing slopes along the southern portion of the watershed.

Regional geologic mapping (Campbell et al., 2014) characterizes the geologic units underlying the Malibu Creek watershed as early to middle Miocene-aged Conejo Volcanics, early Miocene-aged Topanga Canyon Formation, middle Miocene-aged Calabasas Formation, Oligocene-aged Vaqueros Formation, and Oligocene and late Eocene-aged Sespe Formation. The sedimentary bedrock is locally intruded by early to middle Miocene-aged dacite, basalt and andesite sills and dikes. Quaternary-aged young and old alluvial deposits are mapped within the channels of creeks throughout the watershed.

Mulholland Highway traverses the watershed and provides access to the community of Malibou Lake. The Malibou Lake community has a known history of flooding and a significant number of residential structures at risk. Approximately 70 structures burned around the lake, which is created by a dam located at its southeastern end that was reported to be near capacity at the time of the Woolsey Fire (see photograph E-9). USGS debris flow basin modeling indicates numerous drainages with moderate to high debris flow hazard potential that flow into the lake. The lake is reportedly less than 5 feet deep and sediment is removed annually from the lake by dredging. Lake capacity will likely be impacted by post-fire sediment-laden runoff, flooding, and debris flows. VARs in this area include residential structures located on a debris fan along the south shore of the lake (VAR 253) which USGS modeling identifies as having a moderate to high debris flow hazard potential. There is also increased potential for flooding of residential structures along the lake shore, which is in the FEMA 100-year floodplain.

Malibu Creek State Park occupies much of the southern and eastern portions of the watershed and is characterized along its southern boundary by steep canyon headwalls and drainages containing cobble- to boulder-sized rocks. USGS debris flow modeling indicates these drainages constitute a moderate to high debris flow hazard potential. However, many of these drainages flow into Malibu Creek and do not pose a direct risk to people or property downstream. The Salvation Army Camp Lawrence Daley, which suffered significant damage from the fire, is located near the southeastern area of the state park. USGS debris flow basin modeling indicates several drainages with moderate to high debris flow hazard potential toward the Camp Gilmore and Mt. Crags camps. Rockfall is also an observed hazard to the Mt. Crags camp, which is located near the base of steep cliffs comprised of Conejo Volcanics rocks. VARs which constitute high risk from debris flow were identified where drainages flow through camp facilities and guest housing, and where potential rockfall from steep cliffs pose a threat to life safety and property (VARs 156, 157, and 158). The central and northern portions of the park are characterized by moderate to steep drainages flowing south into Las Virgenes Creek and Malibu Creek. VARs in this area include a 24-inch diameter water main (VARs 391 and 392). The water main traverses the lower portions of Liberty Canyon Creek and Las Virgenes Creek, along with a bridge across lower Las Virgenes Creek which provides access to state park housing facilities.

VARs were also identified along the lower reaches of Malibu Creek north of Malibu Lagoon (VARs 187, 226, 288, and 358). It is anticipated that the effects of the moderate to high soil burn severity in the watersheds that drain to the populated areas will increase the risk of flooding. Debris flows, rockfall and flooding may plug culverts and impact structures and infrastructure potentially resulting in adverse impacts to residential structures downstream and restricting residential access along Cross Creek Road in Malibu.

Residential communities and infrastructure observed downslope of steep slopes and debris flow drainages were identified as VARs in Stokes Canyon, Lobo Canyon, Triunfo Canyon, Liberty Canyon, Seminole Hot Springs, and Cornell, as well as along Medea Creek, Potrero Valley Creek, West Carlisle Road, Agoura Road, and Wagon Road. Over 100 VARs were identified within and downslope of the Malibu Creek burn area, including polygons encompassing numerous structures. Thirty-eight of the VARs observed within and downslope of the Malibu Creek burn area were determined to constitute a high risk to public safety, property or both. Residential, commercial and recreational structures located at the base of potential rockfall slopes, the mouths of debris and flood flow catchments, or within delineated floodplains were identified as being at risk.

Most of Stokes Canyon, Liberty Canyon, Lobo Canyon, Triunfo Canyon, Seminole Creek, Malibu Creek, Medea Creek, Potrero Valley Creek, and Las Virgenes Creek drainages are designated as Zone A-Special Flood Hazard Areas by the Federal Emergency Management Agency (FEMA). Residences and structures located within these areas, including Malibu Creek State Park, Paramount Ranch, Malibou Lake, Las Virgenes Reservoir, Westlake Lake, and Seminole Hot Springs, and connecting side roads, are subject to inundation by the 1-percent annual exceedance probability flood event (i.e., a flood event that has a 1-percent chance of being equaled or exceeded each year, or a 100-year flood). Additionally, the lower reach of Liberty Canyon is identified as a designated floodplain by Los Angeles County. It is anticipated that effects of the moderate to high soil burn severity in the watersheds that drain to the populated areas will increase the magnitude and frequency of runoff that could lead to flooding, debris flows, and hyperconcentrated (mud) flows, depending on the intensity of storm events.

Recommendations

- Monitor areas along Malibu Creek, Las Virgenes Creek, Potrero Valley Creek, and Medea Creek, including but not limited to residential, commercial and recreational developments along Seminole Hot Springs, Malibou Lake, Lobo Canyon Road, Stokes Canyon Road, and Triunfo Canyon Road (areas subject to increased inundation during significant storm events).
- Consider installing diversion structures, including sand bags and/or concrete K-rails, along stream banks and around residences when high flood flows are predicted along drainages.
- Implement existing early warning systems, linked to up-to-date storm information. Consider evacuations of residential structures located within flood-prone areas, and at the base of steep canyons and steep side slopes that may be subject to debris flows, floods and/or rockfall hazards, including but not limited to structures

along Stokes Canyon Road, Lobo Canyon Road, West Carlisle Road, Agoura Road, Triunfo Canyon Road, and Wagon Road, as well as along Medea Creek, Potrero Valley Creek, Liberty Canyon, Seminole Hot Springs, and within Malibu Creek State Park.

- While preliminary mitigations can consist of early warnings, staying out of channels during storm events, road signage and warnings, removing large debris from channels, and staging of equipment to clear roadways, additional engineered mitigations can be designed and implemented by professionals specializing in geotechnical engineering, soil erosion and engineering geology.
- Perform storm infrastructure monitoring and monitor road drainage infrastructure along highways and residential roads, including but not limited to Cornell Road, Triunfo Canyon Road, Kanan-Dume Road, and Mulholland Highway.
- Cleanout and monitor culverts and drainage structures prior to and during large rain events where they cross residential streets.
- Monitor and clean out debris basins, as needed.
- Consider constructing diversion structures where debris and flood flow channels may adversely impact residential development or restrict residential access roads where flooding is anticipated during predicted high intensity rain events. Site specific mitigations and containment and diversion structures should be designed by licensed professionals specializing in geotechnical engineering, soil erosion and engineering geology.
- Provide Malibu Creek burn area residents and commercial business owners with this VAR information so they may understand their proximity to hazard areas, and take appropriate actions—including evacuation when directed.

6.3 MALIBU CREEK-NORTH

Observations
The upper Malibu Creek burn area, located between West Lake Boulevard to the west and Palo Comado Canyon Road to the east, is a source of potential hazard to downstream residents and infrastructure. The upper Malibu Creek burn area borders west Los Angeles and southeastern Ventura counties, including the communities of western Thousand Oaks, Westlake Village, Agoura Hills, Oak Park, North Ranch, and western Calabasas. Residences within the upper Malibu Creek burn area are accessed from U.S Highway 101 and State Route 23 via North Westlake Boulevard, Lindero Canyon Road, Kanan Road, Palo Comado Canyon Road, Lost Hills Road, Las Virgenes Road, Thousand Oaks Boulevard, East Avenida De Los Arboles, and numerous local side streets.

Regional geologic mapping (Campbell et al., 2014) characterizes the geologic unit underlying the upper Malibu Creek burn area as Upper Cretaceous Chatsworth Formation overlain by a sequence of lower Tertiary marine and nonmarine clastic rocks. Quaternary alluvial deposits are mapped along the toe of the south-facing slopes, within steep canyons and below canyon outlets.

Unstable slope conditions are apparent in the burned source area. Dry ravel and alluvium/colluvium, including cobble- to boulder-size rocks, existing landslides, and readily available loose silty-sand slope covers were observed in steep drainages, along steep canyon headwalls, and on side slopes above residential areas, suggesting the presence of preexisting rockfall and debris flow hazards. Recent small-scale landslides were observed in steep headwalls and along steep streamside slopes, further confirming active hillslope processes and providing material to stream channels to be mobilized by subsequent debris flows. The northeast-southwest trending Chatsworth Fault and Simi-Santa Rosa fault zones are mapped by Jennings and Bryant (2010) as bounding the northwestern and eastern portions of the upper Malibu Creek burn area. The faults exhibit evidence of late Quaternary and Holocene (<11,000 years) activity. In addition to storm events, landsliding and rockfall may also be triggered by strong ground shaking associated with earthquakes on nearby faults providing another source of material in channels to be mobilized during debris flow events.

Development within the upper Malibu Creek burn area, including parks, public libraries, community children daycare centers, and golf courses, is located within low-lying areas, including Oak Park Community Center. Drainage basins large enough to be included in the USGS debris flow model (less than 3-square miles) generally exhibit a moderate to low probability for debris flow initiation. Basins greater than 3-square miles in size are not included in the USGS model, however, these basins are still subject to flooding and debris flows resulting from increased post-fire runoff.

The lower portions of Lindero, Palo Comado, Las Virgenes, East Las Virgenes, and Big Canyons, and the Medea Creek drainage are designated as Zone A-Special Flood Hazard Areas by the Federal Emergency Management Agency (FEMA). Residences and structures located within these areas are subject to inundation by the 1-percent annual exceedance probability flood event (i.e., a flood event that has a 1-percent chance of being equaled or exceeded each year, or the 100-year flood). Additionally, low-lying areas within the lower reaches of Cheeseboro/Palo Comado Canyons are identified as designated floodplains by Los Angeles County. It is anticipated that the effects of the moderate to high soil burn severity in the watersheds that drain to the populated areas will increase the frequency and magnitude of flooding, debris flows, and hyperconcentrated (mud) flows.

Post-fire conditions are expected to increase adverse conditions in any given storm and rain event. Storm events that under pre-fire conditions were considered manageable may plug culverts and impact structures and infrastructure. Regular cleaning and maintenance of critical drainage structures prior to anticipated storm events will help ensure that drainage structures function at maximum capacity, reducing the potential for adverse impacts to adjacent residential, commercial and recreational structures (e.g., Oak Canyon Community Park, VAR 96).

During fieldwork, a debris basin and drainage structure were observed being excavated by a contractor for a local homeowners association at VAR 72. This basin is at the eastern end of Wembly Avenue and protects the access road to numerous residences. We observed hand crews excavating the buried inlet of the drainage structure and installing erosion control measures around the inlet (see photograph E-12). This drainage structure was buried by a debris flow that initiated in the winter of 2016-17. Because of the lack of a place to store the removed debris, the excavation of material was minimized and plastic sheeting, sand bags, and waddles were being used to stabilize the excavation surrounding the inlet. We consider the capacity of the basin to be compromised and the basin should be completely excavated and the material end hauled to an appropriate site.

Residential communities and condominiums are built downstream of catchments with modeled debris hazards (see photographs E-3 and E-4). On Conifer Circle in the community of Oak Park, concrete v-ditch drains were observed along the slopes above the community. It is unclear whether the v-ditch drains are adequately sized to accommodate the increased runoff associated with post-fire conditions. Overtopping v-ditch drains may result in flood and sediment laden flows impacting homes (VARs 88, and 97). Residential and commercial areas at the outlet of basins where no drainage structures exist are at a heightened risk of adverse impacts (VAR 20).

The following are field observations during the Watershed Emergency Response Team (WERT) evaluation:

- The burn area along both sides of Kanan Road is modeled with a high percentage of moderate soil burn severity, with localized areas of high SBS in a few small basins. Access on Kanan Road may be negatively impacted by storms that are predicted to approach and exceed thresholds modeled to cause debris flows and flooding.
- Most large watercourses have been engineered with debris basins of various sizes.

- Residences west of Oakhill Drive and Medea Creek Lane (VARs 97, 151, 122, 43, 44, 55, and 112) are subject to debris flows which may overwhelm v-ditch drains.
- The community on Kimberly Drive west of Fountainwood Street is engineered with large basins that may minimize the potential for debris flows to impact downstream residential structures, with the exception of (VAR 151) where there is no basin upslope of the residential structure on a catchment modeled with low potential of generating debris flows.

- Road systems generally have well engineered drainage structures; however, debris flow prone areas may inundate and overtop some drainage structures with inadequate flow capacity and inlet protection designed for debris flows.
- Small modeled catchments, or unmodeled catchments within the upper Malibou Lake burn area, generally contain undersized basins and drainage structures or contain only v-ditch drains routing water around the structures. These conditions leave individual residential structures vulnerable to inundation from debris flows and flooding. Many of the v-ditch drains appeared unmaintained and filled with sediment and debris.

Residential communities and infrastructure observed downslope of catchments with the potential to generate debris flows were identified as VARs. Over 28 VARs were identified within the upper Malibu Creek area, including polygons encompassing multiple structures within an individual VAR. Most of the VARs observed within the upper Malibu Creek were determined to constitute a low to moderate risk to public safety, property or combined risk. Hazards identified in the upper Malibu Creek area result from residential structures being located at the base of potential rockfall slopes, the mouths of debris flow and flood-prone catchments, or within delineated floodplains.

Recommendations

- Monitor and maintain road culvert crossings, ditches, and drains. Clean sediment and debris from structure inlets and outlets periodically.
- Consider installing diversion structures, including concrete K-rails or diversion walls, to divert flows around vulnerable residences and keep streams in their channels when high flood flows are predicted along drainages.
- Utilize existing early warning systems, linked to up-to-date storm information. Consider evacuations of residential structures located within flood-prone areas, and at the base of steep canyons and steep side slopes that may be subject to debris flows, floods and/or rockfall hazards. This includes, but is not limited to,

the daycare center on Kanan Road (VAR 20), Oak Canyon Community Park (VAR 100), and Deerhill Road (VARs 111 and 54).

- While preliminary mitigations can consist of early warnings, staying out of channels and low-lying areas during storm events, road signage and closures, removing large debris from channels, and staging of equipment to clear roadways; additional engineered mitigations can be designed and implemented by the appropriate professionals on a site-by-site basis.
- Many parks and riparian open spaces are areas of potential debris flow runout and flooding, such as Oak Canyon Community Park (VAR 100) northwest of Hollytree Drive. Consider closing the park to public access during storm events.
- Monitor and clean out debris basins maintained by various agencies, including county, cities and homeowners associations (HOAs). Elements to consider would be teaming with HOA's to provide heavy equipment and storage for debris removed from drainage basins.
- The debris basin and drainage structure at VAR 72 was buried by debris flows in the 2016-17 storm season. This basin is maintained by the local HOA and should be completely cleaned out and evaluated to determine if it is adequate for the potential post-fire predicted debris volumes and storm flows. A storage site for removed debris needs to be identified.
- Consider constructing diversion structures where debris flow and flood-prone channels may adversely impact residential development or restrict residential access roads when flooding is anticipated during predicted threshold rain events. Site specific mitigations and containment and diversion structures should be designed by licensed professionals specializing in geotechnical engineering, soil erosion and engineering geology (e.g., VAR 71).

6.4 UPPER LOS ANGELES RIVER WATERSHED

Observations

The burned areas in Bell Canyon and other canyons located within the Upper Los Angeles River watershed extending along the northeastern, eastern, and southeastern flank of the Simi Hills between U.S. Highway 101 in the south and Woolsey Canyon Road to the north are a source of potential hazard to downstream residents and improvements. Numerous, steep, short, burned drainages are present in this community, some with ridges capped by sandstone providing a source of large boulders presenting a rockfall hazard. Residences within the Bell Canyon community are accessed from Bell Canyon Boulevard in the western San Fernando Valley. Soil burn severity (SBS) modeling indicates low and moderate SBS throughout the area where burned. Areas within the burn perimeter identified as unburned on the field verified BARC map tend to be associated with areas of relatively dense residential development.

Regional geologic mapping (Campbell et al., 2014) characterizes the primary geologic unit underlying the Bell Canyon community as Cretaceous-period Chatsworth Formation sandstone which was observed outcropping along the ridgetops and in various canyon side walls. The ridgeline bordering Bell Canyon to the south, along with the eastern flank of the burn perimeter and a portion of the ridgeline in the northeastern corner, north of the end of Saddlebow Road, are mapped as underlain by younger Miocene-age to Paleocene-age conglomerate, sandstone, shale, and mudstone, including various members and facies of the Santa Susana Formation, Simi conglomerate, Las Virgenes Formation, Calabasas Formation, and Modelo Formation. Low gradient reaches of Bell Creek in the Bell Canyon community are comprised of young alluvial deposits. These deposits are young and subject to inundation during significant rainfall events.

Unstable slope conditions are apparent in the burned source areas. Dry ravel and alluvium/colluvium, including cobble- to boulder-size rocks, were observed in steep drainages, along the steep canyon headwalls, and on side slopes above the residential areas, suggesting the presence of preexisting rockfall and debris flow hazards. What appears to be historic small-scale surficial landslide features and erosional gullies were observed in steep headwalls and along steep streamside slopes, further confirming active hillslope processes. Traces of the Chatsworth Fault are mapped by Jennings and Bryant (2010) as extending through the eastern portion of the Bell Canyon community; these fault traces exhibit evidence of late Quaternary fault displacement. Additional regional faults (Jennings and Bryant, 2010) include the Simi-Santa Rosa Fault Zone to the northwest (Holocene fault displacement) and the Northridge Hills and Santa Susana faults to the northeast (late Quaternary fault displacement). Movement of the observed landslide features and rockfall may be triggered by periodic strong ground shaking associated with earthquakes on nearby faults.

USGS debris flow modeling on the slopes above the Bell Canyon community and along the eastern flank of the burn perimeter within the Upper Los Angeles River watershed indicates that seven of the 45 (15-percent) drainage basins exhibit debris flow probabilities at 40-percent or greater (at 15-minute 24 mm hr^{-1} rainfall thresholds)[9] within the burned portions of these drainages

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[9] The 15-minute 24 mm hr^{-1} rainfall threshold means rain falling at a rate of 24 mm per hour (0.94 in hr^{-1}) over a period of 15 minutes (i.e., 6 mm (0.24 in) of rain in 15 minutes).

(https://landslides.usgs.gov/hazards/postfire_debrisflow/detail.php?objectid=211). Drainage basins above the residential developments range in area up to a maximum of greater than 1,960 acres.

Residential homes and infrastructure observed downslope of the steep slopes and debris flow drainages were identified as VARs. A total of 28 VARs were identified within the Bell Canyon community, including polygons which encompass two to nine structures, for a total of approximately 47 individual structures. Twelve of the VARs observed within the Bell Canyon community were determined to constitute a high risk to public safety, property or both, resulting from residential structures located at the base of potential rockfall slopes, the toe of debris flow and flood-prone channels, or within observed floodplains. Of the twelve high risk VARs in the Bell Canyon community, four are identified as potential rockfall hazard (VARs 24, 25, 26, and 27), six are identified as potential debris flow/flood hazard (VARs 15, 17, 18, 28, 29, and 19), one VAR was identified for potential flood hazard (VAR 36), and one VAR was identified as “other” due to the potential of increased post-fire runoff exacerbating an existing active landslide directly upslope of the residence (VAR 13).

Although not identified as high-risk VARs, several VARs were identified along Bell Canyon Road (VARs 109 and 334) and Hackamore Lane (VAR 116), which are roads that occupy canyon bottoms and serve as primary community access routes. The VARs identified are locations where the road intersects a drainage and either has a vulnerable drainage structure or no drainage structure. Additional drainage structures not identified may also be vulnerable, as not every drainage structure was specifically evaluated. Impacts to these roads may impede emergency ingress and egress in the Bell Canyon community.

One VAR was identified outside of the Bell Canyon community along the eastern flank of the Simi Hills and the eastern burn perimeter. This VAR was determined not to constitute a high risk to public safety, property or both, resulting from the residential structure being located at the base of potential rockfall slopes, the toe of debris and flood flow channels, or within observed floodplains.

Recommendations

- Implement existing early warning systems for residents and property managers, linked to up-to-date storm information.
- Consider evacuations of residential structures located within debris flow/flood-prone areas, particularly the residences at VARs 36, 15, 17, 18, 28, 29, and 19 that may be subject to debris flows and flooding.
- Consider evacuations of residential structures located at the base of steep side slopes that may be subject to rockfall hazards and consider installing

diversion/deflection/containment structures where appropriate, particularly the residences at VARs 24, 25, 26, and 27. Site specific mitigations and containment and diversion structures should be designed by licensed professionals specializing in geotechnical engineering, soil erosion, and engineering geology.

- Consider diversion structures to divert flows away from structures at VARs 36, 15, 17, 18, 28, 29, and 19. Site specific mitigations and containment and diversion structures should be designed by licensed professionals specializing in geotechnical engineering, soil erosion, and engineering geology.
- Consider professional consultation for a geotechnical engineering solution for landslide mitigation at VAR 14.
- Consider closures of community parks and open spaces located at the mouths of drainages or in the floodplains of larger streams.
- While preliminary mitigations can consist of early warnings, staying out of channels during storm events, road signage and warnings, removing large debris from channels, and staging of equipment to clear roadways, additional engineered site-specific mitigations can be designed and implemented by the appropriate professionals.
- Monitor infrastructure during storms and clean out and monitor drainage infrastructure along residential roads, particularly the drainage systems at VAR 116 (Hackamore Lane) and VARs 109 and 334 (Bell Canyon).
- Provide residents and property managers with this VAR information so they may understand their proximity to hazard areas, and take appropriate actions—including evacuation when directed.

6.5 CALLEGUAS CREEK – WOOLSEY FIRE

Observations

The northwestern portion of the Woolsey Fire burned though a small portion of the Calleguas Creek watershed in the Thousand Oaks and Simi Valley areas. The fire affected the portions of these communities east of Highway 23 and south of Highway 118 burning the surrounding hillslopes upslope of many residential communities. The soil burn severity analysis indicated a varied level of burn intensity in this area, with moderate intensity on the ridgetops and lower severity near the developments.

The burned area encompasses much of the headwaters of the Arroyo Simi and Arroyo Conejos Creeks. Tributaries to these creeks flow freely through the surrounding hills until being captured by engineered structures when they approach the urban areas.

Large tributaries to Arroyo Simi, including Box Canyon, Montgomery Canyon and Oak Canyon, were entirely burned in the fire and will likely see increased flows and debris in the coming years.

Montgomery Canyon and Oak Canyon runoff flows west towards Lang Canyon Road in Simi Valley, where it is captured in a large multi-stepped debris basin located on Long Canyon Road. This structure has a very large capacity and will likely be able to handle increased post-fire flow and debris. Runoff from the Box Canyon drainage flows northwest into southern Simi Valley. This tributary enters the urban area near Rambling Road and Challenger Park at Long Canyon Road. This area was labeled as VAR 126 due to concerns about localized flooding in the Rambling Road and Challenger Park Area.

The headwaters for Arroyo Conejo Creek originate in the hills above Thousand Oaks that were burned at a moderate soil burn severity in the Woolsey Fire. The tributary flows to the west through the wildlands of Oakbrook Regional Park to Westlake Boulevard. Upon entering the urban area, the creek is captured in a large debris basin that appears sufficient to handle increased post-fire runoff, sediment, and debris.

Regional geologic mapping (Campbell et al., 2014) characterizes the geologic units underlying the burned area within the Calleguas Watershed as Cretaceous-period Chatsworth Formation, Miocene-aged Rincon Formation, Eocene to Paleocene-aged Santa Susana Formation, Eocene-aged Llajas Formation, and the Miocene-aged Calabasas Formation. The Santa Susana Formation is described as a shale with interbedded fine-grained sandstones which forms the Simi Hills and are the headwaters for Arroyo Simi Creek. To the north of the Santa Susan Formation is the Llajas Formation, a shallow marine deposit that extends from the burned area into the urban interface. The Llajas Formation crops out within the Quaternary-aged valley deposits in this area of the fire as gentle grass covered hillslopes adjacent to many residential developments in Simi Valley near Woodland Drive, Canyon Crest Drive, Long Canyon Drive, and Valley Gate Road.

The ridgetop and divide between the Agoura Hills and Simi Hills is comprised of the Chatsworth Formation, a Cretaceous-period sandstone. This formation makes up steep ridges in the area and is largely wildlands. The Calabasas Formation, a Miocene-aged volcanic conglomerate, is found to the west of the Chatsworth Formation along the northern portions of Kanan Road near North Ranch Country Club. This formation is undeveloped and forms steep hills with northwestern trending drainages.

To the south and west of the Calabasas Formation is the Rincon Formation, a Micoene-aged finely grained unit comprised of mudstones, siltstone and shale. This formation forms gentle rolling hills and is adjacent to many residential housing developments along Hillcrest Drive, N. Westlake Drive, and Erbes Road in Thousand Oaks.

USGS debris flow modeling on hillsides upslope of the Calleguas watershed indicates that drainage basins exhibit debris flow probabilities of less than 40 percent. Slopes in the Santa Susana, Calabasas and Chatsworth Formations exhibit the highest debris flow probabilities in the area at 20 to 40-percent with short segments near ridgetops showing a high probability (60 to 80-percent) of localized debris flows. Slopes in the Rincon Formation near Thousand Oaks have lower debris flow probabilities of 0 to 20-percent. Debris flow modeling used by field crews used a threshold of 15-minute duration at a rate of 24 mm hr^{-1} of rainfall within the burned portions of these drainages (https://landslides.usgs.gov/hazards/postfire_debrisflow/detail.php?objectid=211). Drainage basins above the residential developments range in size, with a maximum of 1,761 acres for Box Canyon.

A total of 26 VARs were identified in the Calleguas Creek watershed portion of the Woolsey Fire. The majority of the VARs were found in the Rincon Formation in Thousand Oaks. In this area, one resident at VAR 106 reported historical problems with mudflows impacting residential homes in this area following a previous fire. Many of the convergent hillslopes near residential homes were identified as a potential for minor localized flooding and mudslides based on this anecdotal account.

Other VARs in this area identified inadequate drainage facilities or a lack of general maintenance of existing structures, which could pose threats to both life and property.

Recommendations

- Monitor areas near Challenger Park and Rambling Road (VAR 126) that are subject to increased flooding from runoff entering the urban area upslope of an engineered structure.
- Consider installing diversion structures, including sand bags and/or concrete K-rails, along stream banks and around residences when high flood flows are predicted along drainages.
- Implement existing early warning systems, linked to up-to-date storm information. Consider evacuations of residential structures located within flood-prone areas, and at the base of steep canyons and steep side slopes that may be subject to debris flows, floods, and/or rockfall hazards.
- While preliminary mitigations can consist of early warnings, staying out of channels during storm events, road signage and warnings, removing large debris from channels, and staging of equipment to clear roadways, additional engineered mitigations can be designed and implemented by the appropriate professionals.

- Monitor infrastructure during storms and clean out and monitor drainage infrastructure along residential roads, particularly along Erbes Road (VAR 84) and Long Canyon Road.
- Monitor potential localized flooding in areas with inadequate drainage structures (VARs 16, 123, 118) during forecast storms.
- Consider restricting access along Box Canyon during large storm events.
- Consider constructing diversion structures where debris flow channels may adversely impact residential development or restrict residential access roads where flooding is anticipated during predicted high intensity rain events. Site specific mitigations and containment and diversion structures should be designed by licensed professionals specializing in geotechnical engineering, soil erosion, and engineering geology.

6.6 CALLEGUAS CREEK—HILL FIRE

Observations

Within the Calleguas Creek watershed, the perimeter of the Hill Fire is bounded to the north by the Santa Rosa Valley, to the east by Wildwood Park and the Conejo Valley, to the south by Newbury Park and the Dos Ventos community, and to the west by the communities of Camarillo and Camarillo Springs. The Hill Fire burn area is characterized predominantly by a low soil burn severity with isolated pockets of moderate SBS confined locally in the bottoms of canyons along drainages (see photograph E-10). Much of the landscape within the Hill Fire burn area is comprised of wildland parks. Numerous agricultural operations are located at the interface between valley floors and mountainous topography. Portions of the burned area in the Hill Fire proximal to the U.S. Highway 101 corridor, from Camarillo Springs to Newbury Park, comprise the majority of potential hazards to downstream improvements. Within this corridor 9 Values-at-Risk (VARs) were identified, which are discussed later within this section.

Regional geologic mapping (Campbell et al., 2014) characterizes the geologic units underlying the burn area as Miocene-aged Conejo Volcanics (basalt, andesitic basalt) locally intruded by Tertiary-aged crystalline rocks and overlain by Quaternary-aged fan and alluvial deposits. Volcanic rocks in the western portion of the Hill Fire produce rugged topography (e.g., Conejo Mountain) which is characterized by steep drainages filled with abundant cobble- to boulder-size rocks. As previously discussed in Section 2.5.1, recent debris flow events (December 2014, following the Springs Fire) impacted human developments at the mouth of a steep drainage in the Camarillo Springs area.

Regional geologic mapping identifies fan and alluvial deposits (Campbell et al., 2014) within the Hill Fire burn area at the mouths of canyons. The mapped fan deposits are young and subject to inundation during significant rainfall events. Unstable slope conditions are apparent in the burned source areas. Dry ravel and alluvium/colluvium, including cobble-size rocks, were observed in steep drainages, along steep canyon headwalls, and on side slopes above the residential areas adjacent to the reported VARs, suggesting the presence of preexisting rockfall, debris flow, and mud flow hazards. What appears to be historic small-scale surficial landslide features and erosional gullies were observed in steep headwalls and along steep streamside slopes, further confirming active hillslope processes. The potential for increased runoff within steep slopes and drainages along Conejo Mountain pose a risk for debris flows, mud flows, and flooding proximal to canyon outlets and alluvial fans. Landslides identified in regional geologic mapping (Campbell et al., 2014) within the perimeter of the Hill Fire burn area are located within the northern portion of the burn area.

USGS debris flow modeling for the watersheds/catchment areas and slopes within the Hill Fire burn area indicates that drainage basins generally exhibit debris flow probabilities of less than 20-percent. Fifty-five drainage basins were modeled with only eight exhibiting potential debris flow probabilities in excess of 20-percent: seven drainages exhibit a 20-40-percent probability and only one drainage exhibits a 40-60-percent probability. For field work, a debris flow model using a threshold of 15 minute duration at 24 mm hr^{-1} rainfall rate within the burned portions of these drainages was used to identify VARs (https://landslides.usgs.gov/hazards/postfire_debrisflow/detail.php?objectid=252). Drainage basins above the residential developments range in area up to a maximum of 1,077 acres; however, generally drainage basins (51) were typically less than 150 acres in size.

Nine VARs were identified as a result of the impact of the Hill Fire. VARs 5 and 6 are located within the Camarillo Springs community south of U.S. Highway 101, at the base of steep slopes that ascend southward to Conejo Mountain. These VARs are located within 1,000 feet of the site of the 2014 Camarillo Springs debris flows (Figure 14), which were located on San Como Lane to the west. However, it should be noted that the drainage impacting VARs 5 and 6 is smaller in size and exhibits a gentler gradient than the drainage that contributed to the 2014 debris flows.

VARs 7 and 9 are located within the Camarillo Springs Ranch/Camarillo Grove Park area north of U.S. Highway 101 adjacent to drainages that ascend to the east. VAR 2 is the site of Vallecito Mobile Home Park located on the west side of Newbury Park at the base of slopes ascending to Conejo Mountain to the west.

VARs 1, 8, 4, and 3 are located on the north side of U.S. Highway 101 below locally steep slopes and drainages that drain to the south. VAR 1 is the Sage Mountain Assisted Living Facility, at risk of potential inundation of up to 256,000 cubic feet of debris (maximum USGS-modeled potential) via a flow segment with a 20-40-percent probability of debris flow that drains directly into the site. Potential hazard to life and property at this VAR is high. VAR 8 is a section of U.S. Highway 101 below steep slopes adjacent to the highway. VAR 4 is a U.S. Post Office sorting facility.

VAR 3 is the location of the Camarillo Truck Scales. This site is located below over-steepened slopes on all sides that are covered in rock netting that was damaged during the fire. Potential hazard to life and property at this VAR is moderate. Based on empirical data, rockfall has occurred at this VAR which resulted in a broken windshield of a car parked adjacent to the base of a slope. Post-fire conditions indicate a potential risk for increased rockfall conditions.

Recommendations

- Consider installing diversion structures, including concrete K-rails or diversion walls, to divert flows around vulnerable residences and keep streams in their channels when high flood flows are predicted along drainages.
- Utilize existing early warning systems, linked to up-to-date storm information. Consider evacuations of residential structures located within flood/hyperconcentrated flow/debris flow prone areas (e.g., VAR 1/Sage Mountain Assisted Living Facility), and at the base of steep canyons and steep side slopes that may be subject to debris flows, floods, and/or rockfall hazards.
- While preliminary mitigations can consist of early warnings, staying out of channels and low-lying areas during storm events, road signage and closures, removing large debris from channels, and staging of equipment to clear roadways, additional engineered mitigations can be designed and implemented by the appropriate professionals on a site-by-site basis.
- Monitor infrastructure during storms and clean out and monitor drainage infrastructure along residential roads and highways alike (e.g., along San Como Lane in Camarillo Springs and along the length of U.S. Highway 101 from VAR 3 to 4 (Camarillo Truck Scales to US Post Office sorting facility)).
- Monitor potential localized flooding in areas with inadequate drainage structures (e.g., VAR 2 during forecast storms).
- Consider constructing diversion structures where debris flow channels may adversely impact residential development or restrict residential access roads where flooding is anticipated during predicted high intensity rain events. Site specific mitigations and containment and diversion structures should be designed

by licensed professionals specializing in geotechnical engineering, soil erosion, and engineering geology.

7 GENERAL RECOMMENDATIONS

Early Warning Systems

Existing early warning systems should be used and improved such that residents can be alerted to incoming storms, allowing enough time to safely vacate hazard areas. In areas where cellular reception is poor or non-existent, methods should be developed to effectively contact residents. For example, installation of temporary mobile cellular towers should be considered. Early warning systems for the Woolsey and Hill fires should take advantage of the following services:

National Weather Service Forecasting

Flash flood and debris flow warnings with practical lead times of several hours must come from a combination of weather forecasts, rainfall measurements of approaching storms, and knowledge of triggering thresholds. The following information is from the National Weather Service (NWS); they provide flash flood and post-fire debris flow "watch" and "warning" notifications in burn areas:

The NWS provides 24/7 information on watches, warnings, and advisories for California. For additional information, see:

NWS – Los Angeles Forecast Office: https://www.weather.gov/lox/

NWS - Post-wildfire flash flood and debris flow guide

http://www.wrh.noaa.gov/lox/hydrology/files/DebrisFlowSurvivalGuide.pdf

Alert LACo (Los Angeles County)

Alert LACo is used to alert Los Angeles County community members of urgent actions to take during disasters, such as earthquakes, wildfires, and floods. The Sheriff's Department uses Alert LA County to contact users if there is an emergency or disaster in a community. The system sends shelter-in-place instructions, evacuation, and other emergency messages. It has accessibility features for people with disabilities and others with access and functional needs. Users can select a preferred language for notifications.

Users can add cell phones, VOIP phones, emails, and additional addresses to receive alerts. The Alert LA County database automatically includes listed and unlisted land line telephone numbers, so they do not need to be registered.

https://www.lacounty.gov/emergency/alert-la/

VC Alert (Ventura County)
VC Alert is a high-speed emergency notification system to deliver critical messages (voicemail, email, texts) about local emergencies and other important community news. The system enables officials to provide essential information quickly to each resident in Ventura County. Users may select to receive important messages such as evacuation notices directly to a home phone, cell phone, work phone, email, or text.

Residents are encouraged to sign up and receive real-time emergency messages should a critical situation occur.

https://www.readyventuracounty.org/vc-alert/

Community-Based Emergency Notification Systems
Several community-based emergency notification systems are available for use for communities affected by the Woolsey and Hill fires. These include:

Agoura Hills – Connect-Cty: http://stagea11.visioninternet.net/i-want-to/connect-cty

Calabasas – MyConnect Portal: https://cityofcalabasas.bbcportal.com/Entry

Hidden Hills – Blackboard Connect: https://hiddenhillscity.org/city-departments/emergency-preparedness/

Malibu – Alerts and Emergency Notification:
https://www.malibucity.org/566/Alerts-Emergency-Notifications

Westlake Village - https://hiddenhillscity.org/city-departments/emergency-preparedness/

Wireless Emergency Alerts (WEA)
WEA is an alert system originated by the NWS that can inform residents and businesses of flash flood warnings and other potential hazards. WEA alerts are emergency messages sent by authorized government alerting authorities through a mobile carrier. Government partners include local and state public safety agencies, FEMA, the FCC, the Department of Homeland Security, and the National Weather Service. No signup is required, and alerts are automatically sent to WEA-capable phones during an emergency. Residents and businesses interested in this function must turn on the emergency alert setting for their phone.

https://www.weather.gov/wrn/wea

Emergency Alert System (EAS)
EAS is a national public warning system that may also be used by state and local authorities to deliver important emergency information, such as weather information, to targeted specific areas.

https://www.fcc.gov/general/emergency-alert-system-eas

Integrated Public Alert and Warning System (IPAWS)
IPAWs is a FEMA-originated system that integrates federal, state, and local emergency warning systems (e.g., WEA, EAS) into a single interface.

https://www.fema.gov/integrated-public-alert-warning-system

Education for Residents and General Public

The following information should be conveyed to residents and the general public that can be affected by post-fire runoff and erosion associated with the Woolsey and Hill fires:

First and foremost, it is critical that residents heed evacuation warnings from local officials. In the absence of an official notice, residents should stay informed of evolving conditions around their homes, and be aware of the following (Suzanne Perry, USGS (retired), personal communication).

