

Hydrology Resource Assessment

Yolla Bolly Complex

Shasta, Trinity, Tehama Counties, California

Shasta-Trinity National Forest

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1. Objectives

The objective of this assessment is to evaluate the effects of the Yolla Bolly Complex Fires on watershed hydrologic processes and function including changes in runoff, soil conditions and watershed response to precipitation events. The assessment follows procedures for assessing burned areas as described in Chapter 2520 of the Forest Service Manual.¹ This assessment focuses on fire-induced changes in hydrologic processes and functions that pose a significant threat to human life and property, and critical natural and cultural resources. Values at risk are identified and a determination as to whether or not an emergency condition exists is made for each value. Treatment recommendations are developed for resources where emergency conditions exist.

The Yolla Bolly Complex burned on both the Shasta-Trinity and Mendocino National Forests. The Mendocino National Forest completed a Burn Area Emergency Assessment for the southern portion of the fire including areas within the South Fork Cottonwood Creek 5th Field Watershed located on the Shasta-Trinity National Forest. This report supplements the existing assessment for the South Fork of Cottonwood Creek and contributes additional information for the Trough Fire which burned to the west of the Yolla Bolly Complex and was not previously analyzed. This assessment does not cover burn areas located outside of the South Fork Cottonwood Creek Watershed on the Mendocino National Forest.

2. Values At Risk

The BAER team identified several categories of issues, threats and resource concerns for the Yolla Bolly Complex. Because the fire burned mainly within the wilderness and in similarly remote areas there were no values at risk associated with life and property other than potential impacts to some Forest system roads. Values at risk that were identified for the South Fork Cottonwood and South Fork Trinity River areas include the following:

¹ USDA Forest Service, 2004. FSM 2500 – Watershed and Air Management, Chapter 2520 – Watershed Protection and Management, Amendment No.: 2500-2004-1. 44 p.

- 1) Facility structures and homes: The Yolla Bolly Complex Fires burned on mostly USFS ownership that had no structures that were at risk from erosion and flooding.
- 2) Roads and Trails: Two roads and numerous trails are now at risk due to increased flows from high soil burn severity with undersized culverts and numerous stream crossings.
 - a) Trough Fire:
 - i) Roads 27N24A and 27N27 are at risk from anticipated increased stream flows from burned hillslopes due to undersized and plugged culverts.
 - b) Vinegar Fire:
 - i) Trail crossings on trails throughout the Vinegar fire could fail due to moderate to high soil burn severity slopes above and anticipated stream flows.
 - ii) Trail stump burn-outs pose extreme safety hazard to foot and horse travelers. These areas also contribute to trail failure due to erosion and sloughing.
 - iii) Hazard trees that could fall on hikers throughout the trails in the hot burned areas and areas that have been reburned (Hermit Fire).
- 3) Threats to Water Quality and Fisheries: With Moderate to high soil burn severity water quality could be compromised due to steep burned soils on many soils that are sandy loam.
 - a) Trough Fire:
 - i) Burned hillslopes of Rainbow Ridge will experience accelerated erosion and sediments that will affect water quality and listed critical fish habitat for Coho and Steelhead in the upper South Fork of the Trinity River due to its direct proximity to the South Fork.
 - b) Vinegar Fire:
 - i) Cumulative sediment introduction into the upper South Fork of Cottonwood Creek that will add to the front country fires effects (Noble, Deerlick, Moon, and the Gulch fires).
- 4) Threats to Soil Productivity/Ecosystem Stability: Areas that have moderate to high soil burn severity are at risk from accelerated erosion and loss of soil stability and soil fertility.
 - a) Trough Fire:
 - i) Severely burned hillslopes of Rainbow Ridge could experience accelerated erosion that could strip topsoil and decrease soil productivity significantly.
 - b) Vinegar Fire:
 - i) Severely burned hillslopes of Sanford, Long, and Syd Cabin Ridges could experience accelerated erosion that could strip topsoil and decrease soil productivity significantly.
- 5) Threats to Cultural Resources: With loss of cover and possible erosion due to the fires, cultural resources are now exposed and are vulnerable to vandalism.
 - a) Trough Fire:
 - i) Trough Ridge heritage site is open and exposed to erosion and vandalism.

