Rim Recovery Environmental Impact Statement

Groveland and Mi-Wok Ranger Districts
Stanislaus National Forest

Watershed Management Report

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Analysis Framework: Statute, Regulation, Forest Plan and Other Direction

Protection of water quantity and quality is an important part of the mission of the Forest Service (USDA 2007). Management activities on national forest lands must be planned and implemented to protect the hydrologic functions of forest watersheds, including the volume, timing, and quality of streamflow.

Direction relevant to the action alternatives as they affect water resources includes:

The Clean Water Act of 1948 (as amended in 1972 and 1987): establishes as federal policy for the control of point and non-point pollution, and assigns the states the primary responsibility for control of water pollution. Compliance with the Clean Water Act by national forests in California is achieved under state law (see below).

Non-point source pollution on National Forests is managed through the Regional Water Quality Management Handbook (USDA 2011), which relies on implementation of prescribed regional best management practices (BMPs), as well as national BMPs (USDA 2012). There are 35 regional BMPs and 23 national BMPS relevant to this project. These BMPs and their associated management requirements are listed in Chapter 2 and in Appendix B of the Watershed Report. One of the Regional BMPs (BMP 2.13) requires the development of an Erosion Control Plan for projects with ground-disturbing activities. A plan was developed for this project and is included in the project record.

The California Water Code consists of a comprehensive body of law that incorporates all state laws related to water, including water rights, water developments, and water quality. The laws related to water quality (sections 13000 to 13485) apply to waters on the national forests and are directed at protecting the beneficial uses of water. Of particular relevance for the Proposed Action is section 13369, which deals with non-point-source pollution and best management practices.

The Porter-Cologne Water-Quality Act, as amended in 2006, is included in the California Water Code. This act provides for the protection of water quality by the state Water Resources Control Board and the regional water quality control boards, which are authorized by the U.S. Environmental Protection Agency to enforce the Clean Water Act in California.

A Conditional Waiver of Waste Discharge Requirements for Discharges Relating to Timber Harvest Activities is issued to the Forest Service by the Central Valley Regional Water Quality Control Board (Water Board). These waivers are required for all timber harvest activities that will or will likely discharge waste that could affect the quality of the waters of the State.

The Forest Plan Direction (USDA 2010) includes standards and guidelines for Watershed Management. The standards and guidelines associated with Riparian Conservation Objectives that are applicable to this project are described in the “Compliance with the Forest Plan and Other Direction” section of this report.

Effects Analysis Methodology

The four project alternatives were analyzed at three watershed scales to determine direct, indirect and cumulative watershed effects of the Rim Fire Recovery Project. These included large scale watersheds (40,000 to 250,000 acres) and two nesting smaller scales, 10,000 to 40,000 acres and 2,000 to 10,000 acres.

Beneficial uses of water and water quality objectives in the California Water Quality Control Plan (Basin Plan) of the Central Valley Regional Water Quality Control Board (CVRWQCB 2011) were utilized as a regulatory benchmark regarding the existing condition and to assess the effects of the proposed action and its alternatives on water quality. The water quality parameters considered in the watershed analysis were water temperature, sediment related parameters, and pesticides (registered borate compound). These are the pollutants with the potential of being affected by project management activities.

Assumptions Specific to Watershed

1. Watershed condition from the Rim Fire will recover, as will effects of the Rim Fire Recovery Project.
2. Water quality effects will occur at a magnitude below adversely affecting beneficial uses of water unless uncontrollable events occur. These include an abnormally high amount and/or intensity of precipitation or the occurrence of another fire in the project area as the watersheds recover from the effects of the Rim Fire.
3. Water Quality Best Management Practices will be implemented and effective unless uncontrollable factors occur. These include an abnormally high amount and/or intensity of precipitation or the occurrence of another fire in the project area as the watersheds recover from the effects of the Rim Fire.
4. See the Soils Report for assumptions associated with Disturbed WEPP modeling.
5. See Appendix A of the Watershed Report for a list of assumptions associated with Equivalent Roaded Area (ERA) modeling for cumulative watershed effects.

Data Sources

Satellite Imagery – Worldview, Landsat, and LiDAR

Forest Land Management Databases and planning documents – Forest Service Activity Tracking System (FACTS) and the Schedule of Proposed Actions (SOPA)

Stanislaus StreamScape Inventory – Stream Survey Data from 2005-2012

Benthic Macroinvertebrate Inventory, Clavey River Ecosystem Project (CREP), 2007

Burned Area Emergency Response Program – Past Fire information; Rim Fire watershed data

Geographic Information Systems (GIS)

Stanislaus National Forest Wild and Scenic River Study 1991

Tuolumne River Wild and Scenic Management Plan 1988 (reprint 2002)

CalFire – Timber Harvest Plans (THPs), Non Industrial Timber Management Plans (NTMPs), and Notices of Emergency Timber Operations (Frese 2013-2014)

Yosemite National Park – GIS shapefile with past and future activities within Park boundaries

Watershed Indicators

Water Quality Parameters – temperature, sediment, pesticides (measure – meet WQ objectives)

Stream Condition – channel form, streambank stability, pool sediment (measure – SSI protocol)

Riparian Vegetation – recovery (measures – no damage from project activities; recruitment unimpeded)

Ground Cover – riparian areas (measures - retention of existing; addition in riparian areas and WSAs (acres))

Cumulative watershed effects (measure – ERA)

Watershed Methodology

The direct, indirect and cumulative effects of the four project alternatives were evaluated using the following methods:

Direct and Indirect Effects

Literature Review – A thorough review of the literature was conducted related to the direct and indirect effects of actions that affect the watershed resource as proposed in this project.

Modeling – Disturbed WEPP was utilized to predict project related erosion.

Monitoring – A review of Water Quality Best Management Practices Evaluation Program (BMPEP) results on the Stanislaus National Forest for activities related to the project was conducted. BMPEP monitoring results over the past decade were useful for predicting outcomes of the management activities proposed in this project.

Field Evaluation – Field review of proposed treatment units and watershed conditions within the project area was conducted.

GIS – GIS was used for analyzing data collected from fieldwork, satellite imagery products and forest databases related to the project.

Cumulative Watershed Effects

A Cumulative Watershed Effects analysis was conducted using the CWE model adopted by the Pacific Southwest Region of the USDA Forest Service as a method of addressing cumulative watershed effects (USDA 1990). The model is referred to as Equivalent Roaded Area (ERA). ERA values are calculated using a computer model developed on the Stanislaus National Forest (Rutten and Grant 2008). See Appendix A for further details.

Affected Environment

The Rim Fire started on August 17, 2013 in a remote area of the Stanislaus National Forest near the confluence of the Clavey and Tuolumne Rivers about 20 miles east of Sonora, CA. Exhibiting high to extreme fire behavior with multiple flaming fronts, the fire made runs of 30,000 to 50,000 acres on two consecutive days. It quickly spread up the Tuolumne River watershed and its main tributaries: North Fork Tuolumne, Clavey River, Cherry Creek, Middle Fork Tuolumne and South Fork Tuolumne. It also overlapped into the Merced River at the southern edge of the fire. Overall, 98% of the Rim Fire occurred in the Tuolumne River watershed. Over several weeks it burned 257,314 acres, or 400 square miles, including 154,530 acres of National Forest System (NFS) lands. The fire also burned within Yosemite National Park (78,895 acres), Sierra Pacific Industries private timberland (16,035 acres), other private land (7,725 acres) and Bureau of Land Management (BLM) land (129 acres).

The Rim Fire is the third largest wildfire in California history and the largest wildfire in the recorded history of the Sierra Nevada. It is also California's largest forest fire, burning across a largely conifer dominated forest landscape. The two larger fires were wind driven brush fires near San Diego in 2003 and in Lassen County in 2012.

Watershed Setting

WATERSHED DESCRIPTION

The Rim Fire burned through numerous watersheds in the central and southern portions of the Stanislaus National Forest, and some that overlap eastward into Yosemite National Park where the remainder of the fire occurred. These watersheds are an important component of the water supply, fish and wildlife habitat, recreation, timber production and other values of the Sierra Nevada mountain range. Portions of the watersheds within the Rim Fire perimeter have been burned in several fires during the 20^{th} century, while some areas have not burned in over 100 years.

Watersheds in the Rim Fire are delineated in accordance with the national watershed classification system (USGS 2013). This system is a spatial hierarchy of eight nesting watershed size classes ranging from very large (greater than 250,000 acres) to very small (less than 2,000 acres). This classification system uses the term Hydrologic Unit Code (HUC) to describe all watershed size classes (see Table 1). They are called HUC levels and are numbered in order from one to eight in descending size class. Each HUC level code is a two digit number that ties to a watershed size and name. For example, HUC Level 1 is a two digit code whereas as HUC Level 5 is a 10 digit code. Table 1 shows an example of how this nesting system applies to the Rim Fire watersheds.

Table 1 Hydrologic Unit Code System (HUC)

HUC Level	HUC Name	HUC Size	HUC Examples - Rim Fire
1	Region	100,000,000 (average)	NA
2	Sub-region	10,000,000 (average)	NA
3	Basin	7,000,000 (average)	San Joaquin River
4	Sub-basin	450,000 (average)	Tuolumne River
5	Watershed	~40,000-250,000	Clavey River
6	Sub-watershed	~10,000-40-000	Reed Creek
7	Drainage	~2,000-10,000	Reynolds Creek
8	Sub-drainage	~Less than 2,000	Lost Creek

The Stanislaus National Forest includes HUC Level 4 through 8 watersheds. (The term watershed is often used generically even though each HUC level has a unique name). The HUC Level 4 watersheds on the forest are the headwaters of large rivers that continue downstream off the forest (e.g., Tuolumne River).

While some of the HUC Level 5 watersheds on the forest extend somewhat downstream and upstream from the forest boundaries most are entirely within the forest. Many more HUC Levels 6 watersheds are within the forest boundary and nearly all HUC Level 7 and 8 watersheds are contained within the forest.

Within the Rim Fire there are nine HUC 5 Level watersheds. Within these, there are 18 HUC Level 6 watersheds. Table 2 displays the HUC Level 5 and HUC Level 6 watersheds relevant to the fire area, including total HUC Level 5 and HUC Level 6 watershed acreage. Note that the HUC Level 6 watershed acreage does not add up to that of seven of the nine HUC Level 5 watersheds. This is because in those watersheds there are additional HUC Level 6 watersheds that were fully outside the fire perimeter. Watershed acreage within the Stanislaus National Forest boundary is less in some watersheds and will be described in the existing condition and environmental consequences sections of this report. The HUC Level 5 watersheds in Table 2 are listed clockwise around the fire area beginning where the main channel of the Tuolumne River exits the Rim Fire perimeter.

Table 2 Principal Watersheds in the Rim Fire Area

HUC Level 5 (40,000-250,000 Acres)		HUC Level 6 (10,000-40,000 Acres)	
Name	Acres	Name	Acres
Big Creek-Tuolumne River	81,721	Big Creek	18,734
		Grapevine Cr-Tuolumne River	23,817
		Jawbone Cr-Tuolumne River	27,629
North Fork Tuolumne River	63,849	Lower North Fork Tuolumne River	34,210
Clavey River	100,645	Lower Clavey River	17,871
		Middle Clavey River	26,912
		Reed Creek	24,527
Cherry Creek	90,892	Lower Cherry Creek	24,383
		Upper Cherry Creek	16,344
		West Fork Cherry Creek	26,149
Eleanor Creek	59,906	Miguel-Eleanor Creek	15,798
Falls Creek-Tuolumne River	124,244	Poopenaut Valley-Tuolumne River	18,232
Middle Fork Tuolumne River	46,635	Lower Middle Fork Tuolumne River	14,928
		Upper Middle Fork Tuolumne River	31,707
South Fork Tuolumne River	57,855	Lower South Fork Tuolumne River	19,988
		Upper South Fork Tuolumne River	37,866
North Fork Merced River	79,110	Bull Creek	21,064
		Bean Creek-North Fork Merced River	36,739

Given the large size of the fire, the HUC Level 6 watersheds are the most appropriate scale for watershed description and analysis of the effects of the Rim Fire Recovery Project. HUC Level 5 watersheds will be described for spatial context and broad scale analysis, and selected HUC Level 7 watersheds will be discussed where more detailed analysis is indicated. Figure 1 displays the HUC Level 6 watersheds relevant to the Rim Fire.

Figure 1 HUC Level 6 Watersheds in the Rim Fire Area

WATERSHED CHARACTERISTICS

The 400 square mile Rim Fire encompasses a diverse and complex landscape. The watersheds within the fire perimeter rise in elevation from about 1,000 to 7,000 feet and include rock-rimmed river canyons, mountain meadows, major rivers and small secluded streams.

Climate

The Rim Fire area is within the Mediterranean climate zone designated Csa in the Koppen-Geiger Climate Classification System (Kottek et al. 2006). This zone consists of warm, mostly dry summers and cool, wet winters. In degrees Fahrenheit, Rim Fire area average summer high temperatures are about 95 at the lowest elevations and 75 at the higher elevations. Average low winter temperatures are about 30 degrees at the lowest elevations and 20 degrees at the highest. Extreme high and low temperatures vary about 10-15 degrees from average. Precipitation increases in elevation, with a range of about 30 to 50 inches per year across the fire area. Annual variation in precipitation can vary up to about 50 to 150% of average depending on wet or dry years. About 80% of the annual precipitation occurs from November through March. Rain dominates areas below about 4,000 feet though occasional snow occurs in the coldest months. Between 4,000 and 5,000 feet rain and snow is mixed, and above 5,000 feet snow is more common across the landscape. Warm frontal storms can raise snow levels to 7,000 feet or higher.

Geology and Geomorphology

The Rim Fire landscape includes all three of the principal geologic types in the Sierra Nevada mountain range. Metamorphic rock occupies much of the lower elevations and the Sierra granitic batholith and relic volcanic flows generally occur at higher elevations.

Landforms within the Rim Fire are dramatic, punctuated by river canyons, glaciation, a lava cap, and large expanses of gentle to moderately steep slopes spread across much of the fire area.

The main geomorphic feature in the Rim Fire is the Tuolumne River canyon, which has carved an east-west chasm about 2,500 to 3,000 feet deep through the entire length of the fire area. The adjacent Clavey River has a similarly deep canyon in its lower reaches. The Jawbone Lava Cap lies atop the broad east ridge of the lower Clavey River, a remnant of an ancient lava flow that originated east of the Sierra Nevada mountain range prior to the Sierra uplift about 10 million years ago. North of the Tuolumne canyon the watersheds gradually rise to about 6,000 feet from Duckwall Mountain on the west to Woods Ridge on the east, near Cherry Lake. The landscape climbs to almost 7,000 feet west of Cherry Lake.

Glaciation is another striking geomorphic feature in some eastern locations of the Rim Fire. Glacial periods up to about 90,000 years ago have scoured the upper portions of Tuolumne River canyon as well as Cherry and Eleanor Creeks. Remnant small glaciated alluvial deposits are found in some stream valleys in the fire area down to about 4,500 feet.

The morphology of the landscape of the Middle and South Forks of the Tuolumne River south of the Tuolumne canyon to about state Highway 120 is the most gentle within the fire area. The river gradients are low until at their combined confluence they suddenly drop about 1,000 feet off into the Tuolumne Canyon near the Rim of the World vista point on Highway 120. The Upper South Fork Tuolumne watershed south of Highway 120 rises about 2,500 feet rather rapidly up its Big Creek tributary to Pilot ridge near the south edge of the fire area.

The Water Landscape

Rivers

The Rim Fire area is largely dominated by the Tuolumne River. It is the largest tributary of the San Joaquin River, which originates in the southern Sierra Nevada and drains northward for about 200 miles to the San Francisco Bay delta. The Tuolumne River, with its headwaters at the Sierra crest in Yosemite National Park, has carved a spectacular river canyon for over 50 miles through the western part of the park and then down through the length of the Stanislaus National Forest, including the entire Rim Fire, before leveling out in the foothills.

The North Fork of the Merced River plays a minor role in the waterscape of the Rim Fire. The fire barely burned within it over the south ridge of the South Fork Tuolumne River.

Flow Regimes

The streamflow regime of the Tuolumne River watershed on the Stanislaus National Forest consists of a combination of free flowing and regulated flow river segments. The free flowing streams include the Clavey River and the North, Middle and South Forks of the Tuolumne River, which total about 103 river miles. Annual peak flows in these waters usually occurs during spring snowmelt runoff, often from late May to the middle of June. However, in years with large winter rain-on-snow storms, annual peak flows usually occur in December and January. The highest peak flows of record in the Tuolumne River have been recorded in these months. The annual low flow period is from late summer through fall. While this time period rarely varies, the low flow rates in the free flowing streams can be very low in dry years with even the HUC 5 main channels dropping well below 10 cubic feet per second.

The regulated flow regime portion of the Tuolumne River watershed occurs downstream of Hetch Hetchy Reservoir on the river's main channel in Yosemite National Park and from two of its HUC level 5 tributaries, Cherry Creek and Eleanor Creek. These reservoirs alter flows along a total of about 41 river miles. The dams forming Hetch Hetchy reservoir as well as at nearby Cherry Lake and Lake Eleanor impound and release water on a schedule primarily designed to produce hydroelectric power and divert water out of the watershed for domestic use. These operations alter the annual natural flow regime by decreasing peak flows, increasing low flows, and altering the natural timing of both.

The North Fork Merced River is a free flowing stream. It is the furthest downstream tributary of the Merced River which originates at the Sierra Crest and runs westward through Yosemite National Park. The Merced River is a fully free flowing river upstream of the Sierra Nevada foothills.

Stream Channels

The morphology of the main channels of the HUC 5 level streams in the Rim Fire are largely bedrock controlled. They rest in streambeds where bedrock dominates, though the streams also include boulders and cobbles with finer particles in pools and at stream margins. Most of the channels have large pools between steeper sections. Minimal length of the stream gradient along these channels is gentle enough to accumulate excessive sediment; that is, they are efficient at transporting most sediment and woody debris in high flows, though some is retained. The free flowing streams are generally at equilibrium between sediment transport and accumulation. Their flows are little affected by forest management activities and show response only to large natural disturbances such as floods. The main channel of the Tuolumne River, due to sediment trapping in the reservoirs, may be somewhat sediment starved as happens downstream of most reservoirs. The watersheds upstream of the Tuolumne River reservoirs are strongly dominated by glaciated bedrock.

The smaller streams in the fire area watersheds have more variable morphology. Though they, too, are mostly bedrock controlled, some have low gradient sections intermittently along their paths toward the larger streams. These gentle sections are more sensitive to disturbance where their streambeds and banks consist of finer grained materials. They are thus more erodible and have greater susceptibility to alteration by management activities and floods.

Key Watershed Values

The main channel of the Tuolumne River throughout the length of the fire on the Stanislaus National Forest was congressionally designated in 1984 as a Wild and Scenic River under the Wild and Scenic Rivers Act of 1968. It is also home to one of the premier whitewater rafting runs in the United States, and is recognized internationally as well. Its challenging waters provide a unique recreational experience on the Stanislaus National Forest.

The Clavey River is a proposed Wild and Scenic River. At 47 miles in length it is one of the longest remaining free flowing streams in the Sierra Nevada. It is also designated as a Critical Aquatic Refuge (CAR) in the Forest Plan Direction (USDA 2010). At 100,000 acres, the Clavey River is the largest CAR in the Pacific Southwest Region of the Forest Service. The Clavey River is also the first designated wild trout stream by the California Department of Fish and Wildlife, established in 1971. It has also since been designated a Heritage Trout Water by CDFW – one of only ten streams in California that "best exemplify indigenous strains of native trout within their historic drainages" (CDFW 2014). In addition, the middle portion of the Clavey River watershed contains the largest contiguous remaining old growth forest area on the Stanislaus National Forest.

The lowest two miles of the South Fork of the Tuolumne River is an eligible Wild and Scenic River. This is the deeply carved river segment which drops steeply from where the Middle Fork of the Tuolumne River meets it to the main channel of the Tuolumne River 1,000 feet below.

Vegetation Communities

Vegetation is a critically important watershed component. It shades soil to hold moisture, inputs organic matter which builds soil and provides cover that minimizes erosion and stream sedimentation. It also helps store water in the soil by intercepting precipitation, thus reducing excessive runoff and producing high quality water.

Hillslope vegetation in the Rim Fire area is dominated by broad expanses of coniferous forests above the deep river canyons of the Tuolumne and Clavey Rivers. These mid-elevation forests consist mostly of the Sierra Nevada mixed conifer association, which includes ponderosa, white fir, sugar pine, Douglas fir and incense cedar. As elevations increase within the fire area, the mixed conifer belt grades into Jeffrey pine and red fir-lodgepole pine stands in some locations. Grass-oak woodlands and mountain chaparral communities dominate river canyon vegetation, and oak stands often occupy drier sites at mid-elevations.

The other principal vegetation community in the fire area is in the riparian zone along its numerous waterways and in wetlands such as meadows, springs, fens, and ponds. This vegetation consists of a combination of riparian obligate plants (those associated with easily available water) and non-obligate trees and shrubs such as conifers and hardwoods. While these plants occupy a small portion of the landscape they provide a disproportionately large value for vegetative diversity and support a wide range of aquatic, wildlife, recreational and aesthetic values. Principal obligate vegetation species in the Rim Fire area include dogwoods, maples, willows, alders, cottonwoods and aspens, and non-obligates are the conifer species commensurate with the elevations at which they mostly occur.

Watershed Condition

Several factors that affect watershed condition occur in the Rim Fire Recovery Project area. These include natural events, and management activities that create ground disturbance and alter natural hydrologic regimes. Natural events include wildfire, weather related occurrences such as floods and droughts, and natural recovery following disturbances. Key activities include vegetation management, transportation system development, and large scale water supply uses.