- Be prepared for debris flows for 2-5 years after a wildfire. Don't worry about every storm, as it takes more intense rain (typically about ½ inch per hour – like being in a thunderstorm) on a recently burned slope to trigger a debris flow.
- Follow all evacuation orders. Debris flows can destroy everything in their path.
- Pay attention to official weather forecasts. The National Weather Service will issue a Flash Flood "Watch" or "Warning" for a given area when rainfall is anticipated to be intense. Also – and this is important - the rain in the mountains can be different than where you are. It's the rain in the mountains that will start the debris flow.
- Don't rely on what you've seen in past debris flows. Debris flows can hit new areas or return to previous areas; they might be smaller - or larger - the next time. Whatever happened before, the next time could be different.
- If you must shelter in place, choose your spot in advance and stay alert. Find the highest point nearby (such as a second story or roof) and be ready to get

there with a moment's notice. Listen and watch for rushing water, mud, unusual sounds. Survivors describe sounds of cracking, breaking, roaring, or a freight train.

- Never underestimate a debris flow. Unlike other landslides, debris flows can start in places they've never been before. They can leave stream channels and plow through neighborhoods. When a debris flow is small, people can control it with walls, K-rails, and sandbags. When a debris flow is big enough, nothing can stop it.
- Expect other flood dangers. Storms that can cause debris flows can also cause more common flooding dangers.
- Turn Around, Don't Drown!® Never drive, walk, or bicycle through a flooded road or path. Even a few inches of water can hide currents that can sweep you away. Also, the water level can rise before you finish crossing.

For an easy to understand summary of debris flows, see Geology.com, What is a Debris Flow and this alluvial fan presentation.

Increased Flood Flows, Erosion and Sedimentation

Estimated hydrologic response for heavily burned watersheds suggest an average increase of approximately 290 and 190 percent for the 2-year and 10-year recurrence intervals, respectively (see Section 4.3). Post-fire erosion modeling predicts that erosion, and therefore sedimentation, rates will increase by 15- to more than 20-fold for the 2-year storm, and a 10-fold increase for 10-year storms. Emergency actions, maintenance, and storm response activities should be developed with these conditions in mind.

Debris Flow Runout

No tools are currently available to rapidly predict post-fire debris flow runout. WERT geologists rely partially on geomorphic evidence to estimate the downstream extent of debris flow inundation. However, many of the at-risk sites are within built environments where geomorphic evidence has been altered or destroyed through grading and/or construction. Also, geomorphic evidence may not be sufficient to predict the downstream extent of debris flows under these post-fire conditions. In areas below large, severely burned drainages (e.g., Trancas Canyon (photograph E-8), Arroyo Sequit), the areal extent of debris flow inundation is highly uncertain. The WERT strongly recommends more detailed analysis to further refine the identification downstream debris flow inundation areas.

Increased Rockfall

Numerous rockfall hazards were identified during field evaluations. However, due to the rapid nature of the evaluation, a fully comprehensive evaluation of rockfall hazard was not possible. DeGraff and Gallegos (2012) provide an overview of rockfall hazard following wildfire, along with suggested approaches for identifying these hazards. The WERT strongly recommends more detailed analysis to further refine the identification of rockfall hazard areas.

Road Drainage Systems, Storm Monitoring, and Storm Maintenance

The residential communities within and downstream of the burn area are serviced via a network of roads and highways. Caltrans, Los Angeles and Ventura counties, and various cities and municipalities maintain numerous roads within and downstream of the burn area. Due to the preponderance of moderate soil burn severity, increased flows on slopes and onto the road system and into storm drain systems can be expected. Loose and erodible soils that mantle the slopes could wash down, inundate, and plug these drainage systems. Flows could be diverted down roads and cause erosion and possible blockage, and/or loss of portions of the road infrastructure and structures along roads. The WERT did not evaluate the potential for rockfall, sedimentation, flooding or debris flow hazards at all roads or watercourse crossings along federal, state, county, or municipal road corridors. Existing road drainage systems should be inspected by the appropriate controlling agency to evaluate potential impacts from floods, hyperconcentrated floods, debris torrents, debris flows and sedimentation resulting from storm events. Spatial data generated by the USGS, DOI BAER Team, and the WERT (e.g., USGS debris flow model, ERMiT model, and flood flow predictions) can be used to screen potential at-risk areas.

Storm Drains

Storm drains will be subject to increased flooding, sediment, and debris. In addition, flooding below debris flow prone areas is difficult, if not impossible, to predict. It was beyond the scope of this evaluation to examine every storm drain. The WERT recommends further evaluation of the storm drain systems so that appropriate protective measures are put into place.

Signage

Place temporary signage in areas of potential post-fire rockfall and flooding hazards. Place signage along roads, bridges, and other types of crossings identified at risk of flooding, rockfalls and debris flows. The WERT suggests responsible agencies consider installing gates, warning signs, or other measures to alert and keep people out of areas of identified risk.

Schools

Several schools are located within or downslope/downstream of the Woolsey burn area, with some potentially being affected by post-fire flood and geologic hazards. These include Malibu Middle School and Malibu High School (VAR 263), a pre-school/children’s center near Oak Park Community Center (VAR 20), the Golden Heart Ranch (VAR 386), and Pepperdine University (VARs 17 and 344). Due to the rapid nature of the WERT evaluation, further site investigation is recommended to fully characterize and/or mitigate potential hazards.

State Parks, Regional Parks, and Campgrounds

Several parks and campgrounds are located within or downslope/downstream of the Woolsey burn area, with some potentially being affected by post-fire flood and geologic hazards. Additionally, some parks appear to be purposefully placed as flood/debris control infrastructure. Campgrounds should be closed in response to NWS flash flood watches and warnings. Signage should be placed in campgrounds and at trailheads and park entrances to warn users of post-fire watershed hazards.

Potential Mineralogical Hazard Sites

Owing to the relief and potential access limitations following significant storm events, it may be difficult to access known sites. Additional recommendations are as follows:

- Regularly inspect drainage culverts at access road crossings for debris blockage before and after a storm event.
- Maintain channels free of debris upstream of structures; improve routing of drainage; consult with qualified professionals to review natural drainage and conveyance structures.
- Manage surficial storm runoff to divert around waste containment ponds, fill caps, and other environmental cleanup infrastructure.
- Manage and patrol roads that are prone to rockfall and erosion prior to and following storm events.
- Expect higher erosion and sedimentation rates, as well as increased runoff from these mining sites. Take appropriate actions to reduce the potential for these processes to further impact infrastructure and the environment.
- Locate oil/gas wells identified as status unknown and evaluate potential impacts to infrastructure and potential environmental issues at that site.
- The Los Angeles Regional Water Quality Control Board should evaluate storm water control and treatment systems at the Santa Susana Field Laboratory site and assess if they are adequate to perform under the expected increased storm flows and debris flow frequency and magnitude.

Burned Structures

Before burned structures are replaced with temporary housing or rebuilt they should be specifically evaluated for site-specific post-fire hazards such as rockfall, flooding, debris flow, and excessive sedimentation. These evaluations should be conducted by qualified licensed professionals, such as licensed civil/geotechnical engineers and licensed geologists.

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9 REFERENCES

ABC7 News (2014) Nov 2, 2014: Camarillo Springs evacuation order lifted after debris flow. http://abc7.com/weather/1-rescued-residents-evacuated-after-camarillo-mudslide/376277/.

Ainsworth, J. and T.A. Doss. 1995. Natural history of fire and flood cycles. California Coastal Commission. Excerpted from Federal Wildland Fire Management Policy and Program Review, Draft Report, 6/9/95. Accessed on-line at: http://www.coastal.ca.gov/fire/ucsbfire.html.

Atwater, T. 1970. Implications of Plate Tectonics for the Cenozoic Tectonic Evolution of Western North America. Geological Society of America Bulletin. Vol. 81, No. 12: p. 3513-3536.

Atwater, T. 1998. Plate Tectonic History of Southern California with Emphasis on the Western Transverse Ranges and Northern Channel Islands *in* Weigand, P.W., ed., Contributions to the geology of the Northern Channel Islands, Southern California: American Association of Petroleum Geologists, Pacific Section, MP 45, p. 1-8.

Barrows, A.G., Tan, S.S., and P.J. Irvine. 1993. Damaging landslides related to the intense rainstorms of January-February 1993, southern California. California Geology, Vol 46, No. 5, pp. 123-131.

Bedrossian, T.L., Roffers, P.D., Hayhurst, C.A., Lancaster, J.T., and Short, W.R., 2012 (revised), Geologic compilation of Quaternary surficial deposits in southern California, including maps of the onshore portion of the Santa Barbara 30' x 60' Quadrangle, Los Angeles 30' x 60' Quadrangle, eastern three-quarters of the Cuyama 30' x 60' Quadrangle, and Lancaster 30' x 60' Quadrangle: California Geological Survey, Alluvial Fan Task Force, Special Report 217, 21 p., map scale 1:100,000.

Birkeland, P.W. 1972. Late Quaternary Eustatic Sea-Level Changes Along The Malibu Coast, Los Angeles County, California. Geology. Vol. 80: p.432-448.

Calkin, D.E., K.D. Hyde, P.R. Robichaud, J.G. Jones, L.E., Ashmun, D. Loeffler. 2007. Assessing post-fire values-at-risk with a new calculation tool. GTR RMRS-GTR-205. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 32 p.

Campbell, R.H., 1980, Landslide maps showing field classification, Point Dume quadrangle, California: U. S. Geological Survey, Miscellaneous Field Studies Map MF 1167, scale 1:24,000.

Campbell, R.H., Blackerby, B.A., Yerkes, R.F., Schoelhamer, J.E., Birkeland, P.W., and C.M. Wentworth. 1996. Geologic map of the Point Dume quadrangle, Los Angeles County, California. United States Geological Survey Series 1747. DOI 10.3133/gq1747

Campbell, R.H., Wills, C.J., Irvine, P.J., and B.J. Swanson. 2014. Preliminary Geologic Map of the Los Angeles 30' x 60' Quadrangle, California. California Department of Conservation, California Geological Survey. Sacramento, CA.

Cannon, S.H., Boldt, E.M., Kean, J.W., Laber, J.L, and D.M. Staley. 2010. Relations between rainfall and postfire debris-flow and flood magnitudes for emergency-response planning, San Gabriel Mountains, southern California. U.S. Geological Survey Open–File Report 2010-1039. 31p.

Cannon, S.H., J.E. Gartner, M.J. Rupert, and J.A. Michael. 2003. Emergency assessment of debris-flow peak discharges from basins burned by the Grand Prix and Old Fires of 2003, southern California. U.S. Geological Survey Open File Report 03-475.

Cannon, S.H., Gartner, J.E., Wilson, R.C., Bowers, J.C., and J.L. Laber. 2008. Storm rainfall conditions for floods and debris flows from recently burned areas in southwestern Colorado and southern California. Geomorphology. Vol. 96, p. 250-269.

Capelli, M.H. 1999. Damn Sand Rights: Removing Rindge and Matilija Dams, Conference Proceedings, Sand Rights '99 Bringing Back the Beaches, California Shore and Beach & Coastal Zone Foundation, 12 p. http://friendsofventurariver.org/wp-content/themes/client-sites/venturariver/docs/rindge-and-matilija-dam-removal.pdf

CBS Los Angeles (2014) Nov 1, 2014: Major debris flow forces evacuation of 11 Camarillo Springs Homes. http://losangeles.cbslocal.com/2014/11/01/major-debris-flow-forces-evacuation-of-11-camarillo-springshomes/.

CGS (California Geological Survey). 2002. Note 36: California Geomorphic Provinces. California Department of Conservation, California Geological Survey. Sacramento, CA.

Colburn, I.P., 1996. Stratigraphy and sedimentary structures of the Paleogene successions in the west central Santa Monica Mountains, Los Angeles County, California, *in* Abbott, P. L., and Cooper, J. D., eds., Field Conference Guide 1996: Pacific Section, AAPG (American Association of Petroleum Geologists), Guidebook 73, Pacific Section SEPM (Society for Sedimentary Geology), Book 80, p. 93-116.

Crouch, J.K., 1979, Neogene tectonic evolution of the California Continental Borderland and western Transverse Ranges: Geological Society of America Bulletin, Part 1, v. 90, p. 338-345.

Crouch, J.K. and J. Suppe. 1993. Late Cenozoic tectonic evolution of the Los Angeles basin and inner California borderland: A model for core complex-like crustal extension. Geological Society of America Bulletin. Vol. 105, p. 1415-1434.

Daily Mail UK. 14 Dec 2014: the street that was buried by a mudslide. http://www.dailymail.co.uk/news/article-2873433/Devastation-California-mudslide-seen-air-boulder-strewn-rivers-mud-swepthillsides-submerged-homes.html.

DeGraff, J.V. and A.J. Gallegos. 2012. Technical Note: The Challenge of Improving Identification of Rockfall Hazard after Wildfire. Environmental and Engineering Geoscience. Vol. XVIII, No. 5: 389-387.

Dibblee, T.W. Jr., 1982, Geology of the Santa Monica Mountains and Simi Hills, southern California, in Fife, D.L., and Minch, J.A., eds., Geology and Mineral Wealth of the California Transverse Ranges: South Coast Geological Society, Guidebook No. 10, Mason Hill Volume, p. 94-130.

Dibblee, T.W., Jr., 1992, Geologic map of the Calabasas quadrangle, Los Angeles and Ventura Counties, California: Dibblee Foundation Map No. DF-37, scale 1:24,000.

Dibblee, T.W., Jr., 1993, Geologic map of the Malibu Beach quadrangle, Los Angeles County, California: Dibblee Foundation Map No. DF-47, scale 1:24,000.

Dibblee, T.W. Jr., and Ehrenspeck, H.E., 1990a, Geologic map of the Camarillo and Newbury Park Quadrangles, Ventura County, California: Dibblee Geological Foundation Map DF-28, scale 1:24,000.

Dibblee, T.W. Jr., and Ehrenspeck, H.E., 1990b, Geologic Map of the Point Mugu and Triunfo Pass Quadrangles, Ventura and Los Angeles Counties, California: Dibblee Geological Foundation Map DF-29, Santa Barbara, California, 1:24,000.

Dibblee, T.W. Jr. and H.E. Ehrenspeck. 1993. Field Relations of Miocene volcanic and sedimentary rocks of the western Santa Monica Mountains, California. *In* Weigand, P.W., Fritsche, A.E., and Davis, G.E., eds. Depositional and volcanic environments of middle Tertiary rocks in the Santa Monica Mountains, southern California: Pacific Section, SEPM (Society for Sedimentary Geology), Book 72.

Dibblee, T.W. Jr., and Ehrenspeck, H.E., 1993a, Geologic map of the Point Dume Quadrangle, Ventura and Los Angeles counties, California: Dibblee Geological Foundation Map DF-48, Santa Barbara, California, scale 1:24,000.

Dibblee, T.W. Jr., and Ehrenspeck, H.E., 1993b, Geologic map of the Thousand Oaks Quadrangle, Ventura and Los Angeles counties, California: Dibblee Geological Foundation Map DF-49, Santa Barbara, California, scale 1:24,000.

Eaton E. C., 1936. Flood and erosion control problems and their solution. Transactions of the American Society of Civil Engineers. Vol. 101. No 1: p. 1302–1330

Earp, S. 2007. Alluvial Fan Task Force study area flood history. Unpublished Final Report. Water Resources Institute, Cal State San Bernardino. 72 p. https://aftf.csusb.edu/documents/AFTF%20Study%20Area%20Flood%20History_ALL.pdf

Ehlig, P.L. and Steiner, E.A., compilers, 1992, Engineering geology field trips: Orange County, Santa Monica Mountains, and Malibu: Association of Engineering Geologists, Southern California Section, Annual Meeting Guidebook and Volume, p, B1 – B110 and C1- C91.

Foltz, R.B., Copeland, N.S., and W.J. Elliot. 2009. Reopening abandoned forest roads in northern Idaho, USA: Quantification of runoff, sediment concentration, infiltration, and interrill erosion parameters. Journal of Environmental Management. Vol. 90: p. 2542-2550.

Fritsche, A.E., 1993, Middle Tertiary stratigraphic terminology for the Santa Monica Mountains, southern California, in, Weigand, P.W., Fritsche, A.E., and Davis, G.E., 1993, Depositional and volcanic environments of middle Tertiary rocks in the Santa Monica Mountains, southern California: Pacific Section, SEPM (Society for Sedimentary Geology), Book 89, p. 1-12.

Fritsche, A.E., Weigand, P.W., Colburn, I.P., and Harma, R.L., 2001, Transverse/Peninsular Ranges connections – Evidence for the incredible Miocene rotation, in Dunne, G. and Cooper, J., compilers, Geologic Excursions in southwestern California: Pacific Section SEPM (Society for Sedimentary Geology), Book 89, p. 101-147.

Gartner, J.E., S.H. Cannon, and P.M. Santi. 2014. Empirical models for predicting volumes of sediment deposited by debris flows and sediment-laden floods in the transverse ranges of southern California. Engineering Geology. 176: 45-55.

Gatwood, E., Pedersen, J., and Casey, K. 2000. Los Angeles District Method for Prediction of Debris Yield. U.S. Army Corps of Engineers, Los Angeles District, Los Angeles, CA. 166 p.

Hollingsworth, R.A. 1984. Field guide to selected engineering geologic features, Malibu, Los Angeles County, California: Association of Engineering Geologists, Southern California Section, Annual Field Trip Guidebook, June 2, 1984, 112 p. and Appendix.

Hornafius, J.S., Luyendyk, B.P., Terres, R.R., and M.J. Kamerling. 1986. Timing and extent of Neogene tectonic rotation in the western Transverse Ranges, California. Geological Society of America Bulletin. Vol. 97: p. 1476-1487.

Hubbert, K.R., P.M. Wohlgemuth, and J.L. Beyers. 2012. Effects of hydromulch on post-fire erosion and plant recovery in chaparral shrublands of southern California. International Journal of Wildland Fire. 21(2): 155-167.

Ingersoll, R.V. and P.E. Rumelhart. 1999. Three-stage evolution of the Los Angeles basin, southern California. Geology, Vol. 27, No. 7: p. 593-596.

Irvine, P. J. 1994. Post-Winter Reconnaissance of the Green Meadows Fire Area, California Department of Conservation, Division of Mines and Geology, letter report dated August 24, 1994. 13 p., and Appendix A.

Jennings, C.W., Bryant, W.A., 2010, Fault Activity Map of California, Geological Data Map No.6, California Geological Survey, Scale 1:750,000.

Kamerling, M.J. and B.P. Luyendyk. 1979. Tectonic rotations of the Santa Monica Mountains region, western Transverse Ranges, California, suggested by paleomagnetic vectors. Geological Society of America Bulletin. Vol. 90: p. 331-337.

Keaton, J. R., field trip chairman, 1979, Field guide to selected engineering geologic features, Santa Monica Mountains: Association of Engineering Geologists, Southern California Section, Annual Field Trip Guidebook, May 19, 1979, 121 p.

Keaton, J.R., Wartman, J., Anderson, S., Benoît, J., deLaChapelle, J., Gilbert, R., and D.R. Montgomery. 2014. The 22 March 2014 Oso Landslide, Snohomish County, Washington. Geotechnical Extreme Events Response Report. 186 p.

Keeley, J.E. 2009. Fire intensity, fire severity and burn severity: a brief review and suggested usage. International Journal of Wildland Fire, 18(1): 116-126.

Keene, A.G., and Slosson, J., trip leaders, 1986, Field Trip Number 13: Active landslides along the Pacific Coast Highway in the Pacific Palisades-Malibu area, Los Angeles City/County, in Ehlig, P. L., compiler, Landslides and landslide mitigation in southern California: Geological Society of America, Cordilleran Section Annual Meeting Guidebook and Volume, Trips 3, 13 and 16, p. 43-150.

Kelleher, K. 1995. "Sun Shines as Malibu Digs Out: Storms: The latest round of flooding and mudslides leaves about 100 homes damaged. It is the city's worst disaster since the 1993 wildfires." Los Angeles Times, dated March 13, 1995: http://articles.latimes.com/1995-03-13/local/me-42250_1_worst-disaster

Kennedy, J.M. and L. Earnest. 1993. "Laguna, Malibu Hit by Mudslides: Weather: Storm brings little rain, but sends scorched hillsides tumbling. Residents brace for a hard winter." Los Angeles Times, dated November 12, 1993. http://articles.latimes.com/1993-11-12/news/mn-56134_1_laguna-beach

Kinoshita, A.M.; Hogue, T.S.; Napper, C. 2014. Evaluating pre- and post-fire peak discharge predictions across western U.S. watersheds. Journal of the American Water Resources Association 50: 1540-1557.

LACDPW (Los Angeles County Department of Public Works). 2006. Sedimentation manual. Second Edition. Water Resources Division, January 2006. Alhambra, CA. 69 p. plus Appendices.

Lamb, M.P., J.S. Scheingross, W.H. Amidon, E. Swanson, and A. Limaye. 2011. A model for fire-induced sediment yield by dry ravel in steep landscapes. Journal of Geophysical Research: Earth Surface. 116, F03006, doi.org/10.1029/2010JF001878

Lancaster, J.T., Spittler, T.E., and Short, W.R., 2015, Alluvial Fan Flooding Hazards: An Engineering Geologic Approach to Preliminary Assessment. California Geological Survey Special Report 227. Sacramento, CA. 46 p. ftp://ftp.consrv.ca.gov/pub/dmg/pubs/sr/SR_227/CGS_SR227_Alluvial_Fan_Engineering_Geologic_Approach_Final_July_2015.pdf

LA (Los Angeles) Times. Nov 12, 1993: Laguna, Malibu Hit by Mudslides: Weather: Storm brings little rain, but sends scorched hillsides tumbling. Residents brace for a hard winter. http://articles. latimes.com/1993-11-12/news/mn-56134_1_laguna-beach

LA (Los Angeles) Times. March 13, 1995: Sun Shines as Malibu Digs Out: Storms: The latest round of flooding and mudslides leaves about 100 homes damaged. It is the city's worst disaster since the 1993 wildfires. http://articles.latimes.com/1995-03-13/local/me-42250_1_worst-disaster

Luyendyk, B.P. 1991. A model for Neogene crustal rotations, transtension, and transpression in southern California. Geological Society of America Bulletin. Vol. 103: p. 1528-1536.

McCrink T.P., Barrows, A.G., Irvine, P.J., McMillan, J.R., Silva, M.A., and Giffen, D.G., 1997a, Earthquake-Induced Landslide Zones in the Simi Valley East and Simi Valley West 7.5-Minute Quadrangles, Ventura and Los Angeles Counties, California: California Division of Mines and Geology Seismic Hazard Zone Report 002, p. 19-38, http://gmw.consrv.ca.gov/shmp/download/quad/SIMI_VALLEY_EAST/reports/simve_eval.pdf 71

McCrink T.P., Barrows, A.G., McMillan, J.R., Silva, M.A., Irvine, P.J., Tan, S.S., Giffen, D.G., and Perez, F.G., 1997b, Earthquake-Induced Landslide Zones in the Topanga 7.5-Minute Quadrangle, Los Angeles County, California: California Division of Mines and Geology Seismic Hazard Zone Report 01, p. 19-34, http://gmw.consrv.ca.gov/shmp/download/quad/TOPANGA/reports/top_eval.pdf

McCrink, T.P., Irvine, P.J., Silva, M.A., Wilson, R.I., and Schlosser, J.P., 1997c, Earthquake-Induced Landslide Zones in the Calabasas 7.5-Minute Quadrangle, Los Angeles and Ventura Counties, California: California Division of Mines and Geology Seismic Hazard Zone Report 06, p. 21-38, http://gmw.consrv.ca.gov/shmp/download/quad/CALABASAS/reports/calab_eval.pdf

Meigs, A., Brozovic, N., and M.L. Johnson, 1999. Steady, balanced rates of uplift and erosion of the Santa Monica Mountains, California. Basin Research. Vol. 11: p. 59-73.

Moody, J.A. and D.A. Martin. 2001. Hydrologic and sedimentologic response of two burned watersheds in Colorado. Denver, Colorado, U.S. Geological Survey, Water-Resources Investigations Report 01-4122. 142 p.

Neary, D.G.; Ryan, K.C.; DeBano, L.F., eds. 2005. Wildland fire in ecosystems: effects of fire on soils and water. Gen. Tech. Rep. RMRS-GTR-42-vol.4. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 250 p.

Nicholson, C., Sorlien, C.C., Atwater, T.. Crowell, J.C., and B.P. Luyendyk. 1994. Microplate capture, rotation of the western Transverse Ranges, and initiation of the San Andreas transform as a low-angle fault system. Geological Society of America Bulletin. Vol. 22: p. 491-495.

NPS (National Park Service), 2011, Wildfire Frequency, Santa Monica Mountains National Recreation Area, Map Scale 1:190,000. https://www.nps.gov/samo/learn/management/loader.cfm?csModule=security/getfile&pageID=624273

Oakley, N. S., Lancaster, J. T., Kaplan, M. L., & Ralph, F. M. 2017. Synoptic conditions associated with cool season post-fire debris flows in the Transverse Ranges of southern California. Natural Hazards. Vol. 88. No. 1: p. 327-354.

Parsons, A.; Robichaud, P.R.; Lewis, S.A.; Napper, C.; Clark, J.T. 2010. Field guide for mapping post-fire soil burn severity. Gen. Tech. Rep. RMRS-GT-243. Fort Collins, CO. U.S.D.A., Forest Service, Rocky Mountain Research Station. 49 p.

PCR Services. 2001. Watershed management area plan for the Malibu Creek watershed. Final report prepared for Las Virgenes Malibu Conejo Council of

Governments. 98 p. plus appendices. https://dpw.lacounty.gov/wmd/watershed/mc/wmap.pdf

Robichaud, P. R.; Elliot, W. J.; Wagenbrenner, J. W. 2011. Probabilistic soil erosion modeling using the Erosion Risk Management Tool (ERMIT) after wildfires. ISELE Paper Number 11039. Paper presented at the international symposium on erosion and landscape evolution; September 18-21, 2011; Anchorage, AK. ASABE Publication Number 711P0311cd. 8 p.

Robichaud, P.R.; J.W. Wagenbrenner; S.A. Lewis; L.E. Ashmun; R.E. Brown; and P.M. Wohlgemuth. 2013. Post-fire mulching for runoff and erosion mitigation Part II: Effectiveness in reducing runoff and sediment yields from small catchments. Catena. 105: 93-111.

Roth, E.S., 1959, Landslides between Santa Monica and Point Dume: Unpublished Master's Thesis, University of Southern California, 184 p.

Rowe, P.B.; Countryman, C.M.; Storey, H.C. 1949. Probable peak discharges and erosion rates from southern California watersheds as influenced by fire. USDA Forest Service. California Forest and Range Experiment Station, Berkeley, California. 305 p.

Rowe, P.B.; Countryman, C.M.; Storey, H.C. 1954. Hydrologic analysis used to determine effects of fire on peak discharge and erosion rates in southern California watersheds: USDA Forest Service. California Forest and Range Experiment Station, Berkeley, California. 49 p.

Schofield, N. and S. Earp. 2007. Historical perspectives on flooding in southern California. PowerPoint Presentation prepared for the Alluvial Fan Task Force, Plenary Meeting No. 1, December 7, 2007. https://aftf.csusb.edu/documents/History%20of%20Flooding%20in%20Southern%20California.pdf

Silva, M.A., and Irvine, P.J., 2000a, Earthquake-Induced Landslide Zones in the Moorpark 7.5-Minute Quadrangles, Ventura County, California: California Division of Mines and Geology Open File Report 2000-007, p. 13-27, http://gmw.consrv.ca.gov/shmp/download/quad/MOORPARK/reports/moor_eval.pdf

Silva, M.A., and Irvine, P.J., 2000b, Earthquake-Induced Landslide Zones in the Thousand Oaks 7.5- Minute Quadrangle, Ventura and Los Angeles Counties, California: California Division of Mines and Geology Seismic Hazard Zone Report 042, p. 17-36,

Silva, M.A., and Irvine, P.J., 2001a, Earthquake-Induced Landslide Zones in the Malibu Beach 7.5- Minute Quadrangle, Los Angeles County, California: California Division of Mines and Geology Seismic Hazard Zone Report 050, p. 19-42, http://gmw.consrv.ca.gov/shmp/download/quad/MALIBU_BEACH/reports/malib_eval.pdf

Silva, M.A., and Irvine, P.J., 2001b, Earthquake-Induced Landslide Zones in the Point Dume 7.5-Minute Quadrangle, Los Angeles and Ventura Counties, California: California Division of Mines and 76 Geology Seismic Hazard Zone Report 056, p. 19-44, http://gmw.consrv.ca.gov/shmp/download/quad/POINT_DUME/reports/poid_eval.pdf

Silva, M.A., and Wiegers, M.O., 2002, Earthquake-Induced Landslide Zones in the Triunfo Pass 7.5- Minute Quadrangle, Los Angeles County, California: California Division of Mines and Geology Seismic Hazard Zone Report 059, p. 17-36, http://gmw.consrv.ca.gov/shmp/download/quad/TRIUNFO_PASS/reports/trip_eval.pdf

Slagel, M. and G. Griggs. 2006. Cumulative losses of sand to the California coast by dam impoundment. Final Report prepared for the California Coastal Sediment Management Workgroup and the California Department of Boating and Waterways. 41 p.

Staley, D.M.; Negri, J.A.; Kean, J.W.; Tillery, A.C.; Youberg, A.M. 2016. Updated logistic regression equations for the calculation of post-fire debris-flow likelihood in the western United States: U.S. Geological Survey Open-File Report 2016-1106, 13 p., available at http://pubs.usgs.gov/of/2016/1106/

Sukup SJ, Laber J, Sweet D, Thompson R. 2016. Analysis of an intense narrow cold frontal rainband and the springs fire debris flow of 12 December 2014. NWS technical attachment 1601. http://www.wrh.noaa.gov/media/wrh/online_publications/TAs/TA1601.pdf.

URS Greiner Woodward Clyde, 1999, Site assessment for State Route 1 from McClure Tunnel to Busch Drive (Zuma Beach), (K.P. 56.720 to K.P. 88.577): Prepared for Caltrans, District 7, Contract No. 07A0322-A, Task Order No. 1.

USACE (United States Army Corps of Engineers). 1994. Reconnaissance Report: Malibu/Los Angeles County Coastline, Los Angeles County, California. U.S. Army Corps of Engineers, Los Angeles District.

USDA-NRCS (United States Department of Agriculture, Natural Resources Conservation Service). 2006. Soil survey of Santa Monica Mountains National Recreation Area, California. Accessible online at: http://soils.usda.gov/survey/printed_surveys/

Takenaka, K. and W. Tripp. 2018. Woolsey Fire soil assessment report. Department of Interior Burned Area Emergency Response Report. Thousand Oaks, CA. 19 p.

Treiman, J.A., 1994, Malibu Coast Fault, Los Angeles County, California: California Division of Mines and Geology Fault Evaluation Report FER-229, 42 p, ftp://ftp.consrv.ca.gov/pub/dmg/pubs/fer/229/

Walls, C., Rockwell, T., Mueller, K, Bock, Y., Williams, S., Pfanner, J., Dolan, J., and P. Fang. 1998. Escape tectonics in the Los Angeles metropolitan region and implications for seismic risk. Nature. Vol. 394: p.356-360.

Weber, F.H., 1980, Landsliding and Flooding in Southern California During the Winter of 1979-1980 (Principally February 13-21, 1980), California Division of Mines and Geology Open-File Report 80-3 LA, 69 p.

Weber, F.H., Treiman, J.A., Tan, S.S., and Miller, R.V., 1979, Landslides in the Los Angeles Region, California: Effects of the February-March 1978 Rains, California Division of Mines and Geology Open-File Report 79-4, 277p., 1 plate.

Weigand, P.W., Fritsche, A.E., and Davis, G.E., eds. 1993. Depositional and volcanic environments of middle Tertiary rocks in the Santa Monica Mountains, southern California: Pacific Section, SEPM (Society for Sedimentary Geology), Book 72.

Weigand, P.W., and Savage, K.L., 1993, Review of the petrology and geochemistry of the Miocene Conejo Volcanics of the Santa Monica Mountains, California, in Weigand, P. W., Fritsche, A.E., and Davis, G.E., eds., Depositional and volcanic environments of middle Tertiary rocks in the Santa Monica Mountains, southern California: Pacific Section, SEPM (Society for Sedimentary Geology), Book 72, p. 93-112.

WEST, 2011. Sediment/debris bulking factors and post-fire hydrology for Ventura County. May 2011.

Yeats, R.S. 1968. Southern California structure, sea-floor spreading, and history of the Pacific Basin. Geological Society of America Bulletin. Vol. 70: p. 1693-1702.

Yerkes, R.F. and R.H. Campbell. 1979. Stratigraphic Nomenclature of the Central Santa Monica Mountains, Los Angeles County, California. U.S. Geological Survey Bulletin 1457-E. Washington, D.C. 38 p.

Yerkes, R.F. and R.H. Campbell. 1980. Geologic map of east-central Santa Monica Mountains, Los Angeles County, California. U.S. Geological Survey. Doi: 10.3133/i1146.

10 APPENDICES

Appendix A. LIST OF CONTACTS

Name	Organization	Position	Phone	Email
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			310-570-5541 (C)	
Susan Shu	City of Los Angeles Public Works - Stormwater	Sr. Civil Engineer	213-485-4493	susan.shu@lacity.org
Jack Husted	County of Los Angeles Public Works	Civil Engineer	626-458-6149 (O)	jhusted@dpw.lacounty.gov
			626-632-1257 (C)	
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			626-476-0372 (M)	
Carolina Hernandez	Los Angeles County Public Works		626-300-3318 (O)	chernandez@dpw.lacounty.gov
			626-476-4150 (M)	
Russ Colby	Los Angeles Water Board		213-620-6373	Russ.Colby@waterboards.ca.gov
Wen Yang	Los Angeles Water Board		213-620-2253	Wen.Yang@waterboards.ca.gov
Sterling Klippel	Los Angeles County Flood Control	Engineer	626-607-6264	SKLIPPEL@dpw.lacounty.gov
Iraj Nasseri	Los Angeles County Flood Control	H&H / GIS		
Kevin McGowan	Ventura County Office of Emergency Services	Manager	805-797-6450	Kevin.Mcgowan@ventura.org
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			805-766-2894 (C)	
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Jim O'Tousa	Ventura County	County Geologist	805-654-2034	jim.o'tousa@ventura.org
Jim Suero	California State Parks	Forester		James.Suero@parks.ca.gov
Gustavo Ortega	Caltrans	Senior EG	213-910-8734	gustavo.ortega@dot.ca.gov
Ed Siribohdi	Caltrans	Senior Landscape Architect	213-400-9125	ed.siribohdi@dot.ca.gov
Mike Takeshita	Los Angeles County Fire Department	Division Chief	323-855-0095	Mike.Takeshita@fire.lacounty.gov
Brian Henman	Caltrans		858-705-1344	
Chris Harris	Caltrans	Geologist--LA Office	562-665-0454	
Chris Holbeck	NPS	Regional Wilderness Coordinator	402-661-1864	chris_holbeck@nps.gov
Richard Schwab	NPS	National Post-Fire Programs Coordinator	208.830.4791	richard_schwab@nps.gov
Francis Rengers	USGS	Geomorphologist	303-273-8637	frengers@usgs.gov
Mike Miranda	LACDPW	Civil Engineer	909-618-3123	mmirand@dpw.lacounty.gov
John Kelly	LACDPW	Deputy Director		jkelly@bh.lacounty.gov
Rudy Rivera	LACDPW	Civil Engineer	714-715-4465	

Name	Organization	Position	Phone	Email
Shannon Ggem	Malibou Lake Mountain Club Homeowners Assoc.	Director	(213) 999-9907	
Lance Grindle	LACDPW	Principle Engineer	626-458-3917	lgrindle@dpw.lacounty.gov
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Shauna Jensen	USFS	Hydrologist		smjensen@fs.fed.us
Scott Sheppard	USFS	Hydrologist		briansheppard@fs.fed.us
Kellen Takenaka	USFS	Soil Scientist	559-297-0706x4936	ktakenaka@fs.fed.us
Pat Wood	LACDPW	Senior Civil Engineer	626-458-6131	pwood@dpw.lacounty.gov
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Jim Royal	LA County Sheriff Department	Station Lieutenant, Malibu/Lost Hills Station	(818) 878-1808	jroyal@lasd.org
Garrett Shay	Caltrans	Trainee	781-507-1734	
Scott Harris	Las Virgenes Municipal Water District	Water Conservation Coordinator	818-251-2170	Sharris@LVMWD.com
David Lippman	Las Virgenes Municipal Water District	Director of Facilities and Operations	818-251-2221	dlippman@LVMWD.com
Rossana D'Antonio	LACDPW	Deputy Director	626-458-4004	rdantonio@dpw.lacounty.gov
Philippe Eskandar	City of Westlake Village	Administrative Analyst	818-706-1613	philippe@wlv.org
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J. Lopez	Los Angeles County Fire Department	Assistant Chief		J.Lopez@fire.lacounty.gov
Adam Uehara	Los Angeles County Fire Department	Section Chief	310-995-3840	Adam.uehara@fire.lacounty.gov
Bruce Rindahl	Ventura County Watershed Protection District	Watershed Resources and Technology	805-654-2003	Bruce.Rindahl@ventura.org
Lisa Campanaro	Raleigh Enterprises	Chief Operating Officer	310-899-8900 x5216	lcampanaro@raleightenterprises.com
Timothy Pershing	California State Assembly	Senior Field Representative	310-450-0041	Tim.Pershing@asm.ca.gov

Appendix B. SUMMARY OF DEBRIS FLOW MODEL OUTPUTS FOR THE WOOLSEY AND HILL FIRES

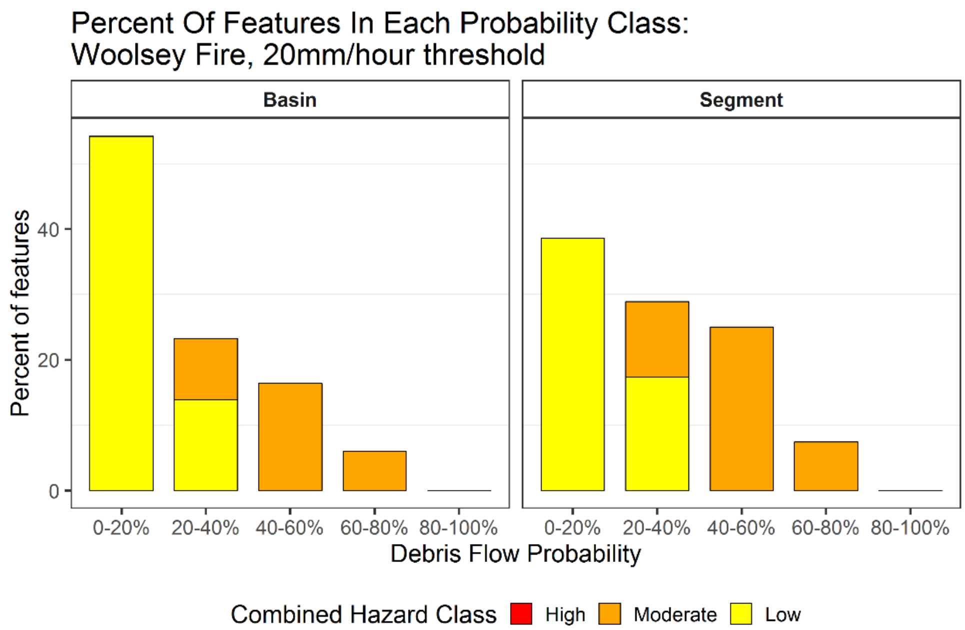

Figure B-1. Percent of basins and streams by debris flow probability class for the Woolsey Fire (20 mm hr^{-1} for 15-minute duration).