- ii) Big Hunter heritage site is open and exposed to erosion and vandalism.
- b) Vinegar Fire:
 - i) West Low Gap heritage site is open and exposed to erosion and vandalism.
 - ii) Chicago Camp heritage site is open and exposed to erosion and vandalism.
- 6) Threats to Wildlife Resources: Burned areas are a loss of habitat and soil productivity and could threaten wildlife viability. No values were at risk for wildlife due to the mosaic nature of the burns. Habitat integrity seemed fine for cover except for the reburn of the Hermit Fire area (west side of the Vinegar Fire).
- 7) Botany (T&E, noxious weeds): Noxious weed issue due to multi-dozer lines on the perimeter of the fires. These areas are prone to noxious weed spreading and introduction throughout the Trough and Vinegar Fires.
- 8) The rest of the fires were evaluated by the Mendocino National Forest for values at risk (Yellow and Grouse).

This assessment evaluates how fire-induced changes in hydrologic processes and function could affect the aforementioned resources of concern.

3. Background Information for Burned Area

The Yolla Bolly Complex began on June 21st, when a large storm system produced over 5,000 lightning strikes in Trinity, Shasta and Tehama Counties causing over 150 fires. The majority of the area burned on the Shasta-Trinity National Forest was located in the headwaters of the South Fork Cottonwood Creek Watershed. A smaller area within the South Fork Trinity River Watershed was burned in the Trough Fire. High and moderate severity burns occurred in drainages tributary to Shell Mountain Creek which is tributary to the upper anadromous reaches of the South Fork Trinity River.

Climate

The climate of assessment area is typified by warm, dry summers and cool wet winters. Substantial variation in temperature and precipitation occurs with elevation. Annual precipitation in the fire area ranges from 50 – 80 inches with precipitation increasing from east to west and with elevation. The majority of winter precipitation fall as snow at elevations above 5,000 feet. Almost all of the precipitation occurs between October and April. During the rainy season precipitation events are dominated by large Pacific storms. Convective storms occur infrequently during the summer months.

Geology

The Yolla Bolly Complex is located within the South Fork Mountain Schist and Franciscan formation, respectively. These formations underlie a wide area along the western and southern boundary of the Shasta-Trinity National Forest.² Refer to the Geology Report for more information.

² USDA Forest Service, 2008. BAER Geologic Assessment, Yolla Bolly Fire Complex.

Hydrology

Hydrologic features found within the Yolla Bolly Complex include the South Forks of both the Trinity River and Cottonwood Creek. HUC 7 watersheds located within the burned area and tributary to these channels are shown in Table 1. The burn area contains approximately 117 miles of ephemeral streams, 97 miles of intermittent streams and 95 miles of perennial streams. Intermittent streams differ from ephemeral streams in that they flow for several months a year while ephemeral streams only flow during precipitation events. The drainage density for the HUC 7 watersheds addressed in this assessment is 2.73 miles of stream channel per square mile.³

HUC 7 Number	HUC 7 Name	Watershed Area (ac)
18010212010102	Shell Mountain Creek	7354
18010212010103	Raspberry Gulch-South Fork Trinity River	9627
18010212010101	Headwaters South Fork Trinity River	10306
18020153040101	Headwaters South Fork Cottonwood Creek	7550
18020153040102	Long Gulch-Tomhead Gulch	5515
18020153040105	Devils Hole Gulch-South Fork Cottonwood Creek	11105
18020153040103	Buck Creek	9796
18020153040104	Harvey Creek	4644
18020153040201	Slides Creek-South Fork Cottonwood Creek	6659

Table 1: HUC 7 Watersheds tributary to South Fork Cottonwood Creek and South Fork Trinity River within Yolla Bolly Complex fire perimeter.

