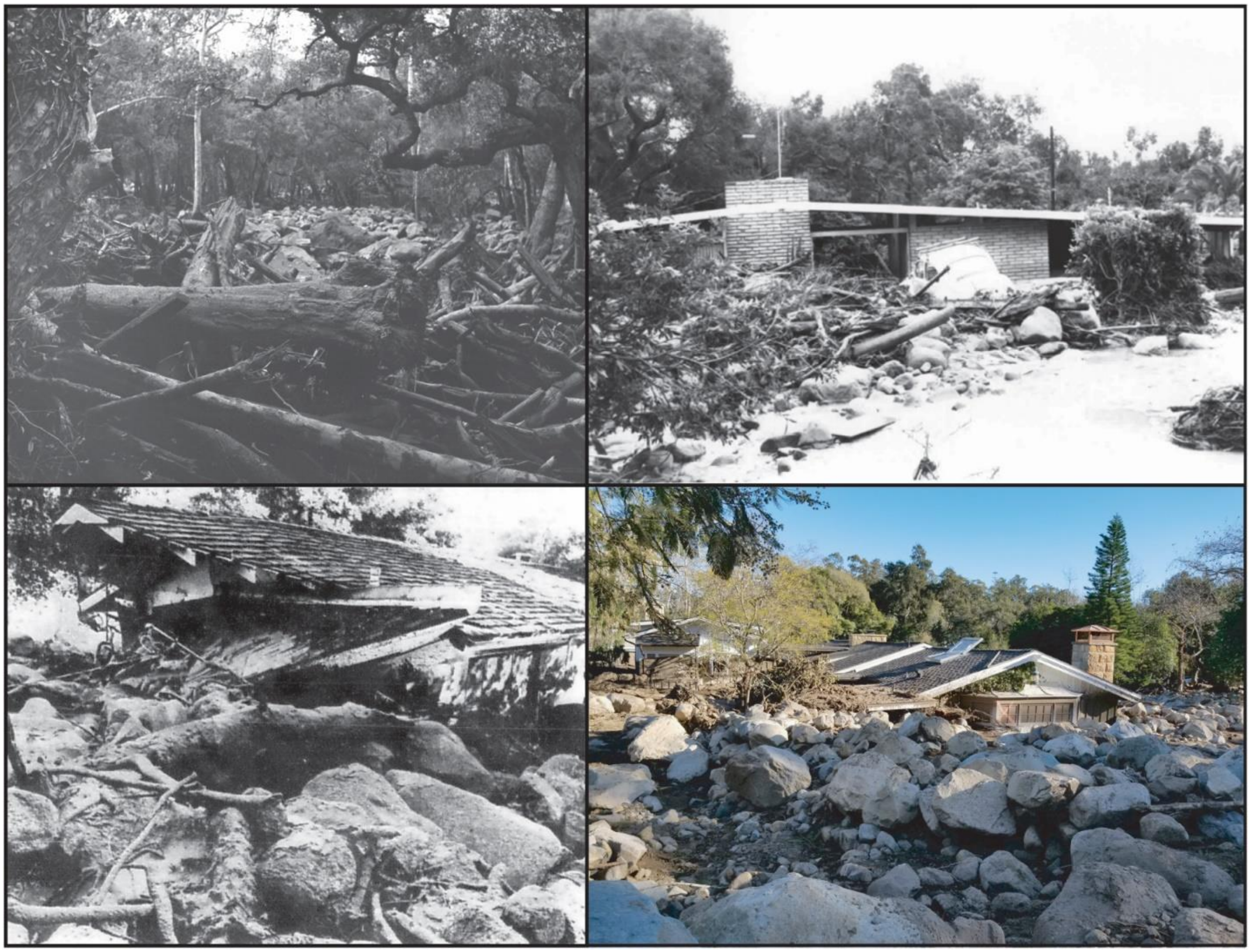
FIRE, FLOOD, AND LANDSLIDE DAM HISTORY:
COMMUNITY OF MONTECITO AND VICINITY
SOUTHERN SANTA BARBARA COUNTY, CALIFORNIA



THE PROJECT FOR
RESILIENT COMMUNITIES

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February 25, 2022

Cover page photographs: Upper left - 1964 debris flows in Cold Springs Creek upstream of the Ashley Road bridge (courtesy of Montecito Association History Committee); upper right - 1969 debris flows in Montecito (courtesy of Montecito Association History Committee); lower left – 1971 debris flows near Toro Creek bridge (The Santa Barbara News Press, December 28, 1971); lower right – 2018 debris flows below the Highway 192 bridge on San Ysidro Creek (Larry Gurrola).

Foreword

This study was funded by The Partnership for Resilient Communities which is now The Project for Resilient Communities (TPRC). We sincerely thank executive director, Pat McElroy and TPRC for their support of this study which will enhance the understanding of the flood history for the community of Montecito. We gratefully recognize an anonymous community member of Montecito for their generous support of this study. This study was advanced by the idea that historical data could shed light on the recent past flood history and improve our knowledge base.

We sincerely express thanks to Trish Davis of the Montecito Association History Committee for her valuable assistance of our research of the fire and flood history of Montecito, and advisement to explore additional avenues of research. Santa Barbara historian Hattie Beresford contributed to our efforts with a review of our mapping of damaged properties in the era of 1914. She also provided assistance in the development history of Montecito and shared her 2006 article, "*Storm Watch: The Day It Rained Worms*" that described debris charged floods in April 1926. . Architectural historian Jean-Guy Dubé assisted in resolving the location of a pre-1861 location of the channel of Montecito Creek.

We appreciate the opportunity to learn from Rick Raives former Director of Public Works at City of Ventura (retired), and how the City of Ventura cooperated with private industry to mitigate a landslide dam outbreak flood in 1998. We also thank Ashlee Mayfield of the Montecito Trails Foundation and Lisa Neubert, Programming Librarian at the City of Santa Barbara for their contributions to this study. Chris Ervin of the Gledhill Library at the Santa Barbara Historical Museum assisted with his knowledge of the local resources and history. We acknowledge Giana Magnoli and Noozhawk for the use of Noozhawk photographs in our report.

This study is in an initial assessment of a long-term debris flow assessment and mitigation study to improve the resiliency of the community and increase protection of the residents and property. The conception of the idea that the community of Montecito could equally employ appropriately placed debris basins at or near the canyon mouths of the Santa Ynez Mountains with the same success as other communities, and the development of these systems would prevent future loss of life was offered by an anonymous community member. The philosophy of "…doing the right thing for the community" formed the foundation for this study. It is with this philosophy that those that place their confidence in us, allowed us the opportunity and privilege to lay the path forward to help the Community of Montecito to become aware of their environment and develop a plan to make the community safer, more resilient in an environmentally cohesive manner.

"*The floods make their own powerful appeal to guard against fires, for in the fires is found the cause of storm damage.*" Thomas M. Storke (Santa Barbara Daily News, November 29, 1926).

"*And don't forget to say that this flood is an excellent lesson in fire prevention... With a protective covering on the ground, a heavy rainfall would not have caused such serious damage."* warned Supervisor Thomas T. Dinsmore following the 1926 landslide dam outbreak flood on San Ysidro Creek (The Morning Press, February 12, 1926).

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Introduction

Discharge of post fire debris flows out of the Santa Ynez Mountains canyon mouths on January 9, 2018 (1-9 event) and through the community of Montecito resulted in devastating impacts that resulted in not only significant loss of life, but substantial infrastructure and property damages (Figures 1A and 1B). The community is located on a series of alluvial fans which were formed by repeated debouching of sediment and debris charged floodwaters from steep, mountain catchments referred to as “debris flows” and “debris laden floods” in this study (Figure 2). The frequency of the debouching of mud and coarse debris and degree of impacts to the community of Montecito over the development history of the last 200 years was largely unknown and is the objective goal of this study.

Flood history studies are commonly part of debris flow hazard assessments (Jacob and Hungr, 2005) and this study utilizes the methodology established by a previous study by Dowling and Santi (2013). In addition, this study requires additional descriptive evidence beyond the Dowling and Santi (2013) methods to classify a debris laden flood and debris flow. An investigation following the 2004 Peeks Creek Debris Flow in Macon County, North Carolina identified 14 historic events in the last 110 years (Latham et al., 2007). They include a report of an 1876 debris flows that clearly described triggering rain, unleashing of soil down to bedrock, that progressively incorporated vegetative debris and entire trees along the flow path. Another study used historic documents to construct a continuous history of landslides, debris flows, and stream floods for the last 150 years which has important implications in the planning process (Tropeano and Turconi, 2002).

Progressive growth of the community of Montecito in high flood hazard areas increases the debris flow risk to residential structures and property owners (Jakob and Hungr, 2005). Most important to community members is the debris flow hazard posed to their property and their family, not necessarily the magnitude of the debris flow. Smaller magnitude debris flows can still cause significant damage from impacts by boulder and log debris. It is the objective of this study to inform community members of the hazards posed and the potential risks, even when the watersheds of Montecito are in a non-burn condition.

Purpose of Study

With the understanding that the community of Montecito is developed on actively accumulating alluvial fans and that the fire-flood sequence is one of the most destructive and dangerous geologic hazards posed to communities developed on such fans, important questions were raised following the 1-9 event. “*How often do debris flows occur in Montecito*” and “*what were the magnitude of impacts”?* Initial opinions to these critical questions were offered, however without much verification in the local historical record. Because of the lack of detailed knowledge, this study of the fire and flood history of the Montecito and surrounding communities was initiated. The net result is a vastly improved knowledge base of the flood history and a better understanding of the occurrence of debris flows in Montecito over the last 200 years. Enhanced understanding of past meteorological factors such as short duration, high intensity or prolonged and saturating

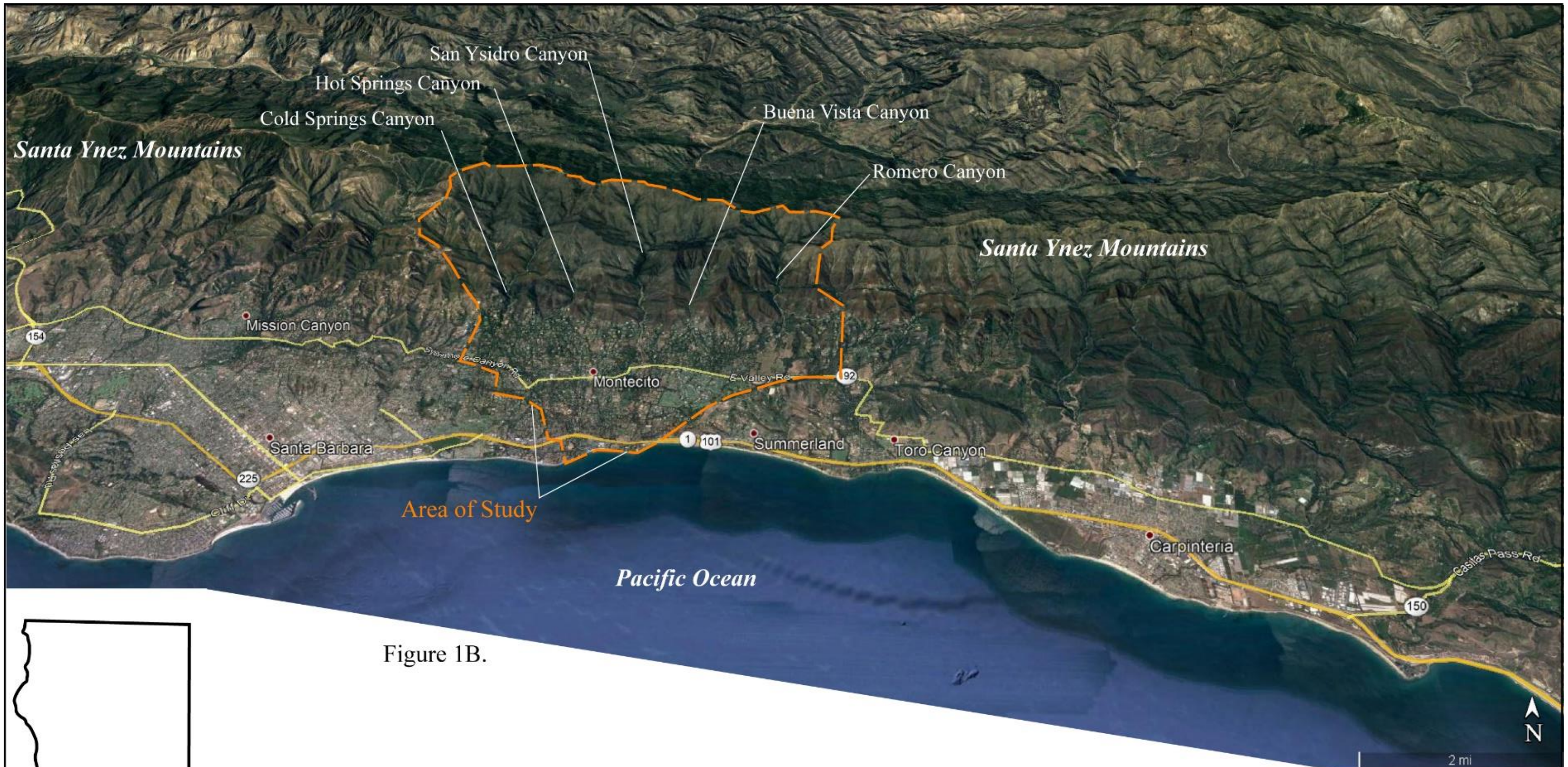

Figure 1B.

Google Earth image.

Figure 1A.

Figure 1A (Left). Location of the western Transverse Rangesin province in southern California. Figure 1B (Above). The communities of Santa Barbara, Montecito, and Carpinteria are situated below the steep slopes of the Santa Ynez Mountains on the coastal plain. The main canyons of the mountian catchments that discharge sediment and water onto the plain are shown. These watersheds form the study area that is shown as an orange, dashed line.

Figures 1A and 1B.

Location Map

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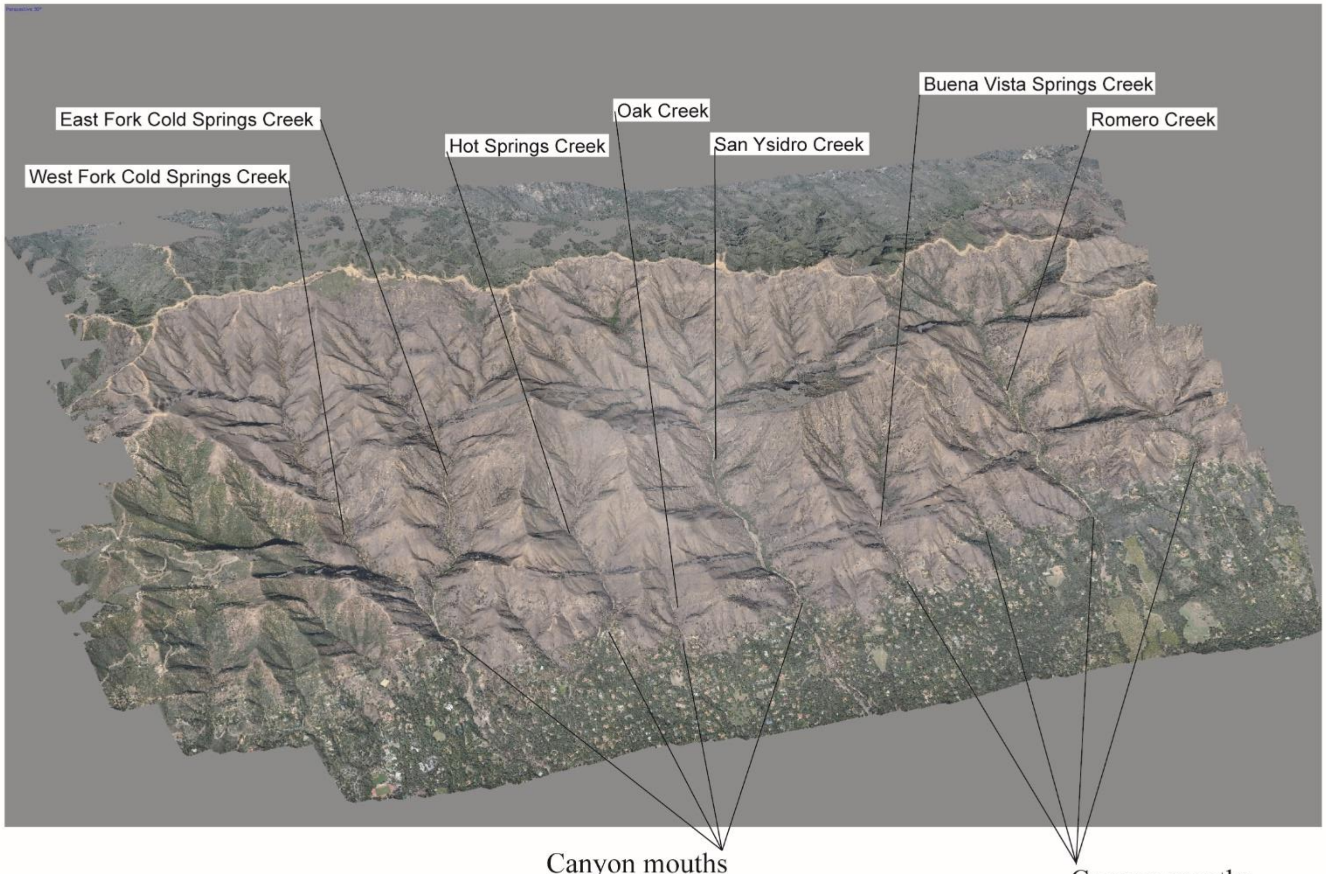

Figure 2.

Mountain Catchments
Montecito, California

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Oblique view of the steep terrain, mountain watersheds (catchments) and the upper fan areas situated below the canyon mouths. These catchments collect runoff, sediment, and debris that drains and debouch at the canyon mouths, where the natural process allows floods, debris laden floods, and debris flows to spread out in a radial manner below the canyon mouths. The community of Montecito is developed on the alluvial fans along and below the canyon mouths.

Image provided by the United States Geological Survey.

precipitation events provide valuable information of the triggering mechanisms. Collectively, the occurrence and frequency of past flood events can be established.

The purpose of this historical study is to research and record past flood events with debris laden flood and debris flow events, and to ascertain the relative level of damages, inundation extent, and mapping of previous flood paths. The goal of this historical research is to acquire evidence of past events, and as a result, establish frequency of these events in the 19th and 20th centuries. Although large debris flow events are especially damaging to communities built on alluvial fans, the cumulative effects of smaller debris flows can also cause significant property damage and loss of human life (Rodine et al., 1974; Dowling and Santi, 2013). This is the reason that smaller debris flow events were also tallied in this study.

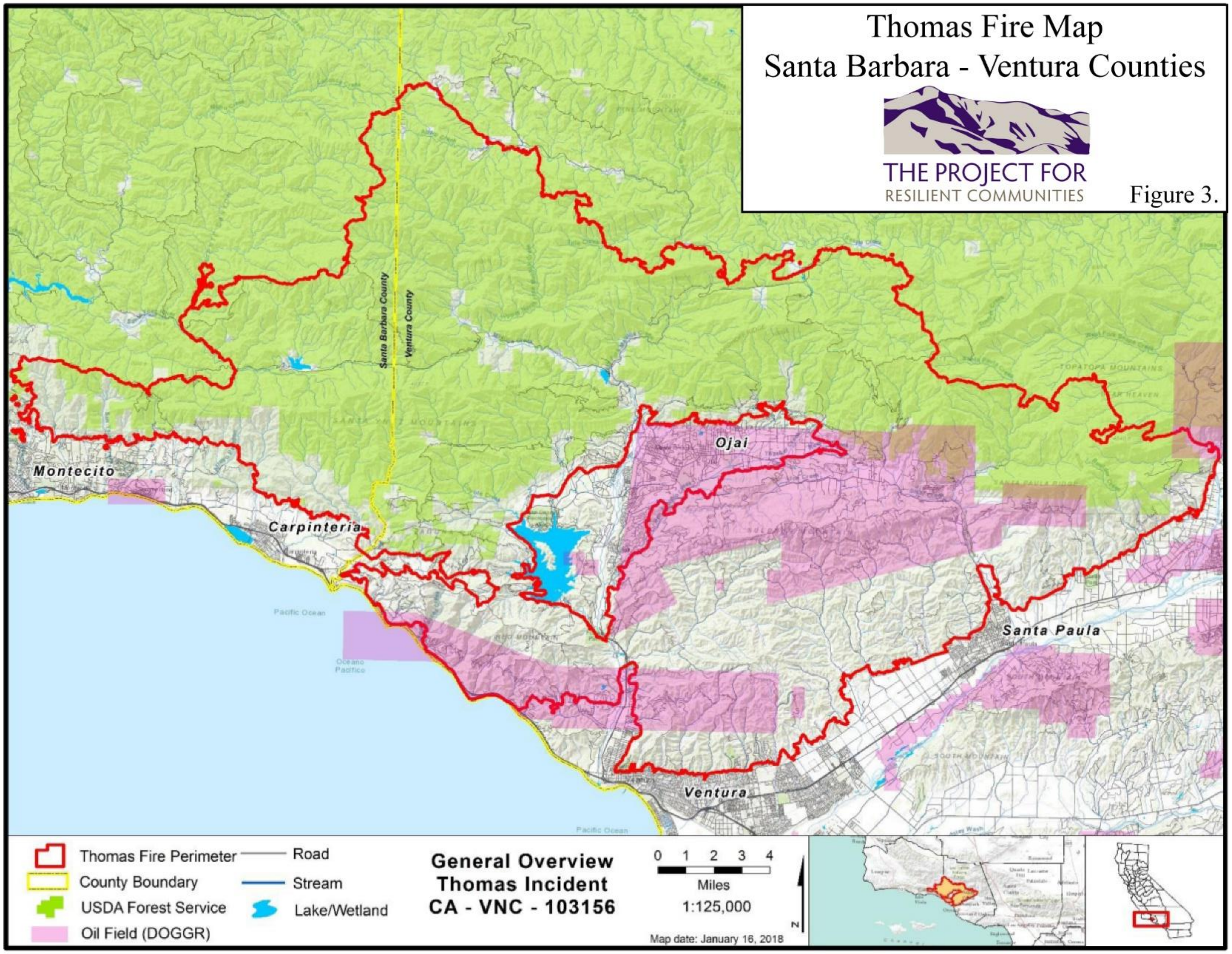
This study is based on the geologic corollary of the Law of Uniformitarianism; the recent past is the key to understanding the near future and places emphasis on historic flood events that can be classified as debris flows, debris laden floods, and landslide dam outbreak floods to establish the causes and triggering factors; relative magnitude of events; determine the number of watersheds affected; and identify those events which occurred in post-fire conditions within a 5-year period. In addition to the fire and flood history, this study accounts for past occurrences of large landslides that created temporary landslide dams that resulted in destructive outbreak floods. A compiled inventory of debris laden flood, debris flow, outbreak flood events is presented in Table 1.

Recent flood events in the 20th century are well-recorded in historic newspapers and literature, however reports become less available in the mid-19th century. Although accounting for flood and debris flow events for nearly 200 years may not represent the long-term (1,000 to 3,000 year) frequency of events, it does provide for a better understanding of the recent factors and processes involved in triggering and the impacts to the communities in the recent past. The population of the Montecito community in the middle 19th was a small fraction of the present-day population with only 47 voters registered by 1869 (Myrick, 1988).

The fire history of the Santa Barbara-Montecito-Carpinteria areas is extensive and this study records fire events that occurred five years or less prior to a flood event to identify post-wildfire debris flow events from events caused by other factors such as long duration, intense rainfall or cumulative high rainfall seasons. This will segregate post-wildfire triggered events from high antecedent moisture conditions where prolonged or high cumulative precipitation often initiates debris flows and landslides. The recognition of wildfire followed by formation of a landslide dam and subsequent outbreak flood is established and understanding of the conditions conducive to formation and the timing of initiation to failure is critical information for emergency response and evacuation plans.

January 9, 2018 Event

The 1-9 debris flow event was preceded by the Thomas Fire which started in Ventura County on the 5th of December 2017 and due to Santa Ana wind conditions, quickly burned westward into the watersheds of Montecito and Carpinteria (Figure 3) (County of Santa Barbara OEM, 2018). Three weeks after the wildfire decimated the vegetation of the Montecito watersheds, a narrow, cold front on January 9, 2018 (1-9) triggered post-fire debris flows that devastated the community of Montecito (Lancaster et al., 2021; Kean, et al., 2019; Lukashov et al., 2019).



Overview of the extent of the 2017-18 Thomas fire in the watersheds of Santa Barbara and Ventura Counties. The community of Montecito is located in the western area of the fire zone. Base map from WERT (2018).

The rainfall event that initiated the 1-9 event, although rare was not unprecedented, and produced sufficiently high precipitation rates in a short period of time discharging post fire debris flows. These voluminous and destructive flows erupted from the canyon mouths and quickly produced overflows in confined channels and at channel bends; creating blockages at bridge and culvert constrictions; and choked channels resulting in the spreading of large volumes of debris on the fan surface and adjoining alluvial fans (Figure 4).

The 1-9 event resulted in twenty-three (23) fatalities, damaged or destroyed over 500 homes, damaged infrastructure including closing Highway 101 for thirteen days, and caused an estimated billion dollars in economic losses (Lancaster et al., 2021; County of Santa Barbara OEM, 2018; Niehaus, 2018 and 2019; Kean et al, 2019). Jackson (2019) reports that 1,000 rescues occurred in the first 24 hours following the disaster which prevented the doubling of the number of fatalities. Extensive recovery included removal of debris and mud from streets, public and private properties, repairing infrastructure, and rebuilding of the community. Additional information regarding the 1-9 event is described in the History of Events Section.

Area of Study

This history evaluation tallies flood events that occurred in watersheds located south of the of the Santa Ynez Mountain ridge divide between Gaviota to the west and Carpinteria to the east (Figure 1B). From west to east, the communities of Goleta, Santa Barbara, Montecito, and Carpinteria are located at the base of the Santa Ynez Mountains on a coastal plain. Special focus was placed on events that occurred within the extent of the community of Montecito and adjacent watersheds including the creeks of Cold Springs, Hot Springs, Oak Creek, San Ysidro, Buena Vista, Romero and Picay (Figure 5).

Analyses of the qualitative and descriptive damages were performed in the Montecito watersheds, including Cold Springs and Hot Springs tributaries as a test to determine if flow paths could be recreated, mapping of past avulsion sites, and assess the debris flow magnitude relative to the 1-9 event, either smaller, similar, or larger in magnitude. Two additional post fire debris flow events that occurred north of the Santa Ynez Mountain ridgeline in 1926 are briefly discussed but not included in the final tally as it provides additional evidence that the fire burned south of the divide creating post-fire conditions in the Santa Ysidro Canyon prior to the 1926 landslide dam outbreak flood.

Methodology

Flood accounts were investigated to tally the number of events and classify the debris charged flood events, in addition to recording details of the events (Table 1). Debris charged flood events are classified as debris flows or debris laden flood events, and these types of floods transport considerable to vast amounts of coarse-grained debris, such as boulder and vegetative debris onto the fans. Vegetative debris consists of brush, tree logs, tree trunks, branches, and other types of chaparral vegetation.

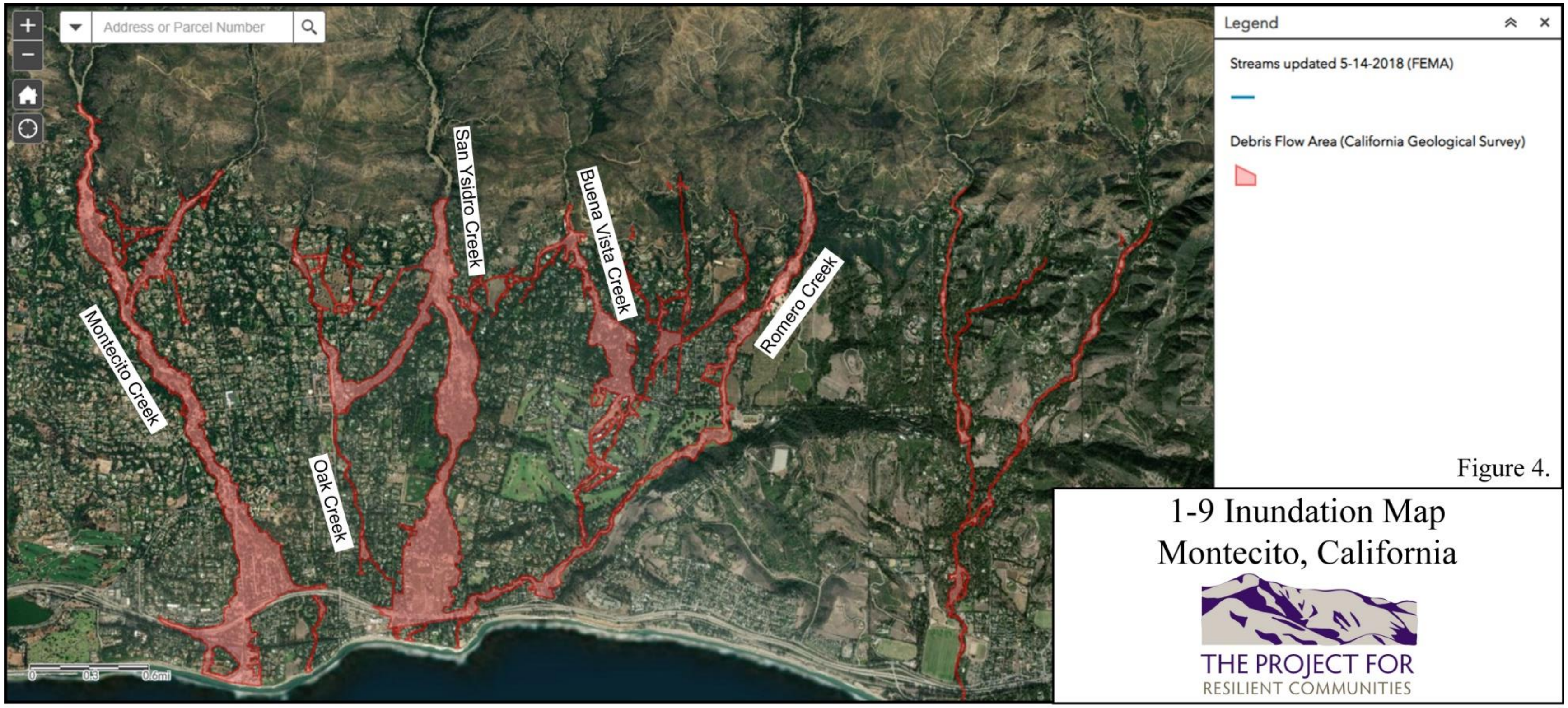
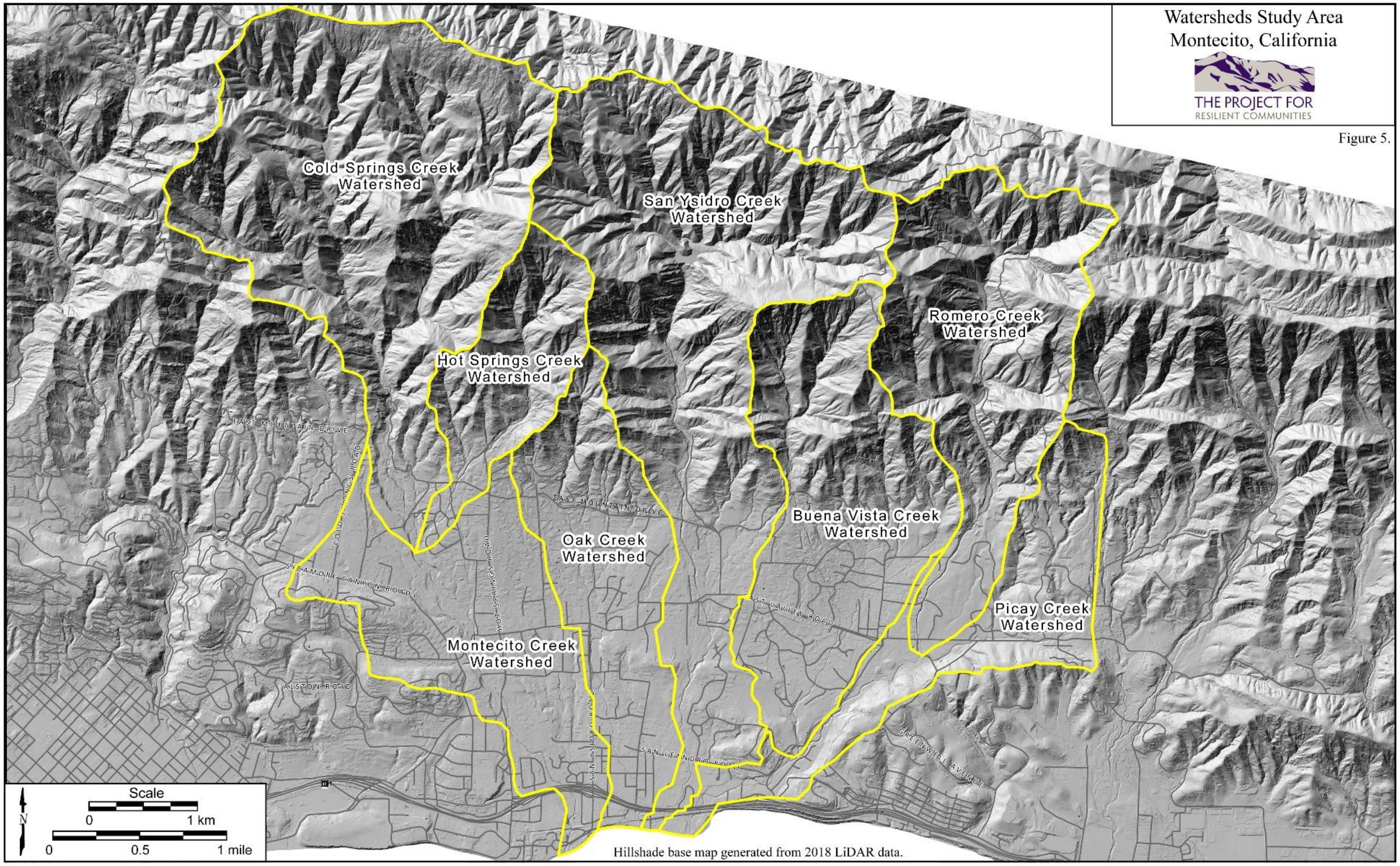


Figure 4.

Debris flow inundation map following the January 9, 2018 event by the California Geological Survey (2018). The extent of the inundation exhibits the nature of debris flow avulsions producing out-of-channel flows. The flows spread out onto the alluvial fan surface that the community is developed on.



HIllshade map showing the major watersheds in the community of Montecito. Note that the principal creeks of the watersheds funnel into a narrow corridor that is about 3/4 mile wide at the coast .

Table 1. List of flood events including debris flows and debris laden floods and assignment of magnitude classification for debris flow events.

YEAR	FIRE NAME	STORM DATE	TYPE	CREEK	LANDSLIDE DAM	MAGNITUDE	EVENT TALLY
1825[1]	Fire burned down from ridgeline into Santa Barbara and Montecito[2,3]	1825	Debris flows	Regional California event;		Class 6	1 PFDF
1861-62		1861-62[4]	Debris flows, debris laden floods, and floods	Western United States flood including California, Oregon, Nevada, Arizona; So. Santa Barbara County Creeks	Outbreak flood on Santa Monica Creek[5] Landslide reported on January 17 in Hot Springs Canyon that resulted in one fatality.[6,7]	Class 6 1000 year flood event.[8]	1 DF/DLF 2 LDOF Likely multiple events
1872	October 1, 1871 fires in Montecito foothills[9]	Reported on February 10, 1872[10]	Debris flows	San Ysidro (Dinsmore Canon)		Class 2	1 PFDF
1878		January 19, 1878[5]	Debris flows Debris laden floods	Eagle Canyon Arroyo Burro		Class 2	1 DF 1DLF
1879	Multiple fires in 1877-1878[11]	January 3, 1879[12]	Debris flows	Hot Springs		Class 2	1 PFDF
1879	Fire September 20, 1879 [13]	December 21, 1879[5, 14]	Debris flows	Carpinteria (Pettinger Canon)	Outbreak flood that resulted in two fatalities.[5, 14]	Class 4	1 LDOF 1 DF
1884	Brush fires, Carpinteria to Montecito 1883[15,16]	February 17-18, 1884[17,18]	Debris laden floods	Mission and all Montecito creeks.	Avulsions at bridges due to debris blockages.[17]		1 DLF
1885	East slope of Carpinteria Creek burning westward	1885[19]	Debris flows	Carpinteria creeks		Class 4	1 PFDF

YEAR	FIRE NAME	STORM DATE	TYPE	CREEK	LANDSLIDE DAM	MAGNITUDE	EVENT TALLY
1889	Great fire of 1889[20]	October 1889[20]	Debris flows	Buena Vista		Class 3	1 PFDF
1906	October 1905[21,22,23]	March 23-, 1906[24, 25,]		Casitas	Landslide Dam	Creek broke through before large lake formed	1 PFLD
		March 25, 1906[24,25, 25b, 25c]	Debris laden floods	Mission			1 DLF
		April 10, 1906[26]	Debris laden floods	Toro			1 DLF
	October 1905[21,22,23]	April 28, 1906[27]		Casitas	Landslide Dam	Reactivated landslide destroyed bridge and fills canyon drainage.	1 PFLD
1907	October 1905[21,22,23]	January 5-8, 1907[28, 29]	Debris laden floods	Mission, San Jose, Montecito			1 PFDLF
1909	October 1905[21,22,23]	January 20 and 26, 1909[53, 54]	Debris laden floods	Mission			2 PFDLF
1911		January 28, 1911	Debris laden floods	Mission	Landslide dam reported in Hot Springs Canyon and warnings sent to Spanishtown.[31]		1 DLF
		March 9, 1911[30]	Debris flows	Hot Springs		Class 4	1 DF

YEAR	FIRE NAME	STORM DATE	TYPE	CREEK	LANDSLIDE DAM	MAGNITUDE	EVENT TALLY
1914	Reported in 1912 – 1913[33,34] in east Santa Barbara/west Montecito foothills; Casitas and Rincon Mountain area	January 25, 1914[35,36,37]	Floods, debris laden floods, and debris flows 6 fatalities[21,39]	Regional southern California event; So. Santa Barbara Creeks, Gaviota to Carpinteria to Ventura and Casitas Pass All canyons for a 50 mile stretch along the coast produced trees and boulders debris, and mud.[39]	Landslide dams forming then progressively breaching.[48,49] Reports of landslides in Mission Canyon threatened to form landslide dams.[50] A great landslide was reported in Shepard's Canyon in Carpinteria.[51] Landslide dam outbreak flood waves in San Ysidro Creek and Santa Monica Creek	Class 6 - first event	1 DF (PFDF in localized areas) 3 LDOF
		February 18, 1914[38]				Class 5 - second event	1 DF
		February 20, 1914[38]				Class 4 - third event	1 DF
1926	Multiple fires reported in 1921, 1922, 1924, 1925 and 1926 in Cold Springs, Hot Springs, and San Ysidro Canyons[52-59]	February 11, 1926,[60,61]	Debris flows	San Ysidro	San Ysidro Creek reported dammed which collapsed and produced an outbreak flood.[60-64]	Class 5	1 LDOF 1 DF
		April 3, 1926[61b]	Debris flows	San Ysidro		Class 4	1 PFDF
		April 5, 1926[61b, 61c,61d,61e]	Debris flows	San Ysidro		Class 4	1 PFDF
1926	Three fires reported in 1922, 1924, and 1925 in Blue Canyon and Pine Canyon areas[52-59]	April 6-8, 1926	Debris laden floods	Santa Ynez			Not included in tally; north of ridge divide
		November 26, 1926[65]	Debris Flows	Santa Ynez	Remnant landslide dams	Class 4	
1964	Coyote[66, 67, 68]	November 9-10, 1964[68]	Debris flows	Hot Springs, Cold Springs, Montecito, San Ysidro, San Antonio	Numerous landslides mapped in watershed with drainage blockages	Class 5	1 PFDF 1 LSDOF

YEAR	FIRE NAME	STORM DATE	TYPE	CREEK	LANDSLIDE DAM	MAGNITUDE	EVENT TALLY
1967	Coyote	January 1967[69]	Debris laden floods	Mission			1 PFDLF
1969	Coyote	January -February 1969	Debris flows, debris laden floods	All Montecito and Carpinteria creeks	Debris dams noted by J. Stubchaer.[70]	Class 5.5	1 PFDF
1971	Romero	December 27, 1971[71]	Debris flows	Romero, Toro, Garrapata, Santa Monica, Franklin, and Carpinteria		Class 5	1 PFDF
1995[72]		January 10, 1995 March 10, 1995	Debris laden floods Debris laden floods	All Montecito, Santa Barbara, Carpinteria, and Goleta creeks	Numerous breached landslide dams in watersheds; landslide dam outbreak flood in Sycamore Canyon resulted in 1 fatality	Greater debris production than 1-9	1 DLF 1 DLF 1 LDOF
2010	Jesusita	February 27, 2010[73] March 3, 2010[73,74]	Debris flows	Gibraltor Road and Southeast of South Portal		Class 1 Class 1	1 PFDF 1 PFDEF
2017	Sherpa	January 20, 2017[73,75]	Debris flows	El Capitan		Class 4	1 PFDF
2018	Thomas	January 9, 2018[76]	Debris flows	All Montecito creeks; E. and W. Toro, Arroyo Paredon, Santa Monica, Carpinteria, and Gobernador		Class 6	1 PFDF
2019	Thomas	February 2, 2019[77,78]	Debris laden floods	San Ysidro and Romero		NA	1 PFDLF
2019	Whittier	February 2, 2019[79]	Debris flow	Duval Canyon on Hwy 154 at Lake Cachuma		Class 2	Not included in tally; north of ridge divide

Notes for Debris Flow Events Table

PFDF – Post fire debris flow.