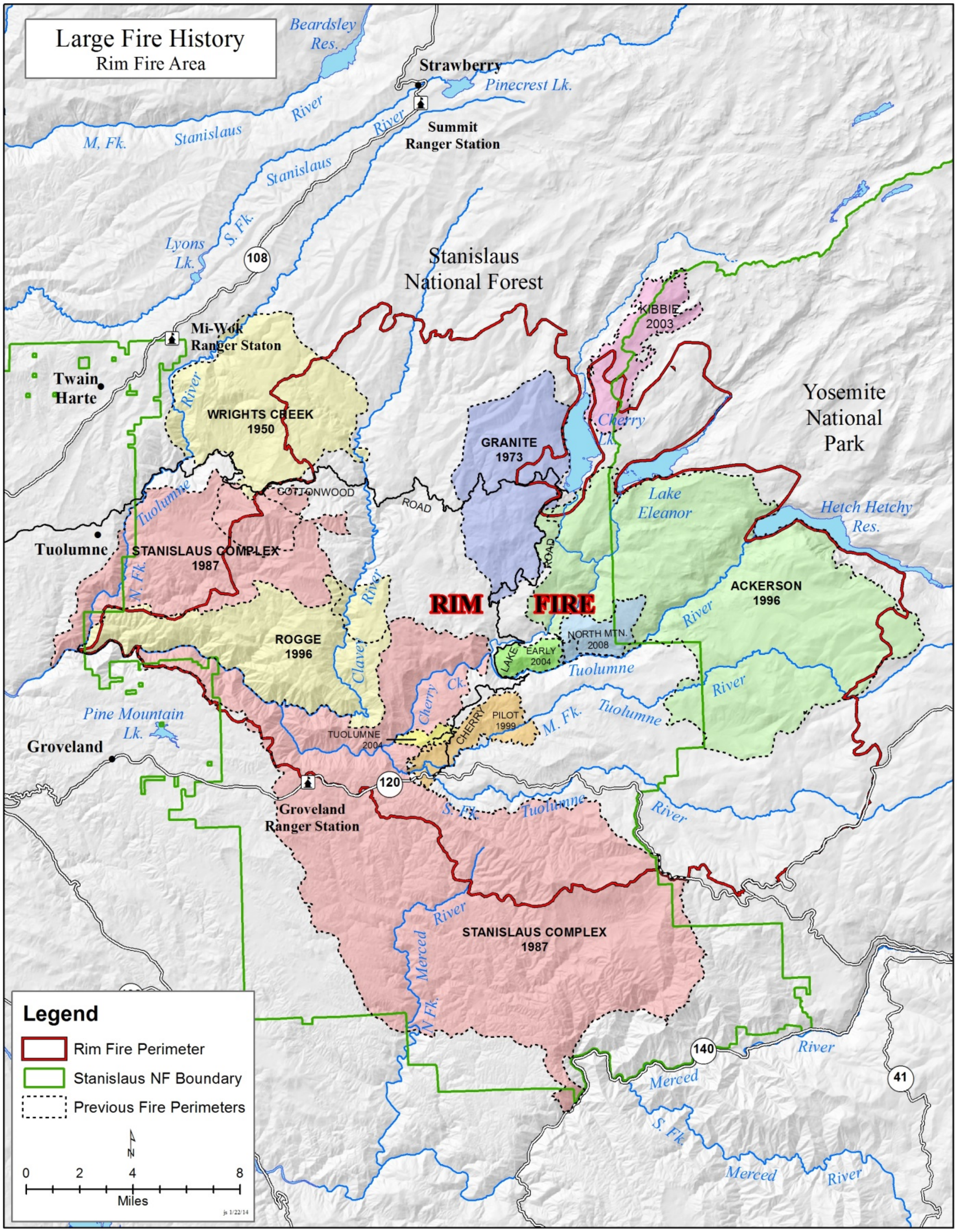
HISTORIC WATERSHED CONDITION

Past natural events and management activities provide context for understanding the existing and potential future condition of the watersheds in the Rim Fire Recovery Project area.

Wildfire

There have been ten large fires over 1,000 acres fully or partly within the Rim Fire perimeter since 1950, most of which are orders of magnitude smaller than the Rim Fire. This portion of the Stanislaus National Forest is truly a wildfire dominated landscape (as is the portion of the Rim Fire within Yosemite National Park). Figure 2 displays the fire history in the Rim Fire watersheds.

Figure 2 Fire History in the Rim Fire Area



The two largest fires, the Rim Fire and the Stanislaus Complex Fire of 1987 have some strikingly similar characteristics. Even though 26 years apart, both began in August in dry years and ended up burning a similar number of acres within the forest boundary. Both had nearly the same initial rate of spread – burning up to nearly 100,000 acres within the first five days - even though the fire causes were different. The 1987 fire was ignited by lightning; the Rim Fire was human caused. And in both fires, the initial rapid spread occurred soon after the fires entered the Tuolumne River canyon. Some areas within the Rim Fire perimeter, in portions of the Clavey River and in the Middle and South Forks of the Tuolumne River, have burned for the first time on record. Other areas have had overlapping burns twice and one other has burned up to four times. Table 3 describes the burn frequency in the Rim Fire area.

Table 3 Burn Frequency within the Rim Fire

Fire Name	Fire Year	Number of Times of Fire Occurrence, Including Initial Fire[1]	Years Reburn Occurred
Wrights Creek	1950	3	1987, 2013
Granite	1973	3	1996, 2013
Stanislaus Complex	1987	4	1996, 2004, 2013
Rogge	1996	2	2013
Ackerson	1996	3	1996, 2013
Pilot	1999	2	2013
Early	2004	2	2013
Tuolumne	2004	2	2013
North Mountain	2008	2	2013
Previously Unburned[2]	2013	1	NA

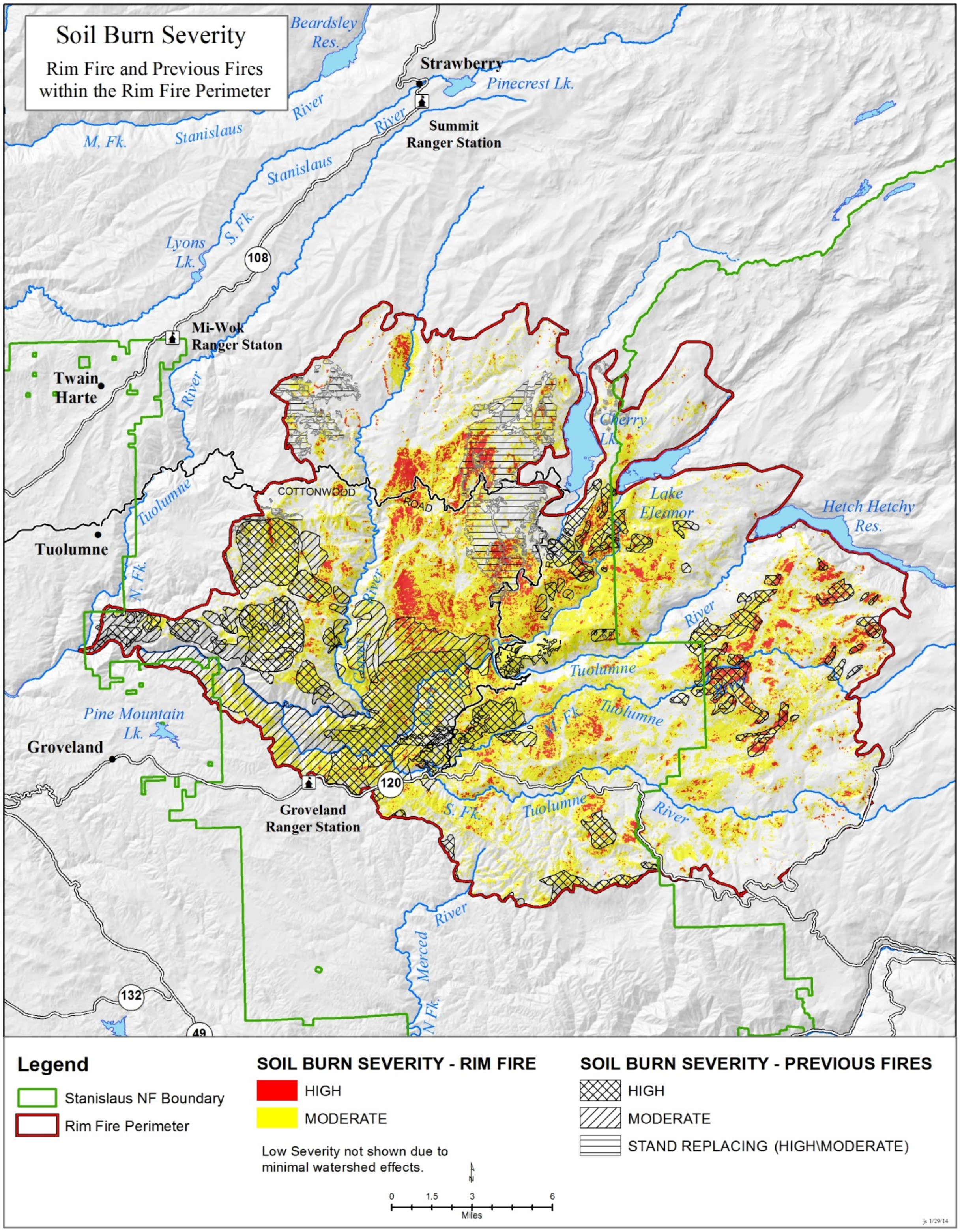
[1] Burned acreage of repeated fires within the Rim Fire perimeter varies widely due to size and location of overlapping fires.

[2] Areas within the Rim Fire which appear as unburned in Figure 2.

In addition to the occurrence of the numerous past wildfires in this area, burn mapping provides a more detailed assessment of where these fires have burned most severely. Figure 3 shows the fire history by soil burn severity to portray where these fires have burned hottest, often more than once.

Fires designated in this figure by the Stand Replacing Fire label indicate that soil burn severity mapping was not conducted or is not on record. This label is a surrogate measure that approximates a combination of high and moderate soil burn severity (see definitions below). Reforestation maps and data were used to locate where all trees were removed and/or the presence of timber plantations within a known fire perimeter to determine where stand replacing fire occurred.

Figure 3 Soil Burn Severity



There are three classes of soil burn severity. High soil burn severity usually chars the soil crust, damaging soil structure, killing plant roots, removing all or mostly all ground cover (litter and duff) and often resulting in strongly water repellent soil. Moderate soil burn severity does less damage since its soil structure effect and degree of water repellency is usually lower. Low soil burn severity has minimal soil impact, usually scorching ground and portions of tree trunks and bases of tree crowns; few trees are killed. The combination of high and moderate soil burn severity usually represents what is known as a stand replacing fire since nearly all trees are killed. Often in forested areas, post-fire vegetation condition acts as a visual indicator of soil burn severity. High soil burn severity is indicated by fully killed trees with all needles and often many branches consumed. Moderate soil burn severity is viewed as dead trees with browned needles remaining in the crowns (most of which fall before winter, providing initial post-fire natural ground cover). Low soil burn severity usually results in patchy ground fire with lower portions of trunks blackened and some lower crowns singed. Soil burn severity classes are shown in Figures 4 (HUC 7 Corral Creek), 5 (HUC 6 Lower Middle Fork Tuolumne River) and 6 (HUC 7 Lower Reed Creek). These photos were taken shortly after the Rim Fire. Note the needlecast in the moderate soil burn severity photo, with more to come from needles still in the trees.

Note: Soil burn severity is a measure of the effect of ground heat as a fire burns across a landscape, and is not the same as fire intensity or vegetation burn severity. Fire intensity is a measure of heat produced by a fire (BTUs). Vegetation burn severity measures both vegetation canopy mortality and vegetation basal area mortality resulting from wildfire. For the remainder of this report reference to burn severity will mean soil burn severity unless otherwise noted.

Figure 4 High Soil Burn Severity

Figure 5 Moderate Soil Burn Severity

Figure 6 Low Soil Burn Severity

Vegetation Management

Timber harvest was first conducted at a large production scale on the forest with the advent of railroad logging in the early 20th century, including in parts of the Rim Fire area. Harvesting accelerated in time with improvements in truck transportation and the national demand for wood after World War II. Timber was mostly clear cut in the early days and though that practice continued to be a method of harvest, other silvicultural methods were developed such as partial cutting that removed and retained some trees in the same area. Reforestation usually occurred where large blocks of trees were removed. The result to date is a mix of second growth timber plantations, stands where some trees were unlogged, and some areas unlogged due to difficult access or for other reasons.

Most recently, silvicultural practices have focused on thinning timber stands to help make them more resilient to the effects of wildfire. The objective of these practices, including very recent projects within the Rim Fire area, is to reduce fuel loading and help restore forest health. Thinning also reduces stand density, which is a tree stressor that makes the stands more susceptible to insect and disease problems.

Active fuel reduction, such as prescribed fire and allowing all or portions of selected wildfires to burn, has been conducted for the past few decades in order to reduce fuel buildup resulting from long term fire suppression and to improve wildlife habitat or other forest values. These vegetation management practices have benefits for forest health and public safety though they remain challenged to be implemented at the large scale by budget limitations and air quality regulations.

Transportation

Road development on the Stanislaus National Forest, including the Rim Fire area, began in the first half of the 20th century. The principal period of road development occurred after World War II, with the majority of the forest roads being built between 1950 and 1990, primarily for timber harvest access. In addition, higher standard roads were also built, designed for multiple uses including public access. All these routes serve as the backbone of the forest's transportation system. In the 1980s the Stanislaus constructed about 30 miles of new roads per year, with a high of 104 miles in 1980. About 5 miles of new roads were built per year in the 1990's, and lesser amounts since then. Some road segments have actually been decommissioned as they are no longer needed. The current emphasis for road management is maintenance and reconstruction. Both of these activities are challenged by a backlog of projects due to budget limitations.

Water Developments

Though not under Forest Service management jurisdiction, water use developments on or near Forest Service lands can affect water resources and/or be affected by large natural events such as the Rim Fire. Two major water use developments occur at present. One is within and immediately adjacent to the Rim Fire, and one is closely downstream.

The federal Raker Act of 1913 authorized the City and County of San Francisco exclusive use of large areas of the Tuolumne River watershed to develop a water supply and hydroelectric power. This includes the three large reservoirs in proximity to one another adjacent to the northeast boundary of the Rim Fire (see Figure 1). Two large associated hydroelectric power plants also exist within the fire area on the Stanislaus National Forest, one on the main channel of the Tuolumne River and one on Cherry Creek. This is the water use development that has resulted in the regulated flows that occur in portions of the Tuolumne River watershed.

Another large water use development is New Don Pedro Reservoir on the Tuolumne River in the Sierra Nevada foothills. This very large impoundment, beginning about one mile downstream of the Stanislaus National Forest boundary, is the 6th largest reservoir in California, with a capacity of 2,030,000 acre feet. It is close to the Rim Fire and is subject to receiving stream sediment transported beyond the forest as a consequence of the Rim Fire.

Stream Condition

Streams inventoried for condition assessment in recent years, as well as field observations, have shown that past stream channel alterations have occurred in some locations. Most have occurred in lower gradient stream reaches. These legacy effects are usually seen as changes in channel shape such downcutting, channel widening, or both. Streambanks may still be unstable and the natural composition of streambed materials (boulders, cobbles, gravels) may be altered.

Legacy effects are results of natural events such as fire and flood, and likely also from past management activities dating back 50 years or much longer in some cases. The most prevalent activities are historic logging and road building. Recent effects of these activities are significantly less since management practices have improved over time.

Recent stream inventories have determined locations of recovering, or rejuvenating, stream reaches, including numerous sites within the Rim Fire area. Rejuvenating reaches are those with obvious stream channel shape alteration beyond the natural range of variability. While they are evidence of past disturbance, they occur in a minor portion of watershed stream mileage. Most are recovering though some will remain as altered channel segments well into the future.

Floods and Droughts

As a natural process, floods can be viewed as both a positive and adverse landscape feature. Floods scour and erode and at the same time replenish streams. But floods in a place or time of watershed susceptibility to accelerated erosion and sedimentation, such as soon after wildfire, can also affect soil productivity, stream condition in reaches sensitive to disturbance, aquatic habitat, and watershed infrastructure. Infrastructure in this context consists primarily of roads and bridges but can include buildings, pipelines or other such features in a flood’s way.

The floods of record that have had the most effect on watershed condition occur from what are known as rain-on-snow storms. These infrequent but often very large events almost always occur in December and January, and are the result of relatively warm winter rainstorms lasting many days. The rain not only produces high runoff but dissolves some of the watershed snowpack that additively can create extremely high peak flows.

Several of these have occurred on the forest over the past century, including within the Rim Fire area. Large such events include December 1955 and 1964, January 1980, February 1986, and January 1997. The latter event was the largest recorded at many stream gages in California (Berenbrock 2014). For example, peak flow in the Clavey River was 47,000 cubic feet per second on January 3, 1997, which was rated between a 100 and 200 year event, and by interpolation of various data analysis models was likely close to a 150 year event (Gotvald et al. 2012).

Large floods can be a significant factor affecting watershed condition. They can result in minimal effects to streams in good condition and past vegetation management activities whose ground disturbances have recovered. But they can notably affect watersheds with very recent management activities or wildfires until vegetation and management impacts have recovered. Large floods also correlate with significant occurrences of forest road damage.

Droughts are also a factor in watershed condition, mostly affecting vulnerability to wildfire and forest insect infestations. Fire occurrence is not always correlated with droughts but they can worsen fire behavior due to low fuel moisture. Droughts can also be followed by bark beetle outbreaks when trees become moisture stressed, especially in dense stands where there is high competition for water. A major outbreak occurred across much of the forest from about 1978-1981 as a result of the extreme drought years 1976-1977, the two driest consecutive years of the 20th century.

Watershed Recovery

Natural recovery is an important factor in watershed condition, including in the Rim Fire area. It is a process that occurs with the same frequency as natural disturbances and management activities. Watersheds have shown the ability to recover, as is evident from past fires, floods and land management practices. Though small scale disturbances in sensitive stream reaches such as meadows, or on erodible soils impacted by vehicles, may take decades or longer to naturally recover, or need active restoration, watershed scale recovery begins soon after disturbances. Reduced watershed cover resulting from ground disturbing activities or natural events often emerges within a year. Forested sites are usually replanted and elsewhere pioneering herbaceous and woody plants capture most sites in a few years, providing watershed cover until trees are replanted or natural tree regeneration occurs. Oaks and riparian trees and shrubs usually resprout. Aquatic habitat recovers or is replenished; many aquatic species are adapted to natural and management disturbances and rebound soon thereafter. Much living cover rebounds within a few years.

Current watershed scale management activity disturbances are less impacting than decades ago, due to improvements in management practices that minimize effects on watershed condition. In most cases natural events such as wildfires and large floods are more significant at the watershed scale.

Water Quality

Though historic detailed water quality assessments have not been made or are not available in the Rim Fire area, there is broad evidence that water quality at the HUC 5, 6 and 7 levels in the Rim Fire area has been good over time, though some impairment has occurred for short durations due to natural events and from management activities.

Observations of water quality after the 1987 Stanislaus Complex Fire, comparable to the Rim Fire, were that post-fire stream turbidity occurred from the initial storms the first winter after the fire. New stream sedimentation continued for a few years in many streams within the fire area. The evidence of this post-fire watershed response diminished rapidly and was essentially gone within 3-5 years. Large-scale downstream effects were apparently negligible since no effects were noted in New Don Pedro Reservoir downstream of the fire.

Road related sediment increases have occurred as a result of large winter storm events. The major rain-on-snow storms of the 1980’s and the largest on record in 1997 resulted in significant road damage, with culvert and stream crossing failures, and road surface erosion from drainage function failures. Stream sedimentation from these occurrences lasted until road repairs were accomplished, usually within a year or two.

Though these occurrences impaired water quality during and shortly afterward, aquatic organisms in stream channels remained viable and showed little or no effect. Fish and amphibian populations remained sustainable, providing evidence that they have survived even longer past intermittent alterations in water quality from management activities and natural events.

Water quality has remained excellent in the main channel of the Tuolumne River as evidenced by the Hetch Hetchy water supply system. Since the 1930’s the City and County of San Francisco has diverted water from Hetch Hetchy reservoir without having to filter it for domestic use.

The Tuolumne River has never been listed as an impaired stream under Section 303(d) of the federal Clean Water Act.

EXISTING WATERSHED CONDITION

Existing watershed condition is the sum of previous effects of ground disturbing management activities and recovery following past natural events. The Rim Fire is the most significant recent event, and the Burned Area Emergency Response treatments that were implemented soon after to mitigate watershed damage represented the first management activity toward fire recovery.

Wildfire Effects

The Rim Fire, like almost all wildfires, is a mosaic of high, moderate and low soil burn severity plus unburned areas within its perimeter. Many past fires occurring within the Rim Fire perimeter have nearly half or more of their total acreage in the low and unburned categories that resulted in minimal to negligible watershed impact. Most watershed damage occurs from high soil burn severity, and lesser from moderate soil burn severity.

The principal effects of soil burn severity are the reduction of ground cover and infiltration capacity. High soil burn severity has the most watershed effect since it usually results in very low remaining ground cover, ranging from 0-20%, and the most increase in water repellency. These factors make it insufficient to adequately prevent accelerated soil erosion and, where eroded soil can reach waterways, cause stream sedimentation. Moderate soil burn severity is usually less damaging since the soil is not as impacted and the singed conifer needles fall to the forest floor initiating replacement of burned ground cover. Low soil burn severity is usually an insignificant factor since most pre-fire cover remains and infiltration is mostly retained.

While the Rim Fire area is the largest of the fires within the forest to date, it does not have the highest soil burn severity. Its high soil burn severity is the second lowest of the principal fires within its perimeter since 1973. Though its high soil burn severity is much less than its next largest predecessor, the Stanislaus Complex Fire of 1987, the Rim Fire has resulted in about 10,000 acres of very low ground cover distributed in various sized large to small patches across the approximately 154,000 acres of national forest land it burned. Table 4 displays soil burn severity for the six largest fires within the Rim Fire perimeter that have soil burn severity information.

