Burned Area Emergency Response
Rim Fire
Stanislaus National Forest
Hydrology and Watershed Specialist Report
September 24, 2013

Tuolumne River near Lumsden Campground

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Fire and site description

This report summarizes the results from the hydrologic assessment of the Rim Fire in the Sierra Nevada of California, as part of the Burned Area Emergency Response (BAER). The Rim Fire was human-caused and began on August 17, 2013, burning 256,895 acres as of September 21, 2013 (84% contained). The fire affected property across land ownership (Table 1) and 26 HUC 6 watersheds (Figure 2). The final soil burn severity was 7% high, 37% moderate, 55% low, and 1% Unburned (Table 2).

Table 1. Acres burned by land ownership

Land owner	Acres burned
U.S. Forest Service	154,108
National Park Service	78,946
Bureau of Land Management	129
Private - SPI	16,034
Private	7,678
Total	256,895

Table 2. Acres burned by Soil Burn Severity

Soil Burn Severity	Acres
High	16,796
Moderate	94,940
Low	143,225
Unburned	1,934
Total	256,895

The Rim Fire took place in a region that experiences moist winters and dry summers (Figure 1). Precipitation throughout the burn area ranges from about 35 to 50 inches per year, with about 90% of the precipitation occurring from October through April. In the lower elevations (<4,500 feet), precipitation is rain dominated with frontal storms accounting for nearly all moisture. The higher elevations (>4,500 feet) have a mix of rain and snow. The rain-on-snow zone, from about 4,500-6,500' in elevation, can produce very high peak flows during long-duration rain storms falling on a shallow snowpack.

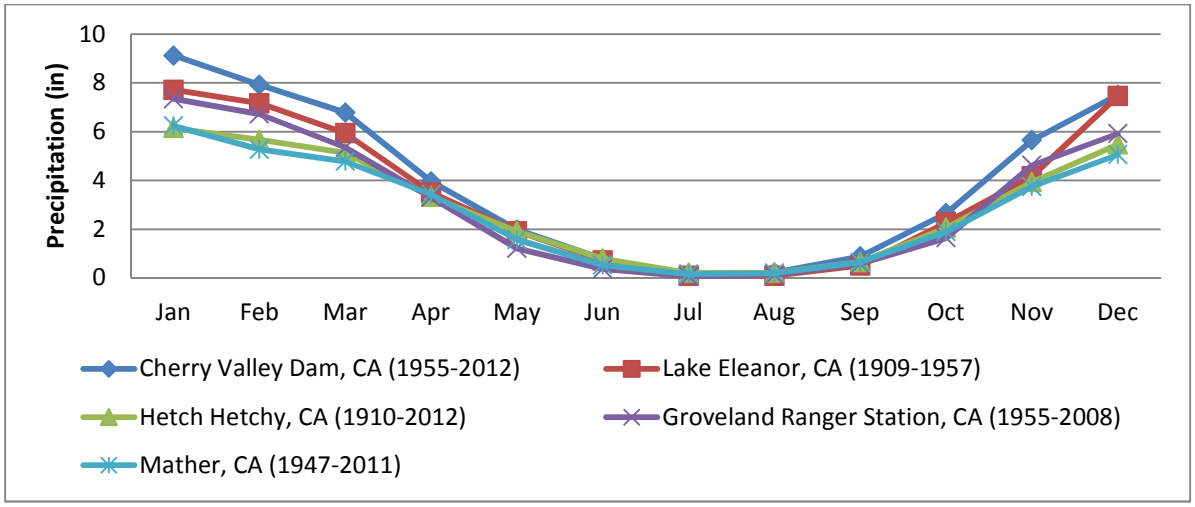


Figure 1. Average monthly precipitation at locations within and around the burned area perimeter

Source: Western Regional Climate Center

Elevation within the burned area perimeter ranges between 880 ft. to 7,751 ft. Vegetation within the burned area was tree dominated (Table 3) and was comprised of a combination of natural forest stands and plantations. Soil burn severity varied by watershed, with the Jawbone Creek-Tuolumne River watershed experiencing the highest percentage of moderate and high soil burn severity. There are approximately 2,655 miles of streams within the burned area (Table 4).

Table 3. Vegetation Types

Vegetation Type	Area (acres)	% of Burned Area
Herbaceous	14,283	5.56
Non-Vegetated	2,492	0.97
Shrub Dominated	27,077	10.54
Tree Dominated	213,043	82.93
Total	256,895	100%

Table 4. Stream length by class

Stream Class	Length (miles)
Ephemeral	2,005
Intermittent	287
Perennial	363
Total	2,655

This report details a hydrologic analysis conducted at two geographic scales; HUC 6 watersheds at their outlet and at selected values at risk (VARs). These VARs could include homes, buildings, power plants, bridges, roads, trails, historical sites, cultural sites, culverts, and campgrounds (Appendix D).

Water Quality

Areas affected by the 2013 Rim Fire drain portions of the San Joaquin basin. Surface water bodies directly impacted by the fires include portions of the Tuolumne (Source to New Don Pedro Reservoir; New Don Pedro Reservoir) and Merced Rivers (Source to McClure Lake). Beneficial uses for these impacted water bodies are summarized in Table 5. In addition, both Hetch Hetchy and New Don Pedro Reservoirs are listed as impaired on the 303(d) list for mercury.

Table 5. Beneficial Uses of Water for Surface Water Bodies within the 2013 Rim Fire (California, 2011).

	Surface Water Bodies		
	Tuolumne River		**Merced River**
Beneficial Uses	**Source to New Don Pedro Reservoir**	**New Don Pedro Reservoir**	**Source to McClure Lake**
Municipal and Domestic Water Supply	E	P	P
Irrigation	E		E
Stock Watering	E		
Hydropower Generation	E	E	E
Water Contact Recreation	E	E	E
Non-contact Water Recreation	E	E	E
Cold Freshwater Habitat	E	E	E
Warm Freshwater Habitat	E	E	E
Wildlife Habitat	E	E	E

E = Existing; P=Potential

Wildfires primarily 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. 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.

The most noticeable effects on water quality will be possible increases in sediment and ash from the burned area into the Tuolumne River, Don Pedro Reservoir, and other waterbodies in and downstream of the fire area. Based on historic precipitation patterns, frontal storms have a high probability of occurring in the weeks following the fire. 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. These hazardous conditions may be worsened in the case of a rain-on-snow event, where long-duration rainstorms falling on a shallow snowpack can produce very high peak flows and result in extensive flooding. This is not, however, an annual event. The last event of this nature occurred in January 1997. Within the Rim Fire, the post-fire watershed threat should be reduced measurably after three to five years. Figure 2 represents all of the 6th field watersheds affected by the fire.

