Canyon Creek Fire
Burned Area Emergency Response
Hydrology and Watershed Specialist Report

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The Canyon Creek Fire was caused by lightning and began on August 12, 2015. As of September 20, 2015, the fire has burned approximately 110,221 acres and is at 95% containment. The fire affected property across several land ownerships (Table 1). Elevation within the burned area perimeter ranges between 3,382ft to 9,042 ft. Moderate and high burn severities tended to occur on steeper slopes. Generally, areas previously burned in recent history experienced lower burn severity or were unburned.

Table 1. Acres burned by land ownership.

Owner	Acres
Bureau of Land Management	2,670
Private Land	16,984
USFS	90566
Total	110,221

This report summarizes the results from the hydrologic assessment of the Canyon Creek Fire in Central Oregon, as part of the Burned Area Emergency Response (BAER) assessment. This report also provides detailed hydrologic analyses conducted for several watersheds. Several Values at Risk (VARs) were identified during aerial and field reconnaissance, fifty-three total. These VARs may include human life, property, roads and trails, municipal watersheds, and Steelhead and Bull Trout Critical Habitat. The watershed above these VARs were delineated (Figures 1-4) and flow analyses were conducted.

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 (Figure 5). BAER team members 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.

Additionally, hydrophobicity tests were conducted in the field within the Canyon Creek Fire to determine the water repellency characteristics of affected soils. Natural repellency (pre-fire) was present due to ash-capped soils. Tests in moderately burned and highly burned areas indicated moderate hydrophobicity.

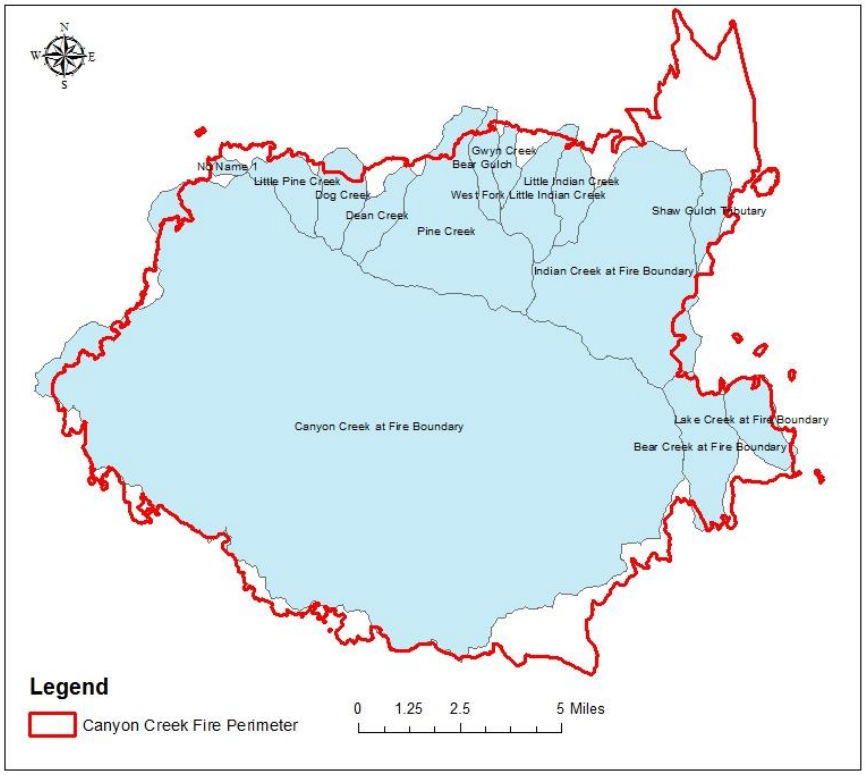

Figure 1. Pour point watersheds affected by the Canyon Creek Fire (1 of 4).

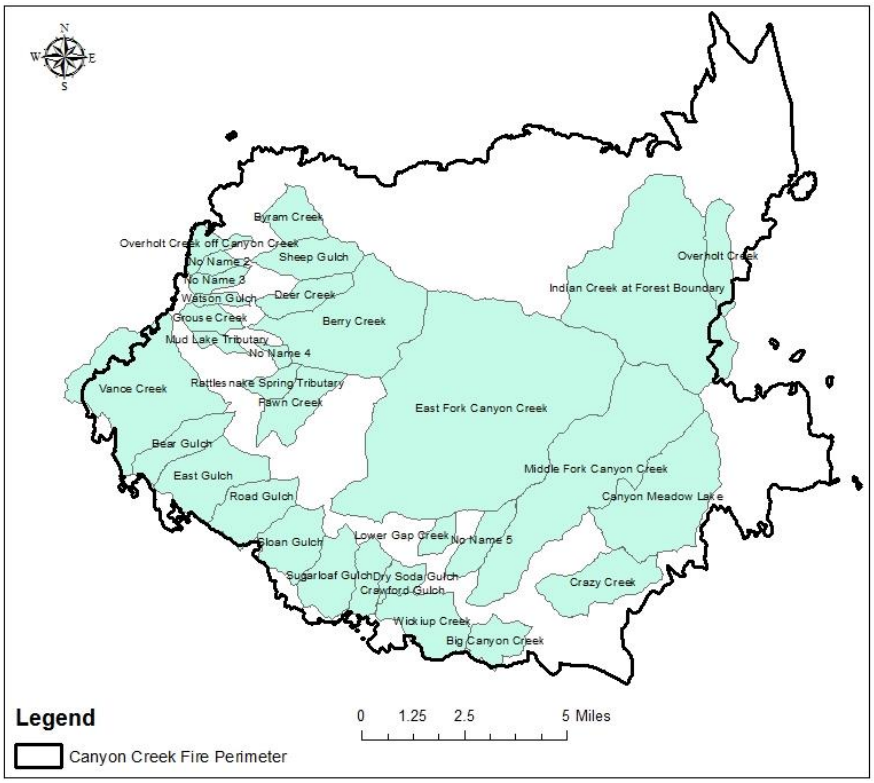

Figure 2. Pour point watersheds affected by the Canyon Creek Fire (2 of 4).

