Burned Area Emergency Response
Holy Fire
Cleveland National Forest
Hydrology and Watershed Specialist Report
August 25, 2018

Overview of Horsethief Canyon above Interstate 15

Submitted by:

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I. Objectives

This report summarizes the results from the hydrologic assessment of the Holy Fire in the center of the Santa Ana Mountains as part of the Burned Area Emergency Response (BAER).

II Potential Values at Risk

Values at Risk (VARs) on Forest Service land (FS) are addressed in Appendix D. Many VARs that could be impacted by the fire are on adjacent private, state, county, or local government lands. The State Watershed Emergency Response Team conducted a detailed analysis of non-FS VARs that will be published in a separate document. The FS BAER team and State WERT team collaborate and share information during post-fire assessments to ensure VARs are identified. On private lands, the primary contact for treatments is the USDA Natural Resources Conservation Service (NRCS).

III. Resource Condition Assessment

Fire and Site Description

The Holy Fire started on August 06, 2018 at 1:30pm (suspected arson). As of August 21, 2018 the fire had burned 22,982 acres (90% contained). The burn occurred adjacent to California State Highway 74 and Interstate 15. Much of the Holy Fire last burned between 1940-80's.

Table 1: Fire History in Holy Fire Perimeter

Holy Fire area impacted	Fires of Note
Coldwater Canyon	Silverado (1987), Unnamed (1942)
Mayhew Canyon	Indian (1966), Wright Cyn (1942)
Indian Canyon	Indian (1966, 1980), Unnamed (1915)
Cow Canyon	Cow (1968), Unnamed (1915)
Horsethief Canyon	Horsethief II (1988), Horse (1985), Indian (1980)
Rice & Bishop Canyons	Cornwell (1956), Unnamed (1938, 1913), Jameson (1954)
McVicker Canyon	Jameson (1954), Rose (1917)
Dickey &Long Canyons	Jameson (1954)
Bell Canyon	Indian (1980), Jameson (1954), Unnamed (1923)
Trabuco & Holy Jim Canyons	Holy (2016, 2002), Indian (1980), Unnamed (1923, 1922)

The Santa Ana Range rises to approximately 5,688 feet at Santiago Peak and 4,607 feet above sea level at Trabuco Peak. Elevation within the burned area perimeter ranges from 1227 ft. to 5688 feet. above sea level. The fire affected property across land ownership (Table 2) and 7

HUC 12 watersheds. See watershed maps in Appendix A. Soil burn severity varied by watershed, with peaks and upper north facing watershed experiencing the highest percentage of high soil burn severity. The final soil burn severity was 14% High, 71% Moderate, 8% Low, and 7% Unburned (Appendix A).

Table 2: Acres Burned by land ownership

Land owner	Acres burned
U.S. Forest Service	18,277
Riverside County	970
Lake Elsinore City	2
Undetermined/Private	3,732
Total	22,982

Table 3: Acres burned by Soil Burn Severity

Soil Burn Severity	Acres
High	3290
Moderate	16258
Low	1780
Unburned	1654
Total	22,982

The Holy Fire took place in a region that receives moist winters and dry summers (Figure 1). Precipitation throughout the burn area ranges from about 13 to 23 inches per year, with 78% of the precipitation occurring from October through April often in several storms events. In lower elevations (<4,500 feet), precipitation is rain dominated by frontal storms which account for nearly all moisture, with infrequent monsoon thunderstorms occurring in late summer. The higher elevations (>4,500 feet) have a mix of rain and snow during the winter. The rain-on-snow zone, from about 4,500-6,500 feet in elevation, can produce very high peak flows during long-duration rain storms falling on a shallow snowpack. Historically, major flooding has occurred during the “Pineapple Express", a weather system which taps into subtropical moisture. Pineapple Express storms land in Southern California between November and March. Warm, long duration storm events can cause major deluges and torrential rains leading to catastrophic flooding. Stream channels in the burn area have the potential to flash flood. Flooding is a natural process. However, areas along Arroyo Trabuco or near drainage from Coldwater, Mayhew, Indian, Horsethief, Rice, McVicker, leach, or Dicky canyons and their tributaries are at notably increased risk for larger, flashier flooding due to the fire. See pour point watershed map, Appendix A.

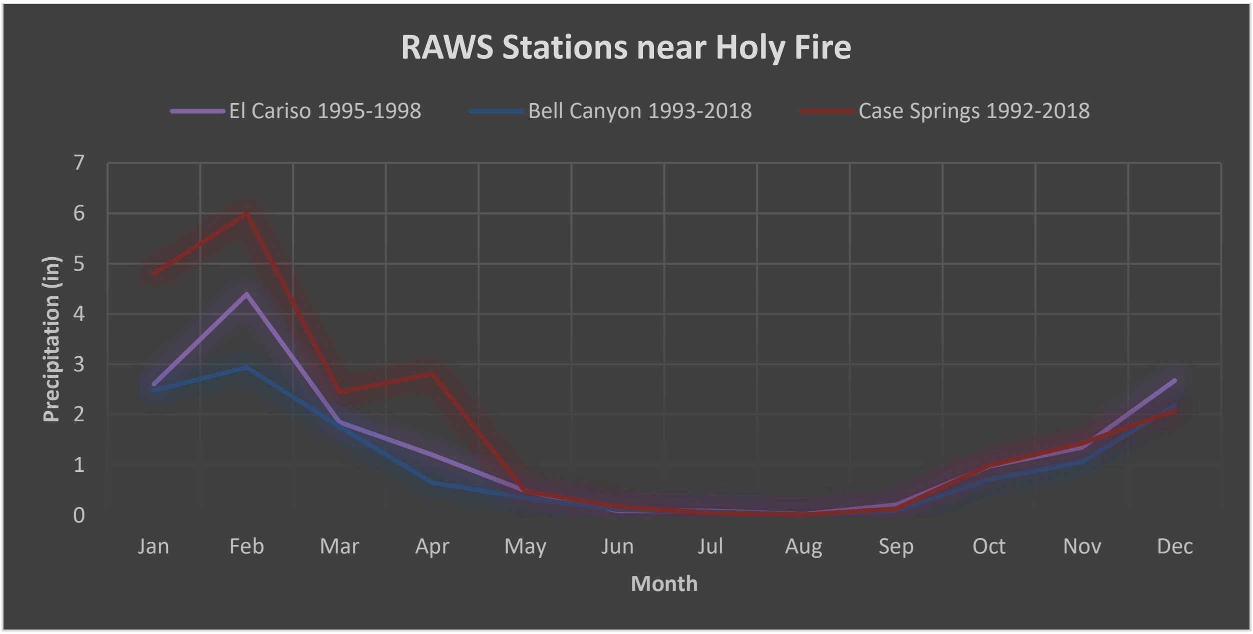

Figure 1: Average monthly Precipitation at locations within and around the burned area perimeter. Source: Western Regional Climate Center

Vegetation within the burned area was chaparral dominated. The fire burned chaparral, Oaks, and timber at higher elevations, oak and sycamore in the perennial channels

There are approximately 15.4 miles of intermittent and perennial streams within the burned area (Table 4).

Table 4: stream length by type within the Holy Fire

Stream Class	Length (miles)
Intermittent	0.8
Perennial	14.6
Total	15.4

Post-Fire Threat Analysis

This report details a hydrologic analysis conducted at watershed points at selected values at risk (VARs) or points of interest, hereafter referred to as pour point watersheds. VARs could include homes, buildings, power plants, bridges, roads, trails, historical sites, cultural sites, culverts, and campgrounds (Appendix D). Not all pour points are related to a specific VAR nor are all VARs assigned a pour point. **Pour points are intended to represent trends of hydrologic response across the burn area**. It is important to note that there are VARs that do not have an assigned pour point that are still at risk from post-fire threats.

Water Quality

Area affected by the 2018 Holy Fire drains southwest into Arroyo Trabuco and San Juan Creek which outlet at Pacific Ocean near Dana Point. This portion of the Fire is covered by the San Diego Region Basin Plan. The Northeastern portion of the fire drains into Temescal Wash which eventually drains into the Prado Flood Control Basin on the Santa Ana River. McVicker, Leach, and Dickey Canyons drain to Lake Elsinore which is the Terminus of the San Jacinto River basin and has an overflow to Temescal Wash. The eastern side is covered by the Santa Ana Region Basin Plan.

Surface waters impacted by the fire include the channels listed above, Lake Elsinore & Lee Lake. The Pacific Ocean is about 20 miles from the burn area. On the Ridge of Upper Santiago Creek HUC 12 watershed, 66 acres burned (0.2% of the watershed). Though Silverado Creek is listed on the California State 303(d) list of impaired water for Toxicity and Salinity and Santiago Creek is listed for Salinity/TDS/Chlorides and Toxicity, the Holy Fire is not expected to have a measurable impact on water quality in this HUC 12 watershed.

Table 5: Beneficial Uses of Water for Surface Water Bodies within the 2018 Holy Fire (CSWQCB 2016).

Beneficial Uses	Surface Water Bodies			
	Temescal Creek Reaches 1-2	Temescal Creek Reach 2	Temescal Creek Reach 3 Lee Lake	Temescal Creek Reaches 4-5
	Source to Santa Ana River	Source to Santa Ana River	Source to Temescal Creek	Source to Lee Lake
Municipal and Domestic Water Supply	+	+	X	+
Agriculture Supply		X	X	X
Industrial Service Supply		X	X	
Industrial Process Supply			X	
Ground Water Recharge		X		X
Navigation				
Hydropower Generation				
Water Contact Recreation	U[3]	X		X
Non-Contact Water Recreation	X	X		X
Commercial & Sportfishing				
Warm freshwater habitat	X	X		X
Limited warm freshwater habitat				
Cold freshwater habitat				
Preservation of Biological habitats				
Wildlife Habitat	X	X		X
Rare, Threatened, or Endangered Species				X
Spawning, reproduction, & Development				
Estuarine Habitat				

X = Existing or Potential, I=Intermittent Uses, +Excepted From Municipal Use, [3] Access prohibited in some portions per agency w/ Jurisdiction, U REC1 and/or REC2 not attainable uses.