DF – Debris flow.

DLF – Debris laden flood.
LDOF – Landslide dam outbreak flood.
LD – Landslide dam without outbreak flood.
Debris laden floods are not assigned magnitudes.

[1] The Morning Press, February 3, 1914.
[2] Michael Redmon, The Independent, October 16, 2003.
[3] Mason, History of Santa Barbara County, 1883.
[4] California's Flood Future, Recommendations for Managing the State's Flood Risk, Attachment C: History of Flood Management in California, Appendices A through F, Final November 2013.
[5] Mason, History of Santa Barbara County, 1883.
[6] The Weekly Butte Democrat (Oroville California), February 8, 1862.
[7] The San Francisco Daily Alta, January 31, 1862.
[8] J. Goodridge, Data on California's Extreme Rainfall from 1862-1995, 1996 California Weather Symposium.
[97] Myrick (1988) described a wildfire in the Montecito foothills in early October, 1871.
[10] The Santa Barbara Daily Press, February 10, 1872.
[11] The Morning Press, January 31, 1877; August 10 and 11, 1877; October 19, 1877; November 30, 1877; November 30, 1878; December 27, 1878.
[12] The Santa Barbara Daily Press, January 3, 1879.
[13] The Santa Barbara Weekly Press reports a wildfire from Santa Barbara to Ojai, September 20, 1879.
[14] The Santa Barbara Weekly Press, December 27, 1879. The account reports landslide dam elevates water level forty feet at the dam location. It is noteworthy to mention that this report mentions that sudden rises in streams by heavy rains in burnt regions produces driftwood charged torrents forming a succession of dams giving way as the result of the upper ones.
[15] The Morning Press, December 15, 1883
[16] The Morning Press, January 30, 1883.
[17] The Santa Barbara Daily Press, February 17, 1884.
[18] The Independent, February 18, 1884.
[19] Michael Redmon, The Independent, October 16, 2003.
[20] Wildfire referred to as the "Great Fire of 1889" by Myrick (1988) as three fires that converged on Montecito. One fire originated north side of the ridgeline and burned over and down Romero Canyon. The other two fires started on the south side of the ridgeline. The fire reportedly burned homes from Summerland to the County Hospital with destruction centered on Romero Canyon burning up to San Ysidro Ranch (D.F. Myrick, 1988, Montecito and Santa Barbara, Vol 1).
[21] The Daily Democrat, October 9, 1905.
[22] The Los Angeles Herald, October 8, 1905.
[23] The Los Angeles Times, October 9, 1905.
[24] The Morning Press, March 18, 1906.
[25] The Morning Press, June 20, 1917.
[25b] The Los Angeles Times, March 24, 1906.
[25c] The Morning Press, March 25, 1906.
[26] The Independent, April 10, 1906.
[27] The Independent, April 28, 1906.
[28] The Morning Press, January 9, 1907. The event resulted in flooding in Montecito and it is worthwhile to note that Montecito Creek changed its course and occupying its former course through the Miramar resort and emptying at the beach east of the resort grounds.

[29] The Los Angeles Times, January 9, 1907. This article provides a second report of Montecito Creek re-occupying its former course through the Miramar resort. It was reported that a great mass of debris was carried on the crest of the torrent.
[30] The Independent, March 9, 1911.
[31] The Independent, March 10, 1911.
[33] Unnamed fire on September 17, 1913 reported in Sycamore Canyon and including the west side of the former Mountain Nook on Mountain Drive with a similar fire reported in 1912 that burned the west of the Mountain Nook (in D. F. Myrick's book Montecito and Santa Barbara, Vol 1 [1988]). A Santa Barbara Morning Press article dated December 5, 1912 described the 1912 fire as mostly burning north of Mountain Drive and burning hottest in the foothills. It also noted that this was the second fire along Mountain Drive.
[34] The Morning Press, September 18, 1913.
[35] The Santa Barbara Daily News, January 26, 1914.
[36] The Morning Press, January 27, 1914.
[37] C.M. Gidney, B. Brooks, and E.M. Sheridan, History of Santa Barbara, San Luis Obispo, and Ventura Counties, California, Volume 2.
[38] The Daily News, February 20, 1914.
[47] Montville, C., Brooks, B., and Sheridan, E.M., 1917, History of Santa Barbara, San Luis Obispo, and Ventura Counties, California, Lewis Publishing Company
[48] The Santa Barbara Daily Press and the Independent, February 4, 1914.
[49] The Santa Barbara Daily Press and the Independent, February 15, 1914.
[50] The Daily News, February 20, 1914.
[51] The Daily News, January 26, 1914.
[52] Unnamed fire reported in October 1921 in nearby canyon which destroyed the Hot Springs Club from flames approaching from the west (D.F. Myrick, 1988, Montecito and Santa Barbara, Vol 1). Also, an unnamed fire on February 27, 1924 reportedly burned Cold Springs Canyon through Rattlesnake and Sycamore Canyons (Stella H. Rouse, in Old Santa Barbara column, Santa Barbara News Press, unknown date; Montecito Association History Committee).
[53] Madera Tribune, July 15, 1921.
[54] The Santa Barbara Morning Press, morning and evening editions, October 21, 1921.
[55] San Pedro Pilot, August 14, 1925.
[56] Humboldt Times, August 15, 1925.
[57] Humboldt Times, August 18, 1925.
[58] Humboldt Times, August 25, 1925.
[59] Humboldt Times, August 27, 1925.
[60] D.F. Myrick, 1988, Montecito and Santa Barbara, Vol. 1.
[61] Montecito Association History Committee.
[61b] Hattie Beresford, Montecito Journal, 2006.
[61c] The Morning Press, April 6, 1926.
[61d] The Daily Press, April 6, 1926.
[61e] The Daily Press, April 8, 1926.
[62] The Morning Press, February 12, 1926.
[63] The Morning Press, February 13, 1926.
[64] The Los Angeles Evening Express, February 12, 1926.
[65] The Santa Barbara Daily Press, November 29, 1926.
[66] Michael Redmon, The Independent, January 26, 2006.
[67] Ray Ford, Coyote Fire 1964, Chapter 4 of Santa Barbara Wildfires.

[68] U.S. Army Engineer District, Los Angeles Corps of Engineers, 1965, Report on Coyote Fire and Resulting Floods, December 7, 1964, Santa Barbara County Flood Control and Water Conservation District, May 1965. Courtesy of Montecito Association Historical Committee.
[69] Lower Mission Creek Interim Report, Feasibility Report and Environmental Impact Statement, Santa Barbara County, California U.S. Army Corps of Engineers.
[70] Santa Barbara County Flood Control & Water Conservation District, 1969, revised by J. Stubchaer, 2013.
[71] Department of the Army, Los Angeles District, Corps of Engineers Los Angeles, CA, 1974, Flood Plain Information Montecito Streams Vicinity of Montecito, Santa Barbara County, California, June 1974.
[72] Santa Barbara County Flood Control and Water Conservation District, 1995, 1995 Floods.
[73] J. Lancaster and N. Oakley, 2018, Southwest extreme precipitation symposium.
[74] Kean et al. 2011.
[75] Noozhawk, January 20, 2017.
[76] County of Santa Barbara Office of Emergency Management, 2018, Thomas Fire and 1/9 debris flow after-action report and improvement plan, Incident period: December 4, 2017 through January 31, 2018, approved, October 16, 2018.
[77] Santa Barbara County Fire twitter announcement, M. Eliason, dated February 2, 2019.
[78] County of Santa Barbara Flood Control videos, 2019.
[79] Noozhawk, February 3, 2019.

Information from both technical and non-technical literature were examined in this study. Technical reports correctly identified the type of flood event including quasi-clear water flood, debris laden flood, and debris flows. The basis for recognizing a flood event is that the flood flow conveyance exceeded the capacity of the creek channels, overbanked, and flowed out-of-channel on the surface of the alluvial fan. A debris laden flood was classified by descriptive or photographic evidence where channels were filled with debris, extensive channel bank erosion, and noted to have conveyed the largest boulders in the channel. If an avulsion was caused by filling of the creek channel with debris and flood inundation resulted, then the event was classified as a debris laden flood.

The Dowling and Santi (2013) study recognized that non-technical literature and historic accounts do not use the terms debris flows and debris laden floods, instead descriptive terms such as "torrent," "flow," or "mudslide" were used to describe debris flows. This study also examined the mechanism of damage, whether by debris impacts or flood inundation, evidence for the type of flow movement, and impacts that caused destruction of bridges and their abutments. Additional criteria supporting the mobilization of debris flows and debris laden floods from the canyon mouths include terms such as "boulders," "logs," "trees," "brush," or "debris."

Floods depicted by 10 to 20 feet high "tidal waves" or "walls" composed of boulders, logs, and trees in the channel or on the fans were classified as debris flows, and if landslide dams were attributed to the cause, a landslide dam outbreak flood event was presumed. If filling of a channel with logs or debris produced a flow avulsion, and if ample debris was deposited on the fan creating debris impacts, then the flood was classified as a debris flow. These criteria follow and exceed the requirements established in the Dowling and Santi (2013) study.

It is especially important to note the impact to a shed or outbuilding or stone house was damaged, and to what extent. Bridge materials such as wood, stone, or concrete were noted for destroyed bridges to assess the extent of impacts, and if described the type of impacts, boulders or logs or floodwaters were also noted. Mapping of the locations of damaged properties and the extent of damage was assimilated and combined with sites of channel blockages. These data were located on historic maps to compile and to reconstruct past flow paths. The flow paths and assessment of the extent of damages to properties were performed to establish "high hazard areas" along past flow paths.

An abundance of evidence was collected for the 1914 event, of sufficient detail (including post-flood photographs) to assign a relative magnitude for the debris flows. A synthesis of the flood damages of selected events tallied in this study are presented in the text of this report.

The research of historical flood events included searching for flood, landslide, and fire related events in:

- Newspaper archive accounts that identify damaged properties, types of inundation, and extent of damages. These data were supplemented with historical and property ownership records, city directories, and published books to map the damages associated with the properties in Montecito. In addition, reports by government agencies including County of Santa Barbara Flood Control and U. S. Army Corps of Engineers reports.

- Research the archives at the Montecito Association History Committee.

- Review maps and aerial photographs at the Special Collections in the University of California, Santa Barbara library.

- Research at the Gledhill Library, Santa Barbara Historical Museum.

- Research at the City of Santa Barbara Library.

- Wildfire and flood histories of Montecito described by David F. Myrick in his 1988 and 2001 books of the history of Montecito entitled, *Montecito and Santa Barbara Volume 1, From Farms to Estates* and *Montecito and Santa Barbara and Volume 2, The Days of the Great Estates*.

- The *History of Santa Barbara County, State of California, Its People and Its Resources*, by Owen H. O'Neill, published in 1939.

- *Exceptional Years: A history of California Floods and Droughts*, by J.M. Guinn, published in 1890.

- Sanborn Map Company fire insurance maps, Chase Realty parcel maps of Montecito, County survey maps and other maps.

- Map alluvial fans including landforms related to debris flow deposition such as lobes, boulder fields, plugs, levees, and snouts utilizing a 2018 lidar-based hillshade base map (Plates 1 and 2).

- Map landslide and landslide dam landforms utilizing stereo aerial photographs in combination with field mapping for initial reconnaissance to create an inventory of landslides in the Montecito watershed (Plate 2).

- Reconstruct flow paths of past debris flows and debris laden floods in the Montecito Creek watershed using descriptive flood damage data and inventory of bridge and culvert blockages where avulsions and flow breakouts occurred (Plate 3).

- Analysis of these historic surveys and maps to locate abandoned creek channels, former channel courses, and other related, but no-longer present on the coastal plain (Plate 4).

- Analyze channel thalweg profiles for portions of Hot Springs Creek and Cold Springs Creek where large landslides area located to assess recency.

This study utilized 19th and 20th century parcel maps of Montecito and Sanborn maps to locate property boundaries; position of the damages on the property; extent of damages including debris impacts and/or floodwater inundation. Parcel surveys and topographic maps were collected of Montecito properties which included pre-1914 and post-1914 topographic and survey maps. These surveys of properties located along a creek often showed the location of the active creek as it would form the parcel boundary line with an adjacent parcel. In some cases, the former channel location was surveyed within or along boundaries of parcels including former channels of Cold Springs, Hot Springs, and Montecito Creeks.

History of Community Development

Native Americans occupying the coastal region of California, later referred to as the Barbareno Chumash, were the first human occupants in the Santa Barbara area dating back as far as 8,000 years (City of Santa Barbara, 2018). During Juan Rodriguez Cabrillo's exploration of the Alta California coastline to claim the lands for Spain, Cabrillo sailed through the Santa Barbara Channel and made the first contact with the Native Americans on the Channel Islands in 1542 (City of Santa Barbara, 2018). Decades later in 1602, Sebastian Vizcaino visited Santa Barbara and surveyed the coastline designating the name, Santa Barbara for the area (City of Santa Barbara, 2018). Subsequently, the government of Spain in 1768 decided to send explorers to establish Presidios and Missions along the Alta California coast with Gaspar de Portola leading the expedition. During Portola's journey along the Alta California coast in 1769, he describes encounters with a number of Chumash villages along the shorelines including Carpinteria, El Montecito and Santa Barbara (Myrick, 1988).

The Santa Barbara Presidio was the first Spanish settlement in 1782 located in the upland area in Santa Barbara (City of Santa Barbara, 2018). Although Montecito was considered for the site of the Santa Barbara Mission, it would be established in 1784 near the banks of Mission Creek. The Spanish referred to the Chumash village of Salaguas (aka Shalawa) on the El Montecito coast as Ranchería de San Bernadino which was located just west of the mouth of Montecito Creek (Beresford, 2021; Geiger, 1965). The Spanish also named the valley of Montecito, El Montecito, which means the little hinterland, the little pastureland, and the little woods (Geiger, 1965). There were 62 Native Americans reported living in El Montecito in 1796 (Myrick, 1988).

The Presidio attracted men and their families from Mexico arriving to work at the Presidio. In the absence of pensions, soldiers of the Presidio were given parcels of land in El Montecito. Most chose to live along the banks of Montecito Creek for the source of water and fish, and became known as Spanishtown, later to be informally referred to as Old Spanishtown, while others chose to live on Romero Hill (Myrick, 1988). As a result of the independence of Mexico from Spain in 1822, the Mexican secularization of the missions in 1834 resulted in the breaking up of vast land holdings into ranchos and granted to presidio soldiers and settlers (California Missions Foundation, 2020). In 1850, California was incorporated as the 31st state and the County of Santa Barbara was one of 27 original counties formed at the time of statehood (California Department of Parks and Recreation, 2020).

The growth of Montecito in the 1850's to the 1870's was the result of cheap land that attracted two types of buyers, land speculators and farmers (Bereford, 2021; Myrick, 1988). The City of Santa Barbara inherited considerable "Pueblo Lands," particularly outside of the city and stretching all the way to Carpinteria Creek (Myrick 1988). The City encouraged development of this area and individuals could petition the City's Common Council for a desired parcel, and for a very small fee, one could claim sizable parcels of land up to 40 acres (Myrick 1988).

The Great Register of 1866-1869 accounted for 47 voters residing in Montecito with 24 Spanish residents, 17 residents born in the eastern states, and 6 residents from Europe (Myrick 1988). By the late 1870s to early 1880's, affluent eastern settlers became "gentlemen farmers" who were enthusiastic horticulturalists farming citrus, fruit, decorative trees, plants, and flowers (Montecito Association History Committee, 2021). Small farms of 15 to 50 acres with praiseworthy farmhouses and elegant residences surrounded by colorful gardens and productive orchards dotted the Montecito landscape (Myrick, 1988). The arrival of the Southern Pacific Railroad in 1887 heightened the existing land boom along with the introduction of electricity to the area which inflated land prices skyward, in some cases not to be matched for 40 years. The Montecito Land Company was the first land development company in Montecito which was formed in 1887 to develop roads, subdivide land, and to promote lot sales (Myrick, 1988).

The Golden Age of the Great Estates began in the 1920's, however the lack of a reliable source of water was a real hindrance to development (Myrick 1987). Domestic water was an individual matter or at best, small cooperative groups were formed to serve small areas. Many wells and horizontal wells were drilled, small reservoirs built, and water companies formed, but it was the development of Juncal Dam and the Doulton tunnel bringing water to Montecito which accelerated the increased growth in the 1920s. The Sanborn Map Company reports a population of Montecito of 2,500 in 1918 and later reported a population of 3,000 in 1940 (Sanborn, 1907, 1918 and 1940).

Montecito is a special landscape with oak woodlands scattered about on the alluvial plains situated in the foothills and below the Santa Ynez Mountain range. The owners of Montecito property protected the area from the vast development occurring in Santa Barbara. State Legislature passed a Planning and Enabling Act in 1929 allowing communities such as Montecito to restrict over-development. Residents rallied together to pass a county zoning ordinance, the first in California history, enabling the community to restrict lot sizes, lot splits, and allowing no development on lots less than one acre (Tompkins, 1980). The Montecito Protective and Improvement Association was formed in 1948 to prohibit sidewalks, concrete curbs and gutters so as not to detract from the rural look of Montecito (Tompkins, 1980). The population of Montecito was reported as 9,500 in 1980, and the population was about 9,000 in 2010. The following decade in 2020, the population declined to 8,600 (Tompkins, 1980; United States Census, 2010 and 2020).

Geology of the Montecito Watersheds and Alluvial Fans

South of the mountain range divide, the Santa Ynez Mountains consists of a series of steeply dipping to overturned Tertiary sedimentary units, comprised of alternating sandstone and shale bedrock formations (Dibblee, 1966; 1982; Minor et al., 2009). The bedrock units that comprise the Montecito watersheds include, from oldest to youngest, Juncal Formation shale; Matilija Formation sandstone; Cozy Dell Formation shale; Coldwater Sandstone; and Sespe Formation sandstone, conglomerates, and siltstone (Plate 2) (Dibblee, 1966; 1982; Minor et al., 2009). Younger Tertiary bedrock formations form the underlying bedrock of the coastal plain and include, from oldest to youngest, Vaqueros Sandstone; Rincon Formation shale and claystone; Monterey Formation (Hoover, 1980; Geotechnical Consultants, 1979). Coarse alluvial fan deposits which overlie the bedrock units, form a wedge of coarse debris that thickens to the south from 10's of feet (10 to 20 m) thick at the canyon mouths to over 650 feet (200 m) thick at the coast (Geotechnical Consultants, 1979; Hoover, 1980; Gurrola, 2006).

High rates of uplift of 1 to 2 mm/year on the Santa Barbara coastal plain, combined with generally weak, erodible bedrock formations produce confined channels with steep side-slopes in the Santa Ynez Mountain watersheds (Dibblee, 1966; 1982; Gurrola, 2006; Minor et al., 2009; Gurrola et al., 2014). Tertiary shale weathers to form thick sequences of fine colluvial sediments on slopes and Tertiary sandstone weathers to form large boulders that eventually enter valley drainages and creek channels (Keller et al., 2020; Alessio et al., 2021). Weathering of shale and siltstone bedrock form thick accumulations of fine colluvial soils at the toe of slopes and exhumation of sandstone outcrops on steep slopes generate ample supply of fine sediment and coarse debris for generation of debris flows in the watersheds of the Santa Ynez Mountains.

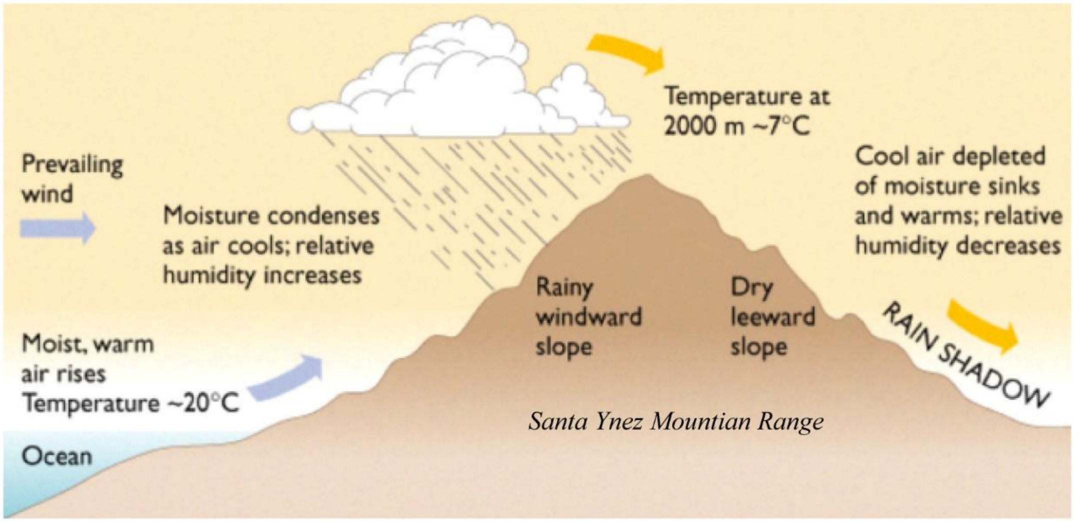
Climate

The Santa Barbara climate is a moderate Mediterranean regime, typically cool and dry in summer with rainfall occurring in winter season, primarily from November to April (NOAA, 1994). The seasonal transitions result in moderate temperature changes, however there are significant seasonal changes in rainfall amounts. The mean annual temperature in coastal Santa Barbara is 60 degrees F with the average daily high temperature is 71 degrees F and the average low is 49 degrees F.

A semi-permanent high pressure in the eastern Pacific controls weather along the California coast for much of the year (NOAA, 1994). Prevailing wind along the California coast is generally from the northwest or west, but the Santa Ynez mountains generally block northwesterly winds creating wind from the south or west. Warm and dry, downslope winds known as “sundowners” occur a few times a year reducing humidity that can exacerbate wildfires, once ignited. Intense conflagrations were known to the early residents of Santa Barbara as noted later in this report.

The steep topography of the Santa Ynez Mountain range creates orographic lifting of air and clouds over the range (Figure 6). The lifting of air over the range cools and condenses the air, and if the temperature cools the air to its saturation (dew) point, then an orographic cloud forms and precipitation falls on the windward side which is the side that the storm is approaching from. The air will rapidly descend on the leeward side increasing temperature and the saturation point, which produces a rain shadow effect where precipitation is significantly less, and temperatures are higher.

Storms that approach southern Santa Barbara County from westerly and southerly directions produce greater rainfall amounts in the upper tributaries of the watersheds above the coastal plain communities of Santa Barbara, Montecito, and Carpinteria. The mean annual rainfall for downtown Santa Barbara is 18.28 inches (46 cm) and annual precipitation amounts ranged from 6.41 inches (16 cm) to 46.97 inches (119 cm) were recorded since 1900 (Santa Barbara County Flood Control District, 2021a). The mean annual rainfall for lower Montecito is 19.65 inches (50 cm) and annual precipitation amounts ranged from 6.15 inches to 54.32 inches since 1925 (County of Santa Barbara, 2021b). The mean annual rainfall at Doulton Tunnel, located higher in the watershed at an elevation of 1,775 feet, is 27.37 inches (69.5 cm) and the annual precipitation ranged from 9.12 inches (23 cm) to 66.56 inches (169 cm) per year (Santa Barbara County Flood Control District, 2021c).



(Grotzinger, Jordan, Press and Siever, 2007)

Orographic lifting of air over mountain topography causes air to condense and form clouds as the air lifts over the highlands. This results in much higher volumes of precipitation to occur at higher elevations in the upper watersheds. If the orographic lifting is greater than 27 feet per second, then precipitation can be stored in the rising clouds preventing the lower foothills from receiving any rain. When the lifting rate is less than 27 feet per second, this "stored" precipitation is suddenly unleashed formenting intense rates of precipitation greater than 1 inch per hour. This phenomena often results in much higher cumulative amounts of precipitation in the upper watersheds and triggers deadly debris flows that impact downstream communities.

Figure 6.

Depiction of Orographic Lifting Over a Mountain Range

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Wildfire History

Pre-Historic Fires

Wildfires are a natural occurrence in the southern California. The occurrence of wildfires is well-established in the history of the Santa Barbara area including the communities of Santa Barbara, Montecito, and Carpinteria (Figure 7). Byrne et al. (1977 and 1979; Mensing et al., 1998) analyzed charcoal accumulation in varved sediments from the Santa Barbara Channel basin for the period 1931 to 1970 and established a strong correlation with accumulation of large charcoal particles to the 1955 Refugio Fire and the 1964 Coyote Fire. Mensing et al. (1998) advanced this type of analysis and the fire history knowledge establishing 20 large fires (> 20,000 ha) between 1425 and 1900 indicating a frequency of wildfire between 20 and 30 years. The Montecito Community Wildfire Protection Plan (Montecito Fire Department, 2016) cite this study affirming the frequency of fire and determining the occurrence has increased in recent years. Since the 1950's, Santa Barbara County has averaged about one large wildfire every decade (Figure 7; Santa Barbara County Fire Safe Council, 2021). Former City of Santa Barbara Fire Chief, Pat McElroy, believes in recent years, wildfires have become larger in their extent, more unpredictable, and burn hotter (Pat McElroy, pers. comm, 2020).

Historic and Recent Fires

The earliest proclamation to prevent wildfires was established in 1793 by Governor Jose Joaquin de Arrillaga that forbid the burning of fields in town and at remote distances due to the widespread damage by wildfires (Michael Redmon, The Independent, October 16, 2003). One of the earliest accounts of a large wildfire was described by Richard Henry Dana, upon his arrival to Santa Barbara in 1835, he recounted that the hills were devoid of large trees and were distracting to the beauty of Santa Barbara (Dana, 1840; Mason, 1883). He later learned it was the result of a great fire in 1823 that had burned from the mountains to the foothills and threatened the town, so the citizens took refuge on the beach for a few days due to the heat and smoke (Michael Redmon, The Independent, October 16, 2003).

Numerous fires were reported in historical accounts including 1823, 1871, 1877 through 1879, 1880, 1883, 1888-89, 1890, 1905, 1912, 1913, 1914, 1920, 1921, 1924, 1925, 1926, 1929, 1931, 1939, 1944, 1949, 1956, 1958, 1964, 1971, 1977, and 1979 (Dana, 1840; Mason, 1883; Wildfire in Mission Canyon was a Sight Unparalleled, Way it Was, Stella Rouse, Montecito Association History Committee; Olden Days, Stella Haverland Rouse, November 29, 1964; In Old Santa Barbara, Santa Barbara News Press, Stella Haverland Rouse, February 27, 1974; Myrick, 1988; Marion Gregston, The Way It Was, Montecito Journal, September 30, 2004; Guillaume Doane, Like Wildfire, Montecito Journal, July 20, 2005; Santa Barbara County Fire Safe Council, 2021). More recent fires include 1980, 1985, 1990, 2004, 2007, 2008, 2009, 2016, 2017, 2018, 2019, and 2021 (Figure 7) (Like Wildfire, Guillaume Doane, Montecito Journal, July 20, 2005; Santa Barbara County Fire Safe Council, 2021; Wildfires in Santa Barbara County, 1985 to 2007, Judith Dale, Santa Maria Times, September 5, 2020; Wildfires in Santa Barbara County, 2008 to

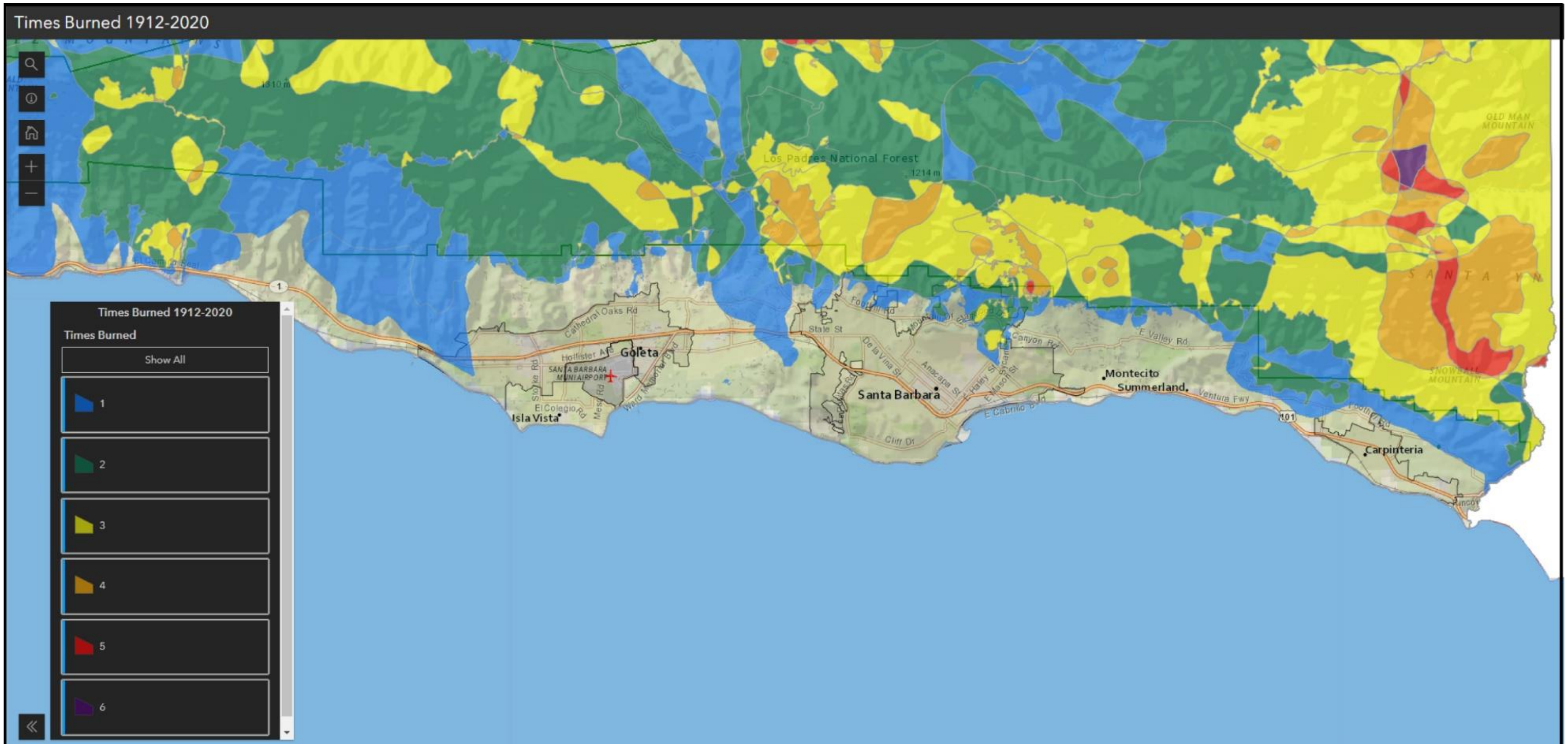

Figure 7.

The map shows the number of times wildfires have burned the moutnain slopes of the Santa Ynez mountain catchments for the period from 1912 to 2020. Following each occurrence of wildfire, an elevated flood hazard results for about three to five years following the fire event.

Reference: https://sbc-gis.maps.arcgis.com/apps/instant/interactivelegend/index.html?appid=628b29027494461c82e2e529ef72f872

Map Showing Frequency of Fires
Santa Ynez Mountain Range

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2015, Judith Dale, Lompoc Record, October 24, 2020; Wildfires in Santa Barbara County, 2016 to 2019, Judith Dale, Santa Maria Times, July 14, 2021).

Climate Change and Future Fire Hazards

Climate change has been the focus of many studies in the 20^{th} and 21^{st} centuries and is well-established. Although there are differing views on whether climate change is anthropogenic (human induced), recent warming trends and repeated record-breaking patterns support the climate is in flux and changing due to human activities.

Swain (2018) analyzed the lengthening of the California's dry summer season by establishing the decreased and delayed precipitation in October and November which have marked the gradual onset of the rainy season in the past, will be characterized by peak intensity Santa Ana wind events. The delayed autumn precipitation combined and intense Santa Ana wind events that follow the dry, summer season will ultimately exacerbate wildfire risks. Swain et al. (2018) anticipates "precipitation whiplash," transitions from very wet to very dry weather, will increase frequency, especially for southern California.

Lukovic et al (2021) also recognized that the rainy season in California is progressively being delayed since the 1960's which tends to worsen droughts and prolong the wildfire season., and in addition, reduces the period of the rainy season which has resulted in shorter and sharper storm events in California. Luković et al. (2021) concluded that the rainy season is now delayed about one month in California.

Delayed onset of precipitation in September and October worsens drought effects and prolongs wildfire seasons. Swain et al. (2018) not only determined that anthropogenic forcing will increase the frequency of precipitation extremes, but also estimated a 3X to 4X increase in the likelihood of a Great Flood similar to the winter of 1861-62. See the Great Flood of 1861-62 event described in the Flood History section of this report.

Post Fire Watershed Conditions.

Wildfires in the steep terrain of the Santa Ynez Mountains produce hydrophobic soils which reduces infiltration and increases runoff and the potential for debris flows (Wells, 1981, 1985, and 1987; Cannon et al., 2001A and 2001B; Santi and Rengers, 2020). Reduction or removal of vegetation canopy and protective ground cover also exacerbates erosion and runoff increasing the potential for flash flooding and for debris flows. These floods discharge elevated volumes of both fine sediment and coarse debris including boulders and vegetation.

Post-fire debris flows appear to be triggered by two types of processes: rainfall runoff which erodes rills that tend to capture loose soils to produce a turbid mud slurry that coalesce into boulder rich channels and generates debris flows and by landslides caused by infiltration of prolonged or heavy rainfall into the ground which promote mobilization of soil and disaggregated clastic sediment (Campbell, 1975; Wells, 1981; U.S.G.S., 2005; Kean et al., 2011 and 2013; Keller et al., 2019; Alessio et al., 2021). This sequence of events characterizes the fire-flood (debris flows) sequence which are intimately related (Keller et al., 2019).

Storm Phenomena in Historic Records

Many accounts and descriptions of flood events in the 19th and early 20th century are referenced to the phenomenon of cloudbursts and lessor accounts of waterspouts (aka water falls). Although these terms appear to generalize rain fall, they denote specific aspects of the intensity, irregular spatial distribution, and duration. The use of the term waterspout(s) in accounts of the 1870's to the 1900's period implies a type of intense rainfall and also relates the resultant debris flow initiation upon where the spout or fall occurs, mobilizing soil and shallow bedrock with the abrupt removal of trees along its path of conveyance.

Cloudburst

The definition of a cloudburst was provided in a report entitled, "Cloudburst Floods in Utah 1850 – 1938" (Woolley, 1946). A foreword section written by Nathan C. Grover, former chief hydraulic engineer of the U.S. Geological Survey, relates that cloudburst storms "…are characterized by intense precipitation that is generally of short duration. On small drainages they cause record floods." He goes on to describe that many such floods are reported in many, if not all sections of country where heavy precipitation falls within narrow boundaries and varies within short distances.

Follansbee and Sawyer (1940) defined a cloudburst as short duration rainfall with great intensity that are confined to small catchment areas. Although cloudburst storms generally cause floodwaters to rapidly rise, most have a short peak flood duration and subside rapidly. However, some cloudburst storm events are recorded in the 19th and 20th centuries that occurred over several hours up to a day or two producing high amounts of rainfall.

Mason (1883) provides a detailed narrative of the atmospheric conditions experienced during a cloudburst. He described the approach of a bank of thick, rolling black clouds from the west and another similar dark bank of clouds approaching from the northeast. The two masses piled up into several miles of thick cloud accumulations as they converged until they met which initiated raindrops as large as bullets. The rain intensified quickly, and although this moisture should have fallen over miles of territory, it precipitated only over a small territory creating a deluge.

It is especially noteworthy that this account by Mason (1883) remarks that the precipitation fell upon timberless territory causing dry ravines a hundred yards long to flow waist deep in water in a short amount of time. Further down the channel, where barely sufficient water to flow and a dry wash prior to the event, water ran 4 to 5 feet deep and a hundred feet wide, temporarily restrained by timber, leaves, and trash until clearing everything in its course. The stream united with other streams forming a mass of runoff sufficiently large to flood a city.

Mason (1883) concluded that a cloudburst is a point of condensation between two opposing and saturated air currents that is suspended over a small area with intense rainfall. The intensity of a cloud bursts results in overwhelming stream channels, especially at canyon mouths carrying logs, boulders, and overflowing the course of the stream channel.

Ultimately, the term cloudburst is used to designate high intensity rainfall that varies spatially in intensity similar to the discharge of a whole cloud at once over relatively small areas. Common in hilly and mountainous areas of the western and southwestern United States, the resultant floods discharge from small precipitous catchment basins and are flashy and destructive in nature carrying boulders and logs.

The cloudburst phenomena describes high intensity, short duration rainfall (Keaton, et al., 1991) and is often related to producing large volume discharges of boulders from the mountains. For example, the formation of large accumulations of boulders in the lower Ojai Valley were attributed to the result a cloudburst (Mason, 1883). The boulder deposits located at the mouth of a canyon were determined to be 100 feet deep in a well excavation that revealed black earth or humus (buried and decaying organic material) indicating a recent event. This humus is the former ground surface that the debris was placed on and where organic materials are in a state of decay. A few feet below the humus, a second humus soil was discovered separated by a gravel indicating a previous cloudburst event, yet much smaller.

Waterspout

Besides the use of waterspout to describe a tornadic or fair-weather waterspout on the ocean or a lake, the terms “waterspout” or “water fall” were used in 1876 to describe a specific type of rain fall event and consequent debris flows (Clingman, 1877). He described a witnessed account of intense rain fall that appeared to fall from the clouds on a small area in western part of North Carolina. A flow of fast-moving mud and timber torn from the slope headed toward observers on an opposite side of a valley but the flow entered a creek and quickly moved downstream as a mass of trees in mud.

Clingman (1877) also observed the waterspouts in another area and used the term to describe an intense, spotty rainfall event which triggered mobilization of soil that quickly flowed downslope tearing out trees and branches along its path. Afterwards he hiked to the source area following a scar in the slope with logs lining the margins of the two mile-long path. He furthers describes his observations the source area, “*The ground was quite steep, the surface ascending at the rate of 25 degrees, probably. There was a circular opening in the ground about twelve or fifteen feet deep in the centre. It had the figure of almost an exact semi-circle on the upper side, and then extended down the mountain, presenting the figure caused by two parallel lines from each of its sides. Across the circle it was seventy-five feet wide, and for some distance down it maintained about the same width. In the centre of the circle, for forty or fifty feet in extent, the rock at the bottom was naked and clean,…*”. He went on to describe, “*The whole depression looked as though it might have been produced by a sudden fall, with great force of a column of water forty to fifty feet in diameter, which not only cut its way down to solid earth, but also tore loose a mass of surrounding earth on which it did not fall directly*.” He also described where trees were stripped away and noted the soils were dry these areas, and boulders several tons in weight were carried off by the torrent. He concluded that less rain fell in the downslope area but that the force of moving earth, mud, and timber caused the ripping out of soil and timber where the spout had not occurred.

