Resource Specialty: Hydrology
Fire Name: Bagley, Shasta Trinity National Forest
Incident #: CA-SNF-002744
Month and Year: September, 2012
Author(s) Name and Home unit Name: Jules Riley, VMS Enterprise Unit

Potential Values at Risk (identified prior to the on-the-ground survey)

Potential values at risk resulting from fire-induced changes hydrologic and geologic processes and function that pose a threat to values as a result of the Bagley Fire were identified. Hydrologic and geologic hazards include water quality, flooding, and debris flows. Values include the health and safety for people, infrastructure including private residences, PG&E facilities, campgrounds, roads and bridges, and biologic values such as fisheries, wildlife, and botanical resources. Values may be located within and downstream of the fire perimeter. The assessment is a two dimensional matrix that considers both the magnitude of potential effect and the probability of occurrence to determine the significance of each risk. Risks that involve potential threat to values are interspersed throughout all three larger watersheds affected by the fire (McCloud River, Pit River, and Squaw Creek).

Initial Concerns Considered in Analysis

- Threats to human health and life within and downstream of the burned area
- Threats to structures, roads and other improvements within and downstream of the burn area
- Threats to Forest sensitive species, and archaeological sites
- Threats to water quality and soil productivity

Values At Moderate – Very High Risk

The BAER team identified several categories of issues, threats and resource concerns resulting from the Bagley Fire. Those considered to pose an emergency because of changed hydrologic and geologic conditions are identified below. The fire burned in a remote area that is sparsely populated. Values that were assessed as moderate to very high risk that may be exacerbated by changes to hydrologic function are listed below:

1) Private residence: Residences exist on floodplains along Squaw Creek, McCloud River, and Clairborne Creek below the Bagely Fire. Discharge from the drainages above the residences was modeled to increase by a factor of two for a ten-year storm for Squaw and Claiborne Creeks. The potential for debris flows has also increased. While flooding of these areas is not considered probable, not enough information is available to determine that there is no risk.

2) Roads and Trails: Numerous roads and three motorized trails are now at risk due to increased flows from high and moderate soil burn severity areas upslope.

a) Roads:
   i) Multiple roads are at risk from anticipated increased stream flows from burned hillslopes due to undersized and/or plugged culverts and inadequate design/maintenance of road drainage.
   ii) Signing for hazards and closure are needed to alert the public and effectively close roads. Previous barriers have been damaged by fire, and others need fortification after vegetation has been consumed.

b) Trails (Bagley 35N46, Garden Ridge 46N40, and 37N15Y, Squaw Creek):
   i) Stream crossings on trails could fail due to moderate to high soil burn severity slopes above and anticipated elevated 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.
   iv) Snags that will fall on the trail will likely cause user-created re-reoutes that have high potential to cause resource damage from accelerated erosion. These fallen trees may also cause safety issues to trail issues by blocking trails.

3) Threats to Water Quality and Aquatic Species (Fisheries and Amphibians): Accelerated erosion and increased runoff will likely result in increased sediment transport through the stream network. Areas impacted from moderate and high soil burn severity have greater likelihood of impacting water quality. Increased sediment delivery to channels and increased runoff both have potential to impact aquatic habitat. Other potential impacts to water quality include changes to water chemistry such as pH, nitorgen, and phosporous.

   a) Squaw Creek and and tributaries:
      i) Substantial portions of the drainages in Upper and Middle Squaw Creek subwatersheds sustained moderated and high burn severities. The burned area is characterized by steep slopes and and soils susceptible to erosion and mass wasting events.

   b) McCloud River Tributaries:
      i) Areas within drainages and sub-drainages sustained moderate and high severity burn from the Bagley Fire. Areas of concern are contiguous sections that burned hot, especially those in proximty to stream channels.

   c) Iron Canyon Creek and other Pit River tributaries:
      i) Substantial portions of the drainages in the Iron Canyon subwatersheds below Iron Canyon Reservoir sustained moderate and high burn severities. The burned area is characterized by steep slopes and and soils susceptible to erosion and mass wasting events. Streamflow in Iron Canyon Creek is substantially reduced from historic levels by PG&E as part of the McCloud Pit Project. Field reconnaissance indicated that Iron Canyon Creek substrate is embedded. The increased erosion without flushing flows may further degrade aquatic habitat.