Beneficial Uses	Surface Water Bodies			
	Temescal Creek Reaches 6 Elsinore Groundwater Subbasin	Coldwater Canyon Creek	Other tributaries to these creeks	San Juan Canyon (Bell and Arroyo Trabuco)
	Source to Temescal Wash	Source to Temescal Creek		Source to Pacific Ocean at Dana Point
Municipal and Domestic Water Supply	+	X	I	+
Agriculture Supply		X		X
Industrial Service Supply				
Industrial Process Supply				
Ground Water Recharge	I	X	I	
Navigation				
Hydropower Generation				
Water Contact Recreation	I	X	I	O
Non-Contact Water Recreation	I	X	I	X
Commercial & Sportfishing				
Warm freshwater habitat	I	X	I	X
Limited warm freshwater habitat				
Cold freshwater habitat				
Preservation of Biological habitats				
Wildlife Habitat	I	X	I	X
Rare, Threatened, or Endangered Species				
Spawning, reproduction, & Development				
Estuarine Habitat				

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Wildfires affect water quality through increased sedimentation. As a result, the primary water quality constituents or characteristics affected by this fire include color, sediment, settleable material, suspended material, and turbidity. Floods and debris flows can entrain large material, which can physically damage infrastructure associated with the beneficial utilization of water (e.g., water conveyance structures; hydropower structures; transportation networks). The loss of riparian shading and the sedimentation of channels by floods and debris flows may increase stream temperature. Fire-induced increases in mass wasting along with extensive tree mortality can result in increases in floating material – primarily in the form of large woody debris. Post-fire delivery of organic debris to stream channels can potentially decrease dissolved oxygen concentrations in streams. Fire-derived ash inputs can increase pH, alkalinity, conductivity, and nutrient flux (e.g. ammonium, nitrate, phosphate, and potassium). Although these changes are generally short lived, nutrients are already impairing beneficial use in Trabuco and Lake Elsinore and low dissolved oxygen is a problem in Lake Elsinore. The Holy Fire will negatively contribute to the impairments. Post-fire increases in runoff and sedimentation within the urban interface, and burned structures and equipment within the fire perimeter may also lead to increases in chemical constituents, oil/grease, and pesticides.

Temescal Creek and Lee Lake were assessed as supporting beneficial uses on the 2014-2016 Integrated Report. Channels impaired from supporting beneficial uses are in Table 6.

Table 6: 303(d) List of Impaired Waters from California 2014-2016 Integrated Report (CSWQCB 2018)

Arroyo Trabuco	Bell Canyon Creek	Lake Elsinore
Nutrients	Toxicity	Toxicity
Nitrogen		Nutrients
Malathion (Pesticides)		PCB
Benthic Community Effects		Organic Enrichment/Low Dissolved Oxygen
Fecal indicator Bacteria		DDT (Dichlorodiphenyltrichloroethane)
Toxicity		

Fire Soil Burn Severity assessment

A Burned Area Reflectance Classification (BARC) image was acquired from the Forest Service Remote Sensing Applications Center. Based on comparisons with archived images, this image classifies the extent of the burned area into four categories: unburned, low severity burn, moderate severity burn, and high severity burn. BAER team member's ground truthed this image through field observations. The BARC image was found to have a relatively high degree of accuracy, but did require modifications to increase both spatial and severity accuracy.

Verification of soil burn severity included recording soil color, degree of organic material consumption, soil structure, fine root consumption and hydrophobicity. Hydrophobicity tests were conducted to determine the water repellency characteristics of affected soils. Soils in which a water drop infiltrated in less than 10 seconds were classified as low, between 10 and 40 seconds was classified as moderate, and greater than 40 seconds was classified as high. These tests were used to further evaluate the effect of the fire on post-fire hydrological response.

Anticipated Watershed Response

Based on historic precipitation patterns, summer thunderstorms may occur as well as longer duration storms in the winter. Flash flooding, mudflows, and debris flows are natural watershed response for this area. The risk of flash flooding and erosional events will increase as a result of the fire, creating hazardous conditions within and downstream of the burned area. The primary watershed responses of the Holy Fire are expected to include: 1) an initial flush of ash, 2) rill and gully erosion in drainages and on steep slopes within the burned area, 3) floods with increased peak flows and sediment deposition, and 4) possible mud and debris flows during precipitation events (see geology report).

Initial erosion of ash and surface soil during the first storm events will reduce slope roughness by filling depressions above rocks, logs, and remaining vegetation. The ability of the burned slopes to detain water and sediment will be reduced accordingly, contributing to increased flood potential and transport distance of eroded materials. These responses are expected to be greatest in initial storm events, and will become less evident as vegetation is reestablished, providing ground cover, increasing surface roughness, and stabilizing and improving the infiltration capacity of the soils. Several factors favor a quick recovery in terms of normal hydrologic response of some hillslopes. The existence of fine roots in the low and moderate severity burn areas just below the surface will likely aid plant recovery, and suggests there still might be a seed source for natural vegetation recovery. The major concern for vegetative recovery and in turn hydrologic recovery is in the high severity burn areas where soil structure and soil productivity have been severely impacted. The estimated vegetative recovery for watersheds affected by the Holy Fire is expected within 5 to 10 years as observed in other watersheds in the Santa Ana Mountains. Forested areas, which lost most trees to high severity fire will take longer to recover as the tree canopy will no longer provide shade to cool the soil surface and may will take more years for seeds to germinate and grow to maturity.

Modeling Post Fire Runoff

Post-fire conditions have been assessed to determine how fire-induced changes to slope hydrology and soil conditions will impact the values at risk. Key to this assessment is the burn severity mapping. Appendix B shows the number of acres affected by the different burn severities within the analysis watersheds. Figures 2, 3, and 4 show the HUC 12, Pour point, and Soil Burn Severity maps for the fire (Appendix A).

There are different methods to modeling post-fire hydrologic responses. This report uses information from Waananen & Crippen, 1977. Another model used for Southern California is Rowe, Countryman, & Storey, 1949, which the State WERT team utilized. There will be some differences in the modeled results; however, despite variations in magnitude of change from pre-post fire discharge in each model, the <u>areas determined to be at risk are consistent</u>. The models are intended to be a rapid assessment to determine areas that may be at risk and results represent trends across the burn area.

<u>Design Flow Runoff Response</u>

The risk or probability (R) that a certain return interval storm (T) will occur over different time periods (n) was calculated by the following equation (Chow et al. 1988):$R = 1 - (1 - \frac{1}{T})^n$. The design storm of 2 years has a 50% chance of occurring in any given year, and a 97% chance of occurring in the next five years. Conversely, there is a 3% chance that the 2 year storm event ***will***

not occur in the next 5 years **(**during the recovery period). The 2 year, 60 minute duration storms anticipated for these watersheds range from 0.747-1.08 inches (NOAA, 2018). Hydrologic design information is displayed in Table 7. The 2 year storm was selected for modeling; however, it **does not** represent a threshold under which no storm damage will occur. It is very possible that smaller storms may result in post-fire flooding and mudslides.

Before an adjusted design flow can be determined, pre-fire design flow must be calculated. This is the flow expected to occur in pre-fire conditions. This is the flow responsible for forming present day channel conditions and flows used to estimate proper performance of culverts and other drainage structures. However due to the lack of real data on that system, and the rapid nature of this assessment, design flow estimates have been calculated based on the equations within the article "Magnitude and Frequency of Floods in California" (Waananen & Crippen, 1977). This is an empirical model based on gauge data. These estimates assume pre-fire ground infiltration and ground cover conditions.

Adjusted design flow is calculated using the same equations as design flow; however runoff response is estimated by assuming an increased runoff commensurate with soil burn severity in terms of recurrence interval. This recurrence interval estimates the response of the newly burnt landscape to an average annual storm. Areas within the Holy Fire perimeter that experienced moderate to high soil burn severity are expected to respond to an average rainfall event, an event usually associated with the 2-year storm, differently than the unburned and low severity burned areas. It is expected the landscape would respond as if the 2-year storm discharge were associated with a 2-year storm (unburned soil burn severity), 5-year event (low soil burn severity) and 10-year event (moderate and high soil burn severity), respectively. Moderate soil burn severity covers most of the fire area and has little or no soil cover in the form of duff or needle cast. High soil burn severity in this fire is in the timbered drainages and is prone to flash flood and debris flows under pre-fire conditions. Lands within Holy Fire perimeter have not burned in 35-70 years, allowing accumulation of stored sediment stored that can be easily mobilized in the post-fire environment. These factors increase the probability of watershed response from area within the burn. As a result, moderate burn severity is assumed to have the same recurrence interval as high burn severity. The unburned lands within the fire would respond as the unburned lands outside the fire and would have a discharge associated with the 2-year return interval. Surface vegetation has burned within the low soil burn severity, however some duff and roots from the past surface plants remain. Thus, initially the low soil burn severity areas would be expected to have a higher response than the unburned but would not be as intense and potentially recover quicker than the moderate and high soil burn severity areas. Consequently the low soil burn severity area would be expected to have a discharge associated with the 5-year return interval. The range in return interval is based on the Southern Coastal California flood frequency equations from Waananen and Crippen (1977). Increases in discharge associated with predicted recurrence intervals are pro-rated across watersheds by soil burn severity to yield post-fire discharge or the adjusted design flow. The flow yield modeling assumes the design storm event. Larger rain events do have the potential to increase the risk of flooding and sedimentation, though these risks are present with or without the effects of the Holy Fire.

Table 7: Hydrologic Design Factors

A. Estimated Vegetative Recovery Period	5-10 years
B. Design Chance of Success	80 %
C. Equivalent Design Recurrence Interval	2 years
D. Design Storm Duration	60 minute
E. Design Storm Magnitude	0.736-1.06 in
F. Design Flow	13.36 cfs / mi^2
G. Estimated Reduction in Infiltration	60%
H. Adjusted Design Flow	54.27 cfs / mi^2

The fire has been analyzed by watersheds. Watersheds are various sizes and shapes and are dependent on the analysis of the desired outlet or pour point above a value at risk or area of concern. Watersheds are defined as the area above a point in which all surface water will flow. These sites may be within or downstream of the burned area. Size of watershed is dependent on the local flow patterns in addition to the need to evaluate a basin for values at risk. Figure 2 (Appendix A) displays the HUC 12 watersheds and the fire perimeter.