A study of debris flows in western North Carolina recognized that Clingman (1877) used the term waterspout to describe a meteorological event but also the geomorphic feature created by this event, this debris flow event was mobilized for a distance of two miles (Latham et al., 2005; Wooten et al., 2007). Latham et al., (2007) incorporated the 1876 event in their accounting of the debris flow history in western North Carolina. The use of the term waterspout was only used in one account (An Aqueous Boom, Santa Barbara Weekly Press, December 27, 1879) to ascribe a possible cause for the 1879 debris flows and is discussed in the following Flood Event Section.

Alluvial Fan Flood Hazards

Alluvial fan floods are often flashy, striking with little warning, travel at extremely high velocities and can readily abandon established channels to erode new channels. Flood flow paths are unpredictable in nature and carry tremendous amounts of sediment and debris charged destructive floods (National Research Council, 1996). Flow volumes, inundation extent, and sediment production vary in magnitude due to watershed characteristics, soils and topography; storm path, duration and intensity; and state of vegetative cover. Depending on watershed conditions, short-duration, high intensity storm events can trigger destructive flood impacts. Large flows lose confinement at canyon mouths debouching sediment and water in a radial distribution that may extend over larger areas than the perceived "floodplain.". Radial flow distribution is a unique characteristic of alluvial fan flooding (Alluvial Fan Task Force, 2010) and is the natural process to accommodate large flows.

Flow paths of floods vary widely on alluvial fans and these paths are unpredictable due to the natural process of radial spreading once discharged from the canyon mouth. Debris flows are characteristically erosive scouring loose alluvium from low flow channel beds and banks and incorporating the alluvial debris into the flow, resulting in bulking of the flows. These flows can super-elevate at channel bends and meanders producing out-of-channel flows and deposition on the alluvial fan surface.

Avulsions occur where debris accumulates creating blockages due to artificial channel constrictions such as bridge crossings, culverts, and storm pipes. Natural channel constrictions occur where previous flows deposited large boulders and creek bank failures also reduce creek flow conveyance. Secondary distributary channels on the fan often accommodate out-of-bank flows from the main creek channels, and it is not uncommon for these distributary channels to be re-occupied during floods.

Flood control measures employed in communities developed on alluvial fans attempt to maintain flows down a single principal channel preventing the natural process of radial spreading out on the fans during high flows. Due to natural and artificial channel constrictions in the principal creeks, avulsions are common and assignment of a flood zone designation of a certain frequency storm may not necessarily accurately reflect flood inundation (National Research Council, 1996). The assumption that alluvial fan flood hazards are dominated by clear water floods within a floodplain is generally not the case. The unpredictable nature of flood flow paths is the consequence that alluvial fan floods transport large volumes of sediment, and the potential for erosion of channels and for deposition of sediment in the channel affects the location and direction of flow paths during a flood event (National Research Council, 1996).

Montecito Watersheds and Alluvial Fans

The west-east trending ridgeline of the mountain range reaches elevations that range from about 3,600 to over 4,800 feet (Gurrola, 2014; Gurrola, 2006). Relief of the catchment drainages ranges from approximately 3,100 to over 4,000 feet from tributary headwaters to canyon mouths. This abrupt and significant elevation change from the ridgeline to canyon mouths is one of the few places where such relief occurs on a coastal plain.

The upper headwater tributaries join to form a main, confined trunk stream (creek), and in some upper catchments, multiple sub-watershed tributaries merge before coalescing into the main, confined trunk stream (creek) (Plate 1). Examples of upper catchments that form tributary sub-watersheds and encompass extensive, steep terrain include the upper segments of the west and east forks of Cold Springs and Hot Springs sub-watersheds. (Plates 1 and 2). These main, confined creeks exhibit steep channel gradients in the catchments that decrease towards the watershed outlet (canyon mouth) where gradients are significantly reduced, and gradually decrease downstream to the coast.

Watershed catchments south of the Santa Ynez Mountain divide are underlain with erodible Tertiary sedimentary rock that readily shed vast amounts of sediment into the confined creeks (Plate 2). Coarse grained rock formations include the Matilija Sandstone and the Coldwater Sandstone, and fine-grained rock formations include the Cozy Dell Shale and the Juncal Formation (shale). These rock formations readily weather breaking down into coarse detritus and fine sediment that supply both debris and mud to the drainages for generation of debris charged flows.

The Montecito catchments are drained by south flowing creeks, that include from west to east, Cold Springs, Hot Springs, Oak, San Ysidro, Buena Vista, Romero, and Picay (Figure 4).

Alluvial fans are directly related to mountain catchments that produces the catchment area from which water and sediment are discharged to a specific fan (Blair and McPherson, 1994). The community of Montecito is developed on alluvial fans that are classified as debris fans formed primarily by debris flows and debris laden floods (Lancaster et al., 2021; Minor et al., 2009; Gurrola, 2006; Stubchaer, 1972). These types of debris charged floods are characteristically flashy in nature, and often occur without any warning.

Precipitation occurs during winter months typically from October through March producing stream flows that transport high volumes of sediment (coarse to fine sediment) in the catchments. The steep terrain combined with a nearly infinite supply of boulder and vegetative debris produces frequent debris-charged floods including debris flows and debris laden floods that are expelled from the canyon mouths and on the fans. The gentle gradient of the fans combined with low conveyance capacities of the main creek channels produces overbank flows that are easily diverted considerable distances away from the incised low flow channels spreading debris, mud, and floodwaters across the fan surface.

Vast amounts of sediment and large debris have been discharged from the watersheds resulting in fans overlapping onto each other forming merged alluvial fans referred to as a bajada. The fans in the Santa Barbara and Montecito area are estimated to be late Pleistocene (125,000 to 11,000 years) and Holocene (less than 11,000 years) in age (Best, 1989; Zepeda, 1987; Gurrola, 2006). Subsurface well log data in Montecito establish thick sequences of bouldery alluvium, indicating that debris floods and debris flows have been occurring for well over 100,000 years (Best, 1989;

Zepeda, 1987; Gurrola, 2006; Keller et al., 2020). Water wells drilled on the lower fan encountered thick horizons of cobble and boulder deposits indicating that the debris flow deposits are greater than 650 feet (200 m) thick in the lower fan area (Hoover, 1980).

The Mission Ridge-Arroyo Parida fault forms a west to east zone of uplift that bisects the fans through Montecito and generally forms the delineation between the upper to mid-fan transition. The upper fan area is mostly composed of debris flow deposits with minor fine sediment flood deposits, whereas the lower fan is composed of both coarse and fine sediments, with the latter resulting from winnowed debris charged flows and sheet flood sedimentation (Plate 2). Creek channels are confined due to incision into the low relief uplifted hills produced by the fault zone, whereas creek channels become unconfined to partially confined south of the fault zone where sheet flow flooding is more prevalent on the lower fan (Plates 1 and 2). Although sheet flood inundation is more common on the lower fan, less frequent, large debris charged floods often transport large boulder and vegetation debris to the lower fans, creating blockages and avulsions, or to be carried out to sea.

It is interesting to note that through Montecito, the Mission Ridge-Arroyo Parida fault zone forms low-relief hills in contrast to west and east of Montecito, where more prominent features such as Mission Ridge and Arroyo Parida Ridge likely result from active faulting. The absence of a prominent ridge in Montecito may be the result of redundant scour and erosion due to debris charged flows, and in combination with more strike-slip displacement (Gurrola, 2006).

Floods, Debris-Laden Floods, and Debris Flows

In southern California mountain catchments, flooding can result from multiple and sequential storm events; long-duration precipitation events such as atmospheric rivers; and post-fire watershed conditions followed by short-duration, high intensity precipitation; formation of short-lived landslide dams; and rapid snowmelt. Alluvial fan flooding occurs below canyon mouths when precipitation-induced runoff drains off the steep slopes of the catchments which is exacerbated by steep channels. The results below canyon mouths are flows exceeding channel capacity and out-of-channel.

High magnitude floods occur relatively infrequently but can quickly avulse and trigger catastrophic flooding resulting in fatalities when people are swept away in swift currents and structures pummeled by boulders that drop out of the debris train when the debris suddenly spreads itself across the fan. Low magnitude floods occur more frequently with lessor impacts occurring on a single creek and more commonly, lower in the fan. The term flood in this report refers to quasi-clearwater flows that transport suspended, fine sediment in relatively small quantities, and the suspended sediment has little effect on flow behavior.

Debris laden floods are more dangerous than clear water floods due to very rapid, surging flows of turbid water that can transport large volumes of coarse debris as bedload onto alluvial fans (Church and Jakob, 2020). Debris laden floods destabilize and scour mobilize most or all of the channel bed alluvium producing significant lateral changes by extensive erosion of channel banks (Church and Jakob, 2020). New channel courses result in addition to conveyance down secondary channels or former main creek channels direct flood and debris impacts away from the low flow channel corridors. Debris fills or overflow channels often create downstream blockages. Debris laden floods can be initiated by storm events that increase channel flows by mobilizing most or all of channel bed and transporting their bedloads for considerable distances; or by dilution of debris flows with stream flows; or by landslide dam outbreak floods where most, if not all of the material including massive boulders are mobilized downstream including the channel bed and bank materials (Church and Jakob, 2020).

Debris flows are rapidly moving flows that freight massive boulders, logs, trees, and other vegetative debris within a slurry of dense, fine sediment (mud). The flows build up a frontal snout as it entrains debris from the channel bed and banks, vegetation, and other anthropogenic debris from homes and property (Figure 8). This type of flow can carry large boulders long distances due to buoyancy forces created by the high viscosity and density of the sediment slurry. Avulsions at constriction points or creek meanders are very common in debris flows and produce out-of-channels flows. Once the flow is on the fan, it readily flows down roadways due to low friction with the road surface, and debris can directly impact infrastructure and homes causing devastating damages.

Landslide Dams, Debris Dams, and Outbreak Floods

Deep-seated landslides are present on the side slopes of the main trunk creek and its tributaries in the Montecito watersheds (Plate 2; Gurrola and Rogers, 2020b; Rogers and Gurrola, 2021). A significant number of landslides exhibit former toes that protrude into valley drainages deflecting creek channels and flows towards the opposite bank. These landslide toes are generally eroded and develop steep escarpments due to rapid channel incision, and some dam remnants are usually preserved on the opposite bank.

The record of past landslide dam outbreak floods established in this study (Table 1) suggests that a significant number of these landslides formed temporary dams that blocked or significantly restricted channel flows for some unknown period of time (Gurrola and Rogers, 2020a; Gurrola and Rogers, 2020b; Rogers and Gurrola, 2021). Temporary lakes form behind these debris dams until the offending mass is overtopped and breaches through and rapid vertical incision, which quickly produces a catastrophic outbreak flood (Lee and Duncan, 1975).

Outbreak floods are typically much larger than rainfall floods in the same catchments (Clauge and Evans, 1994), and this type of flood may entrain boulder and vegetative debris transitioning into debris flows. Outbreak flood discharges commonly increase exponentially to peak discharge, then rapidly decrease due to discharge of the lake and return to background creek flows (Clauge and Evans, 1994).

Peak discharges are controlled by the volume of the lake, dam height and width, physical properties of the debris, mechanism of failure, channel gradients, and volume of available sediment and debris (Clauge and Evans, 1994). The location of the landslide dam in the catchment also influences the potential capacity of the lake as dams in the upper headwaters have limited drainage area as compared to lower areas in the catchment with greater catchment area. Generations of large landslides often occur as the result of over-steepened slopes due channel downcutting, earthquake loads, long duration rainfall events, or cumulative rainfall (Gurrola and Rogers, 2020a; Gurrola and Rogers, 2020b; Rogers and Gurrola, 2021).

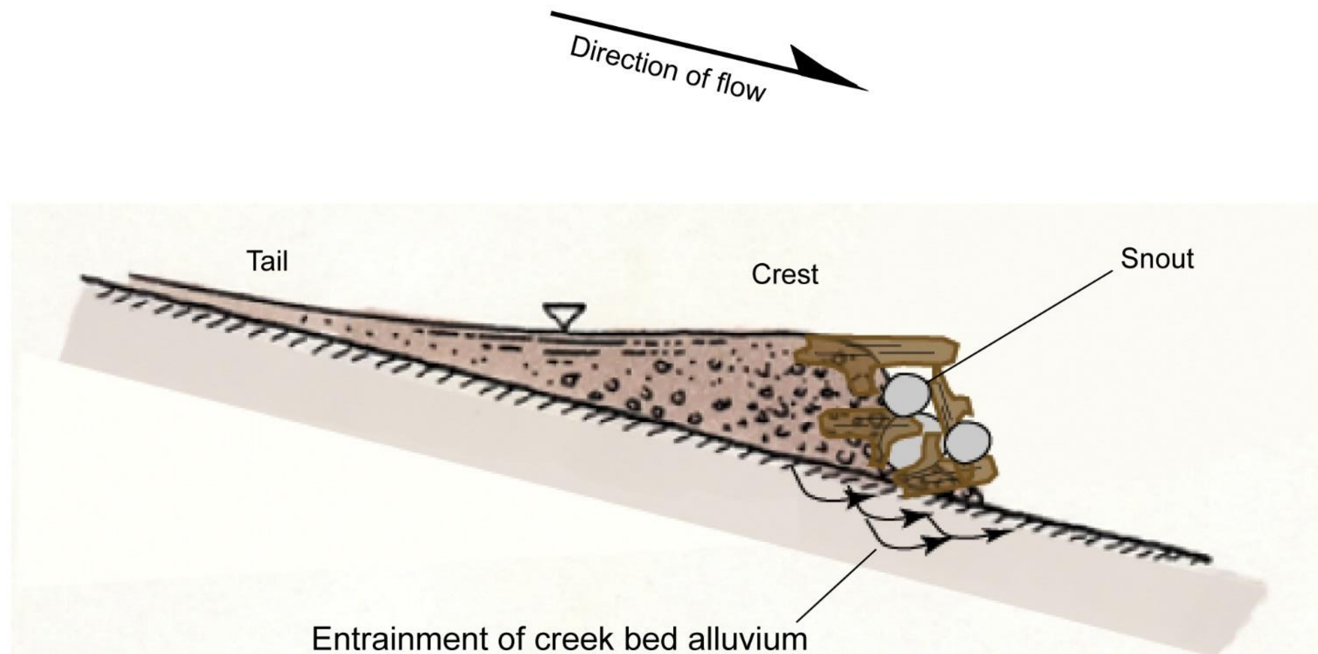

Figure 8.

Diagram of a Debris Flow Snout

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Diagram of a debris flow and snout which builds up due to entrainment of creek bed boulders, vegetative debris, and other incorportated materials such as lumber, building debris, automobiles, etc. The snout becomes an amalgamation of tree logs and boulder debris that overbank and and out-of-channel result in direct impacts with building structures. In the 1964 debris flows, the snout was described as a ..."dry avalanche of trees and boulders".

Large landslides also load the drainages in the mountain catchments with soil, boulder, and tree debris, and floods can transport vast amounts of debris transitioning into debris laden floods and debris flows. Mobilization of this debris may also form plugs and blockages at downstream constrictions restricting flows and creating temporary blockages until it breaches. Debris dams may also form at the mouth of a tributary depositing a debris fan across the main channel and producing obstructions. Natural constrictions such as narrowing of the valley or bedrock impediments may also trap and impound debris that can be stored in the low flow channel until a larger flood event occurs that is capable of sweeping all of the loose material from the main channels, especially mountainous catchments (Rodine, 1974).

Debris dams composed of trees and boulders commonly form in headwater valley tributaries, however deep-seated landslides form larger volume dams and larger temporary lakes than debris dams in the smaller catchments of the upper headwaters (Lancaster, S. T. and Grant, G. E., 2006). Both landslide dams and debris dams are temporary in nature, and those that form in confined creeks of the mountain catchments, increase the potential discharge of outbreak floods.

Formation of debris dams are also prevalent on the fan once discharged from the canyon mouths. As previously mentioned, artificial constrictions developed on the fan create avulsions due to impoundment of debris. Mitigative measures such as staked sacked concrete bags or stonewalls to protect channel banks reduce a channel's flow capacity and increases the potential for channel overtopping and avulsion. Both of types of dam forming processes were observed in the catchments and fan areas of Montecito, and in the recorded flood history of the area.

Flood Event History

The early to mid-19th century period prior to the Great Floods of 1861-62 is largely unknown except for the 1825 debris flow event. The limited information of flood events in this period is provided in accounts of the 1862 or 1914 events, and these events were compared in extent and magnitude to earlier flood events. Determinations were made in the accounts as to which events were greater or similar in magnitude. For example, several early 20th century reports recount 19th century flood events to compare the magnitude and to highlight certain aspects of inundation, or major shifts in river courses, or the discharge of large amounts of vegetative and boulder debris.

The earliest known debris flow event that occurred in southern Santa Barbara County is the 1825 post fire debris flow event which was discussed in a news report that made comparisons to the 1914 event. The common theme among both events was that vast amounts of trees and boulders were discharged from all the southern coastal canyon mouths and that debris was reported similarly deposited on the alluvial plain from mountains to the coasts in areas where they should not be. Another reference to flood following wildfire was noted by O'Neill (1939; Santa Barbara Gazette, October 16, 1856) in October 1856 where wildfires burned in the Montecito hills but details of damages were limited to the City of Santa Barbara and beach areas.

It is important to understand that flood events identified as debris flows in this study reflects the common similarity of voluminous amounts of trees and boulders discharged from canyon mouths. News reports also describe vast amounts of vegetative debris washed up on the beaches that was the result of the debris packages flowing out to the ocean. Often the accounts related impacts to travel in and out of Carpinteria-Montecito-Santa Barbara areas. It is repeatedly noted in accounts that delays of postal mail delivery and delivery of newspapers reports to other cities were delayed several days or weeks following flood events. Locally, news reports describe flood and landslide events that resulted in blockage of train and automobile transportation corridors by floods and landslides or by washed out bridges.

The descriptive detail of events improves in the mid- to late 19th century with more frequent reporting of the weather, creek flows, and flood events. It is at this time that mitigation improvements were orated in opinion and editorial columns or posed as rhetorical questions in flood reports and newspapers accounts. The aspect that landslides pose a threat of blockage of creeks and vastly increasing resultant floods was first noted in an 1862 account in Montecito and subsequent accounts. The first association that greater runoff occurs on mountain slopes and that more vegetative debris is produced from canyon mouths following wildfire was first related in a landslide dam outbreak flood account in 1879 (An Aqueous Boom, Santa Barbara Weekly Press, December 27, 1879).

Post-flood event news accounts vastly improved in the early 20th century and with time, more details were provided in latter half of this period. Flood reports produced by County agencies and the U.S. Army Corps of Engineers in the latter half of the 20th century provide the greatest details of the meteorology that caused the flood event(s), inundation areas, hydrographs of the peak discharge, photographs of damages, and descriptions of subsequent debris basin developments and improvements in flood measurements (Goodridge, 1996).

A minimum of 56 damaging flood events are recorded in the southern Santa Barbara County area from Santa Barbara to the Carpinteria area (Table 1). Notable 19th century flood events occurred in 1825, 1861-62, 1867, 1872, 1875, 1877-78, two events in 1879, 1883, 1884, 1885-86, 1888, and 1889. Early 20th century flood events include four events in 1906, 1907, two events in 1909, two events in 1911, 1912, three events in 1914, 1918, three events in 1926, and 1927. These were followed by events in 1938, 1940-41, 1943, 1950, 1952-53, 1955-56, 1962, 1964, 1966, 1967, 1969, and 1971 (Table 1; County of Santa Barbara, 1974 and 1975; NOAA, 1994; FEMA, 2005; City of Santa Barbara General Plan, 2011; Department of Water Resources, 2013). More recent flood events are also reported in the Santa Barbara area in 1978, 1980, 1982-83, 1991, 1992-93, 1995, 1998, 2005, 2018, and 2019 (Table 1; County of Santa Barbara, 1995; Ward et al., 2018). There were multiple flood events including two events in 1879; four events in 1906; two events in 1900; two events in 1911; three events in 1914; three events in 1926; two events in 1995; and three flood events tallied for the 1861-62, although there were likely multiple events. The 1861-62 event is the maximum annual discharge of record over the past two centuries (Guinn, 1890; Goodridge, 1996).

A total of thirty-six (36) debris flows and debris-laden flood events occurred in the watersheds of southern Santa Barbara County since 1825 and approximately 69% of these events occurred in post-fire watershed conditions. (Table 1). The number of events identified in this study are recognized as a minimum record as unreported or unwitnessed events in the early 19th century are likely in the early history of California (Metropolitan Water District of Southern California, 1931; The Los Angeles Times, March 6, 1938). An accounting of regional flood events in the Los Angeles area by historic accounts established that massive floods occurred in 1815, 1825, 1832, 1833, and 1859, and these events were described as regional southern California events (The Los Angeles Herald, October 15, 1892; The Los Angeles Times, March 6, 1938). The first newspaper established in the Santa Barbara area was the Santa Barbara Gazette founded in 1855 (Library of Congress, 2021; O'Neill, 1939).

Approximately 61% (22 events) of the 36 debris flow and debris laden flood events occurred in the Montecito watersheds and impacted the downstream community since 1825 (Table 1). These events occurred in one or more of the principal watersheds: Cold Springs, Hot Springs, San Ysidro, Buena Vista, Picay, and/or Romero watersheds (Table 1). Roughly 2/3 (63%) of the Montecito events occurred in post-fire watershed conditions and these do not include the 1914 events where 1912-1913 wildfires burned the foothill areas of the western Montecito watersheds and burned east of Carpinteria. Post fire debris flows and debris laden floods discharged from watersheds in Montecito occurred in 1825, 1872, 1879, 1884, 1889, 1907, 1926 (3 events), 1964, 1969, 1971, 2018, and 2019.

A total of 12 landslide dam events were tallied in the last 200 years and 10 of these events produced outbreak floods (Table 1). Two of these events were sufficiently large enough to fill the valley drainage but outbreak floods did not apparently result. The established 10 outbreak floods are also considered a minimum as evidence of landslide dam remnants were observed in aerial photographs for the 1964, 1969, and 1995 flood events.

Debris flow, debris laden floods, and landslide dam outbreak flood events are summarized in the following sections and supplemented with transcribed historic accounts. The transcriptions relate the information specifically provided in the historical accounts and generally utilizes the same descriptive terminology used in the narratives to preserve the nature of the descriptive details. The events are subdivided into 19th century, early 20th century, late 20th century, and recent (early 21st century) categories. Notable debris flow and debris flood events are summarized in more detail and briefly summarized below.

19th Century Fire, Flood, and Landslide Events

1825 Post-Fire Debris Flow Event

One of the first flood events recorded was a large, regional flood precipitated by intense rainfall in southern California from Santa Barbara to San Diego. The event was reported in Los Angeles news accounts as one of the larger flood events (The Los Angeles Times, March 6, 1938) that entrenched the marshes along the Los Angeles River forever draining the lush tule forest but also causing significant flooding of the Santa Ana and San Diego Rivers. The rivers of Los Angeles County were described as "…so swollen that their beds and banks were greatly changed."

Locally, the 1825 flood event is the earliest post-fire debris flow event identified in this study (Dana, 1840; Mason, 1883). Richard Henry Dana reported, upon his arrival to Santa Barbara that the town's beauty was diminished by the absence of large trees on the hillsides. He later learned that a great fire swept them off the hills a dozen years earlier in 1823. The fire was so great and the whole valley became so heated that residents took refuge at the beach for several days (Dana, 1840; Mason, 1883).

A Santa Barbara born native, Jose Graviel Hernandez lived in an adobe near Fithian Ranch and learned of this early 19th century flood event from his ancestors where great destruction occurred along the course of Fithian (Santa Monica) Creek and along the south coast in 1914. He referred to the 1825 event as comparable in severity to the January 25, 1914 debris flow event and similarly noted that the 1825 event cleared out all the trees from the canyons causing much destruction on the plains. He also mentioned the 1914 event was about the same severity and similarly cleared out boulders and trees from the canyons as the 1862 flood event.

Jose Graviel Hernandez had long protested permitting so many large trees to grow and establish themselves in the bottom of the confined bedrock canyons. He forewarned to those who would listen that previous floods caused by hard rain would carry large trees and boulders down the canyons and would cling together acting as a significant flow obstruction. The flood forces would cause it to give way and be equivalent to the bursting of a large dam smashing its way and carrying all before it. He recommended to following a former policy the native Californians and native Americans used in the early 1800's to avoid the formation of debris dams by keeping the lower canyons clear of trees and allowing the flood waters to spread out on the fans below the canyon mouths. This concept allowed the depositional processes of large debris charged events to spread out naturally on the fan allowing the debris to drop out and higher on the fan and preventing this debris from being carried large distances down the fan.

1861-1862 Deluge, Debris Flows and Landslides

Storms occurring in December 1861 through January 1862 are referred to as the Noachian Deluge or the Great Floods in historical accounts and represent the largest magnitude flood event in recorded history for the western United States (Goodridge, 1996; Schimmelmann et al., 1992; Hendy et al., 2015). State Climatologist James Goodridge (1996) recognized the rainfall climate of California has exhibited a higher coefficient of variation over the last 90 years resulting in a greater flood hazards and notably classified this event as a 1,000 year storm. William H. Brewer of the Whitney California Geological Survey wrote "*…The great central valley of the state is under water – the Sacramento and San Joaquin valleys – a region of 250 to 300 miles long and an average of twenty miles wide, a district of five thousand or six thousand square miles, or probable and area of three to three and half millions of acres!*" The floods not only inundated northern, central, and southern California but also encompassed Oregon and the southwest United States. News reports and details of the Great Flood are somewhat limited, one reason cited was that journals (newspapers) suspended business due to economic depression while the remaining (newspapers) issued half or quarter sheet news reports (Sacramento Bee, February 3, 1862).

Rain fell consecutively from December 24, 1861 to February 5, 1862 with the exception of two days in Los Angeles (Los Angeles Star, February 8, 1862) and precipitated sixty-six (66) inches of rain in Los Angeles (Ingram, 2013). A heavy frost event killed fruit trees and damaged grapevines early February but prior to the freeze, trees were in bloom due a previous warm atmosphere which prematurely developed all the vegetation. The subsequent frost killed the blooms suggesting sub-tropical atmospheric river conditions (The Los Angeles Star, February 8, 1862).

O'Neill (1939) reported a "50-inch" rainfall winter in Santa Barbara as the result of the 1861-62 deluge and describes "*immense slides of earth and rocks took place in the mountains (of Santa Barbara County), resulting in considerable change in the appearance of the country*". The narrow coastal plains of Santa Barbara were flooded by the mountain rivers that permanently changed the landscape and creek channel locations of Santa Barbara County (Kuhn and Shepard, 1984; Department of Water Resources, 2013). Another report notes that the Santa Barbara district lost not only houses and trees, but the soil was swept clean from orchards and it was also noted that the floods of southern California were far worse than in the northern California (The Sacramento Bee, February 3, 1862). The extent of destruction was unknown to the oldest inhabitants of Santa Barbara (The Los Angeles Star, February 1, 1862). The filling of Goleta Slough with gravel and sand is attributed to vast amounts of sediment discharged from the mountains. The slough which once permitted a safe harbor for light craft ships could no longer be used (Mason, 1883). In nearby Ventura, measurable rain fell for 60 consecutive days (O'Neill, 1939) and the residents abandoned the town of Ventura to take refuge on higher ground (The Los Angeles Star, February 1, 1862; Kuhn and Shepard, 1984).

Several accounts were ascribed to sudden and almost unexplainable floods in the Santa Barbara area, one of which was the result of a landslide dam outbreak flood in 1861 (Mason, 1883). The family of prominent citizen Russel Heath recounted that the night was clear and moonlit with rain occurring some hours earlier. Hearing the sound of rushing water, the family was met by flood waters that covered the whole plain with 18 inches of water after the rush of the outbreak flood had subsided. Although Heath Ranch was located about a mile below the Fithian (Santa Monica) canyon mouth, the creek had abandoned its channel and formed a new channel 60 feet wide and 8 feet deep. This would not be the only time when Santa Monica Creek flowed through the house but again in the January 28, 1914 debris flow event (Santa Barbara Daily News and the Independent, November 21, 1914).

Another account described a terrific landslide that occurred at the Hot Springs resort on Friday night, January 17 (The San Francisco Daily Alta, January 31, 1862; The Weekly Butte Democrat, February 8, 1862). Three men were camping near the spring when they were awakened by an avalanche of trees and boulders. The men attempted to escape but were caught up in the flood and carried downstream over a quarter mile. Two of the men escaped, one with serious injuries and third man was buried by boulder of enormous size. It took two days before neighbors could reach the scene of the disaster as the flood was sustained for several days. Acres and acres of land, rock, and timber were carried off the flood which opened a new branch of mineral springs and it was noted that the whole surrounding country suffered terribly from the floods (The San Francisco Daily Alta, January 31, 1862; The Weekly Butte Democrat, February 8, 1862).

An earlier landslide is reported to have occurred on the road to the Hot Springs Resort in early 1860 or early in 1861 (The Morning Press, February 13, 1880). Thomas More who was in charge of the laying out the County Road instructed two men to improve the road to the resort in Hot Springs canyon. During their overnight stay in a shanty, they decided to abandon their shelter in one of the heaviest rains and were caught in another landslide, one man was killed by the slide and the other escaped.

1872 Post Fire-Debris Flows and Carpinteria Creek Landslide Dam Event

A small magnitude debris flow event was produced out of Dinsmore (San Ysidro) Canyon and witnessed by residents (Santa Barbara Weekly Press, February 10, 1872; Table 1). The event occurred within a year following wildfires in the foothills of Montecito and originated from above Col. B. T. Dinsmore's property which was located at the mouth of San Ysidro Canyon. A tidal wave of debris tore down the canyon downstream and overflowed creek banks and on to the fan surface. The flow carried trees a foot and half in diameter and huge boulders estimated at 10 to 15 foot high, 6 and 7 feet in diameter, and 10 to 12 feet long. Property damage caused by the flow to the community was not described in detail, but it was noted that after half an hour, the water levels receded and the Dinsmore (San Ysidro) Creek returned to a quiet little brook.

1879 Post Fire-Debris Flows and Carpinteria Creek Landslide Dam Event

Two debris flow events occurred in 1879, one event on January 3 in Montecito and the other event on December 21 in Carpinteria. The first event was preceded by numerous fires reported in the Montecito foothills and mountains in the months of January, August, and September of 1877 (The Morning Press, dated 1877 of January 31, August 10, August 11, and September 4; December 27, 1878). These multiple fire accounts occurred during a drought year where multiple fires were reported in the Montecito area, some of which were purposely started (Mason, 1883; Myrick, 1988). In November 1878, a fire was reported burning in the foothills in November and another large fire was reported burning in the foothills of Montecito in December (The Morning Press, November 30, and December 27, 1878). Most notably in September of 1879, large fires were reported all along the Santa Ynez Mountains from Santa Barbara to Ojai and of particular relevance is that flames and thick smoke were reported emanating from the main range in the Carpinteria area (Santa Barbara Daily Press, September 15, 1879). It is worth noting that the September 1879 news report describes mountain fires in the Carpinteria area and asserts that rain will rush off from the bare slopes in the upcoming winter (The Morning Press, September 20, 1879).

The first debris flow event was reported from Hot Springs Creek where the road was washed away by torrents that carried great boulders, which were left in places that made the roads impassable (The Daily Press, January 3, 1879). The latter debris flow event in 1879 occurred on December 21 in Pettinger Canon, described as the east tributary of Carpinteria Creek, which is the Carpinteria-Sutton Creeks reach (Mason, 1883; Santa Barbara Weekly Press, December 27, 1879). This event resulted in two fatalities, Mrs. Pettinger and a worker who lived on the ranch were carried away in the torrent. The catastrophe was described by Mr. John Pettinger who depicted that the noise of the boulders at 4 a.m. was too loud for him to sleep but he returned to bed. The noise of the boulders became so great at 5 a.m. that he awoke and went to the door with his wife to see trees, logs, and boulders bursting though the picket fence 25 yards away. The debris flow crushed the house and swept it away. Mr. Pettinger did not expect that anyone could live in such destruction, but his children were able to escape when the shed addition they were sleeping in broke away from the main house and temporarily become lodged on elevated ground. The debris flow destroyed the downstream Carpinteria Creek bridge and its stone abutments.

No mention was given who promoted the idea that post-fire conditions leads to greater runoff but it was also mentioned in the report describing Mr. Pettinger's account that the "…sudden great rise in these streams was caused by heavy rains in the burnt regions of the mountains, which clogged the narrow gorge, forming a large dam, which was liberated by the giving way of one of the upper ones;…" (Santa Barbara Weekly Press, 27 December, 1879; Mason, 1883). The report also describes that the dam produced marks on the valley wall forty feet above the creek's normal flow level. The total rainfall in the (Carpinteria) valley after the storm passed was 2-7/8 inches.

1885 Post-Fire Debris Flows

In 1883 an extensive fire was reported on the mountain side between Montecito and Carpinteria which produced heavy clouds of smoke (The Morning Press, January 30, 1883) and a fire in 1882 was reported at Carpinteria Creek in the mountain timber (The Morning Press, December 15, 1882). A brief mention of a post-fire flood event was described in a flood article which stated, "Even after the immediate threat of a fire had passed, other dangers remained. The destruction of watersheds often left communities at the mercy of heavy winter rains and flooding. An 1885 account tells of the devastation caused by tree debris upon the Carpinteria Valley by a flood in the aftermath of a wildfire" (Redmon, Independent, October 16, 2003).

1889 Post-Fire Debris Flows and Floods

The Great Fire of 1889 was described as the most destructive fire burning in the mountains and hills since the founding of the Mission in 1786 (The Morning Press, July 30, 1889). The immense fires were actually three separate fires that occurred during a 100 degree plus heat wave and converged into one massive fire in Montecito on July 27. One fire burned down Romero Canyon from the divide, causing the most destructive damage along the foothills, and the second fire from Summerland to Sycamore Canyon (The Morning Press, July 30, 1889; Myrick, 2001). A third fire burned in Sycamore and Cold Springs Canyons.

In 1889 a "great rain" was reported as the heaviest October rain ever known in Santa Barbara. The event precipitated 6 inches in Montecito between Sunday morning shortly after midnight to the daylight hours with a one-hour rainfall of 1.70 inches between 2 and 3 a.m. in Santa Barbara (The Morning Press, October 22, 1889). The subsequent flood was reported to do great damage including the erosion of precious soil in orchards down to "hard earth." Losses of crops were in the several hundreds of thousands of dollars in the Goleta, Santa Barbara, Montecito, and Carpinteria. A large volume of rocks, trees, and boulder debris carried downstream by Buena Vista Creek that also destroyed a masonry diversion dam (The Morning Press, October 22, 1889; Myrick, 1988).

Early 20th Century Fire, Flood, and Landslide Events

1906 Casitas Creek Landslide Dam

A landslide on March 17, 1906 was described as "enormous" which covered several hundred feet of the County road (now Highway 150) over the Casitas Pass making the road impassable below Rincon Hill (The Independent, April 28, 1906; The Morning Press, March 18, 1906). The slide had reactivated "*The landslide covers fully twelve acres….Tehre(sic) was a bridge across a canyon there, but it was wiped out by the landslide and as a matter of fact it will no longer be necessary for the earth has completely filled the canyon in that spot.*" It was also noted that a carriage could be driven over the slide mass which filled the Casitas Creek drainage although no outbreak flood was reported (The Morning Press, March 18, 1906). The report notes the small creek was diverted around the hill (landslide mass) in a new direction, and this suggests the creek had sufficient time to scour a channel in the landslide which prevented a lake from developing behind it.

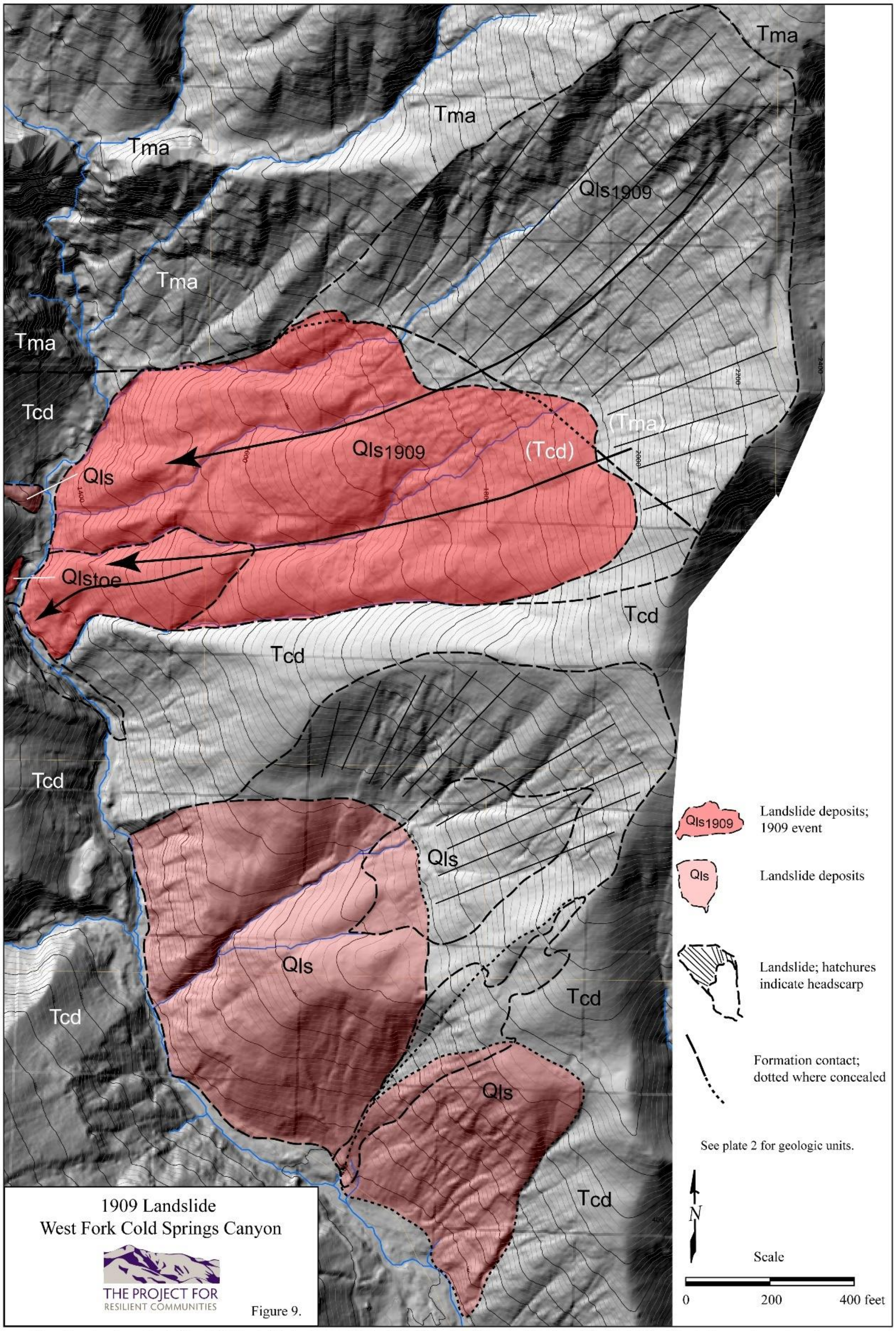
1909 Landslide

A newspaper account of a 1909 flood event in Santa Barbara stated that "*a great mountain slide back of Montecito*" had occurred in the severest part of the storm on February 7 (The Independent, February 8, 1909). The article stated that this landslide could be seen from the downtown Santa Barbara office window of Colonel Slosson of the National Forest Reserve, who stated "*…but a great hunk of the mountain side is gone. It doesn't look so very big from here, but it is big, just the same*." A local historical researcher, Ms. Hattie M. Beresford assisted in establishing that Colonel Slosson's office was located in the present-day Howard-Canfield building at 831 State Street. The building was a three-story structure prior to the 1925 Santa Barbara earthquake but is now a two-story building.