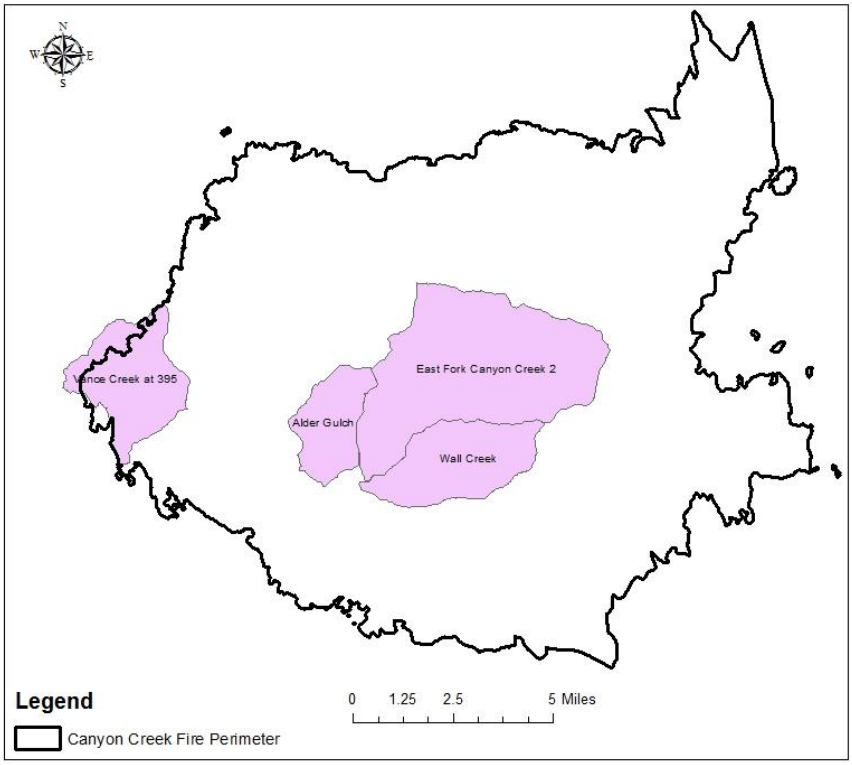

Figure 3. Pour point watersheds affected by the Canyon Creek Fire (3 of 4).

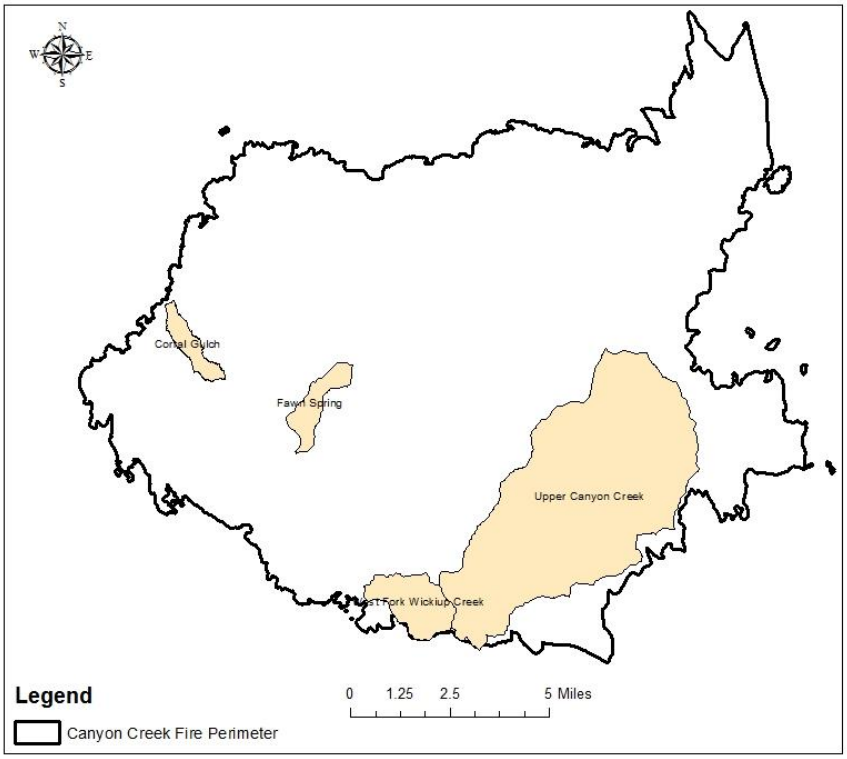

Figure 4. Pour point watersheds affected by Canyon Creek Fire (4 or 4)

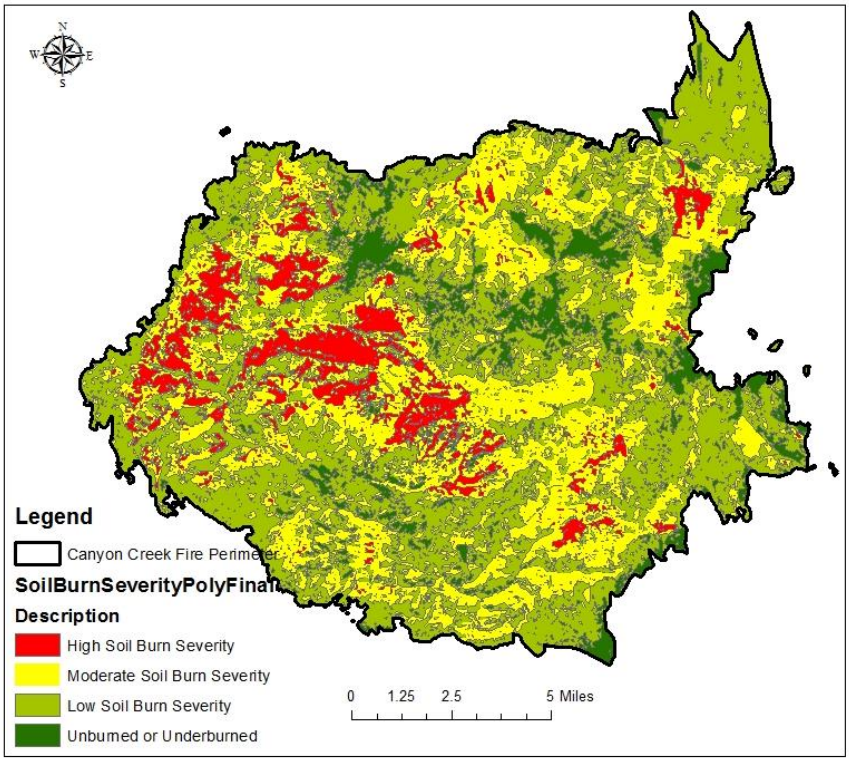

Figure 5. BARC (Burn Severity map) for the Canyon Creek Fire.

Weather and Streamflow Patterns

The Canyon Creek Fire took place within a region that experiences precipitation patterns of snowfall, spring rains, and some summer convective thunderstorms (such as the one that created the fire) (Figure 6).