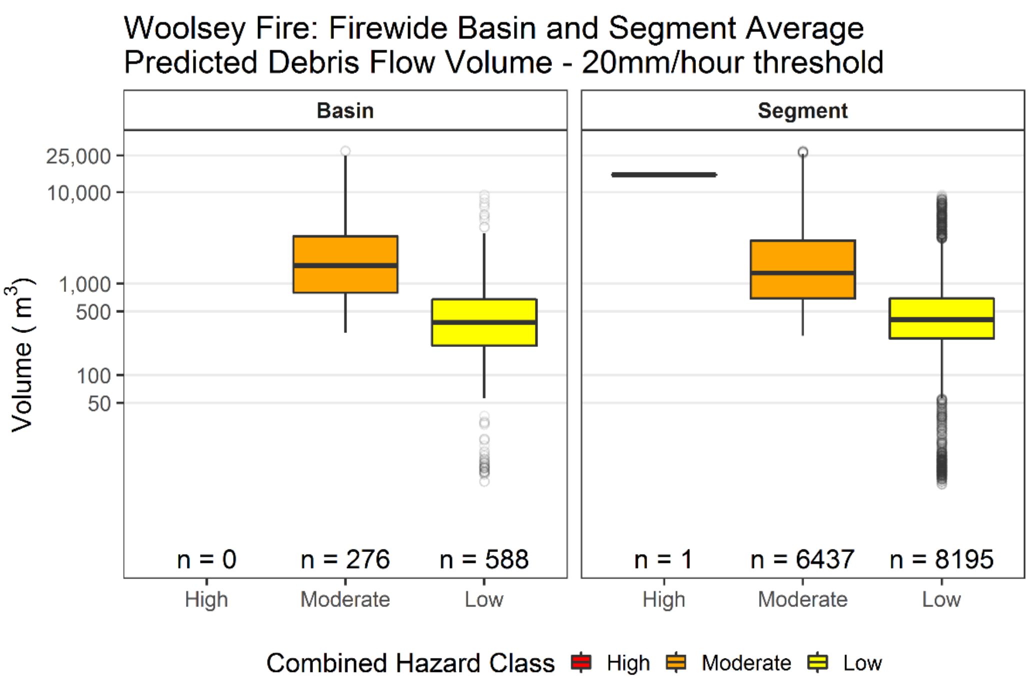

Figure B-2. Debris flow volume by basin and stream segment for the Woolsey Fire (20 mm hr^{-1} for 15-minute duration).

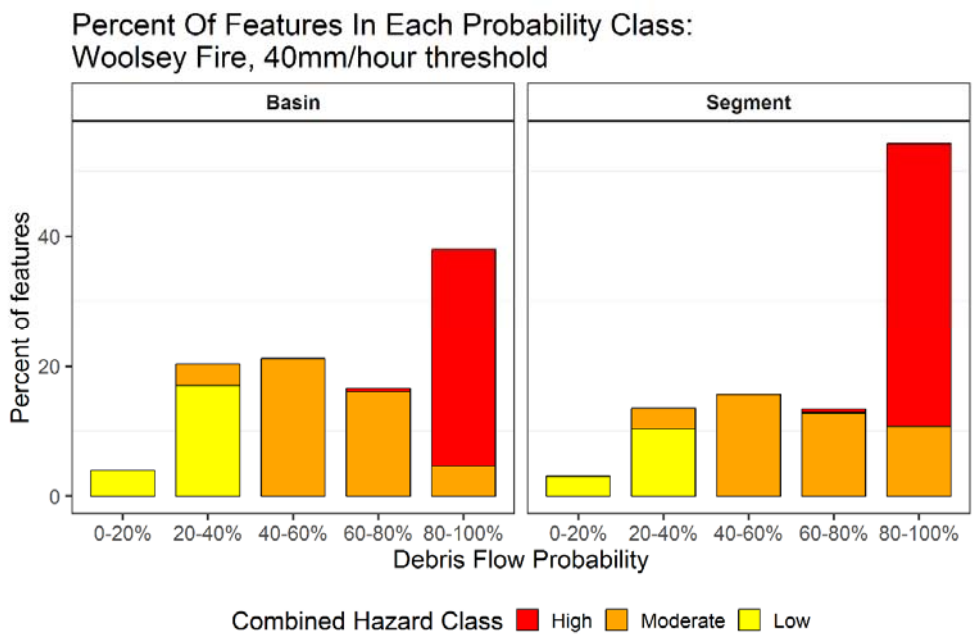

Figure B-3. Percent of basins and streams by debris flow probability class for the Woolsey Fire (40 mm hr^{-1} for 15-minute duration).

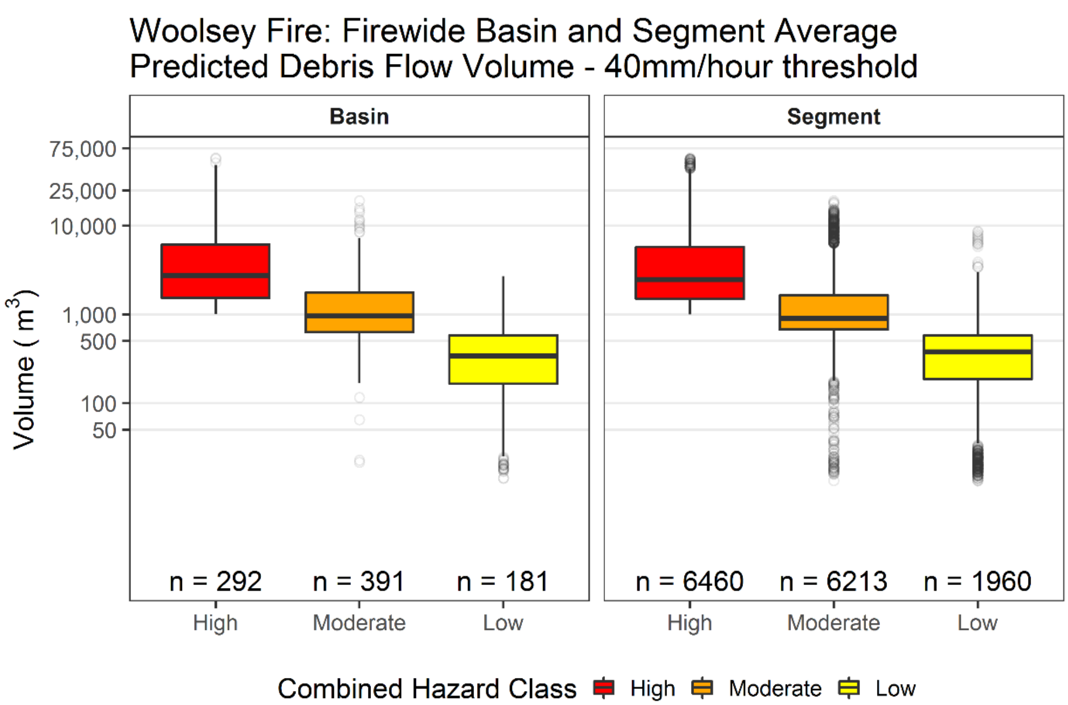

Figure B-4. Debris flow volume by basin and stream segment for the Woolsey Fire (40 mm hr^{-1} for 15-minute duration).

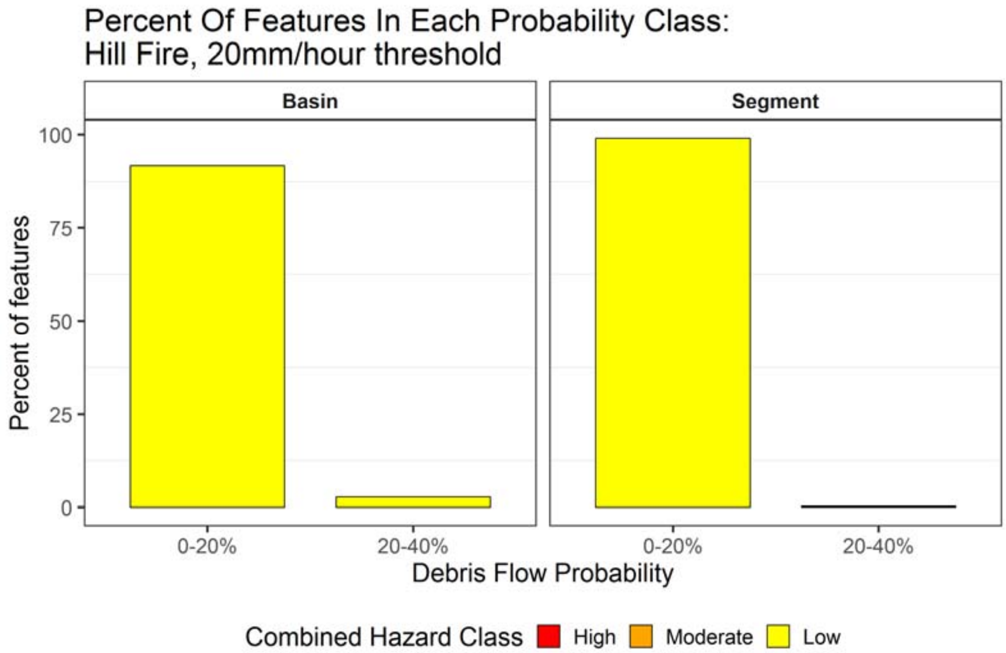

Figure B-5. Percent of basins and streams by debris flow probability class for the Hill Fire (20 mm hr^{-1} for 15-minute duration).

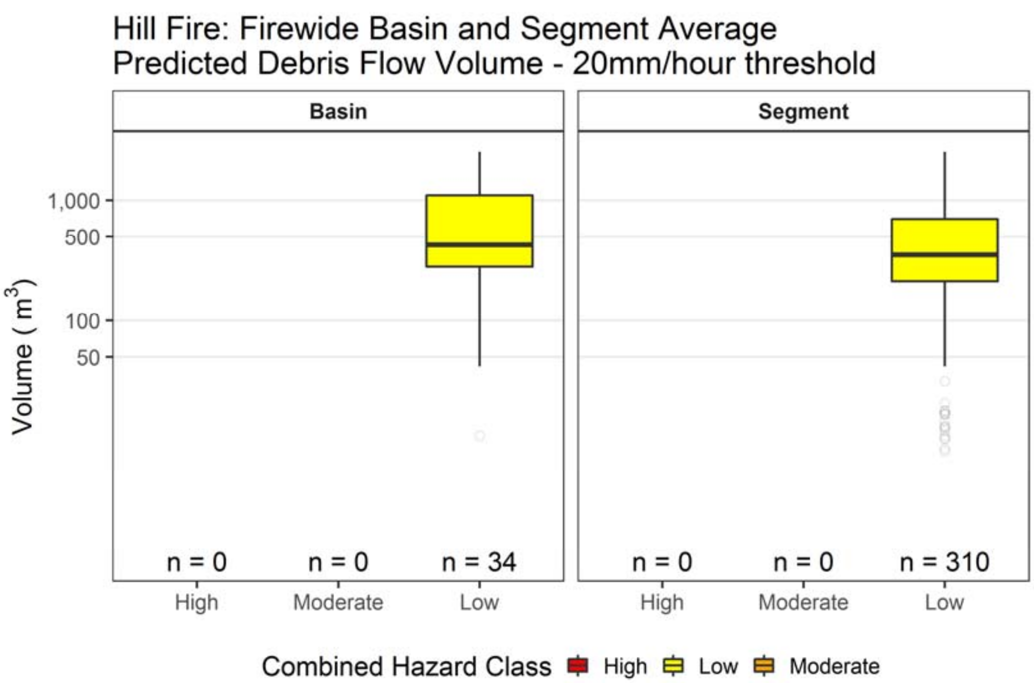

Figure B-6. Debris flow volume by basin and stream segment for the Hill Fire (20 mm hr^{-1} for 15-minute duration).

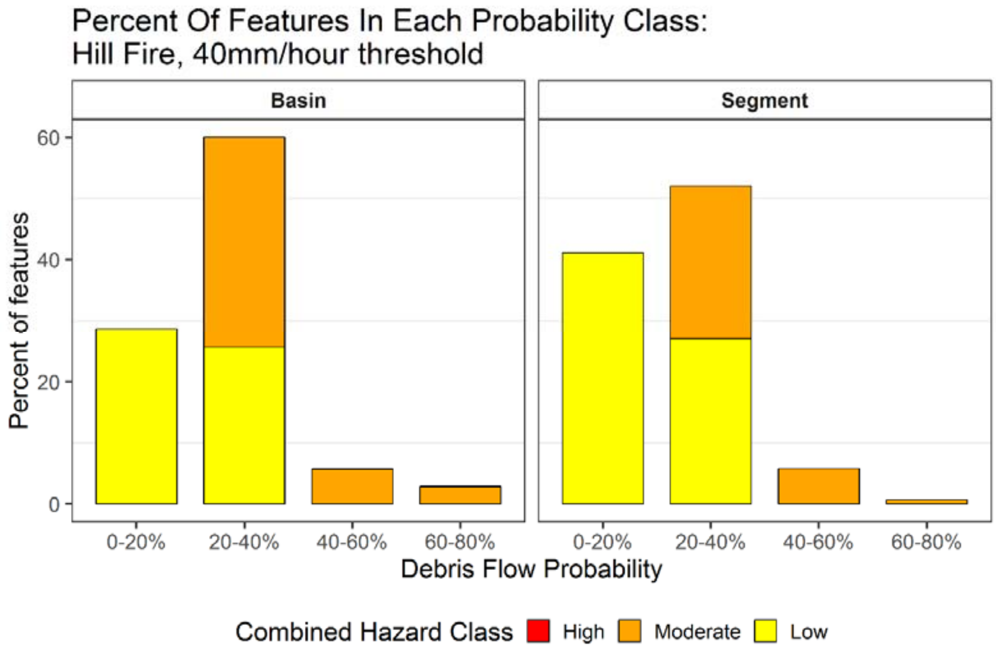

Figure B-7. Percent of basins and streams by debris flow probability class for the Hill Fire (40 mm hr^{-1} for 15-minute duration).

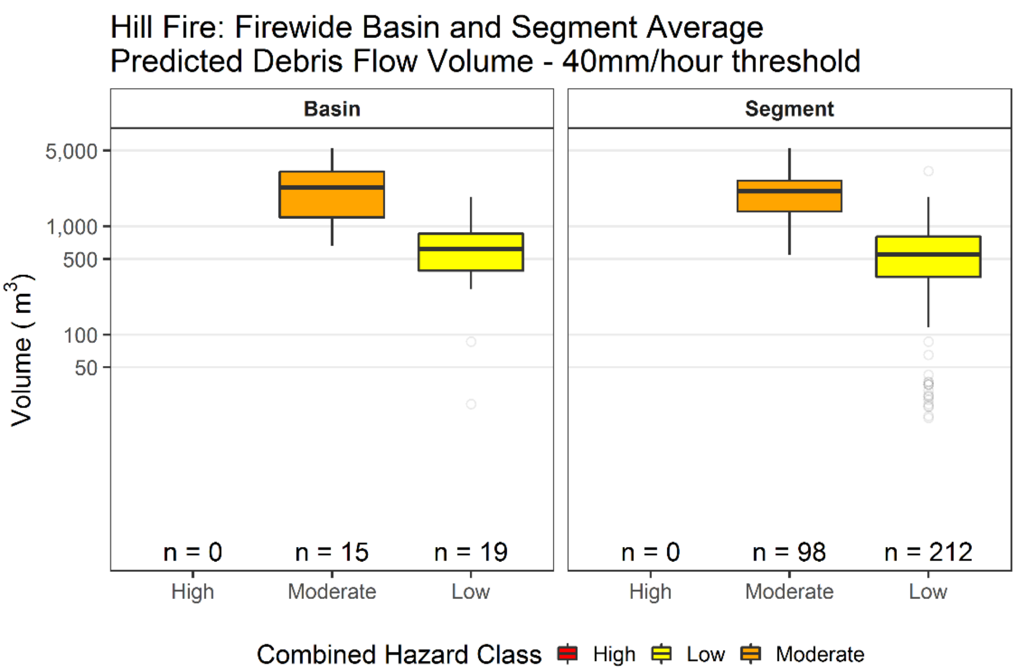

Figure B-8. Debris flow volume by basin and stream segment for the Hill Fire (40 mm hr^{-1} for 15-minute duration).

APPENDIX C. VALUES-AT-RISK TABLE

Shaded rows = polygons
white rows = points

Woolsey - Hill Fires Values at Risk Table

Site	Community / Local area	Latitude	Longitude	Potential hazard / Field observation	Hazard Category	Specific at-risk feature	Feature Category	Potential hazard to life	Potential hazard to property	Preliminary EMP	County	Fire
Ventura County - Hill Fire												
1	Sage Mountain Assisted Living			Assisted living facility at risk of flooding and moderate in flow path of potential debris flow segment.	debris flow / flood	Senior living facility	home	high	high	Early warning system; consult with professional for potential debris flow path	Ventura	Hill
2	Monte Vista Mobile Home Park	34.194012	-118.963	Mobile homes at risk of rockfall and in flow path of low potential debris flow catchment.	rockfall	Mobile homes	home	moderate	moderate	Early warning system	Ventura	Hill
3	Camarillo Truck Scale	34.200471	-118.9557	Steep burned, rocky slopes above truck scales. Partially covered with rock netting which was damaged in fire	rockfall	Trucks/Cars	other	moderate	moderate	Signage, Professional Consultation	Ventura	Hill
4	Below Sage Hill - Hwy 1010			Debris flow or rockfall onto highway	rockfall	Debris flow or rockfall onto highway 10	drainage structure	moderate	moderate	Storm patrol. Review by CalTrans	Ventura	Hill
5	Camarillo Springs	34.198392	-118.977	Residential structure in potential flow path of small catchment upstream	debris flow / flood	Homes	home	low	low	Storm patrol to maintain culvert function	Ventura	Hill
6	Camarillo Springs	34.197411	-118.978	Double box culvert with potential to plug and damage public roadway.	debris flow / flood	Public Road	home	low	low	Storm patrol to maintain box culvert	Ventura	Hill
7	Camarillo Springs Ranch and Camarillo Grove Park			50 horse boarding ranch and park downstream of low potential debris flow paths	flood	Recreation area and boarding area	multiple	low	moderate	Early warning system. Consult with professional to examine flow path capacities.	Ventura	Hill
8	Newbury Park	34.194604	-118.9469	Flooding, debris flow into post office sorting facility	debris flow / flood	USPS Facility	business	no	low	Early warning, storm patrol	Ventura	Hill
9	Camarillo Springs	34.207532	-118.969	Two mobile homes and other structures located in draw, flooding risk	flood	Structures	home	no	low	Improve drainage to divert water away from structures. Use sandbags on site	Ventura	Hill
Ventura County - Woolsey Fire												
10	Deals flat	34.090327	-118.9614	House built at outlet of high probability debris flow channel. Unable to access, evaluated from neighboring property	debris flow / flood	House	home	high	high	Early warning system. Further evaluation necessary	Ventura	Woolsey
11	Yerba Buena	34.108699	-118.9515	Burned out house below rocky crest with large loose boulders.	rockfall	Burned out house	home	high	high	Early warning system.	Ventura	Woolsey
12	Malibu	34.088543	-118.9233	Resort located at confluence of multiple burned drainages prone to debris flows	debris flow / flood	Burned house	home	high	high	Early Warning System	Ventura	Woolsey
13	Bell Canyon	34.205472	-118.6906	House is downslope of steep rocky slope. Rockfall hazard exist confirmed by resident.	rockfall	House	home	high	high	Early warning system. Consult a professional for diversion structures.	Ventura	Woolsey
14	Bell Canyon	34.215472	-118.6761	Existing active land slide can be exacerbated by increased runoff from upslope burned area.	other	House	home	high	high	Engineering controls/ early warning system. Consult professional for engineering mitigation	Ventura	Woolsey

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Woolsey - Hill Fires Values at Risk Table

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15	Bell Canyon	34.213843	-118.6759	House in flow path of low potential debris flow basin, exhibiting active shallow failures.	debris flow / flood	House	home	high	high	Early warning system, consult professional for engineering mitigation.	Ventura	Woolsey
16	Thousand Oaks	34.191374	-118.8335	Two drainage channels directed into paved road with homes. About 50 feet of run out before the first house. One channel is directed at the house with a small berm upstream to deflect flow.	debris flow / flood	House	home	high	high	Early warning system.	Ventura	Woolsey
17	Bell Canyon	34.207565	-118.6819	Home in flow path of low potential debris flow basin. Drainage structure maybe overwhelmed.	debris flow / flood	Home	home	high	high	Drainage structure maintenance, early warning system.	Ventura	Woolsey
18	Bell Canyon	34.200231	-118.6943	House is in flow path of conversing low potential debris flow basin.	debris flow / flood	House	home	high	high	Early warning system, consult with professionals for engineering mitigation.	Ventura	Woolsey
19	Bell Canyon	34.203291	-118.6805	House in flow path of low potential debris flow basin with evidence of prior debris flow deposits.	debris flow / flood	House	home	high	high	Early warning system, consult with professionals for engineering mitigation.	Ventura	Woolsey
20	Oak Park Community Center	34.181201	-118.7726	Pre-School/ children's center in flow path of low potential debris basin. Building has glass walls facing hill slope.	debris flow / flood	Children's play room	recreational	high	moderate	Early warning system, consult with professional for diversion structures.	Ventura	Woolsey
21	Little Sycamore Canyon			Youth camp in floodplain. Structures mostly burned.	debris flow / flood	Campground structures (burned)	recreational	high	high	Early warning system.	Ventura	Woolsey
22	Yerba Buena			Recreational and residential structures within debris flow channels. Appears to be located within the National Park.	debris flow	Residential and camp structures	multiple	high	high	Early Warning System	Ventura	Woolsey
23	West Carlisle			Home and trailers adjacent to the channel in the floodplain. Area is not burned but upstream drainage is burned with steep rocky slopes. Residents report history of flooding and debris flow.	debris flow / flood	Homes and trailers	home	high	high	Early warning system.	Ventura	Woolsey
24	Bell Canyon			Home at risk of rockfall hazard.	rockfall	Residences	home	high	high	Early warning system/ consult with professional for deflection structures.	Ventura	Woolsey
25	Bell Canyon			Homes in rockfall hazard.	rockfall	House	home	high	high	Early warning system/ consult with professional for deflection structures.	Ventura	Woolsey
26	Bell Canyon			Homes are in varying risk (moderate to high) of rockfall hazard. Observed localized small debris slide.	rockfall	Homes	home	high	high	Early warning system/ consult with professional for deflection structures.	Ventura	Woolsey
27	Bell Canyon			Homes in rockfall hazard.	rockfall	House	home	high	high	Early warning system/ consult with professional for deflection structures.	Ventura	Woolsey

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Woolsey - Hill Fires Values at Risk Table

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28	Bell Canyon			Homes appear to be in flow path of low potential debris flow basin. No access granted to field crew.	debris flow / flood	Home	home	high	high	Early warning system/ consult with professional for deflection structures.	Ventura	Woolsey
29	Bell Canyon			Homes appear to be in flow path of low potential debris flow basin. No access granted to field crew.	debris flow / flood	House	home	high	high	Early warning system/Diversion structures	Ventura	Woolsey
30	Yellow hill	34.083528	-118.9445	House built in axis of short high potential debris flow channel, large perched boulders above house, house is burned	rockfall	Residential structure	home	moderate	moderate	Early storm warnings	Ventura	Woolsey
31	Yerba Buena	34.105547	-118.9418	House in the channel near channel elevation. Owner says no history of flooding. Some small rock observed in channel.	debris flow / flood	House	home	moderate	moderate	Early warning system.	Ventura	Woolsey
32	Yerba Buena	34.109337	-118.9454	House below rocky crest with large boulders observed in nearby channels and perched on slope above.	rockfall	House	home	moderate	moderate	Early warning system.	Ventura	Woolsey
33	PCH crossing between Deer and Little Sycamore Canyon	34.05944	-118.9746	30 inch culvert at outlet of high debris flow channel with potential to plug	debris flow / flood	PCH roadway and culvert	multiple	moderate	low	Storm patrol	Ventura	Woolsey
34	PCH at Deer Canyon	34.062481	-118.9857	Six foot diameter box culvert at outlet of moderate debris flow channel with potential to plug	debris flow / flood	PCH roadway and box culvert	multiple	moderate	low	Storm patrol	Ventura	Woolsey
35	Bell Canyon	34.208621	-118.7065	Un modeled steep drainage feeds directly to a house. 35% channel gradient, 50%+ side slopes with loose material.	debris flow / flood	House	home	moderate	moderate	Early warning system/Maintenance to drainage/diversion structures.	Ventura	Woolsey
36	Bell Canyon	34.214705	-118.6754	House in flow path of several low potential debris flow basins directed to 36” culvert in center of property. Resident reported past flooding and culvert clogging.	flood	House	home	moderate	high	Early warning system, culvert maintenance , consult professional for diversion structures and engineering mitigation.	Ventura	Woolsey
37	Lindero Canyon - Upper North Ranch	34.197948	-118.7928	Small steep catchment with large boulders upslope of home. Some history of mud into pool. Flow line runs to north of house. Two large catchments collect runoff and send into culvert either side of house. Could use cleaning. Advised owner.	other	Residence	home	moderate	high	Early warning system.	Ventura	Woolsey
38	Bell Canyon	34.201388	-118.6952	Home in flow path of low potential debris flow basin with existing land slide. Culvert draining basin on Bell Canyon Rd is partially clogged.	debris flow / flood	Residence	home	moderate	moderate	Early warning system, culvert maintenance	Ventura	Woolsey

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Woolsey - Hill Fires Values at Risk Table

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39	North Ranch	34.169465	-118.8068	Partially full debris basin upslope of existing house. House is 100-feet downslope of basin. 50-acre drainage is confined to basin.	debris flow / flood	Home	home	moderate	moderate	Early warning system, maintain/clean out debris basin	Ventura	Woolsey
40	North Ranch	34.173299	-118.8055	House built at toe of short steep drainage. Drainage is diverted around house to driveway. Small rocks on slope. Sediment observed in v-ditch along slope above house.	debris flow / flood	Home	home	moderate	moderate	Early warning system. Clean v-ditch	Ventura	Woolsey
41	Lindero Canyon	34.186028	-118.7957	House below outlet of steep drainage. Woody debris within channel. V-ditch and 3-foot diameter culvert behind playground at rear of house.	debris flow / flood	Home	home	moderate	moderate	Early warning system. Maintain drainage structures.	Ventura	Woolsey
42	Oak Park	34.177555	-118.7701	Home in flow path of un-modeled basin. in the event existing diversion structures get overwhelmed, home maybe impacted.	debris flow / flood	House	home	moderate	moderate	Early warning system/ consult professionals for diversion structures	Ventura	Woolsey
43	Oak Park Community	34.176309	-118.7688	Home in flow path of un-modeled basin. in the event existing diversion structures get overwhelmed, home maybe impacted.	debris flow / flood	House	home	moderate	moderate	Early warning system/ consult professionals for diversion structures	Ventura	Woolsey
44	Oak Park community	34.174801	-118.766	Home in flow path of low potential debris flow basin. in the event flow exceed channel capacity, home maybe impacted.	debris flow / flood	House	home	moderate	high	Early warning system/ consult professionals for diversion structures	Ventura	Woolsey
45	Little Sycamore Canyon			Ranch structures in floodplain of two joining channels. Stone bridge with dual culverts (48" and 36") forms choke point. Both channels have high probability for debris flow.	debris flow / flood	Ranch structures	business	moderate	high	Early warning system.	Ventura	Woolsey
46	Little Sycamore Creek			Resort cabins built in channel. Wooden bridge crossing channel potential choke point.	debris flow / flood	Resort structures	recreational	moderate	moderate	Early warning system.	Ventura	Woolsey
47	Solromar			Proposed Residential development at outlet of high potential debris flow channel. No buildings yet constructed. Unable to access.	debris flow / flood	To be constructed residential structure	home	moderate	moderate	Early storm warning.	Ventura	Woolsey
48	Solromar			High potential debris flow channel outlets to PCH. Burned house and apartment complex at outlet. Debris flow deposits observed in channel. Old alluvial fan mapped at outlet. Sediment in small basin at inlet.	debris flow / flood	House, apartment buildings, PCH	multiple	moderate	moderate	Early storm warning, clean basin at PCH	Ventura	Woolsey

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Woolsey - Hill Fires Values at Risk Table

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49	Yellow hill			Residential structures and road within moderate to high potential debris flow channel and below steep slopes. Large rocks on slopes. Few structures burned.	rockfall	Residential structures	home	moderate	moderate	Early storm warning	Ventura	Woolsey
50	Yerba Buena			Houses built below steep fractured outcrops. Boulders and talus observed along slope above houses.	rockfall	Residential structures	home	moderate	moderate	Early warning system	Ventura	Woolsey
51	North Ranch			Lower portion of drainage is constructed concrete that is directed below two houses, outfall of channel is steep and diverted, upper channel is full of sediment, few large rocks observed in headwall of drainage, irrigation French drains along slope	debris flow / flood	Residential structures	home	moderate	moderate	Early warning system	Ventura	Woolsey
52	Thousand oaks			Houses built at outlet of steep drainage, perched rocks observed at headwall, lower house is burned	debris flow / flood	Residential structures	home	moderate	moderate	Early warning system	Ventura	Woolsey
53	Bell Canyon			Homes in flow path of low potential debris flow basin. in the event drainage structure is over whelmed, homes maybe impacted.	debris flow / flood	House	home	moderate	moderate	Early warning system/Diversion structures	Ventura	Woolsey
54	Oak Park			Houses below steep, incised drainage with large boulders. Chain link catch fence damaged and large pile of boulders in channel. Channel enters terrace drain and makes hard turn above houses potential diversion point.	debris flow / flood	Houses	home	moderate	high	Early warning system. Maintain drainage structures.	Ventura	Woolsey
55	Oak Park			Homes in flow path of low potential debris flow basin. in the event drainage structure is over whelmed, homes maybe impacted.	debris flow / flood	Homes	home	moderate	high	Early warning system/ consult with professional for diversion structures.	Ventura	Woolsey
56	Deer Park Road; first crossing	34.063659	-118.9848	Culvert under residential access road is failing and at risk for plugging, mangled car at inlet	debris flow / flood	Deer Canyon Road and 72-inch culvert	multiple	low	low	Clear channel (remove old car above inlet), replace culvert, storm patrol	Ventura	Woolsey
57	Deals Flat	34.104059	-118.9576	Greenhouse at toe of steep channel with some boulders	rockfall	Green house	home	low	moderate	Early warning system.	Ventura	Woolsey
58	Deer Canyon	34.080155	-118.9683	Guest house in channel with diversion running under structure.	debris flow / flood	Guest house	home	low	low	Early warning system. Clean out drain.	Ventura	Woolsey
59	Solromar	34.052359	-118.9554	House built at outlet of high potential debris flow channel. Channel is diverted around house	debris flow	Residential structure	home	low	moderate	Early storm warning. Possible diversion structure/enhancement	Ventura	Woolsey

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60	Yerba Buena	34.099129	-118.9446	House built in axis of swale, large boulders along slope above and in channel. Culvert upslope of the house potential is a plugging hazard.	debris flow / flood	Residential structure	home	low	low	Early warning system, potential diversion structure	Ventura	Woolsey
61	Yerba Buena	34.108202	-118.9473	Evidence of past debris flow in channel neighboring house.	debris flow	House	home	low	moderate	Early warning system.	Ventura	Woolsey
62	Camp Hess Kramer PCH under crossing	34.053776	-118.9642	Locked chain link fence across PCH undercrossing.	debris flow / flood	Bridge and roadway	drainage structure	low	low	Storm patrol, open fence blocking inlet	Ventura	Woolsey
63	West Carlisle Road	34.115166	-118.8955	Residential structures near channel.	flood	Residential structures	home	low	low	Early warning system.	Ventura	Woolsey
64	West Carlisle Road	34.117698	-118.8878	House near channel in floodplain.	flood	House	home	low	moderate	Early warning system.	Ventura	Woolsey
65	West Carlisle	34.12408	-118.8754	House near channel	flood	House	home	low	low	Early warning system.	Ventura	Woolsey
66	North Ranch	34.202715	-118.8204	About 30-inch diameter culvert at back of house. Culvert has grate and potential to plug. House is not much higher than the channel.	debris flow / flood	House	home	low	low	Early warning system. Maintain drainage.	Ventura	Woolsey
67	North Ranch	34.208973	-118.8236	Apartment building at the outlet of 0-20% potential debris flow channel. Culvert is offset. Gradient and confinement of channel lessen approximately 30-feet from apartment building. Building is about 5-feet above channel outlet, no large rocks observed	debris flow	Apartment building	home	low	low	Early warning system	Ventura	Woolsey
68	Bell Canyon	34.21491	-118.7069	Low potential debris flow basin with home in flow path. Catchment may generate flooding.	flood	House	home	low	low	Maintenance to drainage and existing culvert	Ventura	Woolsey
69	Lindero Canyon	34.196498	-118.7835	Large boulder strewn drainage with potential for avulsion and diversion into house adjacent channel. Modeled low-moderate debris flow segment	debris flow / flood	Residence	home	low	moderate	Early warning system. Consider engineered. Structure to protect property.	Ventura	Woolsey
70	Lindero Canyon	34.196756	-118.7812	Culvert drains low hazard catchment into protected culvert with drop drain backup. Some potential for house to west to be impacted if overflows. Some debris in inlet basin.	debris flow / flood	Residence access road.	drainage structure	low	moderate	Clear inlet.	Ventura	Woolsey
71	Lindero Canyon	34.195448	-118.7768	Catch basin too small for expected volume on modeled low-moderate debris flow segment.	debris flow / flood	Access road could be impacted	drainage structure	low	moderate	Consider enlarging basin or engineered solution.	Ventura	Woolsey
72	Lindero Canyon	34.19519	-118.7715	Plugged main culvert above residential area	debris flow / flood	Culvert plugged. Numerous residences	drainage structure	low	moderate	Unplug culvert. Clean out basin. Early warning system	Ventura	Woolsey