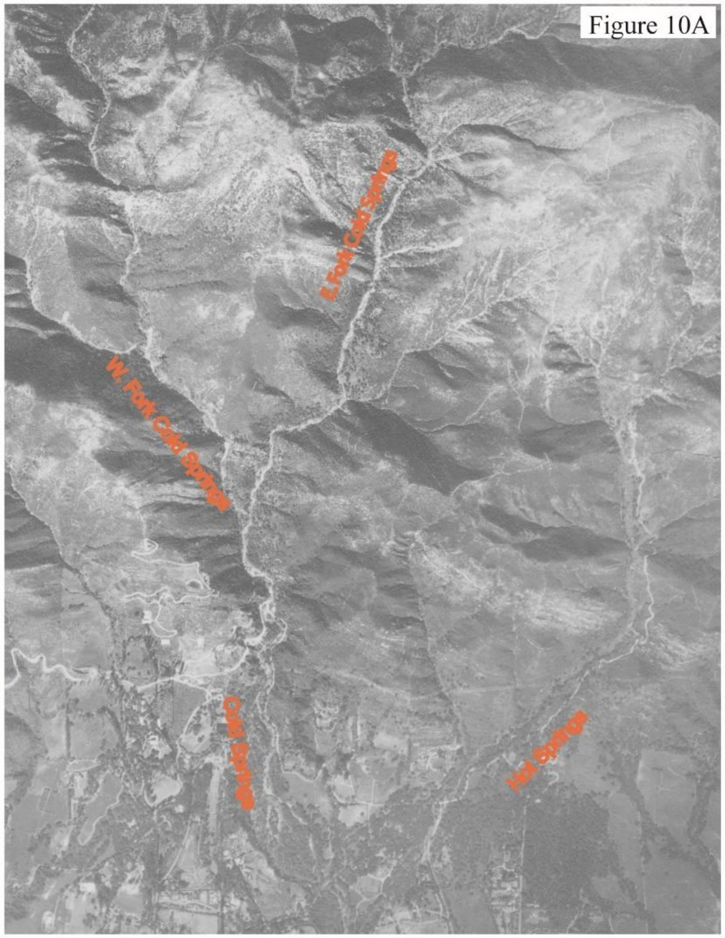
Another newspaper account in The Morning Press (dated February 9, 1909) headlined an article "*Big landslide on Mountain*." This article noted that a remarkable landslide occurred during the storm on the north shoulder of Cold Springs Canyon. More importantly, the article stated the landslide created a "*great gash*" down the mountain side and the scar was plainly visible with the naked eye from the windows of any three-story building on State Street. Based on the description that it is visible with the naked eye from State Street and was on the highest peak south (east) of La Cumbre peak forming the north shoulder of Cold Springs Canyon, this landslide appears to have occurred on the southwest-facing slope of the peak west of Montecito Peak (Plate 1; Figure 9).

Utilizing 1928 and 1929 stereo aerial photographs of the landslide area, the 1909 landslide was likely was the result of a retrogressive landslide complex where the subsequent 1909 upslope failure of Matilija Sandstone collapsed as a debris avalanche (Figures 10A and 10B). This event was preceded by an earlier slope failure of the lower slope in the Cozy Dell Shale. Based on its geomorphic expression, this lower portion likely failed during the record 1861-62 flood event. The initial slide created an over steepened upper slope and subsequently failed as a debris avalanche in 1909. The mass of debris deflected the creek channel over 200 feet to the west and likely denotes the location where a breakout flood occurred in 1914 (Figures 11, 12A, and 12B). Reactivation of this landslide mass due to oversteepening of the toe slope also produced slides in the 1964 Coyote fire debris flow event and the 1995 debris flood event where the toe debris was scoured and evacuated by debris flows.

A second, large landslide that produced previous landslide dams is located south of the 1909 slide and currently poses a greater flood threat (Plate 2; Figures 9, 10A, and 10B). The large slump forms a bench composed of shale-siltstone blocks in a finer-grained matrix. This slump likely produced a landslide dam because of size of the mass, extent of displacement, and the narrow width of the incised drainage. It poses a greater flood hazard because it potentially blocks both a second western tributary of Cold Springs Creek, in addition to the tributary with the 1909 landslide. As a result, a much larger temporary lake may be formed from both tributaries producing a greater outbreak flood (Figure 13). Reactivation of the toe has resulted in subsequent smaller slides of the



Map showing the extent of the 1909 landslide in the west fork of Cold Springs Canyon. The toe of the landslide deflects the creek westward and a remnant of the former dam is present on the west side of the valley. Note the two additional large landslide located downstream of the 1909 slide. The larger of the southern landslides likely created a much larger flood outbreak when it initially failed as it would have blocked an additional tributary.



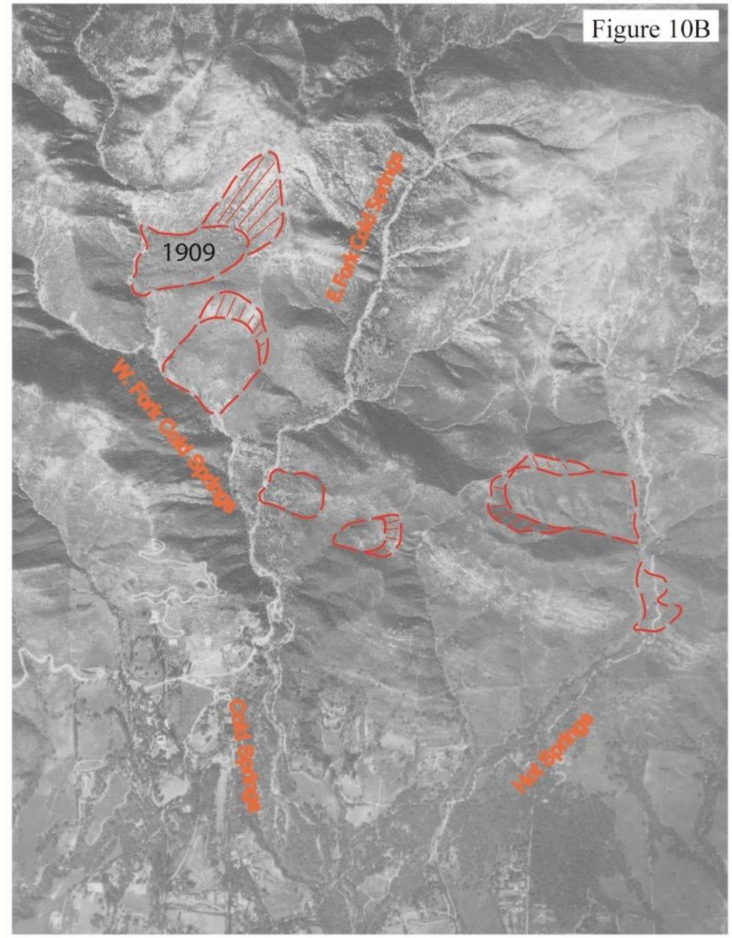


Figure 10A. Aerial photograph flight C-430, frame C-44, dated, 1929 showing the steep terrain in the lower watersheds of Cold Springs and Hot Springs Canyon. Figure 10B. Large, deep seated landslides are shown outlined with red dashed lines and head scarps marked by red hatchures. The landslide observed by Colonel Slosson in 1909 following heavy rainfall forms a steep headscarp area. Note the large mass of landslide debris at the bottom of the slope with the creek channel deflected westward. Other deep seated landslides are shown in the vicinity and these slides present potential dam forming blockages of the watershed.

Figure 10A and 10B.

1929 Aerial Photography of Landslides

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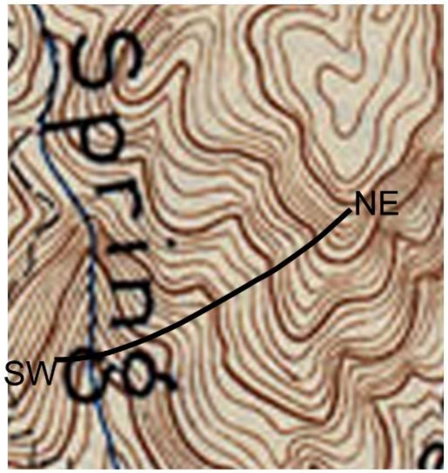
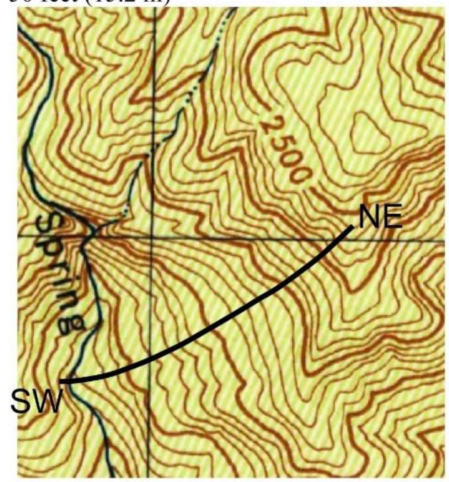
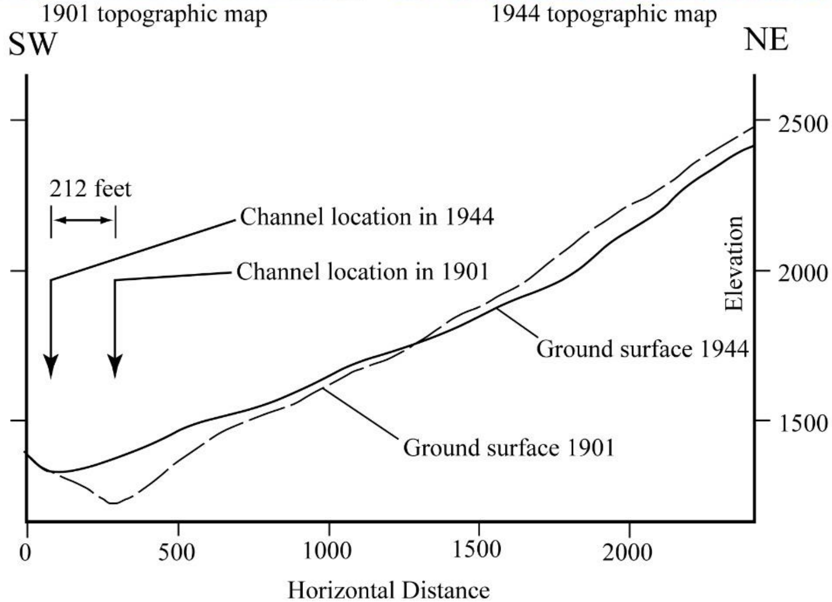
Scale: 1 inch = 1000 feet (305 m)
Contour Interval = 50 feet (15.2 m)



1901 topographic map



1944 topographic map



1 inch = 500 feet

Comparison of topographic profiles generated from a 1901 topographic map (pre-landslide conditions) and a 1944 topographic map (post-landslide conditions). Note that the creek has been deflected westward more than 200 feet and that the former channel is buried by the landslide mass.

Figure 11.

Comparison of 1901 and 1944 Profiles
1909 Landslide

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Figure 12A. View looking north, upstream of the east fork of Cold Springs Creek at the 1909 landslide dam remnant. The slide moved downlope from right to left over running and burying the former creek channel. A new creek channel was formed west of the former channel location where the flood breakout occurred.

Figure 12B. The toe of the landslide is exposed in the eastern bank and reveals sandstone sandstone derived debris that now forms a steepened scarp. Recent scour erosion has partially exposed the basal slide plane.

Figures 12A and 12B.

Toe of the 1909 Landslide
East Fork Cold Springs Canyon

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View of the toe of the large landslide located south of the confluence of the west and east forks of Cold Springs Creek. This landslide has the potential to block flow on both west and east tributary forks which has the potential to produce a much larger outbreak flood as compared to the 1909 landslide.

Figure 13.

Large Landslide
E. Fork Cold Springs Canyon

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toe face in the latter 20th century. The basal slip surface was exposed in the creek channel following the 1-9 event and together with gradual removal of toe materials due to slides, these factors reduce the global stability of the large slump mass.

1911 Hot Springs Canyon Landslide

A landslide described as an avalanche of great boulders did much damage to the Hot Springs resort on March 9, 1911 (The Independent, March 9, 1911). The landslide temporarily blocked Hot Springs Creek and warnings were issued to the residents of Old Spanish Town to beware of an imminent outbreak flood. There was significant damage reported in Montecito, but no additional specifics provided in the newspaper account.

1914 Debris Flows and Landslide Dams

A series of several fires burned the foothill and mountain areas which were at that time, suspected of being started by incendiary devices (Stella Haverland Rouse, Olden Days column, November 29, 1964). A wildfire was reported in Sycamore Canyon on September 17, 1913 which burned the area west of the former Mountain Nook property on Mountain Drive. A similar fire was reported the prior year in 1912 that burned the west of the Mountain Nook (Myrick, 1988). A *Morning Press* article dated December 5, 1912 described the 1912 fire as mostly burning north of Mountain Drive and it was also noted that this was the second fire along Mountain Drive making the 1913 fire on Mountain Drive the third brush fire of the 1912-13 season. A series of fires also broke out on the trail to Inspiration Point and later, a fire in San Ysidro Canyon was reportedly driven by one of the heaviest winds of the year which smoldered for over a week (Stella Haverland Rouse, Olden Days column, November 29, 1964). In addition, fires also burned the Casitas Pass and Shepard's Canyon areas. These fires produced partial burn conditions in the western and central Montecito watersheds, and in the Casitas Valley area.

Three debris flow events occurred in January and February of 1914 and an abundance of data and accounts are synthesized in the following section for the community of Montecito and vicinity. A total of six fatalities occurred over the course of the three events, with four fatalities in the first event, and one fatality in each subsequent event. Large debris including boulders and trees were reported to be discharged from all the canyons along the south coast, and the partially burned watersheds produced greater volumes of debris than those in non-post fire burn conditions.

First Event

The 1914 event on January 25 was often recalled as the most destructive storm in historical times (Gidney et al., 1917). The common theme of these accounts described large volumes of runoff, gigantic boulders, giant tree trunks, and debris of all kinds discharged from the mountains and canyons, with the smaller streams which are typically dry washes, surged with 20 to 30 feet high masses of earth, boulders, and trees. It was noted that "not a particle of soil remained" and large deposits of debris were scattered on the level land (Gidney et al., 1917).

Forest Ranger H. W. Muzzall on stationed on Santa Ynez Mountain observed the January 24th to 25th storm on the Santa Ynez Mountain divide and described it as a long duration precipitation event and not a "cloudburst event (Figure 14; Santa Barbara Daily News, February 4, 1914). A weather report recorded that the storm approached from the southeast and dropped 8.48 inches in two days on downtown Santa Barbara, which is near sea level. However, it should be noted that this storm event was preceded by long duration rainfall beginning January 15 and combined with January 27th storm for precipitating 16 inches of rainfall (The Morning Press, January 27, 1914). Given the storm approached from the southeast and that rain and the storm's intensity were greater on the south side of the divide, this evidence strongly suggests an atmospheric river event was the reason for the flood event and it occurred over the southern California area in general. (Dettinger et al., 2011; Jayme Labor, pers. comm., 2020).

The storm began in the early morning hours of Saturday January 24th and the storm clouds were described as big, black inky clouds of cyclonic nature that abutted up against and hovered over the mountain range creating greater rainfall amounts in the mountain catchments (The Morning Press, January 27, 1914). This observation is consistent with orographic lifting effects created significantly greater rainfall in the upper headwaters of the mountain catchments. The greatest intensity of rain was measured in Santa Barbara on Sunday January 25th, the same day as the debris flow event, where the storm dropped 4.5 inches in just two hours. The precipitation intensities and amounts would have been higher up in the mountains due to orographic lifting.

The January 25th debris flow event inundated watersheds all along the southern Santa Barbara County coastline from Gaviota to Carpinteria and into the Casitas Pass and western Ventura County. The Morning Press (January 27, 1914) describes the 1914 flood as the "worst flood in history of Santa Barbara County." Myrick (1989) referred to these storms as the Great Floods of 1914 and along with other news reports, indicate the greatest damage in Montecito was along Hot-Springs-Montecito Creek and San Ysidro Creek with many bridges wiped out and extensive property damage.

Four deaths were attributed to the first event including Mr. and Mrs. Louis Jones. During the 1914 storm event, Mr. and Mrs. Jones were at the Santa Barbara Country Club when they were informed by telephone that flood waters were overbanking and running close to their home where their four children and a nurse were staying. Their Wildwood property was located on the east bank of San Ysidro Creek near East Valley Road. Another news report conveyed that the Jones' were also aware of past flood impacts to their property and were determined to rescue their children and nurse. They could not drive across Olive Mill Road due to debris and floodwaters, so they abandoned their vehicle near the Miramar Resort in attempt to walk home in the storm. Their bodies were discovered after the storms passed the following day. It was reported they drowned, possibly caught up in the torrent near the blacksmith's shop at the confluence of two creeks (Santa Barbara Daily News and the Independent, February 21, 1914). Their bodies were found about 300 feet apart generally in the vicinity of the Montecito School grove (The Morning Press, February 18, 1914).

A youth drowned in an open ditch on Chino Street near La Cumbre Junior High due to the voluminous amounts of debris that choked Mission Creek (Walker A. Thompkins, Santa Barbara Yesterdays, Santa Barbara News Press, date unknown). A fourth victim to the flood occurred in Carpinteria when a postal carrier was killed by the debris charged floodwaters.

FOREST RANGER IN HILLS SAW HOW FLOOD FORMED

No Cloudburst, But Debris Formed Dams, Which Finally Broke

Ranger H.W. Muzzall, who was in town yesterday from the head waters of the Santa Ynez river, was one of the few person placed in such a position that he could see how the floods formed, and reason out a means of preventing a repetition of the damage.

He says there was no cloud burst, but that the long continued rains turned loose slides at the head every gulch or arroyo, that these carried down masses of debris into the creek beds, stopping up the channels.

They formed actual dams in the creeks, and the continued rains filled these naturally formed reservoirs until the weight of the water was too great for the walls of debris to hold, and one after another they would break, sending down every channel a torrent to swell the floods pouring down the larger waterways.

"Keep the creek channels free of debris, and more than half of the damage from floods will be removed" said Mr. Muzall. His explanation is corroborated by County Surveyor Flourney, who has just completed a close inspection of the various creek beds above Montecito and Santa Barbara.

It was no cloud burst, but the landslides and debris in the creeks that did the damage by impounding water which would break the walls of debris of their own weight, and pour floods upon the city and valley" is Mr. Flournoy's statement.

As a preventative he would have all the creek channels closely watched and kept clear of trees, logs, and general debris. As the recent storm flushed out all these waterways Mr. Flournoy does not believe that there is danger of another such flood for several years, or until the debris is again allowed to check the streams.

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Article of Forest Ranger's H. W. Muzzall describing his account of the initiation of the debris flow event on January 25, 1914. Note that dams formed by debris which is important in identifying debris charged floods, i.e, debris flows and that the debris originated from landslide debris. The initiation occurred as the result of prolonged rainfall with periods of high intensity, and high antecedent moisture.

The Santa Barbara Daily News, page 8, February 4, 1914.

Figure 14.

1914 Debris Flow Plug
Hot Springs Canyon

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The debris flow damages were described as enormous in both suburban and rural areas with two people drowned in Montecito and initially, losses were initially estimated at $500,000 to $750,000 dollars which is equivalent to about $15 to $22 million in 2022 (The Morning Press, January 27, 1914; County of Santa Barbara, 1974; www.dollartimes.com, 2021). The population of Montecito was reported to be ~2,500 with development sparser relative to present-day population densities.

Each canyon in Montecito delivered torrents of water, boulders, trees, and mud which disrupted everything in its path and most significantly, trees and boulders were observed to destroy bridges supporting the occurrence of debris flows. Extensive damage due to debris impacts were also described along Mission, Sycamore, Cold Springs, Hot Springs, and Montecito Creeks which was likely the result of greater runoff and debris production due to partial post-fire conditions in these areas. Sycamore Creek was described as unrecognizable and plugged full of trees with hundreds of trees washed out to sea along all the creeks in Carpinteria. Post-fire conditions in the Cold Springs and Sycamore Canyon watersheds likely contributed to the greater production of vegetative debris in these watersheds. Damages were also noted in Goleta and areas to the north in Gaviota, and areas to the south in Ventura and Los Angeles Counties.

Myrick (1989) reported Hot Springs Creek created a new channel course through the Riven Rock area causing much destruction. A debris flow snout consisting of boulder debris pile was preserved in Hot Springs Canyon (Figure 15). A Morning Press news story reported that Spanish Town located next to Montecito Creek was wiped off the map when blockage occurred at the bridge which diverted the creek out of the channel creating a new course to the west of the bridge and through Old Spanish Town (Figures 16 and 17) (The Morning Press, January 27, 1914). South of Old Spanish Town, the flow path of Montecito Creek was blocked at Hot Springs Road and avulsed down Olive Mill Road where the flow scoured a new channel 20 feet deep. (Plate 3; Figures 18 - 22).

A newspaper account written by local historian and newspaper correspondent, Stella Haverland Rouse (dated August 9, 1968) describes the collapse of a landslide dam in the upper reaches of San Ysidro Creek in 1914. The article describes the breaching of a landslide dam to have occurred shortly after 6 P.M. on January 25th. It unleashed a flood of water that left a path of destruction all the way to the ocean. The discharge quickly eroded the landslide dam and picked up additional debris from the apex of the alluvial fan down to the coastline.

Forest Ranger H. W. Muzzall recorded a detailed account of catastrophic outbreak floods that resulted from multiple landslide dams overtopping and then eroding rapidly across the Santa Ynez Mountains catchments (The Daily News, February 4, 1914). The extreme catastrophic outbreak flood event occurs when a string of landslide dams in the steep catchments begin to experience a cascade of failures that begin at the higher elevations and pick up more discharge and slide debris as they flow down-gradient. These cascading masses become killers when they avulse on the lower alluvial fans transporting boulders > 10 to 20 feet in diameter smash structures like wrecking balls and uprooted trees become battering rams that can puncture structures. Another landslide dam outbreak flood was reported in Fithian Canyon (now Santa Monica Creek) which sent a flood wave of debris about 15-feet high downstream. County Supervisor Deaderick witnessed the outbreak flood and was able to barely escape the destructive wave of boulders and logs.

Forest Ranger Muzzall's account supports the forensic evidence observed by County Surveyor Flournoy that the process of landslide dam formation and subsequent failure occurred in the 1914 event and increased peak discharge. These observations are corroborated by the post-event

A debris plug in the channel of Hot Springs Creek was a source of fascination for the locals. Not all debris flows exit the canyon mouth. This debris flow froze in place in Hot Springs canyon likely due to dewatering of the flow. The photograph shows an escarpment approximately 20 feet in height. Courtesy of the Montecito Association History Committee.

Figure 15.

1914 Debris Flow Plug
Hot Springs Canyon

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Debris flows caused devastation in Old Spanish Town on January 25, 1914 and again on February 18, 1914. A roof sits on a pile of boulders and mud outside of Montecito Creek. Photograph from Noticias, October 2019.

Figure 16.

1914 Debris Flow Path
Old Spanish Town

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Located along the banks of Montecito Creek, Old Spanish Town suffered extensive damage with the loss of over a dozen buildings and an early period Spanish adobe building. The Morning Press newspaper reported a story entitled, "Old Town Wiped From Montecito Map". The main bridge on Montecito Creek was constructed of stone which caused a debris blockage that ultimately collapsed. The blockage diverted the creek to flow around the west abutment producing much damage by impacts of trees and boulders. Photograph courtesy of the Montecito Association History Committee.

Figure 17.

1914 Debris Flow Path
Old Spanis Town

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View of Olive Mill Road where debris flows broke out-of-channel from Montecito Creek at the Hot Springs Road bridge overpass. The avulsion diverted flows down Olive Mill Road incising a gully up to 20 feet deep, in places. This photograph shows boulder and vegetation debris partially filling the gully. Debris flows on February 18, 1914 once again broke out-of-channel at this location during the second debris flow event and scoured another gully similar to this event. Photograph courtesy of the Montecito Association History Committee.

Figure 18.

1914 Debris Flow Path
Olive Mill Road

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A different view of Olive Mill Road at the juncture of Hot Springs Road and Olive Mill Road after the flood had subsided following the first event. Photograph courtesy of the Montecito Association History Committee.

Figure 19.

1914 Debris Flow Path
Olive Mill Road

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View looking along Hot Springs Road at the intersection of Olive Mill Road after the floodwaters had subsided. The out-of-channel flows down the Olive Mill Road corridor re-occurred during the second debris flow event on February 18, 1914. Photograph courtesy of the Montecito Association History Committee.

Figure 20.

1914 Debris Flow Path
Olive Mill Road

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The January 25, 1914 debris flow path down Olive Mill Road destroyed the stone lemon house on William Gould's La Favorita property, located southwest of the Olive Mill Rd and Hot Springs Road intersection. This photograph shows the remains of the stone lemon house. The normal channel course of Montecito Creek is located east of Olive Mill Road at this location. Photograph courtesy of the Montecito Association History Committee.

Figure 21.

1914 Debris Flow Path
Olive Mill Road

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Another view showing the result of out-of-channel debris flows diverted down Olive Mill Road in the first 1914 event. This photograph is in the vicinity of the intersection with Hot Springs Road. Debris flows traversed this road corridor once again on February 18, 1914 after a blockage at the Hot Springs bridge overpass diverted flows onto Olive MIll Road. Photograph courtesy of the Montecito Association History Committee.

Figure 22.

1914 Debris Flow Path
Olive Mill Road

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inspection of the catchments in Montecito by County Surveyor Frank F. Flournoy who described the flood process "…until the day comes when a very large quantity of water will cause them to break away, and to push the other until they become a rolling mass of waters, trees, and rocks, making dams here and there, only to break loose by others piling in, causing a toboggon slides, so as the say of the whole canyon." Frank F. Flournoy's entire account is included in Appendix A because it is so similar to what was observed in the same area in 1964, 1969, 1971, and 2018.

Second Event

A second flood occurred on February 18 in Montecito when conditions were stated to have been nearly as bad as the January 25 storm (Santa Barbara Daily News and The Independent, February 18, 1914). Three inches of rain were reported before 10 a.m. on February 18 and George W. Russell measured 0.65 inch of rain in 20 minutes during the storm. A fifth victim is attributed as a fatality of the 1914 storms by Dr. Julius Hurst as recorded by Maria Churchill (Montecito Association History Committee, 2020) and is corroborated by O'Neill (1939). Ms. Churchill's notes attribute the death of Fanny Stevenson on February 18, 1914 because Dr. Hurst could not attend to his patient due to the flood waters on Montecito Creek. Another interesting note about Dr. Hurst is that it was recounted that he drove an air-cooled Franklin automobile which was well known as very noisy in the village. One of the Niedermuller children was ill and as the family awaited the doctor's arrival, they hear a loud noise thinking it was the doctor's car but it was the debris flow as it reached Olive Mill Road and they quickly abandoned their home.

The upper roads from Montecito to Carpinteria were badly washed out and the storm scoured about a fourth (roughly the silt and mud on the Coast Highway (Santa Barbara Daily News and The Independent, February 19, 1914). Old Spanish Town was once again inundated with debris and floodwaters. Further downstream, Montecito Creek plugged with debris once again at the Hot Springs Road crossing and debris flows were diverted down Olive Mill Road cutting another deep gully in the road (Plate 3). Debris flows also crossed the highway inundating the Olive Mill Road area south of the Coast Highway. In addition, floodwaters were diverted eastward nearly ½ mile along the Coast Highway where the creek reoccupied its former channel at the stables and sunken gardens of the Miramar Resort (Plates 3 and 4). This scenario where Montecito Creek reoccupied its former channel occurred similarly to the first event, and it was reported that out-of-channel flows once again reoccupied the same flow paths as in the January 25 event.

The channel of Mission Creek was reported to be flowing bank full with several bridges submerged. Earth, gravel, and tree debris were reported to have washed down from higher levels of Mission Creek and it created a new course near Oak Park down to the Southern Pacific Railroad (Santa Barbara Daily News and The Independent, February 19, 1914). A 13-year old boy fell into the debris charged floodwaters and drowned when the bank collapsed underneath him while watching Mission Creek floodwater with his family which was the sixth fatality (Santa Barbara Daily News and The Independent, February 19, 1914).

Third Event

A third debris flow sequence occurred as the result of 6 inches of rainfall by 1:30 pm on February 20. Trees and other debris were clogging up bridge crossings over Mission Creek, and it was reported that similar to the first event, large landslides carrying great masses of brush, rocks and trees were threatening to dam Mission Creek (Figures 23 and 24). As a result, heavy damages were reported in Santa Barbara, Montecito, and Carpinteria.

1921-25 Fires

Several fires were recorded during the period of 1921 through 1925 in the Santa Ysidro Mountains, with a couple of these forming large conflagrations, that collectively extended from Santa Barbara to Carpinteria and northeastward into the Casitas Pass and Ojai areas. Wildfires were reported to have burn in areas adjacent to recently burned terrain in the foothills and upper mountain areas, and on both sides of the ridgeline. Another fire erupted in October 1921 that was described as "leaping up to the mountain ridges" and was reported to be the worst fire in years (The Los Angeles Times, October 21, 1921). The fire burned the Hot Springs Club in Hot Springs Canyon and incinerated the watershed in San Ysidro Canyon. Surprisingly, the San Ysidro Cottages were saved (Myrick, 1988; The Los Angeles Evening Express, October 20, 1921; The Los Angeles Times, October 21, 1921).

A fire in Blue Canyon near Gibraltar Lake located north of the Santa Ynez Mountains ridgeline burned a large part of watersheds that drain into the lake and along the Santa Ynez River (The Morning Press, June 27, 1922). This wildfire had crept southward over the ridgeline burning into Cold Springs and Hot Springs Canyons. The Santa Barbara Morning Press reported that more than 10,000 acres had burned and was still burning in the upper San Ysidro Canyon (June 28, 1922).

A fire threatening the watersheds of Santa Barbara in the Santa Ynez Mountains was also reported in August (Eugene Guard, August 9, 1923). Another fire raged out-of-control of firefighters as it headed toward Santa Barbara with a front several miles long. It was reported that the fire killed three firefighters in San Roque Canyon (The Los Angeles Times, September 9, 1923). The fire was still considered out-of-control a week and a half later when it was fanned by brisk northwesterly winds (Anaconda Standard, September 18, 1923). A later news account of the fire stated that fire fighters who have been battling the blaze for three weeks called for additional help (Star Tribune, September 23. 1923).

Another fire was reported on February 27, 1924 that burned fiercely and uncontrolled down Cold Springs, Rattlesnake, and Sycamore Canyons (Stella H. Rouse, in Old Santa Barbara column, Santa Barbara News Press, February 27, 1974; Marion Gregston, Montecito Journal, September 30, 2004; Montecito Association History Committee; Ventura Daily Post, February 27, 1924). The fire was reported to have burned over an eight mile stretch in the foothills behind Montecito (The Los Angeles Times, February 28, 1924).

A second fire started in Blue Canyon on August 13, 1925 and crossed over the ridgeline into upper Cold Springs and Hot Springs Canyons and into San Ysidro and Buena Vista Canyons (Humboldt Times, August 23, 1925 and August 25, 1925). The eastern portion of the fires in San Ysidro and Buena Vista Canyons were declared under control by August 24, 1925 but were still burning in

Clean up and removal of vegetative debris at a bridge constriction resulted in avulsion and diversion of flows. Photograph from Edson Smith Photo Collection, Santa Barbara Library, 2020.

Figure 23.

1914 Debris Flow
Mission Creek

Debris choked bridge on Mission Creek deoicts the vast amounts of vegetative and other debris produced in the 1914 event. Photograph from Edson Smith Photo Collection, Santa Barbara Library, 2020.

Figure 24.

1914 Debris Flow
Mission Creek

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Cold Springs and Hot Springs Canyons (Humboldt Times, August 25, 1925). A follow up report indicated the fire was still burning in these Montecito canyons but under control (Humboldt Times, August 27, 1925).

In late November 1925 the Casitas Pass Fire raged on two fronts and was reported to have burned over 36 square miles (The Los Angeles Times, November 24, 1925). The western part of the fire line was burning along the ridgeline but was expected to be contained when it reached the burn area of the second Blue Canyon Fire and the second fire front was burning in Shepherd's Canyon (The Los Angeles Illustrated Daily News, Marysville Appeal, November 21, 1925; (Ventura County News Press, November 23, 1925).

Three post-fire flood events occurred in 1926 and are described in the following section. All three of these debris flow events related the consequence of the rapid erosion of soil and burned logs from the steep canyon, creating debris torrents in the confined channels that were able to freight large boulders, and was blamed by the absence of vegetation protecting the slopes.

1926 Post-Fire Debris Flows and Landslide Dam Outbreak Flood

San Ysidro Creek First Event

Heavy damage in Montecito was reported in an event that occurred about 7:30 p.m. on the evening of February 11, 1926 in San Ysidro Canyon (The Morning Press, February 12, 1926; Myrick, 1988). The Morning Press headlines of February 12, 1926 read "Heavy Cloudburst Damages Montecito Estates" and "East Valley Road Buried in Mud and Debris Many Feet Deep." This Morning Press edition established that a sudden outbreak flood wave inundated a large area and caused widespread destruction from the mouth of San Ysidro Canyon to the coast.

The cloudburst event was reported to produce intense precipitation in the upper headwaters of San Ysidro Canyon where the watershed was in post-fire conditions. Weather reports detailed that the cloudburst focused rainfall in the headwaters of San Ysidro Creek as a mile to the west, Cold Spring Creek only had a small flow (The Morning Press, February 12, 1926). These reports indicate that the rain began falling over Santa Barbara County after 5 p.m. on February 11th, and Santa Barbara recorded 1.15 inches of rainfall by 9 p.m. Painted Cave and Gibraltar Dam reported 1.2 and 1.5 inches, respectively, and 1.5 inches in Montecito (The Morning Press, February 12, 1926, and again on February 13, 1926). Ultimately, a follow-up report of the storm estimated 2 inches of precipitation befell the upper Montecito area in a 15-minute deluge (The Morning Press, February 13, 1926).

Accounts of the flood event also described the collapse of a landslide dam that was accompanied by a tremendous noise that sounded like a rushing train at 7:30 pm on February 11th shaking the valley. The flood wave peaked at 8:15 pm and residents along San Ysidro Creek (including the San Ysidro resort cottages) and residents living on East Valley Road reported that they were warned of the approaching outbreak flood by a great roar that sounded like thunder accompanied by a quivering of the earth as if a heavy freight train were passing by (The Morning Press, February 12, 1926).

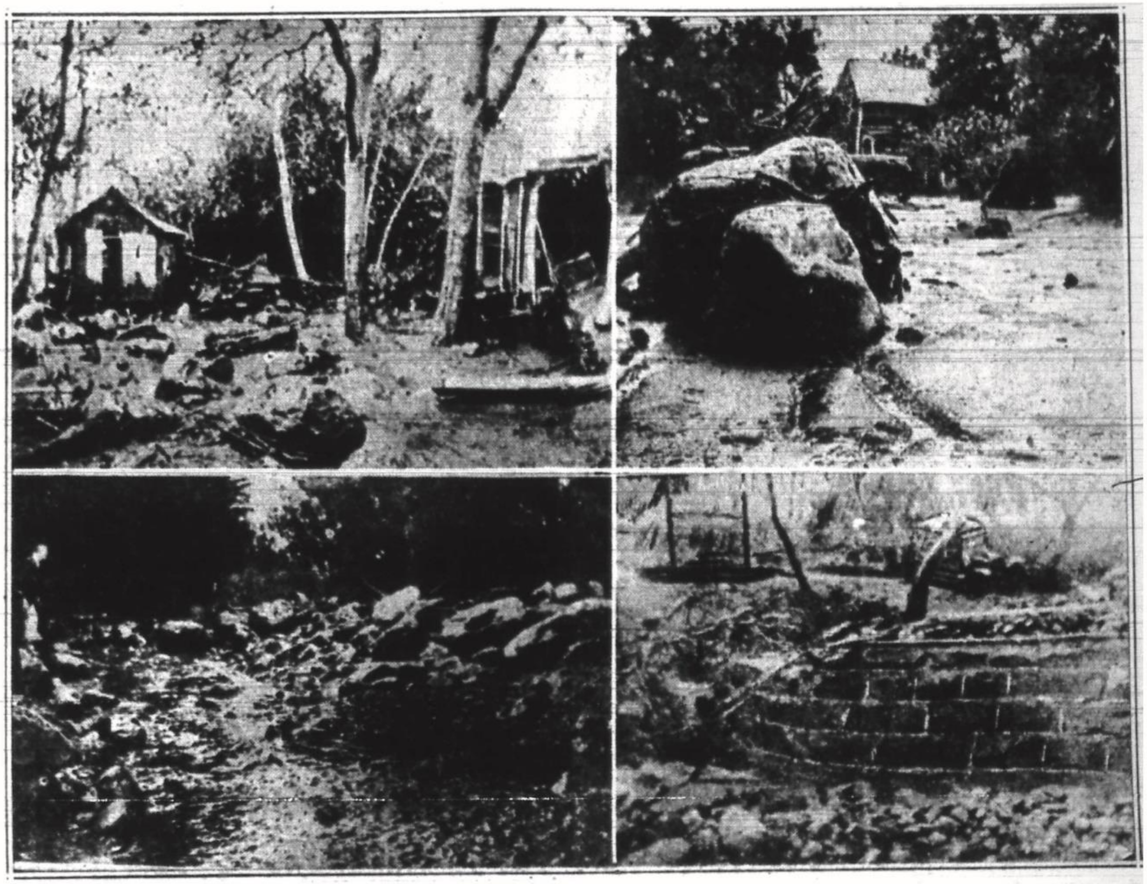
A news report elaborated that "*It was such a temporary dam in the upper canyon that suddenly let go and released water with a passion for destruction*" (Myrick, 1988). The flood waters finally broke through the dam creating a 30-foot high wall of water carrying trees, boulders, and other debris sweeping down the canyon and causing much destruction below (The Los Angeles Evening Express, February 12, 1926). The debris flows overwhelmed the San Ysidro Creek channel leaving evidence of a 30-foot high flood wave along canyon walls which left a trail of damage that extended two miles from the San Ysidro Resort to the Coast Highway, and extended to the beach (Santa Barbara Morning Press, February 12, 1926). The path of total destruction was estimated to be 200 feet wide below the canyon mouth and over 500 feet wide above the Coast Highway (Santa Maria Times, February 12, 1926; The Morning Press, February 13, 1926). Debris from overbank flows impacted San Ysidro Resort property (Figure 25) (Santa Maria Times, February 12, 1926). Two cottages and a 60-foot bridge were destroyed in addition to damages to other buildings (Figure 25 from the Santa Barbara Morning Press, February 13, 1926).

Analysis of 1928 aerial photographs reveal evidence that the flow paths extended north of the Randall Estate, suggesting that the bridge on Mountain Drive likely became plugged with debris and triggered destructive avulsions that diverted flows on east bank through the Hogue, Park, and Wildwood Properties and also on the west bank through the Randall estate. Extensive damage was noted on the Randall Estate above East Valley Road. Four acres of gardens were washed out and the Randall's Packard limousine was swept from the driveway and lodged between a large tree and a mass of boulders with its interior filled with rocks and mud (The Morning Press, February 12, 1926). The swath of destruction also impacted the former Louis Jones property, Wildwood Estate, and the Hogue and Park Estates located north of the Wildwood Estate and above East Valley Road. The main residence and caretaker's cottages on the Wildwood Estate were also damaged by debris and filled with sand and debris (Ventura County Star, February 12, 1926).

The debris flows clogged and blocked the Highway 192 bridge on San Ysidro Creek with vast amounts of tree and log debris with huge boulders and mud several feet deep that blocked Highway 192 from Park Lane to the entrance of Ennisbrook (Figure 25) (The Morning Press, February 12th and 13th editions, 1926). Tractors worked to clear boulders from the highway where large numbers of heavy boulders remained after half of day's work just trying to clean one lane of the old road (Figure 25). Three acres of the Carrington orchards (Glen Oaks neighborhood) was also buried in debris, mud, and muck, and downstream, the lower part of Ennisbrook property could not be reached due to boulders and mud spread across the road (The Morning Press, February 12th and 13th editions, 1926). The flood was reported to flow out-of-bank through the orchards below San Leandro Lane and exited the developed area in the vicinity of Tiburon Bay Lane at Jameson Road, inundating the Coast Highway. Most of the 15-acre orchard on the Oviatt Estate below San Leandro Lane was washed away.

Most significantly, debris flows freighted tree trunks and logs that were up to 30 feet in length, while huge boulders were carried in their muddy slurries past San Leandro Lane and all the way down the alluvial fan to the Coast Highway. The Coast Highway bridge on San Ysidro Creek, caught sufficient debris to rapidly clog with boulder and log debris. A 500-foot wide swath of the Coast Highway was inundated by rocks and sand up to depths of 10 feet or more which closed the highway for several days until clean-up crews could haul off the debris.

Mr. and Mrs. H. R. McKnight were driving south on the state highway a few hundred feet south of the Miramar when they observed the flood wave of water 20 feet high hurdling down a dry wash, about 100 feet north of San Ysidro Creek (The Morning Press, February 12, 1926).