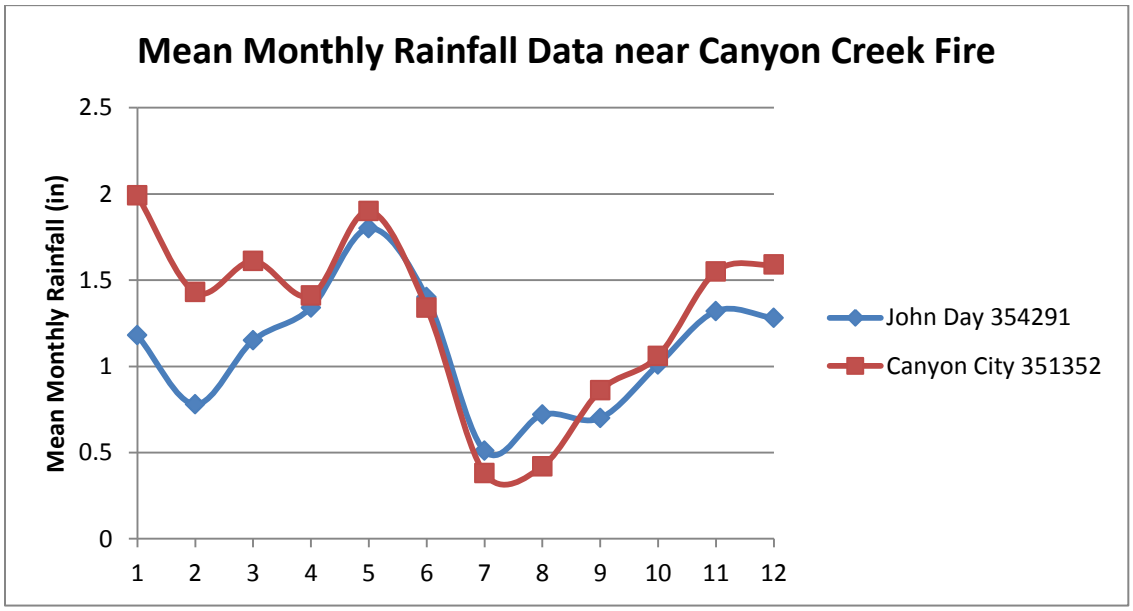

Figure 6. Average monthly precipitation at locations within and around the burned area perimeter
Source: Western Regional Climate Center

Three types of precipitation runoff events can occur in the Canyon Creek Fire area: rainfall from frontal storms moving eastward from the Pacific Ocean, snowmelt (and rain-on-snow), and rainfall from convective storms (Cooper, 2006). Frontal storms affect larger regional areas and last over several days, where the intensities on these storms are low and tend to occur mostly in the winter and spring. The effects of rain-on-snow are similar to a high-intensity rainstorm since they can produce a significant amount of runoff and erosion. These events can have a large effect, depending on the amount of snow melted. Convective events are of short duration and high intensity, occur during the summer months and are also known to result in erosion.

Streamflow patterns were observed with data from Gage No. 14038602 at Canyon Creek near Canyon City (OWRD). The gage is located on Canyon Creek below the confluence with Vance Creek. Average, minimum, and maximum mean daily discharges for the period of record from October 1, 1980 to September 30, 2011 are shown in Figure 7. The highest flows of the annual hydrograph typically occur in the spring months, as a result of spring rains and snowmelt. The annual hydrograph indicates that high flows can occur during the winter months and may be a result of rain-on-snow events.

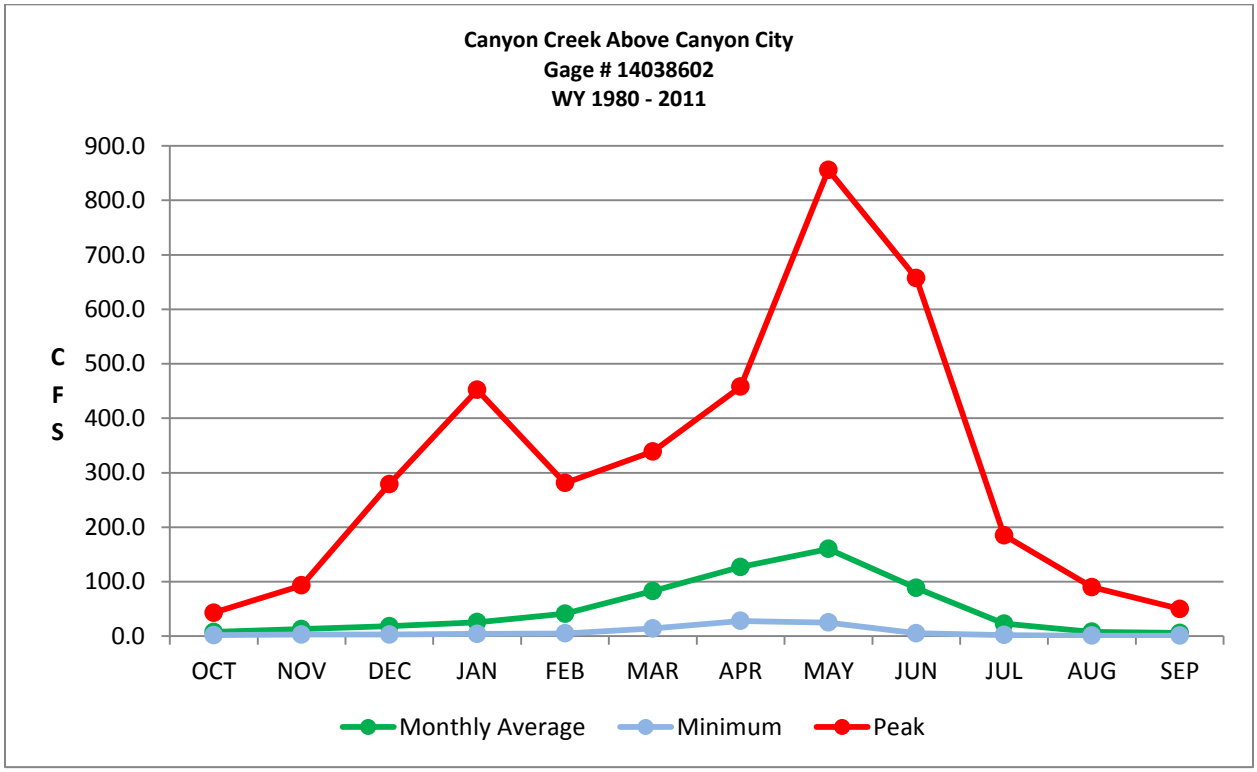

Figure 7. Streamflow patterns from Canyon Creek (Gage # 14038602). OWRD.

To address erosive storms that have a relatively high likelihood of occurring, the 10-year 2-day duration design storm was utilized for analysis of larger watersheds for a winter storm. For smaller, higher elevation watersheds, a convective thunderstorm of 2-year 30-minute duration was used. Limited precipitation storm regressions have been conducted for Central Oregon. Thus, estimates for the design storm were derived from iso-pluvial maps (Miller et al., 1973) and Arkell and Richards (1985). The design storm of 2 years has a 50% chance of occurring in any

given year while the 10-year storm has a 10% chance of occurring in any given year. Anticipated precipitation for the 2-year storm is 0.81 inches and 1.8 inches for the 10-year storm.

Anticipated watershed response

The primary watershed responses of the Canyon Creek 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) flash floods with increased peak flows and sediment deposition. These responses are expected to be most evident during initial storm events immediately after the fire. Thereafter, responses are expected to 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 Canyon Creek Fire is expected to be approximately 5 years. 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 runoff curve number (RCN) model "WILDCAT5" (Hawkins and Greenberg, 1990) was used to estimate pre-fire and post-fire runoff by small watersheds. The model uses NRCS (formerly SCS) Curve Numbers to predict runoff "in a timed pattern from design rainstorms, and uses triangular unit hydrographs to route the rainfall excess to make hydrographs. There is no channel routing involved" (Hawkins and Greenberg, 1990).