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73	North Ranch	34.182711	-118.8241	House built at the outlet of a 20-40% potential debris flow drainage. Small v ditch above house. No rocks on slopes, but thick sediment accumulation in drainage.	debris flow / flood	Residential structure	home	low	low	Early warning system, maintain drainage structures	Ventura	Woolsey
74	North Ranch	34.185143	-118.8261	House built at the outlet of two potential debris flow drainages. Not able to access rear of house to inspect drainage structures. No rocks observed on slopes from distance.	debris flow / flood	Residential structure	home	low	low	Early storm warning, evaluate drainage structures	Ventura	Woolsey
75	North Ranch	34.183657	-118.8249	House built at the outlet of a 20-40% potential debris flow drainage. Small v ditch above house. No rocks on slopes, but thick sediment accumulation in drainage.	debris flow / flood	Residential structure	home	low	low	Early storm warning, maintain drainage structures	Ventura	Woolsey
76	North Ranch	34.181784	-118.8242	House at bottom of steep drainage with V ditch behind fence line. Pool, yard, and garage at back of house.	debris flow / flood	House	home	low	low	Early warning system. Maintain V ditch.	Ventura	Woolsey
77	North Ranch	34.179974	-118.8224	House at bottom of two steep drainages that join. There is about 100 feet of run out with a pool behind the house.	debris flow / flood	House	home	low	low	Early warning system.	Ventura	Woolsey
78	Thousand Oaks	34.174393	-118.8219	Condominium directly at bottom of drainage with V ditch crossing slope. Some small rocky material.	debris flow / flood	Condo	home	low	low	Early warning system. Maintain drainage ditches.	Ventura	Woolsey
79	Thousand Oaks	34.173138	-118.8262	Appears to be a poorly defined earthen recharge basin above the road. Overflow is 10 feet above road. Drainage is larger but low burn. Large stockpiles of rock, sand, and concrete debris upstream. Houses below basin across road.	debris flow / flood	Homes below road.	home	low	low	Remove debris and clean out basin. Consider modifying basin and outflow.	Ventura	Woolsey
80	Thousand Oaks	34.176263	-118.8375	Drainage with a 10% lower slope then about 50 feet of flatter run out. Below that is a church and children's playground. Channel is wide and not defined at the bottom. Soil and rock debris piled in lower channel.	debris flow / flood	Church	business	low	low	Early warning system. Remove debris.	Ventura	Woolsey
81	Thousand oaks	34.183474	-118.8383	Drainage drains directly to house, little rock but potential mudflow	debris flow / flood	Residential structure	home	low	low	Early storm warning, maintain drainages	Ventura	Woolsey
82	Thousand Oaks	34.188128	-118.8353	House near channel with thick deposit of sediment upstream. V ditch drainage channel is choked with debris. Rocky material present in channel.	debris flow / flood	House	home	low	low	Early warning system. Clean drainage.	Ventura	Woolsey

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83	Thousand Oaks	34.203186	-118.8397	Channel drains onto road and could flow over road into home on other side. Outlet terrace is approximately 5-feet above the road.	debris flow / flood	House	home	low	low	Early warning system.	Ventura	Woolsey
84	Thousand Oaks	34.204775	-118.8395	Fifty to one hundred feet of run out at bottom of drainage, but culvert is half filled with sediment. Culvert could overtop affecting homes on other side of road.	flood	House	home	low	low	Clear drainage.	Ventura	Woolsey
85	Lindero Canyon	34.179744	-118.7944	Moderate hazard catchments drain to 42 inch box culvert to 36 inch culvert. Swing gate inlet protection. Potential for clogging and impacting house downslope. Modeled low and moderate	debris flow / flood	Residence	drainage structure	low	moderate	Early warning system. Consider engineer evaluation of structure size to drainage size.	Ventura	Woolsey
86	Bell Canyon	34.209229	-118.6789	House is in flood path of un-modeled basin. Runoff pattern shown in photos are reportedly from fire suppression activities.	debris flow / flood	House in risk of debris flow	home	low	moderate	Early warning system, maintain drainage.	Ventura	Woolsey
87	Bell Canyon	34.20286	-118.674	Park is in flow path of moderate debris flow basin, adjacent to Bell Creek, and in FEMA flood zone.	debris flow / flood	Park	recreational	low	moderate	Early warning system, and park closure.	Ventura	Woolsey
88	Oak Park	34.192715	-118.7707	Drainage directed to house but not able to access to inspect closer.	debris flow / flood	House	home	low	low	Early warning system, additional evaluation necessary.	Ventura	Woolsey
89	North Ranch	34.168464	-118.8075	House built at toe of steep slope. V-ditch which crosses slope is full of soil and debris. Potential for mud flow.	debris flow / flood	Home	home	low	low	Early warning system. Maintain drains and drain inlets on property and neighboring uphill property.	Ventura	Woolsey
90	North Ranch	34.178543	-118.8024	Steep drainage behind house. Drainage v-ditch runs to drop inlet. Potential for plugging.	debris flow / flood	Home	home	low	low	Early warning system. Maintain drainage structures.	Ventura	Woolsey
91	North Ranch	34.183952	-118.8056	Three steep drainages with small rocks upslope of house. Toe of slope is approximately 25-feet from house. Pool. Sediment laden flow observed at fence approximately 75-feet upslope of toe of slope. Sediment observed in cross slope v-ditches.	debris flow / flood	Home	home	low	low	Early warning system. Maintain clean v-drains	Ventura	Woolsey
92	Lindero Canyon	34.187712	-118.8007	House at outlet of steep drainage. Existing 24-inch culvert. Lower slope recently hydro-seeded.	debris flow / flood	Home	home	low	low	Early warning system. Maintain drainage structures	Ventura	Woolsey
93	Lindero Canyon	34.184523	-118.792	Short drainage directed to house. House is built into toe of drainage. No drainage structure.	debris flow / flood	Home	home	low	low	Early warning system.	Ventura	Woolsey

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94	Lindero Canyon	34.181351	-118.7932	House at toe of approximately 8-acre drainage. House is built into the toe of slope. Unable to access what appears to be small drainage structure (culvert?) outside property fence. V-ditch along property line upslope of residence.	debris flow / flood	Home	home	low	low	Early warning system. Maintain drainage structures	Ventura	Woolsey
95	Bell Canyon	34.203325	-118.6721	Storage area may be under mined during high flow events along un-protected fill slope. Storage pad is about 15 ft up slope of flood plain, flood plain is about 50 to 75 ft wide.	flood	Storage facility	utilities	low	moderate	Consult with professionals for engineering mitigation.	Ventura	Woolsey
96	Oak Park Community Park	34.186208	-118.7704	Drainage structure partially plugged with sediment.	debris flow / flood	Public park	recreational	low	moderate	Maintain drainage structures.	Ventura	Woolsey
97	Oak Park	34.178207	-118.7704	Home in flow path of un-modeled basin. in the event existing diversion structures get overwhelmed, home maybe impacted.	debris flow / flood	House	home	low	moderate	Early warning system/ consult professionals for diversion structures	Ventura	Woolsey
98	Lindero Canyon - Upper North Ranch	34.197467	-118.788	Reports of culvert clogging and over flowing road by B Swanson with flood impacts to house. Which house affected not identified but likely down Smokey Ridge Avenue to north.	debris flow / flood	Residential access road and homes	multiple	low	moderate	Early warning system. Consider investigation to reduce clogging and diversion potential.	Ventura	Woolsey
99	Lindero Canyon - Upper North Ranch	34.196665	-118.7814	Potential for flooding and debris flow impacts if culvert basin to east fails.	debris flow / flood	Residence	home	low	moderate	Evaluate potential impacts and consider engineered solution	Ventura	Woolsey
100	Oak Canyon Community Park	34.184963	-118.771	Park in flow path of high and low potential debris flow basins and adjacent to Medea Creek. Park may flood during storm events.	debris flow / flood	Public park	recreational	low	moderate	Park closures, storm patrol.	Ventura	Woolsey
101	Point Mugu State Park			Campground and three structures in FEMA floodplain.	flood	Campground	recreational	low	low	Early warning system.	Ventura	Woolsey
102	Yerba Buena			Rockfall hazard along Yerba Buena Road.	rockfall	Yerba Buena Road	other	low	low	Storm patrol, signage	Ventura	Woolsey
103	North Ranch			Homes in smaller channel with low burn and no rocks. Potential for mud flow.	flood	Homes	home	low	low	Early warning system.	Ventura	Woolsey
104	Lindero Canyon			Residences adjacent modeled low debris flow catchment with potential to avulsion into backyard.	debris flow / flood	Residences and improvements	home	low	moderate	Early warning system	Ventura	Woolsey
105	Morrison Tract			Flood, DF into 2 homes	debris flow / flood	2 residential structures	home	low	moderate	Early warning system. Clean out V drains	Ventura	Woolsey

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Woolsey - Hill Fires Values at Risk Table

Site	Community / Local area	Latitude	Longitude	Potential hazard / Field observation	Hazard Category	Specific at-risk feature	Feature Category	Potential hazard to life	Potential hazard to property	Preliminary EMP	County	Fire
106	Thousand Oaks			Condos at bottom of small steep slope with rocky material up to a foot in diameter. About 30 feet of run out. Resident reported history of post-fire mudflow into structures but no issues with rockfalls.	debris flow	Condos	home	low	moderate	Early warning system.	Ventura	Woolsey
107	Thousand Oaks			Houses directly at bottom of channel with multiple V ditches converging into narrow ally between homes. Resident reported mud deposits in the past. Drainage area is small.	debris flow / flood	Houses	home	low	low	Early warning system.	Ventura	Woolsey
108	Bell Canyon			Home and barn in flow path of low potential debris flow basin.	debris flow / flood	House and barn	home	low	moderate	Early warning system/Diversion structures	Ventura	Woolsey
109	Bell Canyon			Segment of road crosses multiple low potential debris flow basins, some without crossing structures.	debris flow / flood	Primary access road	utilities	low	moderate	Road maintenance / storm patrol	Ventura	Woolsey
110	Oak Park			Two steep drainages point to back of houses. Not able to access to inspect closer.	debris flow / flood	Houses	home	low	low	Early warning system.	Ventura	Woolsey
111	Oak Park			Houses located below steep, burned slopes. Runoff enters terrace drain and makes hard left to debris basin approximately 300 to east	debris flow / flood	Houses	home	low	moderate	Early warning system. Maintain drainage system.	Ventura	Woolsey
112	Oak Park			Homes in flow path of low potential debris flow basin. in the event drainage structure is over whelmed, homes maybe impacted.	debris flow / flood	Homes / community.	home	low	moderate	Early warning system/ consult with professional for diversion structures.	Ventura	Woolsey
113	Alizia Canyon			Condos below steep natural slopes with low burn severity. Increased potential for shallow surficial failures and excess runoff.	debris flow / flood	Condos	home	low	low	Early warning system.	Ventura	Woolsey
114	Bell Canyon	34.202797	-118.6998	Home is in path of low potential debris flow basin, 45% slope. Rockfall hazard. House is protected by flat area and small drainage structures that can become inundated.	debris flow / flood	House	home	no	low	Early warning system, maintenance of diversion structures.	Ventura	Woolsey
115	Lindero Canyon	34.176858	-118.7926	Culvert under house draining un-modeled catchment partially clogged with debris. Drainage has no large boulders and is mostly pebble rock chips and silt.	flood	Residence backyard	drainage structure	no	low	Clean culvert and slope drains.	Ventura	Woolsey
116	Bell Canyon	34.207853	-118.6816	Culvert draining low potential debris flow basin may clog causing street flooding.	debris flow / flood	Street/access	utilities	no	moderate	Culvert and road maintenance, storm petrol.	Ventura	Woolsey

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Woolsey - Hill Fires Values at Risk Table

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117	Bell Canyon	34.20065	-118.6945	House is adjacent to flow path of low potential debris flow basin.	debris flow / flood	House	home	no	low	Early warning system, consult with professional for diversion structures.	Ventura	Woolsey
118	Thousand Oaks, Chumash Indian Museum	34.212553	-118.8147	Museum buildings below burned drainage. Mitigation measures in place including channel clearing and k rails	flood	Museum	recreational	no	low	Early Warning System, Professional Consultation	Ventura	Woolsey
119	Oak Park	34.191253	-118.7547	House located where long, steep terrace drain intersects main drain at 90 angle	flood	House	home	no	moderate	Early Warning System, Professional Consultation	Ventura	Woolsey
120	Oak Park	34.219727	-118.8213	House below partially clogged 18" culvert which could overtop and impact house	flood	Home	home	no	moderate	Early Warning System, Professional Consultation, Maintain Existing Drainage	Ventura	Woolsey
121	Oak Park	34.190526	-118.7622	House located below steep, burned drainage with lots of looses rock	debris flow / flood	House	home	no	low	Early Warning System, Professional Consultation	Ventura	Woolsey
122	Oak Park Community	34.176904	-118.7692	Home in flow path of un-modeled basin. in the event existing diversion structures get overwhelmed, home maybe impacted.	flood	House	home	no	low	Early warning system/ consult professionals for diversion structures	Ventura	Woolsey
123	Similar valley. Coyote hills park	34.241842	-118.7921	Debris basin does not appear large enough for model estimate of 247 cu m debris. Flooding potential from clogging of small inlet structure with mud and woody debris. Some cobbles and scattered small boulders observed in drainage.	debris flow / flood	Flooding of park	recreational	no	low	Maintain drainage Structure	Ventura	Woolsey
124	Bell Canyon			Homes in flow path of low potential debris flow basin. in the event drainage structure is over whelmed, homes maybe impacted.	flood	Homes	home	no	low	Early warning system/Consult with professional for diversion structures	Ventura	Woolsey
125	Thousand Oaks			Homes and park below steep, burned hill-slope. Sediment build-up in contour drain system is reducing capacity and increasing the chance of plugging. A double metal debris fence is situated above the terrace drain system.	flood	Homes/Park	multiple	no	moderate	Maintain contour drain system.	Ventura	Woolsey
126	Challenger Park, Simi Valley			Large burned watershed drains to park.	flood	Park infrastructure	recreational	no	low	Early warning system.	Ventura	Woolsey
127	The Oaks			Houses located below burned drainage with culvert inlet within backyard.	flood	Houses, backyard tennis court.	home	no	low	Maintain drainage system.	Ventura	Woolsey
128	The Vineyard			House located below un-modeled, low severity burned drainage.	flood	House and pool house	home	no	low	Maintain drainage system.	Ventura	Woolsey

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Woolsey - Hill Fires Values at Risk Table

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129	Oak Park			Two houses located below burned drainage with drop culvert that has plugged and overflowed in past according to landowner.	flood	Houses	home	no	moderate	Maintain culvert.	Ventura	Woolsey
130	Bell Canyon			Homes are constructed in channel. Channel routed through properties via culverts and open channels. Past flooding confirmed by a resident.	flood	Homes	home	no	low	Early warning system/ consult with professional for diversion structures.	Ventura	Woolsey
Los Angeles - Woolsey Fire												
131	Trancas Canyon	34.037362	-118.8402	Debris basin with potential for plugging and overflow to residential neighborhood.	debris flow / flood	Residential neighborhood	home	high	high	Early warning, Maintain debris basin structure	Los Angeles	Woolsey
132	Trancas Canyon	34.034274	-118.84	Debris basin with potential for plugging and overflow to residential neighborhood. Lower debris basin partially full and both with burnt boards compromising strength of structure.	debris flow / flood	Residential neighborhood	home	high	high	Early warning, maintain debris basin and replace damaged fence boards	Los Angeles	Woolsey
133	Trancas Canyon	34.041299	-118.8405	Debris basin with potential for plugging and overflow to residential neighborhood.	debris flow / flood	Residential neighborhood	home	high	high	Early warning system, maintain debris basin	Los Angeles	Woolsey
134	Trancas Canyon	34.042263	-118.8447	Debris basin with potential for plugging and overflow to residential neighborhood.	debris flow / flood	Houses, debris basin	home	high	high	Early warning system, maintain debris basin	Los Angeles	Woolsey
135	Malibu	34.040363	-118.8681	House in floodplain and in path of moderate potential debris flow channel.	debris flow / flood	House	home	high	high	Early warning system.	Los Angeles	Woolsey
136	Malibu	34.033601	-118.7343	Potential for bridge with center abutment to clog with woody debris and flood PCH and trailhead parking lot west of creek.	flood	Vehicles on highway	drainage structure	high	high	Storm patrol to maintain drainage under bridge. Close trailhead parking lot prior to storm.	Los Angeles	Woolsey
137	Ramirez Canyon	34.035045	-118.7944	House on low surface adjacent moderate hazard debris flow catchment.	debris flow / flood	Residence	home	high	high	Early warning system	Los Angeles	Woolsey
138	Escondido	34.052181	-118.7759	Burnt House at mouth of moderate debris flow hazard	debris flow / flood	Residence	home	high	high	Early warning system	Los Angeles	Woolsey
139	Vera Canyon	34.083906	-118.8226	Residential structure in flow path of modeled moderate debris flow segment	debris flow / flood	Residential structure	home	high	high	Early warning system	Los Angeles	Woolsey
140	Newton Canyon	34.077708	-118.8101	Winery tasting room in debris flow path of high debris flow potential catchment.	debris flow / flood	Winery tasting room.	business	high	high	Early warning system	Los Angeles	Woolsey
141	Newton Canyon	34.081313	-118.8036	Residence in flow path of high debris flow potential catchment. Evidence of past debris flow observed. Drain paths routed around structure.	debris flow / flood	Residential structure.	home	high	high	Early warning system	Los Angeles	Woolsey

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Woolsey - Hill Fires Values at Risk Table

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142	Newton Canyon	34.080532	-118.8024	Burnt residence in flood plain of high debris flow potential stream.	debris flow / flood	Residence	home	high	high	Early warning system	Los Angeles	Woolsey
143	Newton Canyon Road	34.067498	-118.7858	House and structures in debris flow path. Modeled high debris flow segment	debris flow / flood	House	home	high	high	Early warning system	Los Angeles	Woolsey
144	McReynolds Road	34.075858	-118.7837	Trailer residence in modeled high debris flow segment	debris flow / flood	House	home	high	high	Early warning system	Los Angeles	Woolsey
145	Brewster Mtwy	34.095334	-118.8068	House, shed, and barn.	debris flow / flood	House	home	high	high	Early warning system	Los Angeles	Woolsey
146	Paramount Ranch Estates	34.129024	-118.7435	House at base of convergent drainage with steep slopes. Loose soil and cobbles above v-ditch and chain link fence mid slope	debris flow	Residential structure	home	high	high	Early warning system	Los Angeles	Woolsey
147	Paramount Ranch Estates	34.130668	-118.7441	Burned house at bottom of convergent drainage with steep slopes. No access to house. Viewed from slopes above house	debris flow	Residential structure	home	high	high	Early warning system if rebuilt	Los Angeles	Woolsey
148	Malibu	34.084366	-118.9184	House located on floodplain at confluence of two channels with potential for debris flows	debris flow / flood	Home	home	high	high	Early Warning System	Los Angeles	Woolsey
149	Liberty Canyon	34.12963	-118.7207	Potential debris flow hazard to house from steep convergent natural drainage with cobbles and small boulders in flow line. Engineered drainage devices divert surface runoff around house but no debris catchment or storage capacity.	debris flow	Residential structure	home	high	high	Early warning system	Los Angeles	Woolsey
150	Agoura	34.138896	-118.7433	House below catchment area with cobbles and boulders up to 1.5m, which drains to catch basin with 24 inch CMP. Model indicates low potential for debris flow. Basin does not appear adequate to contain model estimated volume. History of flooding at site.	debris flow / flood	House	home	high	high	Early warning system. Maintain drainage culvert	Los Angeles	Woolsey
151	Agoura Hills	34.167098	-118.7766	Home in flow path of un-modeled basin. In the event existing diversion structures get overwhelmed, home maybe impacted.	debris flow / flood	House	home	high	high	Early warning system/ consult professionals for diversion structures	Los Angeles	Woolsey
152	Malibu			Houses built in floodplain	debris flow / flood	Houses	home	high	high	Early warning	Los Angeles	Woolsey

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Woolsey - Hill Fires Values at Risk Table

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153	Foose Road			Three unburned homes and accessory out-buildings located in flood plain below moderately burned catchment area.	debris flow / flood	Three houses	home	high	high	Early Warning System	Los Angeles	Woolsey
154	Trancas Canyon			Debris flow/Mudflow/Flooding if debris basin capacity at top of canyon is exceeded.	debris flow / flood	Housing Tract	home	high	high	Early Warning System	Los Angeles	Woolsey
155	Ramirez Canyon			Residences in delineated floodplain on flow path with high debris flow potential.	debris flow / flood	Residential structures	home	high	high	Early warning system	Los Angeles	Woolsey
156	Malibu Creek			Steep drainages with large boulders up to 3m. Model indicates high debris flow hazard potential.	debris flow	Camp facilities and guest cabins.	multiple	high	high	Early warning system.	Los Angeles	Woolsey
157	Malibu Creek			Steep drainages with large boulders up to 3m. Model indicates moderate debris flow hazard potential.	debris flow	Camp facilities and guest lodging.	multiple	high	high	Early warning system.	Los Angeles	Woolsey
158	Malibu Creek			Daylighted joints / bedding on cliffs above structures and large boulders up to 4m on slopes. Steep drainages with large boulders up to 3m. Model indicates high debris flow hazard potential.	other	Camp facilities and lodging.	multiple	high	high	Early warning system.	Los Angeles	Woolsey
159	Stokes Canyon			Residential trailers and horse stables in path of moderate potential debris flow model segment. Boulders up to 1.5m in drainage.	debris flow	Two trailers and horse stables	multiple	high	moderate	Early warning system. Move residential trailers away from drainage.	Los Angeles	Woolsey
160	Stokes canyon			Boulders up to 1m observed in drainage. Model indicates moderate debris flow hazard potential.	debris flow	Homes and shipping containers	home	high	high	Early warning system.	Los Angeles	Woolsey
161	Escondido Canyon			Residential structures in delineated floodplain and in flow path of moderate debris flow segments.	debris flow / flood	Residential structures	home	high	high	Early warning system	Los Angeles	Woolsey
162	Cornell/Triunfo Canyon			Debris flow potential exists proximal to alluvial fan deposition on south side of Malibu Creek.	debris flow	Houses	home	high	high	Early Warning System	Los Angeles	Woolsey
163	Seminole Springs			Mobile home community is at risk for flooding and potential debris flows if earthen dam is overtopped; President of community concerned as lake has nearly overtopped during past large storm events. Lake is almost full of sediment.	flood	Houses	home	high	high	Early Warning System, improve capacity of lake with dredging	Los Angeles	Woolsey
164	Upper Escondido Canyon (above falls)			Residential structures at risk of flood and in path of potential high debris flow segment.	debris flow / flood	Residential structures	home	high	high	Early warning system	Los Angeles	Woolsey

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165	CalAmigos			Structures in potential flooding area.	debris flow / flood	Homes/ residential	home	high	high	Early warning system	Los Angeles	Woolsey
166	Newton Canyon Road and Latigo Canyon Road			House and structures in high debris flow potential debris flow path.	debris flow / flood	House	home	high	high	Early warning system	Los Angeles	Woolsey
167	McReynolds Road			Trailer residences (3 trailers) in modeled high debris flow segment	debris flow / flood	Trailers	home	high	high	Early warning system	Los Angeles	Woolsey
168	Paramount Ranch Estates			Residential property	debris flow / flood	House	home	high	high	Early warning system	Los Angeles	Woolsey
169	Malibou Lake			Steep slopes above burned and unburned residential structures.	debris flow	Residential structures	home	high	high	Early warning system	Los Angeles	Woolsey
170	Malibu			Road located in floodplain below large burned drainages with high potential for debris and flooding	debris flow / flood	Road, cars	other	high	high	Early Warning System, Signage	Los Angeles	Woolsey
171	Malibou Lake			Houses at mouth of high modeled debris flow catchments.	debris flow / flood	Houses	home	high	high	Early warning	Los Angeles	Woolsey
172	Liberty Canyon			Steep convergent drainage with cobbles and boulders. Model indicates moderate potential for debris flow hazard, and existing catch basin does not appear adequate for estimated volume.	debris flow	Residential structures	home	high	high	Early warning system	Los Angeles	Woolsey
173	Agoura			Houses below steep slope with many cobble and boulders up to 1.5 m on slope and in drainage. Fill placed for drainage pipes of dirt roads with very small culverts and 18 in steel pipes. History of flooding on site.	debris flow	Residential structures	home	high	high	Early warning system. maintain small culverts for dirt roads on slope	Los Angeles	Woolsey
174	Point Dume	34.029505	-118.8234	Home in and or adjacent to high debris flow potential stream. Berm along right bank of flow path appear degraded but marginally adequate. Extensive sand bags across driveway and yard suggest prior flooding issues. Drains/channel along house are too small	debris flow / flood	Home	home	moderate	high	Consult with professional for flooding analysis.	Los Angeles	Woolsey
175	Point Dume	34.02242	-118.8167	Low water crossing on FEMA flood stream	flood	Public road	drainage structure	moderate	low	Signage.	Los Angeles	Woolsey
176	Point Dume	34.029784	-118.8088	Trailer at mouth of low debris flow potential flow path.	debris flow / flood	Structure	home	moderate	moderate	Move trailer	Los Angeles	Woolsey

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177	Kanan-Dume Rd	34.050347	-118.7986	Debris partially clogging culvert under highway	debris flow / flood	Highway	drainage structure	moderate	moderate	Clean out. Protect inlet	Los Angeles	Woolsey
178	Kanan-Dume Road	34.068819	-118.8119	Partially clogged culvert under highway. Grading adjacent culvert could direct flow on to highway.	debris flow / flood	Culvert. Under major access road.	drainage structure	moderate	moderate	Clear out culvert and correct grading directing flow onto roadway	Los Angeles	Woolsey
179	Ramirez Canyon	34.033486	-118.7913	Residence in low modeled debris flow path with undersized catchment basin for expected volume.	debris flow / flood	residence	home	moderate	moderate	Early warning system	Los Angeles	Woolsey
180	Escondido Beach	34.03279	-118.7626	House built in flow path of low debris flow hazard catchment with history of mud flows per owner interview. Driveway is designed flow path to creek. rockfall potential from surrounding slopes. Boulder currently blocks sidewalk/flow path around house.	debris flow / flood	Residences	home	moderate	high	Early warning system	Los Angeles	Woolsey
181	Latigo Canyon Road	34.034567	-118.757	House in modeled floodplain. Not visited but observed through heavy brush and on lidar topography.	debris flow / flood	Residence	home	moderate	moderate	Early warning system	Los Angeles	Woolsey
182	Escondido	34.047654	-118.7767	Home not mapped in flood zone on low terrace adjacent Escondido Creek. Modeled high debris flow segment	debris flow / flood	Residence	home	moderate	moderate	Early warning system	Los Angeles	Woolsey
183	Escondido	34.05309	-118.7783	Burnt House at confluence of modeled debris flow hazard. Cinder block wall deflection appears enlarged recently.	debris flow / flood	Residence and outbuildings	home	moderate	moderate	Early warning system	Los Angeles	Woolsey
184	Malibu canyon	34.068842	-118.7085	Potential for debris flow onto highway. Model indicates high debris flow potential from steep drainage with large boulders. Existing small deflection berm inadequate to capture and divert debris to small downstream catch basin.	debris flow	vehicles on road	other	moderate	moderate	Storm patrol. Review by CalTrans.	Los Angeles	Woolsey
185	Stokes canyon	34.11099	-118.6943	New home constructed near path of unmodeled drainage with cobbles and small boulders.	debris flow	New home	home	moderate	moderate	Early warning system.	Los Angeles	Woolsey
186	Agoura Hills	34.130629	-118.7655	Home adjacent to unmodeled channel with steep slopes and large rocks. Small debris basin below house at risk of overtopping and flooding house.	debris flow / flood	Home	home	moderate	high	Early warning system. Consult with professional to asses adequacy of debris basin.	Los Angeles	Woolsey
187	Lower Malibu Creek	34.046089	-118.6862	Flood hazard. Unable to verify directly. Observed from road.	flood	Residential structure	home	moderate	high	Early warning system.	Los Angeles	Woolsey

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188	Filbert Road	34.094241	-118.8205	Trailer, chemical storage and water tanks in flood and modeled low-moderate debris flow area	debris flow / flood	Trailer. H2O tanks and chemical storage	multiple	moderate	high	Move trailer. Early warning system. Move tanks	Los Angeles	Woolsey
189	CalAmigos	34.089161	-118.8163	Structure in line of potential debris flow.	debris flow / flood	Structure - outbuilding/office	home	moderate	high	Early warning system	Los Angeles	Woolsey
190	Newton Canyon	34.080632	-118.8032	Garage in flood plain of high debris flow potential stream.	debris flow / flood	Garage structure.	home	moderate	high	Early warning system	Los Angeles	Woolsey
191	McReynolds Road	34.075788	-118.7812	Unknown structures in path of modeled moderate debris flow segment	debris flow	Potential structures	other	moderate	high	Early warning system	Los Angeles	Woolsey
192	Malibu Creek State Park	34.108685	-118.7456	Burned structure. Model indicates high debris flow hazard potential if structure rebuilt or material staged at this location.	debris flow	Staged equipment	other	moderate	moderate	Early warning system. Do not rebuild structure at this location	Los Angeles	Woolsey
193	Malibou Lake	34.121948	-118.7495	House at base of convergent slopes.	debris flow	Residential structure	home	moderate	moderate	Early warning system.	Los Angeles	Woolsey
194	Paramount Ranch Estates	34.130554	-118.746	House at base of convergent drainage with steep slopes.	debris flow	Residential structure	home	moderate	moderate	Early warning system	Los Angeles	Woolsey
195	Malibou Lake	34.136357	-118.7549	House in bottom of convergent drainage. Cobbles and boulders up to 1.5 m in bottom of drainage. Model indicates low debris flow hazard potential.	debris flow	Residential structure	home	moderate	moderate	Early warning	Los Angeles	Woolsey
196	Lobo Canyon	34.122766	-118.7991	House located below steep, burned drainage with large boulders	debris flow	House	home	moderate	moderate	Early Warning System, Professional Consultation	Los Angeles	Woolsey
197	Lobo Canyon	34.122582	-118.7995	House located below steep, burned drainage with large boulders	debris flow	House	home	moderate	moderate	Early Warning System, Professional Consultation	Los Angeles	Woolsey
198	Lobo Canyon	34.123614	-118.8013	House below unstable, burned slopes. Lots of large boulders in channel and catch fence along two drainages above home. Fence partially replaced and damaged and terrace drain above house completely full of sediment	rockfall	House	home	moderate	high	Early warning	Los Angeles	Woolsey
199	Malibou Lake	34.108793	-118.7624	Drainage day lighted in cut slope with no structure. Potential to deliver debris and water to road.	rockfall	Major access road.	other	moderate	moderate	Storm patrol	Los Angeles	Woolsey
200	Malibou Lake	34.110356	-118.765	House at mouth of un-modeled catchment. Permitted and Engineered drainage around house.	debris flow / flood	Residence	home	moderate	moderate	Early warning system.	Los Angeles	Woolsey
201	Malibou Lake	34.102915	-118.757	Rockfall onto residence. A road crosses upslope of house reducing potential.	rockfall	Residence	home	moderate	moderate	Consider engineered deflection structures.	Los Angeles	Woolsey
202	Malibou Lake	34.103244	-118.7551	Burnt House built across mouth of small unmodeled catchment.	debris flow / flood	Residence	home	moderate	high	Consider relocating house when rebuilding or engineered structure.	Los Angeles	Woolsey

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Woolsey - Hill Fires Values at Risk Table

Site	Community / Local area	Latitude	Longitude	Potential hazard / Field observation	Hazard Category	Specific at-risk feature	Feature Category	Potential hazard to life	Potential hazard to property	Preliminary EMP	County	Fire
203	Lobo Canyon	34.112745	-118.8201	Burned out house located at confluence of multiple burned drainages. Engineered channels, bridges and low water crossings severely constrict channel and cutoff access road	debris flow / flood	House	home	moderate	moderate	Early Warning System	Los Angeles	Woolsey
204	Malibu	34.080578	-118.9214	Burned houses and outbuildings located in floodplain of large burned drainages	flood	House	home	moderate	moderate	Early Warning System	Los Angeles	Woolsey
205	Agoura	34.138085	-118.7326	Potential debris flow hazard to house across street from steep unmodeled convergent drainage with cobbles and small boulders.	debris flow	House. Cars parked on street	home	moderate	moderate	K rail placement along street to deflect potential debris and mud	Los Angeles	Woolsey
206	Agoura	34.138464	-118.7355	House with pool below steep natural drainage. Model indicates low potential for debris flow hazard. Cath basin appears too small for model estimated volume.	debris flow	Residential structure and pool	home	moderate	moderate	Early warning system. Maintain catch basin.	Los Angeles	Woolsey
207	Agoura	34.139139	-118.7369	House below steep convergent natural slope and graded slope which drains toward backyard. Limited access and view of slopes.	debris flow	Residential structure	home	moderate	moderate	Early warning system. Maintain slope drains	Los Angeles	Woolsey
208	Lindero Canyon	34.160475	-118.7947	House at toe of alluvial fan. Fan is located at mouth of steep drainage with rock/debris. Existing 4-foot diameter box culvert upslope of house. Fan surface is inclined at approximately 10-degrees.	debris flow / flood	Home	home	moderate	moderate	Early warning system.	Los Angeles	Woolsey
209	Oak Park	34.164846	-118.7852	House at the outlet of short steep drainage. Outcrop at top of slope and perched boulders in drainage. No drainage structure observed. Small dirt road observed mid-slope.	debris flow / flood	Home	home	moderate	moderate	Early warning system.	Los Angeles	Woolsey
210	Malibou Lake			100 year FEMA floodplain. Mostly unverified in field - long history of flooding with annual dredging of the very shallow lake according to resident Director of HOA	flood	Flood of multiple homes	home	moderate	high	Increase storage capacity of lake. Consult with professional to evaluate contamination hazards. Early warning system	Los Angeles	Woolsey
211	Point Dume			Structures in flow path of high probability debris flow path. Flow paths uncertain and channel appears to get smaller down slope. It is possible some drainage collected in drains and piped downslope. Current channel appears undersized for basin size.	debris flow / flood	Home, structures, fence across stream	home	moderate	moderate	Clear fences from channel. Consider engineered deflection structures or catchment basin design. Consider investigating flow path through subdivision and increasing channel capacity.	Los Angeles	Woolsey

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Woolsey - Hill Fires Values at Risk Table

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212	Point Dume			Burnt House cut into fan at mouth of high debris flow modeled Stream. Channel diverted around house pad by wall and drained into channel to south. Swimming pool would act as basin if flow overtops wall.	debris flow / flood	Home, burnt	home	moderate	moderate	Consider hiring geotechnical to evaluate adequacy of deflection structures.	Los Angeles	Woolsey
213	Kanan-Dume Rd			Area of potential rockfall on highway with narrow road margin.	rockfall	Highway	other	moderate	low	Geotechnical/CEG evaluate rockfall potential and design adequate road margin or catchment wall.	Los Angeles	Woolsey
214	Kanan-Dume Rd			Area of potential rockfall on highway with narrow road margin.	rockfall	Highway	other	moderate	low	Geotechnical/CEG evaluate rockfall potential and design adequate road margin or catchment wall.	Los Angeles	Woolsey
215	Kanan-Dume Rd			Area of potential rockfall on highway with narrow road margin.	rockfall	Highway	other	moderate	low	Geotechnical/CEG evaluate rockfall potential and design adequate road margin or catchment wall.	Los Angeles	Woolsey
216	Decker School			Houses located in floodplain below burned area are at risk for mudflow and flooding.	flood	Houses	home	moderate	moderate	Early Warning System	Los Angeles	Woolsey
217	Pepperdine University			Parking lot in flow path. Model indicates moderate potential for debris flow hazard. small debris trap with potential for plugging and overflow.	debris flow / flood	Parked cars	other	moderate	moderate	Early warning system. Cone off parking lot or deflect flow with K-rail. Storm patrol to maintain small debris trap.	Los Angeles	Woolsey
218	Puerco Canyon			Potential debris flow hazard to hikers, bikers, horseback riders during storms. Structures are old abandoned sheds/ shade structures.	debris flow	People in state park	recreational	moderate	no	Close park or post hazard to recreational use prior to storms	Los Angeles	Woolsey
219	Point Dume			Structures in modeled floodplain.	flood	Residential structures	home	moderate	high	Early warning system	Los Angeles	Woolsey
220	Ramirez Canyon			No Access. Residential structures on high debris flow potential flow path at risk of flooding, debris flow and rockfall hazards. Viewed from Kanan-Dume Rd. and using Lidar topography.	debris flow / flood	Residences and outbuildings	home	moderate	moderate	Have professional evaluate on site. Early warning system.	Los Angeles	Woolsey
221	Paradise Cove			Trailer homes in delineated flood zone. Resident of 41 years said it used to flood a lot until they paved creek and increased conveyance. Floodwall along low bank protecting trailer park is failing. Restaurant and parking lot are at risk of diverted flow	flood	Residences	home	moderate	high	Early warning system	Los Angeles	Woolsey
222	Oak Forest Estates			Nearly full debris basin with burned boards. Active channel above carrying 12”+ boulders. Houses exist below.	debris flow / flood	Houses	home	moderate	moderate	Early Warning System, clean out debris basin	Los Angeles	Woolsey