Runoff in both the South Forks of the Trinity and Cottonwood Creek can be characterized as flashy. Precipitation in both basins usually falls as rain during the winter months causing rapid runoff response. Water quality problems within the stream channel network are mainly limited to periods of winter runoff and most commonly associated with increases in turbidity and fine sediment inputs during large winter storms.

The South Fork of the Trinity River originates at an elevation of 7,800 feet and drains an area of 932 square miles. The South Fork Trinity River has a TMDL for sediment. The TMDL was developed to address both natural sources and land-use practices that were accelerating erosion and adversely affecting migration, spawning, reproduction, and early development of cold water fish such as spring and fall run chinook salmon and steelhead trout.⁴ Increased sediment delivery to the South Fork Trinity River is expected to occur as a result of elevated erosion in the Trough Fire area and increased sediment delivery to Shell Mountain Creek (tributary to the South Fork). The TMDL found that sediment delivery to the South Fork averaged 1,053 tons/mi²/yr during the period from 1944 to 1990. Mass wasting activity including landslides and debris flows was the dominant process, contributing 64% of the total sediment yield to the South Fork.

The South Fork of Cottonwood Creek originates at an elevation of 7,900 feet in the Yolla Bolly Mountains. The creek is 56 miles long and drains an area of 397 square miles and is the largest tributary to Cottonwood Creek. Cottonwood Creek is one of the biggest sediment contributors to the Sacramento

³ Drainage densities based on Shasta-Trinity National Forest crenulated stream layer.

⁴ U.S. Environmental Protection Agency, 1998. South Fork Trinity River and Hayfork Creek Total Maximum Daily Loads, 66 p.

River (second only to Cache Creek).⁵ In recent decades water quality in the South Fork of Cottonwood Creek has been impaired by large quantities of sediment originating from a large landslide in the Slides Creek drainage. The Slides Glade landslide which occurred in 1994, has been a large sediment contributor to the creek over the past 15 years and has been responsible for several fish kills. Slides Creek enters the South Fork of the Trinity River immediately below the Yolla Bolly fire perimeter. Portions of the landslide are located within the fire perimeter.

4. Reconnaissance Methods

Reconnaissance of the burn area was conducted using a rapid approach described as a burned area emergency assessment. The burned area emergency assessment is an immediate and rapid assessment of the burned area that is conducted in order to identify post-fire threats, critical values at risk, and need for emergency stabilization measures. The burned area emergency assessment is not a comprehensive evaluation of all fire damage or long-term rehabilitation or restoration needs (FSM 2500, 2004).

Reconnaissance was accomplished by helicopter overviews, driving roads, hiking on trails and cross-country through the burn and interviewing people familiar with the burned area. Specialists that the hydrologists worked with and/or consulted during the field assessments included soil scientists, fisheries biologist, geologist, botanist, archaeologist, GIS specialists and roads engineers.

5. Findings

The Yolla Bolly Complex burned a total of 49,398 acres within portions of the nine HUC 7 drainages evaluated in this report.⁶ BAER soil scientists' determined the burn severity for the fire based on burn intensity information from the BARC and field surveys of the burned area (see Table 2 for definitions).

⁵ CH2MHILL, 2001. Cottonwood Creek Watershed Assessment.

⁶ The fire burned over the ridgetops into 5 other HUC 7 drainages that are not included in this assessment. These drainages were only burned on the top of the ridgelines (i.e. burn acreage was not great enough to justify further assessment).