Time of concentration (T_c) was calculated with the following equation (Dunne and Leopold 1978):

$$T_c = \frac{\text{Channel length}^{1.15}}{7700*(\text{elevation difference})^{0.38}}$$

Soil types delineated by the Malheur National Forest (1974) and BAER soil scientists were utilized to determine hydrologic soil groups. The hydrologic soil group-burn severity combination was calculated for each watershed and each combination was assigned a corresponding runoff curve number.

The curve numbers utilized in this analysis were derived after consulting multiple sources (Hawkins and Greenberg, 1990; Cerrelli, 2005; Story, 2003; Stuart, 2000; and USDA, 2014). These numbers were modeled with an antecedent moisture condition II or average soil moisture conditions. Hydrologic changes from the loss of soil cover and soil water repellency from burning were modified by increasing the curve number. The curve numbers for each burn severity-hydrologic group combination are shown in Table 2. The soil types were modeled as hydrologic soil groups A, B, C and D. The removal of ground cover and increased hydrophobicity will produce flashier flood response and increased peak flows in the area affected by the Canyon Creek Fire.

Table 2. Curve numbers utilized

	Hydrologic Soil Group			
Burn Severity	**A**	**B**	**C**	**D**
Unburned	36	60	73	79
Low	38	62	75	81
Moderate	65	75	85	90
High	70	80	90	95

These curve numbers along with the acres corresponding with the curve numbers and the projected precipitation received from a 2-year 30-minute storm or 10-year 2-day storm were entered into the Wildcat 5 hydrologic model. The projected runoff identified by the Wildcat 5 model was compared with pre-fire projections to predict the increase in runoff due to the fire (Table 4 and 5).

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 flashy 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. Table 3 show the number of acres affected by the different burn severities within the analysis watersheds.

Table 3. VAR watersheds affected by the Canyon Creek Fire.

Pour Point Names	Total Acres	Unburned	Unburned %	Low	Low %	Mod	Mod %	High	High%
Alder Gulch	2522	96	4	995	39	929	37	502	20
Bear Creek at Fire Boundary	2638	363	14	1792	68	483	18	0	0
Bear Gulch N	893	146	16	236	26	474	53	37	4
Bear Gulch S	1068	2	0	563	53	349	33	154	14
Berry Creek	4371	376	9	1251	29	1065	24	1678	38
Big Canyon Creek	832	29	3	400	48	396	48	6	1
Byram Creek	896	0	0	237	26	333	37	326	36
Canyon Creek at Fire Boundary	69812	4936	7	29633	42	24698	35	10546	15

Canyon Meadow Lake	3953	144	4	2379	60	1193	30	236	6
Corral Gulch	636	1	0	100	16	282	44	254	40
Crawford Gulch	469	8	2	252	54	206	44	3	1
Crazy Creek	1781	39	2	727	41	999	56	16	1
Dean Creek	1210	360	30	757	63	91	7	3	0
Deer Creek	832	13	2	81	10	354	43	384	46
Dog Creek	1418	688	49	683	48	45	3	2	0
Dry Soda Gulch	793	39	5	248	31	438	55	68	9
East Fork Canyon Creek	15830	1744	11	5814	37	5915	37	2357	15
East Fork Canyon Creek 2	11155	1391	12	4146	37	4146	37	1472	13
East Gulch	1972	2	0	1053	53	693	35	224	11
Fawn Creek	1236	7	1	348	28	499	40	382	31
Fawn Spring	842	0	0	298	35	341	41	203	24
Grouse Creek	497	1	0	32	6	114	23	350	70
Gwyn Creek	535	7	1	184	34	339	63	6	1
Indian Creek @ Fire Boundary	10649	2365	22	4241	40	3380	32	663	6
Indian Creek @ Forest Boundary	8368	1945	23	3573	43	2618	31	232	3
Lake Creek @ Fire Boundary	1535	587	38	835	54	104	7	9	1
Little Indian Creek	1154	153	13	543	47	458	40	0	0
Little Pine Creek	1279	99	8	589	46	463	36	128	10
Lower Gap Creek	381	65	17	289	76	27	7	0	0
Middle Fork Canyon Creek	7086	222	3	3257	46	3170	45	437	6
Mud Lake Tributary	277	0	0	124	45	93	34	60	22
No Name 1	2066	7	0	123	6	61	3	3	0
No Name 2	271	0	0	39	14	129	48	103	38
No Name 3	374	0	0	28	8	141	38	205	55
No Name 4	180	0	0	17	10	51	28	112	62
No Name 5	838	52	6	549	66	234	28	3	0
Overholt Creek	1007	351	35	178	18	292	29	186	18
Overholt Creek off Canyon Creek	489	14	3	386	79	75	15	14	3
Pine Creek	6684	1105	17	2221	33	2844	43	514	8
Rattlesnake Spring Tributary	433	0	0	217	50	125	29	90	21
Road Gulch	1448	23	2	1263	87	151	10	11	1
Shaw Gulch Tributary	946	51	5	352	37	504	53	39	4
Sheep Gulch	1254	79	6	362	29	469	37	344	27
Sloan Gulch	1358	53	4	665	49	599	44	41	3
Sugarloaf Gulch	1364	113	8	728	53	523	38	1	0
Upper Canyon Creek	15852	509	3	7523	47	6903	44	917	6
Vance Creek	4764	843	18	1738	36	1073	23	1110	23
Vance Creek at 395	4175	843	20	1618	39	913	22	802	19
Wall Creek	4127	271	7	1277	31	1694	41	885	21

Watson Gulch	231	0	0	7	3	71	31	153	66
West Fork Little Indian Creek	1873	300	16	690	37	833	45	50	3
West Fork Wickiup Creek	1514	76	5	833	55	582	38	22	1
Wickiup Creek	1553	77	5	851	55	603	39	22	1

Table 4 and 5 show predicted pre-fire and post-fire estimates of peak flood flows for 2-year, 30-minute storm and 10-year, 2-day storm, respectively. 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 about a 3-fold increase for the 10-year storm from pre-fire, while the 2-year storm show about a 14-fold increase. The peak flow values highlight the post-fire effects on the Canyon Creek Fire, with the most increase reflected in pour point watersheds 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 short duration high intensity rainstorms.

Table 4. Pre-fire and post-fire streamflow estimates using 2-year return interval and 30-minute duration.