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Woolsey - Hill Fires Values at Risk Table

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223	Oak Forest Estates			Potential debris flow/mudflow/flooding may damage and/or exceed existing debris basin which is damaged and partially full (~60%). Houses exist below.	debris flow / flood	1-5 Houses	home	moderate	moderate	Early Warning System, clean out and repair debris basin	Los Angeles	Woolsey
224	Stokes Canyon			Boulders up to 1.5m observed in drainage and on fan. Model indicates moderate debris flow hazard potential.	debris flow	Homes	home	moderate	moderate	Early warning system.	Los Angeles	Woolsey
225	Stokes Canyon			Boulders up to 2m observed in drainage and on fan. Culvert north of Stokes Canyon Road has debris rack but could clog with woody debris and flood property and road. Model indicates moderate debris flow hazard potential.	debris flow / flood	Home	home	moderate	moderate	Early warning system.	Los Angeles	Woolsey
226	Lower Malibu Creek			Flood hazard adjacent to Malibu Creek. Resident indicated previous flooding at base of houses.	flood	Residential structures	home	moderate	high	Early warning system.	Los Angeles	Woolsey
227	Malibu Creek State Park			Potential for debris flow and flooding of state park facility/ housing (if rebuilt). Model indicates moderate debris flow hazard potential.	debris flow / flood	Residential structure and garages	home	moderate	moderate	Early warning system.	Los Angeles	Woolsey
228	Paramount Ranch Estates			Houses below steep burned slopes.	debris flow	Residential structures	home	moderate	moderate	Early warning system	Los Angeles	Woolsey
229	Paramount Ranch Estates			Houses below steep burned slopes.	debris flow	Homes	home	moderate	moderate	Early warning system	Los Angeles	Woolsey
230	Triunfo Canyon/Lobo Canyon			Houses and businesses located in floodplain at risk for flooding.	flood	House, businesses	business	moderate	moderate	Early Warning System.	Los Angeles	Woolsey
231	Lobo Canyon			Barn and house located beneath steep burned drainage with very large boulders.	rockfall	Barn, house	home	moderate	moderate	Early Warning System.	Los Angeles	Woolsey
232	Malibu			Road below steep, unstable slopes	rockfall	Road, cars	other	moderate	moderate	Signage, Professional Consultation	Los Angeles	Woolsey
233	Malibu, Shalom Institute			Flooding of burned and unburned buildings located in floodplain below burned area	debris flow / flood	Buildings	business	moderate	moderate	Early Warning System	Los Angeles	Woolsey
234	Cornell			Potential rockfall from oversteepened road cuts.	rockfall	Cars	other	moderate	low	Storm Patrol	Los Angeles	Woolsey
235	Westlake Hills			Houses near channel in gated community. Unable to access to verify degree of risk. Evaluation included review of lidar.	debris flow / flood	Houses	home	moderate	moderate	Early warning system. Further evaluation necessary.	Los Angeles	Woolsey
236	Malibou Lake			Houses in flow path of moderate hazard catchment.	debris flow / flood	Residences and outbuildings	home	moderate	moderate	Early warning system.	Los Angeles	Woolsey

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Woolsey - Hill Fires Values at Risk Table

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237	Malibou Lake			Houses at mouth of high modeled debris flow catchments.	debris flow / flood	Houses	home	moderate	moderate	Early warning	Los Angeles	Woolsey
238	West Carlisle			Residence and barn in lower area near channel. Bridges form choke points. Resident reported past issues with debris.	debris flow / flood	Residence and barn	home	moderate	moderate	Early warning system.	Los Angeles	Woolsey
239	Westlake Hills			Homes directly below the bottom of small steep drainage with up to 2 foot diameter boulders. 1 foot diameter culvert could get plugged. AC unit in diversion around house is potential choke point..	debris flow / flood	Homes	home	moderate	moderate	Early warning system.	Los Angeles	Woolsey
240	Liberty Canyon			Steep convergent drainage and outflow to street with no catch basin or storage capacity. Model indicates moderate potential for debris flow, which would flow into street and potentially affect houses.	debris flow / flood	Road and houses	home	moderate	moderate	Early warning. Replace existing eroded sand bags in drainage.	Los Angeles	Woolsey
241	Liberty Canyon			Steep convergent natural slopes with low to moderate burn severity above graded slope with terrace drain. Limited access to natural slopes due to iron fence.	debris flow	Residential structures	home	moderate	moderate	Early warning system	Los Angeles	Woolsey
242	Liberty Canyon			Steep convergent natural drainages above road. Scattered cobbles and small boulders on slopes. Potential hazard to parked cars on road	debris flow	Parked cars	other	moderate	moderate	Early warning system	Los Angeles	Woolsey
243	Liberty Canyon			Houses below steep convergent slopes with small failure, and cobbles and small boulders in flowline. Small debris trap at bottom of drainage.	debris flow	Residential structures	home	moderate	moderate	Early warning system. Maintain small debris trap.	Los Angeles	Woolsey
244	Malibu, Decker Canyon			Road below oversteepened cut slopes prone to rockfall	rockfall	Road, cars	other	moderate	moderate	Signage, Professional Consultation	Los Angeles	Woolsey
245	Malibu, Camp Bloomfield			Burned out camp facilities located in floodplain below very large, burned drainage	flood	Building	recreational	moderate	moderate	Early Warning System	Los Angeles	Woolsey
246	Malibu, Camp Bloomfield			Burned out cabins and pool area located below high potential debris flow segment	debris flow	Cabins	recreational	moderate	moderate	Early Warning System	Los Angeles	Woolsey
247	Malibu			Roadway below steep, burned slopes with boulders	rockfall	Road, cars	other	moderate	moderate	Signage, Professional Consultation	Los Angeles	Woolsey
248	Malibu			Roadway below steep, burned slopes with boulders	rockfall	Road, cars	other	moderate	moderate	Signage, Professional Consultation	Los Angeles	Woolsey
249	Malibu			Roadway below steep, burned slopes with boulders	rockfall	Road, cars	other	moderate	moderate	Signage, Professional Consultation	Los Angeles	Woolsey

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Woolsey - Hill Fires Values at Risk Table

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250	Lobo Canyon Road			Road located in floodplain. Low water crossing to Lobo Canyon Road and a double low water crossing in confined canyon before 32066 Lobo Canyon Road can cut off ingress/egress for residents during storm events.	flood	Ingress/ egress	other	moderate	low	Early warning system.	Los Angeles	Woolsey
251	Calabasas			Vehicle traffic on road subject to flooding and woody debris from drainages north of road. Model indicates low debris flow hazard potential.	debris flow / flood	Vehicles on road	other	moderate	moderate	Storm patrol to maintain culvert. Sand bag. Muscle wall or K-rail could keep debris in channel	Los Angeles	Woolsey
252	Westlake Hills			Houses built into toe of alluvial fan below drainage. Rocks observed in drainage. V-ditch above houses appears to drain between houses.	debris flow / flood	residential structures	home	moderate	moderate	Early warning	Los Angeles	Woolsey
253	Malibou Lake			Houses located on debris fan at mouth of catchment with low debris flow hazard. Gas line crosses channel downstream of undersized culvert. Colluvial deposits exposed in channel banks. Surface has some muted bar and swale morphology is modified by grading	debris flow / flood	Houses and improvements, utilities.	multiple	moderate	moderate	Early warning. Consider more detailed geologic investigation and engineered mitigation.	Los Angeles	Woolsey
254	Malibou Lake	34.106106	-118.7685	Residential structure and improvement in delineated flood zone and subject to debris flow hazards. Culvert downslope of residential structure undersized and prone to plugging.	debris flow / flood	House. Currently burned out	home	low	high	Clean out sediment and woody debris for 75 feet above culvert. Clean out woody debris upstream to confluence of both streams. Early warning system	Los Angeles	Woolsey
255	Point Dume	34.033455	-118.8366	House and casita downstream of catchment basin within moderate debris flow segment has potential to be impacted by overflow.	debris flow	Residence	home	low	moderate	Storm patrol. Early warning system.	Los Angeles	Woolsey
256	Point Dume	34.033738	-118.8326	Culvert under Road with trash rack. Potential for plugging and over topping. Likely flow path down residential access road. Side cast from dirt road and debris in channel increase potential for diversion out channel upstream of culvert inlet basin.	debris flow / flood	Culvert and access road to homes	home	low	moderate	Direct road drainage along channel into basin. Dig out channel for about 100 feet upstream of inlet	Los Angeles	Woolsey
257	Point Dume	34.035251	-118.8306	Fence across stream impounding sediment. No potential for diversion but could contribute to bulking of flow if it fails catastrophically releasing impounded debris. Within modeled high debris flow segment	debris flow / flood	Residences downstream	home	low	moderate	Clear fence from impounding channel.	Los Angeles	Woolsey

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258	Point Dume	34.034367	-118.831	Fence across stream impounding sediment. No potential for diversion but could contribute to bulking of flow if it fails catastrophically releasing impounded debris. Within modeled high debris flow segment	debris flow / flood	Residences downstream	home	low	moderate	Clear fence from channel	Los Angeles	Woolsey
259	Point Dume	34.031687	-118.8282	culvert appears undersized for catchment on moderate to low debris flow hazard segment. Culvert appears to have high potential for plugging.	debris flow / flood	Culvert under residential access road	drainage structure	low	moderate	Clear channel 150 feet upstream. Clear out culvert. Install trash rack.	Los Angeles	Woolsey
260	Point Dume	34.030297	-118.8238	Small culvert on low debris flow potential modeled stream. Appears to have high potential for clogging.	flood	Homes at creek level	drainage structure	low	moderate	Protect inlet.	Los Angeles	Woolsey
261	Point Dume	34.030045	-118.8231	High debris flow potential modeled stream crosses residential access road with potential to clog. Fence across stream impounding sediment could contribute to bulking of flow if it fails catastrophically releasing impounded debris.	debris flow / flood	Access road	drainage structure	low	moderate	Clear channel obstruction	Los Angeles	Woolsey
262	Point Dume	34.032917	-118.8215	Drainage structure under residential access road on high debris flow potential stream has potential for clogging and overflowing.	debris flow / flood	Access rd.	drainage structure	low	moderate	Storm patrol.	Los Angeles	Woolsey
263	Point Dume	34.027641	-118.825	High modeled debris flow segment runs down road to protected culvert inlet upstream of school. School in debris flow path but recreation fields provide some space for deposition. If culverts upslope fail this culvert could be overwhelmed.	debris flow / flood	School fields and structures downstream	drainage structure	low	moderate	Consider CE evaluate deflection structures.	Los Angeles	Woolsey
264	Point Dume	34.027336	-118.8236	Residence or outbuilding in modeled low debris flow potential channel. Flow path along school ball fields.	debris flow / flood	Residence or outbuilding	home	low	moderate	early warning system	Los Angeles	Woolsey
265	Point Dume	34.021879	-118.8241	House on stream flow path with low debris flow potential. No access but observed through gate and in lidar hillshade.	debris flow / flood	House and out buildings	home	low	moderate	Early warning	Los Angeles	Woolsey
266	Point Dume	34.024262	-118.8175	Culvert inlet goes beneath road with potential to plug and flow down residential access road. Within modeled low debris flow segment	debris flow / flood	Access road	drainage structure	low	moderate	Inlet protection.	Los Angeles	Woolsey
267	Point Dume	34.029384	-118.8119	Low water crossing in FEMA floodplain and watch stream.	debris flow / flood	Access road	drainage structure	low	low	Signage	Los Angeles	Woolsey

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268	Point Dume	34.0275	-118.8116	House in low potential debris flow path.	debris flow / flood	Residence	home	low	moderate	Enlarge channel around house. Consult PE for channel design and/or deflection structure.	Los Angeles	Woolsey
269	Kanan-Dume Rd	34.061403	-118.8039	Side road intersects highway with small unmodeled catchment with potential to deliver debris and water to highway. Appears to have already channeled muddy water onto highway shoulder.	debris flow / flood	Highway	other	low	low	Deflection structure or dip.	Los Angeles	Woolsey
270	Kanan-Dume Rd	34.045524	-118.798	Culvert under highway, inlet buried.	debris flow / flood	Culvert	drainage structure	low	low	Clean out inlet and protect inlet.	Los Angeles	Woolsey
271	Trancas Canyon	34.037539	-118.8412	Residential structures downstream of unmodeled catchment with potential for flooding.	flood	Residential neighborhood	home	low	low	Early warning system. Consult with professional to improve drainage.	Los Angeles	Woolsey
272	Trancas Canyon	34.037942	-118.8417	Residential structures downstream of unmodeled catchment with potential for flooding.	flood	Residential neighborhood	home	low	low	Early warning system. Consult with professional to improve drainage.	Los Angeles	Woolsey
273	Trancas Canyon	34.038779	-118.8425	Residential structures downstream of unmodeled catchment with potential for flooding.	flood	Residential neighborhood	home	low	low	Early warning system. Consult with professional to improve drainage.	Los Angeles	Woolsey
274	Trancas Canyon	34.039918	-118.8457	Minor flooding of park from burned slopes and construction above, hillsides rilling currently	flood	Park Infrastructure	recreational	low	low	Consult professional to manage upstream drainage to park.	Los Angeles	Woolsey
275	Malibu	34.039877	-118.875	Flooding of Pacific Coast Highway from plugging of culvert	flood	Highway, homes on south side of freeway	multiple	low	low	Storm patrol.	Los Angeles	Woolsey
276	Encinal Canyon	34.044288	-118.8814	Uncontrolled drainage feeds into inside ditch to existing culvert. Water currently flows down road.	debris flow / flood	Road	other	low	low	Connect drainage to existing culvert, storm patrol	Los Angeles	Woolsey
277	Malibu	34.031791	-118.7142	Box culvert subject to clogging with woody debris, and potential to flood Malibu Road and adjacent business.	flood	Box culvert	drainage structure	low	moderate	Storm patrol to maintain culvert function.	Los Angeles	Woolsey
278	Malibu	34.034168	-118.7144	Potential for 6x8 ft arch drain under PCH to clog with woody debris and flood highway.	flood	Arch drain/culvert	drainage structure	low	low	Storm patrol to maintain culvert function. Clear dead woody debris upstream of culvert.	Los Angeles	Woolsey
279	Malibu	34.034967	-118.7244	Potential for catch basin to clog with woody debris and flood PCH.	flood	Catch basin	drainage structure	low	low	Storm patrol to maintain catch basin	Los Angeles	Woolsey
280	Malibu	34.033885	-118.7351	Potential to flood if drainage under PCH is blocked	flood	Restaurant	business	low	low	Storm patrol to maintain drainage under bridge. Sand bags.	Los Angeles	Woolsey
281	Kanan-Dume Road	34.092802	-118.816	Partially clogged culvert under road with low debris flow potential stream.	debris flow / flood	Outbuildings	drainage structure	low	low	Clear out culverts	Los Angeles	Woolsey
282	Kanan-Dume Road	34.090988	-118.8155	Partially clogged culvert inlet with recent dry ravel. Steep bare slopes around inlet. Modeled low debris flow segment	flood	Major access road.	drainage structure	low	low	Clear out inlet. Have professional evaluate stabilization of adjacent slopes.	Los Angeles	Woolsey

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283	Kanan-Dume Road	34.080852	-118.8192	Drop culvert under road has been extended in height with extension beginning to be buried. Expected debris flow volume on high potential catchment could bury drop inlet.	debris flow / flood	Major access road.	drainage structure	low	low	Clear out drop inlet. Clear channel.	Los Angeles	Woolsey
284	Point Dume	34.01164	-118.814	Culvert on low debris flow potential flow path goes under large fill on residential access road. No inlet protection with debris depositing at inlet. Outlet is partially buried. Large capacity upstream of crossing. Within modeled low-mod debris flow segment	debris flow / flood	Access road. Only egress	drainage structure	low	moderate	Clear culvert, check for culvert integrity and protect inlet.	Los Angeles	Woolsey
285	Point Dume	34.020361	-118.7954	Clogged stacked culvert outlets and separating pipe outlet draining under PCH. Degraded condition of outlet does not match newer condition of inlet.	flood	Culvert under PCH draining subdivision	drainage structure	low	low	Clear pipe and check integrity of drainage structure.	Los Angeles	Woolsey
286	Malibu	34.029682	-118.7807	Municipal water supply line crossing modeled low hazard catchment. Water line extends to fire hydrant to east. Flow overtops road and is eroding outboard edge. Fence across stream impounding sediment and debris could contribute to bulking if it fails.	debris flow / flood	Municipal water supply line	utilities	low	moderate	Protect line.	Los Angeles	Woolsey
287	Malibu	34.026881	-118.7653	Bridge in flood zone with utilities (hi pressure gas and water) under deck. Gas line is unprotected and on upstream side of bridge.	debris flow / flood	Access bridge and utilities.	multiple	low	moderate	Evaluate exposed gas line in direct path of bulked flow. Evaluate height of bridge under flood conditions and ingress/egress of local residents.	Los Angeles	Woolsey
288	Malibu	34.04279	-118.6843	Increased likelihood of flooding and woody debris overtopping bridge over Malibu Creek. Bridge engineered for overtopping during flooding, guard rails fold down flat.	flood	Bridge	other	low	moderate	Early warning system.	Los Angeles	Woolsey
289	Malibu	34.04333	-118.6975	Structure in path of low potential debris flow model segment. Unable to assess due to limited access.	debris flow	Laboratory facility.	business	low	low	Early warning system.	Los Angeles	Woolsey
290	Cornell	34.114366	-118.7793	Bridge is potentially submerged at max flood stage. Bridge was damaged in fire and not functional.	flood	Bridge & ingress/ egress in area	other	low	low	Early warning system.	Los Angeles	Woolsey
291	Saratoga Hills	34.125761	-118.7562	Stream drainage is blocked/impeded at rear of property by fence under foot bridge. Potential flooding of backyard equestrian area.	flood	Outbuildings	drainage structure	low	low	Early warning system. Consult with professional to improve drainage through property.	Los Angeles	Woolsey

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292	Calamigos Resort	34.090997	-118.8162	Resort structures and improvements in path of low debris flow potential catchment.	flood	Resort, propane and chemical tanks	multiple	low	low	Storm patrol. Early warning system. Have professional evaluate location of hazardous material storage	Los Angeles	Woolsey
293	Vera Canyon	34.085641	-118.8185	Outbuilding structure (garage) in potential flow path of high debris flow potential catchment.	debris flow / flood	Garage	home	low	high	Early warning system	Los Angeles	Woolsey
294	Malibu Creek State Park	34.108486	-118.7207	36 CMP in culvert could clog with debris and flood Mulholland. Model indicates moderate debris flow hazard potential.	debris flow / flood	Vehicles on Highway	other	low	low	Maintain culvert. Increase capacity by removing excess soil north of road	Los Angeles	Woolsey
295	Malibou Lake	34.118514	-118.7515	Storm drain inlet with no storage capacity could plug. Debris flow would impact road.	debris flow / flood	Storm drain inlet	drainage structure	low	low	Storm patrol to maintain drainage function.	Los Angeles	Woolsey
296	Malibou Lake	34.135885	-118.7541	House with drainage culvert and CMP which flows to street. Many cobbles and boulders on low angle slope and in drainage above house.	debris flow	Residential structure	home	low	low	Storm patrol to maintain drainage function.	Los Angeles	Woolsey
297	Lobo Canyon	34.118236	-118.8021	Home below dynamic, burned drainage with large boulders. Channel constricted near house/deck could result in diversion	debris flow / flood	Deck/Garage	home	low	moderate	Early Warning System, Professional Consultation	Los Angeles	Woolsey
298	Triunfo Canyon	34.132843	-118.8016	Burned out building located adjacent to plugged 36" culvert that drains burned area. Culvert more than 75% plugged	flood	Burned out temple	business	low	moderate	Early Warning System, Maintain Drainage	Los Angeles	Woolsey
299	Westlake Hills	34.109114	-118.8554	House near channel. Bench area upslope may help dissipate flow.	debris flow / flood	House	home	low	low	Early warning system.	Los Angeles	Woolsey
300	Westlake hills	34.11073	-118.8512	House below steep slope with perched boulders	rockfall	Residential structure	home	low	low	Early warning system	Los Angeles	Woolsey
301	Malibou Lake	34.110343	-118.7572	Debris fan cut by road at base of steep un-modeled catchment. Abundant dry ravel in source area. No drainage facility at road.	debris flow / flood	Access road	other	low	low	Storm patrol.	Los Angeles	Woolsey
302	Malibou Lake	34.108821	-118.7614	Debris fan with large boulders intersects road. No drainage structure at road. rockfall, debris flow are likely hazards.	other	Major access road	other	low	moderate	Storm patrol. Have profession evaluate an installation of berm and or drainage structure	Los Angeles	Woolsey
303	Malibou Lake	34.108467	-118.7635	Rockfall, debris flow and flooding from small steep catchment cut by road. No drainage structure at road.	other	Major access road	other	low	low	Storm patrol.	Los Angeles	Woolsey
304	Malibou Lake	34.109094	-118.7646	House built beneath steep slope and in flow path of un-modeled catchment. Driveway will likely become drainage path. Rockfall hazards as well.	debris flow / flood	Residence	home	low	moderate	Early warning system.	Los Angeles	Woolsey

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Woolsey - Hill Fires Values at Risk Table

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305	Malibou Lake	34.111719	-118.769	Undersized drainage structure on modeled moderate debris flow hazard catchment. Potential to plug and enter road.	debris flow / flood	Major. Access road.	drainage structure	low	low	Storm watch. Consider berm adjacent drainage vault.	Los Angeles	Woolsey
306	Malibou Lake	34.113133	-118.7737	LA County maintenance yard.	debris flow / flood	Fuel tanks, shop, office vehicles	utilities	low	moderate	Storm watch. Clear drains upslope of structure.	Los Angeles	Woolsey
307	Malibou Lake	34.114511	-118.7703	House adjacent to low hazard flow path with partially clog concrete drain structure. Steep catchment with abundant debris.	debris flow / flood	Residence	home	low	moderate	Clear drains. Early warning system. Consider engineered structure or upgrading drains.	Los Angeles	Woolsey
308	Malibou Lake	34.113924	-118.7711	Culvert under Road has undersized inlet for expected debris and likely flow. Potential to clog and block road access. Drain ditch upstream partially clogged with debris. Home downstream at risk if overflows.	debris flow / flood	Culvert under access road	other	low	moderate	Clear drains and inlet. Design inlet for larger debris or protect.	Los Angeles	Woolsey
309	Malibou Lake	34.116802	-118.7739	Partially clogged and potentially undersized debris basin. House to north at risk if inlet clogs.	debris flow / flood	Residences and access roads	multiple	low	moderate	Clear out basin and check debris basin size to expected debris production. Storm patrol.	Los Angeles	Woolsey
310	Malibou Lake	34.11294	-118.7721	Small drain drains to house. Modeled low debris flow.	debris flow / flood	Residence	home	low	moderate	Early warning system	Los Angeles	Woolsey
311	Malibou Lake	34.117785	-118.7763	House at mouth of small catchment. Has had mud flow into pool before per resident.	debris flow / flood	Residence	home	low	moderate	Early warning system	Los Angeles	Woolsey
312	Malibou Lake	34.117564	-118.7761	House at mouth of small catchment.	debris flow / flood	Residence	home	low	moderate	Early warning system.	Los Angeles	Woolsey
313	Malibou Lake	34.1183	-118.7769	House at mouth of small catchment.	debris flow / flood	Residence	home	low	moderate	Early warning system	Los Angeles	Woolsey
314	Malibou Lake	34.107425	-118.7618	Debris basin is almost full to capacity.	debris flow / flood	Debris basin overtopping	other	low	moderate	Clean out basin	Los Angeles	Woolsey
315	Malibou Lake	34.109479	-118.7569	Clogged drain leading to residence backyard	flood	Residence below clogged drain.	drainage structure	low	low	Clear drain.	Los Angeles	Woolsey
316	Malibou Lake	34.109654	-118.7545	Bridge submerged in flood zone.	flood	Bridge on access road	other	low	low	Early warning system	Los Angeles	Woolsey
317	Malibou Lake	34.107736	-118.752	House across mouth of un-modeled catchment. Evidence of newly built deflection structures suggest prior issues.	debris flow / flood	Residence	home	low	high	Early warning system.	Los Angeles	Woolsey
318	Westlake Hills	34.132875	-118.8276	House at bottom of small burned drainage with rocks and boulders. 1 foot culvert could get plugged causing flow to run into house.	debris flow / flood	House	home	low	low	Early warning system.	Los Angeles	Woolsey

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Woolsey - Hill Fires Values at Risk Table

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319	Liberty Canyon	34.117469	-118.7202	Bridge across creek in Liberty Canyon has low clearance, and soil beneath abutments is eroded. Woody debris and entrained boulders could damage bridge.	flood	Steel bridge	other	low	moderate	Check abutments for erosion and additional scour after storms prior to use.	Los Angeles	Woolsey
320	Liberty Canyon	34.116277	-118.7207	Debris and cobbles could damage propane tanks in bottom of small drainage.	debris flow	Propane tanks	utilities	low	low	Install Upslope protection for tanks (k rail). Or move tanks out of drainage.	Los Angeles	Woolsey
321	Malibu Creek State Park	34.109597	-118.7125	Bridge with low clearance to channel provides only apparent access to state park housing facility.	debris flow	Wood bridge	other	low	moderate	Storm patrol. Warn residents of potential loss of egress from state park housing if damaged	Los Angeles	Woolsey
322	Lobo Canyon	34.117561	-118.8221	Burned house below steep, rocky hill burned slopes	rockfall	House	home	low	moderate	Early Warning System	Los Angeles	Woolsey
323	Lobo Canyon	34.117243	-118.8249	House below steep, burned slopes. Channel immediately adjacent to house constricted by two footbridges which could lead to diversion into house	debris flow / flood	House	home	low	moderate	Early Warning System	Los Angeles	Woolsey
324	Lobo Canyon, Green Media Studio	34.111798	-118.8257	Burned out studio building located below burned drainage with large boulders in channel. Channel intentionally diverted during construction multiple times and at risk of diverting into studio	debris flow / flood	Studio	business	low	high	Early Warning System	Los Angeles	Woolsey
325	Malibu	34.044585	-118.9033	Burned and unburned buildings located in floodplain of burned drainage	debris flow / flood	Buildings	business	low	moderate	Early Warning System	Los Angeles	Woolsey
326	Malibu	34.080262	-118.9245	Burned house located within burned drainage with potential for debris flow	debris flow	House	home	low	low	Early Warning System	Los Angeles	Woolsey
327	Malibou Lake	34.102666	-118.7628	House located below burned drainage with potential debris flow segment	debris flow / flood	House and Garage	home	low	moderate	Early Warning System	Los Angeles	Woolsey
328	Castle Peak Drive	34.201881	-118.6618	House in path of low potential debris flow basins, in the event existing diversion structures are overwhelmed, house maybe impacted.	debris flow / flood	House	home	low	moderate	Maintain diversion structures/ early warning system.	Los Angeles	Woolsey
329	Agoura	34.137795	-118.7324	Small shallow failure on slope above house could mobilize and overtop drainage ditch with 18 in freeboard.	debris flow	Residential structure	home	low	moderate	Early warning system. Maintain drainage ditch.	Los Angeles	Woolsey
330	Calabasas	34.147654	-118.6716	Health care facility below convergent drainage with low burn severity. Debris rack but no catch basin. Increased potential for muddy runoff and woody debris.	flood	Memory care facility	other	low	low	Early warning system. Clean out and maintain drainage devices	Los Angeles	Woolsey

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Woolsey - Hill Fires Values at Risk Table

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331	Oak Park	34.165894	-118.7838	House at outlet of short steep drainage. Cinder block wall in drainage at property line. Concrete ditch diverts drainage around house. House set back 75-feet from slope between pool and grass area.	debris flow / flood	Home	home	low	low	Early warning system. Maintain v-ditch.	Los Angeles	Woolsey
332	Oak Park	34.164272	-118.7855	House at the outlet of short steep drainage. Outcrop at top of slope and perched boulders in drainage. No drainage structure observed.	debris flow / flood	Home	Home	low	low	Early warning system.	Los Angeles	Woolsey
333	Oak Park	34.166323	-118.7831	House located at outlet of an approximately 12-acre drainage. Approximately 1 to 2-feet of sediment observed in existing LA County maintained basin. Overflow likely directed to street. Homeowner noted rain events producing water/sediment in the yard.	debris flow / flood	Home	home	low	low	Early warning system. Maintain drainage basin.	Los Angeles	Woolsey
334	Bell Canyon	34.207271	-118.6661	Culvert draining low potential debris flow basin may clog due to over grown vegetation, impacting primary community access route.	flood	Bell Canyon Road	utilities	low	low	Clean culvert structure, remove vegetation over growth.	Los Angeles	Woolsey
335	Agoura Hills	34.167801	-118.7671	Home in flow path of un-modeled basin, channel gradient above house is 8% increasing to 30%+. in the event existing diversion structures get overwhelmed, home maybe impacted.	debris flow / flood	House	home	low	moderate	Early warning system/ consult professionals for diversion structures	Los Angeles	Woolsey
336	Agoura Hills	34.16728	-118.7681	Home in flow path of un-modeled basin. in the event existing diversion structures get overwhelmed, home maybe impacted.	debris flow / flood	House	home	low	low	Early warning system/ consult professionals for diversion structures	Los Angeles	Woolsey
337	Malibu Creek State Park	34.107231	-118.7155	Southern California Edison substation below convergent slopes with scattered cobbles and small boulders. Potential for shallow surficial failure and increased muddy runoff.	debris flow / flood	SCE substation	utilities	low	low	Early warning system. Storm patrol.	Los Angeles	Woolsey
338	Malibu	34.033474	-118.7425	Residential building in delineated floodplain.	flood	Outbuilding	home	low	moderate	Consider engineered solution to flood hazards.	Los Angeles	Woolsey
339	Trancas Canyon			Slopes in excess of 2:1 gradients above houses are lacking adequate drainage and debris protection.	flood	Homes	home	low	low	Consult professional to improve drainage.	Los Angeles	Woolsey
340	Point Dume			Homes in debris flow modeled segment. Philip Road will most likely be flow path.	debris flow / flood	Residences and access road	multiple	low	moderate	Evaluate drainage paths and infrastructure	Los Angeles	Woolsey

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Woolsey - Hill Fires Values at Risk Table

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341	Malibu			Undersized culvert drains burned canyon above homes located north of west end of Bailard Road.	debris flow / flood	Houses	home	low	low	Early Warning System	Los Angeles	Woolsey
342	Malibu			Burned Area drains into housing tract through series of undersized culverts	flood	Houses	home	low	moderate	Early warning	Los Angeles	Woolsey
343	Los Angeles County Fire Crew Camp			Undersized partially plugged culverts could lead to flooding of fire camp and destruction of LACO Fire Department equipment	debris flow / flood	Buildings, equipment	business	low	low	Early Warning System, Maintain Drainage	Los Angeles	Woolsey
344	Pepperdine University			Convergent natural slope with cobbles above steep graded slope has low potential for debris flow to housing units below.	debris flow	Residences	other	low	low	Early warning system. Consult with professional for potential use of slope stabilization measures on natural slopes.	Los Angeles	Woolsey
345	Pepperdine University			Potential for debris flow from steep convergent natural slopes with moderate burn severity above graded slopes at rear of residential structures.	debris flow	Residential structures at toe of slope.	home	low	low	Early warning system. Use K-rail on outer edge of road to deflect potential debris flow.	Los Angeles	Woolsey
346	Malibu			Potential flood hazard to business if drainage culvert is clogged.	flood	Nursery business	business	low	moderate	Storm patrol to maintain culvert.	Los Angeles	Woolsey
347	Malibu Hills			Residential structures adjacent to channel. Model indicates low debris flow hazard potential.	debris flow / flood	3 residences	home	low	low	Early storm warning system.	Los Angeles	Woolsey
348	Kanan-Dume Road			Rockfall onto highway with narrow shoulder. Low burn severity area.	rockfall	Major access road	other	low	low	Geotechnical/CEG evaluate rockfall potential and design adequate road margin or catchment wall.	Los Angeles	Woolsey
349	Kanan-Dume Road			Rockfall onto highway with narrow shoulder.	rockfall	Major access road	other	low	low	Geotechnical/CEG evaluate rockfall potential and design adequate road margin or catchment wall.	Los Angeles	Woolsey
350	Kanan-Dume Rd			Rockfall onto highway	rockfall	Major access road	other	low	low	Geotechnical/CEG evaluate rockfall potential and design adequate road margin or catchment wall.	Los Angeles	Woolsey
351	Kanan-Dume Road			Rockfall onto highway. Shoulder appears marginally adequate in width and is appropriately sloped into cutbank.	rockfall	Major access road	other	low	low	Geotechnical/CEG evaluate rockfall potential and design adequate road margin or catchment wall.	Los Angeles	Woolsey
352	Kanan-Dume Road			Rockfall onto highway with narrow shoulder. There are also two small catchments with pipes at risk of rockfall and clogging.	rockfall	Major access road	other	low	low	Geotechnical/CEG evaluate rockfall potential and design adequate road margin or catchment wall.	Los Angeles	Woolsey
353	Kanan-Dume Rd			Rockfall onto highway with narrow shoulder right before tunnel entrance	rockfall	Major access road	other	low	low	Geotechnical/CEG evaluate rockfall potential and design adequate road margin or catchment wall.	Los Angeles	Woolsey
354	Kanan-Dume Road			Area of potential rockfall on to highway. Portions have narrow shoulder	rockfall	Major access road	other	low	low	Geotechnical/CEG evaluate rockfall potential and design adequate road margin or catchment wall.	Los Angeles	Woolsey

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Woolsey - Hill Fires Values at Risk Table

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355	Oak Forest Estates			Potential mudflows/debris flows/flooding of mobile homes below debris basin if capacity is exceeded.	debris flow / flood	5-10 Mobile Homes	home	low	moderate	Early Warning System	Los Angeles	Woolsey
356	Stokes Canyon			Residential structures below steep convergent slopes with cobbles and boulders.	debris flow	Residential structures	home	low	moderate	Early warning system.	Los Angeles	Woolsey
357	Agoura Hills			Potential damage to church camp buildings if adjacent channel overtops during large storm event.	debris flow / flood	Multiple bunkhouses along channel	recreational	low	low	Early Warning System	Los Angeles	Woolsey
358	Lower Malibu Creek			Flood hazard to residential homes and businesses in mapped flood zone.	flood	Residential homes and businesses	home	low	moderate	Early warning system.	Los Angeles	Woolsey
359	Calamigos Resort			Flood. Converging streams with multiple structures. Modeled low, moderate and high debris flow segments all converging	flood	Multiple structures in flood area	multiple	low	moderate	Early warning system	Los Angeles	Woolsey
360	Malibu Creek State Park			Potential rockfall hazard to highway. Boulders observed on slope above road and along highway.	rockfall	Vehicles on highway	other	low	low	Storm patrol. Review by CalTrans	Los Angeles	Woolsey
361				Flood hazard to residences.	flood	Residential structures	home	low	moderate	Early warning system	Los Angeles	Woolsey
362				Horses, stables, and trailers at bottom of canyon. Model indicates low potential for debris flow hazard.	debris flow / flood	Residential structures and horse stables	other	low	moderate	Early warning	Los Angeles	Woolsey
363	Malibou Lake			House at base of convergent slopes. Terrace drain and chain link fence will catch and deflect some debris.	debris flow	Residential structure	home	low	low	Early warning System.	Los Angeles	Woolsey
364	Trancas Canyon			Houses below steep, rocky burned slope may be exposed to rockfall.	rockfall	Houses	home	low	moderate	Early Warning System, Professional Consultation	Los Angeles	Woolsey
365	Malibou Lake			Flood into structures and residences	flood	Residences and structures	multiple	low	low	Early warning system	Los Angeles	Woolsey
366	Little Sycamore Canyon Road			Houses below steep slopes with rock outcrops. Roads between houses and rock outcrops.	rockfall	Houses	home	low	low	Early warning system.	Los Angeles	Woolsey
367	Latigo Canyon Road			Entire road has undersized drainage structures, steep slopes with rockfall and debris hazards already occurring	rockfall	Travelers on the road	drainage structure	low	moderate	Signage. Temporary closures. Storm patrol	Los Angeles	Woolsey
368	Malibou Lake			Houses in potential debris/ flood path if catchment overflows.	debris flow / flood	Residences and access roads	multiple	low	moderate	Early warning system	Los Angeles	Woolsey
369	Malibou Lake			Houses in LA floodzone	flood	Houses and improvements	home	low	moderate	Early warning system	Los Angeles	Woolsey