Table 4 Soil Burn Severity for Selected Fires in Relation to the Rim Fire

Fire Name	Fire Year	Fire Size	Soil Burn Severity		
		Approximate Acres within Stanislaus National Forest	High (%)	Moderate (%)	Low and Unburned Area (%)
Rim	2013	176,800	7	37	56
Stanislaus Complex	1987	147,100	36	20	44
Rogge[1]	1996	19,400	0	41	59
Granite	1973	17,100	55	30	15
Ackerson[2]	1996	11,300	19	14	67
Pilot	1999	4,000	46	25	29

[1] There was no high soil burn severity due to low fuel loading over much of the area because of new tree plantations after the Stanislaus Complex fire.

[2] This fire was much larger overall, with most acreage in Yosemite National Park.

Distribution of soil burn severity within a fire area is also important. A spatial mosaic of all severities can reduce on and off site soil and water effects while concentrations of high soil burn severity can cumulatively increase effects. The largest concentrations of high soil burn severity in the Rim Fire occurred in Granite Creek, within the 1973 Granite Fire, and in the Corral Creek and Reed Creek areas, both believed unburned in about 100 years. Other lesser high soil burn severity concentrations are scattered throughout the fire area, surrounded by moderate and/or low soil burn severity areas as well as unburned areas.

These concentration areas, and other smaller severely burned sites in the fire, were identified by the Rim Fire BAER team as a watershed value at risk for loss of soil productivity and delivery of stream sedimentation. As a result, action to minimize the risk was taken in November, 2013. Helicopters applied weed free rice straw mulch to 4,300 acres of the highest priority portions of these locations (i.e., steep slopes, high erosion risk, and stream proximity). Helimulching produces a uniform layer of straw, about 1 to 1 ½ inches deep that provides 80-100% ground cover. Figure 7 shows results of helimulching in the Corral Creek area.

Figure 7 Rim Fire Helimulch Application

An additional BAER action, mastication, was conducted on approximately 40 acres of high soil burn severity area to increase ground cover. Mastication is mechanical chipping of small trees. Low ground pressure tracked equipment with an articulated arm and a chipping head provides immediate cover to bare areas. Figure 8 shows results of mastication in the Granite Creek area.

Figure 8 Rim Fire Mastication

Another burn concentration area in the Rim Fire is in the Tuolumne River canyon. The fire began near the Clavey River confluence and continued upstream to Cherry Creek, then up Cherry Creek to Eleanor Creek in Yosemite National Park. Much of the canyon vegetation is dominated by chaparral and other flashy fuels which burned hot and fast up canyon, where the fire then spread northward and led to the conifer dominated high soil burn severity concentrations mentioned above. The canyon soil burn severity is classed as moderate, even though vegetation was well consumed, since the fire here had little residence time and thus minimally degraded soil properties or increased watershed runoff response. This concentration area is a near repeat of that of the Stanislaus Complex Fire in 1987. The Tuolumne River canyon burns easily, and the 26 year old vegetation was mature and ready to burn again.

Overall in the Rim Fire, effective watershed cover exists on about 56% of the land within the fire perimeter (the total of the low soil burn severity and the unburned portion within the fire perimeter). This cover consists of living vegetation which primarily includes conifer trees with forest floor litter and duff, plus brush and smaller woody shrubs. This ground cover has been supplemented in much of the moderately burned conifer areas due to needlecast. While this is not as effective as living cover it does provide a measure of effectiveness compared to high burn severity areas since it resists initiation of rainsplash erosion. Helimulching and mastication mitigated some of the worst high soil burn severity areas, but other locations of high soil burn severity areas remain with inadequate cover.

In summary, the Rim Fire was a classic mixed severity fire, not only across the entire fire, but at all watershed scales. Patch size of each soil burn severity class in this mosaic was also mixed – some patches hundreds to several hundreds of acres, others tens to hundreds, and yet others where all three classes occurred within ten acres. Mixed severity was also distributed similarly from stream to ridge within most watersheds. Riparian areas burned in a mosaic as did the hillslopes above them. The largest high soil burn severity patches occurred in the uplands, mostly on south facing slopes where the fire could easily pre-heat fuels.

At the Rim Fire scale, the amount of soil burn severity varies widely among and within all HUC level watersheds. In general it is least for the HUC 5 watersheds, more for the HUC 6 watersheds and greatest for the HUC 7 watersheds. Many HUC 5 watersheds, being the largest, have substantial portions outside the Rim Fire perimeter. The HUC 6 watersheds, though generally having more acreage within the fire, also have a highly variable amount of soil burn severity based on fire location and watershed acreage within the fire perimeter. The HUC 7 watersheds that have the highest burn severity have been selected as watershed analysis emphasis areas due to severe burn and/or concentrated post-fire management activities.

Table 5 provides an overview of the three watershed scales and the portion each occupies within the Rim Fire and the Stanislaus National Forest. It also shows the soil burn severity of each watershed as an indicator of existing condition relative to ground cover and vegetation alteration by the fire. Rim Fire information is provided at the top of the table for comparison with the HUC Level 5, 6, and 7 watersheds. Refer to Figure 1 for the locations of the HUC 6 watersheds as well as to gain an understanding of the locations of their HUC 5 and 7 counterparts.

Table 5 Rim Fire Watershed Condition Overview

HUC Level and Name	HUC % Within Rim Fire Perimeter	HUC % Within Stanislaus National Forest	Soil Burn Severity % Within Watershed Boundary		
			High	Mod	Low & Unburned
Rim Fire Summary[1]	-	69	7	37	56
5 – Big Creek-Tuolumne River	56	70	5	27	68
6 – Big Creek	<1	52	0	<1	>99
6 – Grapevine Creek-Tuolumne River	77	82	1	26	73
6 – Jawbone Creek-Tuolumne River	99	100	14	56	30
7 – Corral Creek	100	100	31	58	11
7 – Lower Jawbone Creek	100	100	10	75	15
5 – North Fork Tuolumne River	9	92	0	3	97
6 – Lower North Fork Tuolumne River	17	89	1	6	93
5 – Clavey River	52	100	3	15	82
6 – Lower Clavey River	100	100	4	45	51
7 – Bear Springs Creek-Lower Clavey River	100	100	7	43	50
6 – Middle Clavey River	69	100	2	11	87
6 – Reed Creek	66	100	7	16	77
7 –Lower Reed Creek	100	100	21	41	38
5 – Cherry Creek	24	93	3	12	85
6 – Lower Cherry Creek	84	98	10	43	47
7 – Granite Creek	100	100	30	62	8
6 – Upper Cherry Creek	7	100	0	1	99
6 – West Fork Cherry Creek	1	100	0	<1	>99
5 – Eleanor Creek[2]	28	2	1	9	90
6 – Miguel Creek-Eleanor Creek	76	6	4	31	65
5 – Falls Creek-Tuolumne River[2]	19	4	1	5	94
6 – Poopenaut Valley-Tuolumne River	99	30	6	33	61
5 – Middle Fork Tuolumne River[2]	68	34	7	32	61
6 – Lower Middle Fork Tuolumne River	100	100	6	57	37
6 – Upper Middle Fork Tuolumne River	53	3	8	21	71
5 – South Fork Tuolumne River[2]	88	41	4	29	67
6 – Lower South Fork Tuolumne River	100	100	4	43	53
6 – Upper South Fork Tuolumne River	83	9	3	22	75
5 – North Fork Merced River	8	81	0	3	97
6 – Bull Creek	6	100	0	2	98
6 – Bean Creek-North Fork Merced River	14	92	0	4	96

[1] Soil Burn Severity % is of the fire area.
[2] Substantial portion of the fire extends east into Yosemite National Park.

Table 5 shows the similarities and variations among watersheds. Watershed area within the fire perimeter ranges from 1 to 100 percent among the HUC 5 and 6 watersheds, and all the HUC 7 watersheds are 100 percent within the perimeter. The percentage of watershed area within the Stanislaus National Forest is high for all watersheds except for portions of the four HUC 5 watersheds that extend east of the forest into Yosemite National Park.

The amount of soil burn severity across the fire also exhibits similarities and variations by watershed. Moderate soil burn severity is greater than high severity in every watershed, ranging from two to ten times as much. High soil burn severity is similar in almost all HUC 5 and HUC 6 watersheds – all nine HUC 5s are less than 10% as are 16 of the 18 HUC 6s. HUC 7 watersheds are dissimilar to their larger counterparts in that they almost all have greater high and moderate soil burn severity.

Table 5 also shows that 25 of the 32 watersheds have more than 50% acreage in the low soil burn severity/unburned class. Half of those watersheds have greater than 75% in this same class. The remaining seven watersheds include all five HUC 7s and two of the more heavily burned HUC 6s – Lower Cherry Creek and the Lower Middle Fork of the Tuolumne River. The fire-wide average of 56% in the low/unburned class is made up of a high percentage of predominantly low/unburned watersheds punctuated by several highly burned ones.

The most visible watershed impact of the fire was in the high soil burn severity areas since it reduced ground cover there to less than 20%, often near zero. Ground cover in the moderate soil burn severity areas was also substantially reduced as nearly all trees were killed by the fire, though needlecast replacement cover of 50% or more occurred in many of the conifer forested areas before winter.

The description of existing condition by watershed that follows will be made in the order of Table 5 and will include the parent HUC 5 watersheds and their smaller HUC 6, and where applicable, HUC 7 nesting watersheds.

Big Creek-Tuolumne River

This HUC 5 watershed has the most contrasting burn severity condition of any of the nine HUC 5 watersheds. It has the most high burn severity of any watershed, the HUC 7 Corral Creek. It also has the lowest amount of burned area of any watershed within the fire perimeter, the HUC 6 Big Creek, where only 10 acres burned. Thus, the conditions in this HUC 5 watershed range from unaffected to severely affected.

The Grapevine-Tuolumne River HUC 6 is the furthest downstream watershed in the Rim Fire. It mostly straddles the lower Tuolumne River canyon and extends up into its south facing Grapevine Creek tributary. Watershed soil burn severity was very low with only 1% in high severity. Its 26% moderate burn severity was well scattered across Grapevine Creek and in the Tuolumne River canyon. Much of this watershed in the river canyon and lower Grapevine Creek is covered with Oak grassland and brush. Higher elevations in Grapevine Creek and the riparian river corridor have conifers. This watershed has a history of minimal response to fire; that is, erosion rates are not significantly greater after than before a fire. Much of the canyon has shallow soils and the fire adapted vegetation regrows rapidly. Little alteration of watershed condition has occurred as a result of the Rim Fire.

The Jawbone Creek -Tuolumne River HUC 6 watershed, in contrast to the above two, has the greatest amount of combined high and moderate soil burn severity - 70% - of any HUC 6 in the Rim Fire. As the fire raced up the Tuolumne River canyon into this watershed the river turns north giving the fire the opportunity to jump northerly out of the canyon and into the forested areas along three of the river's direct tributaries - Alder, Corral and Jawbone Creeks. From there it burned nearly continuously for about 10 miles, almost to the Jawbone Creek headwaters. This area includes about 7,500 acres of forest inholdings, nearly all private timberland though several smaller parcels occur as well.

This watershed is the only one in the Rim Fire to warrant selection of two HUC 7 watersheds for analysis due to high burn severity. Lower Jawbone Creek, with a combined 85% high and moderate soil burn severity, and Corral Creek immediately west, with a combined 89%, was the largest contiguous area of high severity burn in the Rim Fire. In addition, Corral Creek, a small perennial stream, was severely burned in its near-stream area as seen in Figure 4. In order to mitigate these effects, BAER mitigations were implemented soon after the fire. Approximately 1,000 acres of straw mulch was aerially applied to the most severely burned portions of these two HUC 7 watersheds.

The two HUC 7 watersheds are expected to produce the highest erosion and sedimentation in the fire area, and first winter high stream turbidity will be common at times. In addition, the Corral Creek stream channel environment is likely to be altered in the process. A stream inventory conducted in 2012 showed much of the channel to be rejuvenating from past disturbance and still sensitive to further disturbance such as wildfire. The Corral Creek tributaries are also incised, and the riparian conservation area was nearly all burned at high severity. Shade has been nearly fully removed along the channel and some of the streambed large woody debris was burned out in the fire.

North Fork Tuolumne River

Only 9% of the North Fork Tuolumne HUC 5 watershed was within the Rim Fire perimeter, and only 17% of the Lower North Fork Tuolumne HUC 6. Soil burn severity was extremely low and most of it was concentrated in a mosaic of low, moderate and a minor amount of high soil burn severity in Upper Hunter Creek, a HUC 7 watershed on the south side of Duckwall Mountain. This same area burned in the 1987 Stanislaus Complex Fire, though much of it was high soil burn severity. (See Figure 3; the polygon of the Hunter Creek burned area is shown just inside the Rim Fire boundary due east of Tuolumne). Post fire erosion and sedimentation occurred shortly after the fire due to a short duration intense rainstorm in that part of the fire (little other erosion occurred in other parts of the fire). Log jams and a partial kill of the stream's fish were observed in Hunter Creek near the road 1N01 crossing but no more substantial erosion occurred that winter, and natural recovery of ground cover began the next spring. The fishery was not materially affected as fish were commonly observed the next summer.

Field observations in this area soon after the Rim Fire indicated that only minor fire-caused stream effects are expected due to the minimal amount of high burn severity.

Clavey River

The Clavey River is the only Rim Fire HUC 5 watershed fully within the Stanislaus National Forest. Three of its four HUC 6 watersheds experienced fire as the burn moved northward from the fire origin near the Clavey River confluence with the Tuolumne River. The fire did not quite reach the Upper Clavey HUC 6 watershed.

The Lower and Middle Clavey River HUC 6 watersheds were modestly burned, with a well distributed mosaic of mostly low soil burn severity surrounding smaller patches of moderate severity encompassing even smaller patches of high soil burn severity. The near-stream corridor of the main channel of the Clavey River experienced very little moderate or high soil burn severity throughout its 24 miles within the Rim Fire except for one approximately 2 mile moderate and high soil burn severity patch straddling it just downstream of the road 3N01 crossing. The Bear Springs Creek-Lower Clavey River HUC 7 watershed was the least impacted by the Rim Fire among the five HUC 7 watersheds. However, since it has a substantial amount of proposed management activities it is considered for condition assessment and project effects analysis. About 50% of this HUC 7 watershed was in high and moderate soil burn severity, though only 7% was high severity. While its mosaic pattern of low, moderate and high patches was well scattered around the portion of the watershed west of the Clavey River, a single large concentration of high and moderate burn was located in the upper end on the east side of the river. About 160 acres of straw mulch was applied to the most sensitive areas here as part of the BAER watershed stabilization effort.

The Reed Creek HUC 6 watershed burned moderately but with a large contrast within. The lower third of the watershed, downstream of the Bourland-Reynolds Creek confluence, was mostly burned severely. The middle third burned mostly at low burn severity, and the upper third was upstream of the fire perimeter. The concentration of the severe burn in Reed Creek was in the Lower Reed Creek HUC 7 watershed. It was an area as wide as the Reed Creek HUC 6 watershed for about a mile above and two miles below the Reed Creek Cottonwood Road crossing. The fire burned the Reed Creek corridor almost fully within this area. The condition of the Lower Reed Creek watershed burn concentration is likely to produce a notable amount of erosion and stream sedimentation that will be transported through Reed Creek and down into the Clavey River about one mile downstream. However, this is a small portion of the overall length of Reed Creek since upstream the contributing streams either have low severity or no burn. The portion of Lower Reed Creek that burned severely was also an area of BAER mulch application soon after the fire, receiving about 1,900 acres of straw, the highest single concentration of post-fire mulching.

It is not likely that Reed Creek's stream channel will be altered since it is bedrock controlled in this area and highly erosion resistant. Riparian vegetation is likely to be altered substantially in the short term since much of the riparian area was burned to a moderate and high severity.

Overall for the Clavey River watershed in the Rim Fire, it is likely that the fire caused minimal damage to any of the HUC 6 watersheds within the Clavey River. Erosion leading to stream sedimentation and first winter turbidity will be minimal in the context of the values of the Clavey River, and the erosion resistant stream channels should not be damaged. The Wild and Scenic River value, the Critical Aquatic Refuge and the state designation of a Heritage Trout Water will remain unaffected.

Cherry Creek

The Rim Fire burned within three of the five HUC 6 watersheds in the Cherry Creek HUC 5 watershed. Yet it essentially burned in only Lower Cherry Creek, the lowermost of the HUC 6 watersheds, and nearly all of that was in the lower half. All of the other upstream HUC 6 watersheds had minimal or no fire. Upper Cherry Creek had about 700 acres of fire and the West Fork had about 80 acres. The Rim fire did not reach the North and East Forks of Cherry Creek, which like the Upper and West Fork are mostly rockbound wilderness.

Though the Rim Fire occupied only 24 percent of the entire Cherry Creek watershed, its concentration in the lowermost portion was noteworthy. The fire reburned nearly all of the 17,000 acre Granite Fire of 1973, 40 years to the month of the Rim Fire, including the lower half of it which now has burned twice with high severity, especially in the Granite Creek HUC 7 watershed.

Lower Cherry Creek watershed values at risk include the City and County of San Francisco water development features, Cherry Lake and the Holm Powerhouse at the confluence of Cherry Creek and the Tuolumne River. Neither of these will be adversely affected by the Rim fire. Fire surrounded about 75% of Cherry Lake but the burn was nearly all in the low/unburned category thus not posing a sedimentation risk. The Powerhouse can function without being affected by wildfire.

Granite Creek experienced the greatest burn severity of any of the HUC 7 watersheds evaluated for Rim Fire watershed effects. Only 8% of this 4,100 acre watershed remained in the low/unburned soil burn severity class. Of the remaining 92%, or about 3,800 acres, 30% was high soil burn severity, also the highest per HUC 7 watershed, and moderate severity occupied 62%. This steep south facing watershed is apparently no match for extreme fire, having been twice burned to the same extent. Granite Creek is expected to see substantial erosion and subsequent turbidity and stream sedimentation delivered to Cherry Creek. The granitic soil prevalent in the watershed is highly erodible. To minimize the erosion to the extent possible, this was another BAER straw application area, about 750 acres.

Eleanor Creek

Only 28% of this HUC 5 watershed is within the Rim Fire, just 2% is within the Stanislaus National Forest, and nearly all of the watershed is in Yosemite National Park wilderness. Miguel Creek-Eleanor Creek watershed is the only one of its four HUC 6 watersheds that had notable fire, and it is the only one that drains directly into the Cherry Creek watershed. The remaining upstream watersheds all had very small amount of fire and nearly all of it was low/unburned. In addition, they all drain into Eleanor Lake where fire related stream sediment will be mostly trapped.

Only 4% of the Miguel Creek-Eleanor Creek watershed burned at high soil burn severity. And almost all of this was upslope and buffered from streams by surrounding areas of moderate severity. A minor amount of stream sedimentation likely occurred from this watershed.

Falls Creek-Tuolumne River

Similar to Eleanor Creek, this HUC 5 watershed saw a very small amount of the Rim Fire. About 96% of the watershed is in Yosemite National Park. The only portion on the Stanislaus National Forest is its downstream most HUC 6 watershed, Poopenaut Valley, and only the lower 30% of that is within the forest. Much of the Falls Creek-Tuolumne HUC 5, the largest of any burned by the Rim Fire, is upstream of and thus drains into Hetch-Hetchy Reservoir, and little fire occurred in those watersheds.

Most of the fire in the Poopenaut Valley watershed occurred on its upper slopes, substantially distant from the Tuolumne River below. Little stream sedimentation from this upslope erosion is expected.

Middle Fork Tuolumne River

Among the nine HUC 5 watersheds in the Rim Fire, the Middle Fork Tuolumne has the highest combined high and moderate soil burn severity, and its Lower Middle Fork HUC 6 watershed is the second highest among the 18 HUC 6 watersheds in the Rim Fire. Much of this ranking is due to the very high amount of moderate burn severity somewhat uniformly spread across the lower three quarters of the Lower Middle Fork. The 8% of high soil burn severity overlays this moderate burn in relatively small patches compared with more severely burned watersheds. The Rim Fire in the western third of the Lower Middle Fork was a reburn of the 4,000 acre Pilot Fire of 1999. The south facing slope of the Middle Fork in the Pilot Fire, mostly vegetated with brush, was once again thoroughly burned.

The upper half of one long unnamed tributary of the Lower Middle Fork about a mile southwest of Bear Mountain sustained a linear patch of high severity burn on the slope just south of the stream. This area, known as Bear Gully, is a long, incised low gradient stream channel in a highly erodible narrow alluvial valley. This was another of the straw mulch sites identified during the BAER assessment shortly after the Rim Fire. This area, about 75 acres of which had straw aerially applied, was one of four such sites totaling about 240 acres in this watershed.

The Upper Middle Fork of the Tuolumne River, of which 97% is in Yosemite National Park wilderness, was burned in a notably different mosaic pattern. Seventy one percent was in the low/unburned soil burn severity class, well distributed across the 53% of the watershed within the Rim Fire perimeter. Most patches of moderate and high severity were also well scattered with almost all of the high severity areas within the bounds of surrounding moderate severity patches.

Together the Lower and Upper Middle Forks of the Tuolumne River had about 40% of their watersheds burned in a combination of relatively broadly distributed high and moderate burn severity. The remainder was in low or unburned status, including the upper 40% of the Upper Middle Fork which was outside the fire perimeter.

Watershed values at risk in the Middle Fork Tuolumne River include two river side recreation camps and a private land lodging facility. All were barely avoided being burned by both the Pilot and Rim Fires. They experienced stream turbidity and sedimentation as the Middle Fork passed through them in the first winter after the fire, then will likely see much lesser amounts and a decreasing frequency after that. Flooding from potential increases in peak streamflow following the Rim Fire is not expected to affect them. The major flood of 1997, which was greater than a 100 year event, did minimal damage to these facilities.