VAR Pour Point Watersheds	Drainage size (mi^2)	2-year, 30-minute storm		Magnitude of Post-Fire streamflow increase (Post-fire/ Pre-fire)	Pre CFS Per Mi2	Post CFS Per Mi2
		Pre-Fire Discharge (cfs)	Post-Fire Discharge (cfs)			
Alder Gulch	3.9	33.3	391.5	11.7	8.5	99.3
Bear Gulch S	1.7	43.3	195.1	4.5	26.0	113.1
Big Canyon Creek	1.3	6.4	57.3	9.0	4.9	44.1
Corral Gulch	1.0	7.0	70.9	10.1	7.0	71.3
Crawford Gulch	0.7	7.4	32.4	4.4	10.1	44.2
Crazy Creek	2.8	3.2	64.3	20.0	1.2	23.1
Dry Soda Gulch	1.2	5.0	104.2	20.7	4.1	84.1
East Gulch	3.1	78.2	361.7	4.6	25.4	117.4
Fawn Creek	1.9	10.0	326.7	32.5	5.2	169.2
Fawn Spring	1.3	8.0	150.5	18.8	6.1	114.4
Grouse Creek	0.8	1.3	117.1	91.5	1.6	150.7
Lower Gap Creek	0.6	17.1	31.6	1.9	28.6	53.1
Mud Lake Tributary	0.4	5.8	41.9	7.2	13.5	97.0
No Name 1	3.2	8.0	21.7	2.7	26.4	72.0
No Name 2	0.4	3.5	34.2	9.8	8.2	81.0
No Name 3	0.6	0.0	23.2	-	0.0	40.0
No Name 4	0.3	2.2	31.1	14.0	7.9	110.0

No Name 5	1.3	6.1	53.1	8.7	4.7	41.0
Overholt Creek off Canyon Creek	0.8	18.1	50.7	2.8	23.7	66.0
Rattlesnake Spring Tributary	0.7	12.1	91.9	7.6	17.9	136.8
Road Gulch	2.3	40.4	93.8	2.3	17.9	41.0
Sloan Gulch	2.1	25.9	163.8	6.3	12.2	77.2
Sugarloaf Gulch	2.1	17.1	98.1	5.7	8.0	46.0
Vance Creek	7.4	77.5	602.2	7.8	10.4	80.9
Vance Creek at 395	6.5	60.0	495.2	8.3	9.2	75.9
Watson Gulch	0.4	0.1	5.1	42.3	0.3	14.0
West Fork Wickiup Creek	2.4	36.6	106.7	2.9	15.5	45.1
Wickiup Creek	2.4	38.6	109.8	2.8	15.9	45.2

Table 5. Pre-fire and post-fire streamflow estimates using 10-year return interval and 2-day duration.

VAR Pour Point Watersheds	Drainage size (mi^2)	10-year, 2-day storm		Magnitude of Post-Fire streamflow increase (Post-fire/ Pre-fire)	Pre CFS Per Mi2	Post CFS Per Mi2
		Pre-Fire Discharge (cfs)	Post-Fire Discharge (cfs)			
Bear Creek at Fire Boundary	4.1	7	20	3	2	5
Bear Gulch N	1.4	15	38	3	10	27
Berry Creek	6.8	71	246	3	10	36
Byram Creek	1.4	16	55	3	12	39
Canyon Creek at Fire Boundary	109.1	661	1997	3	6	18
Canyon Meadow Dam	6.2	39	95	2	6	15
Dean Creek	1.9	17	22	1	9	12
Deer Creek	1.3	24	77	3	19	60
Dog Creek	2.2	13	16	1	6	7
East Fork Canyon Creek	24.7	191	512	3	8	21
East Fork Canyon Creek 2	17.4	128	336	3	7	19
Gwyn Creek	0.8	18	38	2	21	45
Indian Creek @ Fire Boundary	16.6	178	319	2	11	19
Indian Creek @ Forest Boundary	13.1	145	232	2	11	18
Lake Creek @ Fire Boundary	2.4	24	30	1	10	13
Little Indian Creek	1.8	19	40	2	10	22
Little Pine Creek	2.0	20	52	3	10	26
Middle Fork Canyon Creek	11.1	36	129	4	3	12
Overholt Creek	1.6	17	31	2	11	20
Pine Creek	10.4	97	183	2	9	17
Shaw Gulch Tributary	1.5	2	14	6	2	9
Sheep Gulch	2.0	46	91	2	24	46
Upper Canyon Creek	24.8	118	366	3	5	15
Wall Creek	6.4	65	184	3	10	29

West Fork Little Indian Creek	2.9	24	64	3	8	22

Table 6 shows the averaged results of the peak flow analyses for the modeled storms. Figures 8 and 9 graphically show the change from pre-fire to post-fire in relation to each modeled watershed. Figure 10 shows pre and post fire flow for watersheds with larger flow. 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.

Table 4. Hydrologic design factors

A. Estimated Vegetative Recovery Period	5 years
B. Design Chance of Success	80 %
C. Equivalent Design Recurrence Interval	2 years/10 years
D. Design Storm Duration	0.5 hours/ 48 hours
E. Design Storm Magnitude	0.81 inches/ 1.8 inches
F. Design Flow	11.4 cfs/mi^2/10 cfs/mi^2
G. Estimated Reduction in Infiltration	20%
H. Adjusted Design Flow	76.9 cfs/mi^2/23 cfs/mi^2

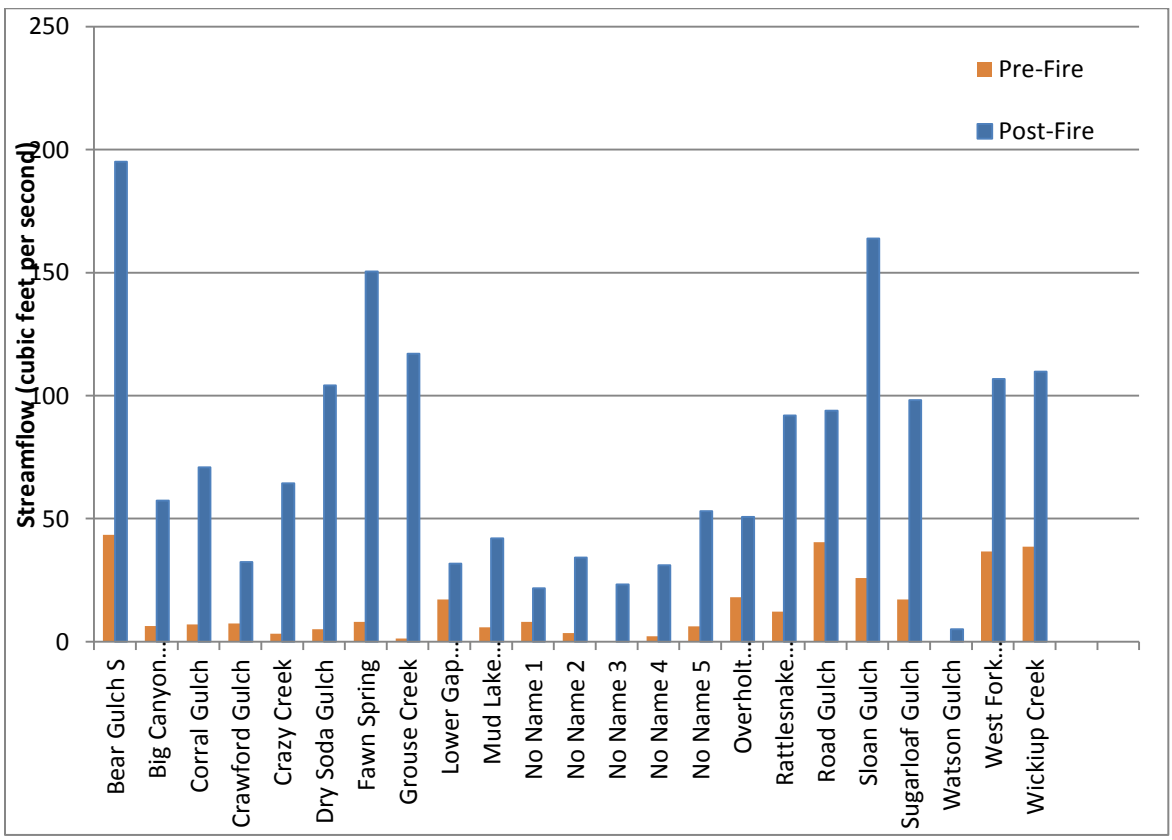

Figure 8 Pre-fire and post-fire streamflow in pour point watersheds 2-year, 30-minute storm.