Photographs of the damages caused by the February 11, 1926 landslide dam outbreak flood (Santa Barbara News Press, February 13, 1926). Upper left, only two buildings remain on the west bank of San Ysidro Creek. Upper right, the front yard of W. H. Hall property sufferred inundation in the first floor of the house and boulders deposited in the front yard. Lower right, location of the destroyed 60-foot bridge at San Ysidro cottages with wrecked vehicle in upper left of photograph. Lower left, boulders deposited on East Valley Road remain after tractors worked half of a day in an attempt to clear the road.

Figure 25

1926 Debris Flow
San Ysidro Creek

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Photograph from The Morning Press (February 13, 1926).

They fled their car just as the flood swept their vehicle away into the Pacific Ocean. Supervisor Dinsmore and his road crew looked for the vehicle, but it was never located.

A temporary dam of trees and boulders likely formed as the result of a large landslide, which quickly stored a large head of water pressure in the upper headwaters. Multiple accounts noted the 1926 debris flow event duplicated the 1914 event in several ways including the outbreak flood (The Morning Press, February 12, 1926; The Los Angeles Times, February 12, 1926; Santa Maria Times, February 12, 1926; Myrick, 1988).

Supervisor Dinsmore also pointed to the fact that the headwaters where the landslide dam formed had been the scene of a forest fire just two years prior to the flood (The Morning Press, February 12, 1926). He used cranes and dynamite to clear debris piles obstructing East Valley Road and San Leandro Lane, as well as the blockages of all the bridges spanning San Ysidro Creek. It was also necessary for Supervisor Dinsmore to use more dynamite to break up obstructions in the low flow channels to direct runoff into its respective water courses, due to impending rains (The Morning Press, February 12, 1926).

San Ysidro Creek Second and Third Events

Debris flows struck the Montecito area again on the 3rd and the 5th of April 1926. These flows were triggered by a sequence of storms that occurred from the 2nd to the 9th of April 1926 and transitioned from debris-laden slurries to debris flows capable of freighting destructive boulders (Hattie Beresford in Montecito Journal, 2006; Santa Barbara Daily News, April 6, 1926; and The Morning Press, April 6, 1926). Initially, light rainfall fell when an atmospheric river system that extended halfway to Hawaii approached the coastline and delivered heavy rainfall. The cumulative precipitation reported for April 8th in Montecito was 6.92 inches and 7.43 inches at up at Gibraltar Dam. These rainfall figures broke the existing records for April rainfall (Morning Press, April 8, 1926). Additional light rain followed, but measured rain amounts were not reported for Montecito.

The second debris flow event occurred on April 3rd, which was described as "*voluminous amounts of tree stumps and logs*" were discharged that had created an earlier blockage at East Valley Road bridge (The Morning Press, April 5, 1926). County crews worked feverishly to clear the blockage and maintain flows in the natural channel. Debris continued to accumulate until debris flows again discharged boulder and vegetative debris that plugged the channel at the bridge crossing, resulting in out-of-channel flows on April 5th. This time Supervisor Tom Dinsmore lit the accumulation of logs and stumps on fire on April 3rd, believing it be the quickest and least expensive alternative to quickly clear the creek of this debris. These set-fires were reported to still be burning three days later in spite of continued heavy downpour (The Morning Press, April 6, 1926).

Heavy rains were also reported on April 4th and 5th and for the third time in two months, debris flows and debris laden floods were discharged out of San Ysidro Canyon which filled the channel with all manner of unconsolidated debris, which succeeded in blocking East Valley Road. Debris dams also formed along San Ysidro Creek. These were described by Supervisor Tom Dinsmore who described the scene as "*boulder and tree stump dams blocking San Ysidro Creek, and causing it to divert its flows westward into the Randall Estate, a quarter mile west of its old location.*" As an expedient, Santa Barbara County crews worked to maintain flow through this new channel (The

Morning Press, April 6, 1926). Three feet of mud, boulders, and trees were deposited on the roadway (Santa Barbara Daily News, April 6, 1926; The Morning Pres, April 6, 1926). The April 5th flows repeated the recent destruction caused by the February 11th, 1926 debris flows, and destroyed many of the unreinforced masonry stone walls and carried away the debris, eroding the pavement of East Valley Road and creating gullies three to four feet deep on the entire drive to Ennisbrook from East Valley Road (The Morning Press, April 6, 1926).

Supervisor Dinsmore planned to use dynamite to break up the tightly bound mixtures of angular boulders and tree debris (Santa Barbara Daily Press, April 6, 1926). He wisely moved the County's aggregate rock crusher and steam shovel into the channel of San Ysidro Creek to hasten the removal of accumulated boulders (The Morning Press, April 6, 1926)

Santa Ynez First and Second Events

News reports on April 6th, 8th, and 9th describe heavy rainfall north of the Santa Ynez ridgeline at Gibraltar Dam (elevation 1,400 ft) which increased the height of the overflow on the spillway to three feet high (The Morning Press and Santa Barbara Daily News, 1926). The report noted that all the boulders and vegetation were scoured from the channel bottom which is indicative of debris laden floods, and with prior post-fire conditions in Blue Canyon and adjacent watersheds, were the result of post-fire conditions in these areas (The Morning Press, April 9, 1926).

A debris flow event was described by Thomas M. Storke in the Editorial Page Section of the Santa Barbara Daily News on November 29, 1926. The article entitled, "*What Brush Fires Did*" assuaged that the damage caused by recent heavy rains was inextricably linked to destructive fires of the past few years. He goes on to establish that half-burned logs and boulders carried by the rushing torrents verified predictions of forest authorities to heightened flood hazards following brush fires. Creek beds were filled with debris producing out-of-channel flows through farmlands and highways, rendering the roads impassable. The nearby slopes were barren of soil that had washed off the slopes and together with the logs and boulders, filled Gibraltar Lake with much debris and causing it to overflow (Gibraltar Dam had only recently been completed, in 1920).

Although this debris flow event occurred north of the Santa Ynez Mountains ridgeline, it is worth noting that not only was it known at the time that floods following brush fires are destructive because they produce and convey much more suspended and solid debris. The damages caused by the fire-flood sequences was greater reason for every individual living within the boundaries of forests in California should make it a personal duty to prevent wildfires. He eloquently stated in his article, "*The floods make their own powerful appeal to guard against fire, for in the fires is found the cause of storm damage*."

Late 20th Century and Recent Events

1964 Coyote Fire

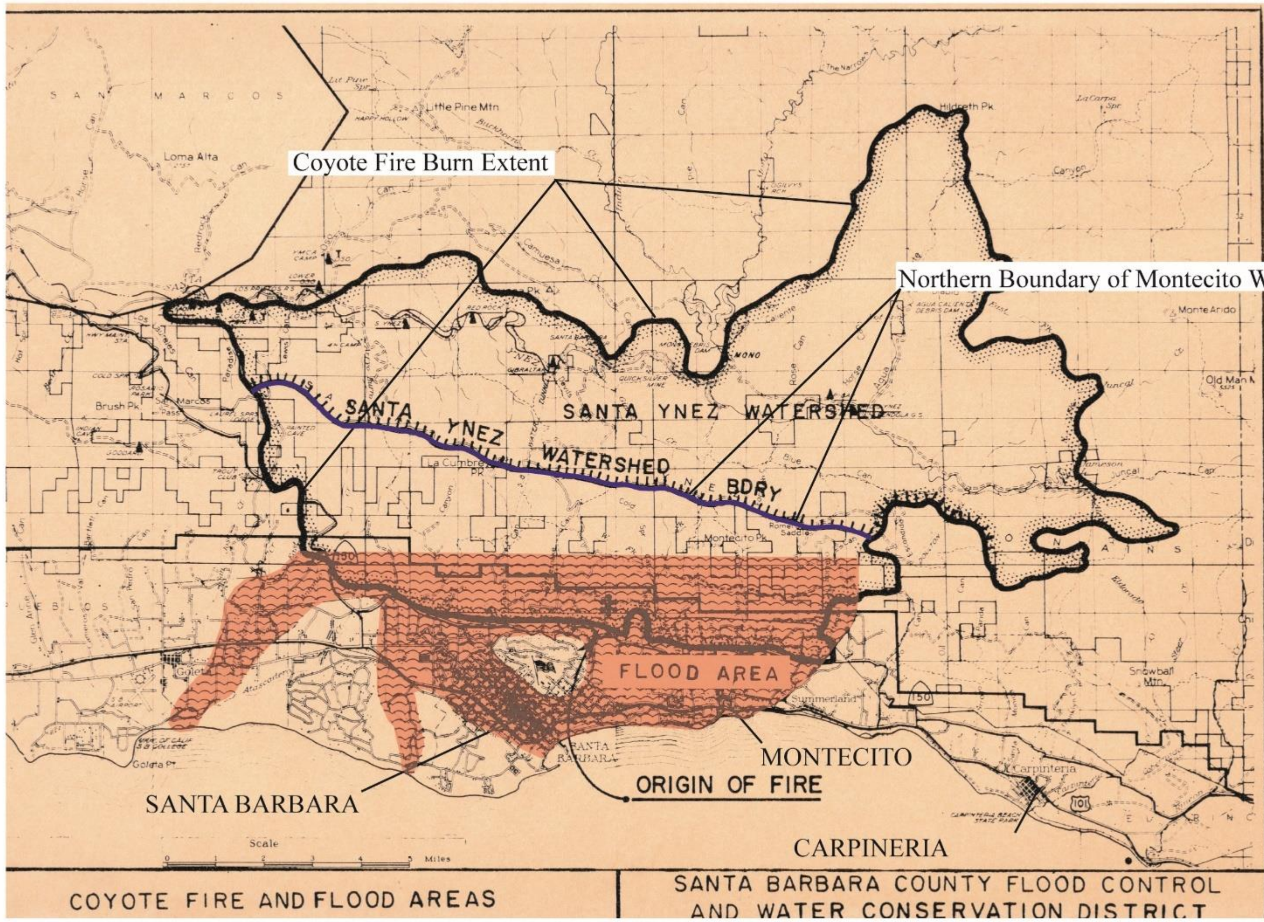
The September 1964 Coyote Fire burned 76,000 acres of steep watershed in the Santa Ynez mountains with about 24,000 acres burned in the Montecito watersheds (U.S. Army Corps, 1965) on the coastal side of Santa Ynez Mountains divide (Figure 26). A state of disaster was declared in Santa Barbara County on September 24, 1964 and the Governor of California also declared a state of disaster (U.S. Army Corps, 1965). It was recognized that there was greater flood hazard posed to downstream communities due to the increased runoff potential and that corrective measures were needed (U.S. Army Corps, 1965).

Appropriations of $860,000 were designated by Congress for construction of six debris basins on San Antonio, San Roque, Mission, Rattlesnake, Montecito, and San Ysidro Creeks. In addition, channel clearing and installation of pipe and wire revetment and application of staked sacked concrete to channel banks was also performed at specific locations where more armoring was needed (County of Santa Barbara, 1964). Although the U.S Army Corps of Engineers estimated that a volume of 500,000 cubic yards of debris could be expected following the Coyote Fire, the capacity of the debris basins that were under construction following the fire was only 92,000 cubic yards (County of Santa Barbara, 1964). It is interesting to note that part of the mitigation plan to allow debris flows to pass at bridge constrictions included demolishing one public bridge (Highway 192 bridge) and two public bridges on San Ysidro creek; one public bridge on Montecito Creek; two public bridges and two private bridges on Hot Springs Creek; and one public bridge and three culverts on Buena Vista Creek (U.S. Army Corps, 1965).

1964 Post-Coyote Fire Debris Flows

The rainfall was described as initially as light rain on November 8 (FEMA, 2005) which was followed by moderately heavy showers between 4:30 and 6:00 a.m. on November 9. A Montecito resident reported that more than 0.6 inch of rain precipitated in 20 minutes (U.S. Army Corps, 1965). Estimates of 0.75 inches of rain were reported by the debris flow event on February 9 in Montecito near Cold Springs Creek and an additional 0.29 inch of rain was measured on February 10 (U.S. Army Corps, 1965; The Los Angeles Times, November 11, 1964).

The resulting debris flows were considered severe in Montecito, Cold Springs, Hot Springs, and San Ysidro Creeks, and also reported from Romero, Buena Vista, Atascadero, Mario Ygnacio, and San Antonio Creeks (U.S. Army Corps, 1965). A resident who lived in the canyon mouth of San Ysidro described an avalanche of dry rocks and trees followed by water and mud moving down the channel flowing at approximately 15 miles per hour (Santa Barbara News Press, November 9, 1964; U.S. Army Corps, 1965; FEMA, 2005). Other eyewitnesses reported 20-foot high walls of mud, trees, boulders, and water (referring to the height of the snout, as portrayed in Figure 8). One resident on Park Lane recalled that she thought it was an earthquake due to the shaking and noise (Santa Barbara News Press, November 9, 1964). Damage to public and private property was estimated in the millions of dollars by FEMA (2005).



Map of the burn area extent of the 1964 Coyote Fire. The blue line line shows the drainage divide of the Santa Ynez Mountains which forms the northern margin of the Montecito watersheds. The red shaded area shows where elevated flood hazards were identified due to the increased potential runoff.

Figure 26.

1964 Coyote Fire Map
and
Flood Hazard Areas

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Santa Barbara County Flood Control (1964).

Bridges were described as “swept away in seconds” due to debris blockages which produced out-of-channel flows in numerous locations, depositing mud, rocks, and trees over large areas. A blockage occurred at the Mountain Drive bridge on Hot Springs Road which caused avulsion flows to be diverted through the Riven Rock area (Figure 27). Debris blockages occurred at two stone bridges in Riven Rock and were later jackhammered by County representatives to allow flows to pass (The Los Angeles Times, November 11, 1964).

The bridge on Cold Springs Creek at Mountain Drive was destroyed as was and about 200 feet of the Mountain Drive roadway (U.S. Army Corps, 1965). Upstream of the Ashley Road bridge, large tree and boulder debris constricted the channel and diverted flows through residences (Figure 28). Below the confluence of Cold Springs Creek and Hot Springs Creek, debris flows blocked the bridge on Montecito Creek at Hot Springs Road sending mud and debris flowing down Olive Mill Road and on the east end of Coast Village Road (Plate 3).

The 1964 debris flows significantly impacted San Ysidro Creek by damaging the gas line on the East Mountain Drive bridge overpass (Figure 29), and downstream logs and tree debris jammed the bridge on Highway 192 (Figures 30 and 31). Debris and mud filled channels, including parts of San Ysidro Creek (Figures 32, 33A and 33B). The mud spread out downstream of the Highway 192 accumulating sediment to depths of 5 feet (Myrick, 1988).

It is noteworthy that living a considerable distance from a creek in Montecito does not necessarily mean that a property is not at risk for inundation from mud (Plate 3). Flood inundation zones were generated by the U.S. Army Corps of Engineers (1965) and compiled with other debris flows, as shown in Plate 3.

1969 Post-Coyote Fire Debris Flows

A series of storms in January and February of 1969 produced the second largest 60-day cumulative precipitation events in the 20^{th} Century, with the largest event recorded in 1907 (FEMA, 2005 and 2015). James Stubchaer, Director of Santa Barbara County Flood Control claimed that the 1914 flood event was more severe in southern Santa Barbara County drainages than the 1969 flood event (Santa Barbara County Flood Control, 1969).

The 1969 storms triggered debris laden floods and debris flows from every watershed facing the Santa Barbara Channel, resulting in five fatalities and causing considerable damage in the communities of Montecito and Carpinteria (FEMA, 2005 and 2015). This event occurred about 4½ years after the Coyote Fire making it the third debris flow event to be triggered as the result of post-fire conditions within a 5-year period. It is noted that the 1967 debris flood in Santa Barbara was the second flood event to occur as the result of post-Coyote fire conditions (Table 1).

The County of Santa Barbara was declared a disaster area by President Nixon on January 25, 1969 (Department of Water Resources, 2013). Rainfall for the month of January 1969 was measured at 21.17 and 22.77 inches at the Casa Dorinda station and at the Cold Springs Debris Basin, respectively. In contrast, 15.55 inches was recorded at the downtown City of Santa rainfall station for January 1969 (Santa Barbara County, 1969). Over 6 inches (6.06) of rain was measured at the Colds Springs Debris Basin in 12 hours on January 25th. Much higher rainfall amounts were measured at higher elevations in the Santa Ynez Mountains where 13.35 inches fell in a 12-hour

Boulder debris and mud choke the channel of Hot Springs Creek (foreground) in Riven Rock. Once the channel filled with debris, flows were diverted on to the fan which resulted in homes inundated with few to several feet of mud.

Figure 27.

1964 Debris Flow
San Ysidro Creek

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Photograph from County of Santa Barbara (1964).

View of Cold Springs Creek looking upstream of the blockage at Ashley Road bridge. Vast amounts of tree log debris formed this extensive blockage at the bridge constriction which blocked the flow and filled the creek channel with boulder debris behind it. Photograph courtesy of the Montecito Association History Committee.

Figure 28.

1964 Debris Flow
Cold Springs Creek

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Photograph taken on San Ysidro Creek at the Mountain Drive bridge showing the damage done to a gas main pipeline. This is the same general location that the 1-9 debris flows triggerred a gas pipeline rupture and explosion. Photograph courtesy of the Montecito Association of History Committee.

Figure 29.

1964 Debris Flow
San Ysidro Creek

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Photograph from County of Santa Barbara (1964).

The November 9, 1964 debris flows discharged voluminous amounts of tree and boulder debris from the mountain watersheds creating blockages at creek channel constrictions. This photograph shows a view looking east at the San Ysidro Creek bridge crossing on Highway 192. Note the tremendous amounts of vegetative debris stacked up on the upstream side of the bridge in the center of the photograph. Later, this bridge was demolished to allow for future debris flows to pass by this constriction point. Photograph courtesy of the Montecito Associatiion History Committee.

Figure 30.

1964 DEBRIS FLOW
SAN YSIDRO CREEK

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Photograph from County of Santa Barbara (1964).

Figure 31A. Photograph of the log jam that blocked the bridge constriction at Highway 192 on San Ysidro Creek .

Figure 31B. View looking east along Highway 192 towards the bridge crossing on San Ysidro Creek. A portion of the debris had been removed but much remains to be cleaned up.

Figure 31.

1964 Debris Flow
San Ysidro Creek

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Photographs from U.S. Army Corps of Engineers (1965).

View of San Ysidro Creek looking upstream from the bridge crossing on Highway 192. The creek channel was filled in with debris and mud. Filling of the creek with debris and mud increases the potential for out-of-bank flows and direct impacts of debris to homes. Photograph courtesy of the Montecito Association of History Committee.

Figure 32.

1964 Debris Flow
San Ysidro Creek

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Photograph from U.S. Army Corps of Engineers (1965).

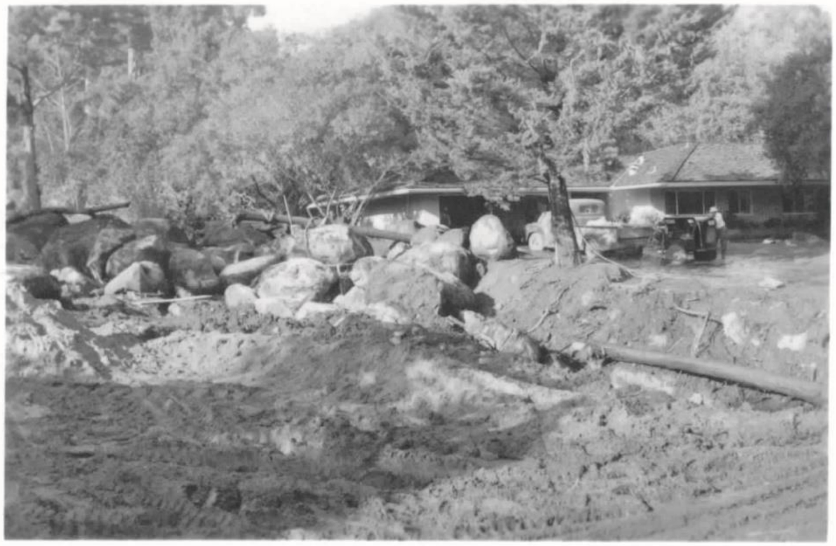

Figure 33A. Photograph looking northeast at the removal of debris from the creek channel of San Ysidro Creek at Highway 192. County of Santa Barbara (1964) estimated that 15,000 cubic yards of debris was removed from the channel for a length of several hundred feet.

Figure 33B. Similar to the debris removal of the 1-9 event, large boulders required drilling and blasting to be removed from the San Ysidro Creek channel.

Figure 33.

1964 Debris Flow
San Ysidro Creek

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Photographs from U.S. Army Corps of Engineers (1965).

period at Juncal Dam, and a total of 16 inches was measured in a 24-hour period causing the Santa Ynez River and many of its tributaries to overflow their banks. The 25 January 1969 storm event was declared a 100-year storm in the upper Santa Ynez watershed (Santa Barbara County, 1969; FEMA, 2005). Rainfall recorded in Carpinteria at near sea level was about 12 inches, but more than 44 inches in the watersheds above Carpinteria (Fenzel and Price, 1971).

Flooding during the January storms was due in large part to very high antecedent moisture levels during the previous 60 days (late November to late January), combined with the fifth year of post-Coyote fire conditions. Heavy rainfall on January 24 and 25 produced massive amounts of boulder and tree debris in the mountain watersheds. Discharge of the debris on to the developed alluvial fans of Montecito and Carpinteria created downstream log jams and blockages at culverts, bridges, and other channel constrictions causing filling of the creek channels upstream of the blockages. Channel flows were diverted at the blockages to produce out-of-channel flows and widespread flooding on the coastal fans. Filling of channels with debris diverted flows on Cold Springs, Hot Springs, Montecito, Oak, San Ysidro, Buena Vista, and Romero Creeks (Figures 34, 35, and 36; Plate 3). This resulted in debris directly impacting infrastructure and residential buildings, in addition to deposition of debris on public roads and highways, and on private property (WERT, 2018; FEMA 2005 and 2015). In some cases, development of residential and accessory buildings encroaches creek channels and obstructs overbank diversion of flows, causing bank erosion and collapse of masonry training walls into the floodwaters (Figures 34-37).

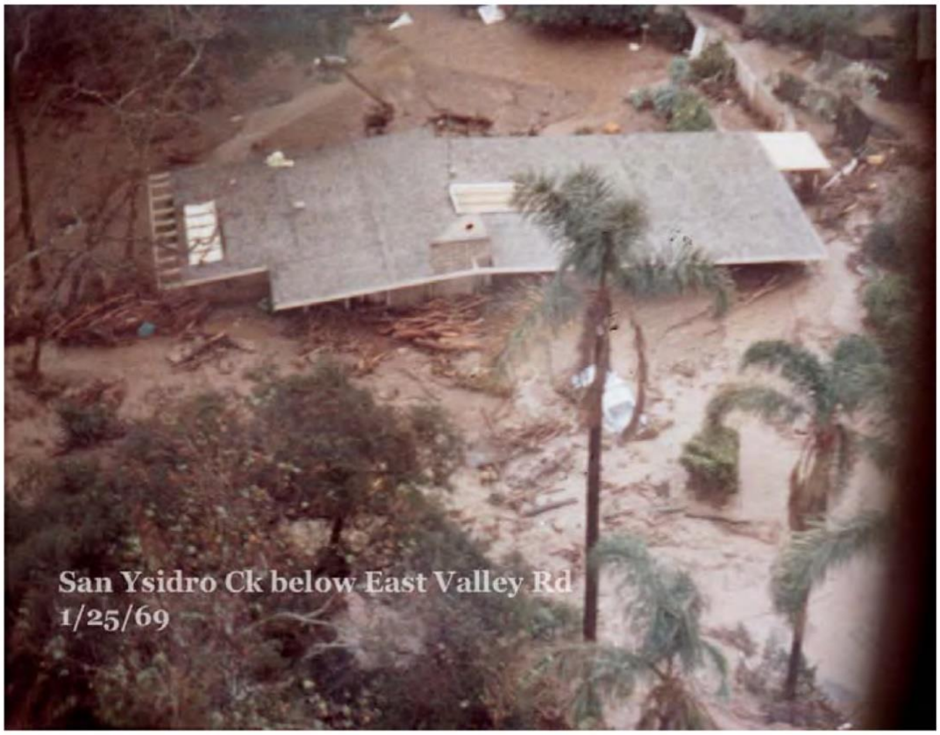
It was noted by Stubchaer (1972) that debris adds immensely to the flood problems as it fills creek channels leaving no room for water to flow, so the turbid discharge is forced out of the perennial low flow creek channel channels (i.e., out-of-channel flows). The 1-9 flow paths were strikingly similar to past avulsions shown in almost all of the post-1914 site photos, especially along Montecito Creek and its tributaries (see Plate 3). Blockages on Montecito Creek at Hot Springs Road and on San Ysidro Creek at Highway 192 resulted in diverted flows in the Glen Oaks and Olive Mill Road areas, respectively, sending 9 to 10 foot (3 m) diameter boulders to impact residential structures (Figure 38).

Further south in Carpinteria, over 1,000 residents were evacuated from homes due to flooding (Santa Barbara County Flood Control, 1969; Santa Barbara News Press, January 26, 1969). Discharge from Santa Monica Creek produced debris flows that choked the Highway 192 bridge causing some of the flows to divert approximately 2/3 of mile eastward into Franklin Creek (Figure 39). Debris from other creeks including Arroyo Paredon, Gobernador, Franklin, east and west branches of Toro, Lillingston, Arroyo Parida, Carpinteria, and Rincon also caused severe destruction from debris flows and flooding.

Additional photographs of the described damages are presented in Appendix B – 1969 Debris Flow Event.

1971 Post-Romero Fire Debris Flows

The Romero Fire began on the 6th of October 1971 just east of Romero Canyon and was deemed controlled ten days later after burning 14,538 acres of watershed above Montecito and Carpinteria (Santa Barbara County Fire Safe Council, 2020; Lance Orozco, 2020). More than



A residence inundated with debris and mud from out-of-channel debris flows from San Ysidro Creek. Note the log and vegetative debris piled up against the home.

Figure 34.

1969 Debris Flow
San Ysidro Creek

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Photograph from Santa Barbara County Flood Control (1969).

Figure 35A. New channel courses result often in Montecito due to plugging and filling with debris and mud. The flow from Romero Creek was diverted down Featherhill Road on January 25, 1969.

Figure 35B. The channel of Buena Vista Creek is filled with boulder debris and located just out of the photograph on the right-side. The debris flows were diverted around and through the residence on January 25, 1969.

Figure 35.

1969 Debris Flow
Romero and Buena Vista Creeks

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Photographs from Santa Barbara County Flood Control (1969).

Vast amounts of boulder and tree debris were discharged from the watersheds creating much damage and destruction. in the 1969 event. The channel of Romero Creek filled with debris on January 25, 1969 causing out-of-channel flows which permits direct impacts of this debris with residential homes.

Figure 36.

1969 Debris Flow
Romero Creek

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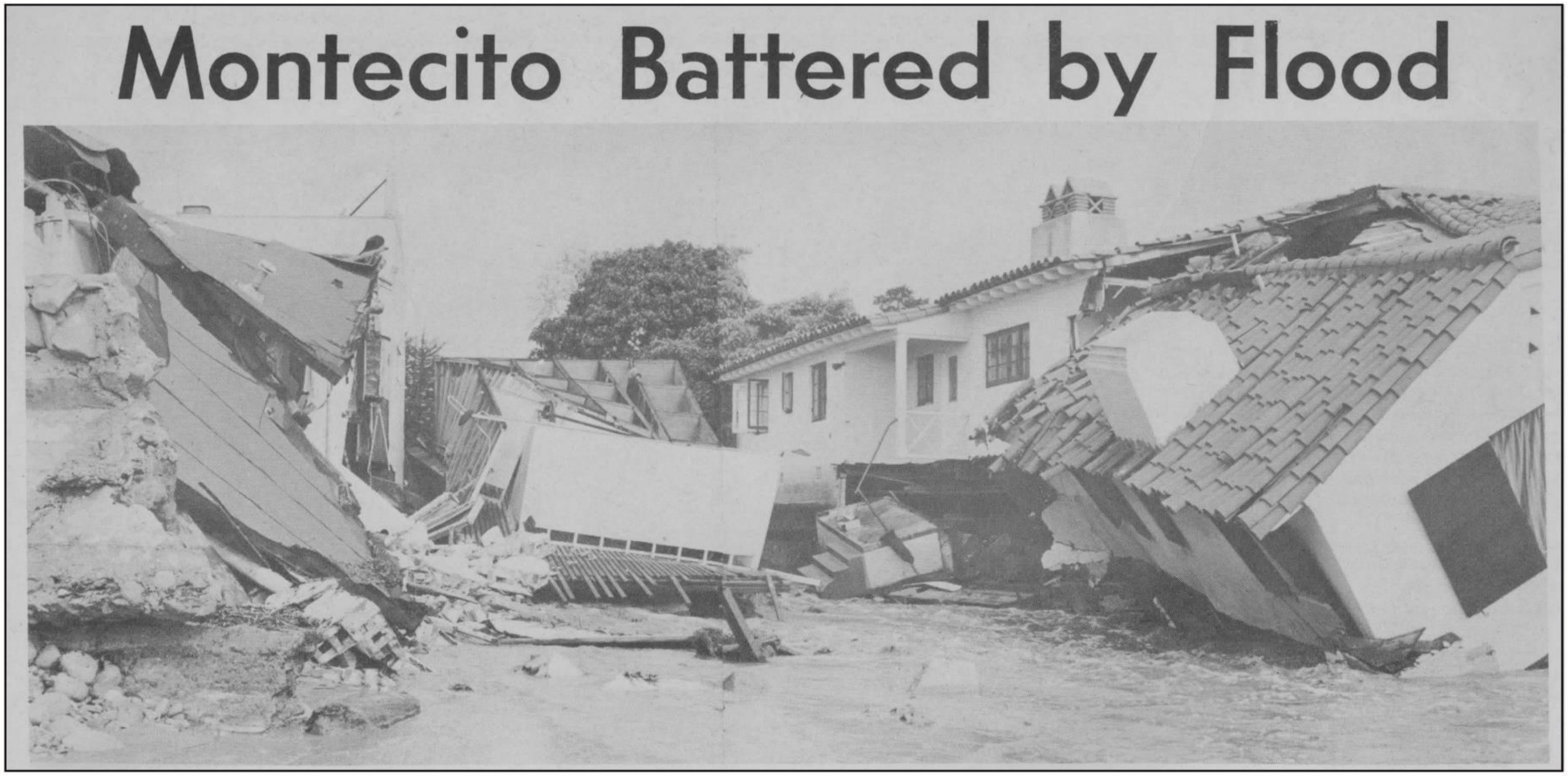
Photograph from Santa Barbara County Flood Control (1969).



Development that encroaches a creek channel as in this case, and builds out over the channel of Montecito Creek, are at extreme risk for flood hazards. Erosion of the channel banks at the mouth of San Ysidro Creek undermined the foundations of these beachfront properties resulting in collapse of the structures into the creek channel. A bathouse once extended from one of the homes over the channel but was ultimately destroyed.

Figure 37.

1969 Debris Flow
San Ysidro Creek

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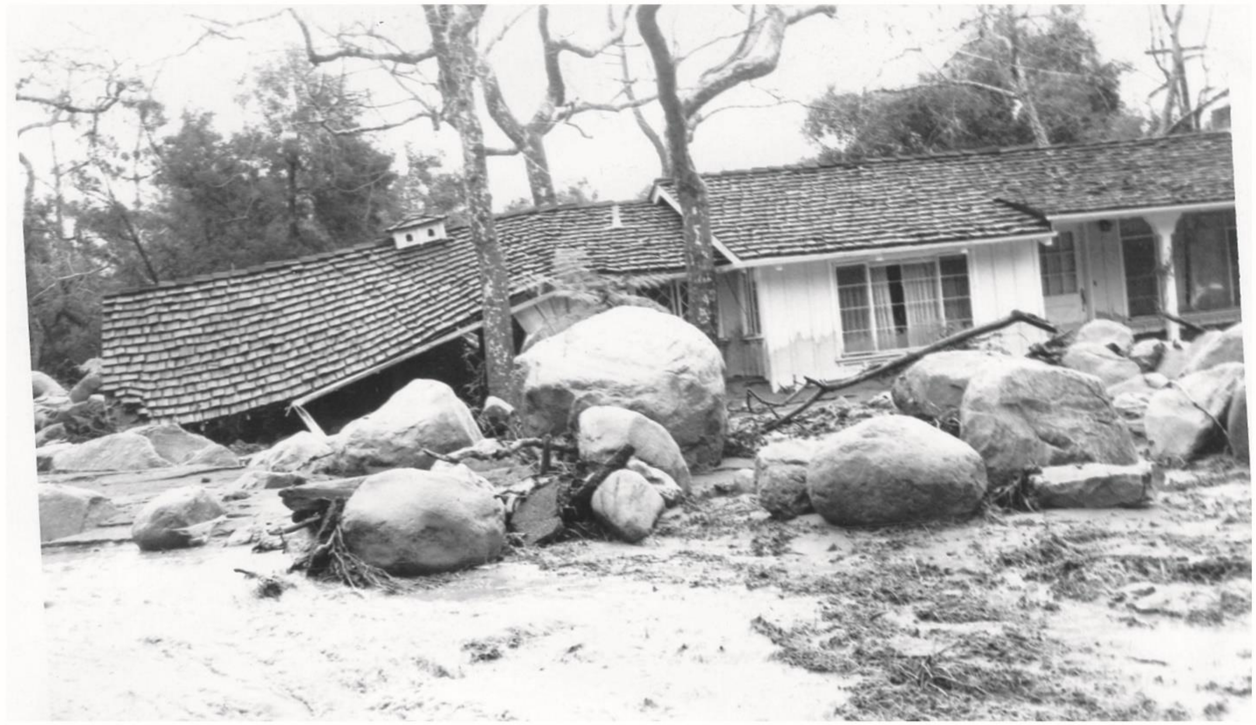
Photographs from Santa Barbara County Flood Control (1969) and Santa Barbara News Press (January 28, 1969).



Huge boulders remain after out-of-bank flows from San Ysidro Creek inundate the Glen Oaks area. Photograph courtesy of the Montecito Association History Committee.

Figure 38.

1969 Debris Flow
San Ysidro Creek

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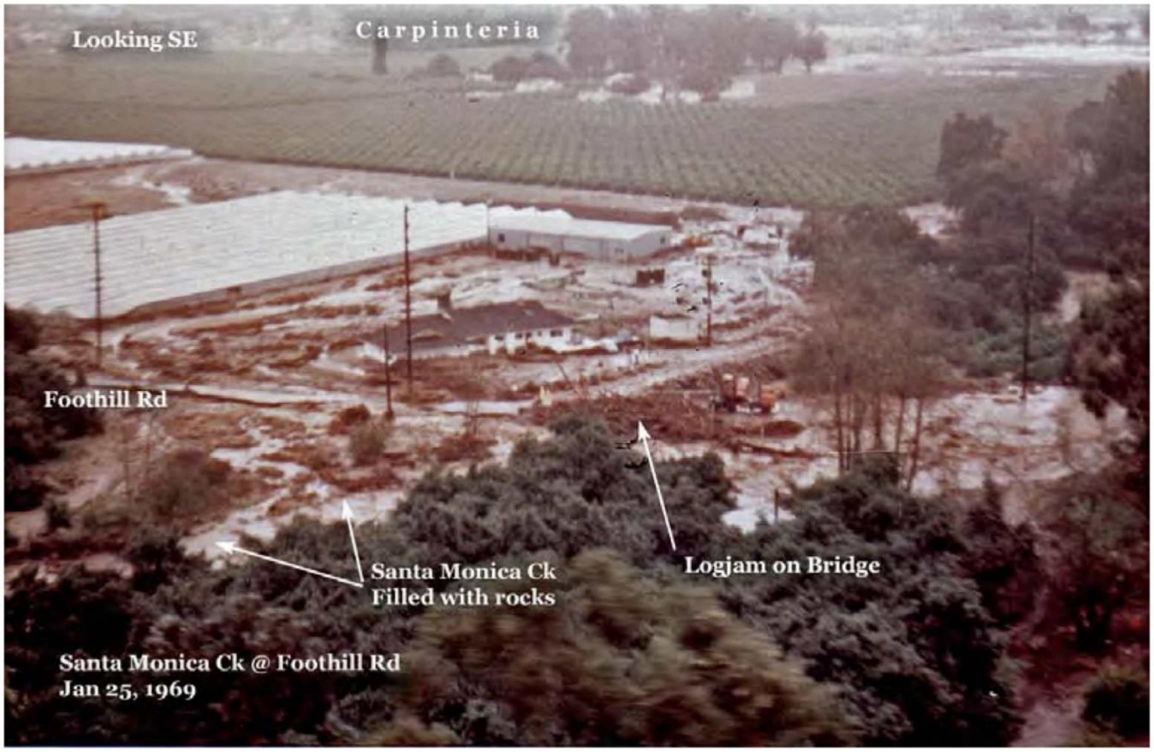

High debris production from Santa Monica Canyon in Carpinteria plugged the bridge on Highway 192 causing diversion of flow eastward into Franklin Creek about 2/3 of a mile away and also westward around the plug. Note the large vegative debris pile in the center of the photograph.

Figure 39.

1969 Debris Flow
Santa Monica Creek

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Photograph from Santa Barbara County Flood Control (1969).

three months later, the area experienced three storms in a 6-day period beginning on December 23 which produced 7 inches of precipitation in Montecito. Heavy downpours were reported on the 27th with 2.20 inches, which triggered debris flows in Montecito and Carpinteria.

The headlines in the Carpinteria Herald read “Carpinteria escapes major loss in flood” and describes that ash from the fire washed to the beach creating a black tide and then the deluge followed with debris and mud (Carpinteria Herald, December 30, 1971). Voluminous boulder and log debris were discharged from the watersheds of Romero Creek, east and west branches of Toro Canyon Creeks, Arroyo Paredon, and Santa Monica Creek. Debris blocked every bridge and culvert in Carpinteria with burned branches, logs, boulders and ash (Carpinteria Press, December 30, 1971).

During the December 1971 event the Torito Road bridge over Toro Creek was destroyed by 6 to 12 feet diameter (2 to 4 m) sandstone boulders, mud, and water (Figure 40). These flows damaged other homes and agricultural infrastructure along this reach of Toro Creek (Figures 41, 42A, 42B, and Figure 43). A home on the upper end of Toro Canyon Road near the Doulton Tunnel was damaged with mud and rock 7 feet deep in the rear of the home and mud as high as the windowsills in the front of the home. Debris from Toro Creek plugged the culvert under Highway 101, flooding the freeway with 3 to 5 feet of mud, vegetation debris, and boulders closing it for a day (Figures 44 and 45; Santa Maria Times, December 28, 1971). Debris flows discharged from Romero Canyon also caused extensive damages along the Romero Creek corridor (Figures 46 and 47).

1995 Debris Floods

Two debris laden flood events inundated the southern Santa Barbara coastal plain on January 10 and March 10, 1995 creating destructive debris laden flood damages on most major creeks from Goleta to Montecito (Figures 48, 49, and 50). The County of Santa Barbara (1995) reported that the 1995 floods were more severe and wide-spread than the 1969 or 1967 floods, and Tom Fayram, County of Santa Barbara Flood Control Manager, noted that the 1995 debris laden floods produced a greater volume of debris than the 1-9 event (Two Years After Fire and Flood, January 26, 2020).

It is important to highlight that each of the January and March debris laden flood events filled the Santa Monica debris basin, with a capacity of approximately 200,000 cu. yds. (153,000 m^3), for a total of roughly 400,000 cu. yds. of debris, mud, and vegetation produced in these two events (Santa Barbara County Flood Control, 1995). This amount is roughly 200% of the debris flows produced in the 1-9 event. Nearly every gauging station in Santa Barbara County recorded the highest flows in Santa Barbara County creeks and the March 10 storm produced the highest recorded 1-hour rainfall intensity of 1.74 inches (County of Santa Barbara, 1995).

A total of 510 structures were reported flooded and damaged in southern Santa Barbara County as a result of the January 10th storm and more than 300 structures were reported as flooded and damaged during the March 10th storm, and many of these were the same structures flooded in the earlier event (County of Santa Barbara, 1995). The total estimated cost of damages was approximately $80 million and both events received Presidential Disaster Declarations (County of Santa Barbara, 1995).

THIS IS where the Torito road bridge was. A gas company worker was out repairing the broken line at 7:30 a.m.

Boulders remain on the roadway and debris fills the channel of Toro Creek where the Torito road bridge was destroyed by debris flows.

Figure 40.

1971 Debris Flow
Toro Creek

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Photograph from Carpinteria Herald (December 30, 1971).