Notable stream sedimentation and first winter turbidity is expected as a result of erosion from the amount and severity of burn in the Middle Fork of the Tuolumne River. Though the Upper Middle Fork is almost entirely within Yosemite, it will deliver downstream sediment to the Stanislaus National Forest. As with most streams in the fire area, first winter turbidity will be common.

South Fork Tuolumne River

This HUC 5 watershed is comprised of the Lower South Fork, 100% within the Stanislaus National Forest, and the Upper South Fork, 91% in Yosemite National Park. The Rim Fire burned the South Fork

HUC 5 watershed similarly in distribution as the Middle Fork but overall to a somewhat lesser extent of high and moderate soil burn severity.

The Lower South Fork saw much of its most active fire along the southwest and northeast perimeter of the watershed, and a concentration at the headwaters of Soldier Creek and along Crocker Ridge. The Soldier Creek burn area was another of the BAER straw treatment areas, about 200 acres. Watershed values at risk included the Carlon Day Use area along the Evergreen Road, Berkeley-Tuolumne Camp and the private inholding at Harden Flat. None of these were damaged by post-fire events though the Berkeley camp was largely destroyed by the fire. HazMat cleanup occurred at the camp soon after the fire.

The Upper South Fork of the Tuolumne River, like the Upper Middle Fork, is almost entirely in Yosemite wilderness. It was burned less than the Lower South Fork but like the Upper Middle Fork will deliver stream sediment to the Stanislaus National Forest.

The HUC 5 South Fork Tuolumne River will see moderate stream sedimentation as a result of the Rim Fire. First winter turbidity will be common during and after storms. Watershed values described above should not be noticeably impacted by stream sediment.

North Fork Merced River

The Rim Fire burned southerly over Pilot Ridge into minor portions of two HUC 6 watersheds in the North Fork Merced River HUC 5 watershed, in which there was essentially no high soil burn severity and only 3% moderate severity burn. This is the near opposite of the Stanislaus Complex Fire of 1987 where much of the North Fork Merced was burned at high severity. Overall, 97% of these watersheds remained unburned following the Rim Fire. The small amount of fire activity that did occur was in the headwaters, and thus downstream watershed effects are likely to be negligible. No watershed values were at risk in the North Fork Merced River.

Vegetation Condition

Hillslopes

The remaining live vegetation within the Rim Fire perimeter consists largely of second growth forest stands from legacy logging as well as more recent various aged timber plantations. It also consists of unlogged natural stands, some of which are very old. Despite the diversity of this vegetation, it almost all currently shares a common trait - high stand density. An excessive number of tree stems per acre creates closed canopies and an undesirable fuel ladder. This was apparent in many areas after the Rim Fire, where many tall, thin suppressed understory trees became readably visible, as evident in Figure 4. This dense condition leaves unburned forest vegetation elsewhere as vulnerable to future high severity wildfires as has recently occurred. In addition, these overstocked stands are more susceptible to episodic insect outbreaks as the trees become moisture stressed and better able to host to bark beetles in or following dry weather cycles. Several large scale fuel reduction treatments have occurred in the Rim Fire area over the past decade. These projects involve tree thinning to reduce fuel loading which also decreases stand density for fire resilience. In the face of the Rim Fire they had mixed success due to its unprecedented magnitude.

The amount of live vegetative canopy cover lost in the Rim Fire watersheds can be estimated by summing the acreage of high and moderate soil burn severity since nearly all vegetation in those soil burn classes is killed by fire. This measure correlates well with vegetation burn severity, as measured by canopy mortality. Canopy mortality assessment is done by placing mortality estimates into quartile classes. Combined high and moderate soil burn severity is similar in acreage to that of the 75-100% canopy mortality class. Either method is suitable for approximating fire effects on vegetation since results are comparable. For example, in the Middle Clavey River watershed, one of the lesser burned HUC 6 watersheds, 13% of its acreage is in the high and moderate class of soil burn severity. That percentage of the watershed can be estimated to have lost canopy vegetation from the fire, with 87% of the vegetation remaining alive in the watershed. At the other end of the spectrum, Granite Creek had 92% of its 4,000 acre watershed burned at high or moderate soil burn severity. Only 8% of the pre-fire canopy remained.

At the scale of the Rim Fire approximately 44% of live vegetative canopy was lost, in various mosaic patterns, and about 56% remained largely unaffected. And as Table 5 showed, the amount of soil burn severity, and with it, vegetation burn severity varied substantially among the watersheds in the fire area.

Riparian Conservation Areas

RCAs are corridors along stream channels and surrounding meadows, springs and other wetland areas that provide habitat for plants that thrive on a high water table. These are called riparian obligate species and include resprouting trees such as alders, big leaf maples, dogwoods, cottonwoods and aspens, shrubs such as willows, and a variety of streamside and meadow herbaceous plants. Conifers also coexist in RCAs with obligate species, often growing well near streams.

The Rim Fire resulted in a similar mosaic burn pattern in RCAs as on hillslopes. Some perennial and intermittent stream reaches burned at high soil burn severity. Some did not burn at all while the adjacent hillslopes did. In burned RCAs, resprouting shrubs and trees began responding with new leaves emerging within several weeks after the fire. In addition, burned overstory conifers in RCAs have created canopy openings that will allow more sunlight to reach the streamside areas to stimulate the growth response of the riparian obligate species, many of which are shade intolerant. In many areas they have become suppressed over time by conifer trees overtopping and shading them in the absence of fire and/or near-stream silvicultural practices such as thinning. A rush of regrowth of these riparian obligates is expected in the next decade in burned RCAs within the Rim Fire. However, while the sudden addition of sunlight favors renewal of the riparian obligate species the reduction of pre-fire stream shading has the potential to increase stream water temperature. The magnitude and duration of the latter effect is uncertain though streams within and downstream of past fires on the Stanislaus National Forest have not been notably altered since stream biotic productivity and aquatic species remain present in sustainable numbers. Rose Creek in the Ruby Fire of 1992 on the Mi-Wok Ranger District is a principal example of such a recovery process in a setting where a dense riparian conifer overstory was completely burned. The trout population survived and became more abundant in the years following with more sunlight and an increase in summer baseflow due to loss of transpiration from tree mortality. In addition, the suppressed willows beneath the pre-fire canopy grew to about 15 feet high within about five years after the fire. (Photos of the riparian vegetation regrowth are in the project record).

The watershed effect of the Rim Fire on vegetation condition in Riparian Conservation Areas (RCAs) is shown by watershed in Table 6. A 100 foot zone along all perennial and intermittent streams (100 feet on each side for a total width of 200 feet) was selected to focus on the immediate near-stream complex of obligate/non-obligate vegetation in the cooler, more moist microclimate along streams, often referred to as the “riparian bubble.” The upslope remainder of the 300 or 150 foot RCA widths are usually dominated by hillslope vegetation and warmer air temperatures.

Both soil and vegetation burn severity measures were assessed for validation of comparability. This 100 foot buffer represents an average of about 7 percent of the total area in the Rim Fire watersheds, with a range of 5-9% among all watersheds.

Table 6 Riparian Conservation Area Soil and Vegetation Burn Severity

HUC Level and Name	Riparian Conservation Area (RCA) (100 Foot Stream Buffer)					Watershed (Total Acres)
	Soil Burn Severity				Vegetation Burn Severity	Soil Burn Severity
	% Acres in RCA H = High M = Moderate L = Low/Unburned				% Acres with 75-100% Canopy Mortality	% Acres in Watershed (From Table 5)
	H	M	L	H + M		H + M
5 – Big Creek-Tuolumne River						
6 – Big Creek	0	0	100	0	0	0
6 – Grapevine Creek-Tuolumne River	0	11	89	11	15	27
6 – Jawbone Creek-Tuolumne River	11	38	51	49	50	70
7 – Corral Creek	41	51	9	92	88	89
7 – Lower Jawbone Creek	3	42	55	45	49	85
5 – North Fork Tuolumne River						
6 – Lower North Fork Tuolumne River	1	8	91	9	6	7
5 – Clavey River						
6 – Lower Clavey River	1	19	80	20	19	49
7 – Bear Springs Creek-Lower Clavey River	2	17	81	19	14	50
6 – Middle Clavey River	1	7	92	8	7	13
6 – Reed Creek	3	10	87	13	11	23
7 –Lower Reed Creek	12	31	56	43	41	62
5 – Cherry Creek						
6 – Lower Cherry Creek	13	34	53	47	45	53
7 – Granite Creek	35	59	6	94	91	92
6 – Upper Cherry Creek	0	0	100	0	0	1
6 – West Fork Cherry Creek	0	0	100	0	0	0
5 – Eleanor Creek[1]						
6 – Miguel Creek-Eleanor Creek	4	34	62	38	41	35
5 – Falls Creek-Tuolumne River[1]						
6 – Poopenaut Valley-Tuolumne River	5	27	68	32	32	39
5 – Middle Fork Tuolumne River[1]						
6 – Lower Middle Fork Tuolumne River	5	50	45	55	50	63
6 – Upper Middle Fork Tuolumne River	3	22	75	25	17	29
5 – South Fork Tuolumne River[1]						
6 – Lower South Fork Tuolumne River	2	23	75	25	18	46
6 – Upper South Fork Tuolumne River	4	19	77	22	17	25
5 – North Fork Merced River						
6 – Bull Creek	0	2	98	2	2	2
6 – Bean Creek-North Fork Merced River	0	2	98	2	2	4

[1] Substantial portion of the fire extends east into Yosemite National Park.

In Table 6, the RCA columns display soil and vegetation burn severity for all HUC 6 and HUC 7 watersheds in the Rim Fire. The RCA H + M column is the sum of high and moderate soil burn severity in the 100 foot stream buffer. The Watershed column displays the sum of the high and moderate burn severity for the entire watershed. The RCA H + M column is the key information for comparing soil to vegetation burn severity and RCA to watershed soil burn severity.

Table 6 shows that RCA soil and vegetation burn severity match closely in almost all watersheds. In 21 of 23 watersheds soil and vegetation burn severity are within 5% of one another, and the remaining two are 7 % and 8%. In most cases the vegetation burn severity is equal to or slightly less than the soil burn severity. The two measures validate they are comparable for estimating vegetation loss. Soil burn severity has the added advantage of also being able to indicate ground cover condition.

Comparing RCA to watershed, the table shows that RCA soil burn severity is in most cases less than for the watershed as a whole. RCA soil burn severity is not higher than watershed soil burn severity in 19 of the 23 watersheds in Table 6. The four that are higher are barely so, and many of the watershed soil burn severity percentages are much higher than the RCA.

The Rim Fire burned less severely near the streams than in the uplands in almost all watersheds, and substantially less in many. And though it burned less in RCAs there was still a notable loss of the stream shade capacity of conifers and riparian obligate trees and shrubs in many watersheds. But while the conifers will be long in returning to replace shade, the riparian trees will fill the void in the short run and also provide biodiversity along stream reaches burned in the Rim Fire.

Transportation System Condition

Road density in the Rim Fire area ranges from about one to six miles of road per square mile, with an average of about 4 miles per square mile. This is similar to other roaded multiple use areas within the forest. Prior to the Rim Fire, the existing road network within its perimeter was adequate to serve the needs of forest management activities. However, minimal road construction is planned for post-fire salvage timber harvest to reach burned areas previously not accessible. This would add much less than one percent to the road network in the fire area, or a negligible change in road density compared with the existing road network.

Because of the maturity of the transportation system in the Rim Fire area, with nearly all roads built 25 to more than 50 years ago, most road cuts and fills have stabilized with vegetation or other ground cover. Over time the sediment discharges that usually result following new construction have decreased. Most road related sediment in recent times originated at locations known as hydrologically connected segments (HCS). These are road portions where drainage from road surfaces or inside ditches can reach stream courses at road stream crossings or through underdrains that can transport sediment to streams. Elsewhere, pre-fire road sediment discharges on outsloped roads were usually filtered by vegetation or other cover on fill slopes and the forest floor. Pre-Rim Fire stream sedimentation from the road system was believed to be low based on stream condition data in the area collected through 2012. Refer to the section below on stream channel condition.

In the fall of 2013, as a Rim Fire BAER action, road drainage improvements such as culvert repair, armored crossings, rolling dips and water bars were installed as needed along approximately 320 miles of roads. In addition, funding was approved for personnel to monitor and repair roads over the winter if needed. These actions were expected to minimize road damage and thus reduce watershed impacts during the first winter after the fire. They represent an emergency improvement to road condition in the fire area. Additional road reconstruction is planned in the Rim Fire Recovery Project.

Road sediment discharge increases are expected as a result of the Rim Fire. Most increases are likely to occur in high soil burn severity areas within the Rim Fire, and to a lesser extent in moderate soil burn severity areas. Problems include locations of improper road drainage function and road-stream crossings which have culverts that are undersized to handle post-fire flow volume and the additional woody debris and sediment it carries. The quantity and effect of fire related sediment delivery increase is uncertain due to variability in winter weather prior to the implementation of the Rim Fire Recovery Project.

Stream Condition

Stream channels in the Rim Fire range from major rivers to small streams that flow only seasonally. Most streams are dominated by moderate slope gradients (2-4%) and secondarily by steep gradients (4-10%). Gentle stream gradients, less than 2%, occur occasionally on some small streams, and more frequently on some of the larger streams. Most streams are bedrock controlled with substantial cobble substrate and lesser amounts of boulder and gravel in the streambeds.

Stream condition inventories were conducted along portions of 23 streams within the Rim Fire area between 2005 and 2012. These are part of the forestwide Stanislaus StreamScape Inventory (SSI) program to determine stream condition prior to management activities or for baseline watershed information (Frazier et al. 2008). SSI consists of 21 attributes of stream condition measured continuously along wadeable stream channels in lengths that have ranged from about 1 to nearly 10 miles. Some larger streams become wadeable by late summer, such as the Middle and South Forks of the Tuolumne River, the Clavey River and Reed Creek. They, among many of their tributaries, comprise the streams represented here. The main channel of the Tuolumne River has not been inventoried due to its size and regulated flow regime which create unsafe SSI working conditions. A summary of the existing condition of these streams, based on key indicators, is shown in Table 7.

Table 7 Stream Condition Summary in the Rim Fire Area

Rim Fire Stream Condition Summary									
Stream Channel Indicators				**Stream Habitat Indicators**					
Streambank Stability		Channel Form		Pool Tail Fine Sediment		Pool Bed Fine Sediment		Water Temperature	
%	# Streams	% Normal or Rejuvenating	# Streams	%	# Streams	%	# Streams	Maximum Degrees C and (F)	# Streams
>75	21	>75	16	<10	16	<10	18	<15 (59)	10
50-75	1	50-75	4	10-20	3	10-20	3	15-20 (59-68)	9
<50	1	<50	3	>20	4	>20	2	>20 (68)	4

Stream Channels

Streambank stability is assessed in quartile percentage classes at 100 meter increments. The summary above represents the percentage of streambank stability on all streams inventoried. Twenty one of the 23 streams have a majority of their stream length in the >75% stability quartile with no 100 meter increments <50% stable. This indicates the streambank stability for the surveyed stream is either fully or highly likely to be greater than 75%, which represents a very stable stream system. Numerous streams have over 90% of their length fully classified in the upper quartile.

Channel form, or cross-sectional shape, is assessed in SSI in four classes which depict excellent to poor condition. The Normal class is one whose channel fits proper morphological features for its stream type. These factors include width-to-depth and entrenchment ratios, streambank angle, and other measures of channel shape (Rosgen 1996). The Rejuvenating class is a channel form that shows evidence of legacy disturbance but is recovering or has recovered to good condition. These classes are combined to assess condition of the channel form. For example, a stream with more than 75% of its length in these classes, provided the Normal class is greater, is seen to be in very good condition. Sixteen of the inventoried streams are in this condition, while the remaining streams have some portions with evidence of accelerated incision or widening.

Overall, the two stream channel indicators show a high percentage of the inventoried streams were in very good condition prior to the Rim Fire. Stream condition is expected to be affected by post-fire erosion and sedimentation though the magnitude is uncertain, largely reliant upon winter weather events. Effects may be mitigated in areas that received BAER hillslope and road treatments in the fall of 2013.

Stream Habitat

SSI quantitatively measures stream pool sediment which can serve as indicators of stream habitat quality and sedimentation. Pools are the sediment reservoirs in streams. Sediment in stream pools is an indicator of erosion from the upstream watershed, and thus shows whether excessive input is present. Excessive sedimentation can arise from ground disturbing management activities such as timber harvest or roads, or from fires, floods or mass wasting (e.g., landslides, debris flows). Fine sediment is measured since it represents the smallest soil particles, which are the key components of aquatic habitat. Excessive fine sediment in stream pool tails can reduce fish spawning success. Excess pool bed sediment reduces pool area that can be used for fish rearing and productivity. These two measurements of streambed sediment are taken while conducting SSI. Pool tail fine sediment is calculated at pool outlets, and pool bed fine sediment is measured throughout the full length of stream pools. Pool tail sediment less than 20% is usually considered suitable for fish spawning. Pool bed sediment, measured as the length of fine sediment deposition in a pool, characterizes the amount of settleable material sourced from the watershed. The same percentage threshold is used for pool bed sediment as for pool tails.

As shown in Table 7, pool tail and pool bed sediment was very low in the inventoried streams. It is not excessive since presence of native fish of all age classes are common or abundant in these streams. The amount of pool sediment in these streams is an indicator of a very stable watershed landscape, including recovery from past disturbances by wildfire and ground disturbing management activities.

Water temperature was also excellent in these streams. The SSI data in Table 7 are the maximum daily temperatures and all are suitable for the native aquatic organism communities. Even the streams with maximum temperatures exceeding 68 degrees Fahrenheit, a threshold of concern for cold water fish, were only slightly higher and their minimum daily temperatures are well below the threshold.

Benthic macroinvertebrates (BMI) are another indicator of stream health. They were sampled in the Clavey River in 2007 as well as several of its tributaries within the Rim Fire perimeter as part of the stream condition inventory for the Clavey River Ecosystem Project (CREP 2008). The BMI data were evaluated using the River Invertebrate Prediction and Classification System (RIVPACS) (Hawkins et al. 2000). Numeric values very close to 1 indicate reference condition, meaning streams are in as good of condition as naturally occurs. Streams and their BMI scores are as follows: Two Mile Creek (0.991), Hull Creek (1.106), Clavey River (0.927), Reed Creek (1.021), Bourland Creek (1.166), Cottonwood Creek (1.166), and Bear Springs Creek (0.932). No impairment of stream habitat or water quality was evident.

Between the time of collection of the stream condition data and the Rim Fire there were no significant management activity disturbances or natural events that would have been likely to substantially alter stream conditions.

Wild and Scenic River Condition

One congressionally designated Wild and Scenic River lies within the Rim Fire perimeter. This includes all of the 29 miles of the main channel of the Tuolumne River that flows through the Stanislaus National Forest. In addition, the lower half of the Clavey River (24 miles) is a proposed Wild and Scenic River, and the lowest 2 miles of the South Fork Tuolumne River is an eligible Wild and Scenic River.

All of these rivers have had Outstandingly Remarkable Values (ORVs) identified which makes them unique among rivers of the United States (USDA 2010). Some ORVs are water related such as Ecologic (which includes free flowing characteristics), Fish, and Recreation (water contact recreation such as boating and swimming). Other ORVs include Scenic, Historical/Cultural, Geologic, Wildlife, and other Recreation activities.

The water related ORVs of the Tuolumne River are recreation, whitewater boating and fish. The water related ORVs of the Clavey River within the Rim Fire are fish and ecologic (free flowing characteristics). There are no water related ORVs for the South Fork Tuolumne River. Its ORV is Scenic (high quality scenery of the river canyon).

The water related ORVs of the Tuolumne and Clavey rivers were in excellent condition prior to the Rim Fire. The condition of the white water boating ORV in the Tuolumne River and the fish ORV in both rivers are expected to remain so as they were following the comparable Stanislaus Complex Fire of 1987. The free flowing ORV in the Clavey River will not be affected.

Water Quality Condition

Prior to the Rim Fire, water quality within the fire perimeter was considered excellent at all the watershed scales previously described. Throughout the main Tuolumne River and its tributaries there is substantial evidence of high quality water. The US Environmental Protection Agency maintains a list of waters with impaired water quality under Section 303(d) of the Federal Clean Water Act (CVRWQCB 2010). The Tuolumne River is not listed as an impaired stream, nor is the Merced River. At the smaller scale, SSI and BMI data collected in the Rim Fire area have shown evidence of excellent water quality where sampled in the watersheds across the fire area.

Water quality effects during the fire from Rim Fire ash deposits into the main channel of the Tuolumne River upstream of and including Hetch Hetchy Reservoir did not impact the San Francisco domestic water supply system. Nor is it likely that later notable sedimentation from the Rim Fire into the reservoir will occur since there is a negligible amount of fire acreage upstream of the Hetch Hetchy dam. Downstream effects of the fire in the Tuolumne River will not impact the water supply system since its diversion infrastructure is essentially closed to environmental effects. Water is transported through tunnels and pipelines all the way from the source at Hetch Hetchy Reservoir to the end point near San Francisco.

Water quality degradation resulting from erosion and stream sedimentation following the Rim Fire occurred as expected for a winter that turned out to be below average in precipitation with few storms exceeding a 1-2 year return interval. Early winter rainfall began to mobilize easily dislodged ash and streamside sediment in highly burned areas with little ground cover. Streams and rivers ran variably turbid, some very much so, during and after succeeding storms depending on rainfall intensity, soil type and other factors. Decreases in turbidity and sediment transport occurred between storms. This process of storm driven sediment delivery and transport repeated itself over the winter. Sediment mobilization, transport and deposition were moderate, without major degradation.