4) Botany (T&E, noxious weeds): Noxious weed issue likely due to multi-dozer lines on the perimeter of the fires. These areas are prone to noxious weed spread and introduction

throughout the Bagley Fire. Increased erosion and surface runoff may faciliate the spread of weed seed sources.

5) Floating debris in Shasta Lake: Large woody debris recruitment into Squaw Creek and, to a lesster extent, McCloud River is likely to substantially increase. The amount of floating debris in Shasta Lake will consequently increase as the wood is transported through the stream network. The floating debris poses a safety risk to boaters.

6) 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.

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

I. Background Information for Burned Area

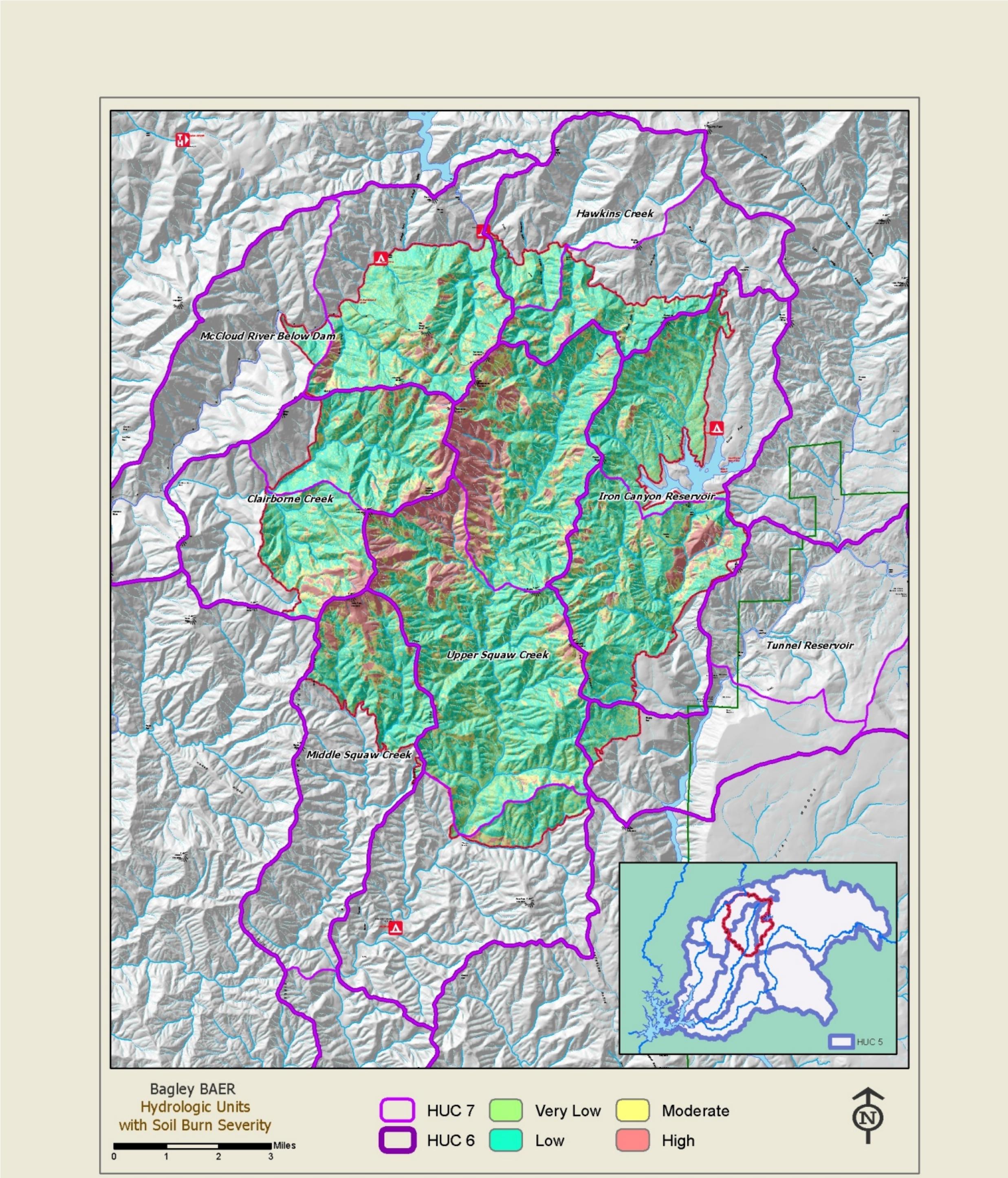
The Bagely Fire began on Saturday, August 18th from a lightning strike. The majority of the area burned on the Shasta-Trinity National Forest was located in the headwaters of the Squaw Creek Watershed and drainages tributary to the McCloud River between McCloud Reservoir and Shasta Lake. A smaller area tributary to the Pit River that borders the north, west, and south perimeters of Iron Canyon Reservoir was burned in the Bagely Fire. High- and moderate-severity burns occurred in several sub-watersheds. The largest areas of high and moderate intensity occurred in the Squaw Creek sub-watersheds.