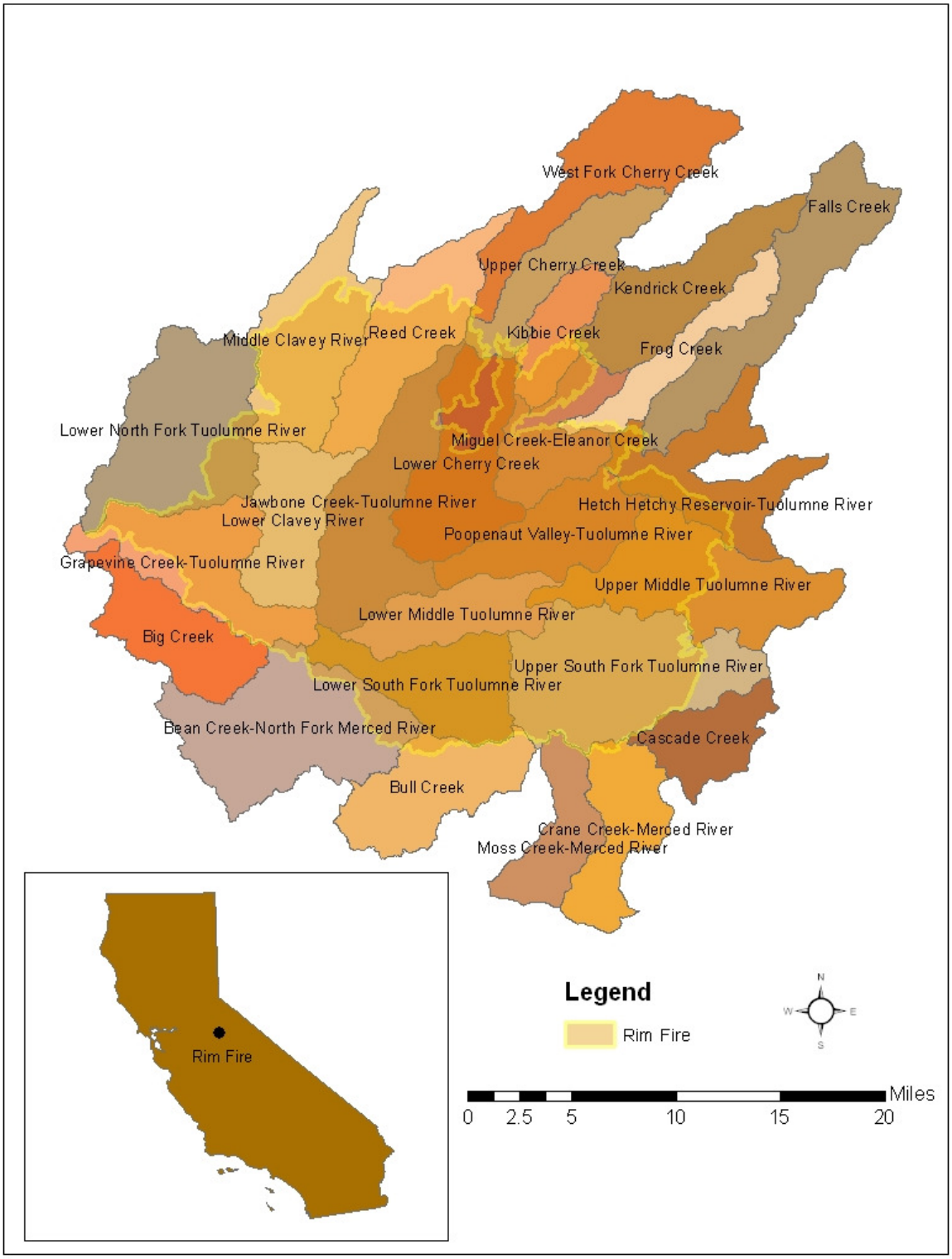


Figure 2. HUC 6 watersheds affected by the Rim Fire

Fire 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 and observations made by helicopter for inaccessible areas. 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

The primary watershed responses of the Rim 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, and 3) floods with increased peak flows and sediment deposition. 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.

The estimated vegetative recovery for watersheds affected by the Rim Fire is expected to recover within 3 to 5 years as observed in other Sierra-Nevada watersheds. Flood potential will decrease as vegetation reestablishes, providing ground cover, increasing surface roughness, and stabilizing and improving the infiltration capacity of the soils. 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, 24 hour duration storms anticipated for these watersheds range between 3.6 inches and 4.2 inches (NOAA, 2013). Hydrologic design information is displayed in Table 6.

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. Design flow estimates have been based on existing gage station information (Department of the Interior, 2013). These estimates assume pre-fire ground infiltration and ground cover conditions.

Adjusted design flow is calculated using the same relationships 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. The Rim Fire is expected to respond to an average rainfall event, an event usually associated with the 1.5-year storm, differently for the low, moderate, and high severity burned areas. It is expected the landscape would respond as if the discharge were associated with a 1.75, 5, and 10-year event, respectively based on observations from other burned watersheds (Kaplan-Henry, 2004). The unburned lands within the fire would respond as the unburned lands outside the fire and would have a discharge associated with the 1.5 year return interval. The range in return interval is based on USGS gage station data in the immediate watershed area. 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 fire has been analyzed at a watershed scale. 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. 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. Appendix A displays maps of the 6th field or HUC 6 watersheds and the fire perimeter and Pourpoint Watersheds and the fire perimeter.

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. This will aid in the potential for floods and will increase the distance that eroded materials are transported. However, 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.

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.

Table 6. Hydrologic design factors

A. Estimated Vegetative Recovery Period	3-5 years
B. Design Chance of Success	80 %
C. Equivalent Design Recurrence Interval	2 years
D. Design Storm Duration	24 hours
E. Design Storm Magnitude	3.6 - 4.2 inches
F. Design Flow	7.57 cfs / mi^2
G. Estimated Reduction in Infiltration	25%
H. Adjusted Design Flow	11.65 cfs / mi^2

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 one to five times pre-fire values. The peak flow values highlight the post-fire effects on the Rim Fire, with the most increase reflected in subwatersheds where burn severity is moderate and high and where the most 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.

The results of a peak flow analysis show that pre-fire area weighted flows were on average 7.57 cfs / mi^2 for a 2 year, 24 hour storm, and 11.65 cfs / mi^2 for post-fire flows. As previously mentioned, the 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.

Flow relationships were developed using USGS gage stations. Gage stations were investigated to provide information on flow conditions following the 1.5, 1.75, 2.0, 5.0, 10, and 25 year events. Gage data provided information on drainages within and near the fire area. The Table 7 displays gage data utilized to develop hydrologic relationships for discharge equations.

Table 7. Gage Station Data for Watersheds Affected or Near the Rim Fire, 2013							
Gage Station Location	**Drainage Area in m^2**	**Discharge in Cubic Feet per Second**					
		Q 1.5	**Q 1.75**	**Q 2.0**	**Q 5.0**	**Q 10**	**Q 25**
11247200 Big Sandy C TRIB NR Tollhouse CA	0.46	4	5	7	22	39	72
11292680 Cascade C NR Pincrest CA	4.97	95	122	148	321	480	738
11283200 Bell C NR Pinecrest CA	9.11	216	262	309	566	776	1,086
11257100 Miami C NR Oakhurst CA	10.60	99	137	174	490	839	1,493
11242400 NF Willow C NR Sugar Pine CA	16.90	210	252	293	850	1,769	2,563
1128100 Tuolumne R NR Oakland Rec Camp CA	87.00	775	1,112	1,450	3,553	5,538	8,724
11283500 Clavey R NR Buck MDW CA	144.00	1,310	2,090	2,870	7,314	17,318	32,388
11278300 Cherry C NR Early Intake CA	226.00	1,080	1,476	1,873	5,717	9,907	17,132

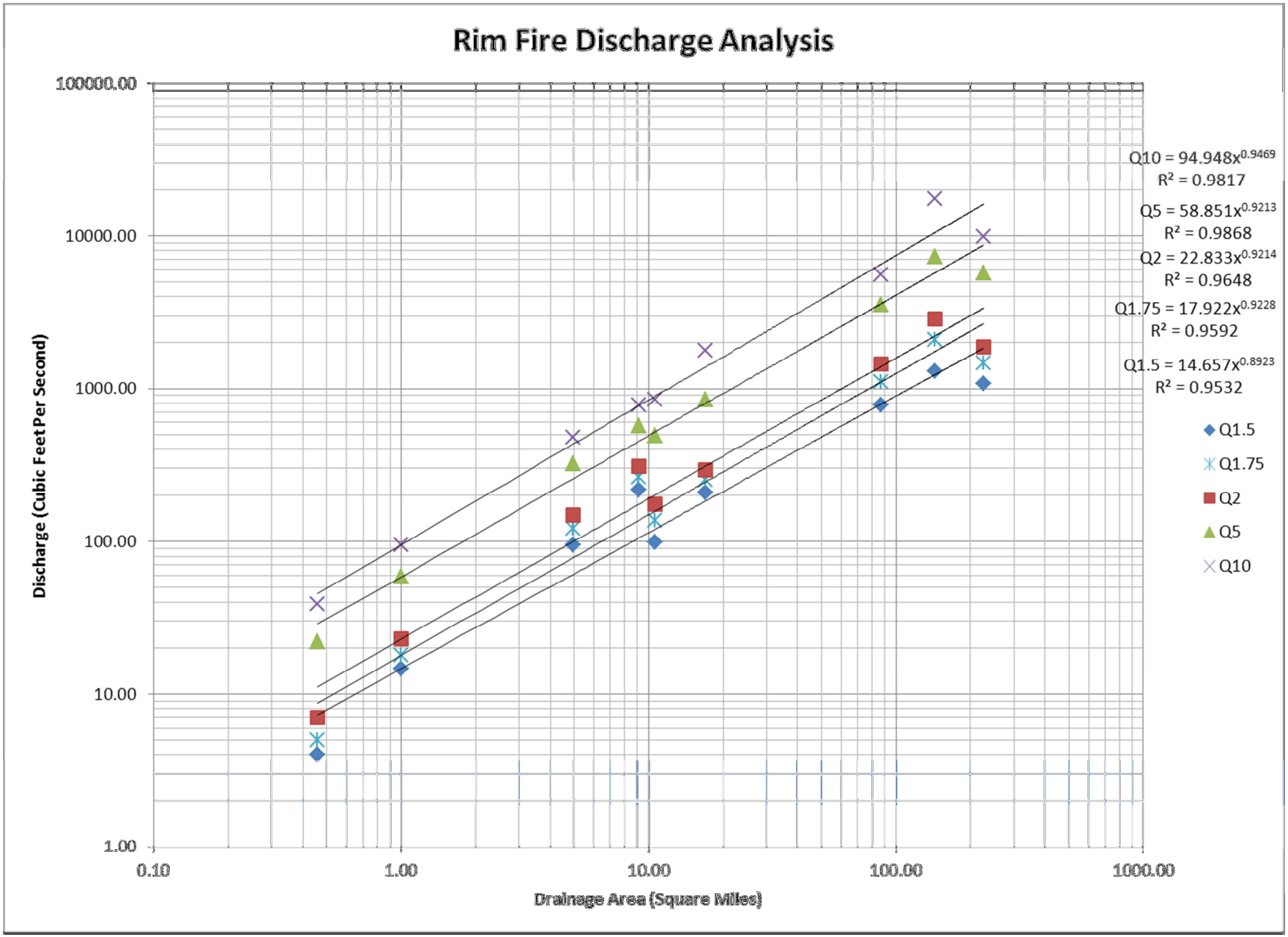
Gage station values were plotted in a log-log plot by recurrence interval using a linear interpolation for the bankfull discharge. Although the 2 and 25-year recurrence intervals are not used in this analysis they have been provided.