Environmental Consequences

Alternative 1 (Proposed Action)

DIRECT AND INDIRECT EFFECTS

Direct and indirect effects of proposed activities are described below for 15 of 18 HUC 6 watersheds and five HUC 7 watersheds. Three HUC 6 watersheds (Big Creek, Upper Cherry Creek, and West Fork Cherry Creek) are not assessed below due to the negligible amount of high and moderate soil burn severity in their watersheds (as seen in Table 5). The selection of five HUC 7 watersheds is described in Appendix A: Cumulative Watershed Effects Analysis Methodology.

Erosion and Sedimentation

Factors Affecting Erosion and Sedimentation

Soil compaction, soil displacement, ground cover, and precipitation intensity have the potential to affect erosion and sedimentation following salvage logging activities. Compaction of soil from mechanized equipment can lead to hydrologic effects such as lower infiltration rates and increased runoff. This increased runoff has the potential to initiate erosion and sedimentation. Soil displacement occurs when logs are dragged in ground-based units and where logs contact the ground in skyline units. Additional displacement may be caused by mechanized equipment tracks, particularly when turning. This displacement can lead to hydrologic effects when ruts caused by displacement concentrate runoff. Ground cover protects soil from rainsplash erosion and slows and filters surface runoff. It is important in controlling sediment production following timber salvage. Although precipitation intensity is not affected by salvage logging activities, it can greatly affect levels of erosion and sedimentation following these activities.

Soil Compaction

Use of heavy equipment for felling and yarding can result in soil compaction. The degree of soil compaction depends on the number of passes by machinery and the texture of soil (Powers 2002). Ground-based salvage logging is more likely to induce soil compaction than skyline or helicopter logging (McIver and Star 2001; Beschta et al. 2004). Robichaud et al. found that soil compaction was less on feller-buncher tracks than on skid trails with multiple passes over the same route. He also found that operating equipment on dry soils and using low ground-pressure equipment helps to minimize compaction (Robichaud et al. 2011). Subsoiling of skid trails on the Stanislaus National Forest was found to not only mitigate recent compaction, but that which occurred during salvage and site preparation decades earlier (Powers 2002). See the Soils report for a detailed discussion of soil compaction.

Compaction of soil from mechanized equipment can lead to hydrologic effects such as lower infiltration rates and increased runoff. These effects are anticipated to be greatest in the portion of the project area where ground based salvage logging is proposed, less where cable logging is proposed, and least where helicopter logging is proposed.

Management requirements include methods to prevent and mitigate compaction and subsequent hydrologic effects within RCAs. This includes mechanized equipment restrictions, wet weather restrictions, and subsoiling requirements.

Soil compaction is anticipated to occur under the proposed action. However, by implementing BMPs and management requirements, these effects would be mitigated. These soil compaction mitigations would, in turn, minimize reductions in infiltration and increases in runoff.

Soil Displacement

Displacement is the removal of the forest floor or the upper portions of the mineral soil (McIver 2003). The impact of soil displacement on hydrologic resources occurs primarily in the potential of ruts to channelize runoff and erosion to surface water. See the Soils report for a detailed discussion of soil displacement.

In ground-based harvesting units, soil displacement may occur where logs are dragged to skid trails using end lining. Less soil displacement occurs with hand felled trees that have one-end suspension to a dozer or skidder. When feller-bunchers are used, there is less dragging of individual logs because the feller-buncher can “bunch” these logs into a pile for the skidder to move. However, additional displacement of soil may occur in the feller-buncher tracks, particularly where the equipment has turned.

In skyline harvesting units, soil displacement may occur in harvest corridors where full suspension is not possible and logs are dragged on the ground. In addition, portions of some skyline units with slopes less than 45% may utilize a feller-buncher to cut the trees. In these locations, additional soil displacement may occur as a result of feller-buncher tracks.

In helicopter units, hand felling and lifting of trees is anticipated to result in negligible soil displacement. However, portions of some helicopter units with slopes less than 45% may utilize a feller-buncher to cut the trees. In these locations, additional soil displacement may occur as a result of feller-buncher tracks.

The potential of soil displacement to lead to channelized runoff and surface erosion is of greatest concern in areas with greater than 15% slopes and low ground cover to filter runoff and break up flow paths. Management requirements designed to minimize this potential include minimizing turning of equipment, smoothing out and/or waterbarring areas of disturbance, and maintaining or providing groundcover.

Soil displacement is anticipated to occur under the proposed action. However, by implementing BMPs and management requirements, these effects would be mitigated. These soil displacement mitigations would, in turn, minimize concentrations of runoff in near-stream areas.

Ground Cover

Ground cover protects soil from rainsplash erosion and slows and filters surface runoff. The percent bare soil is an important control on sediment production following timber salvage (Chase 2006). The presence of even a thin litter layer can substantially reduce soil erosion (Peterson 2009).

In high soil burn severity areas, ground cover has typically been reduced to 0-20%. Post-fire soil losses can be reduced by applications of logging litter (Shakesby et al. 1996, Peterson 2009). However, this woody debris on the ground needs to have good contact with the soil in order to effectively trap sediment (Chase 2006). In areas of moderate soil burn severity, there are typically scorched needles remaining in the dead trees. Delaying timber salvage until after needle cast can help increase ground cover (Shakesby et al. 1996).

Live vegetative recovery may be slowed in portions of treatment units due to ground-based logging. This is because ground-based logging operations remove virtually all live vegetation in the skidder, feller-buncher, and forwarder trails. This can set back live vegetative recovery along these trails by 2-3 years (Robichaud et al. 2011).

Management requirements were designed to maintain or increase ground cover in near-stream areas. Within RCAs, ground cover is expected to increase under the proposed action as a result of maintaining post-fire conifer needle cast, application of ground cover through logging slash or other means, and natural recovery of live vegetation. A maximum of 10 tons/acre of fuel loading is allowed.

Precipitation Intensity

The extent of erosion caused by rainfall depends on the size and velocity of raindrops and the amount of precipitation. High-intensity storms produce larger drops that fall faster than those of low-intensity storms and therefore have greater potential to destroy aggregates and dislodge particles from the soil matrix. Although the same total amount of rain may fall, a short, high-intensity rainfall event causes much more erosion than a long, low-intensity storm. Research has shown that sediment yield (Robichaud et al. 2011) and total suspended sediment (Silins et al. 2009) are positively related to precipitation intensity.

Precipitation intensity cannot be controlled as can soil compaction, soil displacement, and ground cover. However, it is a variable that can have large implications on both post-fire and post-salvage logging erosion and sedimentation.

Erosion and Sedimentation from Treatment Activities

Salvage of Merchantable and Non-Merchantable Trees

The salvage of merchantable trees (likely those dead trees greater than 16 inches diameter at breast height (dbh) by the time of harvest) would involve removal of sawlogs utilizing ground-based, skyline, or helicopter logging systems. The salvage of non-merchantable trees in the form of biomass would utilize ground-based or skyline logging systems and may require a second entry into the unit. In the timber treatment units, only dead trees would be removed. Some live trees may be removed as part of the roadside hazard tree treatment if they pose a threat to health and safety. See Table 8 below for proposed treatments by watershed.

Table 8 Treatment Acreage by Watershed

HUC Level and Name	Watershed Size (ac)	Salvage Logging Units (ac)					% of Watershed Area
		Hazard Tree	Tractor	Skyline	Helicopter	Total	
6 - Grapevine Creek-Tuolumne River	23,817	1,231	60	0	0	1,291	5%
6 - Jawbone Creek-Tuolumne River	27,629	1,243	4,978	26	222	6,469	23%
7 - Corral Creek	4,581	281	2,341	26	0	2,647	58%
7 - Lower Jawbone Creek	5,670	198	1,369	0	222	1,788	32%
6 - Lower North Fork Tuolumne River	34,210	1,058	2	0	0	1,060	3%
6 - Lower Clavey River	17,871	1,984	1,678	82	100	3,844	22%
7 - Bear Springs Creek	7,090	687	1,018	82	100	1,887	27%
6 - Middle Clavey River	26,912	2,889	1,438	202	812	5,341	20%
6 - Reed Creek	24,526	1,391	3,339	0	538	5,269	21%
7 - Lower Reed Creek	7,495	380	2,416	0	451	3,247	43%
6 - Lower Cherry Creek	24,383	868	2,265	0	195	3,327	14%
7 - Granite Creek	4,126	103	996	0	0	1,098	27%
6 - Miguel Creek-Eleanor Creek	15,798	61	316	0	231	609	4%
6 - Poopenaut Valley-Tuolumne River	18,232	71	242	14	0	327	2%
6 - Lower Middle Fork Tuolumne River	14,928	1,097	6,074	76	70	7,317	49%
6 - Upper Middle Fork Tuolumne River	31,707	194	235	18	0	447	1%
6 - Lower South Fork Tuolumne River	19,989	2,862	2,940	810	640	7,253	36%
6 - Upper South Fork Tuolumne River	37,866	426	332	0	0	758	2%
6 - Bull Creek	21,064	245	34	24	5	309	1%
6 - Bean Creek-North Fork Merced River	36,739	932	147	0	116	1,195	3%

Research on salvage logging has shown large variability in sediment production. Some studies have concluded that salvage logging may reduce post-fire sediment production rates by reducing hydrophobicity and disturbing sealed soil surfaces, while others have found increased sediment production rates due to soil compaction and ground disturbance (Chase 2006). Silins et al. found that post-fire salvage logging creates more effective terrestrial sediment transport networks to stream channels and produced more sediment than areas burned but not logged (Silins et al. 2009). Others have found difficulty in distinguishing between erosion due to logging and that from the fire itself (McIver and Starr, 2001). On the Stanislaus National Forest, research following the Stanislaus Complex Fire in 1987 found that differences in sediment production from logged and unlogged sites were not statistically significant. This was attributed to either the high variability in disturbance within each treatment or the large effect of the fire itself on sediment output (Chou et al. 1994).

The type of logging system used can affect sediment production. Helicopter logging and cable yarding systems with partial or full suspension typically have smaller impacts on sediment production (Beschta et al. 2004). Chou et al. measured 18% ground disturbance in cable logged units and 35% ground disturbance in tractor logged units following the Stanislaus Complex Fire (Chou et al. 1994). Chase found no difference in sediment production between tractor, cable, and helicopter sites due to the variability between sites. However, he was able to conclude that post-fire salvage logging treatments that increase ground disturbance and bare soil would generate more sediment (Chase 2006).

Erosion and sedimentation monitoring on green timber sales on four National Forests in California has shown that timber harvest alone rarely initiates large amounts of runoff and surface erosion. Most erosion was initiated by skid trails (Litschert and MacDonald 2009). This research found that sediment delivery from timber harvest may be reduced by locating skid trails away from streams, maintaining high surface roughness downslope of waterbars, and promptly decommissioning skid trails following harvest. Concentrated flow from a skid trail or waterbar was more likely to form a rill or sediment plume when the downslope area had low surface roughness (Litschert and MacDonald 2009). Research on salvage logging tends to agree with the research on green sales. Proper installation and maintenance of waterbars on skid trails and cable corridors should help minimize the increase in sediment production due to salvage logging (Chase 2006).

Despite the variability in research results, there are some key points that are brought up repeatedly in the literature. This includes: (1) Minimize compaction to the extent possible; (2) Minimize soil displacement; (3) Maintain or increase ground cover to filter sediment. Management requirements and BMPs designed to accomplish these three tasks were described above in the sections on soil compaction, soil displacement, and ground cover.

Erosion modeling using Disturbed WEPP (Water Erosion Prediction Project) (Elliot and Hall 2010) was conducted within the fire perimeter to determine both post-fire (pre-implementation) and post-implementation erosion rates for the first year post-fire. The model considers climate, soil texture, soil rock content, soil cover, slope profile, and the vegetative community (this encompasses vegetation burn severity) to estimate erosion rates. These annual erosion rates are based on weather events with a 5-year recurrence interval. This means that there is a 20% chance that erosion rates could be higher than that modeled, and an 80% chance that erosion rates could be less than that modeled. Some watersheds only partially burned and those unburned areas were not modeled. In order to determine erosion rates for entire watersheds, an unburned erosion rate of 0.5 tons/acre was assumed. See the Soils report for more information on the Disturbed WEPP model and assumptions, as well as unit specific analyses. See Table 9 for modeled erosion rates in each watershed.

Table 9 Post-Fire and Post-Implementation Erosion Rates and Percent Change for Each Watershed

HUC Level and Name	Post-Fire Erosion Rate (tons/acre)	Post-Implementation Erosion Rate (tons/acre)	Percent Change Erosion Rate[1]
6 - Grapevine Creek-Tuolumne River	2.0	2.0	0.0
6 - Jawbone Creek-Tuolumne River	3.6	3.6	0.0
7 - Corral Creek	4.7	4.4	-6.4
7 - Lower Jawbone Creek	4.9	4.8	-2.0
6 - Lower North Fork Tuolumne River	0.9	0.9	0.0
6 - Lower Clavey River	2.9	2.9	0.0
7 - Bear Springs Creek	3.1	3.0	-3.2
6 - Middle Clavey River	1.2	1.2	0.0
6 - Reed Creek	1.4	1.3	-7.1
7 - Lower Reed Creek	3.2	3.1	-3.1
6 - Lower Cherry Creek	2.4	2.4	0.0
7 - Granite Creek	3.6	3.7	2.8
6 - Miguel Creek-Eleanor Creek	1.1	1.1	0.0
6 - Poopenaut Valley-Tuolumne River	1.4	1.4	0.0
6 - Lower Middle Fork Tuolumne River	2.9	2.8	-3.4
6 - Upper Middle Fork Tuolumne River	0.9	0.9	0.0
6 - Lower South Fork Tuolumne River	3.1	3.1	0.0
6 - Upper South Fork Tuolumne River	0.9	0.9	0.0
6 - Bull Creek	0.6	0.6	0.0
6 - Bean Creek-North Fork Merced River	0.7	0.7	0.0

[1] A negative percent change indicates a reduction in erosion. A positive percent change indicates an increase in erosion.

As seen in Table 9, thirteen of the fifteen HUC 6 watersheds are anticipated to have negligible changes in erosion at the watershed scale. The two HUC 6 watersheds with projected changes in erosion (Reed Creek and Lower Middle Fork Tuolumne River) had lower erosion rates post-implementation than post-fire. This is attributed to increased ground cover in high vegetation burn severity areas due to the addition of activity fuels. The modeling indicated that all five HUC 7 watersheds would have changed erosion rates following project implementation. Four of the five watersheds would have decreased erosion rates. One of the watersheds, Granite Creek, was projected to have an increase in erosion from 3.6 tons/acre to 3.7 tons/acre. This was attributed to the hazard tree treatment in lightly burned areas where ground cover is anticipated to decrease.

Both increases and decreases in erosion rates at the watershed scale were very minimal. The largest volumetric rate change was 0.3 tons/acre in the Corral Creek watershed and the largest percent change was -7.1% in the Reed Creek watershed.

Although modeling results indicate that changes in erosion rates would likely be minimal as a result of the proposed action, stream sedimentation still has the potential to occur as a result of the proposed action, particularly in areas where logging activities create more effective sediment transport networks to stream channels. From a hydrologic standpoint, increased compaction, increased soil displacement, and changes in ground cover are most critical in the near stream areas where stream sedimentation is most likely. Knowledge of soil burn severity in these areas is important because areas of low soil burn severity have much greater potential to filter sediment than areas of high soil burn severity. See Table 10 for a description of salvage logging acres (combined timber units and hazard tree removal) within 100 feet of perennial or intermittent streams and SAFs by soil burn severity. All system types (ground-based, skyline, and helicopter) are included in this table. The table likely overestimates logging acreage in low soil burn severity areas because any green trees would not be removed unless they were an imminent hazard to a road.

Table 10 Salvage Logging Acres by Soil Burn Severity Within 100 feet of a Perennial Stream, Intermittent Stream, or Special Aquatic Feature

HUC Level and Name	Salvage Logging Acres Within 100 Feet of a Perennial Stream, Intermittent Stream, or Special Aquatic Feature		
	High Soil Burn Severity (ac)	Moderate Soil Burn Severity (ac)	Low Soil Burn Severity (ac)
6 - Grapevine Creek-Tuolumne River	0	26	35
6 - Jawbone Creek-Tuolumne River	73	177	50
7 - Corral Creek	42	66	19
7 - Lower Jawbone Creek	7	49	2
6 - Lower North Fork Tuolumne River	1	14	24
6 - Lower Clavey River	6	47	54
7 - Bear Springs Creek	6	26	31
6 - Middle Clavey River	6	72	156
6 - Reed Creek	47	101	81
7 - Lower Reed Creek	46	91	25
6 - Lower Cherry Creek	58	132	35
7 - Granite Creek	47	76	4
6 - Miguel Creek-Eleanor Creek	0	4	13
6 - Poopenaut Valley-Tuolumne River	4	4	1
6 - Lower Middle Fork Tuolumne River	47	333	140
6 - Upper Middle Fork Tuolumne River	0	12	8
6 - Lower South Fork Tuolumne River	11	174	264
6 - Upper South Fork Tuolumne River	0	6	20
6 - Bull Creek	0	6	11
6 - Bean Creek-North Fork Merced River	0	17	28

As seen in Table 10, there are four HUC 6 watersheds that have the greatest potential for stream sedimentation, based on acres of high soil burn severity proposed for timber harvest within 100 feet of surface water. These are the Jawbone Creek-Tuolumne River, Reed Creek, Lower Cherry Creek, and Lower Middle Fork Tuolumne River watersheds. In addition, the three HUC 7 watersheds with the greatest potential for stream sedimentation are Corral Creek, Lower Reed Creek, and Granite Creek.

Research has shown that buffers reduce overland flow and sediment yield. This is because, in the absence of soil disturbance and compaction caused by machinery, overland flow stands a greater chance of infiltrating the soil profile, resulting in sediment deposition within the buffer. One such experiment found that a 10 meter (33 ft) undisturbed buffer removed 80-90% of runoff and over 95% of sediment produced by logging skid trails (Lacey, 2000). In areas of high soil burn severity, undisturbed buffers do not exist. Therefore, additions of ground cover are needed to reduce overland flow and sediment yield. As described above in the section on ground cover, there is a management requirement to maintain or provide ground cover within 100 feet of perennial and intermittent streams and SAFs to the maximum extent practicable, with the goal of a minimum of 50% well distributed ground cover. Ground cover additions are limited, however, by a fuel loading limit of 10 tons/acre.

An additional site-specific management requirement was developed for areas of high burn severity. The ground-based RCA equipment exclusion zone would be increased to 100 feet in areas where slopes immediately adjacent to perennial and intermittent streams have slopes greater than 25% and slope lengths greater than 100 feet.

The effectiveness of BMPs is monitored annually on the Stanislaus National Forest. Between 2006 and 2012, 20 streamside management zones (SMZs) were evaluated on green timber sales. Of these, only one site was rated as not effective. At this site, sediment had entered the stream channel at an approved crossing. There was minor sheet erosion (no rills or gullies) on the main skid crossing due to low ground cover. This ground cover was predicted to recover in the next year, so no corrective actions were recommended (STF 2007-2013).

Research has indicated that erosion and sedimentation following timber harvest most often originates from skid trails. Between 2006 and 2012, 21 skid trails were evaluated on the Stanislaus National Forest. Of these, BMPs were ineffective at only one site. This was where a skid trail crossed an intermittent channel and surface/sheet erosion deposited approximately 0.5 ft^3 of sediment into the channel. Ground cover on the skid trial was improving with needle cast, so no corrective actions were recommended (STF 2007-2013).

Landings are another area of disturbance that has been monitored on the forest. Between 2006 and 2012, 27 landings were evaluated, and BMPs were found to be ineffective at only one site. At this site, the landing fill slope had rills, but sediment did not reach surface waters.

In addition to conducting BMP monitoring at randomly selected sites on the forest, BMPs were also evaluated at selected sites following the Darby Fire of 2001 and its subsequent salvage sale (Brown Darby Timber Sale). Eight SMZs, 7 skid trails, and 7 landings were evaluated. All BMPs were found to be effective at protecting surface waters (STF 2004). The Darby Fire resulted in mostly low and moderate soil burn severity, so these BMP results apply to those circumstances, not high soil burn severity.

Overall, the effectiveness of BMPs at preventing erosion and sedimentation on the Stanislaus National Forest has been very good in green sales and in areas burned at low or moderate soil burn severity. It is therefore anticipated that BMPs would be effective at minimizing erosion under the proposed action in areas of low and moderate soil burn severity. In areas of high soil burn severity, the risk of erosion and sedimentation is higher. Requirements to subsoil skid trails, the primary sources of erosion, prior to each winter season is anticipated to reduce this risk. The requirement to increase ground cover is anticipated to further reduce this risk. Increasing mechanized equipment exclusion zones to 100 feet in the areas with steep long slopes adjacent to streams would also reduce this risk.

Despite implementation of BMPs and management requirements, increased stream sedimentation is anticipated as a result of the proposed action, particularly in areas where logging activities create more effective sediment transport networks to stream channels. This is more likely to occur in the Jawbone Creek-Tuolumne River, Corral Creek, Reed Creek, Lower Reed Creek, Lower Cherry Creek, Granite

Creek, and Lower Middle Fork Tuolumne River watersheds than in other HUC 6 or HUC 7 watersheds due to the larger acreages of near-stream high soil burn severity.

Piling and Burning

Fuel reduction treatments following timber salvage may include lop and scatter or jackpot burning in the helicopter units and machine pile and burn, hand pile and burn, or jackpot burning in the ground-based and skyline units. Any area with fuels greater than 10 tons/acre may receive these treatments. Because a 200 acre unit could have 2 hand piles or 50 machine piles depending on fuel loading, it is hard to predict the amount of ground disturbance that could occur as a result of these fuel reduction treatments. However, machine pile and burn, hand pile and burn, and jackpot burning is only planned in units which are also being logged, so the acres of ground treated under the proposed action would not increase as a result of these fuel reduction activities.