Term	Definition
Burn Intensity	The intensity of the fire's effect on the watershed vegetation. Low severity indicates ground fire only with only small areas of canopy burned. Moderate severity indicates hot ground fire with frequent scorching of canopy. Tree mortality is high but needles and leaves are not consumed. High severity indicates ground and canopy fire with complete consumption of the forest canopy. Burn intensity is determined based on imagery of the burned area reflectance classification (BARC) as refined by ground surveys.
Burn Severity	Rating of fire impacts on soil hydrologic function (e.g. infiltration capacity, erodability, etc.). Burn severity is determined by refining the burn intensity information from the BARC with additional field surveys. Classes of burn severity are high, moderate, low and unburned.
Watershed Response	A qualitative degree and/or modeled measure of how a watershed will respond to precipitation. Parameters include pre-existing soil moisture; amount of soil cover; amount and distribution of impermeable surfaces (rock outcrop, hydrophobic soils), amount, duration, and intensity of rainfall; watershed area and slope, and lag time between initiation of storm and peak flow runoff. Response is generally measured as peak-flow discharge and sediment yield. Changes in the characteristics of watershed brought about by a fire will increase the efficiency with which waters runs off, thus increasing peak flows and decreasing lag times.

Table 2: Severity and response definitions.



Moderate severity burn area in Deer Creek headwaters – Yolla Bolly Complex.



Trough Fire burn area on Rainbow Ridge.



Intermittent stream channel burned at high severity below Rainbow Ridge – Trough Fire. Channel beds are armored with coarse colluvium and bedrock. All channels draining Rainbow Ridge were incised with steep inner gorge walls that were likely eroding prior to the fire.



Small unnamed perennial stream tributary to Shell Mountain Creek. The Trough Fire burned hot within the riparian corridor. Riparian vegetation resprouting was evident along the entire surveyed channel length.

Watershed Response

Fire effects on runoff were determined by modeling pre-fire and post-fire discharges for HUC 7 watersheds primarily using methods specified in Waananen and Crippen (Waananen and Crippen, 1977). Burn severity was stratified into 5 categories (high, moderate, low, very low/unburned, unburned) for each HUC 7 watershed (Table 3). Pre-fire and projected runoff data for HUC 7 watersheds in the South Fork Cottonwood Creek and South Fork Trinity River that were burned in the Yolla Bolly Complex are shown in Table 4. Increases in runoff were assumed to be due to hydrophobic soils and the loss of vegetation and ground cover (i.e. interception, evapotranspiration, ground cover storage). Elevated streamflows can be expected to occur in the burned watersheds, with greater flow increases in those drainages having higher percentages of high burn severity. Hydrophobic soils occurred on a very small percentage of the burned area and did not play a significant role in increasing runoff at the HUC 7 level.

Projected flow increases resulting from increases in runoff from the burn areas are shown in Table 4. Projected runoff increases for a 2-year recurrence interval storm ranged from a low factor of 2.1 in the Raspberry Gulch/S.F. Trinity drainage to a high factor of 2.7 in the Long Gulch - Tomhead Gulch drainage.⁷

Information on potential runoff and erosion rates was assessed in relation to burn severity and to values at risk in order to determine if a watershed emergency existed for water quality and fisheries resources. The assessment found that high and moderate severity burn areas posed a low risk to water quality and fisheries in the South Fork of Cottonwood Creek. Information from field reconnaissance and burn severity mapping indicated that while the fire had burned hot in some areas of the Yolla Bolly Wilderness the overall burn pattern was patchy resulting in large areas of unburned or low severity burns interspersed with moderate and high severity areas. High severity burn areas were generally located on

⁷ Flow factors represent increases in runoff within fire perimeter only.

upper slopes or ridgetop locations. Large areas of chaparral on the lower slopes of south aspects adjacent to the South Fork of Cottonwood Creek burned at moderate severities. These areas do not appear to have been forested in the past and are likely adapted to frequent fire regimes. Elevated erosion levels can be expected from chaparral areas that burned at moderate severity, however erosion rates should decline gradually as the chaparral plant community becomes reestablished. The BAER report for the Mendocino found that sedimentation effects from the Yolla Bolly fires were expected to be minor and localized and that the increased inputs of sediment would fall within the natural range of variability for the South Fork Cottonwood Creek Watershed.⁸ Furthermore it was also noted that the primary sediment contributor to the South Fork of Cottonwood Creek in recent decades has been Slides Creek which enters the South Fork immediately below the burn area. Slides Creek continues to deliver large quantities of sediment to the South Fork during the rainy season. Emergency treatments would have a low likelihood of having substantial benefits to water quality in the South Fork of Cottonwood Creek downstream of the Slides Creek confluence.