Figure 3 displays discharge relationships and recurrence intervals for the watersheds affected by the Rim fire. The following equations were applied to affected watersheds to yield discharge in cubic feet per second and divided by the size of the watershed to give a discharge in cubic feet per second per square mile for the 1.5, 1.75, 5.0, and 10.0 year discharge values by watershed size. These values were then multiplied by the area of the watershed by soil burn severity which includes unburned lands. These values were then added together to provide a predicted post-fire discharge value by each watershed. Pre-fire discharge was calculated using the bankfull discharge equation. Estimates of pre-fire conditions may be determined from **Figure 3**, Discharge Relationship for Rim Fire Area by Drainage Area and Recurrence Interval.

Appendix C provides values utilized to derive estimates of predicted post burn discharges and a display of the predicted increases in both cubic feet per second and cubic feet per second per square mile for the watersheds affected by the fire.

Figures 4, 5, and 6 provide a visual display of pre and post-fire discharges for all evaluated pourpoint watersheds to illustrate the watersheds that are expected to have a significant increase in water yields.

Figure 3: Rim Fire Discharge Analysis



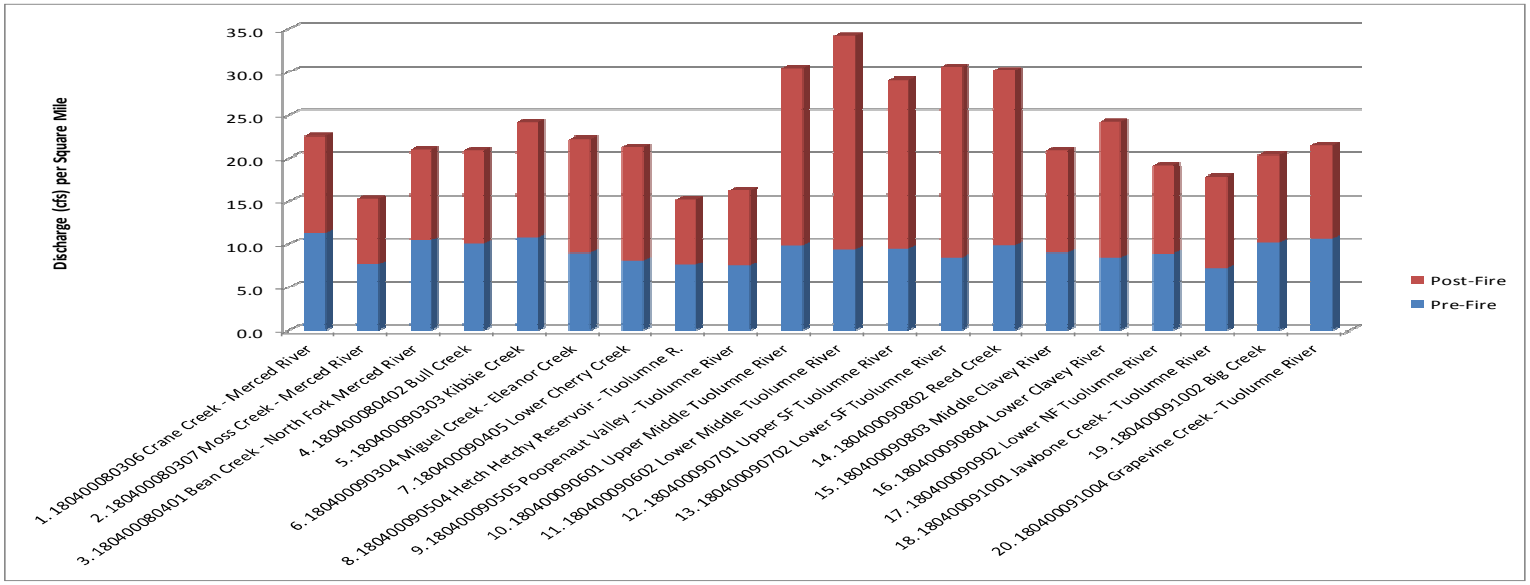


Figure 4. Pre-fire and post-fire streamflow per square mile in watersheds, subwatersheds, and pourpoints (pourpoints 1-20).

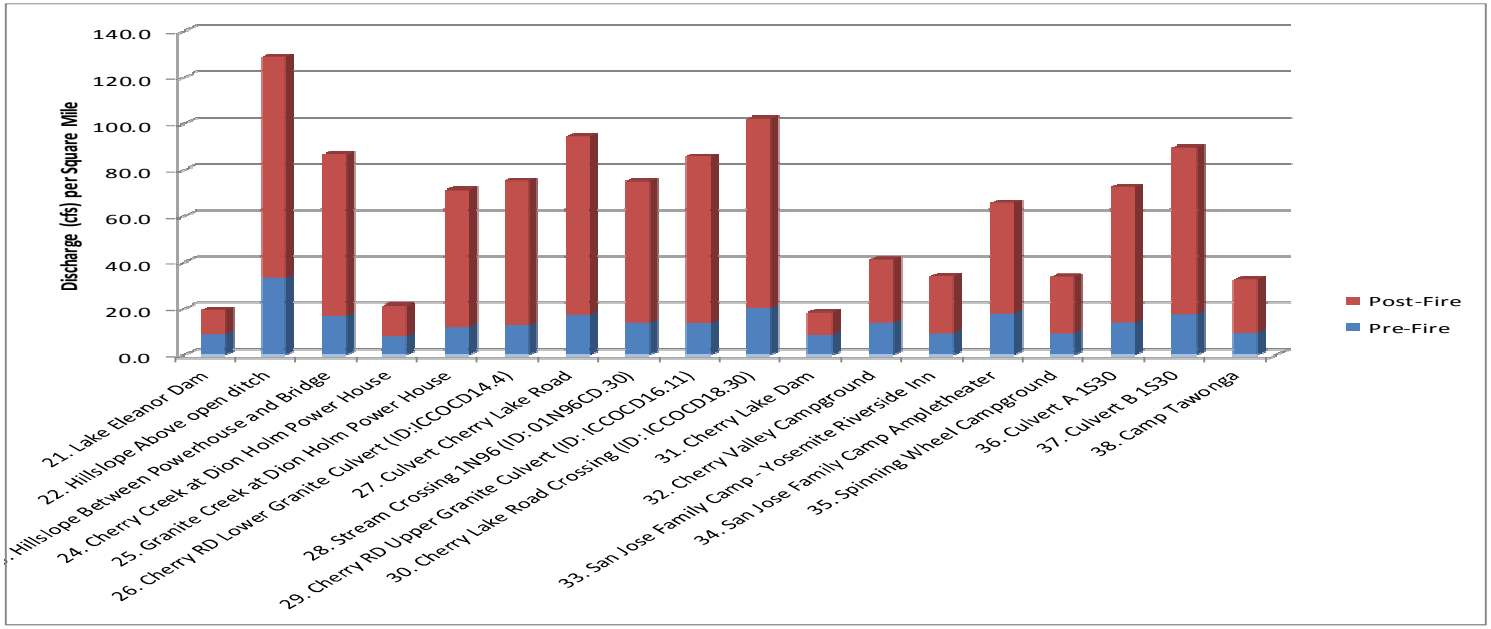


Figure 5. Pre-fire and post-fire streamflow per square mile in watersheds, subwatersheds, and pourpoints (21-38).