Lop and scatter in the helicopter units would increase ground cover and improve contact of ground cover with the soil, increasing the ability of the ground cover to filter sediment. This fuel reduction treatment is anticipated to reduce soil erosion in the units where it is implemented.

Jackpot burning may occur in the helicopter, skyline, or ground-based units. It involves igniting concentrations of fuels on the forest floor, whether they are natural fuels or fuels resulting from a silvicultural cutting treatment (activity fuels). These areas may or may not be lined, depending on conditions on the ground. Ground disturbance as a result of this treatment is anticipated to be minimal. BMPs and management requirements for watershed resources require us to maintain or provide ground cover within 100 feet of perennial and intermittent streams and special aquatic features. This ground cover is anticipated to mitigate effects of jackpot burning. Although some soil movement could occur following this activity, it is anticipated to be minor and short term.

Hand piling and burning would result in reduced fuel loading with very little ground disturbance. Lining of piles, as needed, would create minor soil disturbance. Negligible effective ground cover is anticipated within the pile perimeter following burning. Research on hand piling effects indicated that some localized erosion may occur in the first few years after burning before surface litter or plant cover return. The researchers concluded, however, that this was unlikely to create erosion problems due to the discontinuous arrangement of pile burn scars across treatment units (Hubbert et al. 2013). BMPs and management requirements require placement of burn piles a minimum of 50 feet away from perennial and intermittent streams and SAFs and 25 feet from ephemeral streams. They must be located outside of areas that may receive runoff from roads. Disturbance to obligate riparian vegetation must also be avoided. In addition, minimization of impacts to soils and water quality must be considered when planning pile size, fuel piece size limits, spacing, and burn prescriptions. Although some soil movement could occur following hand piling, it is anticipated to be minor and short term.

Machine piling could be implemented using either a dozer (dozer piling) or an excavator or other similar piece of equipment (grapple piling). Management requirements would prohibit machine piling within 25 feet of an ephemeral stream and within 50 feet of a perennial stream, intermittent stream, or SAF. The disturbance caused by dozer piling is expected to be greater than that caused by grapple piling. That is because the dozer would push the fuels into a pile, whereas an excavator would pick up and place fuels into a pile.

Six BMP evaluations for machine piling were conducted on the Stanislaus National Forest between 1992 and 1998 following green sales. Four of these sites showed no evidence of sediment transport from treated area to the streamside management zone (SMZ). Two evaluations showed sediment deposited in the SMZ, but it did not reach a stream channel (STF 1992-1998). In addition to BMP evaluations, a machine piling unit in the Long Shanahan Project was reviewed in spring, 2010. No rills were seen and sediment did not reach surface water (Janicki 2010). No BMP evaluations have been done on the forest for machine piling following a salvage sale.

In areas of low soil burn severity, riparian buffers are anticipated to be largely intact and have ground cover capable of filtering sediment movement resulting from machine piling. In areas of moderate soil burn severity, riparian buffers may be variable. However, ground cover in the form of needle cast can help filter runoff caused by machine piling disturbance. In areas of high soil burn severity there is little, if any, ground cover to filter sediment laden runoff resulting from the impacts of machine piling. However, implementation of BMPs and management requirements, including increasing ground cover within 100 feet of perennial and intermittent streams and SAFs provides for increased ground cover in these areas. Although it is anticipated that some sediment could reach streams as a result of machine piling, streamside buffers, needle cast, and/or placed ground cover should minimize this.

Roads

Forest roads cause hydrological effects by concentrating and channelizing surface and subsurface flow. Following wildfire, the ability of the landscape to filter runoff from roads can be reduced due to a decrease in ground cover (Peterson 2009).

Approximately 5.4 miles of new road construction, 320 miles of reconstruction, 216 miles of maintenance, 8.4 miles of temporary use-revert, and 13.9 miles of temporary road construction are planned under the proposed action. This would include 6 new permanent stream crossings along the newly constructed roads.

See Table 11 for a breakdown of road related activities by watershed.

Table 11 Road Related Activities by Watershed

HUC Level and Name	Permanent Roads				Temporary Roads (mi)
	Construction (mi)	Reconstruction (mi)	Maintenance (mi)	Temporary Use – Revert (mi)	
6 - Grapevine Creek-Tuolumne River		2.49	32.85		
6 - Jawbone Creek-Tuolumne River	0.74	35.91	24.77	2.15	2.62
7 - Corral Creek	0.46	15.05	5.00	0.29	
7 - Lower Jawbone Creek		8.25	3.20	1.27	2.15
6 - Lower North Fork Tuolumne River		0.36	23.52		
6 - Lower Clavey River		34.19	23.52		
7 - Bear Springs Creek		25.98	4.37		
6 - Middle Clavey River	2.85	39.75	26.42	2.51	2.92
6 - Reed Creek	0.20	25.32	17.85	0.57	1.59
7 - Lower Reed Creek	0.20	13.74	5.08	0.57	1.24
6 - Lower Cherry Creek		30.72	8.34	0.44	0.55
7 - Granite Creek		12.38	1.09		
6 - Miguel Creek-Eleanor Creek		2.69			
6 - Poopenaut Valley-Tuolumne River		1.93	0.70		
6 - Lower Middle Fork Tuolumne River		53.44	10.50	1.25	4.02
6 - Upper Middle Fork Tuolumne River		3.30	1.53		
6 - Lower South Fork Tuolumne River	1.57	70.46	25.20	0.59	1.25
6 - Upper South Fork Tuolumne River	0.04	6.46	2.95	0.90	
6 - Bull Creek		0.51	5.44		0.02
6 - Bean Creek-North Fork Merced River		11.51	10.43		0.26

Road Construction

Newly constructed roads would be designed to engineering standards in accordance with assigned road management objectives. These roads would be added to the Forest transportation system and retained for long-term access. All new system roads would be gated and closed to public vehicular traffic, but remain available for administrative use for future access and utilization of NFS lands.

By altering infiltration rates, road construction can increase overland flow rates and sediment yields (USDA 2013). Soil erosion associated with roads is highest during the first year or two following construction. This is due to the cut banks and fill slopes needing time to revegetate and stabilize (Peterson 2009).

A total of 5.4 miles of new road construction is proposed under Alternative 1. Management requirements and BMPs applicable to these roads are listed in detail in the Management Requirements section of this report, and include maintaining erosion control measures in accordance with an erosion control plan, stabilizing disturbed areas such as cut slopes and fill slopes, minimizing hydrologic connectivity of new roads, scheduling operations during dry periods, and installing erosion control measures prior to precipitation.

Six perennial and intermittent stream crossings are anticipated along the segments of new road construction. These crossings would be designed to pass the 100-year flow plus associated sediment and debris, would be located and designed to minimize water body disturbances, and would involve construction of diversion prevention dips to minimize the likelihood of stream channel diversion down a road. In addition to those design features, during construction of stream crossings, equipment would be clean, excavated materials would be kept out of channels, and channels would be diverted/dewatered as needed during installation of crossing structures.

Increases in permanent road mileage as a result of the proposed action range from a 0.08% increase in the Upper South Fork Tuolumne River watershed to a 1.79% increase in the Middle Clavey River watershed. BMPs and management requirements would limit sediment inputs to streams during road construction.

Although some erosion and sedimentation is anticipated as a result of these activities, particularly in the first year or two following construction, overall increases in erosion and sedimentation are anticipated to be low as the percent increase in road mileage is low.

Road Reconstruction and Maintenance

Reconstruction generally includes work to improve and restore roads. Improvements would provide for serviceability for project haul vehicles, as well as for proper hydrologic function and stream protection in accordance with applicable BMPs. Actions can include surface improvement; construction of drainage dips, culverts, riprap fills or other drainage or stabilization features with potential disturbance outside the established roadway (toe of fill to top of cut); realignment; and widening of curves as needed for log trucks and chip van passage.

Roads being used for the project that are in good condition would be maintained during the project. Maintenance preserves the function and serviceability of the road but generally does not include improvements. Maintenance activities generally include: blading; brushing; removal of roadside hazard trees; repair and/or replacement of road surfaces; cleaning, repair, or installation of drainage structures such as culverts, ditches, and dips; dust abatement; and installation or repair of signs. Maintenance activities generally do not disturb ground outside the existing roadway (toe of fill to top of cut) other than removal of material around culvert inlets.

Reconstruction is proposed on 320 miles of roads and maintenance is proposed on an additional 216 miles of road. Activities on temporary use-revert roads (8.4 miles) are anticipated to be similar to reconstruction. On road surfaces that are draining well, maintenance is important because a lack of road maintenance can result in progressive degradation of road-drainage structures and functions (USDA

2013). However, increased drainage features such as culverts and dips are needed on some roads to minimize hydrologic effects. This is particularly important following fire when there is increased runoff from hillslopes. In these situations, reconstruction is required to adequately improve drainage features and minimize impacts.

BMPs and management requirements applicable to road reconstruction are the same as described above for road construction. Management requirements and BMPs applicable to road maintenance are listed in detail in the Management Requirements section of this report, and include cleaning ditches and drainage structures only as needed, maintaining road surface drainage by removing berms, and watering roads using approved water sources.

The effectiveness of BMPs at protecting water quality following road reconstruction or maintenance has been evaluated on the forest. This includes evaluations of stream crossings along these roads. Between 2006 and 2012, 24 roads were randomly selected for evaluation of road surface drainage and stream crossings following maintenance or reconstruction. Of these, two reconstructed or maintained roads and two stream crossings were not effective. Effects of these were determined to be insignificant or minor and no corrective actions were recommended (STF 2007-2013).

Erosion and sedimentation is anticipated along maintained and reconstructed roads. However, implementation of BMPs and management requirements are expected to minimize these effects. Road reconstruction may actually reduce erosion and sedimentation that is currently occurring as this treatment would involve improving road drainage features.

Temporary Road Construction

Some road segments may be designated as temporary roads. Temporary roads are not intended to be a permanent part of the road system and would be decommissioned after use. Temporary roads may be existing routes which are intended to be used for this project only and then decommissioned or newly constructed roads to be decommissioned after use. Research has indicated that although road decommissioning does not completely eliminate erosion associated with forest roads, it does substantially reduce sediment yields from abandoned logging roads (Madej 2001).

Of the 13.9 miles of temporary roads identified for use under Alternative 1, 10.0 miles (72%) already exist on the ground as non-system routes. While additional traffic on these routes would cause soil disturbance and has the potential for increased erosion and sedimentation, these routes would be decommissioned following use, resulting in a net decrease of 10.0 miles of road on the landscape. The 3.9 miles of new temporary roads would reduce infiltration and lead to potential increases in erosion and sedimentation. However, decommissioning these roads after use would reduce these impacts in the long term.

BMPs and management requirements applicable to temporary roads are the same as those described for road construction, with the following exceptions: road/stream crossings would be removed or treated to prevent diversion potential; road surfaces would be treated through subsoiling, scattering slash, and/or revegetation; the road surface would be effectively drained through features such as waterbars and outsloping, drainage structures would be cleaned and sediment and erosion controls would be intact; and roads would be blocked to prevent vehicle access.

The effectiveness of BMPs at protecting water quality at temporary roads has been evaluated on the forest following green timber sales. Between 2006 and 2012, thirteen temporary roads were randomly selected for evaluation following use. BMPs were found to be implemented and effective at all 13 sites (STF 2007-2013). In the high soil burn severity areas there is less potential for filtering of sediment coming off of temporary roads than would have been seen under green sales. However, mitigations such as stabilizing cut slopes and fill slopes and increasing ground cover within 100 feet of perennial and intermittent streams should increase filtering potential and reduce the risk of off-site soil movement and stream sedimentation.

Material Source Development

There are seven material source sites proposed for use under the proposed action. Development of these sites may include activities such as blasting of rocks and collection and transport of materials off site. Table 12 describes each site proposed for use.

Table 12 Material Source Development Site Descriptions by HUC 6 Watershed

HUC 6 Watershed Name	Pit/Quarry Name	Size (ac)	Distance from Nearest Stream (ft)	Name of Nearest Stream
Jawbone Creek-Tuolumne River	Jawbone Quarry	2-5	200	Jawbone Creek
Middle Clavey River	Duckwall Quarry	<2	0	Intermittent Tributary to Thirteenmile Creek
	Clavey Quarry	2-5	1,000	Clavey River
Reed Creek	Bourland Quarry	<2	200	Paddle Creek
Lower Middle Fork Tuolumne River	Sawmill Quarry	2-5	1,800	Perennial Tributary to the Middle Fork Tuolumne River
Lower South Fork Tuolumne River	Packard Pit	<2	1,200	Intermittent Tributary to the South Fork Tuolumne River
	Unnamed Quarry	<2	800	Intermittent Tributary to the South Fork Tuolumne River

As seen in Table 12, of the seven sites proposed for use, Jawbone Quarry, Duckwall Quarry, and Bourland Quarry are located closest to surface waters. Jawbone Quarry and Bourland Quarry are bounded by a road, which would prevent further expansion towards surface waters. Duckwall Quarry is located on private land and has an intermittent channel running under the site through a culvert. Soil burn severity was primarily low surrounding this site, so the potential of vegetation to filter sediment moving off site remains high. All three sites have been utilized in previous timber sales with no reports of water quality concerns.

Management requirements and BMPs would be applied to all material source development sites. These include limiting the area of disturbance to the minimum necessary for efficient operations, rehabilitating and stabilizing sites after operations are complete to minimize risk of off-site movement, and installing temporary barriers between the extraction area and surface waters to prevent sedimentation (where appropriate). Additional requirements involving maintenance of systems roads and decommissioning of temporary roads would apply at these sites where applicable.

Although evaluation of the effectiveness of BMPs at borrow sites have not been conducted on the Stanislaus National Forest in recent years, evaluations have been done on other forests in the region. From 2003-2007, six evaluations were done, all of which were effective at preventing sediment from reaching surface waters (USDA 2009).

Due to distance from surface waters, roads preventing site expansion towards surface waters, filtering potential of remaining vegetation, and applications of BMPs and management requirements, erosion and sedimentation originating from material source sites are anticipated to be negligible.

Water Source Development

Eighty-one potential water sources have been identified under the proposed action. However, BMPs and management requirements include minimum flow requirements for both fish-bearing and non-fish bearing streams. It is anticipated that many of the proposed drafting sites would not be approved for use due to low flows.

Stream channels may be temporarily dammed to help draft water. However, management requirements and BMPs include maintaining bypass flows and gradually releasing temporary dams so that released impoundments do not discharge sediment into streamflow.

Additional BMPs to minimize impacts of water source development include proper location and treatment of approaches to prevent sediment delivery (such as armoring road approaches), armoring areas subject to high floods, and installing effective erosion control devices where overflow from water trucks or storage tanks may enter a stream.

The effectiveness of BMPs at protecting water quality at water source developments has been evaluated on the forest. Between 2006 and 2012, 12 water sources were randomly selected for evaluation following use. Of these, two sites were not effective at protecting water quality. However, both were described as having insignificant or minor effects to beneficial uses with no measurable water quality impairment and no corrective actions recommended (STF 2007-2013).

BMP effectiveness monitoring has shown that water source development has been completed effectively in the past and has resulted in only minimal sediment inputs to streams. The effects of water source development on erosion and sedimentation are anticipated to be minimal under the proposed action.

Fuel Loading

The proposed action would reduce the fuel loading in the project area watersheds. Coarse woody debris would be reduced to approximately 10 tons/acre. This would result in lower flame lengths and fireline intensities, allowing for direct attack of future wildfires. These reduced fuel loadings could be maintained with prescribed fire. Increased erosion following fire is related to the amount of vegetation removed. Prescribed burns, by design, do not consume extensive areas of organic matter (Baker 1990). Therefore, prescribed fires have been shown to have little impact on erosion and sedimentation, whereas intense wildfires may have substantial impacts (Brooks et al. 1997). Reducing fuel loading and then maintaining this with prescribed fire has less potential for erosion and sedimentation than allowing fuel loading to increase as snags fall and having another large stand-replacing wildfire in the future. See the Fuels report for more information on fuel loading.

Riparian Vegetation

Vegetation within RCAs consists of a combination of riparian obligate plants (those associated with easily available water) and non-obligate trees and shrubs such as conifers and hardwoods. Principal obligate vegetation species in the Rim Fire area include dogwoods, maples, willows, cottonwoods and aspens, and non-obligates are the conifer species commensurate with the elevations at which they mostly occur. Research conducted on the Plumas National Forest indicated that post-fire seedling recruitment and sprouting allowed riparian vegetation to be resilient and maintain stream quality even following high-severity fire (USDA 2013). The resiliency of riparian vegetation following wildfire has been noted in other research as well (Beschta et al. 2004). Management requirements require retention of remaining post-fire obligate riparian shrubs and trees that have live crown foliage or are resprouting.

Riparian vegetation may be beneficially affected by the proposed action where burned overstory trees are removed. Increasing sunlight in streamside areas provides an energy input that often stimulates regrowth of the riparian plant community. Though this effect is largely a result of the fire removing stream shade cover and moisture competition, removal of burned tree boles may have a slight incremental effect. Another variable affecting riparian plant growth is the short term increase in streamflow and near-stream ground water following a fire as a result of a reduction in plant transpiration due to tree mortality.

This post-fire and project-assisted effect has occurred on numerous fires along streams in the Stanislaus National Forest. Most notably this occurred along Rose Creek following the Ruby Fire of 1992. About 3,500 acres of the upper watershed was burned mostly to a high intensity. The riparian conifer canopy was consumed and in the few years following salvage removal, a new willow-alder-sedge community grew rapidly as sunlight and additional base flow occurred.

One fen has been identified within the roadside hazard tree removal area. There are no fens within timber treatment units. Removal of hazard trees near the fen is not anticipated to affect it, as management requirements such as equipment exclusion zones would be implemented.

There are approximately 60 acres of meadows identified within the proposed action treatment units. Removal of trees along meadow edges is not expected to affect meadows, as management requirements would be implemented.

Stream Condition

Stream Flow

Water yield typically increases in the first year following wildfire due to a reduction in soil water storage, interception, and evapotranspiration when vegetation is killed. This change decreases with time as vegetation reoccupies a watershed (Peterson et al. 2009). Under the proposed action, live trees would only be removed if they are a hazard tree and pose a risk to health and safety. Otherwise, all trees proposed for harvest would be dead and their removal would not affect soil water storage, interception, or evapotranspiration beyond the changes that already occurred as a result of the fire.

Modeling has indicated that increased surface roughness promotes infiltration and reduces overland flows, leading to reduced storm peak events and total flows (Smith et al. 2011). BMPs and management requirements under the proposed action would involve adding ground cover and minimizing compaction. Therefore, measurable changes in stream flow are not anticipated to result under the proposed action.

Stream Morphology

Prior to the Rim Fire, stream surveys throughout the project area indicated that most stream banks were stable and that channel form was predominately either normal (no active downcutting or evidence of accelerated past incision) or rejuvenating (evidence of legacy disturbance, but channel has recovered or is recovering to good condition).

Increased high peak flows following the Rim Fire have the potential to cause channel incision, primarily in low-gradient stream reaches with small, mobile substrate. However, measureable changes in flow are not anticipated as a result of the proposed action. Therefore, if channel incision does occur within the project area, it is likely the result of the fire or from large storms, not the proposed action.

Stream banks that were stable pre-fire may no longer have adequate cover to maintain their stability. This is particularly the case in areas of high soil burn severity. As discussed above, riparian vegetation is resilient following fires and is expected to flourish in the post-fire conditions of increased sunlight and water. This would allow for natural recovery of bank stability. The effect of the proposed action on streambank stability is expected to be minimal. Mechanized equipment exclusion zones are applied to all streams so that equipment is only allowed on stream banks at designated crossing locations. Skid trail stream crossings are limited to two per mile on perennial and intermittent streams and three per mile on ephemeral streams. Management requirements to maintain or provide ground cover within 100 feet of perennial and intermittent streams would provide for stability while riparian vegetation recovers.

Large Woody Debris

Following wildfire, snags falling into streams may be the main source of wood to streams until trees in the post-fire riparian areas are large enough to fall into streams and create habitat (Reeves 2006). Under the proposed action, existing downed large woody debris in the channel would be retained. In addition, a minimum of 20 pieces of large woody debris per mile of perennial or intermittent stream would be retained and felled into the stream channel. As a result of the proposed action, large woody debris levels in streams would increase in the short term following project implementation. Levels would be lower, in the long term, however, than if harvesting did not occur near stream channels. See the Aquatics report for more information on large woody debris.

Wild and Scenic Rivers

The Tuolumne River main channel throughout the length of the fire on the Stanislaus National Forest was congressionally designated in 1984 as a Wild and Scenic River under the Wild and Scenic Rivers Act of 1968. Under the proposed action, there are no timber salvage units proposed for treatment within the Wild and Scenic River corridor. For the roadside hazard tree removal, approximately 285 acres of treatment fall within the scenic classification segments of the Tuolumne Wild and Scenic River. This acreage is located along Lumsden Road (1N10), 1N10C, and 1S52. An additional 2 acres of roadside hazard tree treatments fall into the wild classification segments of the Tuolumne River. Although there are no roads in the wild classification segments, Lumsden road abuts these segments, and treating hazard trees along Lumsden road could involve felling of trees within the wild classification area.

The South Fork Tuolumne River has a continuous two mile segment upstream from its confluence of the main channel of the Tuolumne River that is eligible as a Wild and Scenic River with a scenic classification. Less than 1 acre of unit Y01 (tractor) overlaps with the ¼ mile buffer of the South Fork Tuolumne River. In addition, approximately 10 acres of roadside hazard tree removal is proposed within the ¼ mile buffer along roads 1S99Y and FR7858 (permit road through San Jose Camp).