The assessment determined that high and moderate severity burn areas had the potential to increase sediment delivery to Shell Mountain Creek and the South Fork of the Trinity River. Field reconnaissance of tributaries to Shell Mountain Creek located on Rainbow Ridge indicated that the hillslopes and inner gorge areas burned hot and that considerable erosion could occur. Natural erosion processes were active within inner gorge areas, shown in red in Figure 1, prior to the fire. The channel network on Rainbow Ridge is very steep and the channels are already loaded with large amounts of colluvial material. It is likely that much of this material will be mobilized during the upcoming winter. The potential for sediment movement for the Rainbow Ridge tributaries as well as Shell Mountain Creek is shown in Figure 2. In contrast to the Rainbow Ridge channel network the larger tributaries to Shell Mountain Creek have much lower channel gradients ranging from 4-8% and will likely contain coarser sediments from upstream areas. However, the confluence of Shell Mountain Creek with the Trinity River is less than one mile below the burn area and there is a high probability that sediment originating from the burn areas will enter the South Fork. Refer to the Geologic Assessment for the Yolla Bolly Complex for more information on debris flow processes and potentials for the Trough Creek area.⁹



Old debris flow deposit on low gradient reach of unnamed tributary to Shell Mountain Creek within the Trough Fire burn area. This deposit was likely caused by a debris jam that formed in the bedrock constricted channel reach shown in the above right photograph.

⁸ USDA Forest Service, 2008. Initial FS-2500-8 for Yolla Bolly Complex. 10 p.

⁹USDA Forest Service, 2008. BAER Geologic Assessment, Yolla Bolly Fire Complex.