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370	Stokes Canyon			Ranch equipment staging area and storage containers in path of drainage with many small boulders up to 1m. Model indicates moderate debris flow hazard potential.	debris flow	Ranch equipment and storage containers	other	low	low	Move equipment. Early warning system.	Los Angeles	Woolsey
371	Las Virgenes Municipal Water District			Centrate supply tanks and valve/plumbing in path of convergent drainages. Scattered cobbles and small boulders in drainages. Drainage devices installed but no catch basins. Model indicates low to moderate debris flow hazard potential.	debris flow	Centrate supply tank, valves/ plumbing	utilities	low	moderate	Use K rail to block valves and mixer motor/ switch box. Install additional protection of valves and piping on tank	Los Angeles	Woolsey
372	Liberty Canyon			Horse stables and water tank near path of drainage which model indicates high debris flow hazard potential. Cobbles and boulders in drainage.	debris flow	Water tank, plumbing. Horse stables	other	low	low	Early warning system. Install protection for water tank and plumbing	Los Angeles	Woolsey
373	Liberty Canyon			Shallow landslide/ failure on slope northeast of houses could reactivate.	other	Residential structures	home	low	low	Early warning system	Los Angeles	Woolsey
374	Malibu, Leo Carrillo State Park			Park facilities located in floodplain below very large, burned drainage	flood	Buildings, campsites	State Park	low	moderate	Early Warning System	Los Angeles	Woolsey
375	Agoura hills			Houses below convergent drainage. Model indicates low debris flow hazard potential. Catch basin about 30% full.	debris flow	Residential structures	home	low	low	Early warning system. Clean out and maintain basin capacity	Los Angeles	Woolsey
376	Calabasas			Houses below graded slops and steep convergent natural slopes with low burn severity. Drainage devices on graded slopes locally full of sediment and debris.	debris flow / flood	Residential structures	home	low	low	Early warning system. Clean out and maintain drainage devices	Los Angeles	Woolsey
377	Lindero Canyon			Houses built at outflow of steep channel. Minimal runout observed	debris flow / flood	Homes	home	low	low	Early warning system	Los Angeles	Woolsey
378	Palo Comado Canyon			Potential for increased flood potential in un-modeled channel where horse stables and house are located in bottom of channel. House raised slightly off channel bottom but driveway and horse stable are in channel bottom.	flood	Horse stables and house.	other	low	low	Early warning system	Los Angeles	Woolsey

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379	Palo Comado Canyon			Structures and horse stables in FEMA floodplain subject to increased flooding and woody debris damaging facilities. Note: LA county flood hazard area tends beyond FEMA flood hazard area and includes more structures and ranch facilities.	flood	Homes and horse stables	home	low	moderate	Early warning system	Los Angeles	Woolsey
380	Malibou Lake	34.108707	-118.7679	Raw sewage line. Fire appears to have caused coupling to crack. Odor from sewage is present	other	Malibu Lake community	drainage structure	no	low	Notify Las Virgenes Water District	Los Angeles	Woolsey
381	Malibou Lake	34.10976	-118.7524	Pipe on main road into community. Tension crack and overland flow could cause pipe to separate and cause road failure.	other	Culvert and road access to Malibu Lake	drainage structure	no	low	Have professional review to stabilize outlet. Inform county representative	Los Angeles	Woolsey
382	Encinal Canyon	34.04398	-118.885	24" Culvert in moderate debris flow potential stream segment with plugging and diversion potential	flood	Road	other	no	low	Storm Patrol	Los Angeles	Woolsey
383	Agoura Hills	34.131054	-118.7623	Boulders observed in canyons adjacent to inadequate retaining walls at rear drainage area near shed.	debris flow / flood	Out-building (shed)	business	no	low	Early warning	Los Angeles	Woolsey
384	Malibu Creek State Park	34.103562	-118.7138	48 inch CMP May get clogged with woody debris and flood road. Model estimate 3050 cubic m. No storage capacity at culvert.	flood	Road crossing	drainage structure	no	low	Maintain culvert	Los Angeles	Woolsey
385	Triunfo Canyon	34.13477	-118.8032	Horse barns/stables located below burned drainage	flood	Barns/stables	business	no	low	Storm Patrol	Los Angeles	Woolsey
386	Triunfo Canyon, Golden Heart Ranch	34.128658	-118.7961	Camp for children with special needs located below burned drainage. Channel diverted above camp to run immediately adjacent to buildings.	flood	Camp buildings	business	no	low	Early Warning System, Storm Patrol	Los Angeles	Woolsey
387	Triunfo Canyon	34.128153	-118.7944	House located below burned drainage. Channel diverted around garage with berm and 24" culvert	flood	Home	home	no	low	Storm Patrol	Los Angeles	Woolsey
388	Triunfo Canyon	34.126541	-118.7972	House located adjacent to channel below burned drainage. Existing drainage structures may not be sufficient to handle increased flows	flood	House and out-buildings	home	no	low	Storm Patrol	Los Angeles	Woolsey
389	Lobo Canyon	34.118455	-118.8062	Garage and guesthouse located below burned drainage. Small landslide observed above guesthouse	flood	Garage	home	no	low	Early Warning System, Professional Consultation	Los Angeles	Woolsey
390	Triunfo Canyon	34.123544	-118.7883	Buildings located in drainage below burned area	flood	Two storage buildings	business	no	low	Early Warning System	Los Angeles	Woolsey

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391	Malibu Creek State Park	34.110792	-118.7164	24 inch water main in flood hazard of creek in Liberty Canyon has about 7 feet clearance to channel bed. 2 m boulders and woody debris in creek bed.	flood	24 in water main	utilities	no	high	Storm patrol	Los Angeles	Woolsey
392	Malibu Creek State Park	34.11057	-118.713	24 inch water main in flood hazard zone of Las Virgenes Creek could be damaged by woody debris. Approximately 18 ft clearance to channel bed and 8 ft clearance to floodplain.	flood	24 inch water main	utilities	no	moderate	Storm patrol	Los Angeles	Woolsey
393	Malibu	34.099434	-118.8409	Horse barns and outbuildings located in floodplain below burned slopes	flood	Buildings	business	no	low	Early Warning System	Los Angeles	Woolsey
394	Malibou Lake	34.105452	-118.7506	Garage located below burned slopes that drain into street	flood	Garage	home	no	low	Early Warning System	Los Angeles	Woolsey
395	Lindero Canyon	34.163127	-118.7941	House at toe of alluvial fan below approximately 18-acre drainage. House is cut into toe below 4-foot box culvert. Small overflow drains to road. Headwall and channels are rocky (observed from distance).	debris flow / flood	Home	home	no	low	Early warning system. Maintain drainage structures.	Los Angeles	Woolsey
396	Agoura Hills	34.161107	-118.7384	Barns, Stables in old creek bed. Creek diverted under property by 24” culvert which could plug and cause flooding	flood	Buildings	home	no	low	Early Warning System	Los Angeles	Woolsey
397	Lindero Canyon	34.163632	-118.7496	Convergent slope diverted away from large debris basin into roadway and neighborhood by utility road	flood	Street flooding, homes	other	no	low	Correct drainage to flow to debris basin	Los Angeles	Woolsey
398	Malibu			Houses built in floodplain.	flood	Houses	home	no	moderate	Early Warning System, drainage maintenance	Los Angeles	Woolsey
399	Las Virgenes Municipal Water District			Reservoir which receives water from two burned drainages and excess reclaimed water from facility could receive turbid muddy water from surface runoff. Model indicates low debris hazard potential.	debris flow	Reclaimed water reservoir	utilities	no	low	Notify Las Virgenes Water District	Los Angeles	Woolsey
400	Malibu			Burned out buildings located in floodplain below burned drainage	flood	Buildings	home	no	low	Early Warning System	Los Angeles	Woolsey
401	Miller Probation Camp			Probation Center buildings located in floodplain, on-site treatment ponds located close to low probability debris flow channel	flood	Probation Camp, water treatment ponds.	other	no	low	Early warning system.	Los Angeles	Woolsey
402	Malibou Lake			Houses located below burned drainage with no drainage structure. Water drains down street to lake.	flood	Houses	home	no	low	Consult professional to improve drainage.	Los Angeles	Woolsey

Note: These results were based upon a rapid review so that as much time as possible was allowed for emergency measures to be put into place before storm events. This table is part of a broader document and should be used in conjunction with that document to ensure proper implementation of recommendations provided.

Shaded rows = polygons
white rows = points

Woolsey - Hill Fires Values at Risk Table

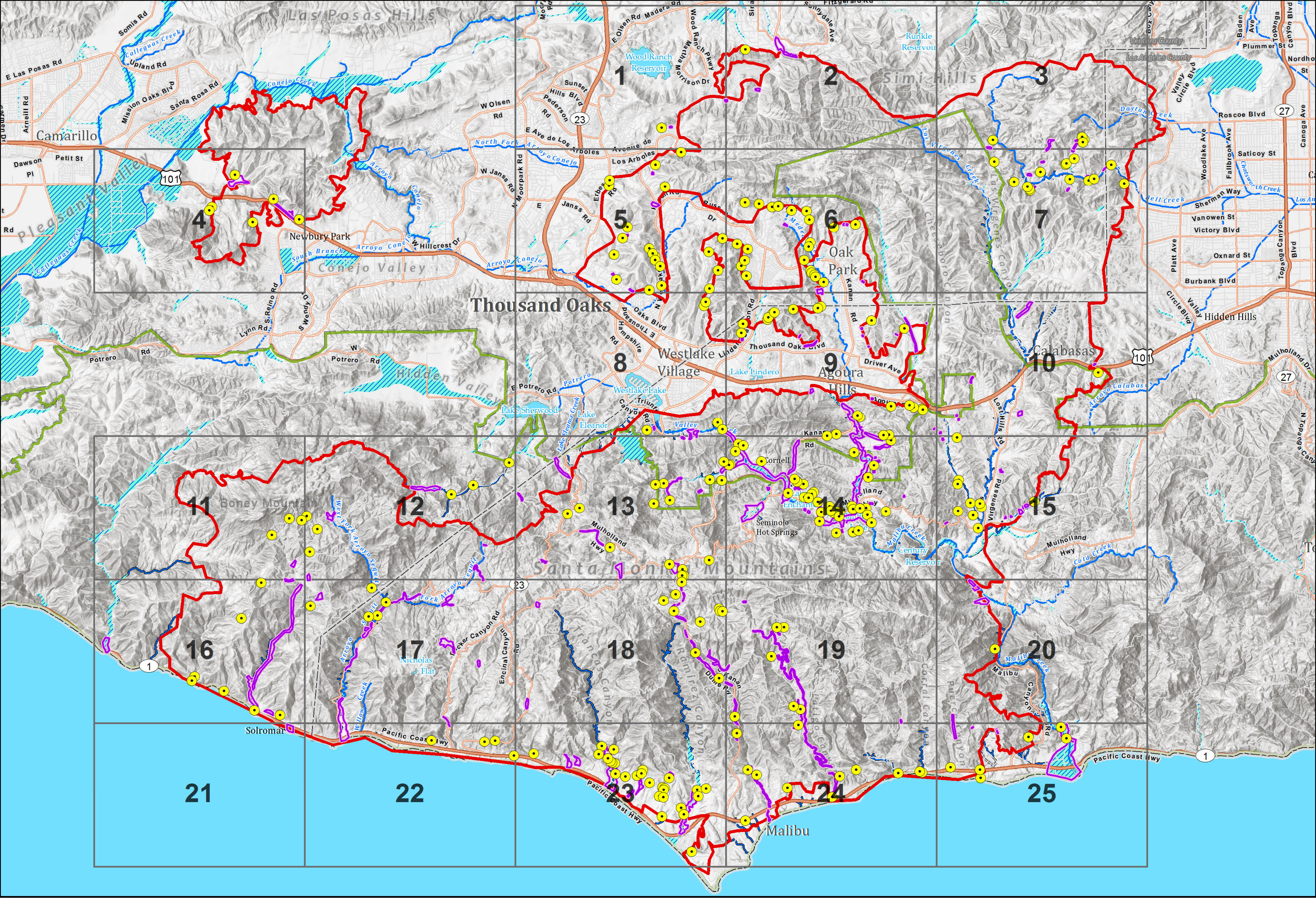
Site	Community / Local area	Latitude	Longitude	Potential hazard / Field observation	Hazard Category	Specific at-risk feature	Feature Category	Potential hazard to life	Potential hazard to property	Preliminary EMP	County	Fire
403	Malibou Lake			Houses located along at confluence of two channels with burned drainages may receive increased runoff and higher flood levels. Culverts under bridge upstream on eastern channel has plugged in past and overtopped per landowner.	flood	Houses	home	no	moderate	Maintain and improve drainage through culverts under bridge.	Los Angeles	Woolsey
404	Malibou Lake			Burned home at base of small burned drainage under utility pole with erosion mat may receive increased runoff during storm events.	flood	House, currently uninhabitable	home	no	low	Consult professional for drainage improvement during rebuilding process.	Los Angeles	Woolsey
405	Oak Park			Potential for runoff from low burn severity drainage and confluence of two terrace drains to overwhelm culvert capacity and flood backyards and houses.	flood	Houses	home	no	low	Maintain drainage facilities.	Los Angeles	Woolsey
406	Oak Park			Potential for Muddy runoff in pool. V-ditch between natural and graded slopes partially full of sediment.	other	Pool and backyard	home	no	low	Clean out drainage ditch and maintain	Los Angeles	Woolsey
407	Agoura Hills			Un-modeled drainage connects to culvert inlet through upper backyard of house. Potential flooding of backyard. No access to Catch basin which is within extended backyard development.	flood	Backyard, trampoline, basketball court	home	no	low	Maintain culvert and contour drains. Consult with professional to improve drainage through backyard.	Los Angeles	Woolsey
408	Agoura Hills			Potential increased muddy runoff and flooding of horse stables.	flood	Horse stables	other	no	low	Early warning. Move horses during storms	Los Angeles	Woolsey
409	Agoura Hills			Drainage benches full of sediment and could flood into park or street. Shallow surficial failures observed on steep slopes. Homeowner said street has flooded in past	flood	Park and road	drainage structure	no	low	Maintain contour drains.	Los Angeles	Woolsey
410	Agoura Hills			Road grading may divert runoff from unmodelled drainage onto street, not toward debris basin. Flooding and muddy runoff likely to impact street	flood	Cars parked in street	drainage structure	no	low	Connect drainage from slopes to flow to debris basin	Los Angeles	Woolsey

Note: These results were based upon a rapid review so that as much time as possible was allowed for emergency measures to be put into place before storm events. This table is part of a broader document and should be used in conjunction with that document to ensure proper implementation of recommendations provided.

General Recommendations (see discussion in report)

1.	Early warning systems	Utilize existing systems tied to incoming storm events
2.	Education for residents and the general public	Local agencies to communicate risks to emergency management agencies and the general public
3.	Situational awareness	Increase situational awareness of affected residents
4.	Develop emergency action plans	Counties and high risk areas to develop emergency action plans
5.	Storm monitoring and maintenance for road drainage structures/infrastructure	Monitor and maintain road drainage and storm drain infrastructure during storm events
6.	Temporary signage	Place temporary signage in areas subject to flooding and debris flow potential
7.	Utilize structure protection	Where appropriate, utilize sand bags, K-rails, Muscle wall
8.	Debris removal from channels	Where needed, remove debris from channels at crossing inlets and outlets
9.	Schools, parks, and campground considerations	Consider closing high risk schools, parks, and campgrounds when significant storms are forecast
10.	Focused evaluations	Encourage focused evaluations of debris flow runout distance and rockfall hazard

APPENDIX D. USGS DEBRIS FLOW MODEL BASIN AND SEGMENT PROBABILITY MAPS



VAR Overview

Hill / Woolsey Fires

CA-VNC-090993 / CA-VNC-091023

December 7, 2018

Woolsey Fire

Hill Fire

Values at Risk (Points)

Values at Risk (Polygons)

0 1 2 4 Miles

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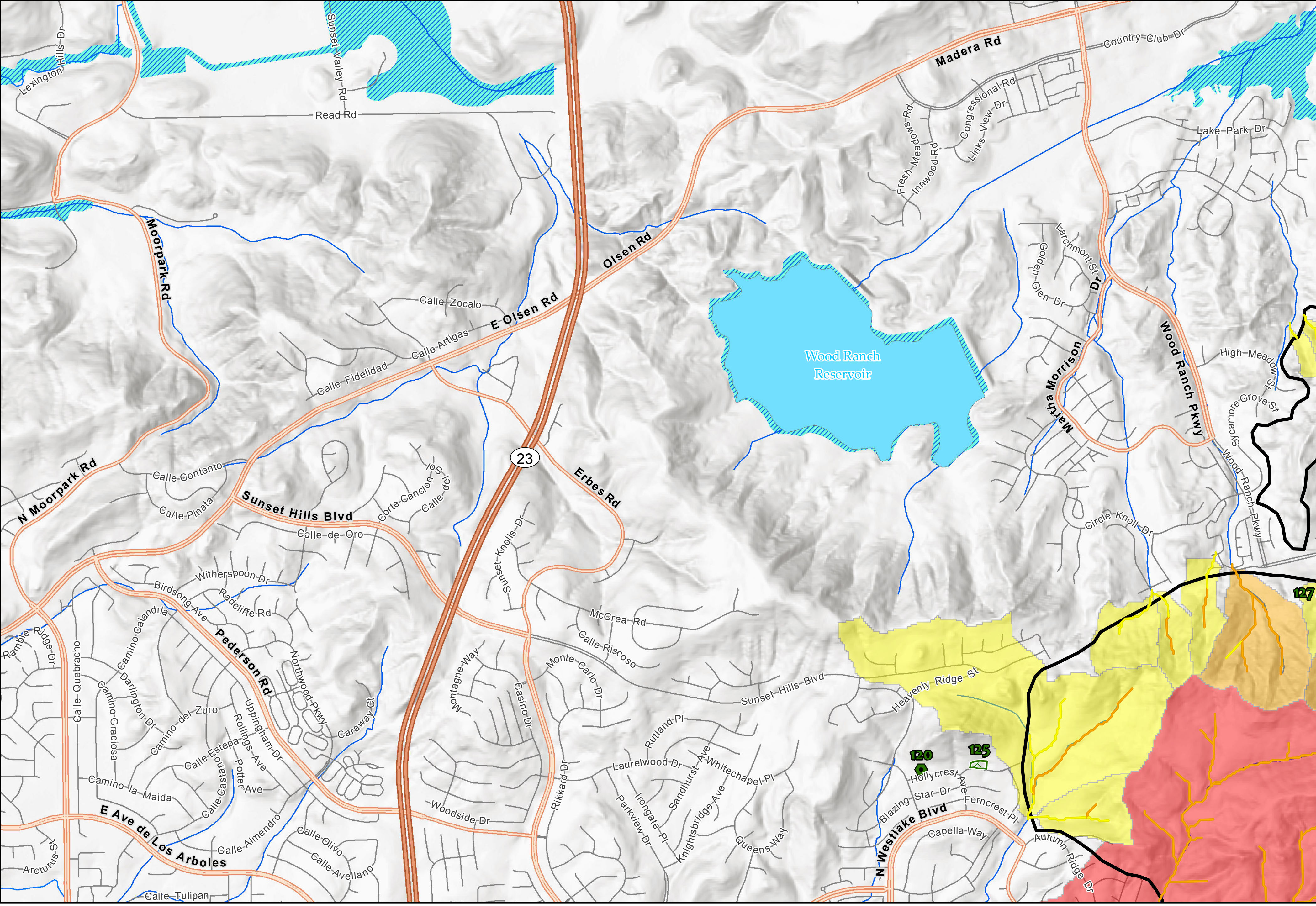
Santa Monica Mountains National Recreation Area

FEMA Annual Chance of Flood Hazard - 1%(100yr)

USGS Watchstream



Woolsey Fire
Hill Fire
Watch Streams
FEMA Annual Chance of Flood Hazard - 1% (100yr)

Potential hazard to life

Value at Risk (Point)	Value at Risk (Polygon)
High	High
Moderate	Moderate
Low	Low
None	None

VAR Map

Hill / Woolsey fires

CA-VNC-090993 / CA-VNC-091023

December 7, 2018

0 0.15 0.3 0.6 Miles

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N

Segment Combined Hazard (15-min 40mm/hr)

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Basin Combined Hazard (15-min 40mm/hr)

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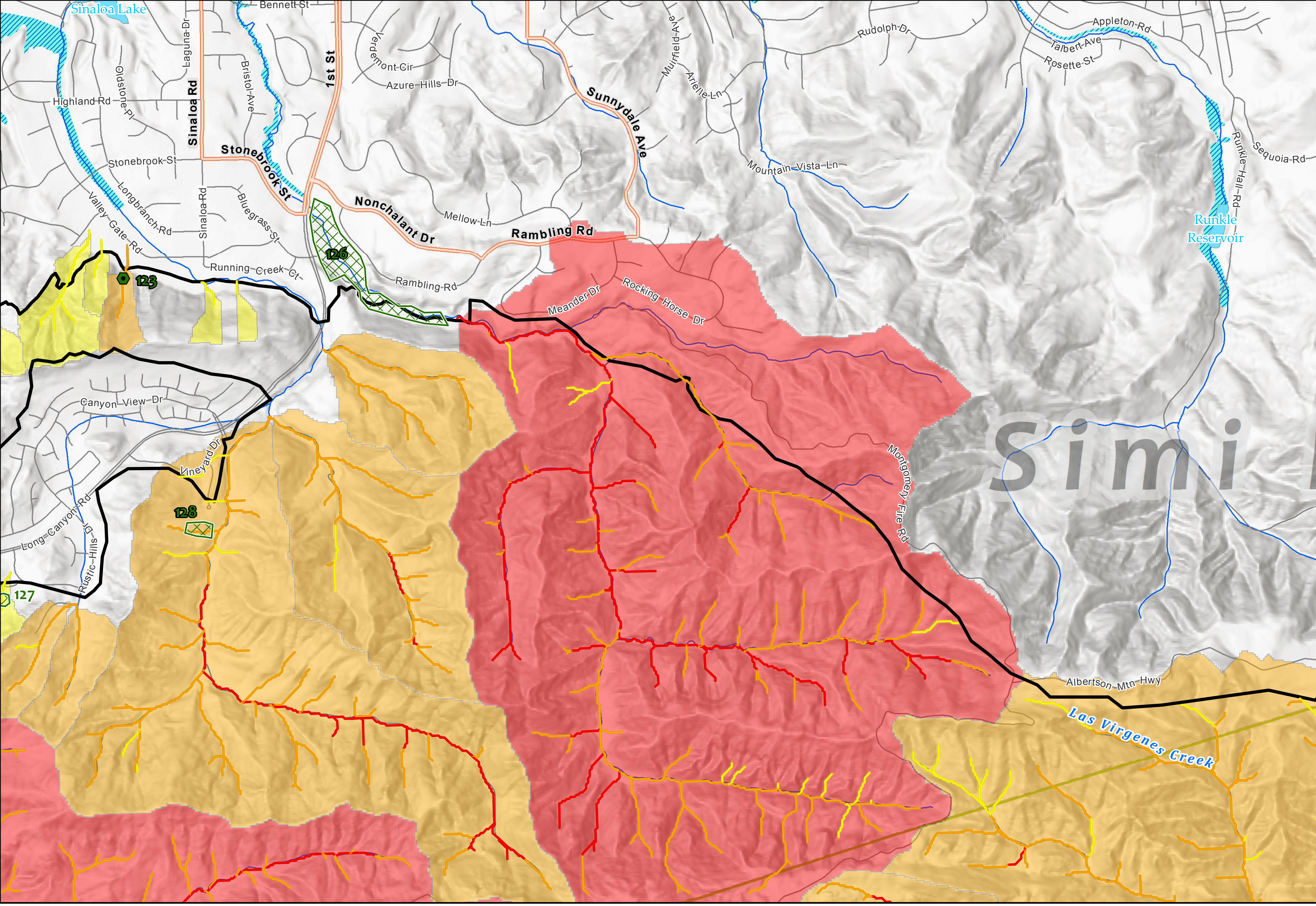

Woolsey Fire | Hill Fire

Watch Streams

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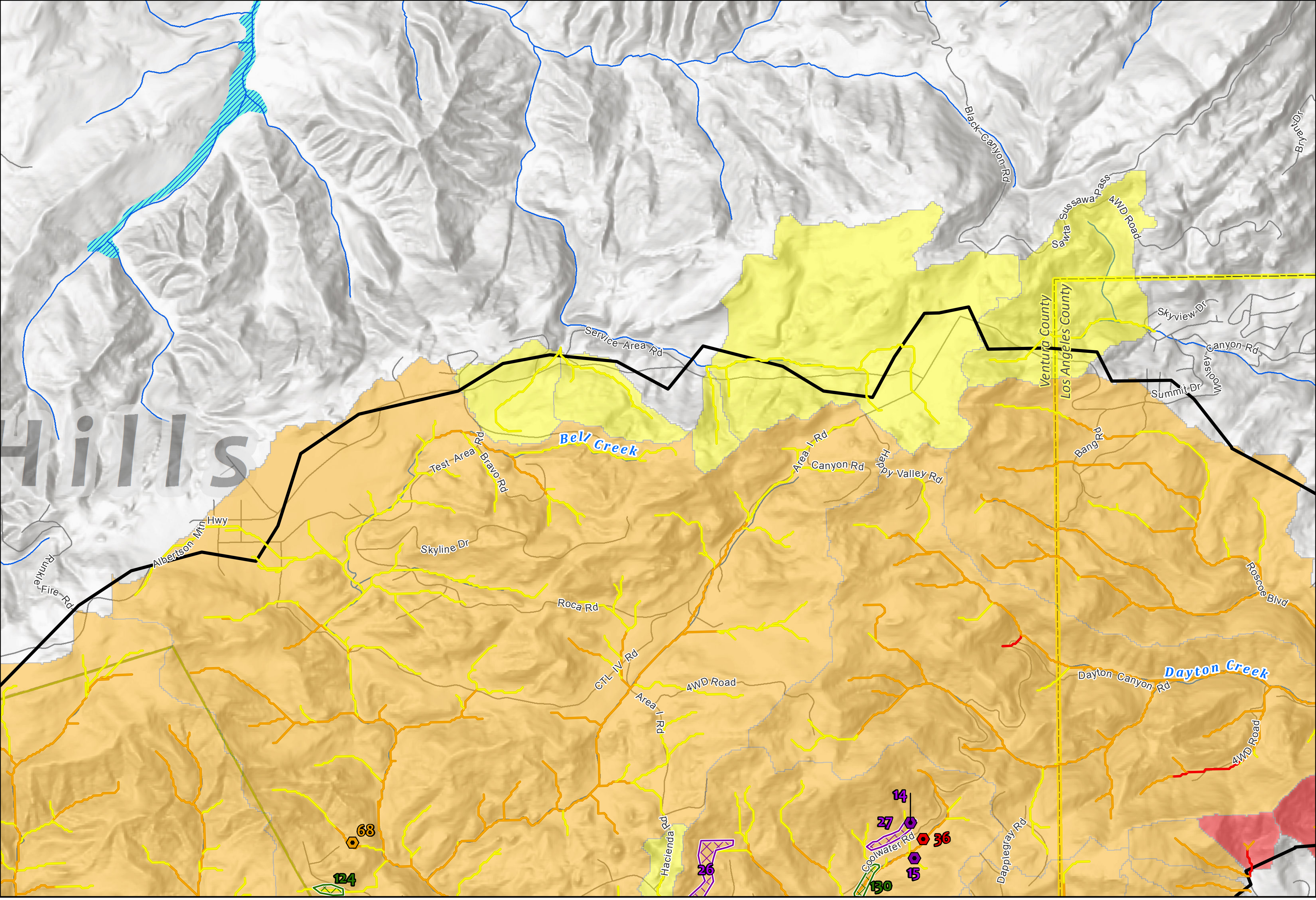

Woolsey Fire
Hill Fire
Watch Streams
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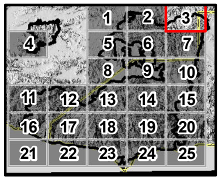

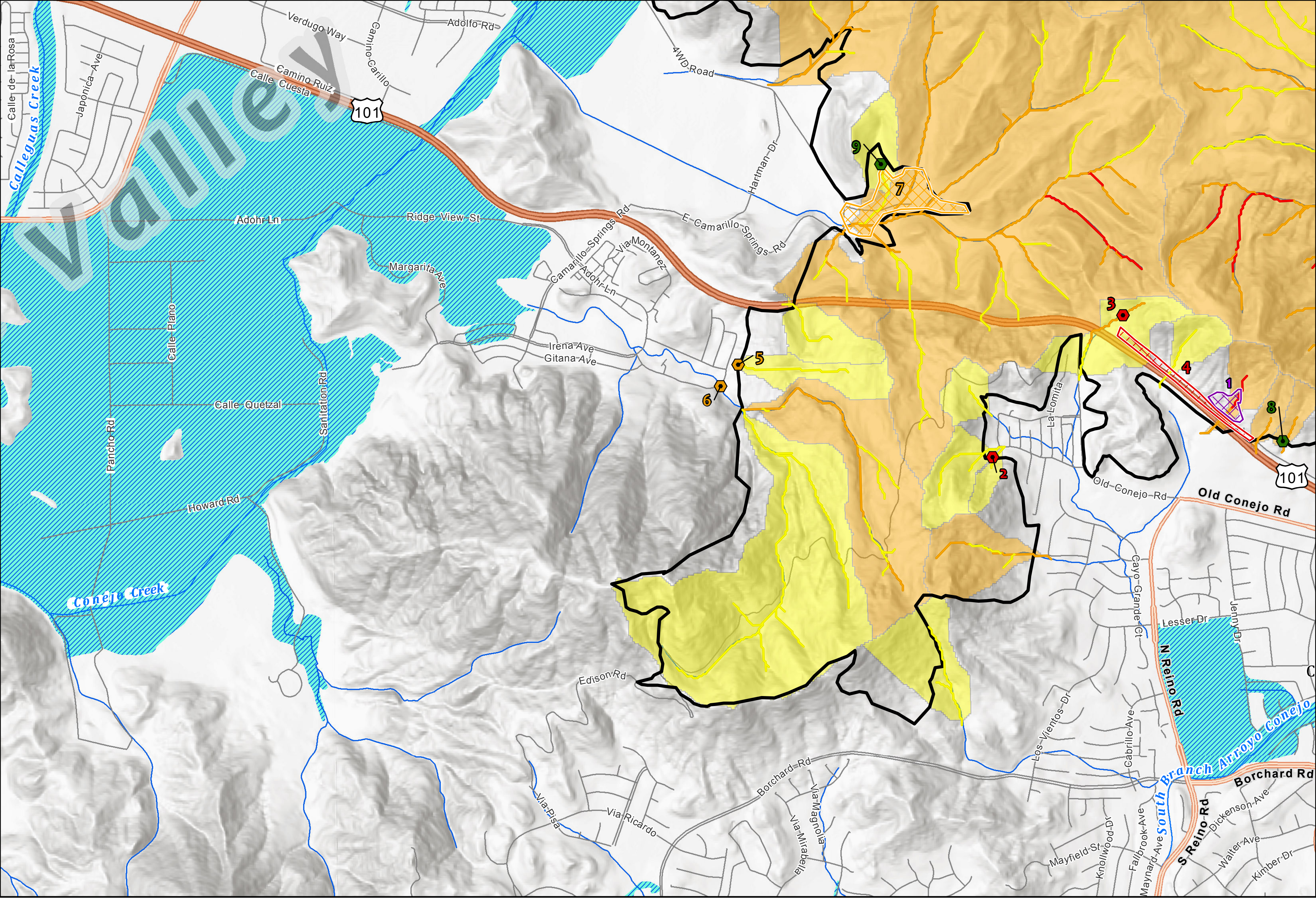

Woolsey Fire
Hill Fire
Watch Streams
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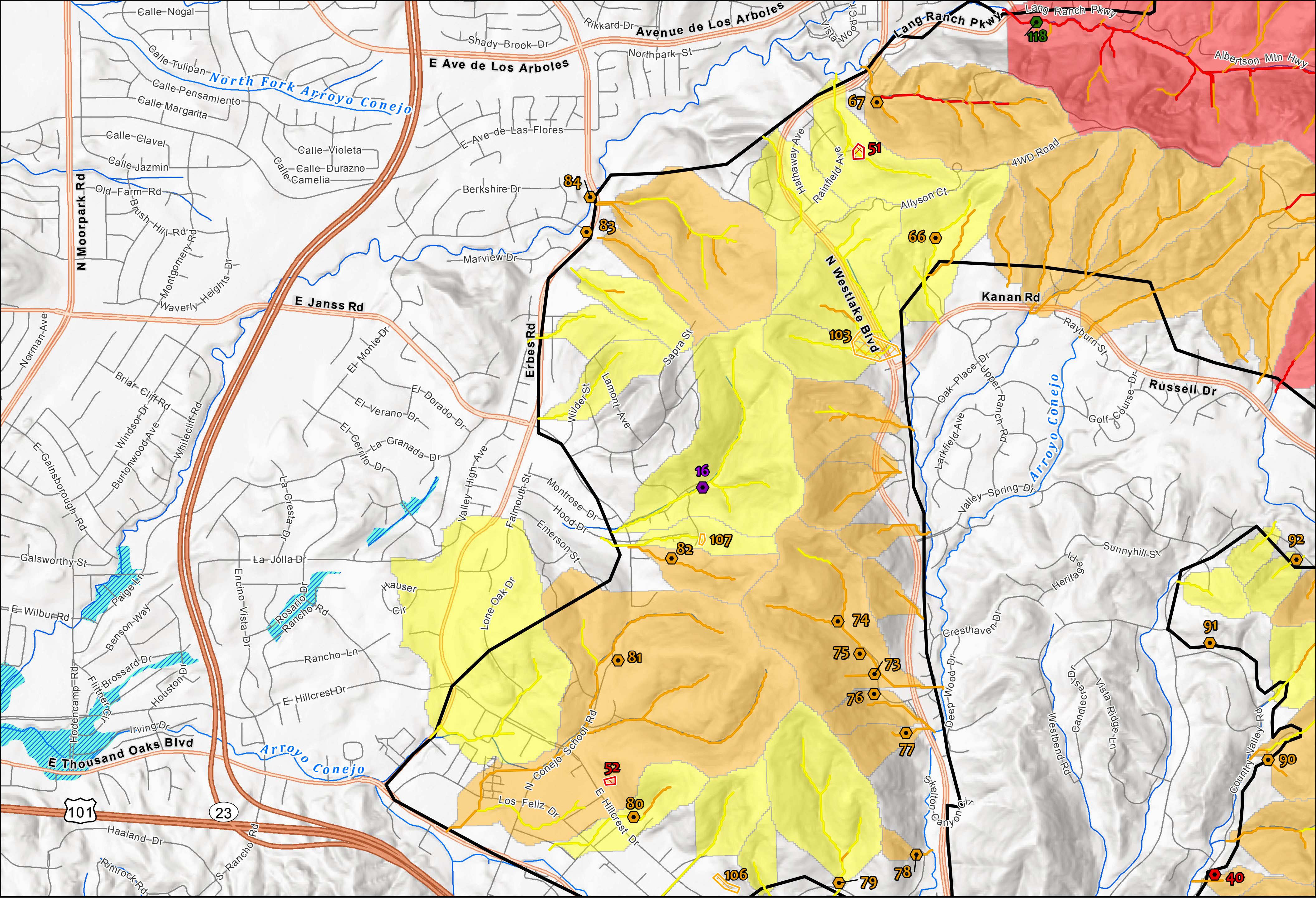

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Hill Fire
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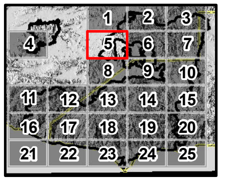