Climate

The climate of the 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 70 to over 80 inches. The highest precipation occurs in the Upper Clairborne, West and North Forks Squaw, and Jessie Creek drainages, all of which experienced high-severity burn conditions. The majority of winter precipitation occurs as rain, although snow frequently falls at elevations above 4,000 feet. Almost all of the precipitation occurs between October and April and is subject to rain on snow events. During the rainy season precipitation events are dominated by large Pacific storms. Convective storms occur infrequently during the summer months.

Geology

The Bagely Fire is located within the Eastern Klamath Mountains and the Western Cascades. These formations underlie a wide area along the eastern boundary of the Shasta-Trinity National Forest. Refer to the Geology Report for more information.



Hydrology

Hydrologic features found within the Bagley Fire include tributaries to the McCloud River, Pit River, and Squaw Creek. The thirteen drainages (HUC 7) located within the burned area and tributary to these channels are shown in Table 1. The burn area contains approximately 1330 miles of mapped ephemeral streams, intermittent streams and 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 9 miles of stream channel per square mile.[1]

Table 1. HUC 7 drainages tributary to McCloud River, Pit River and Squaw Creek within the Bagley Fire burned area

HUC 7 Number	HUC 7 Name	Watershed Area (ac)
18020003090701	Iron Canyon Reservoir	7145
18020003090702	Iron Canyon	7290
18020003090804	Pit 5 Powerhouse	5266
18020003110101	Jessie Creek-Horse Creek	7125
18020003110102	West Fork Squaw Creek-Modin Creek	10303
18020003110103	East Fork Squaw Creek-Hoffmeister Creek	9392
18020003110201	North Fork Squaw Creek-NE	8877
18020004040101	Upper Hawkins Creek	5605
18020004040102	Lower Hawkins Creek	5797
18020004040201	Upper Claiborne Creek	4545
18020004040202	Lower Claiborne Creek	5671
18020004040301	Ah-Di-Na	8457
18020004040302	Bald Mountain Creek-Hat Mountain Creek	8624

The burned drainages can be characterized as having moderate to high runoff potential. Steep slopes, soil types, drainage shape, and abundance of rock outcrops all contribute to rapid hydrologic reponse. Surface runoff reaches the stream quickly. Water quality within the stream channel network is generally considered good and concerns are mainly limited to periods of winter runoff and are most commonly associated with increases in turbidity and fine sediment inputs during large winter storms.

The highest elevation within the Bagley Fire is the summit of Shoeinhorse Mountain (5303 feet), which is highest point of the ridge forming the boundary between McCould River and Squaw Creek Watersheds. The eastern boundary of the Bagley Fire includes the Iron Canyon Reservoir and Tunnel Reservoir sub-watersheds that drain into the Pit River. These three streams comprise the major streams affected by the Bagley Fire and are three of five major tributaries to Shasta Lake Reservoir. The Iron Canyon Reservoir borders a segment eastern boundary of the Bagely Fire. Turbidity in Shasta Lake is episodic and occurs asa a result of scouring from wave action and sediment from spring and storm runoff.