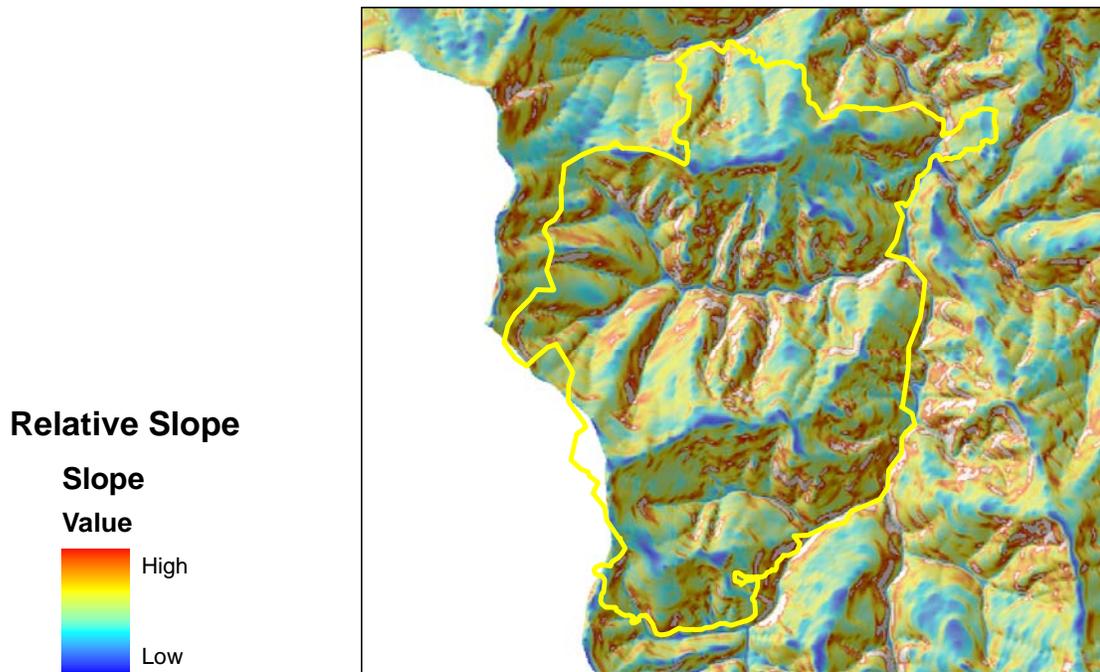


Figure 1: Relative slope map for Trough Fire area. Inner gorge walls shown in red are very steep (>65% slope) and will likely deliver substantial amounts of colluvial material to channels in areas that burned at high and moderate severity.

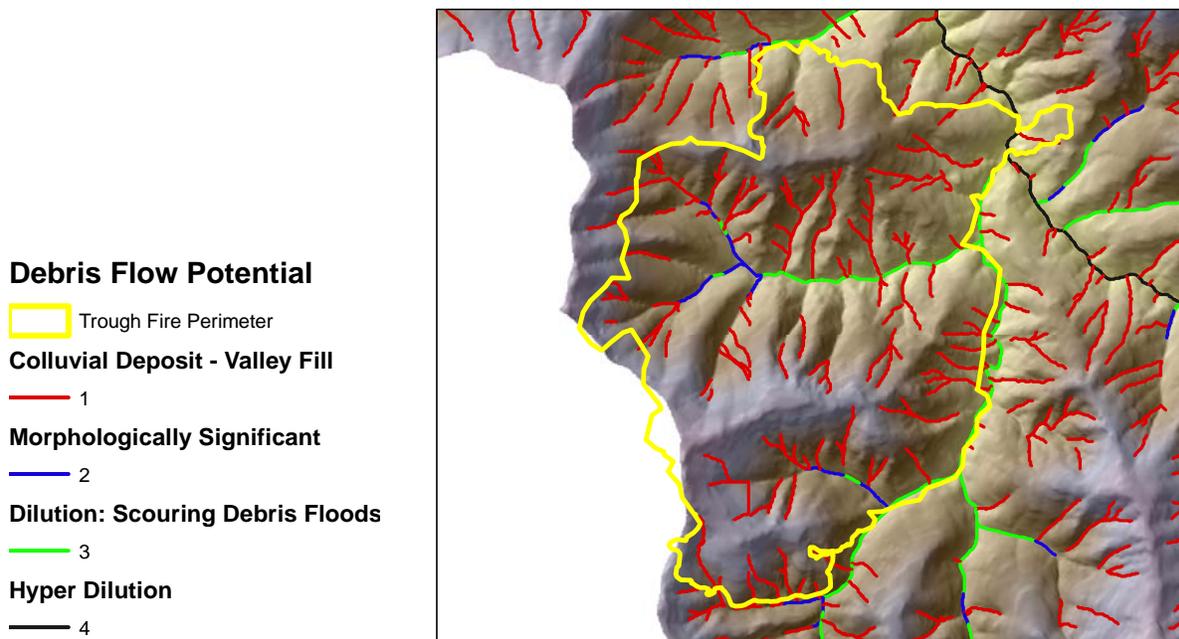


Figure 2: Debris flow impact potential and attenuation for channels draining Trough Fire area.

HUC 7 name	HUC 7 Area (ac)	% Burned by HUC 7	% High	% Mod	% Low	% Unburned Very Low	% Unburned (out of fire perimeter)
Shell Mountain Creek	7354	44%	3%	17%	16%	8%	56%
Raspberry Gulch-South Fork Trinity River	9627	4%	0%	0%	1%	3%	96%
Headwaters South Fork Trinity River	10306	60%	1%	7%	35%	17%	40%
Headwaters South Fork Cottonwood Creek	7550	90%	3%	30%	40%	17%	10%
Long Gulch-Tomhead Gulch	5515	99%	7%	35%	43%	14%	1%
Devils Hole Gulch-South Fork Cottonwood Creek	11105	90%	3%	23%	43%	20%	10%
Buck Creek	9796	100%	0%	17%	54%	29%	0%
Harvey Creek	4644	99%	0%	10%	52%	37%	1%
Slides Creek-South Fork Cottonwood Creek	6659	44%	2%	14%	19%	9%	56%

Table 3: Burn severity for HUC 7 watershed in Yolla Bolly Complex (calculated for entire HUC 7 area).