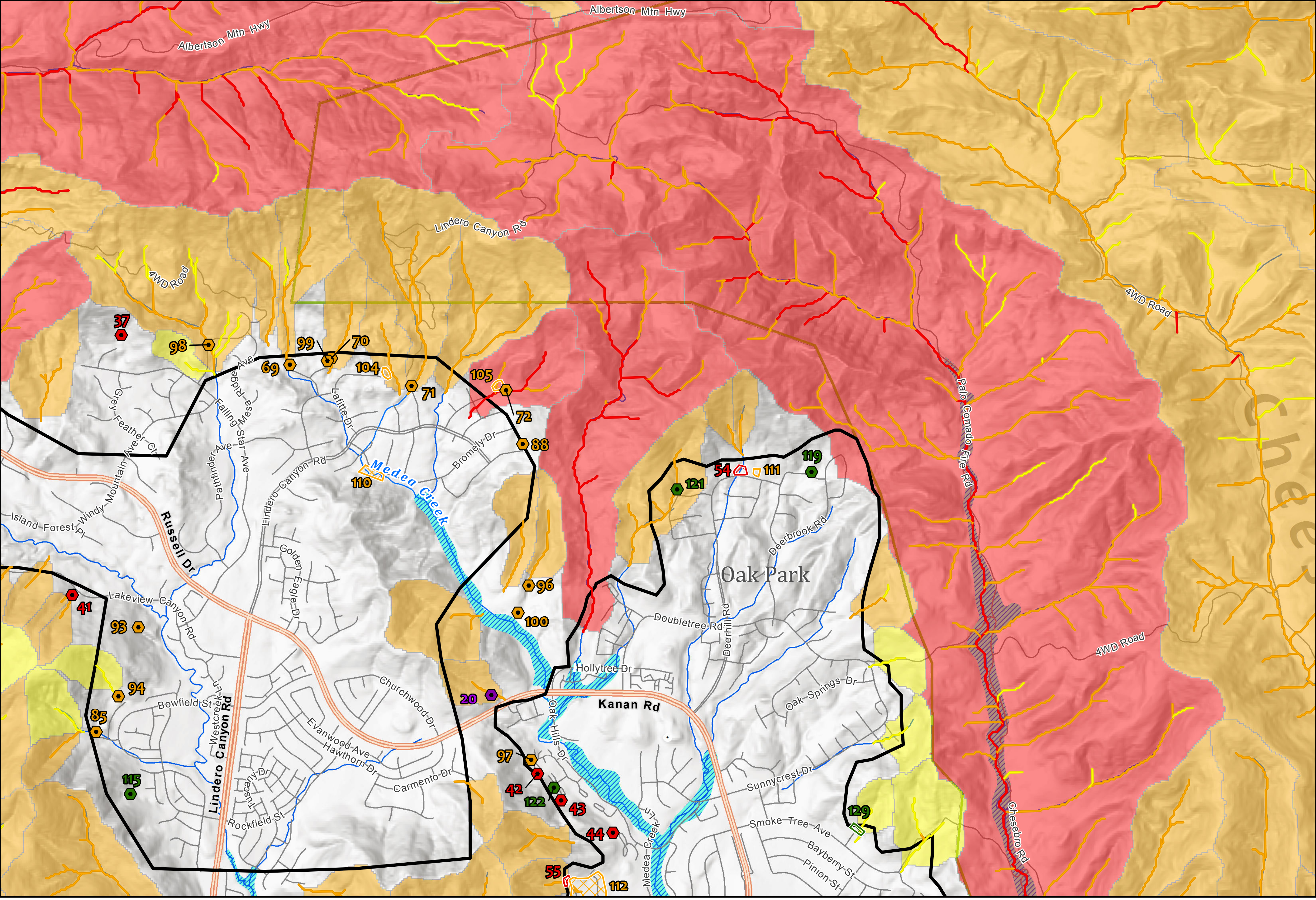

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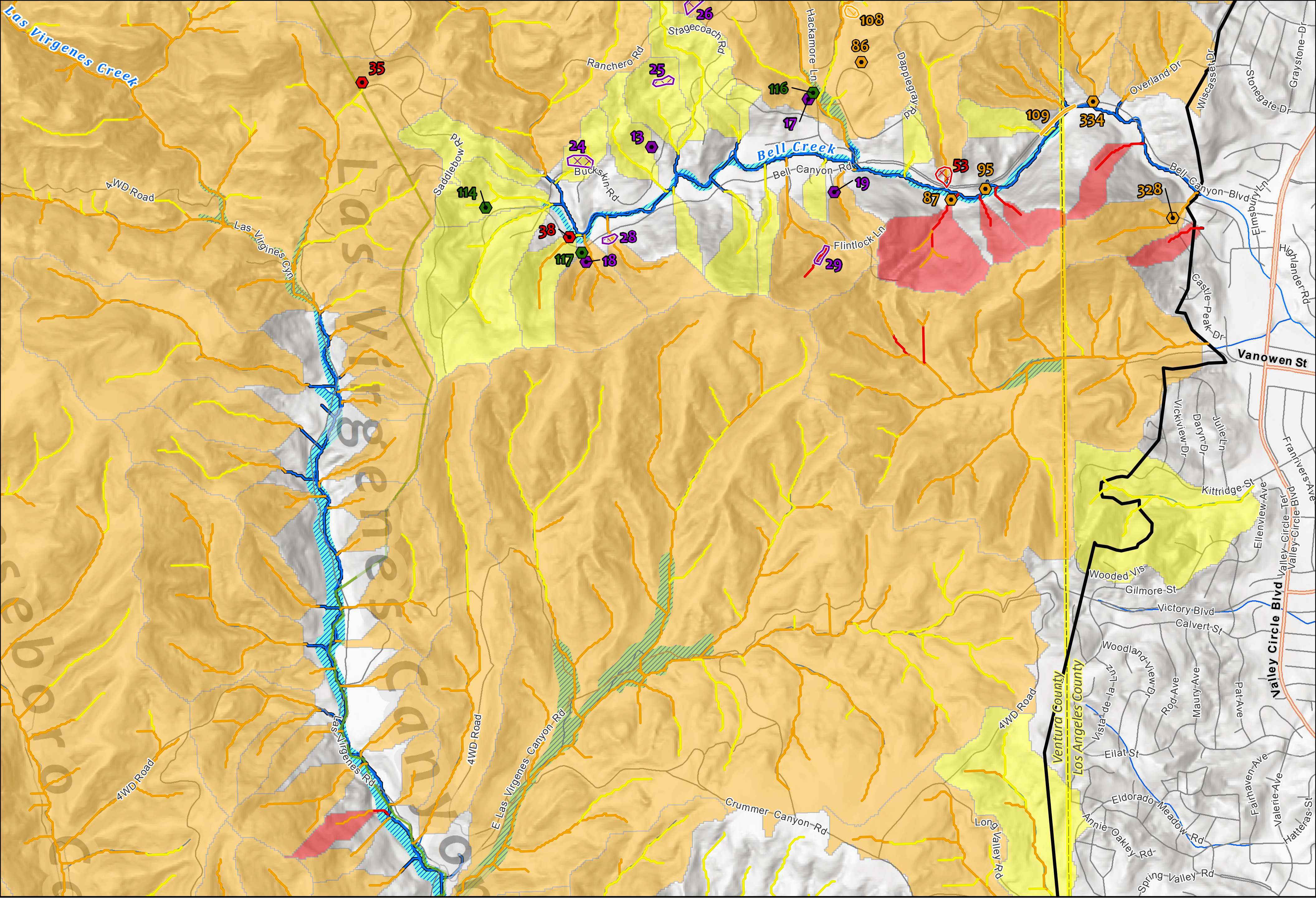

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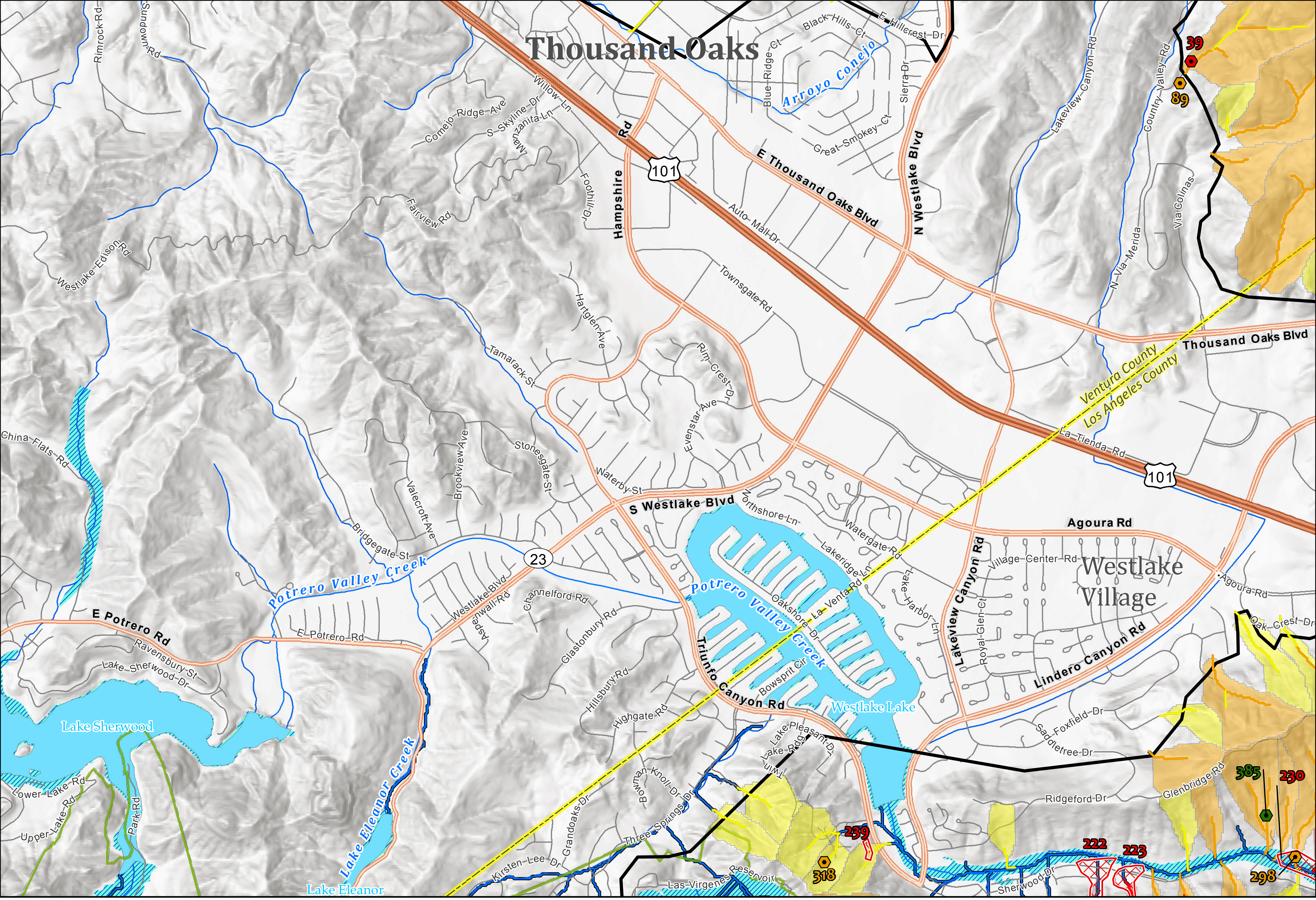

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Hill Fire
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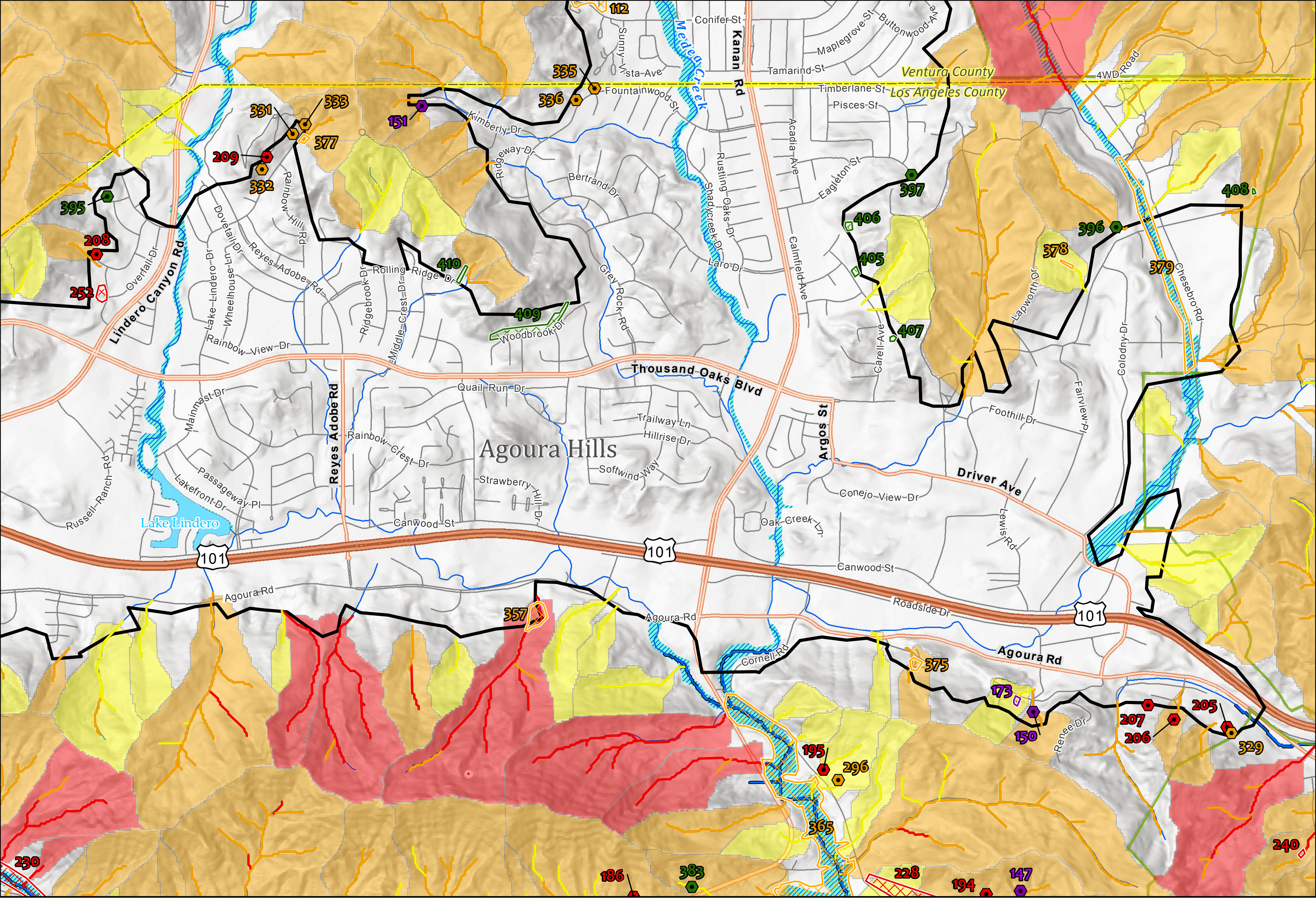

Woolsey Fire Hill Fire

Watch Streams

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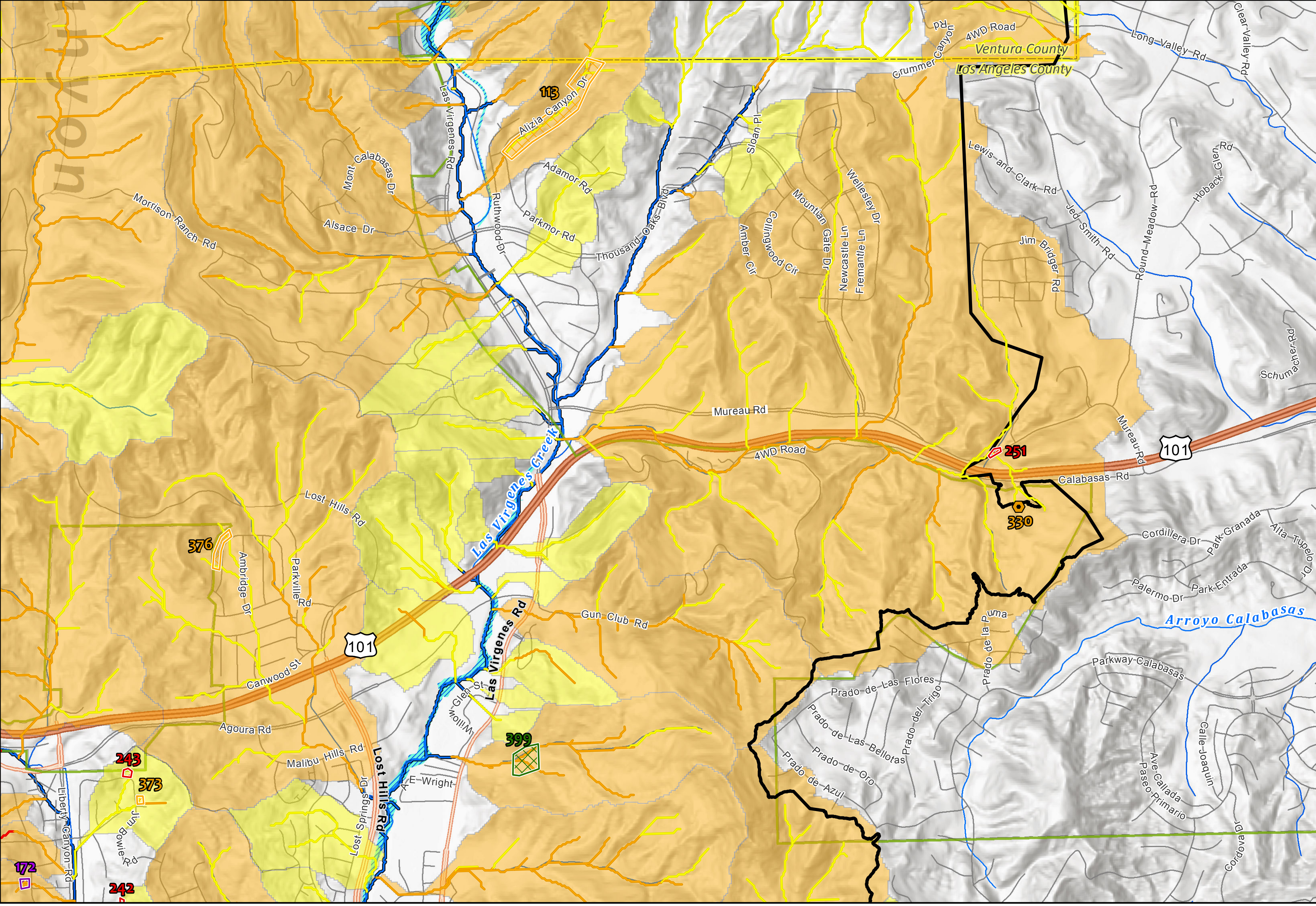

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Hill Fire
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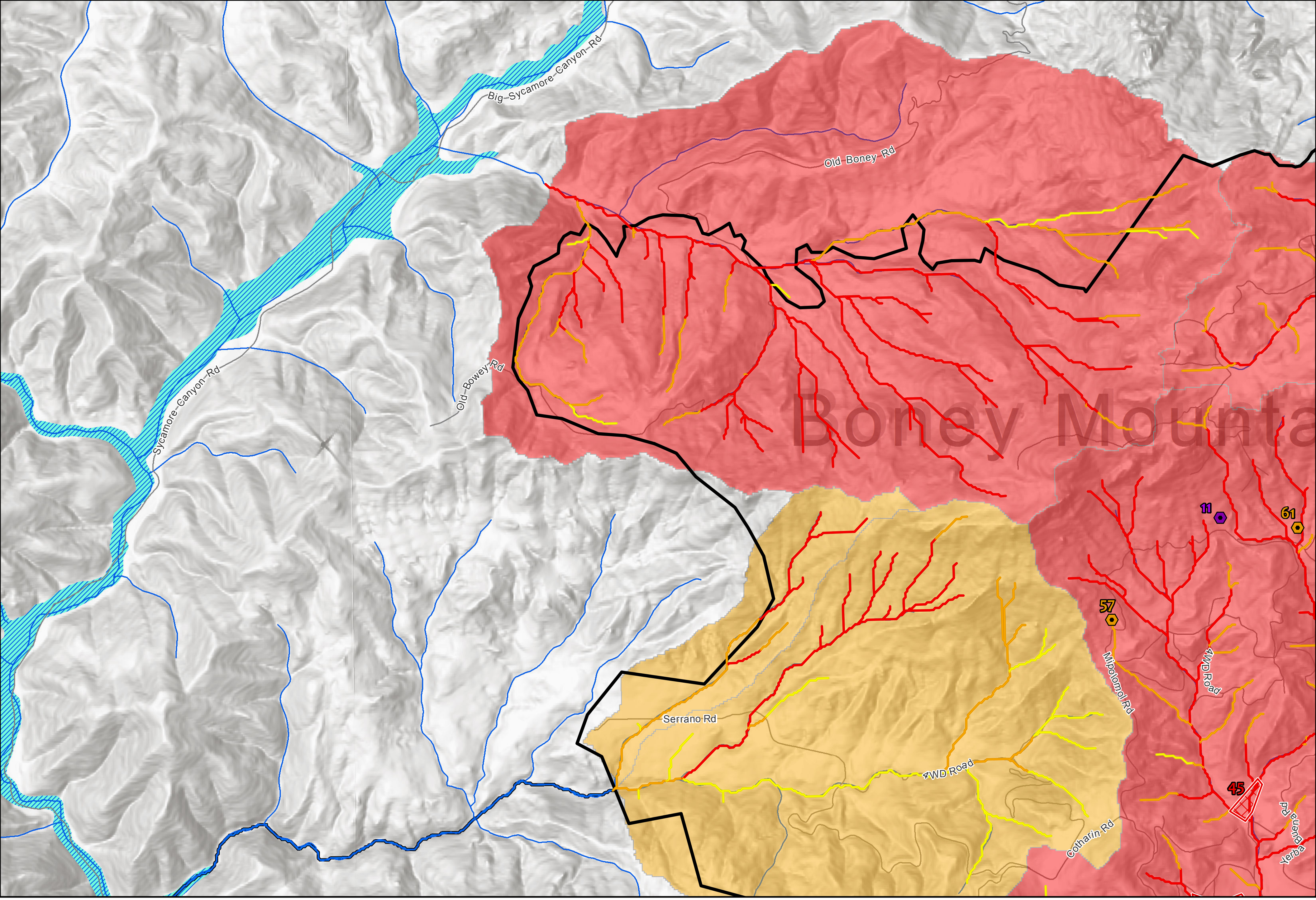

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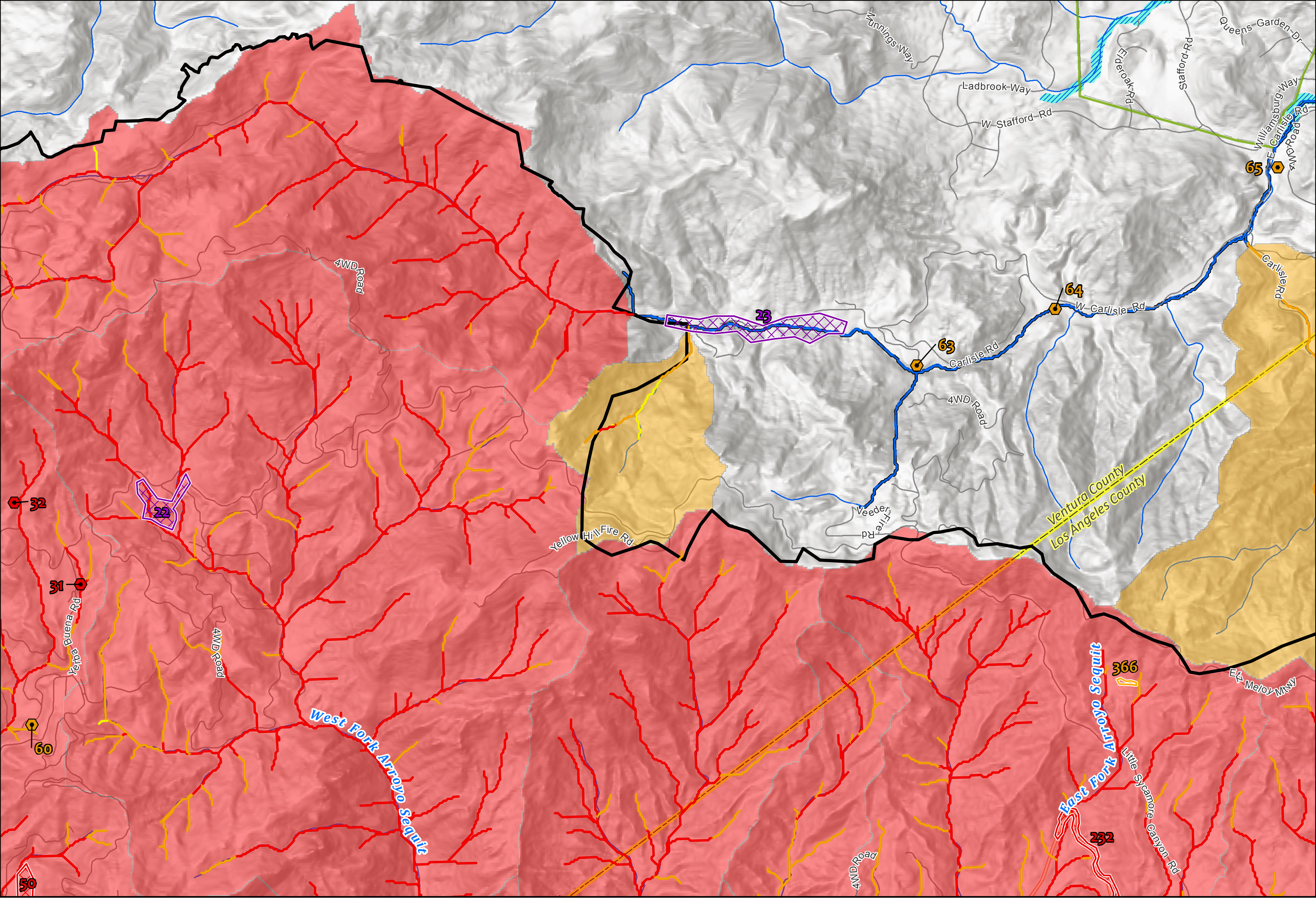

Woolsey Fire | Hill Fire

Watch Streams

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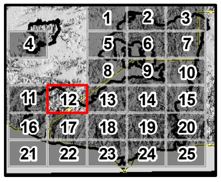

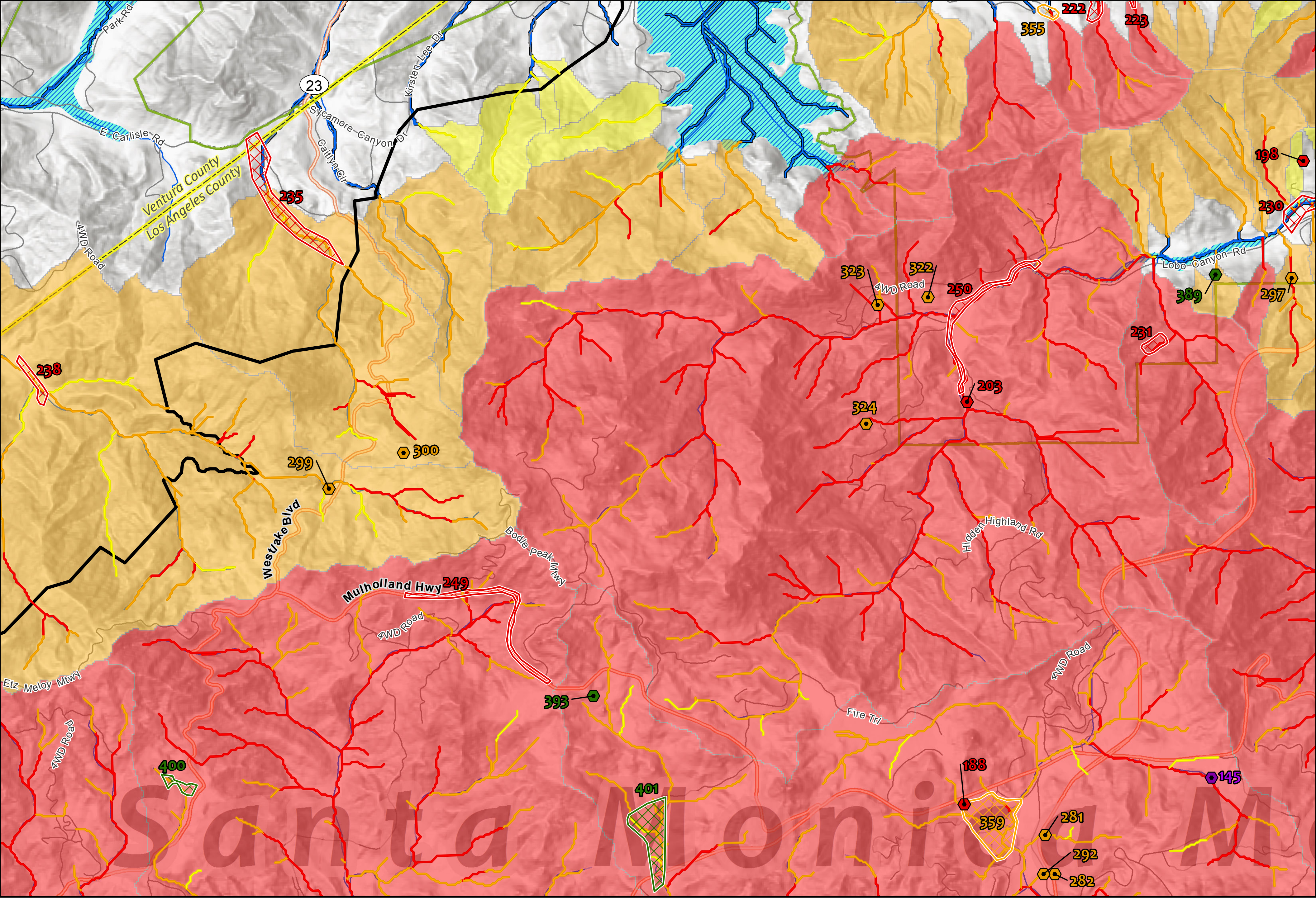

Woolsey Fire
Hill Fire
Watch Streams
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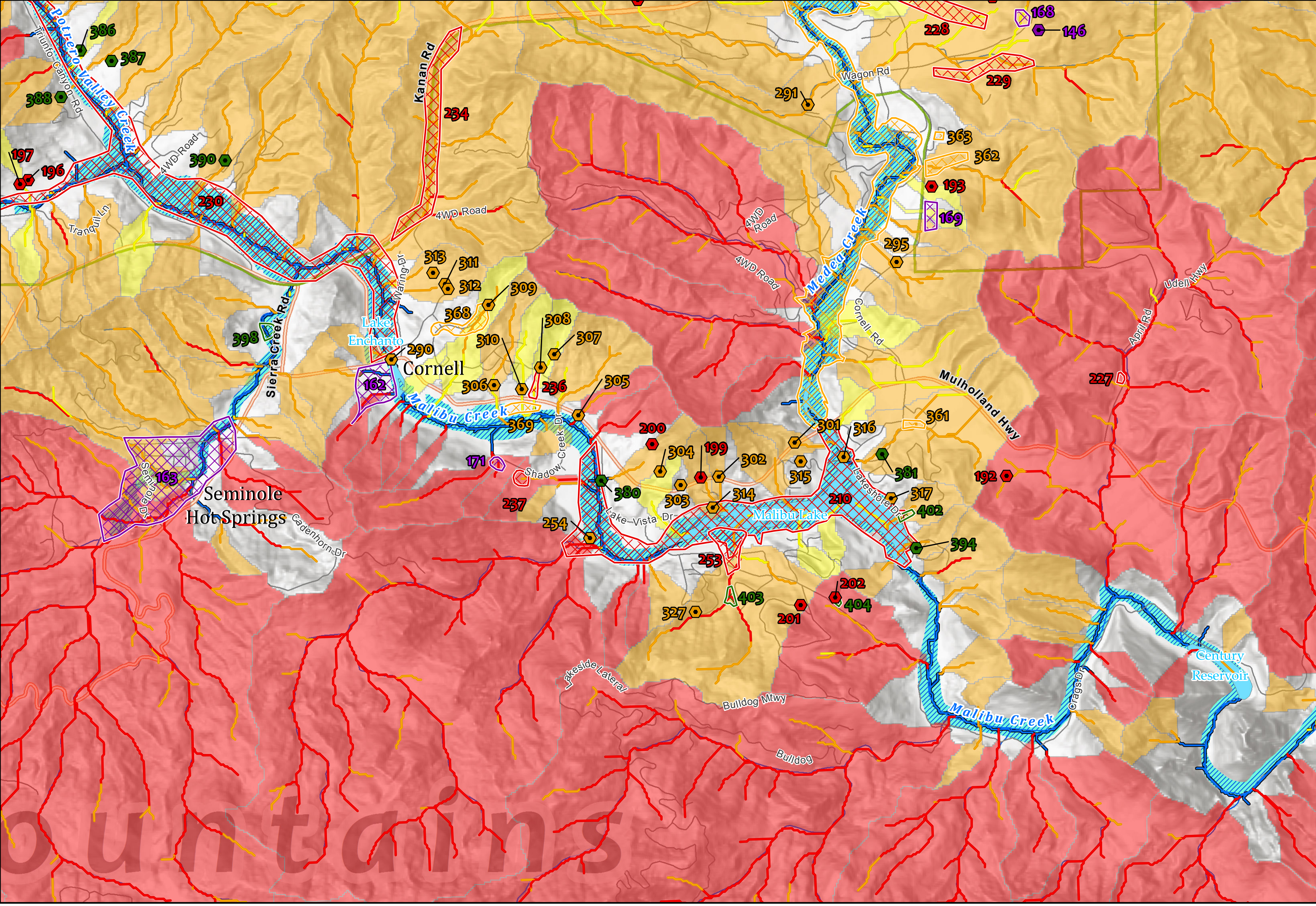

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Hill Fire
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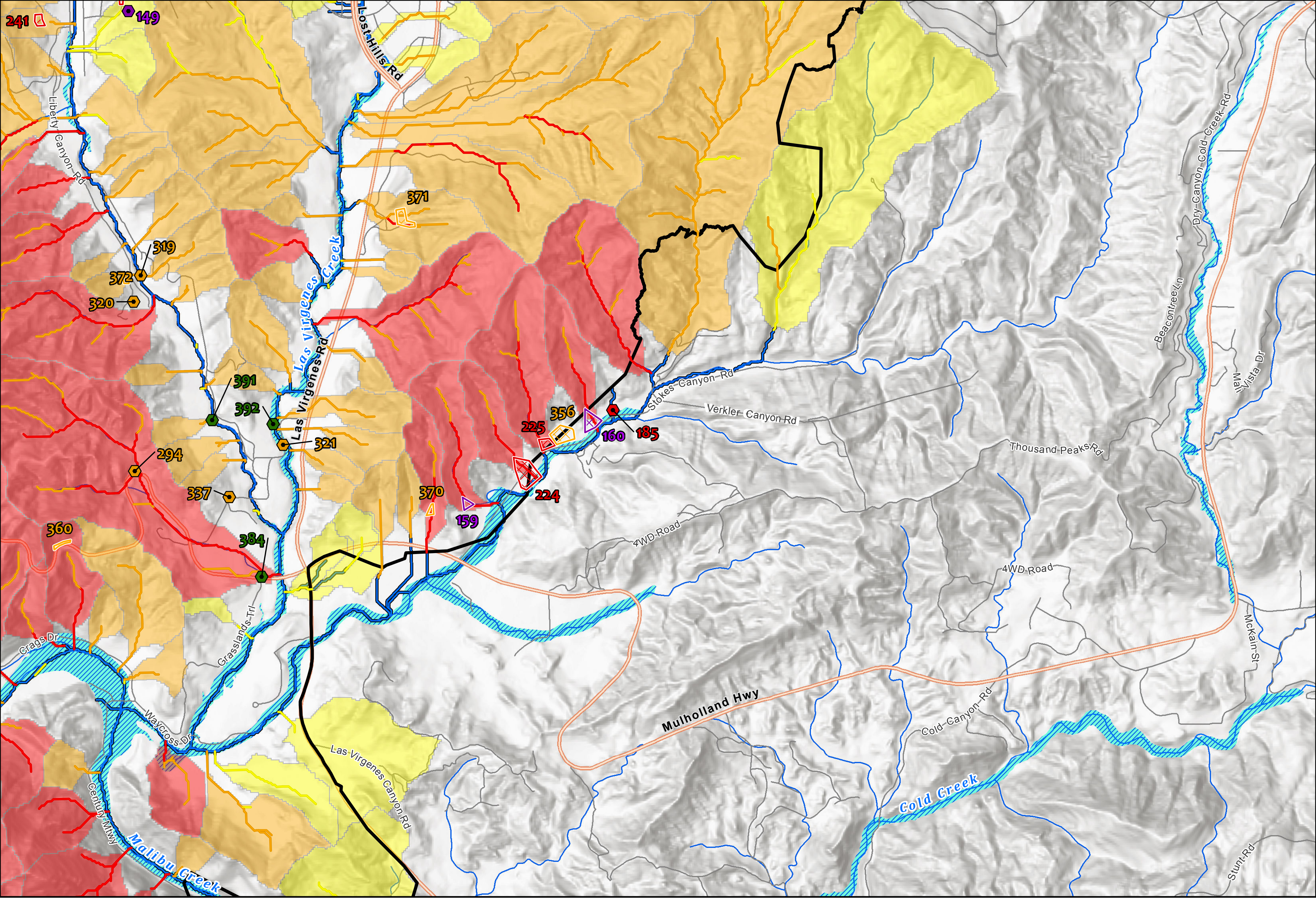

Woolsey Fire | Hill Fire

Watch Streams

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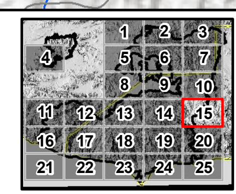