A home near the Toro Creek bridge on East Valley Road was severely damaged by debris flows on December 27, 1971. The occupants were rescued unharmed by first responders.

Figure 41.

1971 Debris Flow
Toro Creek

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The Santa Barbara News Press (December 28, 1971).

THIS TORO CANYON home had its porch sheared off and this mound of boulders was left in the front yard.

Figure 42A. The damaged house is located in the upper right of the photograph. Boulder and log debris remain in the front yard after the passing of debris flows.

SOME old-time residents on Foothill road along the face of the Valley called it a worse flood than 1969. Although little damage was reported to homes, some large fire-fallen logs rattled down the mountain and water was sheeting far out of the creek beds.

Figure 42B. Large log deposited on Foothill Road in Carpinteria.

Photographs from Carpinteria Herald, dated December 30,1972.

Figures 42A and 42B.

1971 Debris Flow
Boulder and Log Debris

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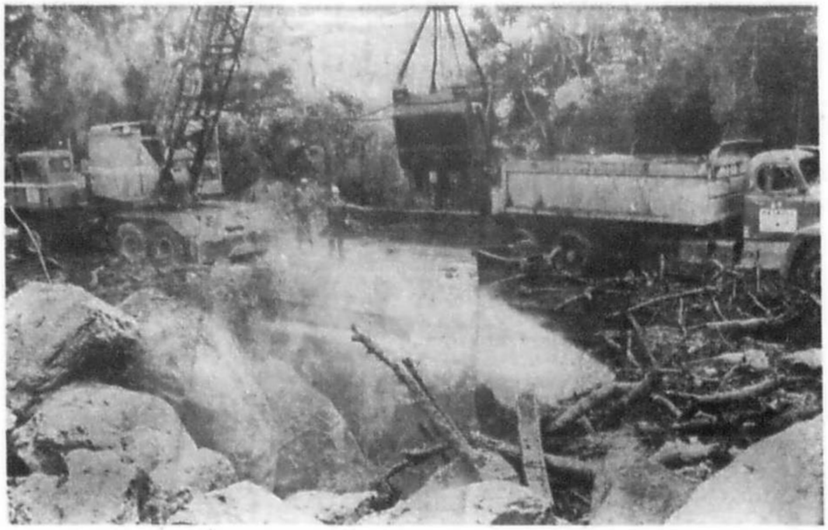

Massive boulders and log debris are removed from the blockage at the bridge overpass on East Valley Road at Toro Creek.

Figure 42.

1971 Debris Flow
East Valley Road

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Photograph from Santa Barbara News Press, December 29, 1971.

Highway 101 is inundated with mud and debris from Toro Creek. The Padaro Lane overpass is located near the top of the photograph

Figure 44.

1971 Debris Flow
Toro Creek

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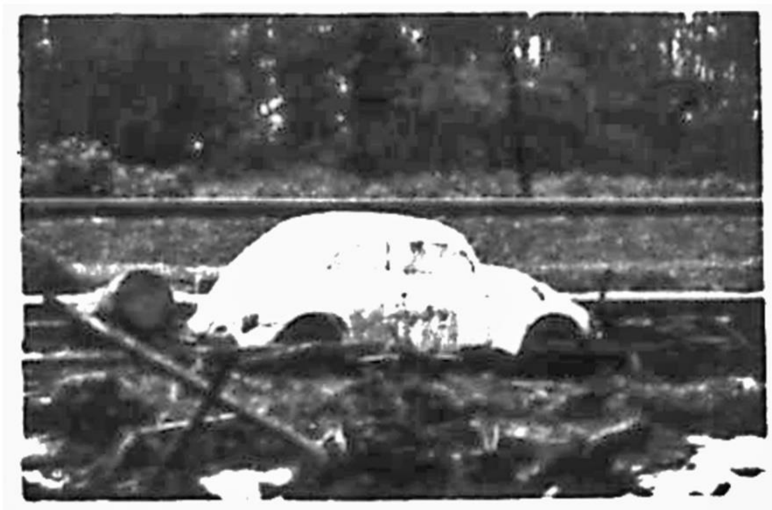
Photograph from U. S. Army Corps of Engineers (1974).



This vehicle is turned the wrong way after encountering debris and mud that inundated both sides of HIghway 101.

Figure 45.

1971 Debris Flow
Highway 101

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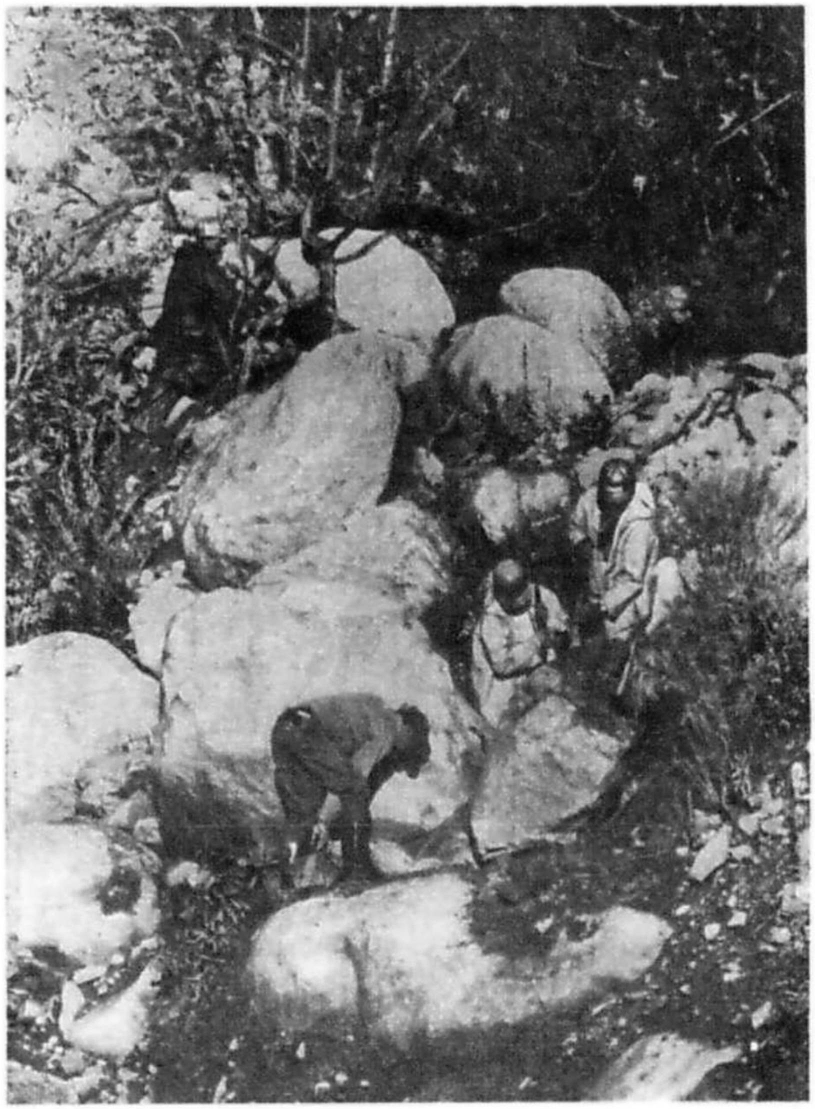
Photograph from Carpinteria Herald (December 30, 1971).



Large boulders are in the process of removal to clear Romero Creek after debris flows filled the creek channel with debris.

Figure 46.

1971 Debris Flow
Romero Creek

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Photograph from Santa Barbara News Press, December 29, 1971.

The plugged culvert under Buena Vista Road on Romero Creek is being cleared of debris .

Figure 47.

1971 Debris Flow
Romero Creek

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Photograph from Santa Barbara News Press, December 29, 1971.

BUENA VISTA CREEK (E. Branch). Jan. 12, 1995.
Upstream of E. Valley Rd. Creek filled with rock.
Montecito.

BUENA VISTA CREEK (E. Branch). Feb. 21, 1995.
Upstream of E. Valley Rd. Creek restored after removal of rock. Montecito.

Debris laden floods discharge vast amounts of debris from the watersheds above Montecito. Deposition and filling of creek channels is one of the consequences of debris floods that produce out-of-channel flows, when directly impacts homes with boulder and vegetative debris.

Figure 48.

1995 Debris Flood
Buena Vista Creek

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Photographs from Santa Barbara County Flood Control (1995).

Boulder debris impacted home near the east branch of Buena Vista Creek after the first debris laden flood event.

Figure 49.

1995 Debris Flood
Buena Vista Creek

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Photographs from Santa Barbara County Flood Control (1995).

***MONTECITO CREEK. Mar. 11, 1995.* Downstream of Olive Mill Rd. Removal of rock, boulders which filled in creek. Montecito.**

Boulder debris filled in the channel of Montecito Creek in the second debris laden flood event creating out-of-channel flows.

Figure 50.

1995 Debris Flood
Montecito Creek

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Photographs from Santa Barbara County Flood Control (1995).

Heavy rains caused periods of flooding on January 4 and January 9 through January 10 with intermittent rains between. Rainfall amounts in Santa Barbara between January 3 through January 11 were measured at 16.69 inches (NOAA, 1995). The duration of the storm loaded many streams with large volumes of debris (Santa Barbara County Flood Control, 1995). The March 10 flood event was a short duration event with rainfall intensities as high as 3 inches per hour which triggered debris flows and caused serious flooding.

Debris plugging culverts was a major problem in addition to the filling of creek beds, both of which resulted in out-of-channel flows that diverted debris onto roads and flooding of homes (Plate 3; Figure 48) (Santa Barbara County Flood Control, 1995). The east branch of Buena Vista Creek completely filled in with debris upstream of plugged culvert on East Valley Drive and East Mountain Drive (Figure 49). Diversion of flows from Montecito Creek down Olive Mill Road inundated the homes along Danielson Road, Virginia Roak, and Virginia Lane, east of Olive Mill Road (Plate 3). Overflows from Oak Creek entered San Ysidro Creek exacerbating flooding along it and inundated Highway 101. Flooding also occurred on Romero Creek in the area below Highway 101 (Santa Barbara County Flood Control, 1995). Highway 101 was also inundated with mud and debris from Arroyo Paredon Creek west of Carpinteria.

Both January and March events filled the Santa Monica Debris Basin to capacity for an estimated debris production volume of about 400,000 cu. yds. (306,000 m^3) (Santa Barbara County Flood Control, 2017). Flood flow paths of the March 1995 event were similar to the January event including inundation of Highway 101 by San Ysidro and Oak Creeks. Diversion of out-of-channel flows from San Ysidro Creek due to plugging and filling of channel constrictions with debris caused San Ysidro Road to become a major conveyance corridor for floodwaters. Oak Creek flooded areas along the creek corridor from East Mountain Drive to Highway 101. Breakout of flows from Montecito Creek once again flowed down Olive Mill Road flooding homes in the area of Danielson Road, Virginia Road, and Virginia Land, east of Olive Mill Road (Figure 50 and Plate 3).

Additional photographs depicting the flood damages of the 1995 debris floods are presented in Appendix C.

2017 Post-Sherpa Fire Debris Flows

The Sherpa fire burned a total of 7,473 acres of the Santa Ynez Mountains from 15 June 2016 until it was 100% contained on July 12, 2016 (County of Santa Barbara, 2021). Out of the total acreage burned, 1,588 acres burned in the Canada del El Capitan watershed and the mouth empties at El Capitan State Beach (Schwartz, 2017). A January 20, 2017 rainstorm produced 2 inches of rain with a peak 15-minute rainfall intensity of 0.75 inch per hour which is equivalent to a 25 to 50 year frequency storm (Schwartz, 2017; NOAA, 2016). High antecedent moisture conditions were present in the watershed as 21.04 inches of rain were recorded in the upper watersheds prior to January 20.

Post-fire debris flows were triggered in the El Capitan watershed damaging buildings and infrastructure associated with the El Capitan Canyon Resort located along the bank of El Capitan Creek. Many cabins, 15 automobiles, bridges, and trees were swept away by the debris flows (Figure 51) (Schwartz, 2017). First responders made 22 rescues of people trapped in cabins or on the property. Schwartz (2017) concluded that the higher elevations of El Capitan watershed delivered large amounts of coarse woody debris including unburned trees due to stripping by the

Debris flows choked with vegetative debris, automobiles, and cabins accumulate upstream of a plugged culvert under Highway 101. Photograph courtesy of managing editor, Giana Magnoli and Noozhawk (noozhawk.com).

Figure 51.

2017 Debris Flood
El Capitan Creek

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flows. Blockages composed of woody debris caused the destruction of one bridge and avulsion at another near the lower end of the resort.

A concrete box culvert underpass of Highway 101 plugged and because the highway is elevated, the highway fill embankment acted as a debris barrier and forming the dirt parking lot into a debris retention basin (Figure 51). The plug at the culvert broke through and large debris including several cars were conveyed to the ocean.

January 9, 2018 Debris Flow Event

The Thomas fire started in Ventura County on December 4, 2017 and quickly advanced westward due to strong Santa Ana offshore winds (County of Santa Barbara OEM, 2018). The first evacuation orders were announced for the City of Carpinteria on December 7 and was expanded to include portions of Montecito on December 10 (County of Santa Barbara, 2017). The wildfires advanced into the Montecito watersheds about December 10-11 and burned the steep terrain of the watersheds before it was contained on January 12, 2018, three days after the 1-9 debris flow event (Cal-Fire, 2020). The Thomas fire burned for 38 days and at the time, was the largest fire in California's history (USDA Forest Service, 2018).

A coordinated effort between county, state, and federal agencies initiated public awareness for the potential for flash floods and debris flows. This public awareness campaign began several days prior to the 1-9 fire-flood event. The National Weather Service (Los Angeles/Oxnard) issued a partner "heads up" email that the threat of heavier rainfall with the most significant potential impact flooding and debris flows in recent burn areas on January 3, 2018 (NOAA/NWS, 2018). A joint press conference hosted by Santa Barbara County was presented on January 5th followed by a flash flood watch with the potential for rainfall rates of 0.5 to 1 inch per hour for recent burn areas on the 6th. This was followed by a flash flood warning at 2:32 AM due to the approaching storm in the morning of January 9th.

Narrow cold front rainbands produced short duration, high intensity rainfall which was not exceptional in the early morning hours of January 9 and triggered significant debris flows from all the Montecito and several of Carpinteria's drainages (De Orla-Barile et al., 2022). The debris flows overwhelmed Montecito's debris retention basins resulting in the flows causing 23 fatalities and catastrophic destruction of homes, property, and infrastructure. Debris flows plugged culverts, pedestrian and vehicular bridge crossings, creek channels, and overtopped creek channels throughout the community of Montecito (Lancaster et al., 2021; Keaton et al., 2019; and Kean et al., 2019). Debris flows entrained coarse woody and boulder debris that directly impacted residential structures, infrastructure, and automobiles, and incorporating this debris into the flows causing further destruction.

Additional photographs depicting the debris impacts and flood inundation damages of the 1-9 debris flows are presented in Appendix D.

Estimates of Debris Flow Volume

Several noteworthy studies conducted on the 1-9 event and Montecito watersheds provide valuable data and findings including Kean et al. (2019), Lukashov et al. (2019), Lancaster et al. (2021), Alessio et al. (2021), and Morell et al. (2021). The latter two studies estimated the volume of sediment eroded on slopes and the debris redistribution in the Montecito watersheds, whereas the others estimated the volume of debris flows on the fans. Debris volume estimates produced by the Montecito watersheds were offered by Kean et al. (2019), Lukashov et al. (2019), and Lancaster et al. (2021) and are presented in Table 2. Although there are subtle differences in their specific methods of calculating the total volume of debris production, their methodology generally used the average sediment thickness and the area of inundation to calculate the total volume. Kean et al. (2019) presented total volume estimates for the Montecito catchments whereas Lukashov et al. (2019) and Lancaster et al. (2021) estimated the total volume produced for the Montecito and Carpinteria catchments.

Table 2. Total Volume of Debris Produced on January 9, 2018

Debris Production	Kean et al. (2019)[1]	Lukashov et al. (2019)[2]	Lancaster et al. (2021)[2]
Estimated total volume (m^3)	679,000[1]	1,014,000[2]	1,498,000[2]
Debris in basins[3] (m^3)	70,393	Included	Included
Debris in creeks[4] (m^3)	67,983	Included	Included
Debris on Hwy 101[5] (m^3)	80,278	80,278	80,278
Debris transported to ocean (m^3)	Unknown	Unknown	Unknown
Revised total volume (m^3)	**897,654**	**1,094,278**	**1,578,278**
Revised total volume (yds^3)	**1,174,087**	**1,431,262**	**2,064,310**

[1] Total production volume estimate for the Montecito watersheds.
[2] Total production volume estimate for the Montecito and Carpinteria watersheds.
[3] Estimate of debris cleared from Montecito debris basin (U.S.A.C.E., 2018a).
[4] Estimate of debris cleared from Montecito creeks (U.S.A.C.E., 2018b).
[5] Estimate of debris cleared from Highway 101 by CalTrans (San Luis Obispo Tribune, January 28, 2018).

Kean et al. (2019) estimated a debris volume that was only discharged from the Montecito catchments, and did not account for the debris and mud retained in the debris basins, transported to the ocean, or deposited on Highway 101. The U.S. Army Corps of Engineers (2018a) report estimated a total volume of 70,393 m^3 of debris (boulders, woody, and mud) removed from the Montecito debris basins, and a total volume of 67,983 m^3 of debris cleared from the Montecito creek channels (U.S.A.C.E., 2018b). Caltrans spokesman Jim Shivers reported that the height of the debris accumulation on Highway 101 was 12 feet and covered about a quarter of a mile of the highway (San Luis Obispo Tribune, January 28, 2018). He reported the cost of removal at $11 million and that crews removed a volume of more than 80,278 m^3 of debris.

Accounting for the volume of debris cleared from the basins, creeks, and Highway 101, and using the accounting estimate calculated by Kean et al. (2019) on the fan, a total debris volume of 897,654 m^3 (1,174,087 yds^3) is estimated in the community of Montecito.

Lukashov et al. (2019) estimated the total volume of debris involved with the 1-9 event in Montecito and Carpinteria watersheds was 643,000 m^3. Their total volume includes the debris volume removed from the debris basins and from creek channels. Accounting for the volume of debris cleared from Highway 101 which was not included in their calculations, the total volume of debris is approximately 1,094,278 m^3 (1,431,262 yds^3).

Lancaster et al. (2021) estimated the total volume of debris at 1,498,000 m^3 produced in the Montecito and Carpinteria catchments, and this volume includes debris removed from the basins and the creeks. However, the volume of debris cleared from Highway 101 was not tallied, and accounting for this volume, a total volume of 1,578,278 m^3 which is equivalent to 2,064,310 yds^3 of debris production for the Montecito and Carpinteria watersheds is estimated.

A study of the sediment erosion in the Montecito source catchment areas estimated the volume of colluvial sediment delivered to creek channels was 241,000 m^3 which includes rill erosion and surface denudation (Allesio et al., 2021). Dry ravel also contributed sediment to the debris flows and was estimated to be 74,200 m^3. Another noteworthy study of the volume of bouldery alluvium estimated that 550,000 cubic meters was redistributed in the Montecito catchments with 85% of this volume, 470,000 m^3, was discharged from the canyon mouths and conveyed to the fans (Morell et al., 2021). Based on these volume estimates, the total volume of sediment and bouldery alluvium debouched from the Montecito catchment was roughly 785,000 m^3 (1.030,000 yds^3). These studies did not estimate the substantial volume of vegetative debris discharged from the Montecito catchments.

Debris Flow Magnitude Classification

Jakob (2005) developed a classification scheme using parameters that are easily obtainable and provide a meaningful measure of assessing hazard and risk (Table 3). These metrics include total debris volume, peak discharge, and inundation area which are presented in studies by Kean et al. (2019), Lukashov et al. (2019), and Lancaster et al. (2021). The magnitude classes range from 1 to 10 with larger class magnitudes representing increasing volume, peak discharge, and area. Magnitude 1 to 6 events include both boulder debris flows and lahars due to volcanic eruptions. Larger Magnitude 7 to 10 events are only known from lahars initiated by volcanic events which typically runout considerable distances due to their fluidized nature (Jakob, 2005).

Table 3. Magnitude classification chart developed by Jakob and Hungr (2005) and Dowling and Santi (2013).

Size Class	Volume total, cu. meters m^3 (yds.^{3})	Inundation Area m^3	Potential Consequences
1	$< 10^2$ (less than 130)	$< 4 \times 10^2$	Very localized damage. Known to have killed forestry workers in small gullies, damage small building
2	10^2 - 10^3 (130 to 1,300)	4×10^2 to 2×10^3	Could bury cars, destroy a small wooden building, break trees, block culverts, and derail trains.
3	$10^3 – 10^4$ (1,300 to 13,080)	2×10^3 to 9×10^3	Could destroy larger buildings, damage concrete bridge piers, block or damage highways and pipelines
4	$10^4 – 10^5$ (13,080 to 130,800)	9×10^3 to 4×10^4	Could destroy parts of villages, destroy sections of infrastructure corridors, bridges, could block creeks,
5	$10^5 – 10^6$ (130,800 to 1,308,000)	4×10^4 to 2×10^5	Could destroy parts of towns, destroy parts of forest 2 km^2 in size, block creeks and small rivers
6	$10^6 – 10^7$ (1,308,000 to 13,080,500)	$>2 \times 10^5$	Could destroy parts of towns, obliterate valleys or fans up to several tens of km^2 in size, dam rivers.

Debris flow magnitude classification scheme based on volume and inundation area (Modified after Jakob and Hungr, 2005 and Dowling and Santi, 2013). The magnitude size classes range from magnitude 1 to magnitude 10, however magnitudes 7 and greater are only observed in volcanic lahar type debris flows. Potential consequences are used to assign a magnitude for each of the historic debris flow events recognized in this study. Although Lancaster et al. (2021) estimates a cumulative inundation area of 5.6 x 10^6 which is much greater than the inundation area for a Magnitude 6 event, they classify this event as a magnitude 6 event.

Inundation Areas

The 1-9 debris flow inundation areas below canyon mouths reflect flow paths that utilize main creek corridors and diverge at constriction points, branch out into former (paleo) channels, roadways, and overbank flows (Plate 3) (Kean et al., 2019; Lancaster et al., 2021). Debris flow paths and the limits of inundation were mapped shortly after the 1-9 event by the U.S.G.S and the California Geological Survey (Kean et al., 2019; Lancaster et al., 2021), and these limits are overlain with historic flow paths established in this study (Plate 3). The limits of the debris flow paths are defined as the boundary between the area of inundation and no inundation.

Estimates of inundation areas for each Montecito watershed were presented by Kean et al. (2019) and are shown in Table 4. However, he does not assign a class to the individual watersheds. The inundation areas on these fans ranged from 0.1 km^2 (0.04 mi.^{2}) in Oak Creek to roughly 1.0 km^2 (0.4 mi.^{2}) along Montecito Creek. The total cumulative area of inundation in the Montecito fans is 2.61 km^2 (1.0 mi^2) which represents the aggregate area of deposition in the community of Montecito. Lancaster et al. (2021) estimated the zone of debris inundation in Montecito at 3.15 km^2.

Table 4. Inundation areas of individual creeks based on Kean et al. (2019).

	Montecito	Oak	San Ysidro	Buena Vista	Romero
Area (m^2)	997,000	102,000	905,000	290,000	312,000
Area (km^2)	1.0	0.1	0.9	0.3	0.3
Area (mi^2)	0.38	0.04	0.35	0.11	.12
Magnitude[1]	6	5	6	6	6

[1] Magnitude is based on inundation area classification scheme developed by Jakob (2005) and modified by Dowling and Santi (2013).

Jakob (2005) classifies inundation areas between 0.04 km^2 and 0.2 km^2 as Magnitude 5 class events and classifies inundations areas greater than 0.2 km^2 as Magnitude 6 class events. Based on these parameters, Oak Creek watershed produced a Magnitude 5 class event and Montecito, San Ysidro, Buena Vista, and Romero watersheds produced Magnitude 6 class events (Table 4).

Although it is the intention of the Jakob (2005) classification scheme to assign magnitude class events to individual catchments, Lancaster et al. (2021) cites the distributed nature of source areas combined with depositional overlap of debris flow deposits restrict the ability to separate material by watershed as described by Jakob (2005). Lancaster et al. (2021) estimates the inundation area for both the Montecito and Carpinteria areas at 5.6 km^2 and notes that aggregate inundation area is greater than double the value used for Magnitude 6 class, and consequently assigns a Magnitude 6 class. Lukashov et al. (2019) assigns a Magnitude 7 class event based on the total volume deposited on both Montecito and Carpinteria fans and the latter. For the 1964 and 1971 debris flow events, Lancaster et al. (2021) classified magnitudes 5 for both of these events as each inundated an area greater than 2 square kilometers (0.8 square mile).

Debris Flow Paths

Entrainment of debris not only occurs in creek channels upstream of the canyon mouths, but it also occurs on the upper fan and through confined channels in the Mission Ridge Fault Zone, with some deposition due to constrictions and blockages with infrastructure, homes, and oak trees (Plate 3). Flows on the lower fan tend to spread laterally due to reduction in channel and fan gradients, and accumulates in depressions such as Highway 101 which acts like a debris basin (Figure 52).

Peak discharge of debris flows produced high flow depths in the lower confined canyons of the mountains and in the upper fan areas situated below canyon mouths and contributed to wider inundation zones in the lower fan areas (Kean et al., 2019). Flow deposition heights were observed to be lower than the mud lines that were produced as the result of peak discharge flows (Kean et al., 2019 and Lancaster et al., 2021).

Sites of avulsions were noted at creek meanders (bends), bridge constrictions and underpasses, and roadway corridors such as Olive Mill Road and El Bosque Road. These roadway paths influenced

Figure 52.

Debris Flow Inundation
State Highway 101

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Aerial photograph of the debris flow inundation of State Highway 101 in the vicinity of the Olive Mill Road overpass on January 9, 2018. Debris, mud, and other debris incorporated into the flows are retained in the highway corridor where the road elevation is lower than the surrounding areas. The highway was closed for thirteen days, the time it took to remove the debris and repair the highway and resulted in economic losses to the local business community and statewide. Photograph courtesy of Noozhawk photograph, January 9, 2018. Photograph credit: California Highway Patrol.

the flows by redirecting them away from the principal creeks for their low friction. The Olive Mill roadway directed debris flows toward the highway. Highway 101 acts as a debris basin due to a much lower road elevation than surrounding areas where it filled with 12 feet of mud and debris (San Luis Obispo Tribune, 2019), and a portion of the debris flows flowed over the highway bridge overpass down Channel Drive and onto the beach.

Sites of avulsion occurred from near the Cold Springs and Hot Springs fan apexes to the confluence that forms Montecito Creek, and these included bridge overpasses at East Mountain Drive at both apexes and at Ashley Road. Additional avulsions occurred at East Valley Road and other smaller private overpasses which increased out-of-channel flows causing much greater destruction. Creek meanders permitted flows to be redirected onto the fan and impact properties located on the outside banks and deposition of debris in the creek channels, also resulted in avulsions producing out-of-bank flows.

Landslide Dams and Outbreak Floods

Deep-seated landslides are primarily caused by high groundwater levels or perched groundwater which arise as the result of high antecedent moisture usually due to higher-than-normal rainfall in southern California (Bowles, 1985). These types of bedrock landslides may also form as the result of shaking due to local and regional earthquakes. Following initial failure of a bedrock slope, the head scarp area is often over steepened, leading to retrogressive failures upslope of the initial slide.

Numerous bedrock landslides are present on the slopes of the main trunk creek and its tributaries as shown in Plate 2 (Gurrola and Rogers, 2020B; Rogers and Gurrola, 2021). A significant number of the landslides exhibit former toes that protruded into the valley drainage pushing the creek channels into the opposing banks. Erosional remnants of these landslide toes are intermittently exposed along the opposite bank. The landslide toes often exhibit steep escarpments due to recent incision by the creek bed, typically as the result of debris-laden floods or debris flows such as the 1-9 event.

The record of ten landslide dam outbreak floods established in this study provides evidence that these landslide masses formed temporary landslide debris dams that blocked the channels for some brief amount of time (Gurrola and Rogers, 2020B; Rogers and Gurrola, 2021). Approximately 89% of the landslide dams documented in the 20th century are overtopped and fail within one year of their formation (Costa and Schuster,1991).

Temporary lakes build up behind landslide dams until overtopping flows trigger rapid incision or catastrophic collapse of the dam, producing an outbreak flood. Outbreak floods are typically much larger than rainfall floods in the same catchments (Clauge and Evans, 1994). The resultant flood from natural dam failures often transform into debris flows due to entrainment of debris within steeply inclined creek channels. Outbreak flood discharges commonly increase exponentially to peak discharge within 12 to 24 hours (Lee and Duncan, 1975), then decrease rapidly due to discharge of the lake and return to background creek flows (Clauge and Evans, 1994).

Peak discharges are controlled by the volume of the temporary reservoir, dam height and width, physical properties of the debris dam, mechanism of failure, creek channel gradients, and amount of available sediment and debris (Clauge and Evans, 1994). The location of the landslide dam in the catchment also influences the potential capacity of the lake as dams in the upper headwaters have limited drainage area as compared to those situated lower in the catchment with greater tributary watershed area. Large masses of displaced landslide debris load the drainages with soil, boulders, and tree debris. Generation of large landslides occur as the result of over steepened slopes due to stream incision, earthquake shaking, and long duration rainfall events or high seasonal cumulative rainfall (Gurrola and Rogers, 2020). Debris dams may also form temporary lakes behind them and form as the result of tributary debris fans, deposition of prior debris flows that create obstructions, and temporary plugging of the creek by debris. Evidence of both of types of dam forming processes is present in the catchments above Montecito.

The occurrence of landslide dam failures in the region is not limited to the 1914 flood event, but was also described in detail in 1861-62, 1879, 1914, and 1926 accounts identified in this report. More recent landslide dams are evident in aerial photographs, including the 1964 and 1969 debris flows and 1995 debris flood events.

Another recent landslide dam occurred in the watersheds that drain into the City of Ventura during El Nino rains in 1998 (The Los Angeles Times, February 16, 17, 18, 19, and 22, 1998). The landslide dam was discovered in the eastern tributary in Hall Canyon after it filled with millions of gallons of water and threatened more than 60 downstream homes and Ventura High School. However, City and County of Ventura officials installed emergency pumps and were able to drain the lake. It took approximately a week from the discovery of the landslide dam to install the pumps and start draining the lake. The lake was successively drained as the result of combined efforts of City of Ventura's emergency and engineering agencies, and local petroleum companies. It was noted by a City of Ventura engineer that the debris dam was composed of fine-grained clayey materials which provided sufficient cohesion of the dam to allow draining of the temporary lake without triggering a rapid drawdown failure.

Landslide debris contributes bouldery and vegetation debris as source material for future debris flows. The process of entrainment of alluvial debris from channel bottoms also incorporates landslide debris deposited in reentries of the valley sides and lowers the creek bed. Above-average winter rainfall seasons create elevated antecedent soil moisture, which decreases the time-to-concentration for runoff and increases peak flows. These swollen debris torrents can re-mobilize portions of the displaced bedrock slides forming landslide debris dams. Large landslides often re-mobilize to generate multiple landslide dams until the majority of the landslide mass is removed and evacuated from the slope.

Discussion and Conclusions

This study establishes that four types of physical processes act in the Montecito watersheds. Quasi-clearwater floods are the most frequent type of flood event in the watersheds of southern Santa Barbara County, and pose the most common flood hazard to the community of Montecito. A total of 56 flood events were recognized in this study and is considered a minimum number of said events. The flood event history for the period from 1826 to 1860 is poorly understood due to lack of written accounts, and there are several regional flood events during this period that were reported in the greater Los Angeles coastal area, some of which coincide with recorded flood events in northern California indicating some large historic storm systems.

A significant number of flood events were debris laden floods which are much more damaging due to voluminous amounts of debris carried as bedload and deposited on the alluvial fan (Church and Jakob, 2020). These debris laden floods cause rapid and extensive bank erosion and channel widening, and in other places, filling of channels causing out-of-bank flow diversions. Debris laden floods often impact structures with boulder and vegetative debris, and inundation by floodwaters. Examples of debris laden floods include 1861-62, 1907, 1909, 1995, and 2019 with the 1995 event producing more debris than the 1-9 event and filling the Santa Monica debris basin twice for a total of 400,000 cu. yds (306,000 m^3).

Debris flows are destructive, fast-moving slurries of debris and mud that entrain logs, massive boulders, and other encountered debris (i.e., homes, fences, infrastructure, etc.) and transports the debris long distances on the fan, often as out-of-bank flows. Natural and artificial flow constriction points in channels are easily clogged by clastic debris that result in out-of-bank debris flows at bridge crossings, channel bends or meanders, and local bank sloughage.

Based on the historic inventory, a total of 36 debris flow and debris laden flood events have impacted the southern Santa Barbara County region, and 25 of these events were initiated in post-fire watersheds. A total of 22 debris flow and debris laden flood events have impacted the community of Montecito, and these past events have easily overwhelmed the natural channel capacity, avulse at constrictions and at sharp bends of the channels, often flowing considerable distances away from the low flow channels they originate from. Such were the cases described in 1914, 1964, 1969, 1971, and 2018 debris flow events in the communities of Montecito, Carpinteria, and Santa Barbara (Plate 3).

Utility of Historic Data

The historical inventory recognized a much greater frequency of destructive debris flows and debris laden flood events than previously assumed. Physical evidence collected to establish this inventory is robust for most of all the 20th century flood events, and this permits the opportunity to recreate flood paths for comparison to more recent events. Comparison of flood paths for the Montecito Creek watershed establish that a number of areas repeatedly plug due to debris accumulations, as shown on Plate 3. These areas of redundant avulsions include:

- The crossing and former East Mountain Drive bridge over Cold Springs Creek.
- The Ashley Road bridge over Cold Springs Creek.
- The East Mountain Drive bridge across Hot Springs Creek.
- The East Valley Road (State Route 192) bridge over Montecito Creek.
- The Hot Springs Road bridge over Montecito Creek.

Diversions at these channel constrictions trigger out-of-bank flows that are conveyed through and/or debris deposited on the following areas:

- Riven Rock
- Old Spanish Town
- Lower Hot Springs Road and Olive Mill Road
- U.S. Highway 101, formerly the Coast or State Highway 1
- Danielson Road

Generally, overbank flows and flood inundation occur in the areas noted above. Spreading of flows occur below the Hot Springs Road bridge in the Riven Rock area and below the Hot Springs Road bridge over Montecito Creek where the flows can easily spread out over a width of 1,500 feet before reaching Highway 101. Flood flows are often conveyed down the roadway corridor of Olive Mill Road, which defines the western margin of the wide swath of inundation located on the northern, upstream side of the highway corridor.

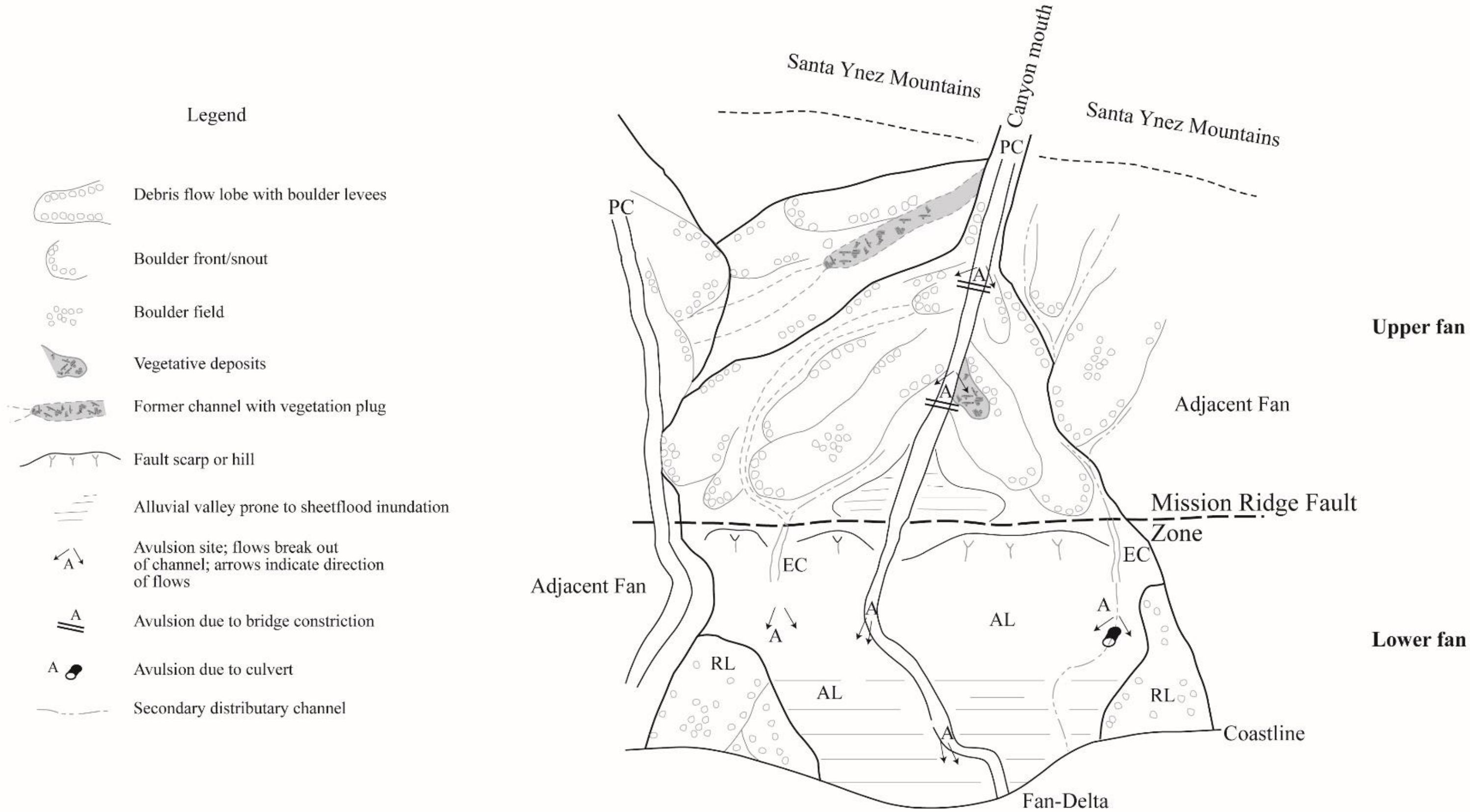
Although some of these flood pathways have repeatedly flowed through Riven Rock, Old Spanish Town, and Olive Mill Road, there remains the potential that the next event or other events may form blockages in the Montecito Creek channel that could establish different flood paths. That is the unpredictable nature of debris flows and debris floods. Recovery and rebuilding after the devastation of the 1-9 event in Montecito has changed the elevations of many of the building pads and overall topography of Montecito. The topographical changes may affect future flood paths.

A model of a debris fan in Montecito is shown in Figure 53 depicting the geomorphology associated with these fans. This model is based on the debris fans of Montecito and generalized to show areas of channel abandonment due to plugging with debris, avulsions, constriction points, and type of flooding on the Montecito fans. This model illustrates the high potential for out-of-channel flows and where they might be expected to occur.

Magnitudes Relative to the January 9, 2018 Event

Although quantitative estimates are not available for 19th and early 20th century debris flow events, magnitudes were classified for all debris flow events based on the collected evidence, so comparisons could be made relative to the 1-9 event based on number of watersheds affected, plugging of creek channels with debris, and extent (land area) of flood inundations. The 1914 event produced debris in watersheds from Gaviota to Carpinteria and eastward to Casitas and Ventura. Every creek channel in Carpinteria plugged with debris creating new channels, some of which extended more than two-thirds of a mile from their original channels.

Debris was deposited along the main creek corridors in the 1914 event and extended beyond the corridors in the lower fan. Similarly to the 1-9 event, debris flows avulsed where Olive Mill Road overpass was constructed over Montecito Creek, which resulted in diversion down Olive Mill Road scouring a 20 feet deep channel with portions of it filled with boulder debris. One out-of-channel flow sequence was diverted from Montecito Creek eastward to flow along the former Coast Highway and re-entered its former channel at the Miramar Resort. Accounting for all the debris produced from these watersheds and the resulting damages, this study establishes that the 1914 event produced a greater volume of debris than the 1-9 event and inundated a greater land



Model of a Montecito debris fan depicting debris flow landforms and associated flood hazards for a fan in the community of Montecito. The active lobe (AL) is the depositionally active part of the fan where the present channel (PC) is located and deposition occurs. Relict lobes (RL) are temporally abandoned portions of the fan and may contain a former channel (FC) where plugging with debris resulted in abandonment. Re-occupation of these abandoned channels may occur due to upstream avulsions that direct out-of-channel flows several hunderd to 2,000 feet away from the present creek. Avulsions due to natural and artificial constrictions in the present creek and secondary distributary channels produce dangerous flows where debris can directly impact and destroy residential structures. Secondary channels become entrenched with confined channels (EC) through the Mission Ridge fault zone as the result of uplift on the south side of the fault. These channels become less confined or unconfined downstream of the fault zone and often produce avulsions where less confined and at channel bends. The lowest part of the fan and localized areas north of the fault zone are subject to sheetflood inumdation. Note that the fan merges with adjacent fans with debris flows overlapping onto adjacent fans.