Smaller watersheds typically show a higher potential for increased sediment delivery and flooding based on the size and steepness of the watershed and extent and location of burn severity. In the Holy Fire, however the large watersheds on the east side and Trabuco Canyon on the west have the steepest grade near the ridges and resulted in the highest increase in risk due to the Fire. Figure 3 (Appendix A) displays pourpoint watersheds analyzed within and downstream of the fire area. The areas that have the highest potential for flooding and increased sediment include:

- Coldwater Canyon
- Mayhew Canyon from I15 to headwaters
- Indian Canyon from I15 to headwaters
- Unnamed Canyon above Mountain Road
- Rice, McVicker, Leach, and Dickey Canyon from the fire perimeter @ community developments
- Trabuco Canyon from channel above the Fire Station (near confluence with Holy Jim Canyon).

High potential for flooding and sediment is due to the fact that high percentages of these watersheds have burned and these watersheds have a high percentage of moderate and high burn severity. The Risk Category as modelled indicates a potential for increased risk of flooding due to the fire. A high intensity precipitation event will produce high runoff, even in areas without the fire. Therefore, areas in the low “increased risk” category may have a high risk of flooding during high intensity precipitation events even though it is not an increased level of risk due to the Holy Fire.

Appendix C shows predicted pre-fire and post-fire estimates of peak flood flows for the design storm. The increase in peak flows is most applicable during the first year of recovery, as hydrologic response will decrease in subsequent years. Predicted post-fire peak flows show an increase of about 2 to 7.4 times pre-fire values. The peak flow values highlight the post-fire effects on the Holy Fire, with the most increase reflected in subwatersheds where burn severity is moderate and high and where the greatest susceptible soils are affected. The early precipitation events fill in available slope detention storage and create the rill and gully networks that are necessary to fully induce the expected increase in flood response from rainstorms. Available rock and sediment on now barren slopes are plentiful. Bulking from side slopes is anticipated to increase risk of large precipitation events. Latent sediment in channels of this fire was also present.

The results of a peak flow analysis show that pre-fire flows, weighted according to watershed area, were on average 13.36 cfs / mi^2 for a 2 year, 60 minute storm, while post-fire weighted flows were on average 54.27 cfs / mi^2 for the same storm. Post-fire flows could lead to plugged culverts, flow over road surfaces, rill and gully erosion of cut and fill slopes, erosion and deposition along road surfaces and relief ditches, loss of long-term soil productivity, and threats to human safety. Some sedimentation of the ephemeral channels is likely to occur at an accelerated rate until vegetation establishes itself and provides ground cover.

Figures 5, 6, 7, 8 and 10 in Appendix C provide a visual display of pre and post-fire discharges and sediment delivery for all evaluated pourpoint watersheds to illustrate the watersheds that are expected to have a significant increased risk of and higher water yields resulting from the Holy Fire.

Sediment is potentially increased after a fire due mostly to consumed vegetation. After the first year post fire sediment also goes down dramatically but may be continue to be elevated for several years depending on available precipitation and flushing flows. High and moderate soil burn severity are analyzed as one unit as they are both expected to have a high watershed response and would consequently act similarly as far as post fire increases in flow and sediment.

Implications of Post-Fire Runoff on VARs.

The objective of this analysis is to predict post-fire runoff with the goal of mitigating risk to life, property, and natural and cultural resources. After identifying potential VARs, the magnitude of this risk was systematically evaluated. The risk matrix shown in Table 8 was utilized to identify values in need of mitigation efforts.

The probability of damage or loss within one to three years is classified into four categories: unlikely occurrence (<10%); possible occurrence (>10% to <50%); likely occurrence (>50% to <90%); and very likely or nearly certain occurrence (>90%). This information is combined with an assessment of the magnitude of the consequences. These are classified as major, with implications for loss of life or injury to humans, substantial property damage, irreversible damage to critical natural or cultural resources; moderate, indicating injury or illness to humans, moderate property damage, damage to critical natural or cultural resources resulting in considerable or long term effects; or minor, with property damage limited in economic value and/or too few investments, damage to natural or cultural resources resulting in minimal, recoverable or localized effects.

Table 8: Risk Assessment Matrix

Probability of Damage or Loss	Magnitude of Consequences		
	Major	Moderate	Minor
	Risk		
Very likely	Very High	Very High	Low
Likely	Very High	High	Low
Possible	High	Intermediate	Low
Unlikely	Intermediate	Low	Very Low

Localized treatments for individual VARs vary. Specific recommended treatments to mitigate altered flows could include wattles, stream channel cleanout, stream channel armoring, rolling dips, overflow structures, low-water stream crossings, culvert modification, catchment-basin cleanout, storm inspections and response, trail stabilization, road closures, mitigation for threatened and endangered aquatic species, warning signage, jersey barriers, sandbags, securing sources of hazardous materials, and flood warning systems. See Appendix D for identified VARs and their recommended treatment.

Forest Service roads and trails in or below the burn are at some increased risk. The Forest Road 6S13 into Trabuco canyon is located in the drainage bottom near Arroyo Trabuco and a sole access route to the Holy Jim and Trabuco Recreational Residence tracts and hiking trail heads up each canyon. The valley is narrow in some spots and the proximity of the road to the channel (crossing the channel multiple times) puts the road at risk for flooding and debris flow events. There are three low-water crossings in Trabuco Canyon on FS lands that WILL become impassable during and after storm events. The threat of post-fire flooding and sediment delivery at the crossings pose a VERY HIGH risk to human life and safety during storm events. It is very possible that the road will washout in several locations. Following the 2016 Holy Fire, 7 cars were trapped in the mudflows that crossed Trabuco Road. The 2016 fire burned a small 146 acre side drainage that drained across the road to the mainstem of Trabuco Creek. The 2018 Holy Fire burned 4,373 acres above the 6S13 road crossings, primarily with moderate to high soil burn severity. See Table 13 in Appendix D for a completed list of values of risk.

On the east side of the fire, communication and coordination with the State of California Watershed Emergency Response Team (WERT), the Natural Resources Conservation Service (NRCS), State/County/Local governments/departments/agencies, and Emergency Services to coordinate evaluation and notification of Values at Risk off forest land.

IV. Emergency Determination

As a result of the Holy Fire, significant increases in runoff are expected in some pourpoint watersheds. These increases are the result of the large percentages of high or moderate soil burn severity within these watersheds. The pourpoint watersheds show increases in water yield from multipliers of 2.12 (Bell Canyon Creek) to 7.37 (Trabuco Canyon above the fire station) times greater than pre-fire conditions. These estimated increases are for the 2-year storm or a discharge that has a 50% chance of occurring over the course of a year. The 2 year storm was selected for modeling; however, it **does not** represent a threshold under which no storm damage will occur. It is very possible that smaller storms may result in post-fire flooding and mudslides. Depending on location of the values at risk from the Holy Fire; these values may be affected as a result of the burn under design storm conditions and constitute an emergency during the next damaging storm event.

V. Treatments to Mitigate the Emergency

Landscape treatment proposed to address threats to water quality was closure of the fire area which will allow natural recovery to occur. No other cost effective treatment was determined to be effective in mitigating risks to water quality. Though treatments beyond closure of the fire area for water quality and hydrologic function were not directly proposed, other treatments such as OHV prevention, trail and road stabilization, and hazardous material stabilization are expected to assist in watershed recovery and reduce further degradation, reducing risk to watershed resources as recovery occurs.

Forest Area Closure, signs and gates, and coordination with special use permittees will mitigate threats to life and safety from flooding hazards. Interagency communication to inform the Santa Ana and San Diego Waterboards, Caltrans, Riverside and Orange County Emergency Management Departments, and others of the potential risks to water quality and watershed function will help other agencies address non-Forest System lands as did coordination with the State WERT. Details on FS values at risk and treatments may be found in the 2500-8 BAER Report.

References

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List of Appendices

Appendix A: Pour Point Watershed Maps for Holy Fire, Soil Burn Severity Map.

Appendix B: HUC 12 Watersheds Affected by the Holy Fire. Percent of watersheds burned are reported in parentheses

Appendix C: Pre-Fire and Post- Fire flow using 2 year return interval from Waananen and Crippen Flood Frequency equations