HUC 7 name	Pre '2-yr Qp (cfs)	Pre '10-yr Qp (cfs)	Post 2-yr Qp (cfs)	Post '10-yr Qp (cfs)	Post '2-yr Peak Increase x normal	Post '10-yr Peak Increase x normal
Shell Mountain Creek	351	932	951	2284	2.7	2.5
Raspberry Gulch-South Fork Trinity River	57	157	121	333	2.1	2.1
Headwaters South Fork Trinity River	595	1596	1353	3510	2.3	2.2
Headwaters South Fork Cottonwood Creek	652	1723	1671	4072	2.6	2.4
Long Gulch-Tomhead Gulch	422	1114	1125	2703	2.7	2.4
Devils Hole Gulch-South Fork Cottonwood Creek	813	2132	2017	4942	2.5	2.3
Buck Creek	763	2037	1763	4517	2.3	2.2
Harvey Creek	356	972	792	2109	2.2	2.2
Slides Creek-South Fork Cottonwood Creek	227	624	586	1486	2.6	2.4

Table 4: Pre-fire runoff and post-fire predicted flows for HUC 7 watersheds in Yolla Bolly Complex (calculated for HUC 7 area within fire perimeter only).

6. Treatment Recommendations for Water Quality and Fisheries Resources

1. Road Treatments

Treatment: Improve road drainage in Trough Fire area. Replace plugged and damaged culverts with functional culverts. Upsize culverts where necessary. Maintain and add drainage dips to improve road drainage for roads located within or below high severity burn areas. Use storm patrols to monitor undersized pipes located in moderate and high severity burn areas where no culvert upgrades are planned and access can occur safely.

Rationale: The Shasta-Trinity National Forest Land and Resource Management Plan states that all culverts and bridges should be sized to convey the flow of a 100-year flood event and associated bedload and debris. The BAER team identified several roads with undersized and blocked culverts and drainage issues located within and below areas of the complex that burned at moderate and high severity. Treatments were recommended when it was determined that failure of the road drainage systems could adversely affect values at risk including anadromous fisheries, water quality and soil productivity.

2. Hillslope Treatments

Treatment: Mulch approximately 230 acres of high severity burn areas in the Trough Fire area.

Rationale: High severity burn areas have the potential to erode and transport large quantities of sediment into stream channels tributary to the South Fork Trinity River. The BAER team identified hillslope mulching needs in areas where they determined that elevated erosion and sedimentation could impact values at risk including anadromous habitat, resident trout habitat, and soil productivity. High severity areas were further stratified by slope to identify the areas that were suitable for mulching (i.e. hillslopes with slopes less than 60%).

7. Monitoring Recommendations

- Monitor the effectiveness of treatments and no treatments to determine overall effectiveness of BAER rehabilitation efforts.

BAER treatments for the Yolla Bolly Complex have been identified based on the determination that an emergency situation exists for individual or multiple resource values. It is recommended that post-treatment monitoring occur for two purposes:

- a. Determine effectiveness of BAER treatments in controlling sediment and runoff and reducing or eliminating impacts to values at risk within the Trough Fire burn area.
- b. Determine if treatments were identified correctly by assessing the condition of watersheds where no treatments were recommended and comparing the treated and untreated areas. It is recognized that this activity cannot be funded by BAER, however this type of monitoring is needed to improve understanding of how treatments, or no treatments effect watershed functions and values. Improving our understanding of how untreated areas respond to fall and winter storms should also improve our ability to prescribe appropriate treatments in the future.