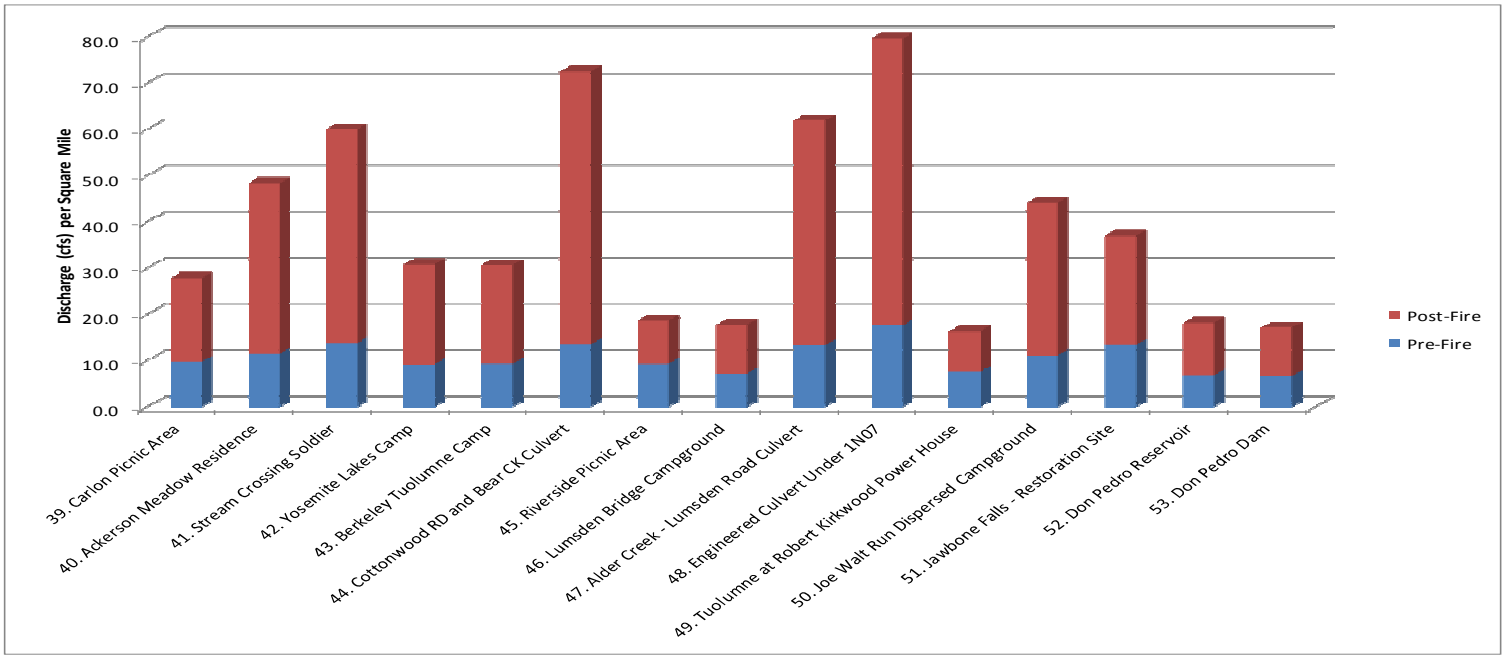


Figure 6. Pre-fire and post-fire streamflow per square mile in watersheds, subwatersheds, and pourpoints (39-53).

Implications of post-fire runoff

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.

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

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 to few investments, damage to natural or cultural resources resulting in minimal, recoverable or localized effects.

Localized treatment 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.

Conclusions

As a result of the Rim Fire significant increases in runoff are expected in some pourpoint watersheds. These increases are result of the large percentages of high or moderate soil burn severity within these watersheds. The HUC 6 watersheds, Lower Middle Fork Tuolumne River and Lower South Fork Tuolumne River, show increases in water yield of 2.6 and 2.65 times greater respectively than pre fire conditions. The pourpoint watersheds, Cherry Lake Road upper Granite Creek culvert and Granite Creek at Dion Holm Power House, show increases in water yield of 5.17 and 4.93 times greater respectively than pre-fire conditions. This increase is for the

Q1.5 storm or a discharge that has a 75% chance of occurring over the course of the year. Depending on location of the values at risk from the Rim Fire; these values may be affected as a result of the burn under design storm conditions. Details on values at risk and treatments may be found in the 2500-8 BAER Report for the Rim Fire.

References

California State Water Quality Control Board. October 2011. Water Quality Control Plan for the Sacramento River Basin and San Joaquin River Basin. Central Valley Region.

Chow, V.T., Maidment D. R., and Mays L.W. 1988. Applied Hydrology. McGraw-Hill, New York.

Department of the Interior, United States Geologic Survey. Site Inventory for the Nation. http://waterdata.usgs.gov/nwis/inventory. Accessed 18 September 2013.

Kaplan-Henry, Terry. October 2004. McNally Postfire Discharge and the Relationship of Sierra Nevada-Wide Flood Frequency Curves and Local Kern River Discharge Curves. Advancing the Fundamental Sciences; Proceedings of the Forest Service National Earth Sciences Confrence, San Diego, 18-22 October 2004.

NOAA. Hydrometerological Design Studies Center. http://hdsc.nws.noaa.gov/hdsc/pfds/. Accessed 17 September 2013.

List of Appendices

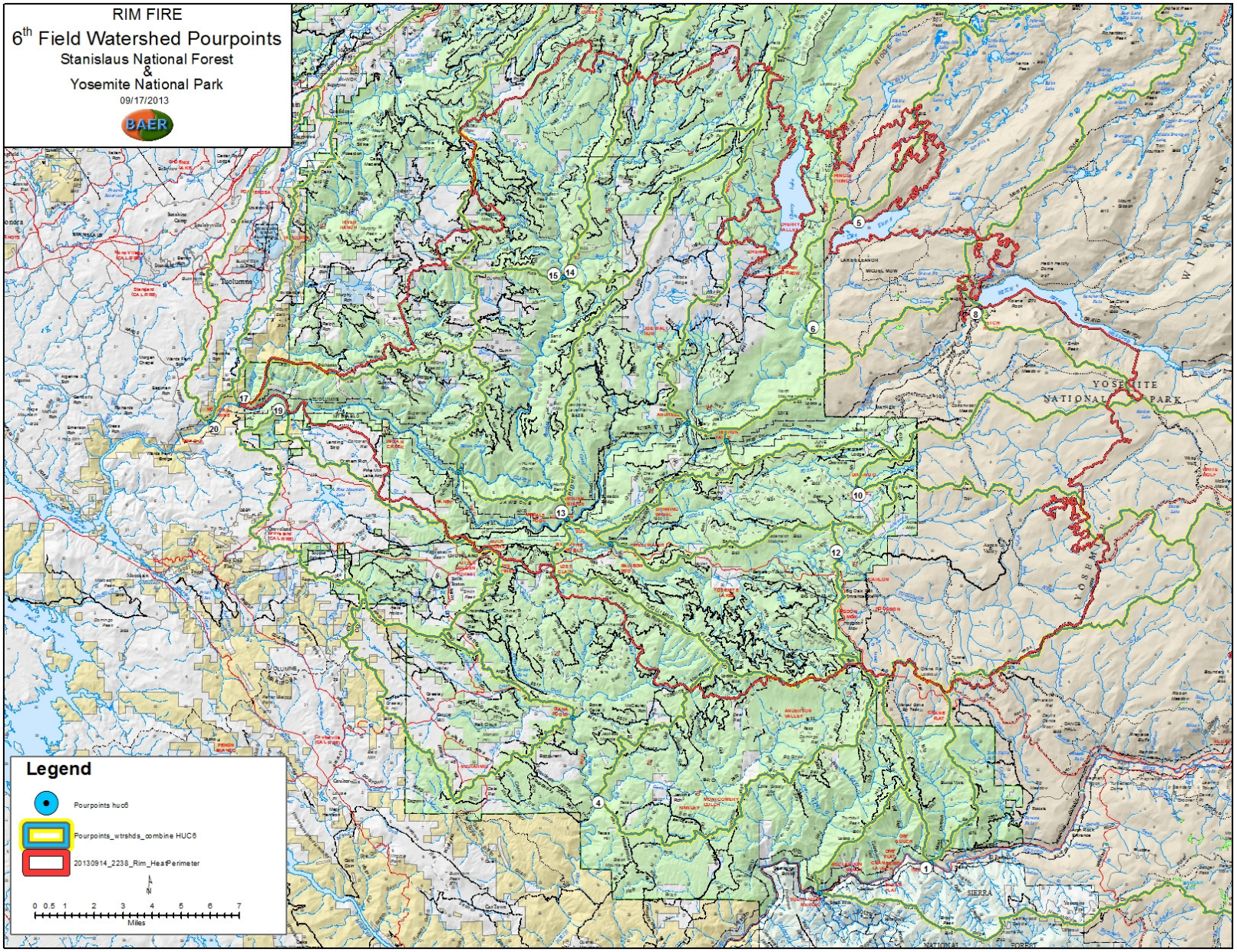
Appendix A: Pour Point Watershed Maps for Rim Fire