Fire History

Although large fires have historically occurred in proximity to the Bagely Fire, fires larger than 100 acres are notably absent in the last 70 years. The Shasta-Trinity National Forest fire history documents only three fires of size intersecting the current Bagely Fire.

Reconnaissance Methods

Reconnaissance of the fire area was conducted using a rapid approach described as a burned area emergency assessment. The burned area emergency assessment is an immediate and

[1] Drainage densities based on Shasta-Trinity National Forest crenulated stream layer.

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 hydrologist worked with and/or consulted during the field assessments included soil scientist, fisheries biologist, geologists, botanist, archaeologist, OHV specialist, GIS specialists and roads engineers.

The Bagley Fire burned a total of 46,010 acres within portions of the thirteen HUC 7 drainages evaluated in this report.[2] 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 below for definitions).

Table 2: Severity and response definitions

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.

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

[2]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).

Crippen, 1977). Burn severity was stratified into four categories (high, moderate, low, very low/unburned, and outside burned perimeter) for each HUC 7 watershed (Table 3). Pre-fire and projected runoff data for HUC 7 watersheds that drain into the McCloud River, Squaw Creek, or Pit River that were burned in the Bagely Fire are shown in Table 4.

Although specific streams are impacted from high severity within each HUC7 drainage, modeling was not conducted at a higher scale because this refined level of modeling would not change analysis of the values at risk. 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 low, moderate, and high severity of the burned area and play a significant role in increasing runoff predictions at the HUC 7 level for several drainages. Field sampling by the soil scientist indicated that water repellancy occurred on 80% of the high severity burn areas at 2 – 8 inch depth. Water repellancy on low and moderate severity burn areas was less severe both spatially and vertically in the soil profile. Soil repellancy is likely to persist for one to three years. For a more detailed summary of water repellant soils, see the Soil specialist's report.

Projected flow increases resulting from increases in runoff from the burn areas are shown in Table 4. Each of the HUC7 hydrologic drainages were modeled as distinct units, and do not always represent the total predicted flow in the main channel. Increases in runoff were based of burn severity mapping. Field sampling was conducted in areas denoted as unburned/very low severity from the BARC. Field sampling results indicated that many of these areas burned at very low intensity and others were unburned. For purposes of hydrologic post-fire modeling, all of these areas were assumed to be very low severity. Projected runoff increases for a 2-year recurrence interval storm ranged from no effect in the Bald Mountain Creek-Hat Mountain Creek drainage (McCloud River) to a high factor of 2.9 in the Jessie Creek-Horse Creek drainage (Squaw Creek). Three percent and one hundred percent of the drainages burned, respectively.

Photo of low severity burn mapped as very low/unburned by BARC.

Table 3: Burn severity for HUC 7 watershed in Bagley Fire

(calculated for entire HUC 7 area)

HUC 7 name	HUC 7 Area (ac)	% Burned by HUC 7	% High	% Mod	% Low	% Unburned Very Low	% Unburned (out of fire perimeter)
Iron Canyon Reservoir	7145	51%	1%	4%	24%	22%	49%
Iron Canyon	7290	80%	7%	17%	39%	16%	20%
Pit 5 Powerhouse	5266	10%	0%	1%	6%	4%	90%
Jessie Creek-Horse Creek	7125	100%	22%	23%	41%	13%	0%
West Fork Squaw Creek-Modin Creek	10303	100%	14%	17%	44%	25%	0%
East Fork Squaw Creek-Hoffmeister Creek	9392	10%	0%	1%	5%	4%	90%
North Fork Squaw Creek-NE	8877	33%	5%	7%	16%	5%	67%
Upper Hawkins Creek	5605	37%	1%	7%	23%	6%	63%
Lower Hawkins Creek	5797	15%	0%	2%	8%	4%	85%
Upper Claiborne Creek	4545	81%	10%	19%	40%	11%	19%

HUC 7 name	HUC 7 Area (ac)	% Burned by HUC 7	% High	% Mod	% Low	% Unburned Very Low	% Unburned (out of fire perimeter)
Lower Claiborne Creek	5671	46%	5%	12%	21%	7%	54%
Ah-Di-Na	8457	61%	5%	12%	31%	14%	39%
Bald Mountain Creek-Hat Mountain Creek	8624	3%	0%	0%	2%	0%	97%