Appendix D: Values at Risk Table

APPENDIX A: MAPS

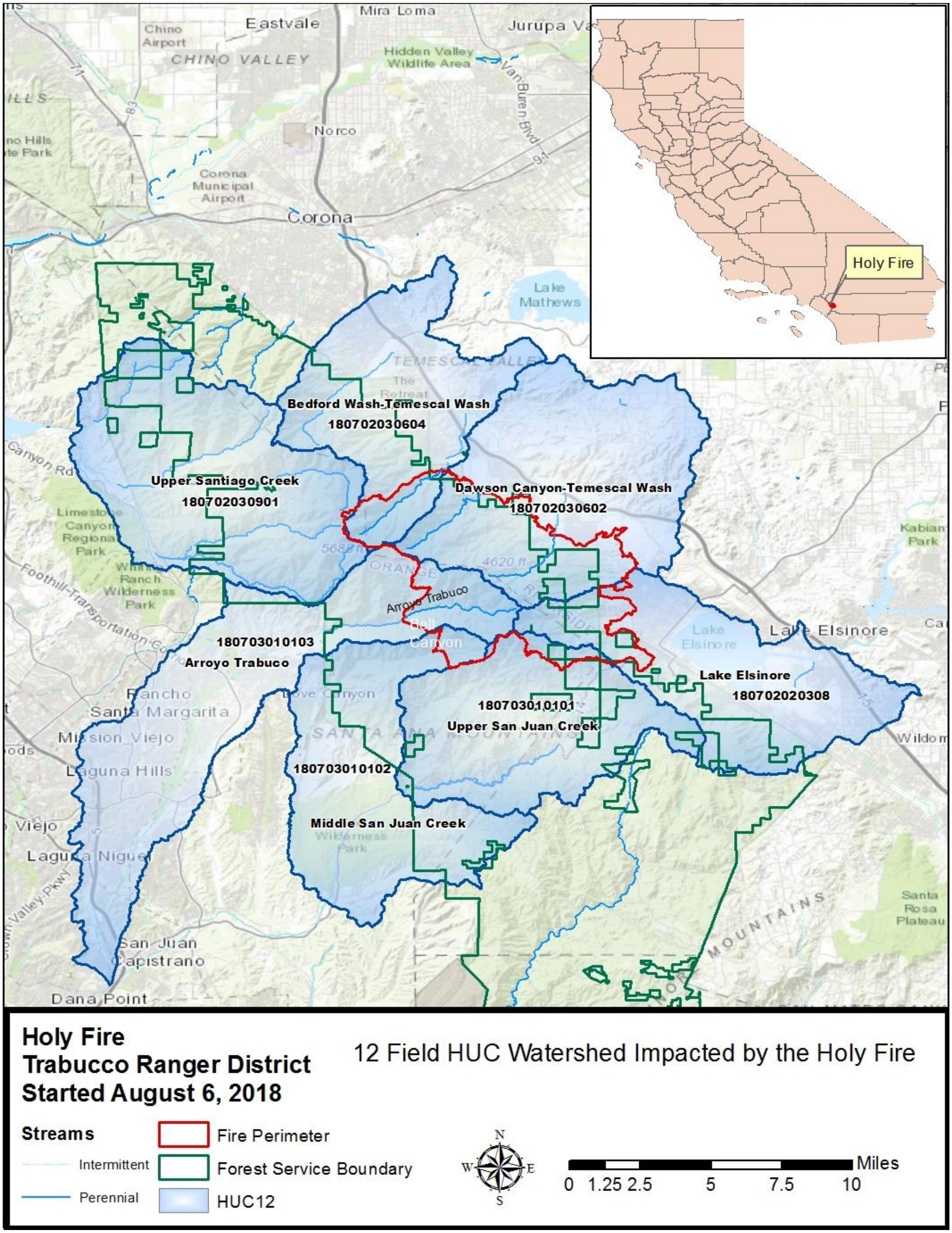

Figure 2: HUC 12 Watersheds Impacted by the Fire

01 Trabuco Canyon - above Oniel Park	11 Mayhew at the Mine	21 Horsethief Canyon at fire perimeter
02 Trabuco Canyon - at the FS Boundry	12 Mayhew above the Mine	22 Unnamed Canyon above Mountain Road
03 Trabuco Canyon - above Fire Station	13 Unnamed Canyon east of mine at Mayhew	23 Unnamed Cyn east of Coyote Mesa Drive
04 Holy Jim Canyon - at Trabuco	14 Unnamed Canyon at Campbell Ranch Road	24 Bishop Canyon
05 Holy Jim Canyon - Above Trail Head	15 Unnamed Canyon at Indian Truck Trail	25 Rice Canyon
06 Bell Canyon	16 Indian Canyon at Interstate 15	26 McVicker Canyon
07 Coldwater Canyon	17 Indian Canyon at Community Development	27 Leach Canyon
08 Unnamed Cyn - west abv mine at Coldwater	18 Indian Canyon at Crilly Road	28 Dickey Canyon at Toft Drive
09 Unnamed Cyn - east abv mine at Coldwater	19 Horsethief at Interstate 15	29 Unnamed at Greenwood Drive
10 Mayhew at Interstate 15	20 Unnamed Canyon above Bosley Lane	30 Unnamed at Calle Codomiz
		31 Long Canyon at TRD541301-2

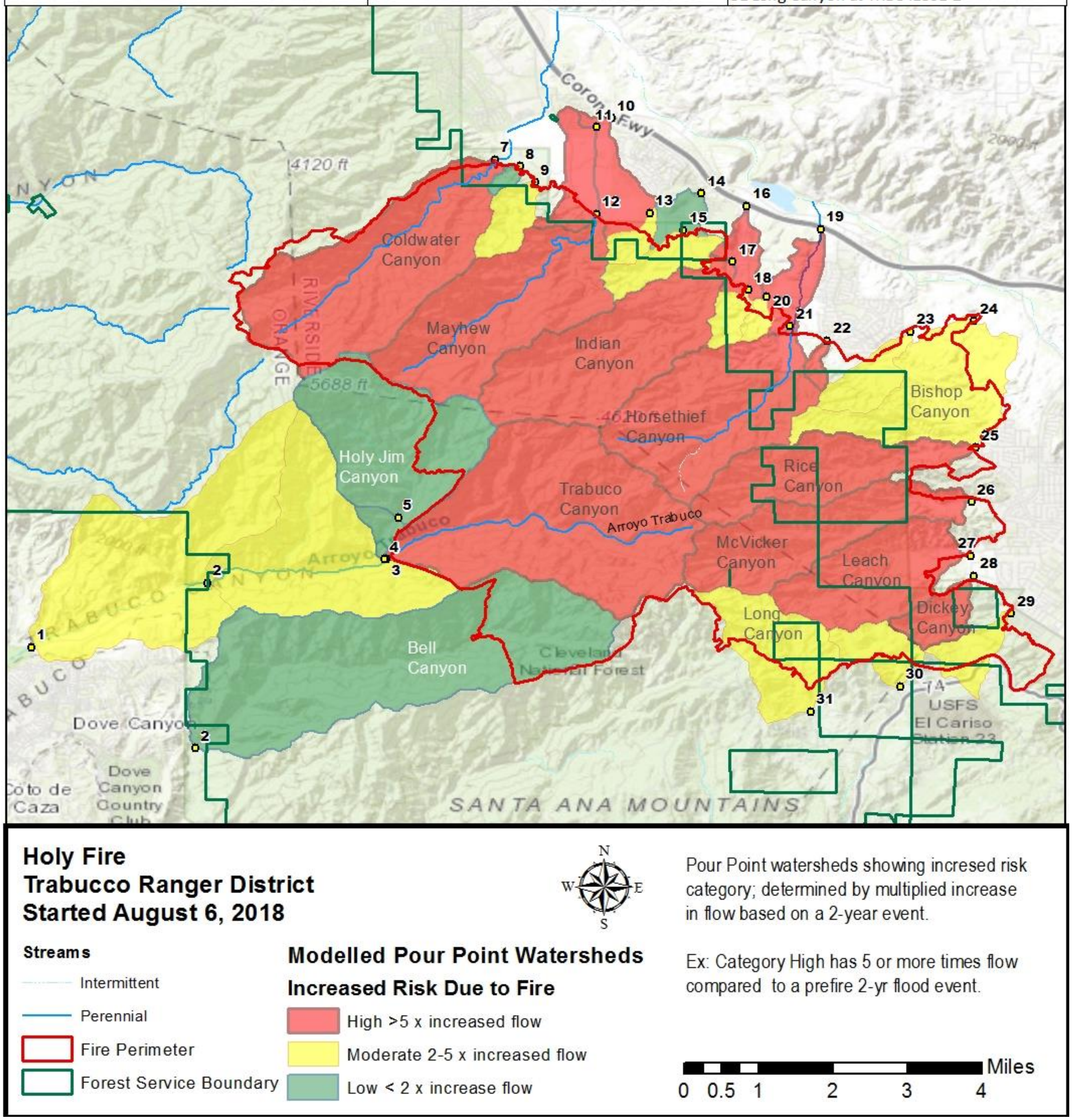

Figure 3: Pour Point Watershed Affected by the 2018 Holy Fire

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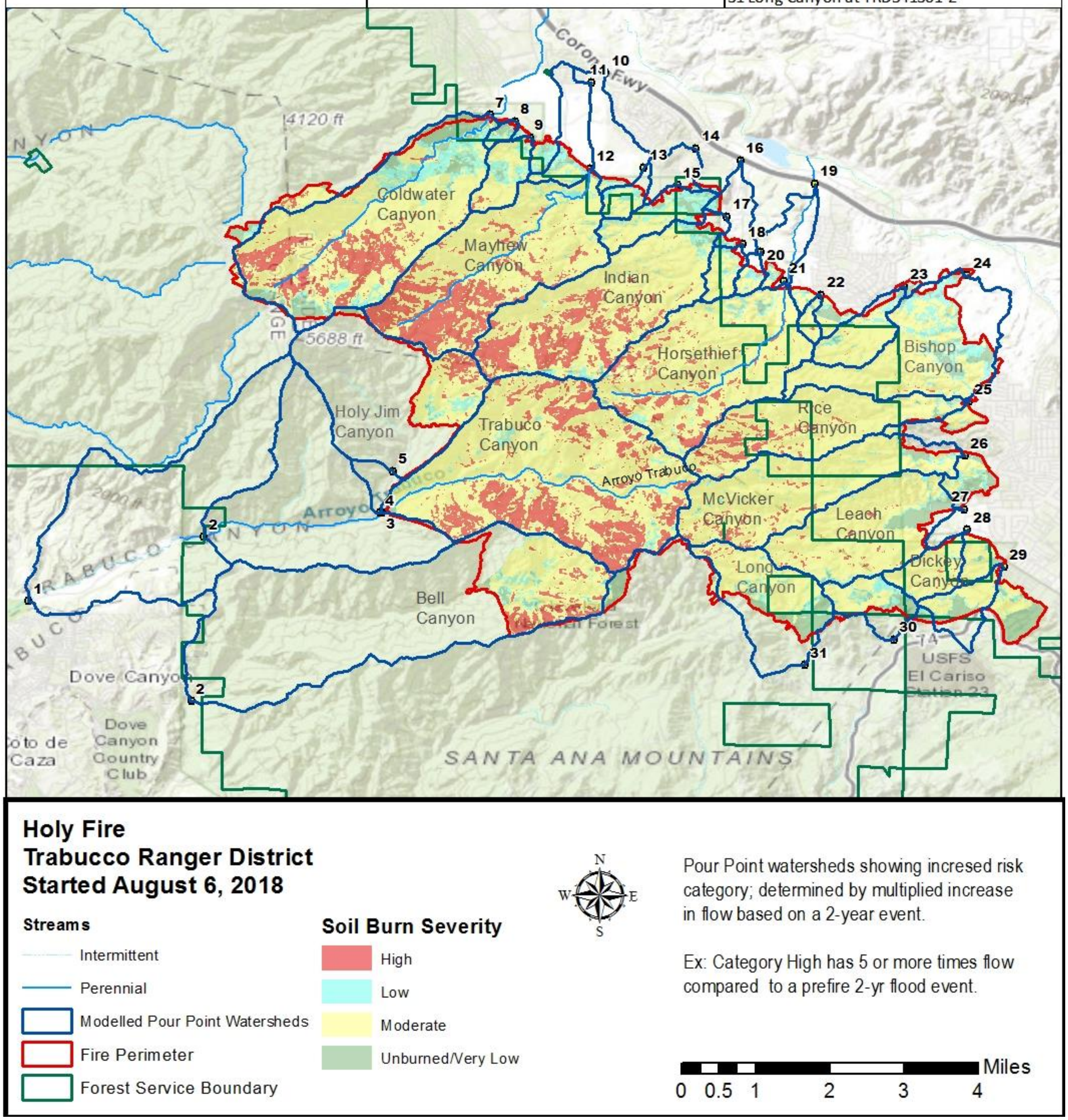

Figure 4: Soil Burn Severities shown within the pour point watersheds and fire perimeter

APPENDIX B: HUC 12 watersheds and pourpoint watersheds affected by the 2018 Holy Fire.