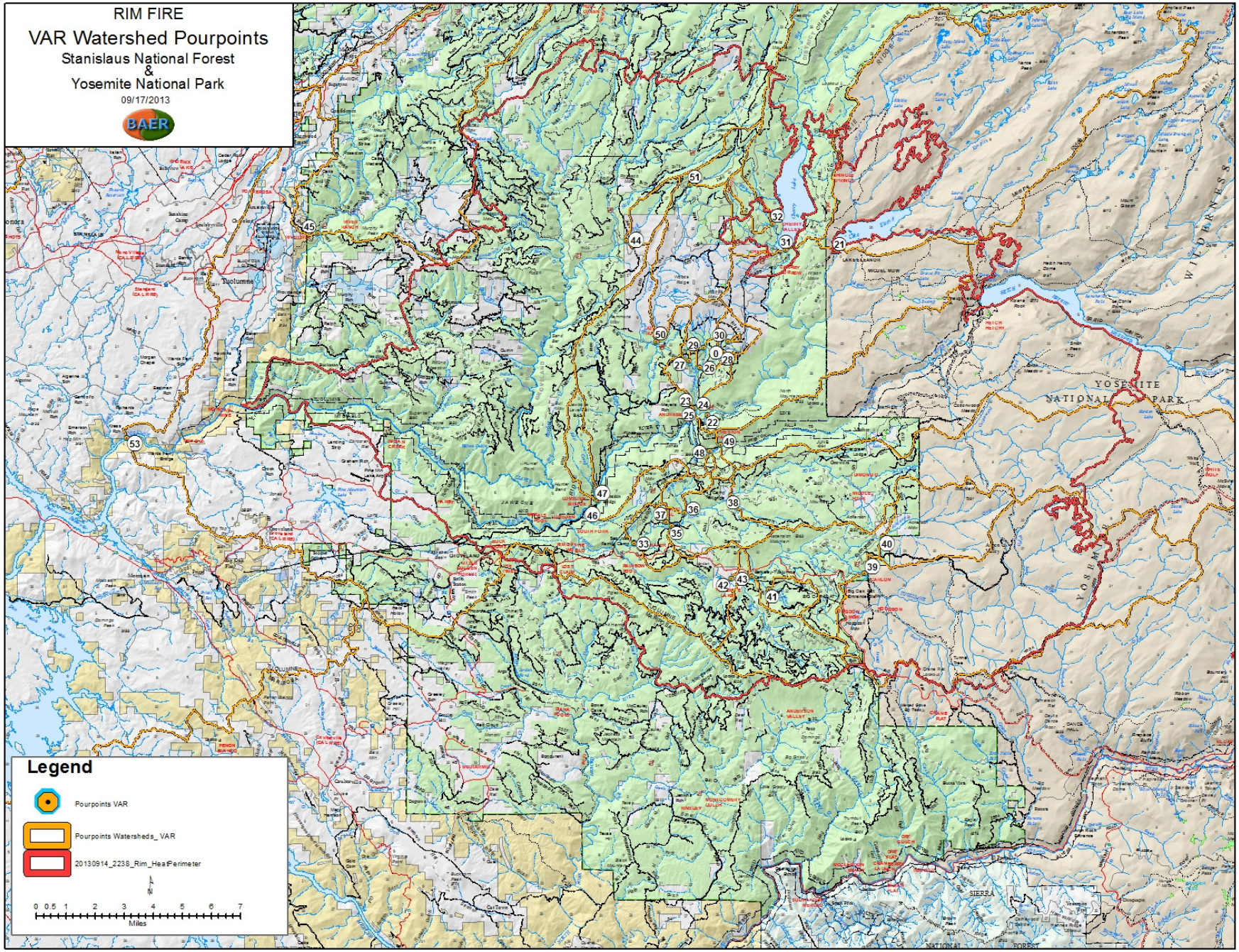
Appendix B: HUC 6 Watersheds Affected by the Rim Fire. Percent of watersheds burned are reported in parentheses

Appendix C: Pre-Fire and Post- Fire flow numbers using 2 year return interval with 24 hour intensity

Appendix D: Values at Risk Table

APPENDIX A: Pour Point Watershed Maps for Rim Fire




RIM FIRE
VAR Watershed Pourpoints
Stanislaus National Forest
&
Yosemite National Park
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Legend
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0 0.5 1 2 3 4 5 6 7
Miles
YOSEMITE NATIONAL PARK
WILDERNESS
Tuolumne

APPENDIX B: HUC 6 watersheds and pourpoint watersheds affected by the Rim Fire. Percent of watersheds burned are reported parentheses.

Watershed	Watershed acres	High Acres	Moderate Acres	Low Acres	Unburned Acres
1. 180400080306 Crane Creek - Merced River	7,290	0 (0%)	6 (0%)	13 (0%)	7,264 (100%)
2. 180400080307 Moss Creek - Merced River	268,800	0 (0%)	13 (0%)	64 (0%)	268,723 (100%)
3. 180400080401 Bean Creek - North Fork Merced River	14,464	0 (0%)	0 (0%)	6 (0%)	14,458 (100%)
4. 180400080402 Bull Creek	21,043	6.4 (0%)	378 (2%)	698 (3%)	19,962 (95%)
5. 180400090303 Kibbie Creek	10,285	32 (0%)	474 (5%)	1,530 (15%)	8,249.6 (80%)
6. 180400090304 Miguel Creek - Eleanor Creek	58,560	730 (1%)	5,600 (10%)	5,670 (10%)	46,560 (80%)
7. 180400090405 Lower Cherry Creek	148,480	3,213 (2%)	16,243 (11%)	11,603 (8%)	117,414 (79%)
8. 180400090504 Hetch Hetchy Reservoir - Tuolumne R.	291,853	77 (0%)	339 (0%)	1,190 (0%)	290,240 (100%)
9. 180400090505 Poopenaut Valley - Tuolumne River	315,597	1,901 (1%)	8,307 (3%)	9,312 (3%)	296,077 (94%)
10. 180400090601 Upper Middle Tuolumne River	26,310	1,645 (6%)	4,665.6 (18%)	3,821 (15%)	16,179 (61%)
11. 180400090602 Lower Middle Tuolumne River	41,229	2,611 (6%)	13,126 (32%)	8,288 (20%)	17,203 (42%)
12. 180400090701 Upper SF Tuolumne River	37,824	1,280 (3%)	7,699 (19%)	13,805 (33%)	14,400 (35%)
13. 180400090702 Lower SF Tuolumne River	98,989	4,685 (12%)	30,041.6 (79%)	31,098 (82%)	33,165 (88%)
14. 180400090802 Reed Creek	25,811	1,658 (6%)	3,942 (15%)	6,534 (25%)	13,670 (53%)
15. 180400090803 Middle Clavey River	58,106	499 (1%)	2,880 (5%)	10,758 (19%)	43,968 (76%)
16. 180400090804 Lower Clavey River	101,766	2,899 (3%)	14,867 (15%)	24,979 (25%)	59,021 (58%)
17. 180400090902 Lower NF Tuolumne River	63,846	122 (0%)	2,099 (3%)	3,098 (5%)	58,534.4 (92%)
18. 180400091001 Jawbone Creek - Tuolumne River	491,635	8,928 (2%)	39,891 (8%)	27,469 (6%)	415,347 (84%)
19. 180400091002 Big Creek	18,765	0 (0%)	0 (0%)	12.8 (0%)	18,752 (100%)
20. 180400091004 Grapevine Creek - Tuolumne River	11,501	0 (0%)	0 (0%)	6.4 (0%)	11,494 (100%)