Figure 53.

Los Angeles County
Debris Basins Map

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area than the 1-9 event. Therefore, the 1914 debris flow event is classified as a magnitude 6 debris flow event which is the same at the 1-9 event

It is noteworthy that the 1825 and 1861-62 events were described as exhibiting similar magnitudes and damages in historical accounts of the regional 1914 debris flow events. The 1861-62 flood event likely produced multiple debris flows, debris laden floods, and landslide dam outbreak flood events, in addition to flooding of the alluvial fans. Therefore, a magnitude 6 is assigned to the 1825 and 1861-62 events, compiling a total of four Magnitude 6 events. As described earlier in this report, the 1995 debris laden flood events produced more debris than the aggregate amount of 1-9 in the Montecito and Carpinteria areas, and therefore is similar in magnitude to the events described above, and should be included with the other Magnitude 6 events. Based on the qualitative and quantitative evidence collected in this historical inventory, the 1825, 1861-62, 1914, and 1995 events are classified as magnitude 6 events, and all of these were greater in magnitude, regional extent, and production of debris than the 1-9 event.

Therefore, a total of four events meets or exceeds the debris production and inundation area of the 1-9 event over the last 200 years, so we are including the 1-9 event to make a total of five Magnitude 6 debris events impacting Montecito over the previous 200 years.

A total of 36 debris flow and debris laden flood events were recorded affecting the south coast of southern Santa Barbara County during the last 200 years, and 5 (14%) of these events were considered large in magnitude and extent (Table 1). Slightly more than half (21 events) of the 36 events (58%) were generated in a single watershed and the remaining 15 events (42%) discharged from multiple watersheds. Approximately 69% (25 events) of the 36 events occurred in post-fire conditions and the remaining 31% appear to have been triggered by high rainfall and/or high antecedent moisture levels. Historical flood activity of the Montecito watersheds is shown in Figure 54 which shows flood events for the last 200 year period.

A total of 22 (61%) debris flow and debris laden flood events impacted the community of Montecito in the last 200 years and 15 (68%) of these events occurred within a 5-year period following wildfires. The number of cumulative events in this study is considered a minimum value since there exists an informational gap on flood events that might have occurred between 1826 and 1860 due to paucity of accounts.

Implications for Future Hazards and Mitigation

Future debris flow events are not likely to perfectly mimic the same flow paths and inundation extent as the January 9, 2018 event, when all five watersheds above Montecito received triggering precipitation more or less simultaneously, producing devastating debris flows. Storms don’t tend to strike the coastline simultaneously unless their mean wind trajectory (azimuth) is normal to the coast and the coastline is straight, which appears to have occurred in the 1914 event. In most instances there is considerable variability in recorded precipitation at any given time such as in the first 1926 event. Therefore, storms will more frequently produce heavy precipitation in one or two neighboring watersheds and produce debris flows in these affected watersheds. This is in contrast to less frequent events where all the Montecito watersheds received heavy precipitation, and these large magnitude events produce not only large magnitude debris flows and debris laden floods

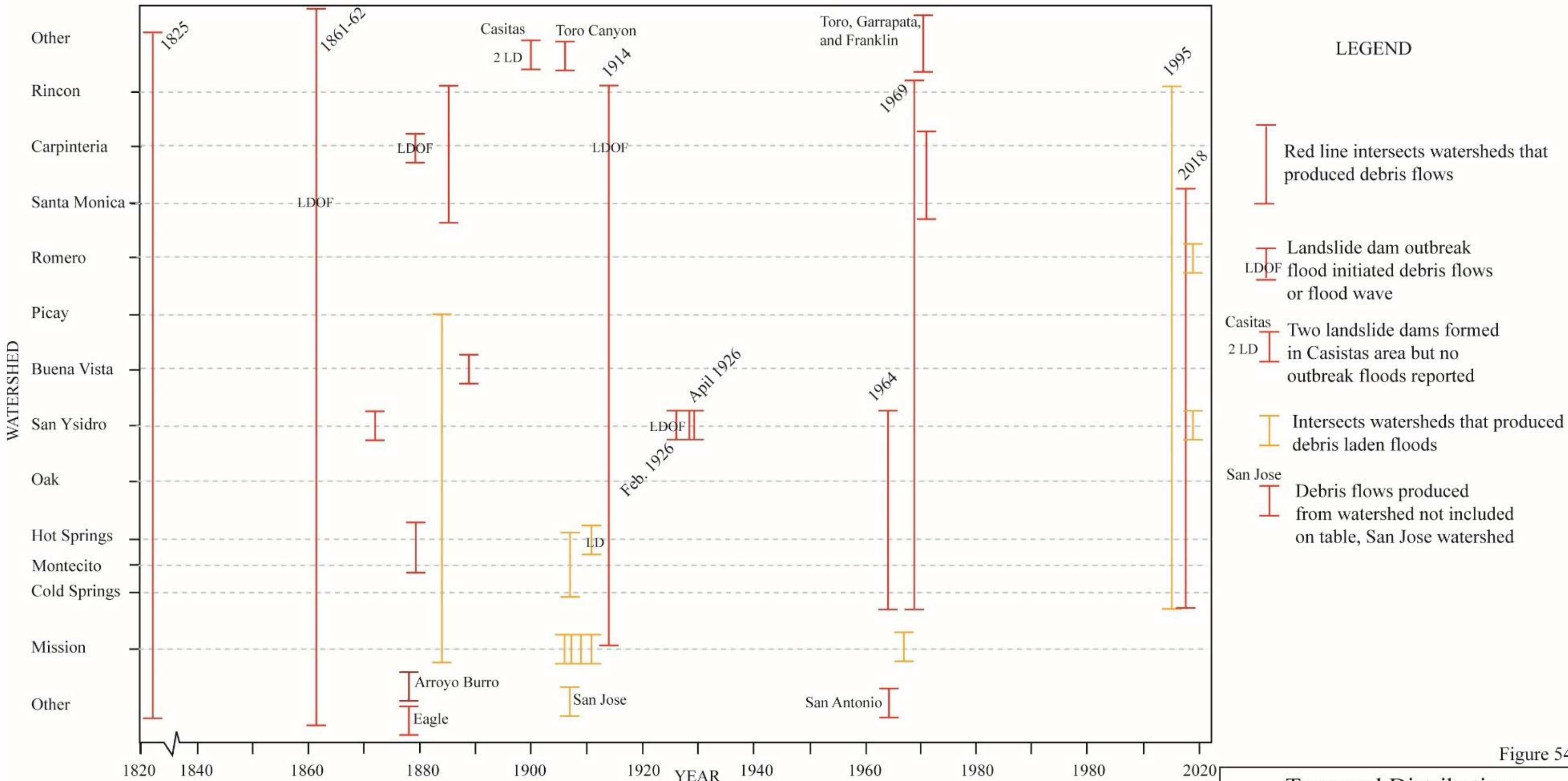

Figure 54.

Temporal Distribution Debris Flows/Floods

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Temporal and spatial distribution of historic debris flow and debris laden flood events that were discharged from watersheds on the y-axis. The events that were initiated by landslide dam outbreak floods are denoted with LDOF and events where a landslide dam did not result in an outbreak flood are designated with LD. Several of these events were combined events discharging floods-debris laden floods-debris flows and the largest events occurred in 1825, 1861-62, 1914, 1995, and 2018.

from the Montecito watersheds but includes adjacent watersheds along the coast of southern Santa Barbara County.

Large events have occurred in the Montecito watersheds in 1825, 1861-62, 1914, 1995, and 2018 during the last 197 years. Although the record for the period 1825 to 1861 is largely unknown, the recurrence interval between large flood events ranges from 23 to 81 years, with a mean recurrence frequency of about 40 years.

Three debris flow events occurred within a 1-month period in 1914 and in partial post-fire conditions, however due to the limited area of burn conditions, these events were not classified as post-fire events. It was repeatedly noted in accounts that watersheds along the south coasts of Santa Barbara County issued floodwaters charged with voluminous amounts of boulder and tree debris and this study establishes that high antecedent moisture conditions existed in the watersheds due to heavy cumulative rainfall in the 60 days preceding the three debris flows sequence. Following the first 1914 debris flow event, an editorial written by County Surveyor F. F. Flournoy shortly after the event opined that there was insufficient sediment and tree vegetation in the canyons to produce another similar debris charged flood event for at least 100 years. However, 12 years later another sequence of debris flows were discharged from San Ysidro Canyon.

Two fire events, the pre-1926 unnamed fires and the 1964 Coyote fire, each triggered three debris flow and debris laden flood events within a 5-year period following the event. Three debris flows occurred within a 2-months period in 1926 and these events occurred in the San Ysidro watershed and in post-fire conditions. Two additional events, a debris flow and debris laden flood, were triggered north the of Santa Ynez Mountains divide, however were not included in the flood inventory for southern Santa Barbara County.

The 1964 Coyote fire produced debris flows in Montecito about two months following the fire, a debris laden flood in Santa Barbara in 1967, and debris flows in Montecito and Carpinteria in January 1969. These examples of multiple events combined with the number of events occurring in the last 200 years suggest that the watersheds of Montecito and Carpinteria are capable of regenerating ample boulder and vegetation debris. Not only were debris flows discharged from Santa Monica Canyon in 1969, but the January and March 1995 debris laden floods filled the Santa Monica debris basin in each event. Recent field mapping indicates that there is abundant bouldery debris and woody vegetation to produce destructive debris flows in the watersheds above Montecito and in Santa Monica Canyon.

It was noted in a 1972 report by former flood control director, James Stubchaer that the need for and feasibility of flood control works on creeks in Montecito had been studied extensively since 1962 but concluded that the costs exceeded the present and future benefits. Although it was stated that "*Because there is no justification for complete flood control works on any stream in the Montecito area and because floods in the area pose a severe threat to life and property it seems prudent to include consideration of flood hazards in the planning process*." and "*Much of the developable land is subject to some degree of flood hazard*." it was concluded that the few debris basins constructed concurrently with emergency work to reclaim the creek channels would not provide a degree of flood protection sufficient to allow development to occur without regard to flood hazards (Stubchaer, 1972). Alternatively, it proposed to include consideration in the planning process such as high hazards should not be built on at all, and in other areas subject to periodic flooding, local measures for the creation of "open space" or channel set-back may be needed to avoid flood damage to structures and improvements.

This historical study was successful in reconstructing the 1914 debris flows with subsequent debris flows and debris laden floods, and is applicable to the adjacent watersheds above Montecito. Although this report presents the determination that adequate floodways must be provided for the passage of floods and basins for retention of debris, a study by U.C. Berkeley concludes that despite policies discouraging developments in hazard zones, exposure to flood hazards has increased significantly even though the community of Montecito joined the National Flood Insurance Program in 1979 (Anna Serra Llobet, pers. comm., 2021). Consequently, the debris flow hazard remains high for significant portions of the community including homes located along the Cold Springs, Hot Springs, and Montecito Creek corridors which is located within the subject area of this study (Table 5).

Comparison of the total capacity of the two debris basins and two debris nets in the Montecito Creek watershed is roughly 45,500 yds^3. The total volume of debris flows estimated by the U.S. Geological Survey (Kean et al., 2019) from the Cold Springs and Hot Springs Creeks watersheds is greater than 300,000 yds^3. Comparison of the Cold Springs watershed to the Santa Monica watershed demonstrates that these watersheds are generally similar in size, terrain, and geology (Table 5). The Santa Monica watershed discharged roughly 200,000 yds^3 in the 1-9 event. Assuming that a similar large debris flow event occurs in the future with a similar debris flow volume of 200,000 yds^3 to 300,000 yds^3, the existing debris retention capacity in the Montecito Creek watershed is only about 15% to 23% of the total potential debris flow. Small debris flow events with volumes less than 45,500 yds^3 should be contained by the existing retention system. However, moderate to large debris flows may avulse at constriction points or bends in creek channels once the flows are conveyed past the Cold Springs basin and likely not conveyed into the lower Casa Dorinda basin.

Table 5. Comparison of capacity of debris basins and 1-9 debris flow volume estimates of Montecito Watershed including Cold Springs Creek.

Watershed name	Cold Springs [1]	Santa Monica
Watershed area, acres (sq. km)	2,336[1] (9.5)	2,209 (9.5)
Basin name, Year built Capacity, cu. yds. (m^3)	Cold Springs 1964 30,000[2, 3] (23,000 m^2) Casa Dorinda 2002 5,500[2] (4,200 m^3)	Santa Monica 1977 208,000[2]
Debris nets on West and East Forks[4] yds^3 (m^3)	10,000[4] (7,500)	
Total capacity of debris basins and nets[5], yds^3 (m^3)	**45,500**[5] (35,000)	**200,000**[2] (153,000)
Debris flow volume of January 9, 2018 removed from basin, yds^3 (m^3) Kean et al. (2019) Volume, yds^3 (m^3)	24,782 (19,000) 302,000 (231,000)	**200,000**[6] (153,000)

[1] Represents Cold Springs Creek watershed only (Watershed Emergency Response Team, 2018).
[2] Santa Barbara County (2017).
[3] Expansion estimated about 130% (Burns, Montecito Journal, April 29, 2021.
[4] Storrer Environmental (2019).
[5] Volume estimate includes debris basin and nets installed on Cold Springs and the Casa Dorinda basin on lower Montecito Creek. This total capacity of retention systems is for all of Montecito Creek and Cold Springs Creek and Hot Springs Creek tributaries.
[6] Completely filled basin to capacity (Noozhawk, February 20, 2018).

A prime example of the reduction of hazards of debris flows and debris laden floods is the utilization of the Santa Monica debris basin on Santa Monica Creek in Carpinteria (Figure 55A, 55B, and 55C). County of Santa Barbara Flood Control manager, Tom Fayram, stated "*Santa Monica Debris Basin was the hero. It took the brunt of the storm*" (Noozhawk, February 20, 2018). He went on to state "*We avoided some horrific damage that would have certainly happened if we didn't have this*."

Figure 55A

Figure 55C

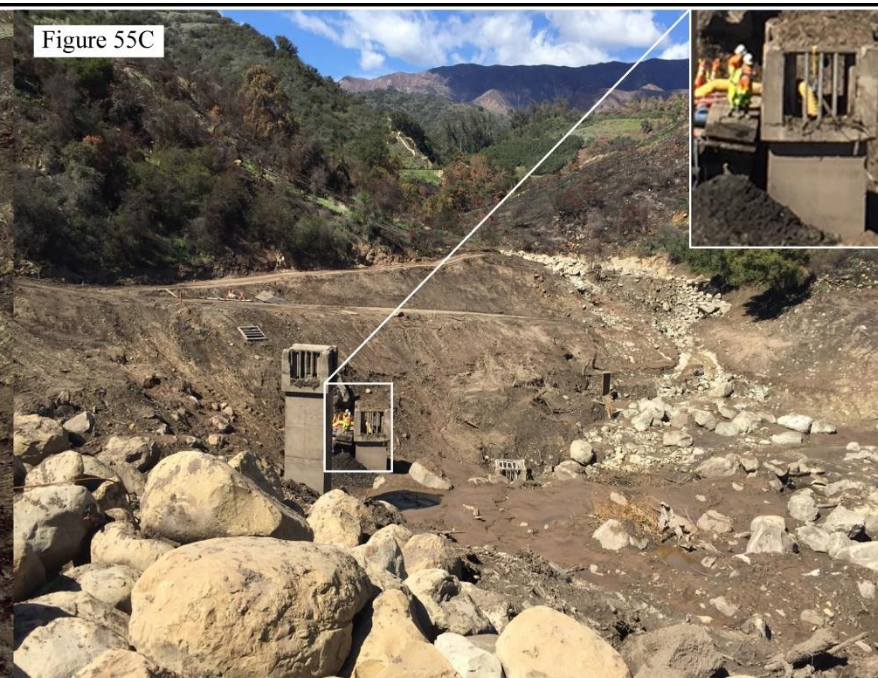

Figure 55B

Figure 55A (upper left). View of the Santa Monica debris basin filled with mud, boulder, and vegetative debris after the 1-9 debris flows. An upstream bridge is buried in the muck and mud and vegetative debris choke the spillway in the lower left of the image. Google Earth aerial image dated January 12, 2018. Figure 55B (lower left). View of vast amounts of vegetative debris discharged out of Santa Monica Canyon and captured by the basin. Figure 55C (upper right and inset). View of the empty basin on March 15, 2018. Note that the two intake valves were completely buried in the muck note the contractors working on the shorter intake valve for scale (see inset image). Photographs provided by Maureen Spencer of the County of Santa Barbara Flood Control District.

Figures 55A, 55B and 55C.

Santa Monica Debris Basin
Carpinteria, California

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Given that 1-9 resulted in 23 fatalities, extensive property and infrastructure damages, and monetary losses in excess of $1 billion dollars (Lancaster et al., 2021), it is imperative that a study be performed to identify the best locations for debris retention basins in all the lower watersheds of Montecito. Placing debris basins on the alluvial fan, especially on the mid- to lower fan does not reduce the risk of devastating debris flows to residences upstream of the basins.

The Los Angeles County Flood Control District is considered to be the gold standard in flood control for municipalities and continues to implement a maintenance program for 162 existing debris basins (Los Angeles County Public Works, 2021). Their policy is to place debris basins in the lower mountain catchments or at the canyon mouths of the catchments (Figure 56). Utilizing the catchments and the canyon mouths permits the debris to be retained prior to producing devastating impacts to homes and property.

A critical factor to develop debris basins at the appropriate locations is the potential for debris flows to breakout of the main channels and re-occupy secondary or previously abandoned creek channels or utilize roadway corridors. One example is the presence of the former channel of San Ysidro Creek which was the main channel for San Ysidro Creek prior to the 1861-62 floods and presently generally coincides with El Bosque Road. Since the channel was abandoned in 1862, it becomes reoccupied during out-of-channel flows and was a secondary flow path in the 1-9 event.

If a debris blockage or filling of the channel of San Ysidro Creek were to occur in the area of Mountain Drive, diversion of the debris flows down El Bosque Road could direct the flows away from the future Randall Road debris basin. Although debris flows have repeatedly inundated the property along Randall Road, there is always the potential that debris flows could be partially or entirely diverted down El Bosque Road and place the residents at significant risks. Flood flow paths on alluvial fans remain unpredictable and the potential for avulsions and re-direction of flows remain high due to the inherent natural process of blockages, filling of channels, and radial spreading of debris. Debris basins placed at appropriate locations at the canyon mouths or above in confined valleys, can significantly reduce the devasting impacts of boulder and log debris to the community developed on the fan.

Considering the new understanding of the frequency of damaging debris flows established in this flood inventory together with the total debris volume produced in the 1-9 event, the determination that the existing debris basins are insufficient for mitigation of moderate to large debris flows is without question. With the understanding that the community of Montecito is developed on amalgamated debris fans, it is recommended that a study of the geomorphology and hydrology of the watersheds proceed for the purpose of identifying ideal sites near the canyon mouths on the principal creeks for debris retention systems.

The debris retention systems should be redundant so that a multi-functional chain of structures are developed; the systems should be robust to withstand and endure severe impacts by boulder and vegetative debris; and the systems should be resilient so that they are economically feasible over the long term.

Development of a master plan study to study and strategize the components of mitigation and alternative solutions is recommended. A master mitigation plan adopts a multiple mitigation, functional chain strategy in structural mitigation methods providing redundancy in the debris retention and other mitigation systems. This functional chain strategy provides a range of mitigation techniques serving multiple purposes for reduction of debris flow impacts and will be applied to each of the Montecito watersheds. This plan will provide a long-term strategy for

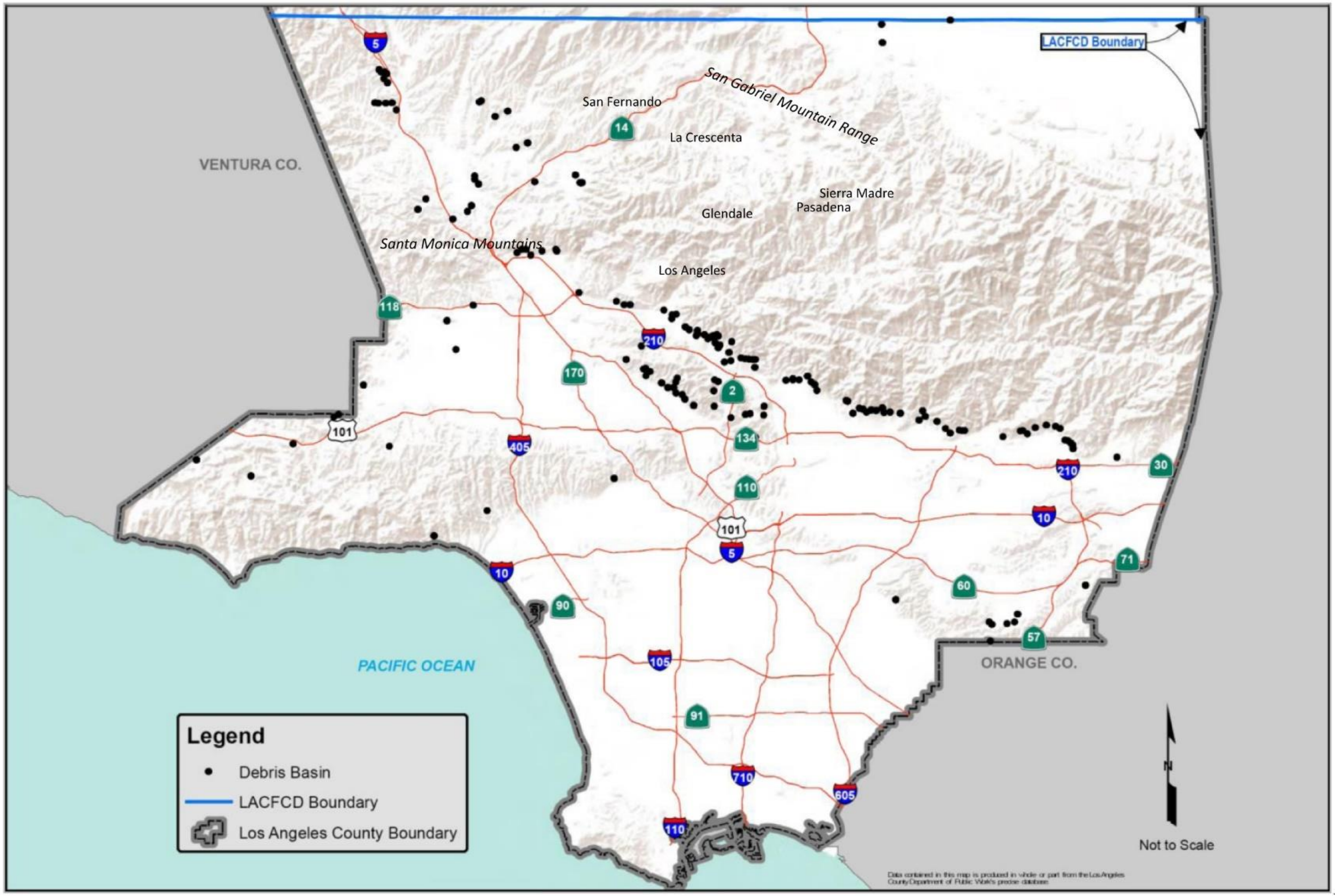

Figure 56.

Locations of 162 debris basin by the County of Los Angeles Public Works. These basins generally range in capacity from 20,000 to 70,000 cubic yards. Note that the majority of the basins are located at the mouths of canyons or in mountain catchments and not on the alluvial fan.

Los Angeles County
Debris Basins Map

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mitigative measures and will aid in the reduction of debris flow hazards, assist in educating the community of the recent history of debris charged floods, and set a series of goals for each watershed and creek corridor to locate additional debris basins, ideally near the canyon mouths, in addition to complimentary structures such as debris nets, rakes, bollards, and other mitigative measures.

Debris retention systems in combination with supplemental systems such as bollards would capture coarse wood and boulder debris; reduce the bulking material from the flows; reduce the potential for direct impacts to homes and infrastructure; and ultimately reduce the volume of flows to better permit the flow to convey within the creek channels to the ocean. Conveyance of flows in creek channels should also be included in the study to provide recommendations for reduction of constriction points in creeks, thus reduce the potential for out-of-channel flows. These retention structures will be designed to be harmonious with the surrounding environment.

In summary, the following conclusions and recommendations are presented from this study:

- Incorporate these findings in future hydrologic analyses including the frequency of events, the types of events, and magnitudes of events.

- The frequency of events and high boulder and vegetative debris production establishes that the Montecito and Carpinteria watersheds are transport limited with respect to debris. This means there is sufficient debris for multiple events following wildfires, which has been demonstrated by redundant debris flows. Two consecutive debris laden floods in 1995 filled the Santa Monica debris basin twice for a volume production of 400,000 yds^3 (306,000 m^3).

- High hazard areas are recognized when assessing past debris flow and debris laden flood paths in Montecito. The high hazard areas within the Montecito Creek watershed and tributaries include:
    - Riven Rock
    - Old Spanish Town
    - Lower Hot Springs Road and Olive Mill Road
    - Highway 101 at the Olive Mill Road overpass, formerly the Coast or State Highway
    - Danielson Road

- Avulsion sites tend to re-occur at the same locations and should be addressed with additional mitigation. These areas include:
    - The crossing and former East Mountain Drive bridge on Cold Springs Creek.
    - The Ashley Road bridge on Cold Springs Creek.
    - The East Mountain Drive bridge over Hot Springs Creek.
    - Highway 192 bridge over Montecito Creek.
    - Hot Springs Road bridge over Montecito Creek.
    - Olive Mill Road and Highway 101

- It is recommended that flow paths be reconstructed such as in Plate 3 and past abandoned channels mapped in Plate 4 for the other watersheds in the community of Montecito including Oak, San Ysidro, Buena Vista, and Romero Creeks. This will permit the identification of high hazard areas.

- The response to 1-9 impacts of re-building on elevated pads may affect future flow paths and subsequent LiDAR acquisition to better understand post-debris flow reconstruction is recommended for future analysis and modeling.

- The present debris nets constructed on the west and east forks of Cold Springs, in addition to the four nets installed on other creeks in Montecito, should be retained beyond the temporary 5 years status to compliment the now expanded Cold Springs debris basin. The combination of the net structures with the basins on Cold Springs and Montecito Creeks may retain a lower volume Magnitude 4 debris flow event (Tables 4 and 5), if the basins are regularly mucked of collected debris to maintain their design capacity.

- Evaluation of a location for a debris retention system should be performed for siting near the apex of Hot Springs Creek. This watershed has experience landslide dams and outbreak floods based on the historic evidence. Landslides remain active in the lower catchment and in addition, the 1-9 event caused fatalities and severe damages on the upper fan area. It may be necessary to construct a series of small basins or vary the structural systems (i.e., debris net, debris rakes, or basins) due to topographic and property constraints.

- Additional debris basin structures or combination of debris retention elements on Cold Springs Creek such as bollards, rakes, or a series of small basins could increase the protection for this reach and the downstream community.

- Landslide dams and resultant outbreak floods should be analyzed for present slope stability to understand the magnification of potential break-out floods and develop hazard zones. From this, evacuation routes may be pre-determined when a landslide dam forms in any of the Montecito catchments. The City of Ventura was able to deter an outbreak flood as there are established roads into the watersheds, however this is not the situation that exists in the mountainous catchments of Montecito.

- Initiation of a study to analyze the watersheds of Montecito for a spectrum of rainfall events should be performed to understand the range of potential magnitudes and volume of debris flows. Some of this work has been completed in published work and future work can dovetail off this initial work.

- The objective of these studies is to search for sites suitable for future debris basins. A key aspect in the selection process will be the traffic corridor connecting the debris basins with temporary debris storage sites on the alluvial fan, preferably within 2 to 3 miles of the basins. This is so “wet debris” can be moved out of the basins during the storm season as easily and quickly as possible, to maintain the storage capacity of each basin. This will require a comprehensive study that includes geomorphologic and hydrologic analyses, together with modeling analyses of flow paths using the latest debris flow software to analyze the ever-changing topography of Montecito.

- A mitigation plan is recommended that adopts a multiple mitigation, functional chain strategy in structural mitigation methods providing redundancy, robustness, and resilience in the debris retention and other mitigation systems. This functional chain strategy provides a range of mitigation techniques serving multiple purposes for reduction of debris flow impacts and should be applied to each of the Montecito watersheds.

- Development of a Master Plan will also establish design standards and guidelines that will:
    - Prohibit under-designed infrastructure bridge crossings and culverts that form constriction points causing avulsions (channel break-outs);
    - Improve the conveyance of flow through the existing creek corridors in the community of Montecito from the watershed divide to the coastline; and
    - Improve the defense from not only future debris flows, but also from more frequent flood events often accompanied by debris or “debris laden floods.”
    - Identify high hazard zones in the community of Montecito to restrict development in key zones to reduce the net hazards posed to the existing community.

A master plan, or blueprint, can establish a vision for the future and enable a coordinated – long term effort subdivided into phased studies to improve the geologic and hydrologic conditions over time. Over the years, there have been emergency projects such as the Corps of Engineers (Corps) constructed basins, bridge replacements for capital projects or replacements, and individual projects to improve flooding/debris conditions. However, these projects have never been constructed to fit into an overall Master Plan. With a Master Plan in place, future construction of any public or private project and/or facility will adhere to the long-term strategy of creek and habitat improvements, additional debris retention structures, and planning and policy decision making process. Flood standards will be established as part of this master plan for each watershed in Montecito, and although it will certainly take time to achieve these goals, overall improvements in debris and flooding conditions will never result without such a plan, which would require future planning with consideration of geologic hazards, especially for debris flow hazards.

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APPENDIX A – County Surveyor Frank F. Flournoy Landslide Dams Account

THE MORNING PRESS, SANTA BARBARA, CALIFORNIA, SUNDAY, FEBRUARY 15, 1914.

No Such Flood Again For 100 Years Is Reassuring Promise Of County Surveyor

BY FRANK F. FLOURNOY.

I have been requested by The Morning Press to give my opinion and advice as to the flood that occurred some three weeks ago; and I hope before any person criticises my theories he will first take a few trips up the various canyons in this vicinity, see the beds of creeks, inspect the flooded districts and observe what I herein mention.

I will endeavor to explain my view of this storm and the cause of the flood. We learn in mineralogy and by observations on the mountains that the earth's surface in a prehistoric age was all level; that God Almighty saw f't to put it otherwise, and caused anticlines, sinclines, folds, slips, faults, etc., as the human race has named them; but a common layman sees it as a great seam, a line of rocks, or a stratum appearing on the side of our mountain canyon, looking as if it had been placed there by a mighty mason; a seam of sand stone, a seam of shale, a seam of broken rock, making a perfect line. This, if you were informed, you would understand to be a huge anticlinal or a great up-heaved rainbow-shaped ledge, forming possible the whole backbone of the Santa Ynez mountain ridge, and with the aid of water have caused the canyons along its sides.

All of this was the work of the hand of God. Also he made the ocean, the islands, the hills and the beach. But there are other things that God has caused, among them the great storms that wash down from the mountains great rocks from the ledges, to grind upon each other in boulder form, making sand, and with the vegetable life causing silts to form the areable land below. Often these boulders reach the level land. Live oaks and other trees grow up around them and sycamore and alder trees grow thickly along the water courses in the canyons, while the chapparal brush grows along the mountain sides, all of which form a jungle, with the roots platting amongst the rocks, causing pockets to catch water, and making basins, and keeping the sift and the sands from the lower lands until the day comes when a very large quantity of water will cause them to break away, and one to push the other until they become a rolling mass of water, trees and rocks, making dams here and there, only to break loose by others piling in, causing a toboggon slide, so as to say, of the whole canyon. You can see that a good many trees from one foot to three feet in diameter were uprooted and broken, some times in two or three pieces, by the recent flood; some of the boulders that were moved weigh as much as thirty tons or more, and yet very few of the large boulders got to the ocean.

F. F. Flournoy, County Surveyor

I am trying to concentrate the minds of the readers in regard to these rocks that now appear in the mountain creek beds and the overflow of some upon the level, sloping land. They are all scratched and rubbed to a yellow color. The oak, sycamore and alder trees washed down show that it took at least from 60 to 70 years for them to get their growth before they were destroyed; especially in and along the canyons where the better soil is below. How long do you suppose it was since such storms took place, before the last one? Look at the moss covered round boulders on the Riven Rock or McCormick property along Montecito creek, and other places, with oaks two and four feet in diameter, and one oak close to the bank of the creek on the McCormick property bears the marks of a surveyor, dated 1853 in the field notes. The tree was then 16 inches in diameter. Now it is 24 inches. These rocks were put there by just such a flood as this we have recently experienced.

Will it be repeated within the next 60 or 70 years? I do not believe it will, on account of the fact that the canyons are now free of interfering trees, vegetable life and silts that will take fully 75 to 100 years to replace. It is a two to one chance that it will be a longer time than that. If a big storm should come next year, say as large as the last one, it would run off through the cleared channels very rapidly, as there would be nothing to dam the flow. It was very noticeable how quickly the water in the streams cleared after the flood. Why Because all the sand and silt on the watershed above were gone, and nothing but the bed rock and the strewn boulders remained.

I have been to the top of the mountains in four different canyons back of Montecito since the storm, and find this to be the fact.

I believe that all of the creek beds for ten miles on each side of the city should be cleared of the drift wood before next winter, just to clear the channels. I believe that the county should condemn a 20 foot strip above each bridge for at least 1000 feet, to make certain that it is kept clean of projecting boulders and trees which may turn the stream into a crooked channel.

Some people will say bridges should be made larger. Why, if they would stop to think for one moment—suppose I should have planned a bridge to take the water and debris that came down the Spanishtown creek in Montecito, so the water would not have run over it or endanger it in any way. I would have had a bridge plan of my own, that is all; because no common sense man would have accepted it. Likewise at least ten places that I know of.

As to the seven great bridges along the Santa Ynez and Santa Maria rivers not going out—it is good luck, that's all. I believe the important thing in bridge work is foundation first, water and debris space second. The superstructure we can see at all times.

My theory as to the last storm is that it was caused by the meeting of two big rains, one coming in on the lower currents of air, from the south, the other on the upper currents from the north, both influenced in their course by the tops of the mountains.

Editorial written by County Surveyor Frank Flournoy describing his observations of landslide dams plugging creek channels in the watershed canyon in the first debris flow event in 1914.

APPENDIX B – 1969 DEBRIS FLOW EVENT

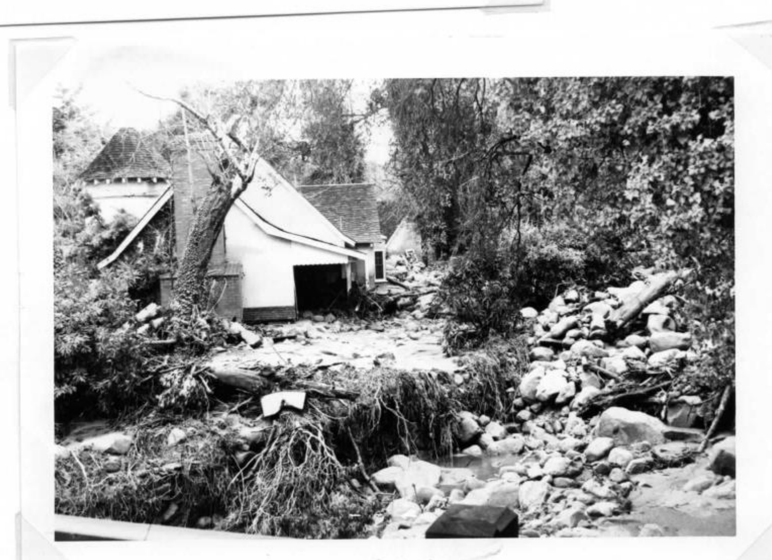
NEWS-PRESS FILE

Floodwaters knocked supports out from under the carport at this home on San Ysidro Road in Montecito in 1969.

Santa Barbara News Press, January 15, 1995.

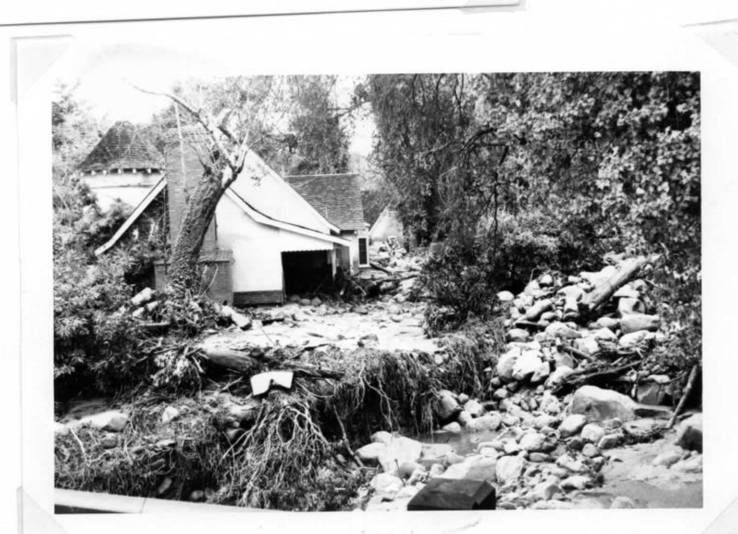
Photographs from the Montecito Association History Committee.

Photographs from the Montecito Association History Committee.



Photographs from the Montecito Association History Committee.

Photographs from the Montecito Association History Committee.



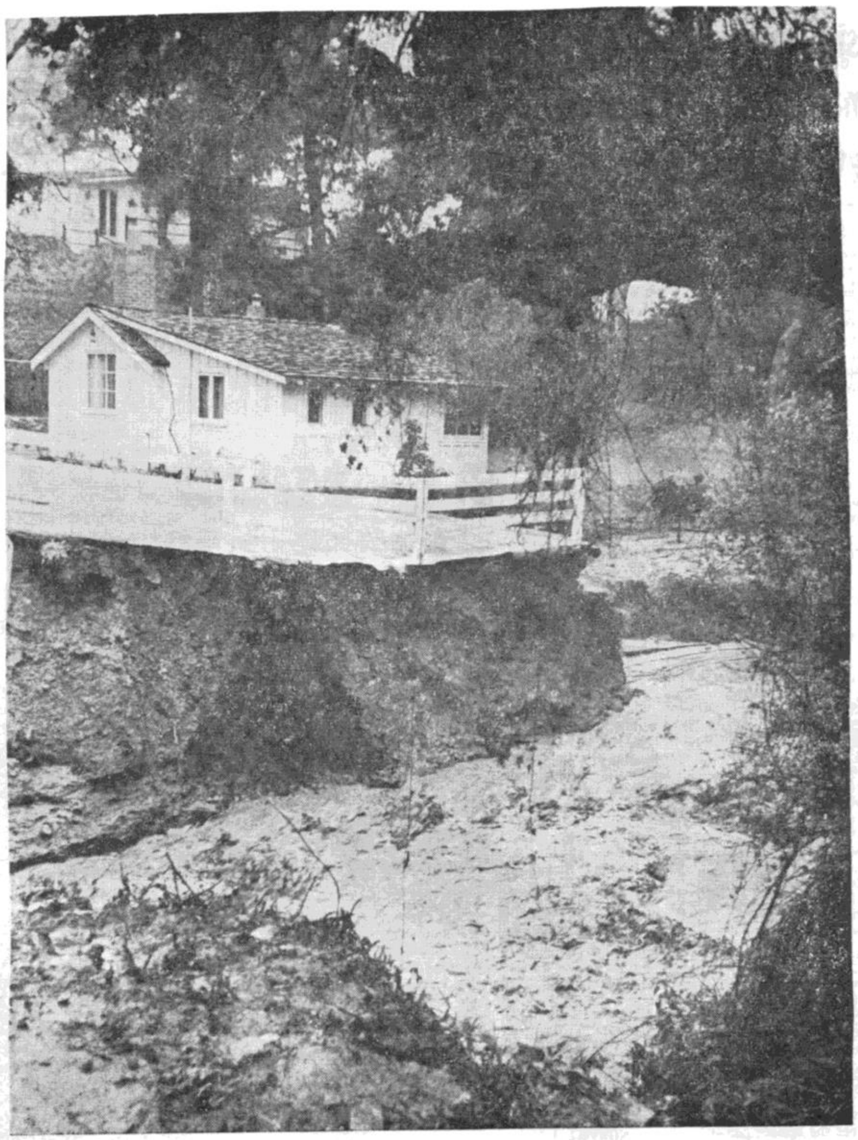
Photographs from the Montecito Association History Committee.