Table 9: Burn Severity of HUC 12 and Pour Point Watersheds affected by the Holy Fire

Watersheds affected by the Holy Fire	Watershed Area (Miles^2)	Burn Severity		Watershed Response	
		Miles^2 High or Moderate	Miles^2 Low or unburned	Times increase flow	Increased Risk Due to Fire Category
01 Trabuco Canyon - above Oniel Park	17	5.9	10.8	3.54	Moderate
02 Trabuco Canyon - at the FS Boundry	12	5.9	6.2	4.43	Moderate
03 Trabuco Canyon - above Fire Station	6	5.3	0.2	7.37	High
04 Holy Jim Canyon - at Trabuco	3	0.6	2.6	2.18	Low
05 Holy Jim Canyon - Above Trail Head	3	0.6	2.4	2.25	Low
06 Bell Canyon	7	1.1	5.4	2.12	Low
07 Coldwater Canyon	4	3.1	1.0	5.92	High
08 Unnamed Cyn - west abv mine at Coldwater	0	0.0	0.1	2.09	Low
09 Unnamed Cyn - east abv mine at Coldwater	0	0.3	0.1	4.65	Moderate
10 Mayhew at Interstate 15	5	3.6	1.3	5.63	High
11 Mayhew at the Mine	4	3.4	0.6	6.31	High
12 Mayhew above the Mine	3	3.3	0.1	6.98	High
13 Unnamed Canyon east of mine at Mayhew	0	0.1	0.1	3.61	Moderate
14 Unnamed Canyon at Campbell Ranch Road	1	0.3	0.6	2.74	Low
15 Unnamed Canyon at Indian Truck Trail	1	0.3	0.3	3.71	Moderate
16 Indian Canyon at Interstate 15	4	3.1	0.7	6.06	High
17 Indian Canyon at Community Development	3	2.9	0.3	6.60	High
18 Indian Canyon at Crilly Road	0	0.2	0.1	4.64	Moderate
19 Horsethief at Interstate 15	4	3.2	0.7	6.11	High
20 Unnamed Canyon above Bosley Lane	0	0.1	0.1	3.12	Moderate

Watersheds affected by the Holy Fire	Watershed Area (Miles^2)	Burn Severity		Watershed Response	
		Miles^2 High or Moderate	Miles^2 Low or unburned	Times increase flow	Increased Risk Due to Fire Category
21 Horsethief Canyon at fire perimeter	3	3.1	0.1	6.89	High
22 Unnamed Canyon above Mountain Road	0	0.1	0.0	5.17	High
23 Unnamed Cyn east of Coyote Mesa Drive	1	0.4	0.1	4.93	Moderate
24 Bishop Canyon	2	1.3	1.0	4.22	Moderate
25 Rice Canyon	2	1.9	0.1	6.43	High
26 McVicker Canyon	2	2.1	0.2	6.17	High
27 Leach Canyon	2	1.7	0.3	5.77	High
28 Dickey Canyon at Toft Drive	0	0.4	0.0	5.83	High
29 Unnamed at Greenwood Drive	0	0.2	0.3	3.22	Moderate
30 Unnamed at Calle Codomiz	1	0.2	0.3	3.19	Moderate
31 Long Canyon at TRD541301-2	1	0.7	0.8	3.68	Moderate

Percent of watersheds burned are reported parentheses. Watershed Response Columns show the multiplied times increase when comparing pre-fire stream flow or sediment delivery with post fire quantities.

Table 10: Change in Discharge and Sediment Yield at Pourpoint Watersheds Affected by the Holy Fire

Watersheds affected by the Holy Fire	Watershed Area (Miles^2)	Discharge (cfs)			Sediment Yield (Cubic Yards)		
		Pre Fire	Post Fire	Times increase flow	Prefire in y^3/mi^2	Postfire cubic yards	Multiplied increase sediment
01 Trabuco Canyon - above Oniel Park	17	9.6	34.16	3.54	1,100	196,581.0	10.66
02 Trabuco Canyon - at the FS Boundry	12	10.6	46.73	4.43	1,100	191,479.7	14.36
03 Trabuco Canyon - above Fire Station	6	13.2	97.00	7.37	1,100	166,094.6	27.44
04 Holy Jim Canyon - at Trabuco	3	15.3	33.45	2.18	1,100	21,466.2	6.12
05 Holy Jim Canyon - Above Trail Head	3	15.5	34.98	2.25	1,100	21,249.7	6.46
06 Bell Canyon	7	11.2	23.70	2.12	640	14,691.4	3.51
07 Coldwater Canyon	4	14.9	88.07	5.92	1,630	172,750.3	25.68
08 Unnamed Cyn - west abv mine at Coldwater	0	19.4	40.64	2.09	1,630	1,202.6	9.26
09 Unnamed Cyn - east abv mine at Coldwater	0	12.0	55.86	4.65	1,630	17,969.1	24.84
10 Mayhew at Interstate 15	5	9.5	53.28	5.63	1,630	196,136.4	24.77
11 Mayhew at the Mine	4	10.0	63.35	6.31	1,630	187,747.2	28.68
12 Mayhew above the Mine	3	10.4	72.97	6.98	1,630	182,076.0	32.64
13 Unnamed Canyon east of mine at Mayhew	0	22.5	81.24	3.61	1,630	6,632.8	18.34
14 Unnamed Canyon at Campbell Ranch Road	1	9.0	24.80	2.74	1,630	16,125.2	11.90
15 Unnamed Canyon at Indian Truck Trail	1	17.2	63.86	3.71	1,630	15,566.5	17.72
16 Indian Canyon at Interstate 15	4	10.0	60.37	6.06	1,630	171,238.0	27.59
17 Indian Canyon at Community Development	3	10.5	69.12	6.60	1,630	160,154.9	30.86

18 Indian Canyon at Crilly Road	0	22.1	102.63	4.64	1,630	10,407.2	24.77
19 Horsethief at Interstate 15	4	10.4	63.52	6.11	1,630	174,637.9	27.69
20 Unnamed Canyon above Bosley Lane	0	26.8	83.62	3.12	1,630	3,349.5	15.66
21 Horsethief Canyon at fire perimeter	3	10.9	75.29	6.89	1,630	169,385.4	32.19
22 Unnamed Canyon above Mountain Road	0	28.7	148.34	5.17	1,630	5,119.0	30.45
23 Unnamed Cyn east of Coyote Mesa Drive	1	10.7	52.80	4.93	1,630	23,675.9	26.26
24 Bishop Canyon	2	7.2	30.56	4.22	1,630	71,415.4	19.46
25 Rice Canyon	2	7.5	48.49	6.43	1,630	102,589.5	32.46
26 McVicker Canyon	2	7.2	44.15	6.17	1,750	124,938.0	30.50
27 Leach Canyon	2	7.5	43.46	5.77	1,750	98,127.4	28.66
28 Dickey Canyon at Toft Drive	0	11.3	66.12	5.83	1,750	25,621.1	32.42
29 Unnamed at Greenwood Drive	0	11.3	36.20	3.22	1,750	12,675.5	15.56
30 Unnamed at Calle Codomiz	1	19.3	61.73	3.19	1,750	13,515.5	14.41
31 Long Canyon at TRD541301-2	1	14.5	53.31	3.68	1,750	41,955.2	16.02

Pre-fire & post-fire flow numbers using 2 year return interval and the Waananan & Crippen equations for south coast region of California (1977) and sediment using the Rowe, Countryman, and Storey(1949) model.