Table B1: Burn Severity of 6th Field Watersheds Affected by the Rim Fire

Watershed	Watershed acres	High Acres	Moderate Acres	Low Acres	Unburned Acres
21. Lake Eleanor Dam	49510	83.2 (0%)	1171.2 (2%)	3123.2 (6%)	45132.8 (91%)
22. Hillslope Above open ditch	0.32	0.0128 (4%)	0.2496 (78%)	0.064 (20%)	0 (0%)
23. Hillslope Between Powerhouse and Bridge	169	26 (15%)	134 (80%)	4 (3%)	0 (0%)
24. Cherry Creek at Dion Holm Power House	148077	3168 (2%)	15948.8 (11%)	11552 (8%)	117408 (79%)
25. Granite Creek at Dion Holm Power House	4045	1248 (31%)	2502.4 (62%)	275.2 (7%)	25.6 (1%)
26. Cherry RD Lower Granite Culvert (ID:ICCOCD14.4)	2509	934.4 (37%)	1331.2 (53%)	224 (9%)	19.2 (1%)
27. Culvert Cherry Lake Road	122	32 (26%)	89.6 (74%)	0 (0%)	0 (0%)
28. Stream Crossing 1N96 (ID: 01N96CD.30)	902	262.4 (29%)	486.4 (54%)	134.4 (15%)	12.8 (1%)
29. Cherry RD Upper Granite Culvert (ID: ICCOCD16.11)	1043	492.8 (47%)	505.6 (48%)	38.4 (4%)	6.4 (1%)
30. Cherry Lake Road Crossing (ID: ICCOCD18.30)	32	6.4 (20%)	25.6 (80%)	0 (0%)	0 (0%)
31. Cherry Lake Dam	73875	172.8 (0%)	1510.4 (2%)	2937.6 (4%)	69254.4 (94%)
32. Cherry Valley Campground	883	256 (3%)	192 (22%)	250 (28%)	422 (48%)
33. San Jose Family Camp - Yosemite Riverside Inn	40864	2598 (6%)	12902 (32%)	8179 (20%)	17184 (42%)
34. San Jose Family Camp Amphitheater	95	0.40 (0%)	53 (56%)	33 (35%)	8 (8%)
35. Spinning Wheel Campground	39168	2554 (7%)	11776 (30%)	7718 (20%)	17126 (44%)
36. Culvert A 1S30	813	38 (5%)	749 (92%)	26 (3%)	0 (0%)
37. Culvert B 1S30	109	13 (12%)	96 (88%)	0 (0%)	0 (0%)
38. Camp Tawonga	34778	2221 (6%)	8800 (25%)	6765 (19%)	16992 (49%)
39. Carlon Picnic Area	29946	653 (2%)	5062 (17%)	10400 (35%)	13830 (46%)
40. Ackerson Meadow Residence	6259	582 (9%)	2867 (46%)	2547 (41%)	262 (4%)
41. Stream Crossing Soldier	1146	141 (12%)	582 (51%)	397 (35%)	32 (3%)
42. Yosemite Lakes Camp	49792	1766 (4%)	13274 (27%)	19315 (39%)	15430 (31%)
43. Berkeley Tuolumne Camp	43686	1619 (4%)	10982 (25%)	16250 (37%)	14829 (34%)
44. Cottonwood RD and Bear CK Culvert	1363	301 (22%)	909 (67%)	147 (11%)	6 (0%)
45. Riverside Picnic Area	44179	0 (0%)	96 (0%)	454 (1%)	43622 (99%)
46. Lumsden Bridge Campground	489318	8838 (2%)	38502 (8%)	26874 (5%)	415104 (85%)
47. Alder Creek - Lumsden Road Culvert	1517	115 (8%)	1043 (69%)	346 (23%)	13 (1%)
48. Engineered Culvert Under 1N07	115	0 (0%)	102 (89%)	6 (6%)	6 (6%)
49. Tuolumne at Robert Kirkwood Power House	315872	1901 (1%)	8429 (3%)	9446 (3%)	296102 (94%)
50. Joe Walt Run Dispersed Campground	8166	1037 (13%)	2483 (30%)	3315 (41%)	1338 (16%)
51. Jawbone Falls - Restoration Site	1446	6 (0%)	275 (19%)	800 (55%)	365 (25%)
52. Don Pedro Reservoir	819002	16762 (2%)	92998 (11%)	95955 (12%)	613286 (75%)

Watershed	Watershed acres	High Acres	Moderate Acres	Low Acres	Unburned Acres
53. Don Pedro Dam	981184	16762 (2%)	92998 (9%)	95955 (10%)	775462 (79%)

Table B2: Burn Severity of Pour Point Watersheds Affected by the Rim Fire

APPENDIX C: Pre-fire & post-fire flow numbers using 2 year return interval with 24 hour intensity

Watershed	Watershed acres	Pre Fire Discharge	Post Fire Discharge	Times Increase
1. 180400080306 Crane Creek - Merced River	7,290	128	129	1.00
2. 180400080307 Moss Creek - Merced River	268,800	3212	3213	1.00
3. 180400080401 Bean Creek - North Fork Merced River	14,464	237	237	1.00
4. 180400080402 Bull Creek	21,043	331	356	1.08
5. 180400090303 Kibbie Creek	10,285	175	214	1.22
6. 180400090304 Miguel Creek - Eleanor Creek	58,560	825	1214	1.47
7. 180400090405 Lower Cherry Creek	148,480	1891	3039	1.61
8. 180400090504 Hetch Hetchy Reservoir - Tuolumne R.	291,853	3457	3486	1.01
9. 180400090505 Poopenaut Valley - Tuolumne River	315,597	3707	4311	1.16
10. 180400090601 Upper Middle Tuolumne River	26,310	404	849	2.10
11. 180400090602 Lower Middle Tuolumne River	41,229	603	1600	2.65
12. 180400090701 Upper SF Tuolumne River	37,824	558	1161	2.08
13. 180400090702 Lower SF Tuolumne River	98,989	1317	3421	2.60
14. 180400090802 Reed Creek	25,811	397	821	2.07
15. 180400090803 Middle Clavey River	58,106	819	1076	1.31
16. 180400090804 Lower Clavey River	101,766	1350	2502	1.85
17. 180400090902 Lower NF Tuolumne River	63,846	891	1026	1.15
18. 180400091001 Jawbone Creek - Tuolumne River	491,635	5505	8216	1.49
19. 180400091002 Big Creek	18,765	299	299	1.00
20. 180400091004 Grapevine Creek - Tuolumne River	11,501	193	193	1.00

Table C1: Change in Discharge for 6th Field Watersheds Affected by the Rim Fire

Watershed	Watershed acres	Pre Fire Discharge	Post Fire Discharge	Times Increase
21. Lake Eleanor Dam	49,510	710	796	1.12
22. Hillslope Above open ditch	0.32	0.02	0.05	2.88
23. Hillslope Between Powerhouse and Bridge	169	4	18	4.11
24. Cherry Creek at Dion Holm Power House	148,077	1887	3016	1.60
25. Granite Creek at Dion Holm Power House	4,045	76	374	4.93
26. Cherry RD Lower Granite Culvert (ID:ICCOCD14.4)	2,509	50	245	4.94
27. Culvert Cherry Lake Road	122	3	15	4.38
28. Stream Crossing 1N96 (ID: 01N96CD.30)	902	20	86	4.30
29. Cherry RD Upper Granite Culvert (ID: ICCOCD16.11)	1,043	23	117	5.17
30. Cherry Lake Road Crossing (ID: ICCOCD18.30)	32	1	4	4.04
31. Cherry Lake Dam	73,875	1015	1124	1.11
32. Cherry Valley Campground	883	20	37	1.90
33. San Jose Family Camp - Yosemite Riverside Inn	40,864	598	1582	2.65
34. San Jose Family Camp Ampletheater	95	3	7	2.64
35. Spinning Wheel Campground	39,168	576	1497	2.60
36. Culvert A 1S30	813	18	74	4.07
37. Culvert B 1S30	109	3	12	4.06
38. Camp Tawonga	34,778	518	1250	2.41
39. Carlon Picnic Area	29,946	453	849	1.87
40. Ackerson Meadow Residence	6,259	112	361	3.22
41. Stream Crossing Soldier	1,146	25	83	3.36
42. Yosemite Lakes Camp	49,792	713	1682	2.36
43. Berkeley Tuolumne Camp	43,686	635	1460	2.30
44. Cottonwood RD and Bear CK Culvert	1,363	29	126	4.37
45. Riverside Picnic Area	44,179	641	649	1.01
46. Lumsden Bridge Campground	489,318	5482	8122	1.48
47. Alder Creek - Lumsden Road Culvert	1,517	32	115	3.64
48. Engineered Culvert Under 1N07	115	3	11	3.52
49. Tuolumne at Robert Kirkwood Power House	315,872	3709	4320	1.16
50. Joe Walt Run Dispersed Campground	8,166	142	421	2.96
51. Jawbone Falls - Restoration Site	1,446	30	53	1.76
52. Don Pedro Reservoir	819,002	8680	14617	1.68
53. Don Pedro Dam	981,184	10198	16071	1.58