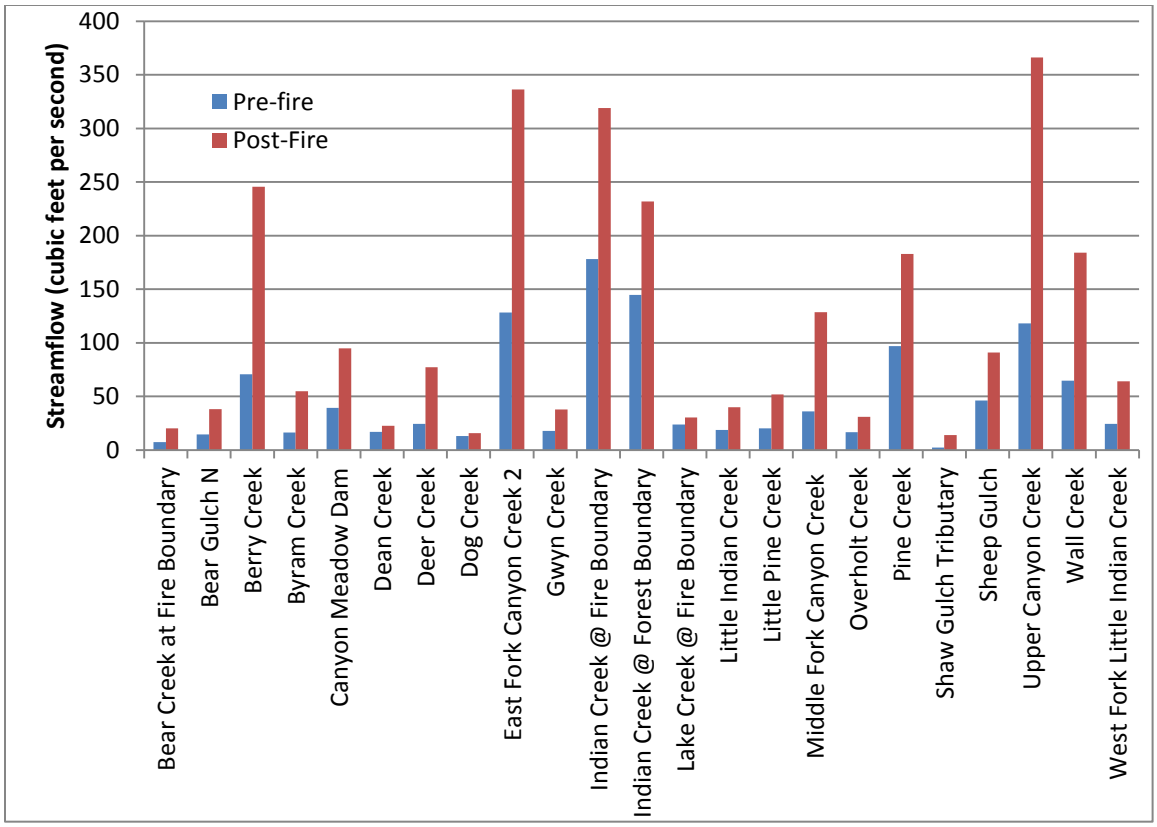

Figure 9. Pre-fire and post-fire streamflow in pour point watersheds 10-year, 2-day storm.

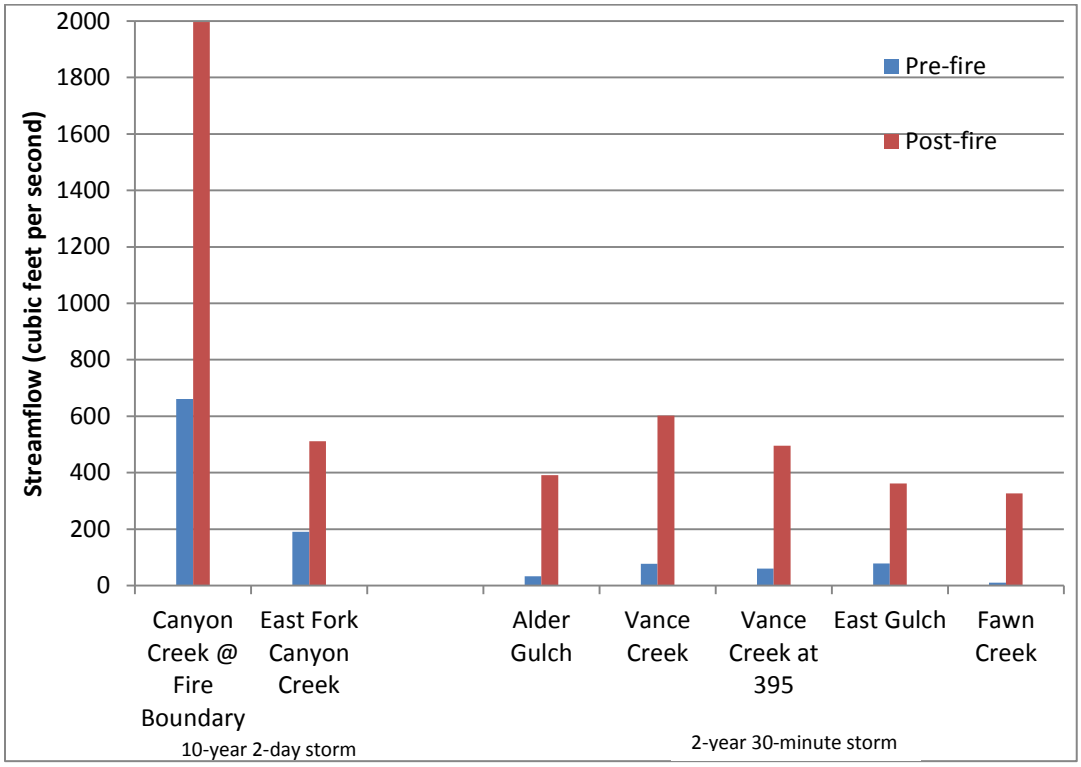

Figure 10. Pre-fire and post-fire streamflow in pour point watersheds with larger flow.