THIS CHRONICLE OF THE JANUARY, 1969, FLOODS IN SANTA BARBARA COUNTY HAS BEEN COMPILED BY THE SANTA BARBARA COUNTY FLOOD CONTROL & WATER CONSERVATION DISTRICT FROM THE FOLLOWING NEWSPAPERS:

SANTA BARBARA NEWS-PRESS
LOMPOC RECORD
CARPINTERIA HERALD
SANTA MARIA TIMES
LOS ANGELES TIMES

FEBRUARY, 1969

The following news clippings and photographs are from the County of Santa Barbara Flood Control report of the 1969 floods.



IF MAN doesn't make a hole big enough for the floods, the raging waters will make one of their own, as illustrated in this Montecito scene of a hanging house.

Sunday Edition

SANTA BARBARA NEWS-PRESS

The Oldest Daily Newspaper in Southern California

WEATHER
Santa Barbara
Rain
Santa Maria
Rain
Lompoc
Rain
(Details on Page A-10)

One Hundred and Fourteenth Year No. 250 | Nine Sections | SANTA BARBARA, CALIFORNIA, SUNDAY MORNING, JANUARY 26, 1969 | 120 Pages | SINGLE COPIES TWENTY-FIVE CENTS | PAGE A-1

WETTEST JANUARY SINCE 1916 DOUSES SANTA BARBARA COUNTY

1,000 Flee Homes in Carpinteria

By Tom Kleveland
News-Press Staff Writer

Three raging creeks boiling up and out of their banks left only three parts of Carpinteria relatively flood-free last night, the northeastern part of town near Foothill Road, the upper part of the Concha Loma tract and the downtown business area.

The rest of this little city of 7,000 was a morass of deep and slippery mud and debris, standing water or silt-laden flood waters racing to the sea. The water levels rose and fell with each new sharp downpour in the foothills and mountains.

1,000 HOMELESS

But authorities were unaware of any loss of life or any injuries. City Manager Jack B. Arnold estimated that at least 1,000 persons were homeless and most of them found shelter with friends or relatives.

Rescue operations began about 10:30 p.m. Friday when some of the low-lying residential tracts were flooded, some with several feet of muddy water. Water and mud raced through homes, tore out retaining walls and flattened chain link fences.

Many of the evacuees spent the rest of the night on civil defense cots set up in Carpinteria Junior igh School. Salvation Army Maj. Wilfred J. Mahy said he arrived about midnight from Santa Barbara —"we never would have made it on the highway without our four-wheel vehicle." He set up a refreshment stand and supplied clothing to dozens of persons, some of whom arrived soaking wet.

At dawn, the Red Cross moved in to assist. Mrs. George Hoffman, manager of the cafeteria at Canalino School, arrived as a volunteer and took charge of cooking at the junior high school. They served about 200 persons before noon.

COMMUNITY HELPS

The volunteers said community response was gratifying. By 1 p.m. yesterday they asked radio stations to cancel requests for food and clothing; they had too much.

A foot or more of water raced across the Carpinteria High School campus and into the buildings, enough to float a boat being pushed around by youngsters. Custodians said they were afraid damage was aggravated by the frolicking youngsters. They explained: The waters would flow against the bottom of a door and drop their load of silt, meaning that relatively clean water was flowing under the doors and into the classrooms. Then, said the authorities, "the kids open the doors and the mud flows in." Outnumbered, they

See Page A-4, Col. 7

IT'S GOOD EXERCISE but very hard work, said Lucy Diaz, left, slogging through knee-deep mud as she salvages some belongings from her home in the Kramer tract in Carpinteria that she evacuated the night before.
—News-Press photos by Wally Stein

More Rain Is Expected

By Steve Sullivan
News-Press Staff Writer

Raging waters from the second-wettest January in 101 years etched heroism, devastation and loss across the sodden face of Santa Barbara County, and additional rain is forecast.

Rain is expected to be heavy at times in the north county area today, where the Lompoc sewage treatment plant is submerged, and showery periods, occasionally heavy, will continue to pelt the South Coast, not yet cleared of muck and debris.

The Santa Barbara official rain record stood at 14.45 inches for the month last night, highest since 1867, except for 17.22 inches posted in January of 1916. The average for

Additional stories of Santa Barbara County flooding may be found on pages A-5, 12 and 17 in today's News-Press. Three full pages of photos may be found on pages A-6, 8 and 9.

an entire rain year is 17.75. The city's season total to date is 17.96, after 4.19 inches from the new storm. The city total for two major storms in the past eight days is 12.59 inches.

Helicopters were to take off at daybreak today, if the fog lifts, to evacuate families stranded overnight in the flood-ravaged Paradise area of the upper Santa Ynez Valley. See story Page A-17.

The choppers had to turn back to Santa Barbara yesterday afternoon due to dense fog.

Eleven helicopters are to pluck the families from the Santa Ynez River community and ferry them to an evacuation center at Solvang.

Several homes were destroyed and others badly battered by the rising river, but no injuries were reported. The only access road was cut when a bridge washed out.

WATER AVALANCHES

Yesterday, from the time avalanches of water roared down Montecito canyons to jam bridges and the four big flood gates at Lake Cachuma swung open to spill a 16-foot head of water down the Santa Ynez River, the county reeled under the impact of storm damage.

A cloudburst ruptured over the mountains behind Montecito and Carpinteria before 5 a.m., scouring three canyons and wiping out three sections of the 18-inch transmission line of the Montecito County Water District.

When the waters from swollen Santa Monica Creek reached Foothill Road, virtually the entire force rolled across the 47-acre campus of Carpinteria High School, wreaking havoc that prompted officials to close the school tomorrow.

Two hundred head of livestock were seen at one time going down the Santa Ynez River below the dam, which could no longer tame the river. The force spread the river into a 600-foot-wide torrent in the area of the dam's spilling

See Page A-4, Col. 1

Woman Lost in Flood 12 Hours Found Alive

Lost for 12 hours in the flood-devastated area of her home in Montecito, Mrs. William E. Stephens was found alive at 5 p.m. yesterday and was admitted to St. Francis Hospital suffering from exposure.

Wife of a prominent local dentist who was in the same hospital after being rescued by four young men, Mrs. Stephens had been presumed dead most of yesterday by neighbors, relatives, and friends.

Word was flashed about 5 p.m. that an ambulance had been called to the most easterly intersection of East Valley Road with Glen Oaks Drive, scene of the pre-dawn deluge of five homes.

PULLED FROM WATER

She was found by a civilian member of the Santa Barbara Four-Wheel Drive Club rescue unit working with a sheriff's unit in the area. When they heard her yelling, and went to her, they found that others had also heard her pleas for help and were pulling her out of the muck and water.

When Tim McDonald, driver for Coast Ambulance, arrived, Mrs. Stephens was sitting in a jeep, and walked to the guerney on which she was placed aboard the ambulance.

Dressed in a blouse and shorts, she was completely mud-covered and apparently had saved herself after being swept from the cluster of homes swamped by the overflow of San Ysidro Creek.

SWEPT BENEATH CAR

She reported having been swept beneath a car at their home, 1775 Glen Oaks Dr., and into the creek, where she endured the ordeal of mud, rocks, and raging water most of the day.

Keith Searl, of the Four-Wheel Drive Club, said Mrs. Stephens was found in the water hanging on to the root of a tree, on the opposite side of the water from where her rescuers were. Men used ropes to reach her.

The hospital, where Dr. Stephens had been taken about 10:45 a.m. after resting at a neighbor's home, reported Mrs. Stephens was in "pretty fair" condition. She had apparently suffered considerably from the cold.

Charles Smith, who lives at 1780 Glen Oaks Dr., said he awakened about 4 a.m., but went back to sleep, to be awakened again an hour later, when Dr. Stephens called. Stephens said water was coming into their house, and asked if he and his wife could come to their home.

Smith alerted other neighbors on the short street, which swings like a crescent below East Valley Road, across San Ysidro Creek.

While he was phoning, Dr. Stephens and his wife had attempted to leave the house,

See Page A-4, Col. 1

Many Communities Isolated by Floods

LOS ANGELES (AP) — Mudslides buried sleepers alive and surging floodwaters isolated communities and caused untold devastation yesterday as Southern California was deluged anew by rain — up to 12 inches in 24 hours in some places.

Officials called the flooding the worst here since 1938. The U.S. Geological Survey said that in the 150 miles north from Los Angeles to San Luis Obispo the flow of water across slopes and stream beds was the largest in history.

Officials confirmed 11 deaths and reported five others.

The storm hit in force Friday after six straight days of rain.

Rain slackened in some

See Page A-4, Col. 6

WHEN RINGO'S cleaned up he's a fine looking poodle, but he missed the boat the night before when the people departed the Kramer tract, in Carpinteria, so he's shown here in his casual dress. That's Helen Corral, a friend, boosting the heavy dog over the fence and into the arms of Helen Mendez, who did not miss the boat.

INSIDE THE NEWS-PRESS

RESIDENTS of the Topanga Canyon area, some of them carrying pets, walk past downed power poles yesterday as they head for safety and flee from their homes, endangered by mud slides. This section is about five miles from Malibu Beach on the Pacific Ocean. Continuing heavy rains in Southern California caused numerous mud slides.
—AP Photofax

WITH DELIBERATE HASTE this bulldozer is diverting Toro Creek away from its devastating attacks against all that is left of the shored-up embankment that, before the storm, was about 15 feet away from the Michael O'Shaughnessey home on Torito Road.
—News-Press photo

BEFORE AND AFTER PICTURES

Usually Friendly Toro Creek Became a Mouse That Roared

By Katherine McCloskey
News-Press Staff Writer

It takes before and after pictures to really show what "the" storm did to Toro Canyon at Torito Road, off Toro Canyon Road.

In "normal" California weather (whatever that is) it's the kind of usually bone-dry, tiny, friendly, meandering rivulet Californians love. The kind that makes Easterners smile condescendingly as they recall the "criks" back home.

That's a creek? What do you mean? There isn't even a drop of water in it. Not even a suspicion of a drop, they'll protest.

All right. That's fair enough. It all applies to Toro Creek—most of the time. But not now. Not since 5 a.m. Saturday when it got hit simultaneously with cascading torrents of water bursting out of the confines of what—on some maps, at least—are shown as the east and the west branches of Toro Creek.

That did it.

At almost the same moment there was a loud roar, "like a bomb," and the gas main at Toro Canyon and East Valley Road burst.

Everything happened at once, it seems now to the 15 or so families whose comfortable, isolated, homes surrounded what was a warm California meadow to the west of Toro Canyon Road just above its intersection with Foothill Road.

BRIDGE COLLAPSES

The bridge spanning the little creek just below the Michael O'Shaughnessy home crashed down, flopped over on its side like a lumbering elephant lowering itself down into a waterhole. That took care of getting across the creek.

Then came the mad rush of waters jumping out over the creek banks, tearing up 15-year-old pine trees as if they were the fresh weeds of springtime, pulling out ceanothus covered with the lilac of spring and tossing it aside like the desert wind does tumbleweed.

That little creek had—not the strength of 10—but that of hundreds of thousands.

Huge, white-faced boulders jammed up against homes. "But they don't belong there," protests F. K. Lightfoot, "we never had boulders like that before."

And standing on the edge of his homesite (it used to be well back from the split where the creek ran) he remembers the three footbridges he built to span that slit of a creek. The ones that aren't there, now.

"Why, when I'd walk down the dry creek bed, stretch my arm as far above my head as I could, I couldn't even touch a sliver of wood from the bridges.

"Now look."

What he means is that even late yesterday afternoon the "creek" was right up to the edge of his property.

The A-frame cottage above Lightfoot's, owned by a Neville family from Los Angeles looks comfortably at home skirted with big, little and inbetween size boulders.

The only problem is, the rocks don't belong there, either.

And what they've done is to completely shut off from view the carport underneath the wooden deck extending out from the eastern side of the home. So what looks a comparatively small, one-story cottage is really—or will be when the rocks are removed, or something—a two-story cottage with storage rooms and a carport beneath a wooden deck.

SOIL REMOVED

The most serious damage is to the O'Shaughnessy home. There tons of water forced out a new creek channel and, literally, removed some 10 feet of soil, about 10 feet high, from beneath the wooden deck.

Things soon will get back to normal, everybody believes. Then groceries can come in by Torito Road, instead of being "dragged up and over" Lambert Road or up, over and down East Valley.

A bridge, of sorts, was in place, yesterday afternoon, thanks to the Southern California Edison Co. A crew delivered telephone poles to the site, set them across the creek banks and thus made a sort of bridge. Today planks will go from poles to poles and there'll be a bridge. For cars? Not yet, it seems. But a bridge, and nobody will be isolated, and kind and concerned friends won't have to worry any more.

Even when the bulldozer that came in to divert the creek into new channels yesterday afternoon hit the water pipe and water had to be shut off, residents kept their philosophic cool.

"The human race is wonderful, just wonderful, when the tough times come," O'Shaughnessy summed it up.

Nobody disagreed.

Hundreds Evacuated In County Floods; Damage in Millions

Santa Barbara County was declared a disaster area by Gov. Reagan today as the worst flood in 55 years drove hundreds from their homes, caused $4,500,000 property damage that was rising hourly, and closed most highways leading out of the city.

Little relief was in sight. The Weather Bureau forecast a 90 percent chance of still more rain tonight. The probability of more rain here tomorrow was 80 percent.

Particularly hard hit were Carpinteria and portions of the Santa Ynez Valley, including Paradise Camp.

The current storm had dumped 4.03 more inches of rain on the city and nine inches during the past 24 hours at Gibraltar Dam.

The governor declared the entire county a disaster area after Raymond D. Johnson, county administrative officer and civil defense director, had made the request.

BILL SIGNED

Assemblyman Don MacGillivray (R), Santa Barbara, called this afternoon from Sacramento to report that the governor had signed the bill after the former mayor of Santa Barbara also had contacted him to relay information supplied by County Supervisor Daniel G. Grant.

An estimated 500 persons were driven from their homes in the Carpinteria area and approximately 300 in the Paradise area, where Herb Gents, owner of the Paradise Store, said he thought that all 158 homes had been evacuated. He said there were reports that several families were on rooftops and up in trees awaiting rescue.

Two helicopters arrived at the airport here about noon en route to Vandenberg Air Force Base, where they were to refuel before reporting to the Paradise area for rescue work. Seven more copters reportedly were en route behind the first two.

BUSES CANCELED

All runs of the Greyhound Bus Lines southbound from Santa Barbara were closed today, as heavy flooding continued to threaten the routes. Sources at the bus station here advised that lines northbound were still running as of 12:30 p.m., but could be stopped at any time.

National guardsmen were dispatched to Carpinteria, one of the county's hardest-hit communities, by Maj. Gen. Charles A. Ott, commander of the guard unit here.

The guardsmen were sent to watch for looters after an estimated 500 persons were forced from their homes. The city was virtually isolated because of highway flooding.

Mayor Allan R. Coates Jr., who is also a major in the National Guard, is in charge of the guardsmen.

City Manager Jack Arnold declared a state of emergency in Carpinteria at 7:15 a.m.

HIGHWAYS CLOSED

Highways were closed between Montecito and Carpinteria, Las Cruces and Lompoc, and in the Santa Maria area, but a Montecito woman was reported missing.

A Southern Pacific freight train burst into flames last night after it was derailed near El Capitan when water undermined the tracks, injuring one man as six locomotives and 20 freight cars left the tracks. Six cars loaded with an estimated 70 new automobiles burned all night.

'LIKE A RIVER'

"I guess we are isolated," said Mayor Allan Coates Jr. U.S. 101 was "flowing like a river," he said.

Most evacuees have gone to stay with friends or relatives, but about 50, including children, spent the night in emergency facilities at Carpinteria Junior High School.

An emergency civil defense hospital and cots were set up there, and the Red Cross was assisting.

The city declared a state of emergency Monday, when many families fled their homes.

About 300 or 400 more families were driven out last night by flooding.

Worst conditions north of the freeway were at Canalino Village subdivision and Pace Park No. 1 and 2, and Loop's Restaurant.

On the south side hardest hit was the Old Town area, where many low income families live.

TRUCK STUCK

A city truck got stuck helping get families out of flooded homes and cars, and a road

See Page A-2, Col. 1

MONTECITO WOMAN LOST IN SAN YSIDRO CREEK

The Glen Oaks Drive area of Montecito was a small pocket of tragedy in the countywide disaster area about 5 a.m. today when the wife of Dr. William E. Stephens was apparently lost in the swollen waters of San Ysidro Creek.

The sheriff's office said it has not been able to find Mrs. Stephens. A youth took Dr. Stephens to safety. He is in St. Francis Hospital this afternoon recovering from shock and head and back injuries he suffered.

THIS WAS one of the scenes witnessed by motorists on Highway 101 yesterday in the Carpinteria Valley—muck and mire window deep in stalled cars, a youngster plowing through oozy mud after he unearthed his minibike. —News-Press photo

1,000 Flee Homes in Carpinteria

JAN 26, 1969

By Tom Kleveland

News-Press Staff Writer

Three raging creeks boiling up and out of their banks left only three parts of Carpinteria relatively flood-free last night, the northeastern part of town near Foothill Road, the upper part of the Concha Loma tract and the downtown business area.

The rest of this little city of 7,000 was a morass of deep and slippery mud and debris, standing water or silt-laden flood waters racing to the sea. The water levels rose and fell with each new sharp downpour in the foothills and mountains.

1,000 HOMELESS

But authorities were unaware of any loss of life or any injuries. City Manager Jack B. Arnold estimated that at least 1,000 persons were homeless and most of them found shelter with friends or relatives.

Rescue operations began about 10:30 p.m. Friday when some of the low-lying residential tracts were flooded, some with several feet of muddy water. Water and mud raced through homes, tore out retaining walls and flattened chain link fences.

Many of the evacuees spent the rest of the night on civil defense cots set up in Carpinteria Junior High School. Salvation Army Maj. Wilfred J. Mahy said he arrived about midnight from Santa Barbara —"we never would have made it on the highway without our four-wheel vehicle." He set up a refreshment stand and supplied clothing to dozens of persons, some of whom arrived soaking wet.

At dawn, the Red Cross moved in to assist. Mrs. George Hoffman, manager of the cafeteria at Canalino School, arrived as a volunteer and took charge of cooking at the junior high school. They served about 200 persons before noon.

COMMUNITY HELPS

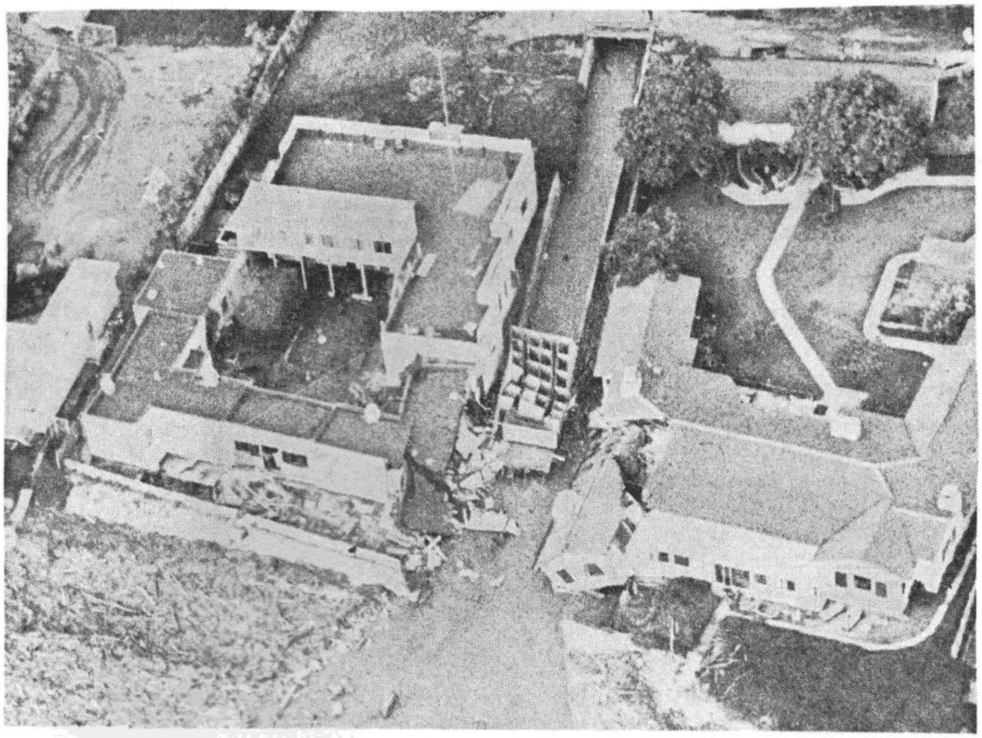
The volunteers said community response was gratifying. By 1 p.m. yesterday they asked radio stations to cancel requests for food and clothing; they had too much.

A foot or more of water raced across the Carpinteria High School campus and into the buildings, enough to float a boat being pushed around by youngsters. Custodians said they were afraid damage was aggravated by the frolicking youngsters. They explained: The waters would flow against the bottom of a door and drop their load of silt, meaning that relatively clean water was flowing under the doors and into the classrooms. Then, said the authorities. "the kids open the doors and the mud flows in." Outnumbered, they

See Page A-4, Col. 7

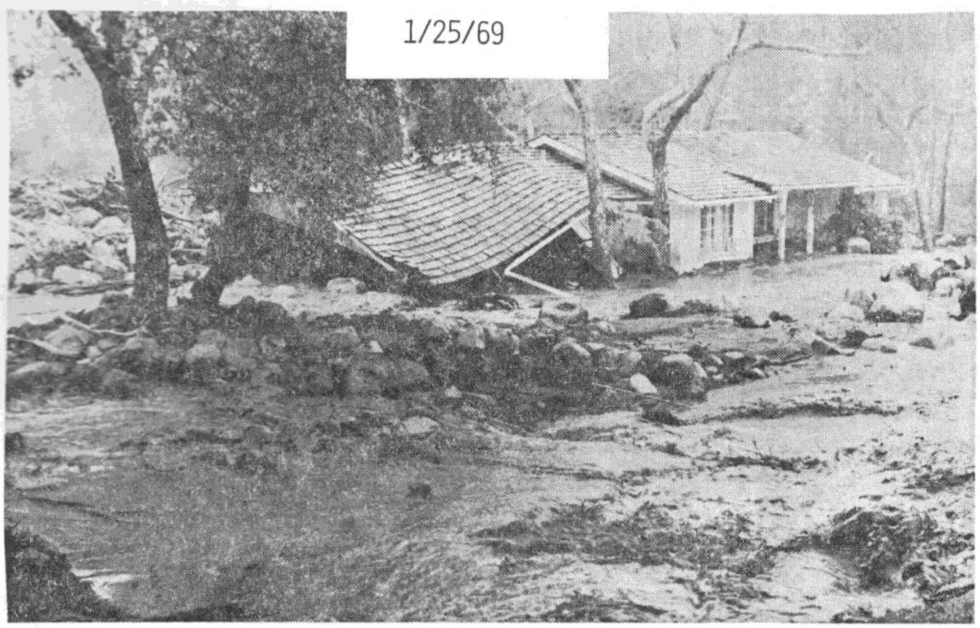
A BIG TREE, apparently undermined by a week of almost constant rain, toppled over across the street at 318 E. Anapamu St.
—News-Press photo by Wally Stein

MRS. HOYT LINDSLEY, 74 Olive Mill Rd., stands in front of her home, finding a broom a rather ineffective tool against the debris and torrent of water that gushed down the street in front of her home, which is near the intersection of Danielson Road in Montecito.
—News-Press photo



RAIN-FAT Oak Creek ate away at the foundation of these two Montecito buildings, owned by the Sisters of the Immaculate Heart, causing parts of them to crumble like milk-soaked cookies. A structure connecting the two buildings over the creek fell into the channel, seen at center. Posilipo Lane begins at top of picture.

MONTECITO AREA
FLOODING
1/25/69



MUD AND WATER up to two feet deep on lovely carpeting, the supports knocked out from under the carport, filled now with boulders rolled down by the flooding San Ysidro Creek, this was the scene at 1790 Glen Oaks Dr. in Montecito, summer home of Kenneth Simpson of Pasadena.

APPENDIX C – 1995 DEBRIS FLOOD EVENT

First-hand look at destruction shocks city, county officials

By KEITH E. DALTON
and RHONDA PARKS
NEWS-PRESS STAFF WRITERS

Damage estimates for Santa Barbara County soared over $100 million Friday as officials got a closer look at the destruction caused by one of the worst storms this century.

The preliminary estimate for repair and cleanup costs in unincorporated areas is $90 million, most of it in Montecito and along the creeks between Carpinteria and the Santa Barbara city limits, county officials said.

The city of Santa Barbara's projection remained at $14.5 million, while Carpinteria estimated damage at $1 million.

As a result of the natural disaster, Santa Barbara officials on Friday asked for $8 million from the bankrupt Orange County fund holding $37.5 million in city money. The city may have to pay interest on the withdrawal.

The money would be deducted from the city's final settlement to be determined in the ongoing federal bankruptcy proceedings, said City Administrator Sandra Lizarraga.

County officials, meanwhile, said they are certain that their damage assessments will go higher. Their $90 million estimate is based on a preliminary visual survey of the damage by engineers and other specialists.

"Overwhelming," said 1st District county Supervisor Naomi Schwartz, clearly shaken after inspecting an oceanfront home off Posilipo Lane on Fernald Point. There, roiling flood waters and debris from San Ysidro Creek felled several large trees, washed away the creekbank right up to the living-room doors and dumped huge sandstone boulders in its place.

Schwartz and Santa Barbara Acting Mayor Harriet Miller led a large group of local officials on a vehicle tour of Montecito's worst-hit areas Friday.

SEE **STORM** ON **A14**

Damage toll

Here is a list of the property damage caused by this week's storm:

	Homes	Businesses
Santa Barbara	300	60
Montecito	200	6
Carpinteria	30	1
Goleta	10	1
Lompoc	2	0
Santa Maria	1	0

Here are the estimated costs of repair and cleanup:

	Private property	Public property
	Numbers are in millions	
County of Santa Barbara unincorporated areas including Montecito and Goleta	$10	$90
Santa Barbara city	$7.5	$7

MICHELLE SHAPIRO/NEWS-PRESS

Santa Barbara News Press, January 14, 1995.

Clean up of debris at the mouth of San Ysidro Creek after debris laden floods in March 1995. Photographs from the Montecito Association History Committee.

View to southwest at the mouth of San Ysidro Creek and some of the debris cleared from the channel. Photographs from the Montecito Association History Committee.

Boulder and vegetative debris.

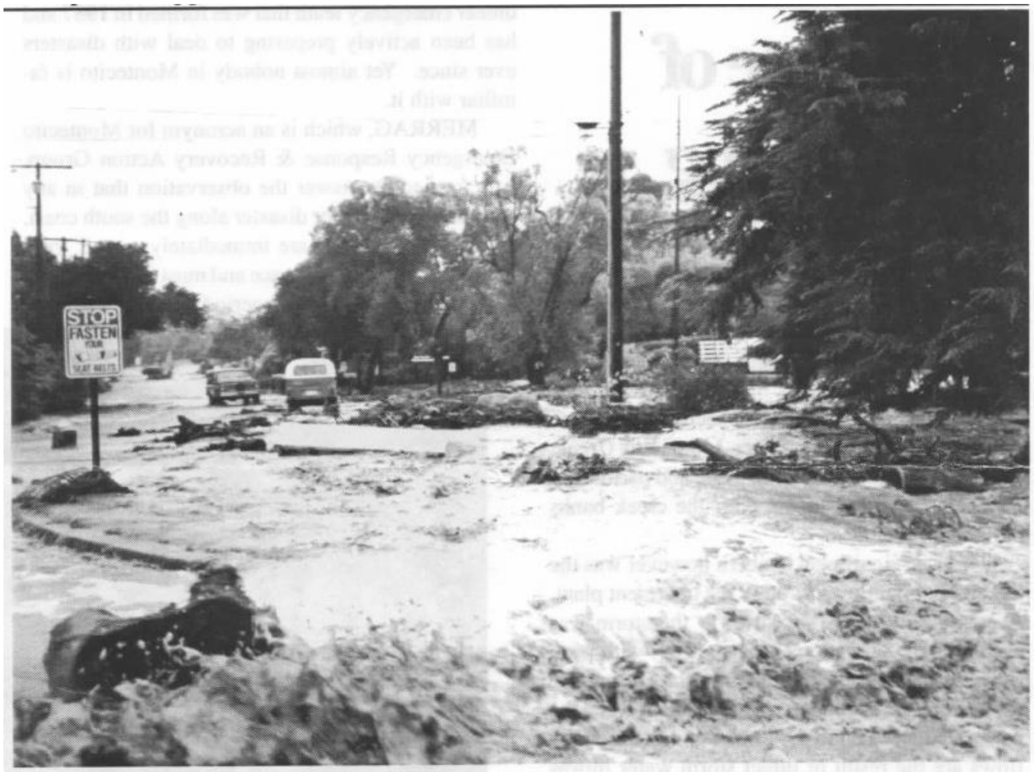
Upper photograph: A jackhammer whittles down a massive automobile size boulder on Mountain Drive. Lower photograph: Accumulated woody and rock debris on Mountain Drive in Montecito. Photographs from the Montecito Association History Committee.

STEVE MALONE/NEWS-PRESS

An excavator digs out boulders and other debris from Westmont Creek.

Santa Barbara News Press photograph (March 13, 1995) shows an excavator removing debris from Westmont Creek after the second debris flood event.

Santa Barbara News Press photograph of First District Supervisor Naomi Schwartz surveys damage to homes along Montecito Creek. Santa Barbara News Press March 13, 1995.



Oak Creek flowing across the Montecito Water District front yard onto San Ysidro Road as the result of a clogged culvert.

Accumulated Debris at Cold Springs School

Upper and lower photographs from The Montecito Villager, Special Flood Section January 1995.

"Financially, we're in a disaster."
TOM FAYRAM, COUNTY FLOOD CONTROL

STEVE MALONE/NEWS-PRESS

Mountain Drive above Montecito is one of the roadways still needing major storm-related repairs. Last winter's storms caused an estimated $10 million in damage to county roads. Officials say less than half the repair work has been completed and there is no funding available to finish the job.

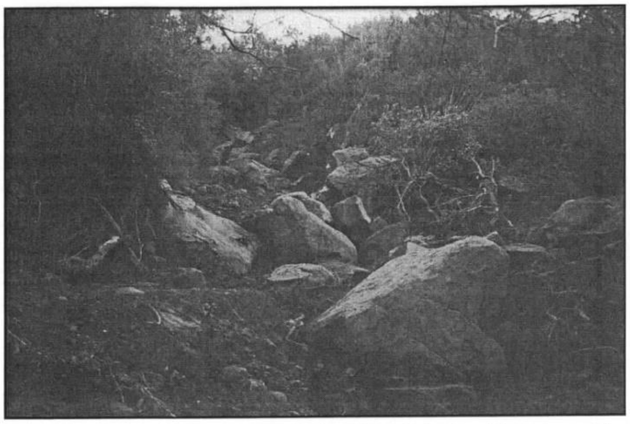
LACK OF MONEY BLOCKS ROAD TO RECOVERY

STEVE MALONE/NEWS-PRESS

Hard-hit roads like Mountain Drive near Coyote Road have been repaired just enough to make them passable.

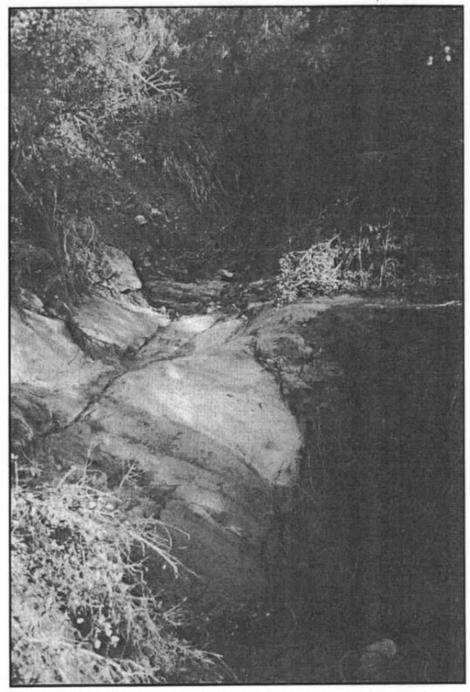
Upper and lower photographs: Santa Barbara News Press photographs, March 13, 1995.

Santa Barbara News Press photograph, January 12, 1995



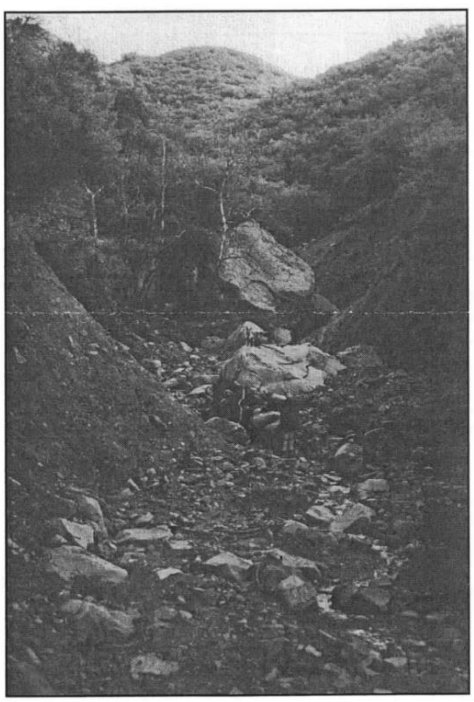
This large wash out about 150 yards from San Ysidro Road leaves us with many rocks to move and a trail that needs to be redefined.

Old Pueblo Trail



This was a dirt trail switch back just past the Bakewell Memorial. It is now impassible for horses and the rock will have to be chipped away at and a new trail made.

San Ysidro Trail

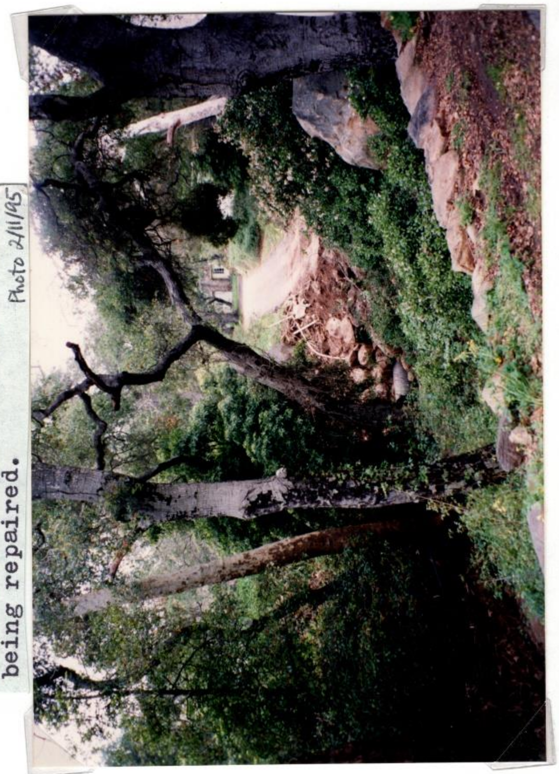


This was the Edison Road just above the cut off to Buena Vista and below the San Ysidro Trail head. As you can see it is now a revine about 30 feet deep.

Reported and Photographed
by Michael Bill
Vice President of the
Montecito Trails Foundation

Photographs taken by Michael Bill of the damage following the 1995 debris flood events. Photographs from the Montecito Association History Committee.

Flood damage from storm 1/10/95
Access road to 849 and 855 Ashley
Road over culvert destroyed, now
being repaired.
Photo 2/11/95



Photographs from the Montecito Association History Committee.

APPENDIX D – 2018 DEBRIS FLOW EVENT

Rescue personnel watch over the cleanup process in the 300 block of Hot Springs Road on Friday.

ERICK MADRID / NEWS-PRESS

Santa Barbara News Press, January 13, 2018.

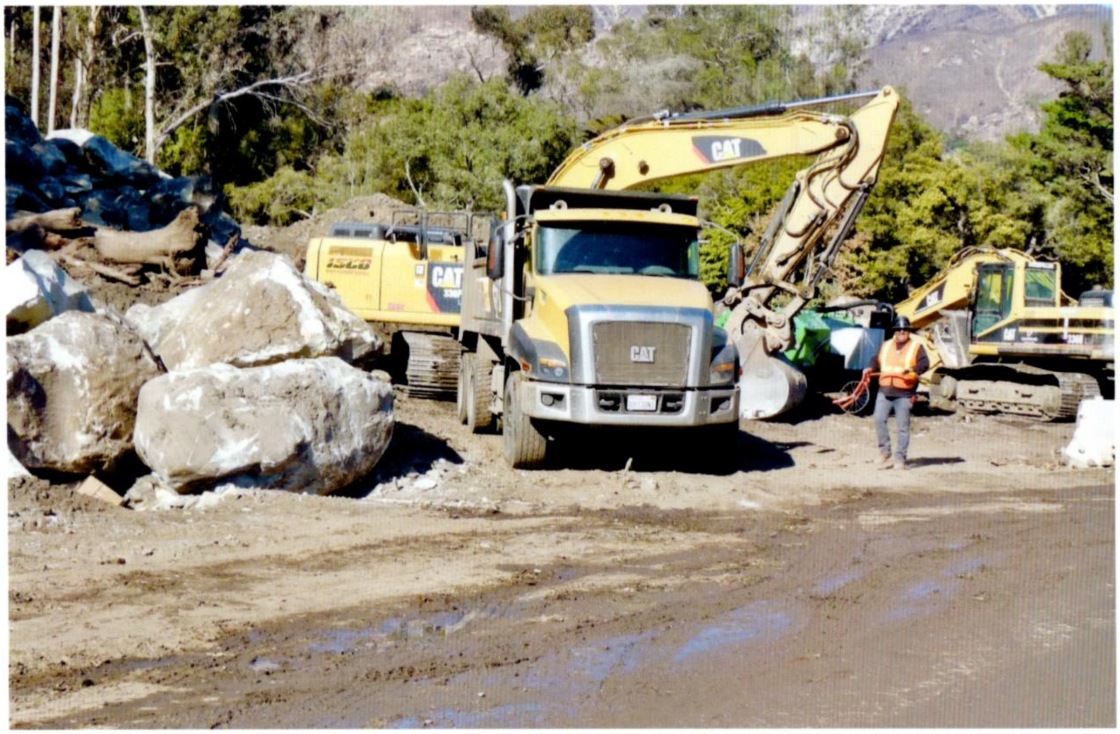
Rescue workers search in and around vehicles for missing persons after devastating mudslides in Montecito.

REUTERS

Santa Barbara News Press, January 13, 2018.

The foundation of a home remains after the devastating impacts of large boulders completely destroyed the home located next to Montecito Creek.

Boulders and log debris cause severe destruction along the flow paths and this automobile exhibits the results of these impacts.



Clean up of massive boulders in Montecito following the 1-9 event. Photograph from the Montecito Association History Committee.

Mud and debris cover Highway 101 below Olive Mill Road. Photograph from the Montecito Association History Committee.

Upper photograph: Boulder and entrained debris cover the area of the lower fan in Montecito. Lower photograph: Mud and debris cover Channel Drive at Butterfly Beach. Photographs from the Montecito Association History Committee.

Upper photograph: A loader works to clear debris from Highway 101. Lower photograph: Mud and debris fill the topographically low area of Highway 101 which acts as a debris basin below Olive Mill Road. Photographs from the Montecito Association History Committee.

Crews work to clear the debris blockage under the Highway 192 bridge crossing on San Ysidro Creek, however a massive boulder is lodged in the constriction. The photograph is to the southeast on the upstream side of the bridge which obliterated the railings.

Boulders and log debris downstream of the Highway 192 bridge in the Glen Oaks area of Montecito.

A residence destroyed along San Ysidro Creek on the lower part of the alluvial fan.

A snag of boulder and log debris along the flow paths in the lower part of the fan.