Table C2: Change in Discharge for Pour Point Watersheds Affected by the Rim Fire

Appendix D: Values-At-Risk by HUC 6 Watershed

Rim BAER

Stanislaus National Forest – Groveland and Mi-Wok Ranger District

This appendix includes values at risk (VARs) that were identified and analyzed by the Rim 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 D1. 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 to few investments, damage to natural or cultural resources resulting in minimal, recoverable or localized effects.

Table D3 includes all values at risk identified by HUC 6 watershed. 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 (yellow for intermediate risk, red 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 Rim Fire.

Table D2: Color Scheme Legend

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

Table D3: HUC6 Watershed by Values at Risk

180400090405 Lower Cherry Creek

Value (Life/Property/ Resources)	Value At Risk	Probability of Damage or Loss	Magnitude of Consequences	Risk	Treatment
Property	Kibbie trailhead	Unlikely	Minor	Very Low	None

180400090505 Poopenaut Valley-Tuolumne River

Value (Life/Property/ Resources)	Value At Risk	Probability of Damage or Loss	Magnitude of Consequences	Risk	Treatment
Property	Cherry Lake Boat Ramp	Unlikely Flooding.	Moderate	Low	None.
Life / Property	Cherry Valley Campground	Possible Flooding.	Moderate	Intermediate	Place warning signs.
Life / Property	Cherry Valley dispersed camp	Unlikely Flooding.	Minor	Very Low	None.
Life / Property	Cherry Fire Station	Unlikely	Minor	Very Low	None.
Property	Eleanor trailhead	Unlikely	Minor	Very Low	None
Property	Cherry Lake Road crossing (ICCOCV 18.3)	Likely Flooding	Moderate	High	Consult with Hetch Hetchy water and power.
Property	Cherry Lake Road crossing (FS spur road)	Likely Flooding	Moderate	High	Culvert removal. See Engineering.
Property	Cherry Lake Road crossing (Spur road 1N96CV.30)	Likely Flooding	Moderate	High	Consult with Hetch Hetchy water and power.
Property	Cherry Lake Road crossing (Spur road Example of a small drainage)	Possible failure	Moderate	Intermediate	Consult with Hetch Hetchy water and power.
Property	Cherry Creek Road (Granite Ck ICCOCV 16.11)	Likely Flooding	Moderate	High	Consult with Hetch Hetchy water and power.
Property	Cherry Creek Road mainstem of Granite Creek (ICCOCV 14.40)	Likely Flooding	Moderate	High	Consult with Hetch Hetchy water and power.
Property	Don Holm Powerhouse	Possible Flooding/ Debris Flow	Moderate	Intermediate	Consult with Hetch Hetchy water and power.

180400090601 Upper Middle Tuolumne River

Value (Life/Property/ Resources)	Value At Risk	Probability of Damage or Loss	Magnitude of Consequences	Risk	Treatment
Life / Property	Middle Fork Picnic Site: Toilet and tables	Unlikely flooding	Moderate	Low	None. Check for hazard trees prior to opening.
Life / Property	Middle Tuolumne River Bridge	Unlikely flooding	Minor	Very Low	None.

180400090602 Lower Middle Tuolumne River

Value (Life/Property/ Resources)	Value At Risk	Probability of Damage or Loss	Magnitude of Consequences	Risk	Treatment
Natural Resources	South Fork Campground	Likely transport of hazmat.	Moderate	High	Pump exposed pit toilet and cover pit. Treat hazard trees prior to opening. See Recreation treatment.
Life / Property	South Fork Tuolumne river bridge	Unlikely flooding.	Moderate	Low	None.
Property	San Jose Camp: Structures	Possible Flooding	Moderate	Intermediate	Storm inspection and response
Property	San Jose Family Camp: Amphitheater	Possible Flooding and sedimentation.	Moderate	Intermediate	Consult with camp permittees/care-takers.
Natural Resources	San Jose Camp: Soil and Water Quality	Possible hazmat release from burned tents, trailer, tool shed.	Moderate	Intermediate	Site containment with silt fencing for burned structures.
Property	Yosemite Riverside Inn: Structures	Possible Flooding	Moderate	Intermediate	Contact NRCS.
Property	Spinning Wheel Ranch: Structures	Unlikely Flooding	Moderate	Low	None.
Property	Spinning Wheel Campground	Unlikely flooding.	Minor	Very Low	None.
Natural Resources	Spinning Wheel: Soil and Water Quality from burned pit toilet	Likely Hazmat transport.	Moderate	High	Pump exposed pit toilet waste and cover pit. See Recreation treatment.
Natural Resources	Spinning Wheel: Soil and Water Quality from dump materials.	Likely Hazmat transport.	Moderate	High	Contain dump materials in stream with filter cloth and riprap.
Natural Resources	Spinning Wheel: Soil and Water Quality from chemically treated barriers.	Possible Hazmat transport.	Minor	Low	Remove/dispose burned chemically treated wood. See Heritage treatment.
Natural Resources	Spinning Wheel: Soil and Water Quality from dumped auto.	Unlikely Hazmat transport.	Minor	Very Low.	None.
Natural Resources	Spinning Wheel: Soil and Water Quality from can dump.	Unlikely Hazmat transport.	Minor	Very Low.	None.
Property	Hetch Hetchy Adit	Unlikely to have hazards.	Minor	Very Low.	None.
Property	Sweetwater Campground	Unlikely Flooding.	Moderate	Low.	None.

Value (Life/Property/ Resources)	Value At Risk	Probability of Damage or Loss	Magnitude of Consequences	Risk	Treatment
Life / Property	Private property near Ackerson Meadow: House and Barn. Fence extends across small seasonal drainage that could trap debris.	Possible Flooding.	Moderate	Intermediate	Inform NRCS.
Life / Property	Diamond O Campground: Toilets, tables, building.	Unlikely flooding.	Minor	Very Low	None.
Life / Property	Peach Growers Rec Residence: Cabins	Unlikely flooding.	Moderate	Low	Contact NRCS for other needs (include falling of hazard trees).
Property	Evergreen Lodge	Unlikely flooding.	Moderate	Low	Coordination with State Emergency Assessment Team (SEAT) and Natural Resource Conservation Service (NRCS)
Natural Resources	Bear Gulch Headcut Stabilization Project. Headcut stabilization treatments.	Likely loss of previous headcut stabilization treatments and flooding.	Moderate	High	Strengthen existing headcut treatment and stabilize two headcuts below in gully. Armor site with filter cloth and riprap/woody debris. Removal of hazard trees before implementation.
Natural Resources	Scout Gully Watershed Restoration Project: Gully stabilization treatments and loss of electric fence	Possible loss of previous gully stabilization treatments	Moderate	Intermediate	Coordinate with Range to dispose of battery and replace electric fence if grazing is continued.