Validation and Discussions

OWRD Comparison

To help validate results from Wildcat5, pre-fire peak flow values were compared using the Oregon Water Resources Department (OWRD) peak discharge auto-delineation program. Peak discharges at unmeasured sites are estimated using regression analyses based on a regionalization of peak discharges at surrounding measured sites. These estimates were compared to the 10-year, 48-hour design flow estimates. Results for most of the pour point watersheds are comparable to pre-fire streamflow estimates and are within an order of magnitude (Table 7). The peak discharge estimations best approximate 10-year 2-day events rather than 2-year 30-minute events and are therefore not used to validate these storm types. It should be noted that the OWRD peak flows are derived from a regression model and may not accurately reflect true stream flows.

Table 7. Comparison of Pre-Fire flows for Wildcat5 and ORWD methods.

VAR Pour Point Watersheds	Wildcat5 10-Year, 48-hour streamflow (cfs)	OWRD 10-year peak flow (cfs)
Bear Creek at Fire Boundary	7	81.2
Bear Gulch	15	39.7
Berry Creek	71	49.8
Byram Gulch	16	23.8
Canyon Creek at Fire Boundary	661	582
Canyon Meadow Lake	39	60.1
Dean Creek	17	27.9
Deer Creek	24	11.7
Dog Creek	13	46.4
East Fork Canyon Creek	191	262
East Fork Canyon Creek 2	128	262
Gwyn Creek	18	36
Indian Creek at Fire Boundary	178	196
Indian Creek at Forest Boundary	178	146
Lake Creek at Fire Boundary	24	91.9
Little Indian Creek	19	27.9
Little Pine Creek	20	40.1
Middle Fork Canyon Creek	36	90.5
Overholt Creek	17	37.1
Pine Creek	97	146
Shaw Gulch Tributary	2	38.5
Sheep Gulch	46	18
Upper Canyon Creek	114	154
Wall Creek	65	58.1
West Fork Little Indian Creek	24	47.4

2011 Canyon City Flood

On May 16, 2011 the gaging station at Canyon Creek (#14038602) recorded a peak flow of 856 cfs (Figure 11). The gage is at an elevation of about 4,000 ft with a drainage area of 86.2 mi^2. Regression equations place this event around a 40-year event. 48 hours leading to this peak flow, precipitation recorded at the Fall Mountain RAWS station (elevation 5,948) totaled 1.7 inches.

Analysis of pour point Canyon Creek at Fire Boundary has a watershed size of 109.1 mi^2 and a pre-fire peak flow of 661 cfs for a 10-year, 2-day storm event (1.8 inches). This modeled storm event seems comparable, within an order of magnitude, to the May 2011 event.

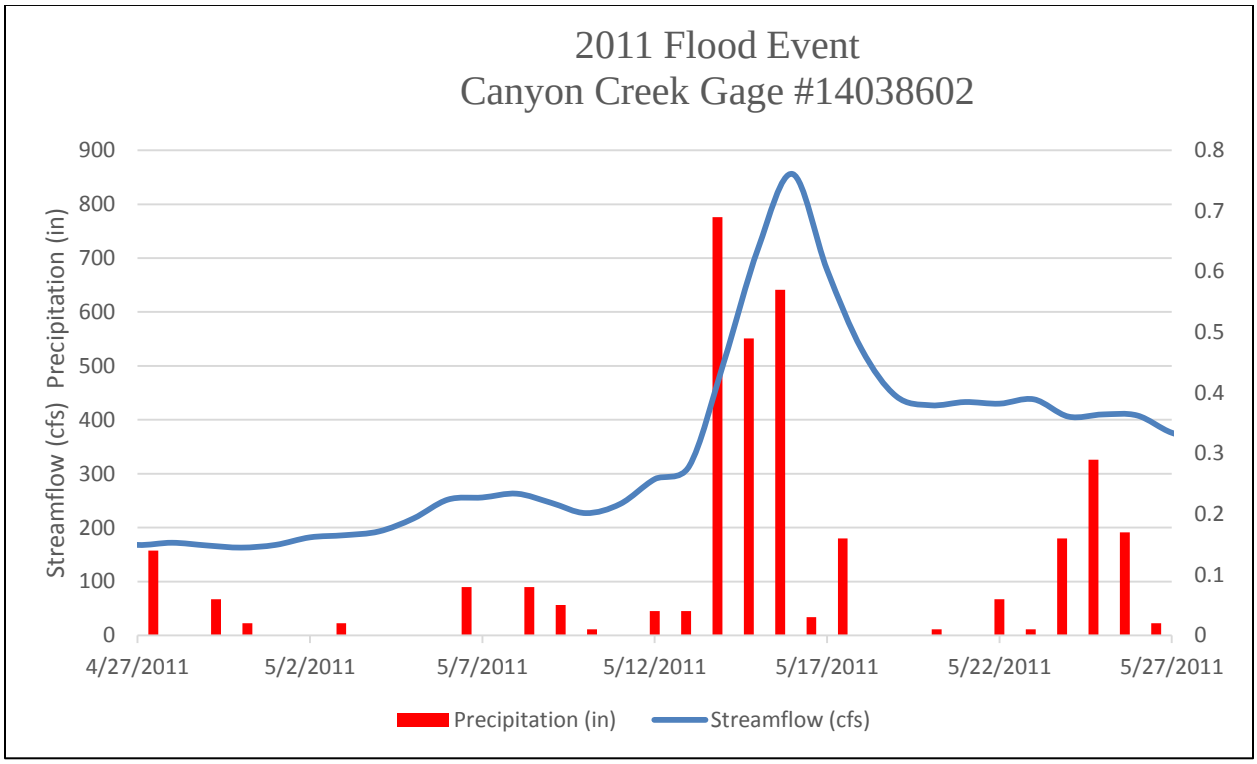

Figure 11. 2011 Flood event at Canyon City, Or.

Canyon Meadow Lake

WEST Consultants, Inc. conducted a hydrologic analysis of the Canyon Creek Meadows Dam and Reservoir. This report analyzed three scenarios: leaving the dam as is, removing the dam and repairing the dam. Dam repairs would maintain the reservoir pool in the spring and summer and maintain a minimum flow of approximately three cubic feet per second. Results of the analysis indicate that modifications to the downstream hydrology of Canyon Creek are greatest immediately downstream of the dam and diminish in the downstream direction. The study also analyzed the ability of the dam to provide flood control for the communities of Canyon City and John Day. Results show flood frequency curves fall within the 5- and 95- percent confidence limits of the existing conditions. This suggests there would be no significant difference for flood control to downstream communities through repairing the dam. This is due to the extent of the

drainage area upstream of Canyon Meadows Dam (6.3 square miles) compared to the area that drains Canyon City (111 square miles).