8. References

CH2MHILL, 2001. Cottonwood Creek Watershed Assessment.

USDA Forest Service, 2004. FSM 2500 – Watershed and Air Management, Chapter 2520 – Watershed Protection and Management, Amendment No.: 2500-2004-1. 44 p.

USDA Forest Service, 2008. Initial FS-2500-8 for the Yolla Bolly Complex. 10 p.

U.S. Environmental Protection Agency, 1998. South Fork Trinity River and Hayfork Creek Total Maximum Daily Loads, 66 p.

US Geological Survey. Waananen, A.O., Crippen, J.R. 1977. Magnitude and frequency of floods in California. Water Resources Investigations 77-21. 96 p.

Western U.S. Precipitation Frequency Maps for Northern California, NOAA Atlas 2 published in 1973. <http://www.wrcc.dri.edu/pcpnfreq.html>.

9. Appendix A. Hydrologic Design Factors used in FS-2500-8

The hydrologic design factors developed for this analysis were completed for the initial FS-2500-8 by personnel on the Mendocino National Forest.

- A. Estimated Vegetative Recovery Period: A recovery period of approximately **7 years** was selected for areas burned at high and moderate intensity. This value represents the number of years of vegetative recovery that will have to occur before early seral stage plant communities become effective in reducing hillslope erosion in areas that burned at moderate and high intensity.
- B. Design Chance of Success: The design chance of success ranges from 60 to 95 percent depending on the type of proposed treatment and the resource being evaluated. Hillslope mulching treatments proposed for the Trough Fire area have a 95 percent probability of success for prevention of surface erosion on areas where mulch is applied. The potential for these treatments to reduce sediment inputs to Shell Mountain Creek and the South Fork Trinity River is less (60%) because it will not be possible to treat all of the ground. Road treatments are small in scale and have very low risk associated with them. Road treatments will have a very high probability of success (95%) in controlling runoff from high severity areas.
- C. Equivalent Design Recurrence Interval: The **2 and 10 year recurrence interval** storms were chosen for flow calculations.
- D. Design Storm Duration: A design storm duration of **6 hours** was chosen for watersheds affected by the Yolla Bolly Complex. Large winter storms with durations of 1-3 days have the greatest potential to cause peak flows in the Coastal Ranges of Northern California, however Fall events may bring rain to high elevations where the majority of the high burn severity areas are located and pose a greater risk for runoff induced impacts from the burn areas.
- E. Design Storm Magnitude: The 2 year, 6 hour rainfall event was determined to be **2.2 inches**. The 10 year, 6 hour rainfall event was determined to be **2.8 inches**. Both values were derived from the Western U.S. Precipitation Frequency Maps for Northern California (NOAA Atlas 2 published in 1973).

- F. Design Flow: The pre-event design flow was calculated for the burned area within each HUC 7 watershed according to methodology developed by Waananen and Crippen, 1977. The standard regression equations were used due to high variability in results using the formula associated with known gaging stations. The total pre-fire runoff per unit area from a 2-year recurrence interval storm was calculated to be **72 cubic feet per second per square mile** for the South Fork Trinity River and **52 cubic feet per second per square mile** for the South Fork of Cottonwood Creek.
- G. Estimated Reduction in Infiltration: The reduction of infiltration based on the amount of hydrophobic soil in high severity burn areas was too small to be measurable and is not factored into the flow analysis.
- H. Adjusted Design Flow: The adjusted design flow was calculated based on the reduction of infiltration from both high and moderate intensity burn areas. Increases in runoff were generally very low due to the small amount of total watershed acreage affected by high and moderate severity burns. The total post-fire runoff in response to a 2 year recurrence interval storm was calculated to be **170 and 129 cubic feet per second per square mile** for the South Fork Trinity and South Fork Cottonwood Creek watersheds, respectively. Comparison of pre and post-runoff values indicates that runoff in the South Fork Trinity River and South Fork Cottonwood Creek drainages will increase by factors of 2.4 and 2.5, respectively.