180400090701 Upper South Fork Tuolumne River

Value (Life/Property/ Resources)	Value At Risk	Probability of Damage or Loss	Magnitude of Consequences	Risk	Treatment
Property	Harden Flat: Sunset Farms: cottages	Unlikely Erosion.	Moderate	Low	Contact NRCS.
Natural Resources	Ackerson Meadow	Possible increase in erosion at existing meadow headcut.	Minor	Low	None.
Life / Property	Ackerson Meadow: House	Unlikely flooding.	Minor	Very Low	None.
Life / Property	Carlon Trailhead/picnic area: Site also has localized diesel spill that occurred during suppression activities.	Unlikely Flooding/transport of Hazmat	Moderate	Low	Inform Forest of issue.
Property	Evergreen Road bridge	Unlikely flooding.	Minor	Very Low.	None.
Life / Property	Lower Carlon picnic area/Historic structures	Unlikely Flooding.	Moderate	Low	None.

180400090702 Lower South Fork Tuolumne River

Value (Life/Property/ Resources)	Value At Risk	Probability of Damage or Loss	Magnitude of Consequences	Risk	Treatment
Life / Property	Harden Flat: Thousand Lakes campground/transportation	Likely Flooding	Moderate	High	Contact NRCS.
Life / Property	Yosemite Lakes Campground: dam in stream	Possible flooding.	Minor	Low.	None.
Property	Harden Flat: Thousand Lakes water system	Very Likely Sedimentation	Moderate	Very High.	Contact NRCS.
Life / Property	Soldier Creek stream crossing at Harden Flat	Likely failure	Moderate	High.	Clean out culvert and monitor. See Engineering.
Natural Resources	Berkeley Tuolumne Camp: Water quality related to burned structures in/around creek.	Very likely transport of Hazmat.	Major	Very High.	Contact district and permittee to coordinate removal of hazmat.
Property	Camp Tawonga: campground/water system/water quality	Possible Sedimentation	Moderate	Intermediate	Contact NRCS.
Property	USGS Flow Gage Station at Rainbow Pool	Unlikely Flooding	Minor	Very Low.	None.
Life / Property	Lost Claim Campground	Possible Flooding	Minor	Low	None.
Property	Rim of the World Vista Point	Unlikely flooding.	Minor	Very Low.	None.

Value (Life/Property/ Resources)	Value At Risk	Probability of Damage or Loss	Magnitude of Consequences	Risk	Treatment
Life / Property	Unnamed private property: homes	Possible Sedimentation	Minor.	Low	Inform NRCS and owners. Hazard trees appear to have been partially addressed.
Property	Colfax Springs: Private Residences on Forest Rd. 1s66	Unlikely Sedimentation	Minor	Very Low.	None.
Life and Safety	Mine near highway 120, human safety	Possible access/fall into pit	Major	High	Place protective fencing around mine site and post warning sign.

180400090802 Reed Creek

Value (Life/Property/ Resources)	Value At Risk	Probability of Damage or Loss	Magnitude of Consequences	Risk	Treatment
Natural Resources	Water Quality: Burned Feller-buncher. Hazardous-material includes: hydraulic fluid, diesel, battery acid, heavy metals, and plastics.	Possible transport of hazmat.	Moderate	Intermediate	Inform Timber Operator/owner of item. Recommend cleanup of item.
Life / Property	roadway and bridge	Possible Channel Downcutting	Minor	Low	Channel-debris clearing; remove debris from culvert inlet. See Engineering treatment.

180400090803 Middle Clavey River

Value (Life/Property/ Resources)	Value At Risk	Probability of Damage or Loss	Magnitude of Consequences	Risk	Treatment
Natural Resources	Duckwall Lookout: water and soil productivity from burnt structures. Includes microwave dishes, solar panels, and a swamp cooler. Includes plastics and fiberglass.	Unlikely transport of hazmat.	Minor	Very low.	None. Future cleanup to be conducted by Forest.

180400090804 Lower Clavey River

Value (Life/Property/ Resources)	Value At Risk	Probability of Damage or Loss	Magnitude of Consequences	Risk	Treatment
Property	Quinn Ranch	Unlikely flooding.	Minor	Very Low.	None

180400090902 Lower North Fork Tuolumne River

Value (Life/Property/ Resources)	Value At Risk	Probability of Damage or Loss	Magnitude of Consequences	Risk	Treatment
Property	Riverside Picnic: day use area	Unlikely Flooding	Moderate	Low	None.
Property	unnamed ranch	Unlikely Flooding.	Moderate	Low	None

180400091001 Jawbone Creek-Tuolumne River

Value (Life/Property/ Resources)	Value At Risk	Probability of Damage or Loss	Magnitude of Consequences	Risk	Treatment
Life / Property	Lumsden Bridge Campground	Possible Flooding	Moderate	Intermediate	Post warning signs.
Life / Property	Lumsden Bridge	Unlikely Flooding.	Minor	Very Low.	None.
Natural Resources	Alder Crk. Crossing	Likely Road failure, erosion.	Moderate	High	Add diversion potential dip and dip to disconnect road erosion from the crossing. See Engineering.
Property	Kirkwood Powerhouse	Possible Sedimentation	Moderate	Intermediate	Consult with Hetch Hetchy Water and Power
Property	Flume into Kirkwood Powerhouse	Possible Rockfall.	Moderate	Intermediate	Consult with Hetch Hetchy Water and Power
Property	Switch yard near Kirkwood Powerhouse	Possible Flooding.	Moderate	Intermediate	Consult with Hetch Hetchy Water and Power
Life / Property	Joe Walt dispersed camp	Possible Flooding.	Moderate	Intermediate	Close or place warning signs.
Natural Resources	Jawbone Station: water quality	Likely transport of Hazmat from burned structure.	Moderate	High	Install erosion control. Silt fencing 100+ft until further cleanup.
Natural Resources	Meyers Ranch: water quality	Likely transport of Hazmat from burned structure.	Moderate	High	Notify NRCS and owners.
Property	Meyers Corral	Unlikely Flooding.	Minor	Very Low	None.
Natural Resources	Meyers diversion ditch	Likely Erosion and Sedimentation.	Moderate	High	Notify NRCS, owners, and FS District. Look into special uses permit.
Life / Property	Homes Near Drew Meadow/ Gravel Ridge	Unlikely Flooding.	Minor	Very Low	None
Natural Resources	1N04 restored meadow seep	Possible Channel Downcutting	Moderate	Intermediate	Replace protective fencing and barriers. Contact Range.
Natural Resources	Jawbone Creek riparian restoration	Possible Channel Downcutting	Minor	Low	None
Natural Resources	White Fir riparian restoration	Possible Channel Downcutting	Moderate	Intermediate	Additional armor below shotgun culvert. Contact engineering.
Life / Property	Bridge near Kirkwood Powerhouse	Possible Flooding	Moderate	Intermediate	Consult with Hetch Hetchy Water and Power

180400091004 Grapevine Creek-Tuolumne River

Value (Life/Property/ Resources)	Value At Risk	Probability of Damage or Loss	Magnitude of Consequences	Risk	Treatment
Life / Property	Lumsden Put-in: Toilet, trail, LWC	Likely Debris flow/flooding	Moderate	High	Post warning signs.
Life / Property	Lumsden Campground	Unlikely Flooding	Moderate	Low	None.
Life and Safety	1N10	Very Likely Road failure, erosion.	Moderate	Very High.	Close road. Stormproof. Warning signs. Discussed in Engineering report.
Property	Guinn Ranch	Unlikely.	Minor	Very Low.	None
Property	Rogge Ranch	Unlikely	Minor	Very Low.	None
Property	Round Meadow Ranch	Unlikely	Minor	Very Low.	None
Property	Hamby Trailhead	Unlikely Flooding	Minor	Very Low.	None.
Property	Hamby Trail	Likely Trail Incision, loss of tread	Moderate	High	Stormproof and improve drainage.
Natural Resources	Soil Productivity along Ferretti Rd. from Chemical Contamination from burned barriers. Sensitive Plant Area vulnerable to vehicle impacts.	Possible Chemical Contamination and vehicle impacts	Minor	Low	Hazmat cleanup/new barricades. See Recreation treatment.
Life / Property	Residences near Ferretti Road	Unlikely Flooding	Minor	Very Low.	None
Property	Don Pedro Reservoir	Very Likely Sedimentation	Moderate	Very High.	Install Boom, Interagency Coordination

180400080402 Bull Creek

Value (Life/Property/ Resources)	Value At Risk	Probability of Damage or Loss	Magnitude of Consequences	Risk	Treatment
Natural Resources	Pilot Peak Lookout: Soil and water quality. Burned buildings, need silt fencing to prevent transfer of hazmat.	Likely transport of hazmat.	Moderate	High	Install silt fencing for containment of hazmat material.