Table 4: Pre-fire runoff and post-fire predicted flows for HUC 7 watersheds in Bagely Fire (calculated for 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
Iron Canyon Reservoir	695	1998	1125	3601	1.6	1.8
Iron Canyon	899	2415	2004	4612	2.2	1.9
Pit 5 Powerhouse	860	2204	965	2368	1.1	1.1
Jessie Creek-Horse Creek	1023	2695	2919	6522	2.9	2.4
West Fork Squaw Creek-Modin Creek	1323	3453	3428	7327	2.6	2.1
East Fork Squaw Creek-Hoffmeister Creek	1551	3809	1758	4122	1.1	1.1
North Fork Squaw Creek-NE	989	2720	1540	3887	1.6	1.4
Upper Hawkins Creek	629	1803	956	2533	1.5	1.4
Lower Hawkins Creek	595	1741	704	1961	1.2	1.1
Upper Claiborne Creek	360	1165	841	2513	2.3	2.2
Lower Claiborne Creek	916	2387	1608	3950	1.8	1.7
Ah-Di-Na	1442	3567	2754	6470	1.9	1.8
Bald Mountain Creek-Hat Mountain Creek	1565	3776	1632	3925	1.0	1.0

Riparian reserves often experienced lower severity burn that the surrounding hillslopes; however a a number of riparian reserves experienced moderate and high severity. The capability of riparian reserves in these areas to filter mobilized soil is substantially dimenished until groundcover can be re-established.

Table 5: Acres Riparian Reserves burn severity by HUC7

HUC 7 name	High	Mod	Low	Very Low/ Unburned	% High/ Mod
Iron Canyon Reservoir	11	68	622	641	6
Iron Canyon	198	462	1155	482	29
Pit 5 Powerhouse		2	55	58	2
Jessie Creek-Horse Creek	496	552	1317	488	37
West Fork Squaw Creek-Modin Creek	442	490	1641	1270	24
East Fork Squaw Creek-Hoffmeister Creek	2	24	121	105	10
North Fork Squaw Creek-NE	64	151	487	185	24
Upper Hawkins Creek	10	113	459	153	17
Lower Hawkins Creek	0	20	173	111	7
Upper Claiborne Creek	98	297	748	211	29
Lower Claiborne Creek	76	187	435	171	30
Ah-Di-Na	92	270	978	509	20
Bald Mountain Creek-Hat Mountain Creek		6	54	22	7

Increased sediment delivery to the McCloud River, Pit River, and Squaw Creek, and consequently Shasta Lake, is expected to occur as a result of elevated erosion in the Bagley Fire area. During the first post-fire year, the largest amount of fine sediment and ash will likely be moved through the stream network. Consecutive years experience greater percentages of coarse sediment. Accelerated depostition of alluvial fans as the streams enter Shasta Lake is expected. Turbidity in Shasta Lake is episodic and occurs from both from scouring in the reservoir from wave action and also sediment delivered by spring and storm runoff. The frequency and magnitude of turbidity from runoff, especially from Squaw Creek is expected to increase. The effects to Shasta Lake will be increased turbidity. Sediment increase will be greatest during the winter season following the fire. Sediment delivery from the Bagely Fire will likely decrease rapidly within the first three years and reach pre-fire conditions in 10 – 15 years.

II. Emergency Determination

The emergency to values at risk from hydrologic hazards (i.e., water quality, flooding, and debris flows) caused by the Bagley Fire include potential adverse effects for the health and safety of people, , roads and trails within and downstream the fire perimeter.

III. Treatments to Mitigate the Emergency

A. Treatment Type (including monitoring if applicable)

- Conduct road repairs and maintenace to protect from hydrologic and geologic hazards
- Enhance trail drainage and reduce hazards to trail users caused by fire
- Sign for hazards and closures on Forest Service Roads and trails
- Inform cooperators and adjacent land owners of hazards
- Monitor and coordinate with stakeholders during storm events

- Obtain air photos and lidar imaging
- Install RAWS and turbidity sensors in Squaw Creek
- Mulch moderate and high severity burn areas where where land base is treatable

B. Treatment Objective

Human Health and Safety, Mitigate Property Damage, Mitigate Water Quality Degredation, Monitor for hazardous situations and effectiveness of treatments.