The Clavey River is a proposed Wild and Scenic River. More than half of the Clavey's eligible length falls within the Rim Fire area. Within the scenic classification segments, the following activities are proposed under Alternative 1: approximately 50 acres of ground based harvesting, 8 acres of skyline, and 506 acres of helicopter logging in salvage units; approximately 256 acres of roadside hazard tree removal along roads 1N01, 2N29, 2N29A, and 3N56Y; 2.65 miles of road reconstruction, 5.50 miles of road maintenance, and 0.28 miles of new road construction; and use of the Clavey Quarry, an existing material source site. An additional 11.9 acres of roadside hazard tree removal is proposed within the wild classification segment of the Clavey River. This is located where road 2N40 overlaps the ¼ mile buffer on the wild classification segment, and could involve the removal of trees within the wild classification area.

Free-Flowing Condition

Maintaining the free-flowing condition of the Tuolumne River, Clavey River, and South Fork Tuolumne River is necessary to maintain their wild and scenic values. The treatments proposed under Alternative 1 would not affect the existing flow regimes of these rivers, as nothing would be placed in their stream channels. Constriction of flow is not anticipated as a result of road construction, as no stream crossings are proposed within the ¼ mile buffers of these rivers. Minor increases in stream flow may have occurred following the fire, as fire-killed trees no longer utilize water, resulting in reduced evapotranspiration rates along the hillslopes. Removal of these fire-killed trees under the proposed action would not result in any further measurable changes to evapotranspiration rates.

Water Quality

Maintaining high water quality is also needed to maintain the wild and scenic values of the Tuolumne, Clavey, and South Fork Tuolumne Rivers. As described in the section on erosion and sedimentation, management requirements have been designed to minimize water quality impacts. This includes requirements such as maintaining or increasing ground cover, subsoiling compacted areas, smoothing out ruts, and improving drainage features on existing roads. While some sedimentation could occur as a result of the proposed action, it is anticipated to be minimal and of short duration and is not expected to affect the long-term beneficial uses and purposes for which these rivers were designated or made eligible.

Water Quality (Beneficial Uses of Water)

Uses of water for the Tuolumne River from its source to New Don Pedro Reservoir are municipal and domestic supply, irrigation, stock watering, power, contact and non-contact recreation, warm and cold water freshwater habitat, and wildlife habitat. Existing uses of water for the Merced River from its source to McClure Lake are irrigation, power, contact and non-contact recreation, warm and cold water freshwater habitat, and wildlife habitat. A potential use for the Merced River is municipal and domestic water supply (CVRWQCB, 2011).

Beneficial uses are maintained when their related water quality objectives are met. Water quality objectives that could be affected by the proposed action are water temperature, sediment related parameters (sediment, settleable material, suspended material, and turbidity), and pesticides. Temperature relates to changes that might adversely affect aquatic species. The sediment related parameters can affect municipal and domestic water supply, power, contact and non-contact recreation (i.e., swimming, fishing), freshwater habitat (cold water fisheries), and wildlife (amphibian and aquatic reptile species).

Pesticides can affect municipal and domestic supply, contact and non-contact recreation, and warm and cold freshwater habitat.

There are no 303(d) listed impaired waterbodies within the project analysis area. This indicates that water quality is excellent at this large scale.

Water Temperature

Stream channel shade is highly influential in regulating water temperatures (Rutherford et al. 2004). Channel shade was reduced in portions of the project area where near-stream trees were killed by the fire. Removal of the near-stream dead conifer trees is anticipated to have very little effect on stream shading. These trees, if left standing, would provide little to no shade in the future. Therefore, warm and cold water freshwater habitat would not be affected by the proposed action.

Sediment-Related Parameters

Prior to the Rim Fire, stream surveys indicated that pool tail and pool bed fine sediment was mostly very low throughout the fire area. The presence of native fishes of all age classes further indicated that stream sediment was not excessive and thus suitable for sustaining successful reproduction. Increases in erosion and sedimentation are anticipated as a result of the proposed action, particularly in areas which have high soil burn severity adjacent to streams. Sediment deposition in streams is anticipated to be greatest in low gradient depositional reaches. Although sediment may reach streams in high gradient areas, these transport reaches are capable of moving sediment and minimizing accumulations in pool tails and pool beds. BMPs and management requirements are designed to minimize these inputs of sediment.

The amount of suspended and bed load sediment caused by the proposed action should not impair any of the applicable beneficial uses. Research following the Stanislaus Complex in 1987 found that differences in sediment production from logged and unlogged sites were not statistically significant. This was attributed to either the high variability in disturbance within each treatment or the large effect of the fire itself on sediment output (Chou et al. 1994). In addition, the proposed action has been designed to minimize watershed effects through the implementation of management requirements, including mechanized equipment buffers on streams, maintaining or providing ground cover along streams, and subsoiling skid trails, landings, and temporary roads.

Pesticides (Registered Borate Compound)

A registered borate compound is proposed for application to tree stumps 14 inches and greater in diameter to limit the spread and establishment of new centers of annosum root disease within mixed severity harvest areas. Following application to tree stumps, rainfall and consequent runoff could lead to contamination of standing water or streams. In addition, accidental spills into a small body of water are possible (USDA 2006). However, given the highly focused application method for borate, application of granular product to cut tree stump surfaces, the potential to contaminate surface water is limited. In addition, management requirements, including not applying within 10 feet of surface water, when rain is falling, or when rain is likely that day (i.e. when the National Weather Service forecasts 50% or greater chance), would minimize any actual effect to a minor or negligible amount. Effects to municipal and domestic supply, contact and non-contact recreation, and warm and cold freshwater habitat are not anticipated. See the Risk Assessment Report for Registered Borate Application for more information.

Summary

None of the sediment related beneficial uses of water should be impaired as a result of the proposed action. Minor, short term increases in sediment related parameters are expected but not to the extent of adversely affecting beneficial uses. Anticipated sediment increases vary by watershed based on amount of project activity and watershed effects of the Rim Fire. Streams with special designations such as Wild and Scenic Rivers or Heritage Trout Waters are not expected to be adversely affected. No known impairment of beneficial uses has occurred as a result of other past fire salvage harvesting on the Stanislaus National Forest, in settings where the percentage of high soil burn severity was greater than the Rim Fire.

Water temperature is not expected to be altered as a result of this alternative. Removal of the near-stream dead conifer trees is anticipated to have very little effect on stream shading. These trees, if left standing, would provide little to no shade in the future. Therefore, water temperature should not be affected.

No pesticide contamination is expected as a result of the proposed action. The borate compound applied to tree stumps is not expected to enter water.

CUMULATIVE EFFECTS

The process for analyzing cumulative watershed effects (CWE) consists of two steps: (1) an office evaluation which consists of determining the risk of cumulative effects using a predictive model and researching watershed history, and (2) field evaluation of streamcourse indicators of cumulative effects.

Step 1, the risk of cumulative effects, is evaluated using the Forest Service equivalent roaded acreage (ERA) methodology, which has been adopted by Region 5 as a method of addressing cumulative watershed effects (USDA 1990). A description of the ERA methodology can be found in Appendix A: Cumulative Watershed Effects Analysis Methodology.

Understanding watershed history (i.e. past management activities, hydrologic events, wildfire) is important to build a temporal context of past impacts, current condition and potential future effects. Analysis of watershed history, including land disturbance history, is essential to help predict effects of future management activities on water quality and watershed condition. This history is considered in the ERA model. The temporal scope analyzed is based upon the estimated time of recovery from each past activity or event. It varies by activity and ranges from 1 to 10 years. The temporal scope for known future activities also varies by activity and ranges from 1 to 10 years into the future. Not all future activities used to calculate ERA values have a defined proposed action. Therefore, assumptions were made about when and where activities would likely occur. These assumptions were documented in Appendix A.

Step 2, field evaluation, is necessary for comparing the modeled ERA prediction with actual and expected future field conditions. Project-related water quality parameters and watershed condition are evaluated via in-stream and near-stream indicators of condition. This evaluation is essential to help interpret cumulative effects of past projects and potential cumulative effects given proposed activities and other reasonably foreseeable future activities. Field review was used to verify that the geographic and temporal extent of analysis was adequate for evaluation of cumulative watershed effects (Connaughton 2005).

Equivalent Roaded Acres (ERAs)

Three of the fifteen HUC 6 analysis watersheds had a maximum of 6% of their watershed acreage burned at high or moderate soil burn severity. These watersheds (Bean Creek-North Fork Merced River, Bull Creek, and Lower North Fork Tuolumne River) also all had a maximum of 4% of their acreage proposed for treatment under the proposed action. Therefore, these watersheds were not analyzed in detail following the ERA methodology. The effects of the small acreage of high or moderate soil burn severity and the small acreage of proposed treatments on these watersheds made it very unlikely to have measurable cumulative watershed effects, leading to the determination that ERA calculations were unnecessary.

The CWE ERA analysis for the Rim Fire Recovery EIS was conducted on all lands (public and private) within twelve HUC 6 and five HUC 7 level watersheds. GIS analysis was used to calculate acreages of activities in the watersheds. ERA values for these activities were summed and then were compared to a Threshold of Concern (TOC). The TOC for all HUC 6 and HUC 7 watersheds analyzed was 12-14%. See Table 13 for a summary of ERA values by watershed. Highlighted values denote watersheds over the TOC.

Table 13 Annual % ERA for each HUC 6 and HUC 7 Analysis Watershed

HUC Level and Name	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
6 - Grapevine Creek-Tuolumne River	4.31	3.51	2.52	2.37	2.19	2.01	1.83	1.70	1.56	1.43
6 - Jawbone Creek-Tuolumne River	16.24	14.89	11.79	10.34	8.80	7.08	5.46	4.51	3.57	2.63
7 - Corral Creek	20.03	21.39	17.96	15.86	13.61	10.80	8.01	6.70	5.39	4.08
7 - Lower Jawbone Creek	14.00	12.75	9.47	8.58	7.55	6.26	4.98	4.20	3.43	2.66
6 - Lower Clavey River	9.59	8.94	7.13	6.40	5.65	4.78	3.93	3.27	2.62	2.00
7 - Bear Springs Creek	13.00	12.44	10.28	9.14	8.00	6.67	5.37	4.38	3.38	2.50
6 - Middle Clavey River	4.93	5.42	4.93	5.32	5.62	5.77	5.05	4.44	3.83	3.24
6 - Reed Creek	8.23	9.47	8.48	8.05	7.17	6.12	5.04	4.30	3.58	2.85
7 - Lower Reed Creek	17.47	18.10	15.40	13.40	11.50	9.23	7.07	5.90	4.73	3.56
6 - Lower Cherry Creek	11.36	10.11	7.91	6.95	5.93	4.82	3.74	3.15	2.55	1.96
7 - Granite Creek	26.52	24.13	19.54	16.92	14.18	11.18	8.29	6.82	5.35	3.90
6 - Miguel Creek-Eleanor Creek	3.69	2.64	1.36	1.12	0.89	0.63	0.37	0.32	0.28	0.23
6 - Poopenaut Valley-Tuolumne River	4.56	3.30	1.91	1.63	1.32	0.99	0.66	0.60	0.54	0.49
6 - Lower Middle Fork Tuolumne River	12.72	15.13	13.25	12.18	10.92	9.34	7.82	6.62	5.43	4.25
6 - Upper Middle Fork Tuolumne River	3.74	2.78	1.74	1.36	0.99	0.60	0.22	0.20	0.17	0.15
6 - Lower South Fork Tuolumne River	9.13	9.91	8.58	7.94	7.50	6.51	5.59	4.87	4.15	3.44
6 - Upper South Fork Tuolumne River	3.19	2.47	1.56	1.34	1.11	0.88	0.66	0.60	0.54	0.47

Of the twelve HUC 6 watersheds analyzed, six were well below the TOC of 12-14%. These watersheds (Grapevine Creek-Tuolumne River, Middle Clavey River, Miguel Creek-Eleanor Creek, Poopenaut Valley-Tuolumne River, Upper Middle Fork Tuolumne River, and Upper South Fork Tuolumne River) all had ERA values of less than 6%.

An additional four HUC 6 watersheds (Lower Clavey River, Reed Creek, Lower Cherry Creek, and Lower South Fork Tuolumne River) approached, but didn’t exceed, the TOC. Two HUC 6 watersheds (Jawbone Creek-Tuolumne River and Lower Middle Fork Tuolumne River) exceeded the TOC.

Five HUC 7 watersheds were evaluated for cumulative watershed effects using the ERA methodology. The description as to how and why these were selected can be found in Appendix A: Cumulative Watershed Effects Analysis Methodology. All five exceeded the TOC.

All watersheds that approached or exceeded the TOC are discussed in detail below. Cumulative watershed effects are not anticipated on the six HUC 6 watersheds that were well under the threshold of concern (ERA values less than 6%), so these are not discussed individually.

Previous analyses on the forest have indicated that the effects of livestock grazing at the watershed scale are very low. Ground disturbance from livestock grazing is essentially a site issue rather than a watershed scale issue. This is because the spatial impacts of livestock grazing are much higher in low gradient stream channels through meadows than in upland areas, and low gradient stream areas make up an extremely small percentage of the watershed acreage in this project. This results in negligible change to ERA values. Because of this, cumulative impacts of grazing are described narratively for this project.

HUC 6 and 7 Watersheds

Management requirements and BMPs were proposed to maintain or improve current conditions in the watersheds. This includes increasing ground cover within 100 feet of perennial and intermittent streams and special aquatic features and exclusion zones for ground-based equipment. Effectiveness monitoring is done annually on projects throughout the forest at randomly selected sites to determine if BMPs were effective. If Alternative 1 were selected, additional monitoring beyond effectiveness monitoring would be required by the Central Valley Regional Water Quality Control Board for all watersheds (both HUC 6 and HUC 7) over the TOC. Forensic monitoring inspections would be conducted during the winter period. These inspections are designed to detect potentially significant sources of pollution such as failed management measures or natural sources. The goal of winter forensic monitoring is to locate sources of sediment production in a timely manner so that rapid corrective action may be taken where feasible and appropriate (CVRWQCB 2005). In addition, in accordance with the Region 5 Forest Service Water Quality Management Handbook, project-level in-channel monitoring would be conducted following the Stream Condition Inventory (SCI) protocol (USDA 2011, Frazier et al. 2005).

Stream condition in the project area watersheds was evaluated to determine if there were indications of past or present cumulative effects, and the potential for adverse impacts from future cumulative effects. The evaluation of stream condition included pre-fire stream surveys in most watersheds following the StreamScape Inventory (SSI) Protocol, which included observations of streambed sediment, streambank stability, and attributes of stream morphology (Frazier et al. 2008).

Jawbone Creek-Tuolumne River (HUC 6)

<u>ERA Summary</u>

The ERA in the Jawbone Creek-Tuolumne River watershed would increase from its current 14.68% (no action) to 16.24% in the first year of implementation, 2014. This is the maximum ERA. The ERA falls back below the TOC by 2016 and by 2023 is down to 2.63%. The previous activities in the watershed, which have an ERA value of 9.99% in 2014, are large contributors to the high ERA values. These activities include the fire itself, fire suppression, timber harvest on private and Forest Service lands before the fire, and salvage activities on private lands after the fire.

The ERA in the Corral Creek HUC 7 watershed would increase from its current 16.33% (no action) to 20.03% in the first year of implementation, 2014. This would further increase in 2015, with a maximum ERA of 21.39%. The ERA falls back below the TOC by 2019 and by 2023 is down to 4.08%. The ERA is over the 12-14% threshold of concern for this watershed. This is due in large part to the previous activities in the watershed, which have an ERA value of 12.71%. Although there were a few previous land management activities in the watershed, the main reason the previous activities ERA was so high was because 89% of the watershed burned at high or moderate soil burn severity.

The ERA in the Lower Jawbone Creek HUC 7 watershed would increase from its current 11.80% (no action) to 14.00% in the first year of implementation, 2014. This is the maximum ERA. The ERA falls back below the TOC by 2016 and by 2023 is down to 2.66%. The ERA is over the 12-14% threshold of concern for this watershed. This is due in large part to the previous activities in the watershed, which have an ERA value of 9.95%. Although there were a few previous land management activities in the watershed, the main reason the previous activities ERA was so high was because 85% of the watershed burned at high or moderate soil burn severity.

Stream Condition Summary

Pre-fire stream surveys in the Jawbone Creek-Tuolumne River watershed were conducted in Drew Creek and Corral Creek. Surveys indicated that the condition of Drew Creek was good overall (i.e., stable banks, normal channel morphology, and low pool bed sediment). The RCA surrounding Drew Creek burned at low severity, so stream condition post-fire is likely the same as pre-fire. Very little treatment is proposed under Alternative 1 in the southern part of the Jawbone Creek-Tuolumne River watershed near Drew Creek, so stream condition is anticipated to remain good.

Pre-fire stream surveys in Corral Creek, on the other hand, showed much of the channel to be rejuvenating from past disturbance. Pre-fire bank stability was moderate, and was substantially reduced by the fire. This stream is still sensitive to further disturbance. Due to this sensitivity, additional management requirements were put in place for Corral Creek. A large equipment exclusion zone prohibits mechanized equipment between Corral Creek and its near-stream roads. Ground cover will be maintained or provided along its banks to minimize erosion and increase stability. This is in addition to 700 acres of straw mulch that was applied to the watershed as part of BAER treatments. Despite these treatments, Corral Creek is one of the areas which have the greatest potential for stream sedimentation following treatment.

Pre-fire stream surveys were not conducted in the Lower Jawbone Creek HUC 7 watershed. However, the acreage of high soil burn severity in this watershed was relatively low (10%). There was only 3% high soil burn severity within 100 feet of streams, meaning that most of the high soil burn severity was on the hillslopes. In this watershed, there are only 7 acres of salvage logging treatment proposed in a high soil burn severity area within 100 feet of a perennial stream, intermittent stream, or SAF. This low acreage of treatment proposed within the highest risk area makes it likely that any increases in sedimentation would be minimal.

The proposed action is anticipated to result in increased sedimentation in the Jawbone Creek-Tuolumne River watershed, particularly in the Corral Creek HUC 7 watershed. However, management requirements and BMPs are anticipated to minimize these effects to the extent feasible. Monitoring is anticipated to identify any problem areas so that corrective action could be taken quickly. Due to these mitigations, the proposed action is not anticipated to result in adverse off-site cumulative effects to sediment-related water quality parameters or to watershed condition (i.e. degradation of stream channel morphology, accelerated erosion or loss of soil productivity). The proposed action also is not anticipated to result in cumulative effects to water temperature, as only dead trees would be removed and these provide minimal shade.

Lower Clavey River (HUC 6)

ERA Summary

The ERA in the Lower Clavey River watershed would increase from its current 8.41% (no action) to 9.59% in the first year of implementation, 2014. This is the maximum ERA and does not exceed the 12-14% TOC. The ERA gradually decreases to a low of 2.00% in 2023. Approximately half of the 9.59% ERA was due to previous activities, including the fire itself and timber harvest (both green sales and salvage) on private land.

The ERA in the Bear Springs Creek HUC 7 watershed would increase from its current 11.36% (no action) to 13.00% in the first year of implementation, 2014. This is the maximum ERA. The ERA falls back below the TOC by 2016 and by 2023 is down to 2.50%. The ERA is over the 12-14% threshold of concern for this watershed. This is due in large part to the previous activities in the watershed, which have an ERA value of 5.92%. These previous activities include the fire itself, in which 50% of the watershed burned at moderate or high soil burn severity, as well as timber activities (both green tree sales and salvage) on private lands. An additional 4.20% of the ERA is attributed to planned salvage activities on private land as well as hazard tree removal on Forest Service lands along maintenance level 3, 4, and 5 roads.

Stream Condition Summary

Pre-fire stream surveys in the Lower Clavey River watershed were conducted in Bull Meadow Creek. Surveys indicated that the condition of Bull Meadow Creek was variable. Although most of the bank stability was high, there were transects with less than 50% stability, and 17% of the surveyed channel length was incised. Despite this, pool bed sediment and pool tail sediment was low. The RCA surrounding Bull Meadow Creek burned primarily at low and moderate severity, so stream condition post-fire is likely the same as pre-fire. Very little treatment is proposed under Alternative 1 in the southern part of the Lower Clavey River watershed near Bull Meadow Creek, so stream condition is anticipated to remain unchanged.

Pre-fire stream surveys were not conducted in the Bear Springs Creek HUC 7 watershed. However, the acreage of high soil burn severity in this watershed was low (7%). There was only 2% high soil burn severity within 100 feet of streams, meaning that most of the high soil burn severity was on the hillslopes.

In the Lower Clavey River watershed, there are only 6 acres of salvage logging treatment proposed in a high soil burn severity area within 100 feet of a perennial stream, intermittent stream, or SAF. All of this acreage is within the Bear Springs Creek HUC 7 watershed. This low acreage of treatment proposed within the highest risk area makes it likely that any increases in sedimentation would be minimal. Due to implementation of management requirements and BMPs, as well as monitoring to identify problem areas, the proposed action is not anticipated to result in adverse off-site cumulative effects to sediment-related water quality parameters or to watershed condition (i.e. degradation of stream channel morphology, accelerated erosion or loss of soil productivity). The proposed action also is not anticipated to result in cumulative effects to water temperature, as only dead trees would be removed and these provide minimal shade.

Reed Creek (HUC 6)

ERA Summary

The ERA in the Reed Creek watershed would increase from its current 7.06% (no action) to 8.23% in the first year of implementation, 2014. This would further increase in 2015, with a maximum ERA of 9.47%. This maximum ERA does not exceed the 12-14% TOC. The ERA gradually decreases to a low of 2.85% in 2023. More than half of the ERA value in 2014 was due to previous activities, including the fire itself, fire suppression, timber harvest on private and FS lands before the fire, and salvage activities on private lands after the fire.