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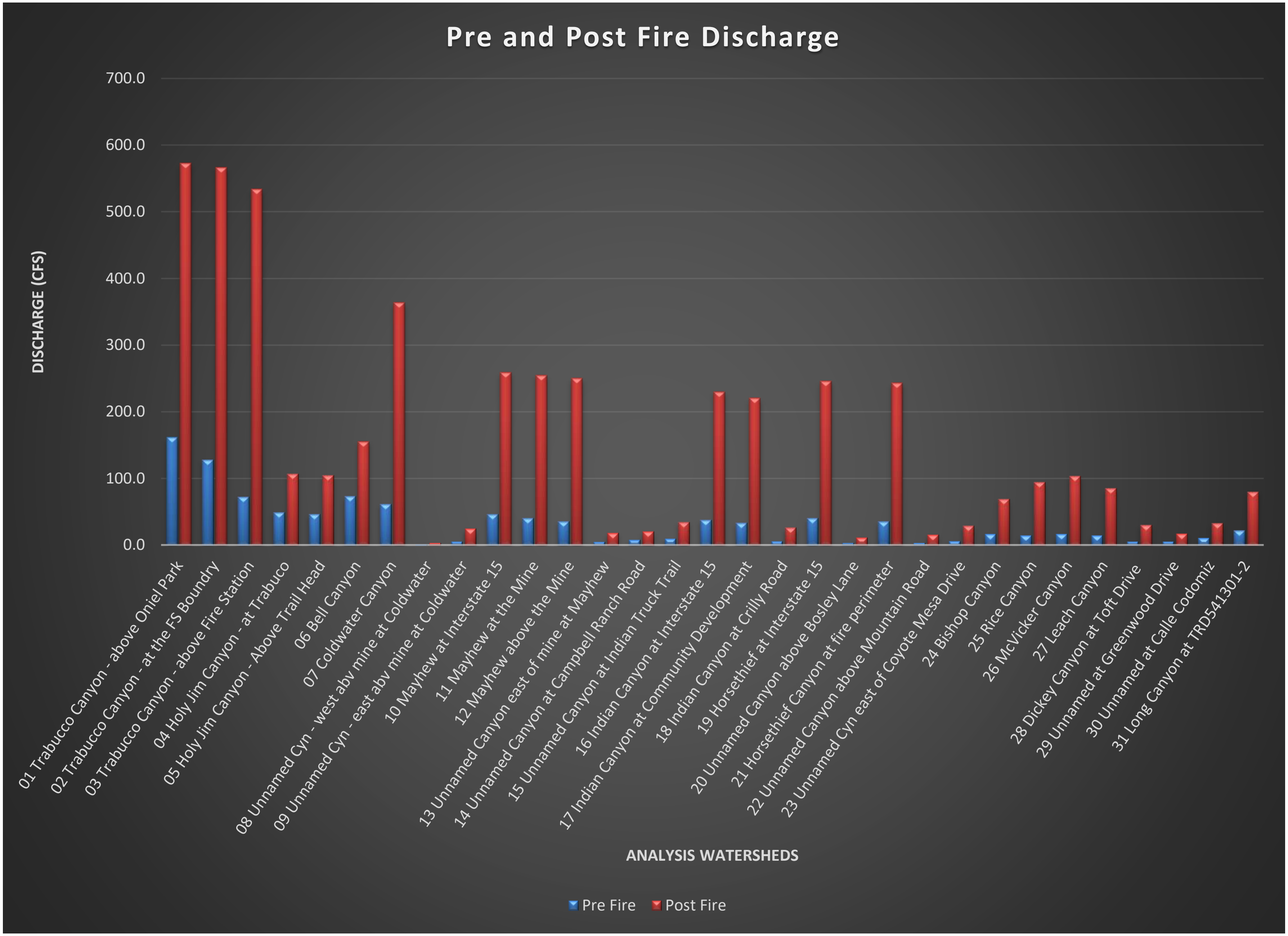

Figure 5: Pre and Post Fire Discharge in Cubic Feet per Second (CFS) for HUC 12 and Pour Point Watersheds

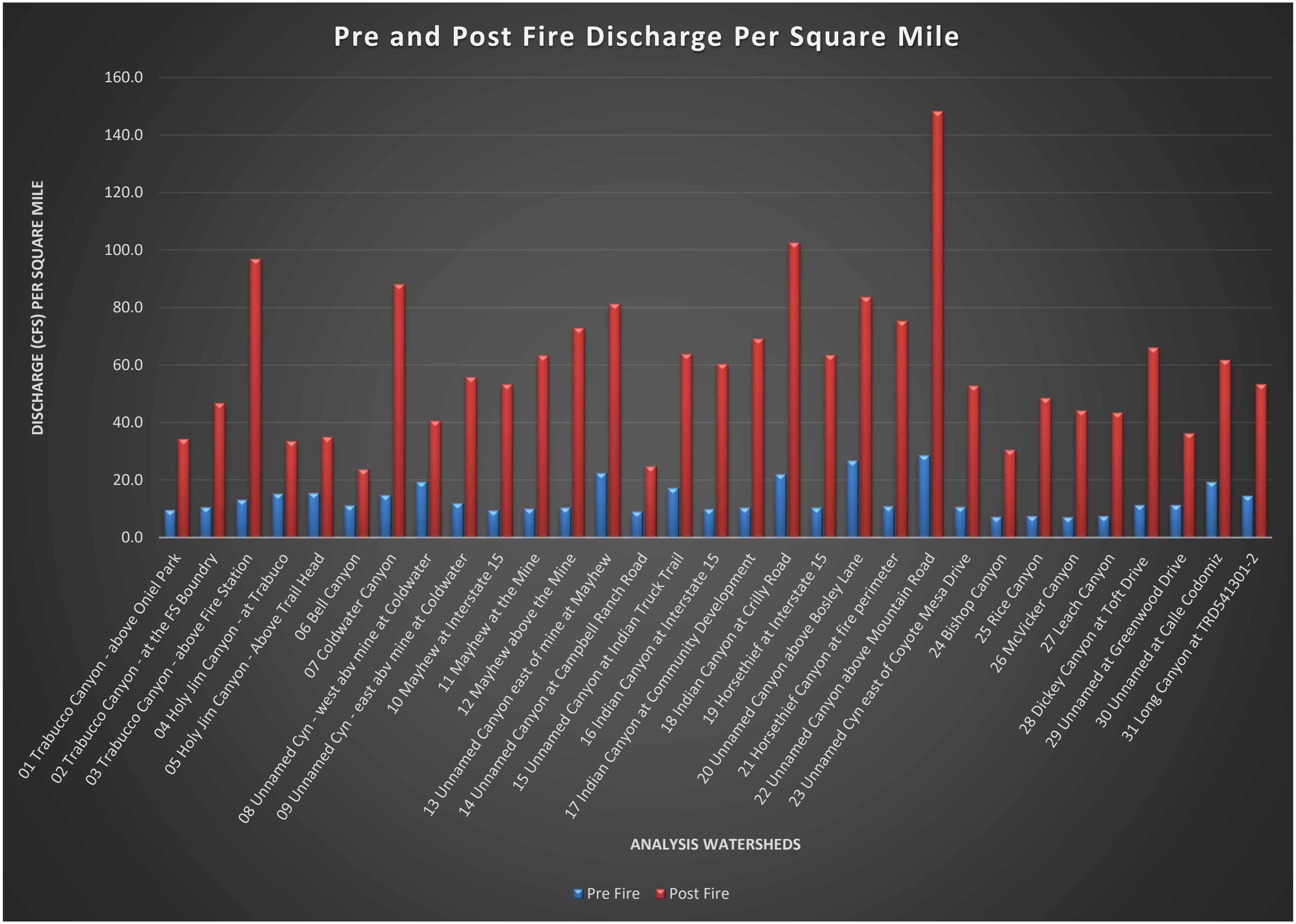

Figure 6: Pre and Post Fire Discharge (CFS) per Square Mile for HUC 12 and Pour Point watersheds

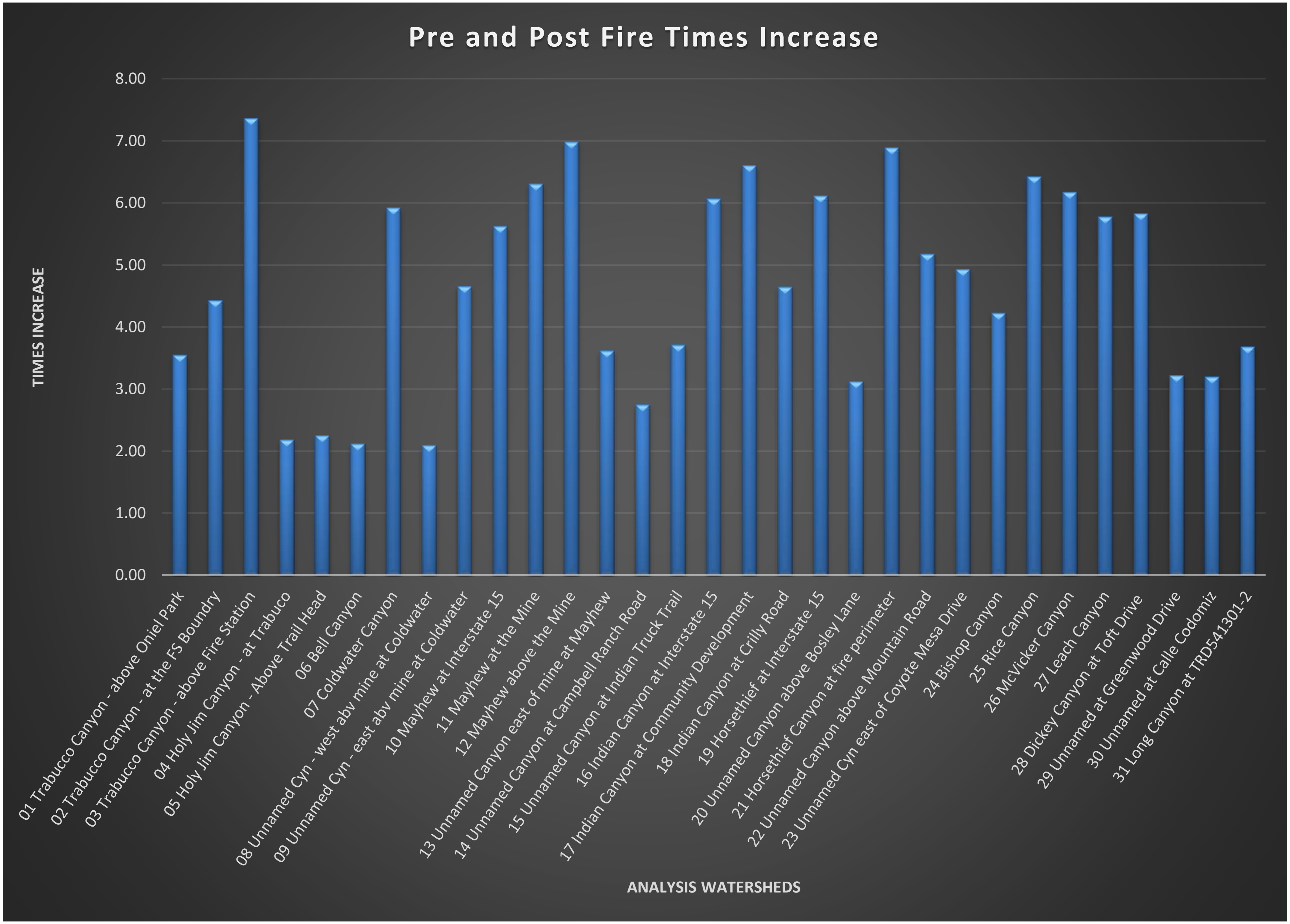

Figure 7: Pre and Post fire Multiplied increase of flow for a 2 year storm event.