C. Treatment Description

See specialist reports for detailed descriptions of land treatments (Soils), culvert replacement and drainage repair (Engineering), Trails (OHV), and slide stabilization (Geology).

- Acquire lidar imaging of the burned area for vulnerability and risk assessment
- Install turbidity sensors in Squaw Creek
- Campgrounds (Chirpchatter and Madrone) - Install warning signs describing the flood hazard at each campground or seasonal closures
- Install RAWS or other monitoring system for early warning of flood hazard
- Inform cooperators, forest visitors and residents of potential hazards
- Consider seasonal closures for high severity areas

D. Treatment Cost

- Storm Monitoring and Coordination with public and private agencies - $XXXX
- Turbidity Sensors - $XXXX
- Temporary RAWS Station - $XXXX
- Air photos and Lidar imaging - $XXXX

IV. Discussion/Summary/Recommendations

Values at greatest risk to damage from flooding, debris flows, sedimentation, and erosion are roads and trails in proximity to streams and in high/moderate burn severity areas. Specific roads and trails have been identified in specialist reports. Private residences located at McCloud River Club and in floodplains along Squaw Creek below Madrone Campground may be susceptible to flooding. Madrone and Chirpchatter Campgrounds have a higher potential to flood based on annecdotal information from the 1997 floods and modeled flows for Squaw Creek. Risk of flooding along Squaw Creek decreases with increased distance downstream of the Bagley Fire.

Proposed land and road treatments would likely reduce peak flows and reduce risk of debris flows and sediment delivery. Installation of precipitation gage in Upper Squaw Creek that is remotely monitored would serve to provide early warning of potential flooding downstream. Air photos and especially lidar imaging provide tools for ascertaining vulnerability and risk to areas from flooding and mass wasting events. Turbidity sensors are requested for monitoring water quality concerns and effectiveness of treatments.

References

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

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 15 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. A period of 15 years was used because the majority of the treatments addressed high burn severities that occurred in mixed conifer forests that will take longer to re-establish conifers when compared to other vegetation types (e.g. chaparral).

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 2.8 inches. The 10-year, 6-hour rainfall event was determined to be 4.0 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 forumula associated with known gaging stations. The total pre-fire runoff per unit area from a 2-year recurrence interval storm was calculated to be 134 cubic feet per square mile for the fire area.

G. Estimated Reduction in Infiltration: The reduction of infiltration in high severity areas sampled indicate a reduction of 80% infiltration. Average reduction of infiltration within the fire perimeter based on sample points and burn severity mapping is approximately 30%.

H. Adjusted Design Flow: The adjusted design flow was calculated based on the reduction of infiltration from both high and moderate intensity burn areas. The total post-fire runoff in response to a 2-year recurrence interval storm was calculated to be 241 cubic feet per square mile for the fire area.