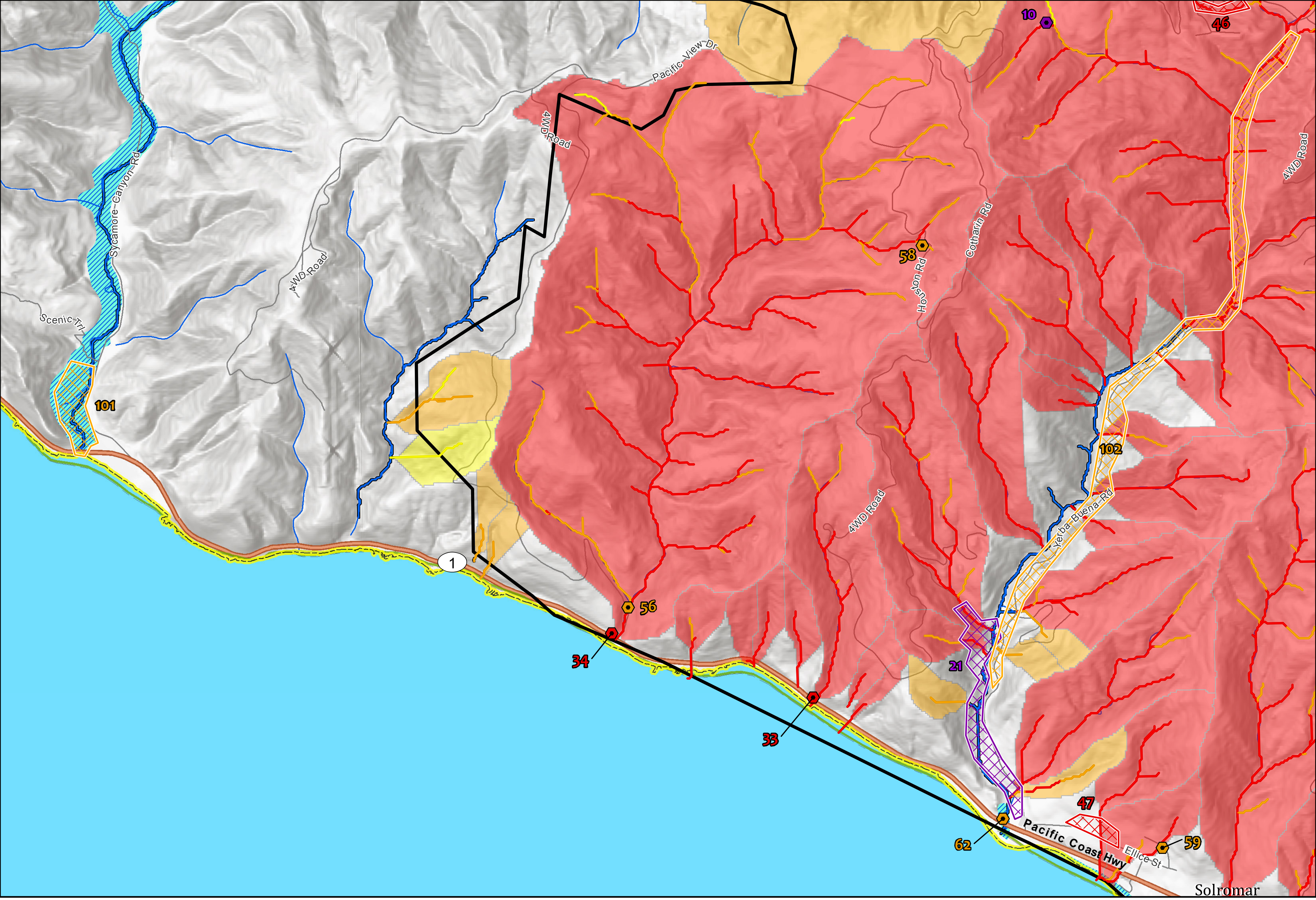

Woolsey Fire
Hill Fire
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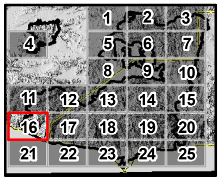

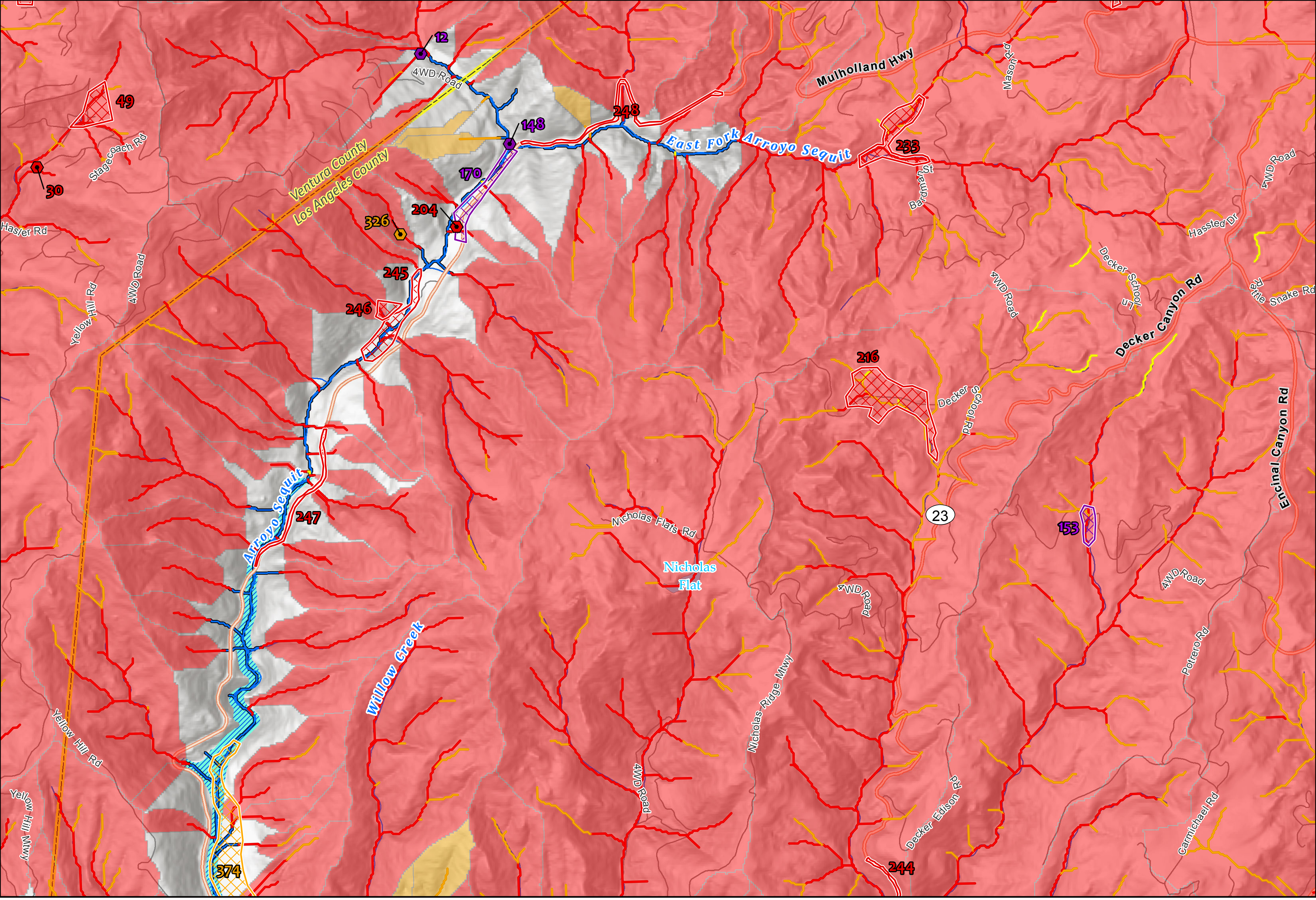

Woolsey Fire
Hill Fire
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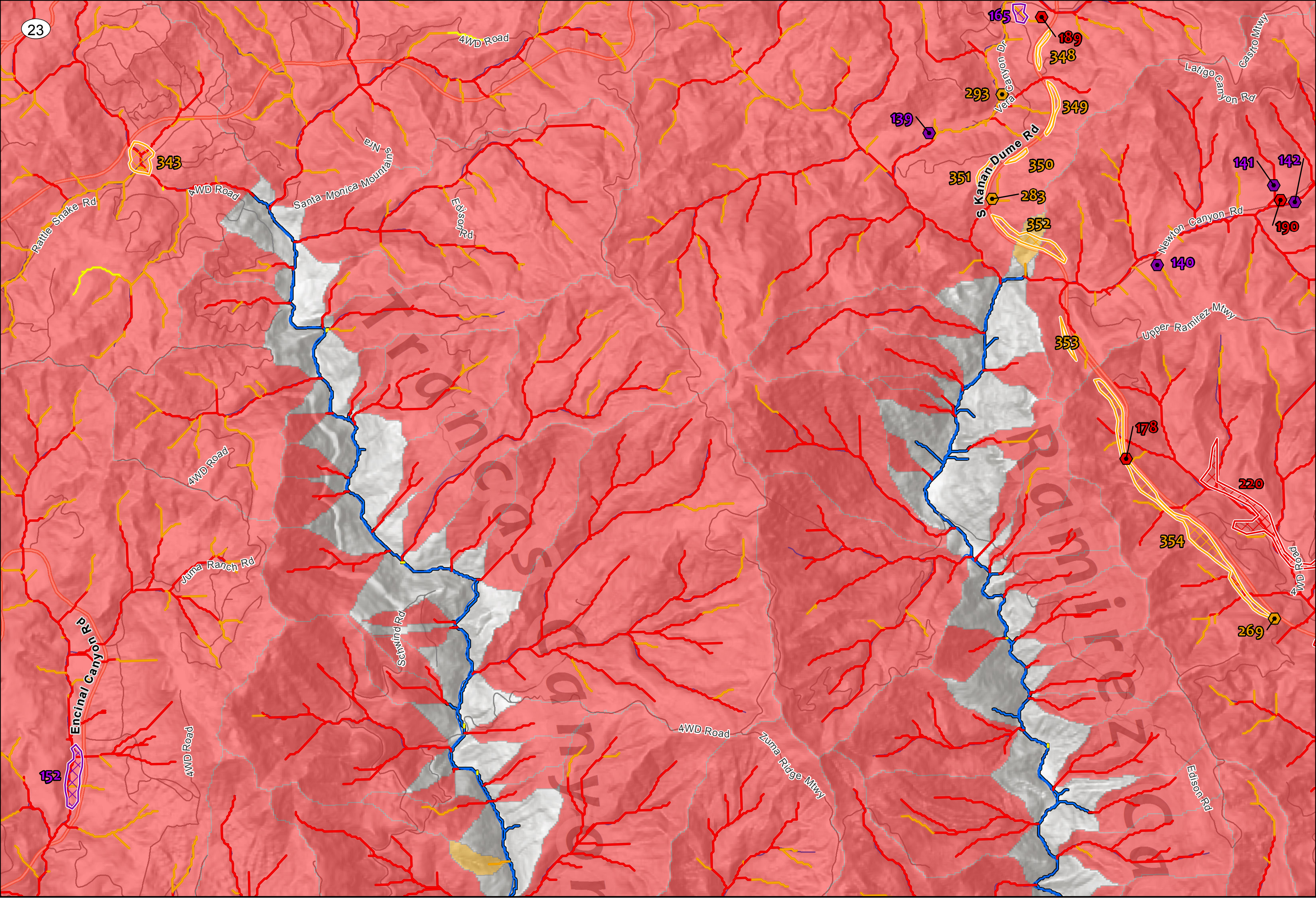

Woolsey Fire Hill Fire

Watch Streams

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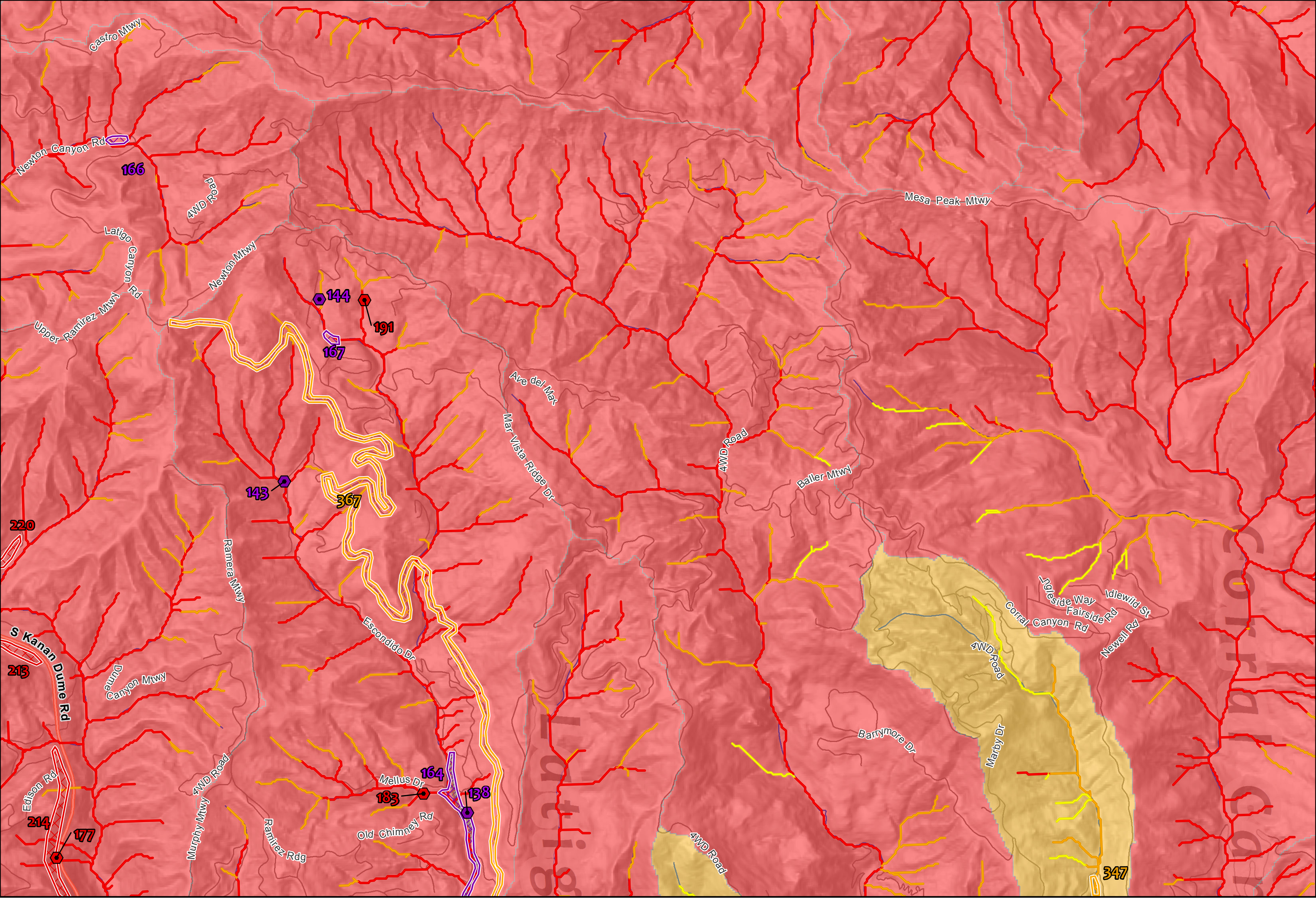

Woolsey Fire Hill Fire

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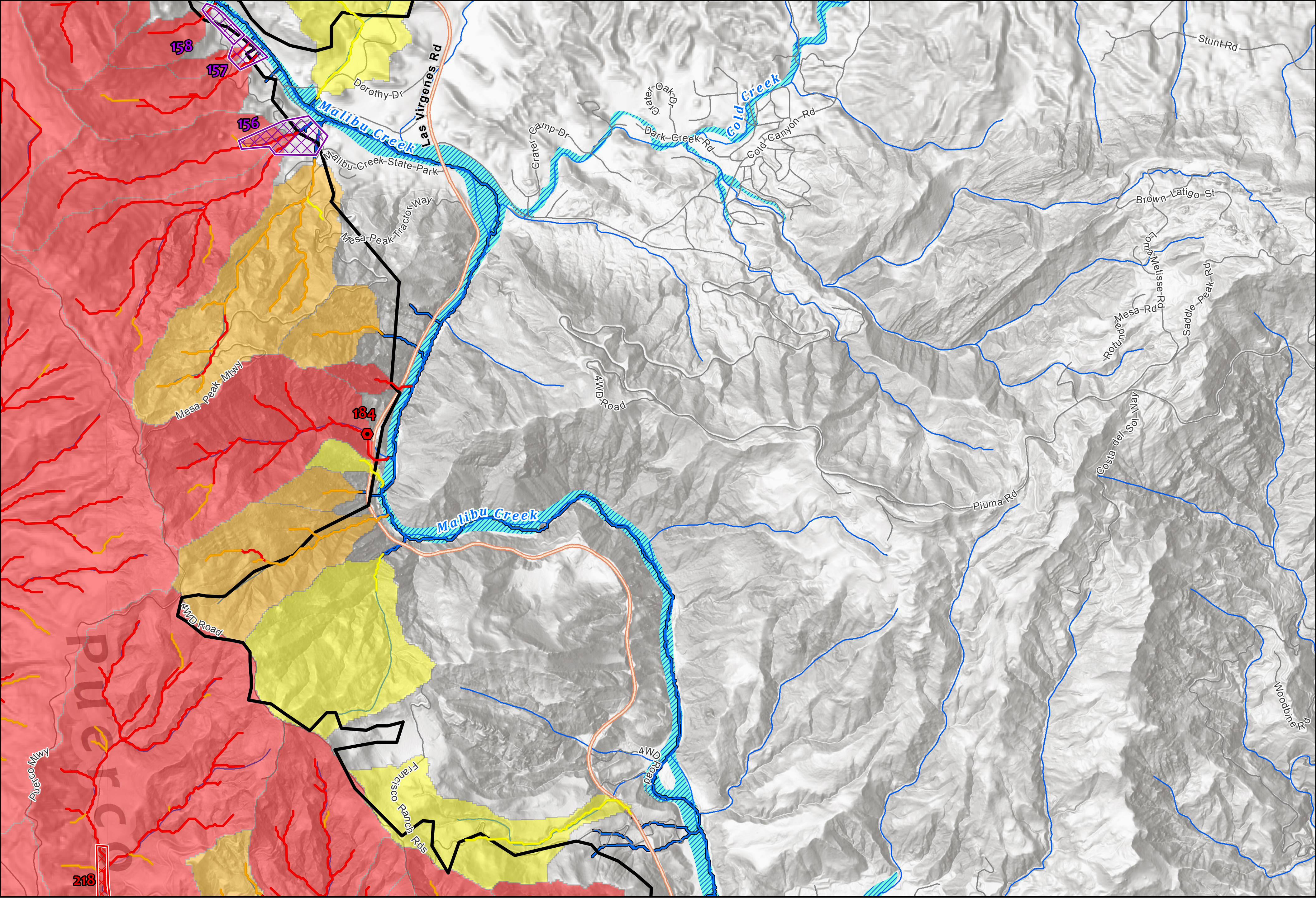

Woolsey Fire
Hill Fire
Watch Streams
FEMA Annual Chance of Flood Hazard - 1% (100yr)

Potential hazard to life

Value at Risk (Point)	Value at Risk (Polygon)
High	High
Moderate	Moderate
Low	Low
None	None

VAR Map

Hill / Woolsey fires

CA-VNC-090993 / CA-VNC-091023

December 7, 2018

0 0.15 0.3 0.6 Miles

1:24,000

N

Segment Combined Hazard
(15-min 40mm/hr)

- Low
- Moderate
- High

Basin Combined Hazard
(15-min 40mm/hr)

- Low
- Moderate
- High

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25

Woolsey Fire
Hill Fire
Watch Streams
FEMA Annual Chance of Flood Hazard - 1% (100yr)

Potential hazard to life

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VAR Map

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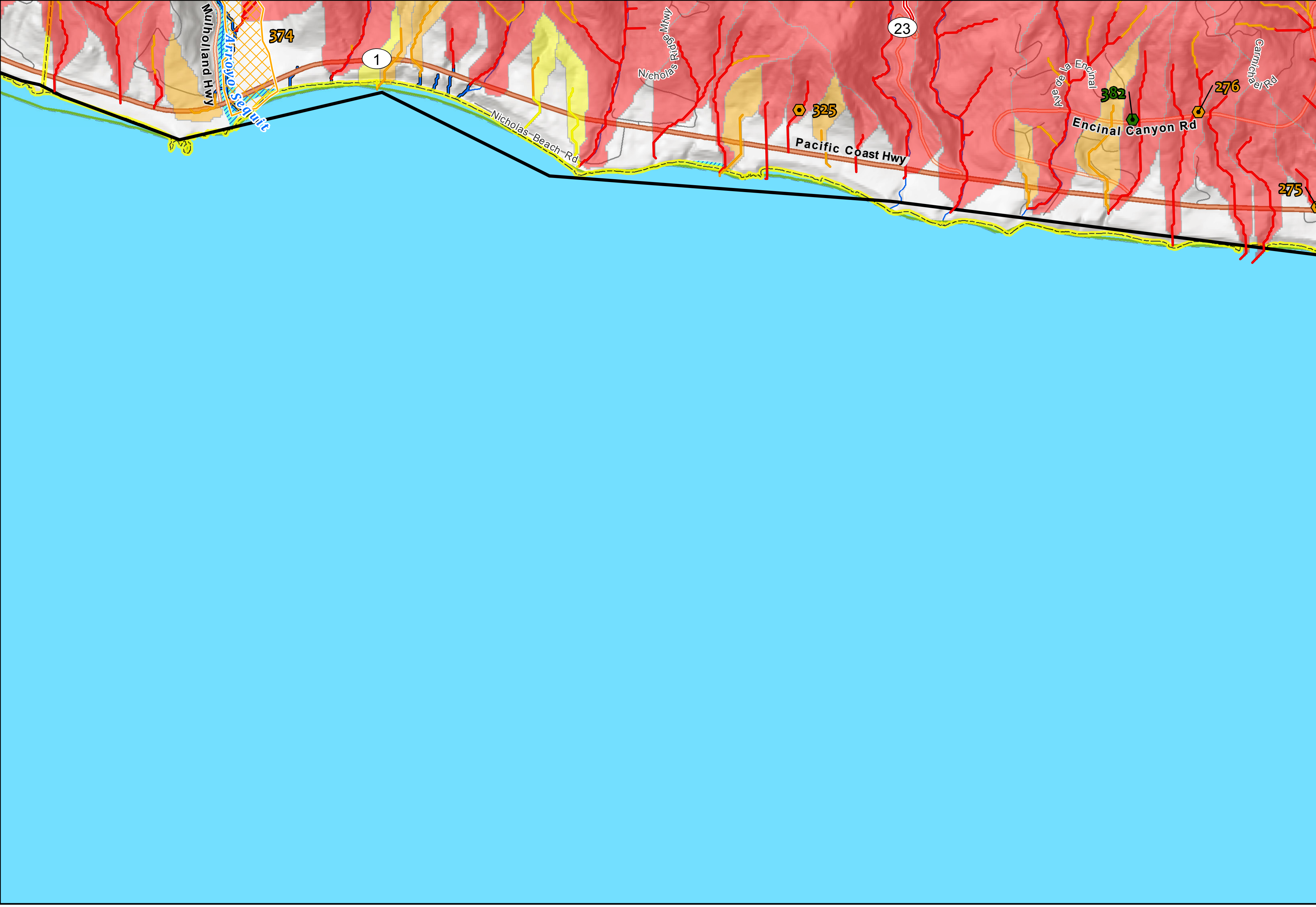

Woolsey Fire
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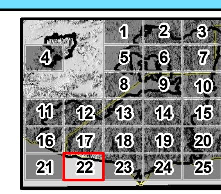

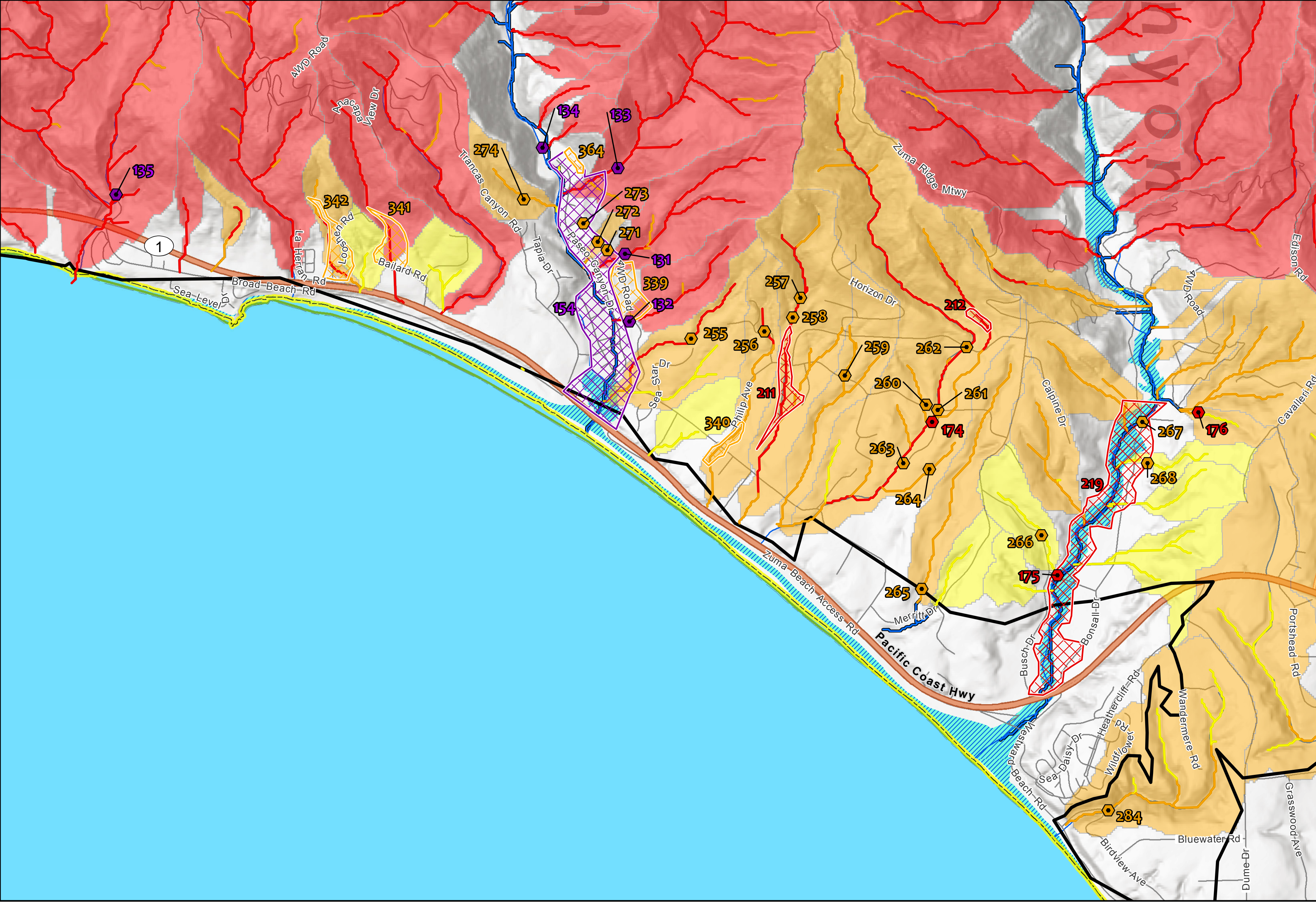

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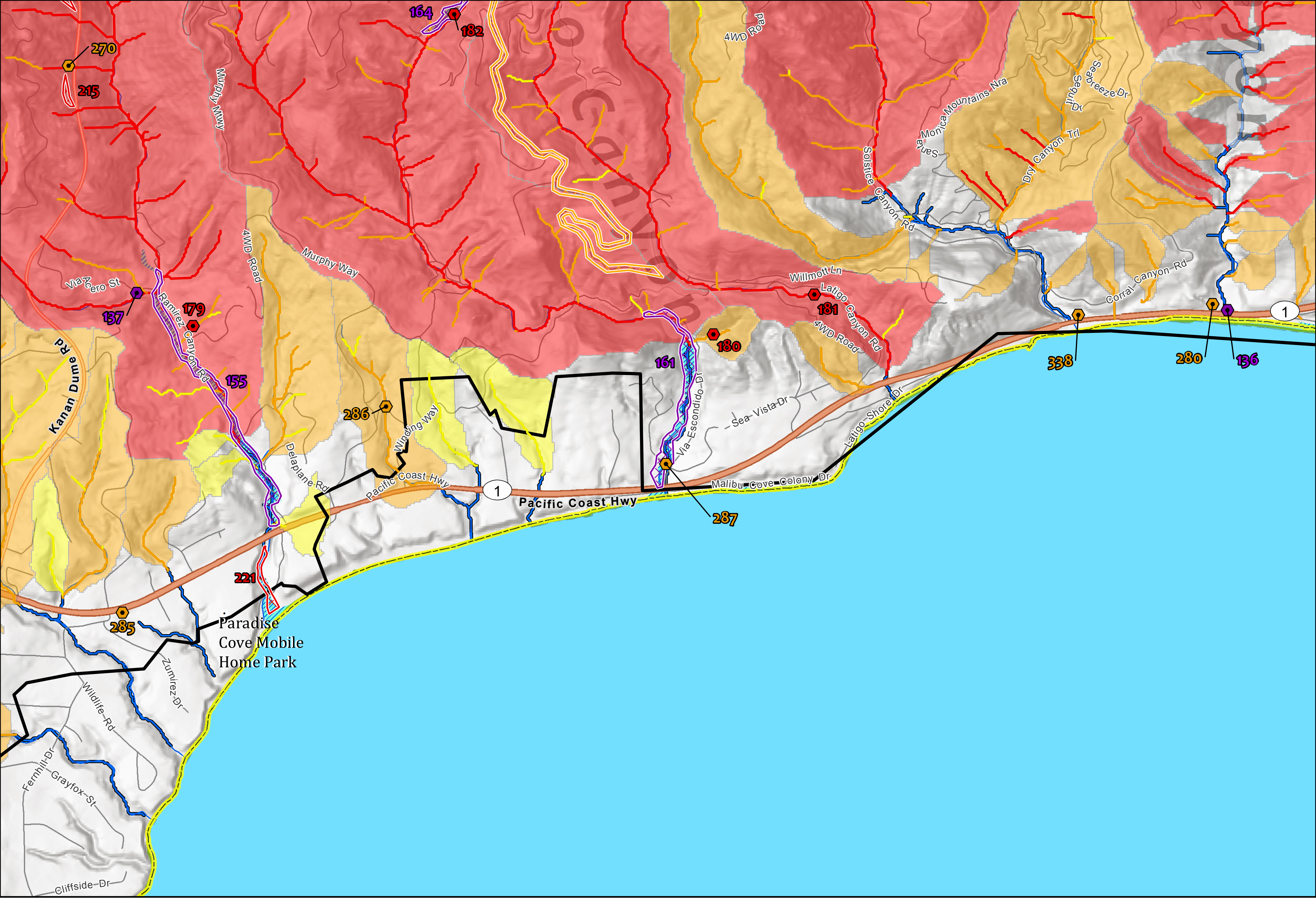
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25



Woolsey Fire
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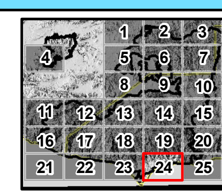

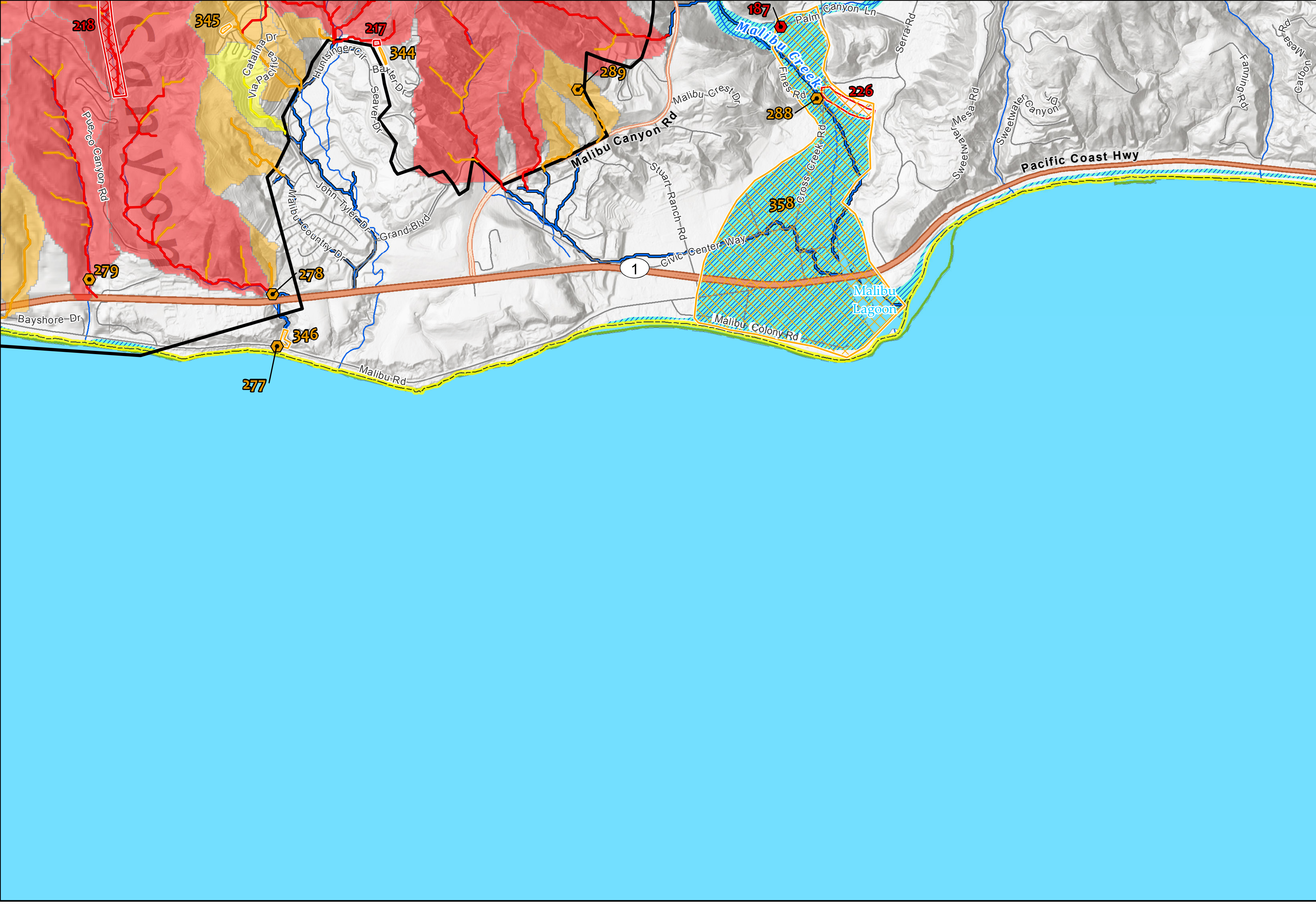

Woolsey Fire
Hill Fire
Watch Streams
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December 7, 2018

0 0.15 0.3 0.6 Miles

1:24,000

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Basin Combined Hazard (15-min 40mm/hr)

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APPENDIX E. PHOTOGRAPHS

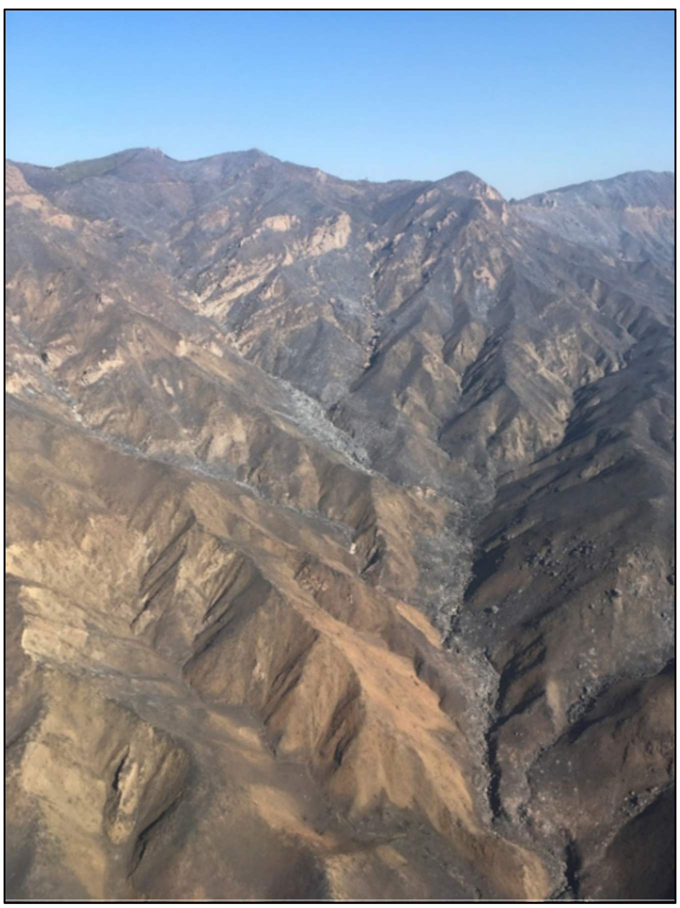
E-1. BARC map validation in the Woolsey Fire with the DOI BAER team on November 21, 2018.

E-2. WERT VAR identification in the Little Sycamore Canyon, located in the Santa Monica Coastal Front region.

E-3. Oak Park existing hazard recorded by the WERT (Malibu Creek north region)

E-4. Oak Park homes determined to be at risk from flooding and debris flows.

E-5. Dry ravel along Yreba Buena Road, located in the Santa Monica Coastal Front region.



E-6. View of the steep Santa Monica Mountains burned by the Woolsey Fire on November 20, 2018.

E-7. Upper Trancas Canyon debris basin, located in the Santa Monica Coastal Front region.

E-8. Upper Trancas Canyon above the debris basin.

E-9. Malibou Lake dam.

E-10. Hill Fire burned slope.

X-11. View of the Malibu Coast and the Woolsey Fire burn area from a helicopter flight on November 20, 2018.

E-12. Wembly Avenue debris basin filled with sediment, Oak Park.

APPENDIX F. VALUES-AT-RISK INFORMATION SHEETS

[See Separate Appendix]