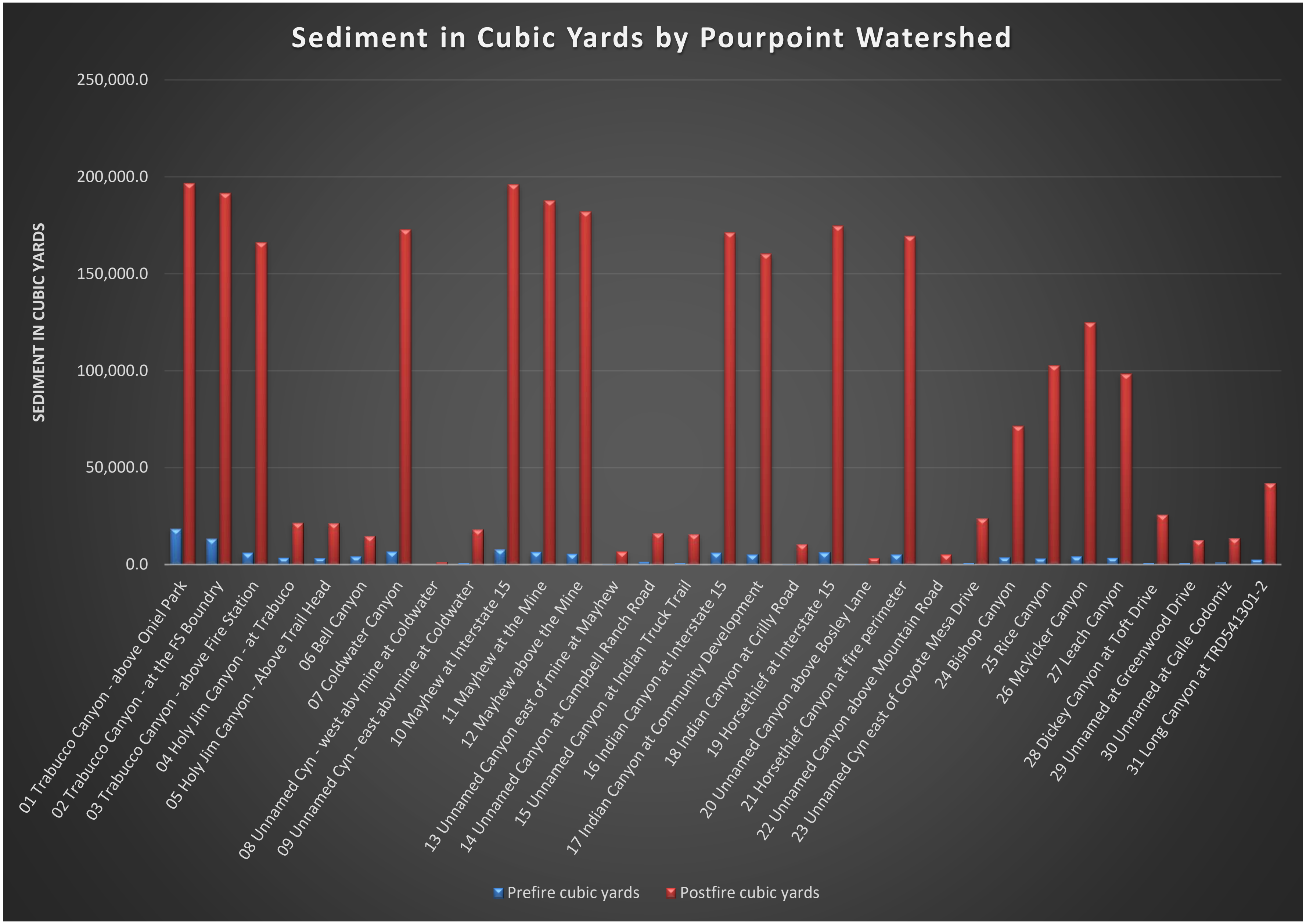

Figure 8: Pre-fire and post-fire Sediment (Cubic Yards) by Pourpoint Watershed.

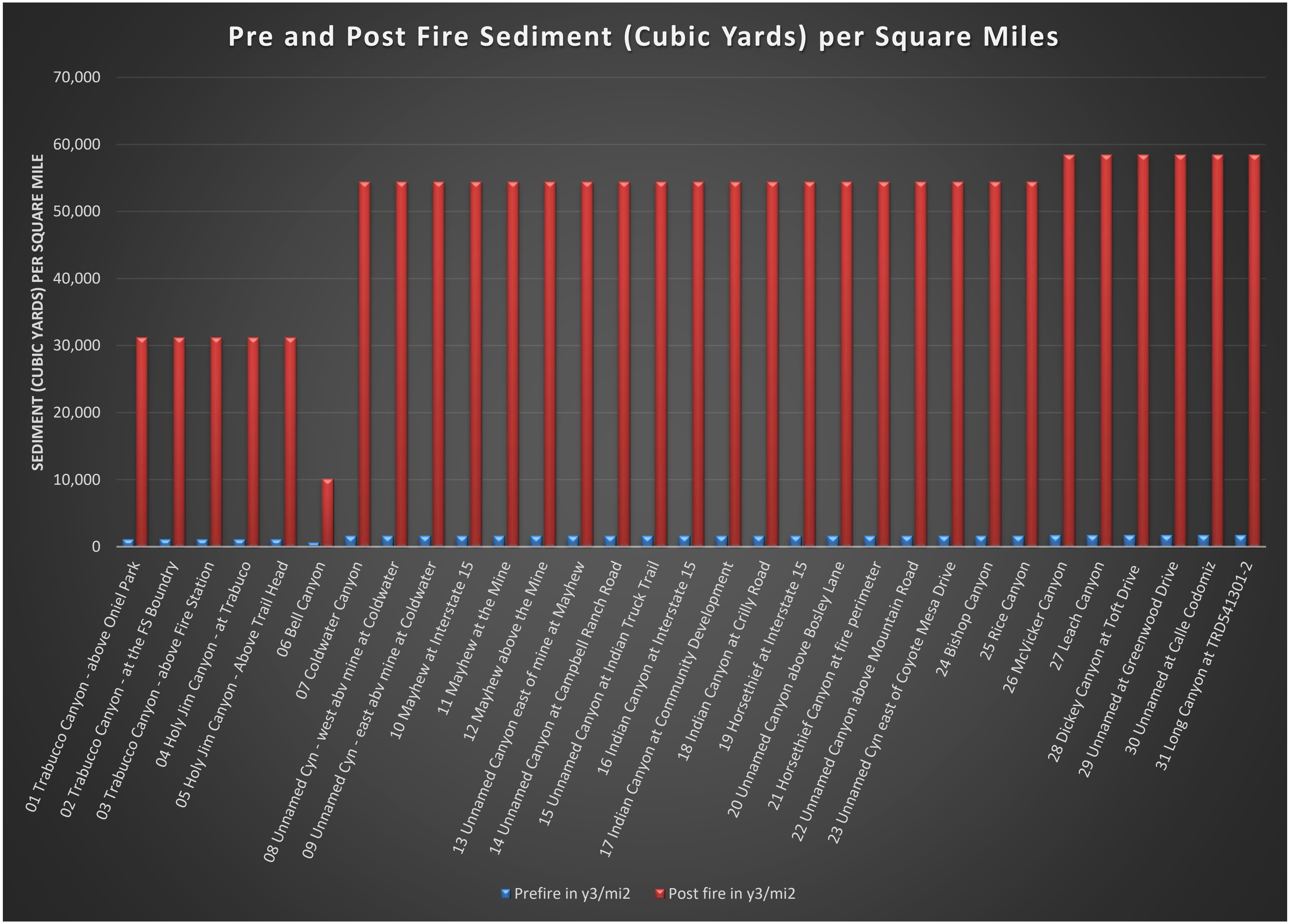

Figure 9: Pre-fire and post-fire Sediment (Cubic Yards) per square mile in watersheds, subwatersheds, and pourpoints