Appendix B

		Magnitude of Consequences			
Value	**Probability**	**Life**	**Property/Resource**	**Risk - Life**	**Risk - Property**
Iron Canyon Infrastructure	Possible	None	Moderate	N/A	Intermediate
Madrone	**Possible**	**Major**	**Moderate**	**High**	**Intermediate**
Chripchatter	**Possible**	**Major**	**Moderate**	**High**	**Intermediate**
Ah-Di-Na	Unlikely	Major	Moderate	Intermediate	Low
Fishermans Loop	Unlikely	Major	Moderate	Intermediate	Low
Ash Camp	Unlikely	Major	Moderate	Intermediate	Low
McCloud River Club	**Possible**	**Major**	**Moderate**	**High**	**Intermediate**
Bollibokka Club	Unlikely	Major	Moderate	Intermediate	Low
Private Residence	**Possible**	**Major**	**Moderate**	**High**	**Intermediate**
Microwave Towers - Tamarack	Unlikely	None	Minor	N/A	Very Low
Nature Conservancy Cabin	Unlikely	None	Minor	N/A	Very Low
Landline Boundaries	Likely	None	Minor	N/A	Low
Fish/Aquatics					
T&E Fish Species	Unlikely	None	Minor	N/A	Very Low
Sensitive Fish Species					
Lower Squaw	**Likely**	**None**	**Very High**	**N/A**	**High**
Iron Canyon	**Likely**	**None**	**Very High**	**N/A**	**High**
Lady Bug	**Likely**	**None**	**Very High**	**N/A**	**High**
T&E Amphibians Species	Unlikely	None	Minor	N/A	Very Low
Sensitive Amphibians Species	**Likely**	**None**	**Very High**	**N/A**	**High**
Water Quality					
Pvt Residence	Possible	None	Minor	N/A	Low
Shasta Lake	Likely	None	Minor	N/A	Low
Water Control - sediment introduced and fill in					
Shasta Lake	Likely	None	Minor	N/A	Low
Iron Canyon	Unlikely	None	Minor	N/A	Very Low
Floating Debris in reservoirs	**Likely**	**Major**	**Moderate**	**Very High**	**High**
Roads	**Very Likely**	**None**	**Moderate**	**N/A**	**Very High**
Non-Motorized Trail					
PCT	Unlikely	None	Minor	N/A	Very Low
Squaw Creek Trail	**Possible**	**None**	**Moderate**	**N/A**	**Intermediate**
Motorized Trails					
Bagley 35N46	**Likely**	**Moderate**	**Moderate**	**High**	**High**
Garden Ridge 46N40	**Likely**	**Moderate**	**Moderate**	**High**	**High**
37N15Y	**Very Likely**	**Moderate**	**Moderate**	**Very High**	**Very High**
Cultural					
Pre/Historical Sites	**Possible**	**None**	**Moderate**	**N/A**	**Intermediate**

		Magnitude of Consequences			
Value	**Probability**	**Life**	**Property/Resource**	**Risk - Life**	**Risk - Property**
Wildlife					
Habitat	Likely	None	Minor	N/A	Low
T&E Wildlife Species		None		N/A	
Sensitive Wildlife Species		None		N/A	
Soil Productivity	Likely	None	Minor	N/A	Low
High Burn Severity	**Likely**	**None**	**Moderate**	**N/A**	**High**
Botany					
T&E Botany Species	Unlikely	None	Minor	N/A	Very Low
Sensitive Plants	Unlikely	None	Minor	N/A	Very Low
Invasive Weeds	**Likely**	**None**	**Moderate**	**N/A**	**High**

Appendix C

Qualitative terminology for use in assessing risk to property (modified by Koler from Fell et al. 2005)

Qualitative measures of likelihood of occurrence		
Level	**Descriptor**	**Description**
A	Almost certain	The event is expected to occur
B	Likely	The event will probably occur under adverse conditions
C	Possible	The event could occur under adverse conditions
D	Unlikely	The event could occur under very adverse circumstances
E	Rare	The event is conceivable but only under exceptional circumstances
F	Not credible	The event is inconceivable or fanciful
Qualitative measures of consequences to the resource and human life and safety		
1	Catastrophic	Resource is completely destroyed or large scale damage occurs requiring major engineering works for stabilization
2	Major	Extensive damage to most of the resource, or extending beyond site boundaries requiring significant stabilization
3	Medium	Moderate damage to some of the resource, or significant part of the site requires large stabilization works
4	Minor	Limited damage to part of the resource, or part of the site requires some reinstatement/stabilization works
5	Insignificant	Little damage

Qualitative risk analysis matrix – classes of risk to resource					
	Consequences to the resource				
Likelihood	Catastrophic	Major	Medium	Minor	Insignificant
Almost certain	VH	VH	H	H	H
Likely	VH	H	H	M	L-M
Possible	H	H	M	L-M	VL-L
Unlikely	M-H	M	L-M	VL-L	VL
Rare	M-L	L-M	VL-L	VL	VL
Not credible	VL	VL	VL	VL	VL

Legend – VH: very high risk; H: high risk; M: moderate risk; L: low risk; VL: very low risk