Risk Assessment

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

Potential Values at Risk from Flooding and Erosion include the following:

- Life/Safety and Private Property at bottom of drainages
- Municipal Watershed for Canyon City (Byram Creek)
- Canyon Meadow Lake
- Roads and Trails
- Critical Habitat for Steelhead and Bull Trout
- Hydrologic Functions
- Soil Productivity

The extensive list and analysis of VARs are compiled within the 2500-8 BAER report for the Canyon Creek Fire.

Treatment Analysis

Identified localized treatment for individual VARs vary. Specific recommended treatments to mitigate altered flows may include: rolling dips, overflow structures, culvert modification, storm inspections and response, trail stabilization, road closures, mitigation for threatened and endangered aquatic species, warning signage, sandbags, securing sources of hazardous materials, and flood warning systems. More details on these treatments can be found in the 2500-8 BAER report for the Canyon Creek Fire.

After assessing the risk associated with each VAR, the feasibility of mitigating this risk with **landscape treatments (mulching)** was analyzed. Slopes less than 20% do not significantly benefit from treatment. Slopes exceeding 50% are also ineffective for successful treatment. For these reasons, only those slopes between 20% and 50% were considered as candidates for treatment.

Additionally, treatment is not considered in unburned or low severity burn areas within the fire perimeter since they still retain canopy and ground cover. Potential treatment polygons were hand drawn and digitalized in GIS. Further refinement of these polygons included acquisition of World View Image and aerial reconnaissance to eliminate areas that have canopy or are too rocky for effective treatment.

Hillslope (mulching) treatments are most effective when the drainage can be treated from the headwaters down, as to not undermine the treatment downstream or downslope. Some of the headwaters within the fire perimeter have treatable slopes, approximately 3,532 acres. High burn severity acres with a mulch application are assumed to react like a moderate burn severity, while proposed moderate burn severity treatment are assumed to react like low burn severity. The soil types were re-modeled in Wildcat 5 with the same hydrologic soil groups A, B, C, and D (Table 2). Table 9 and figure 12 show results of the proposed mulching treatments.

Table 9. Reduction in Peak Flows with mulching treatment

VAR Pour Point Watershed	Drainage Area (acres)	Treatment Area (acres)	% Treated	Design Storm (10-year 48-hour)		
				Post-Fire Discharge (cfs)	Post Treatment (cfs)	Flow Difference (%)
Berry Creek	4371	1158	26%	246	215	-12.56
Canyon Creek at Fire Boundary	69812	2886	4%	1997	1779	-10.89
East Fork Canyon Creek	15830	734	5%	512	498	-2.68
East Fork Canyon Creek 2	11155	478	4%	336	327	-2.73
Indian Creek @ Fire Boundary	10649	436	4%	319	296	-7.08
Indian Creek @ Forest Boundary	8368	82	1%	232	230	-0.82
Overholt Creek	1007	140	14%	31	28	-9.10
Pine Creek	6684	211	3%	183	179	-2.17

Upper Canyon Creek	15852	221	1%	366	360	-1.67
Wall Creek	4127	256	6%	184	179	-2.92
				Design Storm (2-year 30-minute)		
Bear Gulch S	1068	14	1%	195.1	193.3	-0.95
No Name 4	180	117	65%	31.1	21.5	-30.96
Vance Creek at 395	4175	310	7%	495.2	447.7	-9.60
Vance Creek	4764	496	10%	602.2	557.8	-7.38

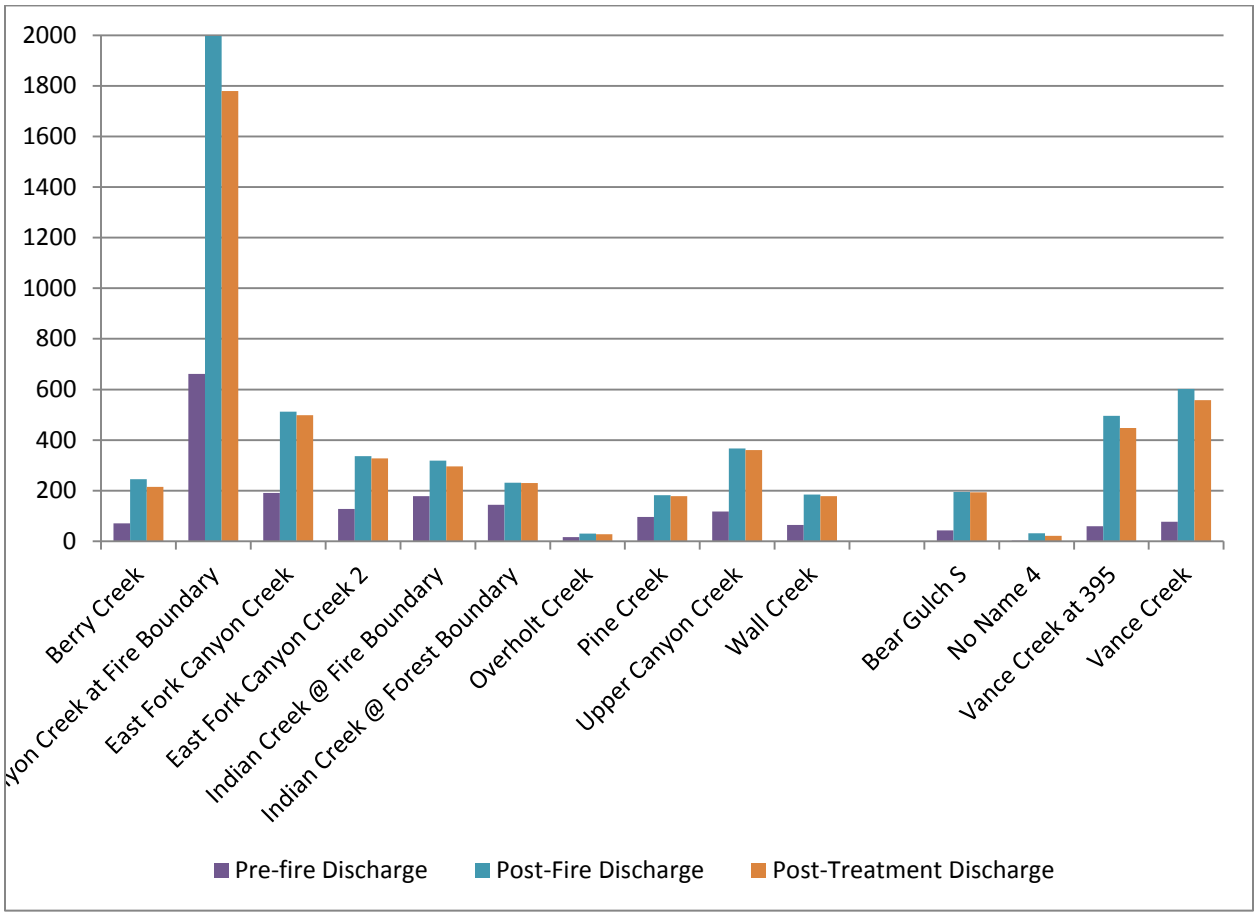

Figure 12. Reduction in Peak Flows Post-Fire with mulching treatments

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