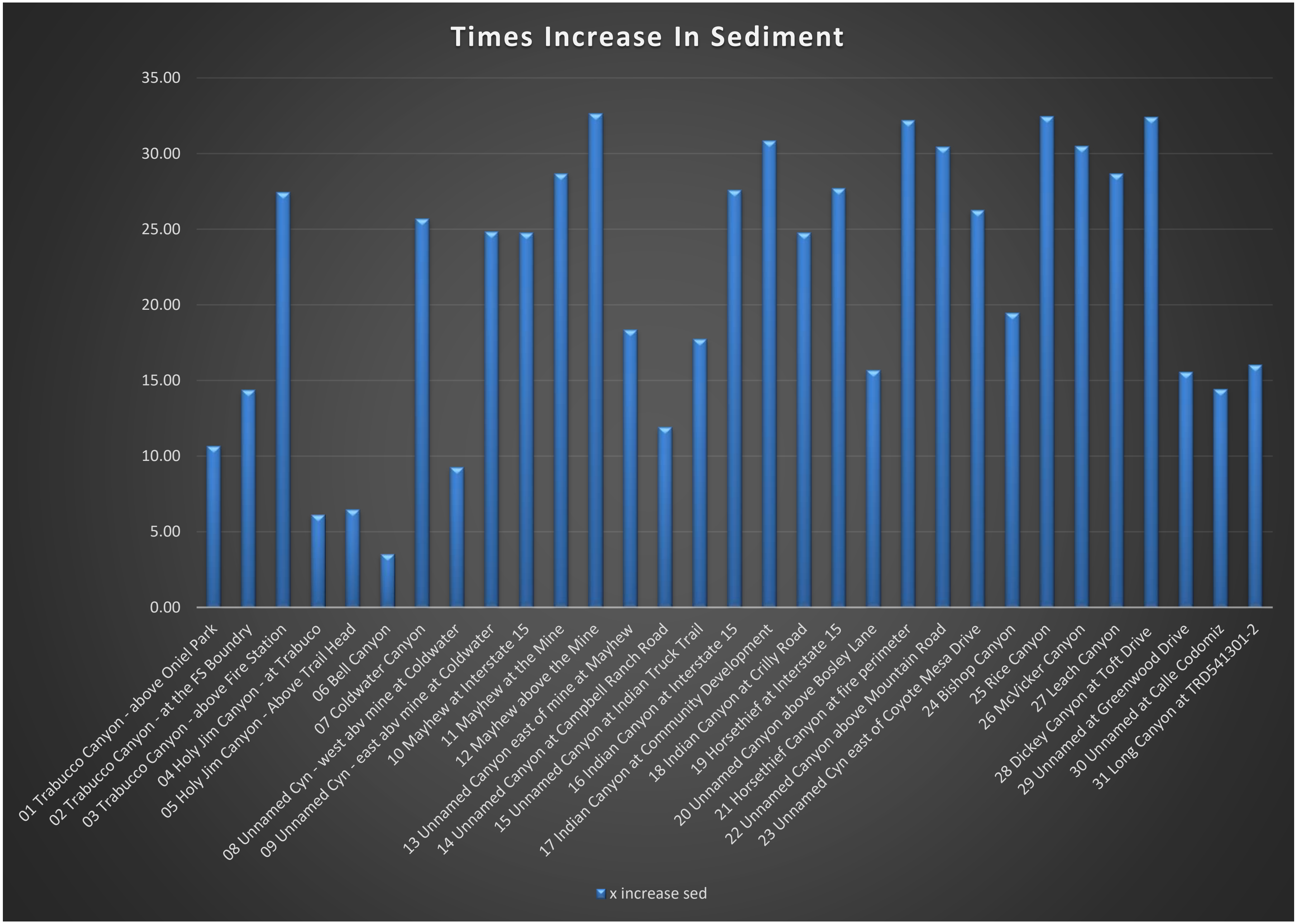

Figure 10:Pre and Post fire Multiplied increase of sediment yield for a 2 year storm event

Appendix D: Values-At-Risk

Holy Fire BAER

Cleavland National Forest

This appendix includes values at risk (VARs) that were identified and analyzed by the Holy BAER assessment. The objective of this analysis is to predict post-fire effects with the goal of mitigating risk to life, property, and natural and cultural resources. After identifying potential VARs, the magnitude of this risk was systematically evaluated. The risk matrix shown in Table D1 was utilized to identify values in need of mitigation efforts.

Table 11: Risk assessment matrix

Probability of Damage or Loss	Magnitude of Consequences		
	Major	Moderate	Minor
	Risk		
Very likely	Very High	Very High	Low
Likely	Very High	High	Low
Possible	High	Intermediate	Low
Unlikely	Intermediate	Low	Very Low

The probability of damage or loss within one to three years is classified into four categories: unlikely occurrence (<10%); possible occurrence (>10% to <50%); likely occurrence (>50% to < 90%); and very likely or nearly certain occurrence (>90%). This information is combined with an assessment of the magnitude of the consequences. These are classified as major, with implications for loss of life or injury to humans, substantial property damage, irreversible damage to critical natural or cultural resources; moderate, indicating injury or illness to humans, moderate property damage, damage to critical natural or cultural resources resulting in considerable or long term effects; or minor, with property damage limited in economic value and/or too few investments, damage to natural or cultural resources resulting in minimal, recoverable or localized effects.

Table D3 includes all values at risk by threat category. Tables also include information on risk assessment, proposed treatments, and other notes. VARs were highlighted to identify that a treatment was proposed. Table D2 shows the color scheme legend that was used (green for intermediate risk, orange for high risk, and dark red for very high risk). For more information on VARs, proposed treatments, and the VAR map refer to the 2500-8 for the Holy Fire.

Table 12: Color Scheme Legend

	Risk Level
	Very High
	High
	Intermediate (Where Treatments Are Recommended)

Table 13: Holy BAER - Forest Service Values at Risk.

Holy BAER - Forest Service Values At Risk Tracking Table

High / Very High Risk		
Intermediate Risk		
Low / Very Low Risk		

Category	Life/ Property/ Resources	Value at Risk	Threat to Value at Risk	Probability of Damage or Loss	Magnitude of Consequence	Risk	Treatment
Special Uses	Life/Property	Trabuco Rec. Res. Tract	Debris flow, landslides, rockfall, flooding, erosion, sedimentation.	Very Likely	Major	Very High	L3. Burned Area Closure; P5. Interagency Coordination
Special Uses	Life/Property	Holy Jim Rec. Res. Tract	Debris flow, flooding, erosion, sedimentation.	Likely	Major	Very High	L3. Burned Area Closure; P5. Interagency Coordination
Special Uses	Property	Utilities: AT&T & SCE	Debris flow, rockfall, flooding, loss of water control, soil erosion, loss of road tread.	Likely	Moderate	High	P5. Interagency Coordination
Special Uses	Life/Resources	Human Life/Water Quality	Access into well/contamination of water quality	Likely	Major	Very High	L3. Burned Area Closure; P5. Interagency Coordination

NFS Road	Life	Safe travel along Trabuco Road/Access to Trabuco Canyon	Debris flow, rockfall, flooding, erosion, sedimentation.	Very Likely	Major	Very High	L3. Burned Area Closure; P1. Road Signs/Gates
NFS Road	Property/ Resources	Trabuco Road & Bridge	Debris flow, flooding, sedimentation, erosion, rockfall.	Very Likely	Major	Very High	R1. Storm Inspection/Resp., R2. Road Stormproofing
NFS Road	Life/Property	Holy Jim Bridge	Debris flow, flooding, erosion.	Possible	Moderate	Intermediate	L3. Burned Area Closure; R2. Road Stormproofing
NFS Road	Life/Property	Holy Jim Road/Crossings	Debris flow, flooding.	Likely	Major	Very High	**L3**. Burned Area Closure
NFS Road	Property/Life/ Resources	North Main Divide (3S04) and Indian Truck Trail (5S01)	Rockfall, loss of water control, sedimentation, soil erosion, loss of road tread.	Very Likely	Major	Very High	**L3.** Burned Area Closure, **R1.** Storm Inspection/Resp., **R2**. Road Stormproofing, **R3**. Road Drainage Structure Replacement, **P1**. Road Signs/ Gates

NFS Road	Life	Safety on El Cariso Road	Rockfall, (loss of water control, sedimentation, soil erosion, loss of road tread).	Possible	Major	High	P1. Road Signs
Recreation	Life and Safety	Human Life and Safety in the burn scar	Debris flow, rockfall, hazard trees, stump holes, unstable lands, flash flooding.	Very Likely	Major	Very High	L3. Burned Area Closure; P1. Road Signs/Gates; P2. Trail Hazard Signs
Recreation	Resources	Hydrologic Function, spread of invasive weeds, soil productivity, vegetative recovery	Human traffic by foot, motorized/non-motorized travel	Likely	Major	Very High	L3. Burned Area Closure; L5. OHV Trespass Prevention; P1. Road Signs/Gates; P2. Trail Hazard Signs
Recreation	Life/Property	E&W Horsethief Trail, Trabuco Trail	Debris flow, rockfall, flooding. Loss of water control, soil erosion, loss of trail tread.	Very Likely	Major	Very High	L3. Burned Area Closure; T1. Trail Stabilization; P2. Trail Hazard Signs
Recreation	Property	Los Pinos Trail	Loss of water control, soil erosion, loss of trail tread	Possible	Minor	Low	No Treatment

Recreation	Life/Property	Holy Jim Waterfall Trail	Debris flow, flooding, erosion.	Very Likely	Major	Very High	L3. Burned Area Closure; P2. Trail Hazard Signs.
Recreation	Life/Property	Trabuco Canyon Recreation sites.	Debris flow, landslides, rockfall, flooding, erosion.	Very Likely	Major	Very High	L3. Burned Area Closure; T1. Trail Stabilization; P2. Trail Hazard Signs
Hazardous Material	Life	Human Safety	Open addit(s)/mines	Possible	Moderate	Intermediate	L3. Burned Area Closure; P5. Interagency Coordination
Hazardous Material	Life/Resources	Human Life/Safety/ Water quality	Exposure to and transport of Hazardous Material from burned cabins and associated infrastructure	Very Likely	Major	Very High	L3. Burned Area Closure; P3. Hazmat Stabilization; P5. Interagency Coordination

Watershed	Resources	Hydrologic Function	Riparian Recovery	Very Likely	Moderate	Very High	L3. Burned Area Closure, L4. Natural Recovery
Watershed	Resources	Soil productivity	Erosion on low productivity soils	Likely	Moderate	High	L3. Burned Area Closure, L4. Natural Recovery
Watershed	Resources	Soil productivity and water quality near Coldwater Creek Trail.	Loss of water control, soil erosion on Coldwater Creek trail.	Unlikely	Minor	Very Low	No Treatment
Botany/Weeds	Resources	Native Plant Recovery/Soil Productivity in suppression areas	Invasive species, OHV incursion	Very Likely	Moderate	Very High	L1. Invasive plant detection and eradication related to suppression; L5. OHV Trespass Prevention

Botany/Weeds	Resources	Native Plant Recovery/Soil Productivity in riparian areas	Invasive species	Very Likely	Moderate	Very High	L2. Invasive plant detection and eradication in Riparian Areas
Wildlife	Resources	Theatened California Gnatcatcher Suitable Habitat	Loss of habitat	Very Likely	Moderate	Very High	L3. Burned Area Closure; L4. Natural Recovery
Heritage	Resources	Historic Road ODM	OHV trespass	Possible	Moderate	Intermediate	L3. Burned Area Closure; L5. OHV Trespass Prevention
Heritage	Resources	Historic Property: Lithic Scatter	Erosion, debris flow, flooding, sedimentation.	Likely	Moderate	High	L6.Historic Properities Protection
Heritage	Resources	Historic Cabins in Holy Jim and Trabuco Canyons	Erosion, debris flow, flooding, sedimentation.	Very Likely	Major	Very High	P5.Interagency Coordination
Heritage	Resources	Trabuco Rd Features	Erosion, debris flow, flooding, sedimentation.	Likely	Major	Very High	R2. Road Stormproofing
Heritage	Resources	Trabuco Guard Station	Erosion, debris flow, flooding, sedimentation.	Likely	Moderate	High	R2. Road Stormproofing
Heritage	Resources	Historic Properties	Sheet erosion	Unlikely	Moderate	Low	No Treatment