The ERA in the Lower Reed Creek HUC 7 watershed would increase from its current 14.98% (no action) to 17.47% in the first year of implementation, 2014. This would further increase in 2015, with a maximum ERA of 18.10%. The ERA falls back below the TOC by 2018 and by 2023 is down to 3.56%. The ERA is over the 12-14% threshold of concern for this watershed. This is due in large part to the previous activities in the watershed, which have an ERA value of 12.38% in 2014. These previous activities include the fire itself, in which 62% of the watershed burned at moderate or high soil burn severity, as well as timber activities (both green tree sales and salvage) on private and Forest Service lands.

Stream Condition Summary

Over 30 miles of pre-fire stream surveys in the Reed Creek watershed were conducted in Bourland Creek, Little Reynolds Creek, Lost Creek, Niagara Creek, Reed Creek, and Reynolds Creek. Surveys indicated that the condition of these creeks was predominately good. Bank stability was high or moderate for 80-100% of stream lengths. Channel form was mostly normal or rejuvenating, with the exception of a large incised section of Lost Creek and smaller sections of incision elsewhere. Despite these areas of instability, pool bed sediment and pool tail sediment was low.

The concentration of severe burn was in the Lower Reed Creek HUC 7 watershed. Reed Creek and Niagara Creek are the main channels in this watershed. Reed Creek had high bank stability pre-fire and had 99% of its length in a normal channel form. Niagara Creek had more evidence of past instability, with sections of low bank stability (6% of surveyed length) and almost half its length incised, incised and widened, or rejuvenating. Despite this, both streams had low pool bed and pool tail sediment.

In the Reed Creek watershed, there are 47 acres of salvage logging treatment proposed in a high soil burn severity area within 100 feet of a perennial stream, intermittent stream, or SAF. Most of this treatment (46 of the 47 acres) is within the Lower Reed Creek watershed. Reed Creek is bedrock controlled and highly erosion resistant, so changes in stream channel form are unlikely. Niagara Creek is more sensitive to disturbance, as its dominant substrate is gravel which is much more easily mobilized in high flows. Management requirements and BMPs were designed to address this sensitivity. This includes equipment exclusion zones and ground cover treatments. In addition, about 1,900 acres of straw mulch was applied to this watershed as part of BAER treatments. Despite these treatments, the Lower Reed Creek HUC 7 watershed is one of the areas which have the greatest potential for stream sedimentation following treatment.

The proposed action is anticipated to result in increased sedimentation in the Reed Creek watershed, particularly in the Lower Reed Creek HUC 7 watershed. However, management requirements and BMPs are anticipated to minimize these effects to the extent feasible. Monitoring is anticipated to identify any problem areas so that corrective action could be taken quickly. Due to these mitigations, the proposed action is not anticipated to result in adverse off-site cumulative effects to sediment-related water quality parameters or to watershed condition (i.e. degradation of stream channel morphology, accelerated erosion or loss of soil productivity). The proposed action also is not anticipated to result in cumulative effects to water temperature, as only dead trees would be removed and these provide minimal shade.

Lower Cherry Creek (HUC 6)

ERA Summary

The ERA in the Lower Cherry Creek watershed would increase from its current 10.58% (no action) to 11.36% in the first year of implementation, 2014. This is the maximum ERA and does not exceed the 12-14% TOC. The ERA gradually decreases to a low of 1.96% in 2023. More than half of the 11.36% ERA was due to previous activities, including the fire itself, fire suppression, and timber activities (both green tree sales and salvage) on private and Forest Service lands.

The ERA in the Granite Creek HUC 7 watershed would increase from its current 24.68% (no action) to 26.52% in the first year of implementation, 2014. This is the maximum ERA. The ERA falls back below the TOC by 2019 and by 2023 is down to 3.90%. The ERA is over the 12-14% threshold of concern for this watershed. This is due primarily to the previous activities in the watershed, which have an ERA value of 17.66% in 2014. These previous activities include the fire itself, in which 92% of the watershed burned at moderate or high soil burn severity, as well as timber activities (both green tree sales and salvage) on private and Forest Service lands.

Stream Condition Summary

No pre-fire SSI data was collected for the Lower Cherry Creek watershed. In this watershed, there are 58 acres of salvage logging treatment proposed in a high soil burn severity area within 100 feet of a perennial stream, intermittent stream, or SAF. Most of this treatment (47 of the 58 acres) is within the Granite Creek watershed. The granitic soil prevalent in this watershed is highly erodible. Approximately 30% of the watershed burned at high soil burn severity, and an additional 62% burned at moderate soil burn severity. Because of this sensitivity, about 750 acres of straw mulch was applied to the Granite Creek watershed as part of BAER treatments.

The proposed action is anticipated to result in increased sedimentation in the Lower Cherry Creek watershed, particularly in the Granite Creek HUC 7 watershed. This watershed experienced the greatest burn severity of any of the HUC 7 watersheds. However, management requirements and BMPs are anticipated to minimize these effects to the extent feasible. Monitoring is anticipated to identify any problem areas so that corrective action could be taken quickly. Due to these mitigations, the proposed action is not anticipated to result in adverse off-site cumulative effects to sediment-related water quality parameters or to watershed condition (i.e. degradation of stream channel morphology, accelerated erosion or loss of soil productivity). The proposed action also is not anticipated to result in cumulative effects to water temperature, as only dead trees would be removed and these provide minimal shade.

Lower Middle Fork Tuolumne River (HUC 6)

ERA Summary

The ERA in the Lower Middle Fork Tuolumne River watershed would increase from its current 9.96% (no action) to 12.72% in the first year of implementation, 2014. This would further increase in 2015, with a maximum ERA of 15.13%. The ERA falls back below the TOC by 2018 and by 2023 is down to 4.25%. The ERA is over the 12-14% threshold of concern for this watershed. This is due in large part to the previous activities in the watershed, which have an ERA value of 7.21% in 2014. These previous activities include the fire itself, in which 63% of the watershed burned at moderate or high soil burn severity, as well as timber activities on private and Forest Service lands.

Stream Condition Summary

Nearly 10 miles of pre-fire stream survey data was collected on the main channel of the Middle Fork Tuolumne River. Bank stability was very high and channel form was normal for its entire length, indicating no evidence of past channel incision. Pool tail and pool bed fine sediment was also low. Part of this watershed was burned previously in the Pilot Fire, and good pre-Rim Fire condition indicates that impacts of past wildfire have not affected stream channel stability.

The areas of high soil burn severity in the Lower Middle Fork Tuolumne River watershed were relatively small patches well distributed throughout the watershed. The spatial mosaic of severity classes can reduce on and off site soil and water effects by interrupting erosion pathways and reducing sediment delivery to streams.

The proposed action is anticipated to result in increased sedimentation in the Lower Middle Fork Tuolumne River watershed. However, management requirements and BMPs are anticipated to minimize these effects to the extent feasible. Monitoring is anticipated to identify any problem areas so that corrective action could be taken quickly. Due to these mitigations, the proposed action is not anticipated to result in adverse off-site cumulative effects to sediment-related water quality parameters or to watershed condition (i.e. degradation of stream channel morphology, accelerated erosion or loss of soil productivity). The proposed action also is not anticipated to result in cumulative effects to water temperature, as only dead trees would be removed and these provide minimal shade.

Lower South Fork Tuolumne River (HUC 6)

ERA Summary

The ERA in the Lower South Fork Tuolumne River watershed would increase from its current 7.01% (no action) to 9.13% in the first year of implementation, 2014. This would further increase in 2015, with a maximum ERA of 9.91%. This is the maximum ERA and does not exceed the 12-14% TOC. The ERA gradually decreases to a low of 3.44% in 2023. Approximately half of the 2014 ERA value was due to previous activities, including the fire itself, in which 47% of the watershed burned at moderate or high soil burn severity, fire suppression, and timber activities (both green tree sales and salvage) on private and Forest Service lands.

Stream Condition Summary

Nearly 7 miles of pre-fire stream survey data was collected on the main channel of the South Fork Tuolumne River. Sections of Big Creek, Rush Creek, and Soldier Creek were also surveyed. Bank stability was moderate to high and all four streams had normal channel form for 100% of their lengths. Pool tail and pool bed sediment was higher than that seen in the other watersheds described above, but all size classes of fish were present in streams, indicating that sediment was not excessive regarding aquatic life.

The proposed action is anticipated to result in increased sedimentation in the Lower Middle Fork Tuolumne River watershed. However, management requirements and BMPs are anticipated to minimize these effects to the extent feasible. Monitoring is anticipated to identify any problem areas so that corrective action could be taken quickly. Due to these mitigations, the proposed action is not anticipated to result in adverse off-site cumulative effects to sediment-related water quality parameters or to watershed condition (i.e. degradation of stream channel morphology, accelerated erosion or loss of soil productivity). The proposed action also is not anticipated to result in cumulative effects to water temperature, as only dead trees would be removed and these provide minimal shade.

Grazing

There are active grazing allotments located in all of the analysis HUC 6 and HUC 7 watersheds except Miguel Creek-Eleanor Creek. The resumption of grazing on these allotments has the potential to slow recovery of riparian vegetation and increase ground disturbance, particularly along stream banks. However, Forest Plan Standards and Guidelines require the prevention of disturbance from livestock from exceeding 20 percent of stream reach or 20 percent of natural lake and pond shorelines. It also limits browse to no more than 20 percent of the annual leader growth on mature riparian shrubs and no more than 20 percent of individual seedlings. In this project area the browse limit would apply to streamside areas where riparian obligates trees and shrubs are naturally resprouting and reseeding after the fire. Although resumption of grazing within the analysis watersheds is anticipated to result in ground disturbance and a reduction in riparian vegetation, these effects are anticipated to be localized and adherence to Standards and Guidelines should allow for riparian vegetation recovery to progress naturally.

Alternative 2 (No Action)

DIRECT AND INDIRECT EFFECTS

Erosion and Sedimentation

Factors Affecting Erosion and Sedimentation

Soil Compaction

Under the no action alternative, there would be no risk of soil compaction as management activities utilizing mechanized equipment would not occur. However, activities under the action alternatives that are designed to reduce soil compaction would not occur either.

Field review and LiDAR imagery has indicated an extensive skid trail network within the project area. Many of these pre-existing skid trails were not properly decommissioned in the past, and thus are concentrating runoff and causing erosion and sedimentation. Litschert and MacDonald evaluated 200 harvest units in the Sierras ranging in age from 2 to 18 years. The majority (84%) of the rills and sediment plumes found originated from skid trails (Litschert and MacDonald 2009), indicating that skid trails are the primary source of erosion and sedimentation following timber harvest. Past subsoiling of skid trails on the Stanislaus National Forest was found to not only mitigate recent compaction, but that which occurred during salvage and site preparation decades earlier (Powers 2002). Under the action alternatives, existing skid trails would be re-used to the extent practicable, and then subsoiled and waterbarred, reducing compaction and the risk of erosion and sedimentation. This would not occur under Alternative 2.

Soil Displacement

Soil displacement would not occur as a result of Alternative 2.

Ground Cover

Under the no action alternative, ground cover in high soil burn severity areas is expected to be lower than that found under any action alternative. That is because ground cover treatments such as drop and lop, mastication, and lop and scatter of activity fuels would not occur. Over time, trees falling would increase ground cover in these areas. This woody debris on the ground needs to have good contact with the soil in order to effectively trap sediment (Chase 2006). Unlike drop and lop, mastication, and lop and scatter of activity fuels where fuels are chopped into smaller pieces with the goal of creating good contact with the soil, natural falling of trees may or may not have good ground contact.

Live vegetative recovery would increase over time under the no action alternative. This recovery is anticipated to be faster than under the action alternatives because disturbance by heavy equipment would not occur.

Ground cover is expected to be less under Alternative 2 than the action alternatives until the area could naturally regain ground cover, through both the falling of snags and the recovery of live vegetation.

Erosion and Sedimentation from Treatment Activities

Salvage of Merchantable and Non-Merchantable Trees

Erosion modeling using Disturbed WEPP (Water Erosion Prediction Project) was conducted within the fire perimeter to determine both post-fire (pre-implementation) and post-implementation erosion rates for the first year post-fire. With only one exception, erosion rates for HUC 6 and HUC 7 watersheds under the no action alternative were either the same or greater than erosion rates under any action alternative. This was attributed to the increase in ground cover that would occur under the action alternatives, but would not occur under the no action alternative.

Logging activities create more effective sediment transport networks to stream channels. These transport networks would not be created under Alternative 2. However, sediment transport networks originating from existing skid trails would not be mitigated by subsoiling under Alternative 2, as they would be under the action alternatives.

Piling and Burning

No piling and burning would occur under Alternative 2, so there is no risk of erosion and sedimentation.

Roads

Road Construction

The increased overland flow rates and sediment yields associated with road construction (USDA 2013) would not occur under Alternative 2. However, this is a minor benefit since there is minimal road construction in the proposed action, much less in Alternative 3 and none in Alternative 4.

Road Reconstruction and Maintenance

One of the purposes of the Rim Fire Recovery project is to improve road infrastructure to ensure proper hydrologic function. This is particularly important following fire when there is increased runoff from hillslopes. Increased drainage features such as culverts and dips are needed on some roads to minimize hydrologic effects. In these situations, reconstruction is required to adequately improve drainage features and minimize impacts. On road surfaces that are draining well, maintenance is important because a lack of road maintenance can result in progressive degradation of road-drainage structures and functions (USDA 2013). This reconstruction and maintenance would not occur under Alternative 2, so the goal of ensuring proper hydrologic function would not be met. Any sediment related issues associated with roads within the project area would continue on current trends and may degrade with time.

Roadside hazard trees would not be removed under the no action alternative. This means that many maintenance level 2 roads would be closed to access either through gates or through snags falling across roads. This would limit the ability of the forest to conduct storm patrols on roads. Excessive concentrations of downed trees and debris above stream crossings could increase the risk of future crossing failures by causing plugging problems at culverts and bridges. Because access on these roads would be limited, discovery of the problem sites would be delayed, likely resulting in greater damage to road surfaces and subsequent stream sedimentation.

Temporary Road Construction

The increased overland flow rates and sediment yields associated with new temporary road construction (USDA 2013) would not occur under Alternative 2. However, 70-72% of the temporary roads proposed for use under the action alternatives already exist on the ground. These roads would be decommissioned following use, resulting in a net decrease of up to 22.7 miles of road on the landscape. This decommissioning of existing roads would not occur under the no action alternative.

Material Source Development

No material sources would be developed under Alternative 2, so there is no risk of erosion and sedimentation.

Water Source Development

No water sources would be developed under Alternative 2, so there is no risk of erosion and sedimentation.

Fuel Loading

The no action alternative would allow for fuel loading to increase in the project area. Nearly all snags would be expected to fall by approximately 20 years post-fire. The limbs and boles from these fallen trees would accumulate as surface fuels. This fuel is expected to increase each decade as trees fall over. Within 10 years, surface fuels are projected to average 78 tons per acre due to dead trees falling over. Within 30 years, surface fuels are projected to average 98 tons per acre.

Increased erosion following fire is related to the amount of vegetation removed. Prescribed fires, by design, do not consume extensive areas of organic matter (Baker 1990). Therefore, they have been shown to have little impact on erosion and sedimentation, whereas intense wildfires may have substantial impacts (Brooks et al. 1997). The high fuel loadings that are projected to occur under Alternative 2 could not be maintained with prescribed fire. Fire behavior is expected to increase once standing dead is on the ground. A future reburn under such extreme fuel loading would likely lead to soil erosion and sedimentation much more severe than that caused by the reduction of fuel loading under the action alternatives and maintaining these reduced loadings in the future by utilizing prescribed fire.

Riparian Vegetation

Under Alternative 2, there would be no disturbance to riparian vegetation. However, the removal of burned tree boles could have a slight incremental effect on increasing sunlight, and this would not occur under Alternative 2.

Stream Condition

Stream Flow

No changes in stream flow are anticipated as a result of the no action alternative.

Stream Morphology

Ground cover treatments along stream banks have the potential to increase bank stability post-fire, particularly in areas where a high percentage of ground cover was consumed by the fire. These treatments would not occur under Alternative 2. Bank stability would increase over time as live vegetation recovered, but percent cover along stream banks would likely be lower under Alternative 2 than the action alternatives until live vegetative recovery occurs.

Large Woody Debris

Levels of large woody debris in streams would be high under Alternative 2 as all snags would be retained and over time many near-stream snags would fall into streams. The effects of these fallen snags on roads were discussed above in the Erosion and Sedimentation section. The effect of this high level of LWD on stream condition is uncertain. In streams with low levels of LWD this extra loading may be beneficial in storing stream sediment. In streams with high levels of LWD, this extra loading may be excessive. Larger rivers should be capable of transporting these high loads of LWD to downstream reservoirs.

Wild and Scenic Rivers

Alternative 2 would have no effect on the free-flowing condition of eligible or designated Wild and Scenic Rivers. Activities that may be beneficial to water quality would not occur. This includes subsoiling of existing skid trails and reconstructing roads to improve drainage and reduce hydrologic connectivity. However, the high water quality needed to maintain the wild and scenic values of the Tuolumne, Clavey, and South Fork Tuolumne Rivers would be maintained under Alternative 2.

Water Quality (Beneficial Uses of Water)

Water Temperature

No effect to water temperature is anticipated under Alternative 2.

Sediment-Related Parameters

Ground disturbance from mechanized equipment that could lead to stream sedimentation would not occur under Alternative 2. However, activities that could reduce stream sedimentation, such as ground cover treatments, subsoiling of existing skid trails, road reconstruction to reduce hydrologic connectivity, and decommissioning of existing temporary roads would not occur.

Pesticides (Registered Borate Compound)

A registered borate compound would not be used under Alternative 2.

Summary

Beneficial uses of water would continue to be met.

CUMULATIVE EFFECTS

Equivalent Roaded Acres (ERAs)

ERAs were calculated for twelve HUC 6 and five HUC 7 watersheds. See Table 14 for ERA values. Highlighted values denote watersheds over the TOC.

Table 14 Annual % ERA for each HUC 6 and HUC 7 Analysis Watershed

HUC Level and Name	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
6 - Grapevine Creek-Tuolumne River	3.91	2.99	2.05	1.95	1.83	1.70	1.58	1.51	1.43	1.35
6 - Jawbone Creek-Tuolumne River	14.68	11.68	8.58	7.33	5.99	4.68	3.47	2.93	2.38	1.84
7 - Corral Creek	16.33	12.95	9.39	7.76	6.03	4.31	2.60	2.37	2.14	1.91
7 - Lower Jawbone Creek	11.80	8.73	5.61	4.98	4.17	3.39	2.60	2.31	2.02	1.73
6 - Lower Clavey River	8.41	6.45	4.44	3.93	3.39	2.86	2.33	1.99	1.66	1.37
7 - Bear Springs Creek	11.36	9.11	6.82	5.95	5.06	4.18	3.29	2.72	2.14	1.67
6 - Middle Clavey River	3.64	3.25	2.73	3.36	3.86	4.28	3.82	3.46	3.10	2.76
6 - Reed Creek	7.06	6.17	5.50	5.30	4.63	3.95	3.22	2.85	2.48	2.11
7 - Lower Reed Creek	14.98	12.43	9.51	7.92	6.39	4.85	3.43	2.98	2.53	2.07
6 - Lower Cherry Creek	10.58	8.30	5.99	5.16	4.28	3.41	2.56	2.20	1.84	1.48
7 - Granite Creek	24.68	20.33	15.82	13.39	10.86	8.33	5.92	4.93	3.94	2.96
6 - Miguel Creek-Eleanor Creek	3.47	2.22	0.98	0.77	0.56	0.36	0.15	0.15	0.14	0.14
6 - Poopenaut Valley-Tuolumne River	4.45	3.06	1.68	1.41	1.11	0.81	0.51	0.48	0.46	0.43
6 - Lower Middle Fork Tuolumne River	9.96	7.68	5.23	4.66	3.95	3.36	2.84	2.62	2.41	2.21
6 - Upper Middle Fork Tuolumne River	3.66	2.61	1.56	1.20	0.83	0.47	0.11	0.11	0.11	0.11
6 - Lower South Fork Tuolumne River	7.01	5.62	3.97	3.75	3.69	3.30	2.91	2.72	2.53	2.34
6 - Upper South Fork Tuolumne River	3.07	2.22	1.28	1.09	0.88	0.69	0.50	0.47	0.44	0.41

HUC 6 and 7 Watersheds

ERAs exceed the threshold of concern in one HUC 6 and three HUC 7 watersheds under the no action alternative. These high values can be attributed to the fire itself as well as past and future management activities on private and Forest Service lands.

Grazing

The effects of grazing under Alternative 2 are expected to be the same as described for Alternative 1.

Alternative 3

DIRECT AND INDIRECT EFFECTS

Erosion and Sedimentation

Factors Affecting Erosion and Sedimentation

As described under Alternative 1, soil compaction, soil displacement, ground cover, and precipitation intensity have the potential to affect erosion and sedimentation following salvage logging activities. The potential for soil compaction and displacement are similar to Alternative 1 because there are similar acreages of mechanical treatment proposed and because management requirements and BMPs prescribed under Alternative 1 are also prescribed under Alternative 3. Precipitation intensity also has the same potential to affect erosion and sedimentation as described under Alternative 1 since that is a factor that cannot be controlled.

Alternative 3 includes site-specific requirements for increasing ground cover to reduce erosion and sedimentation in watershed sensitive areas (WSAs). WSAs are portions of the watersheds that were determined to be at high risk of soil erosion and sedimentation due to the combined effects of the Rim

Fire and proposed recovery activities. Criteria for evaluating the existence of WSAs include: proposed recovery activities, burn severity, percent slope, slope shape, slope length, existing and potential soil cover, proximity to intermittent and perennial drainages, and proximity to high runoff response soils. Two treatments are prescribed to achieve increased ground cover: mastication and drop and lop. Mastication is proposed on 1,309 acres of WSAs and would involve grinding or shredding dead trees less than 10 inches dbh into chunks less than 2 feet in length to create ground cover. Drop and lop is proposed on an additional 2,228 acres of WSAs. This treatment would involve felling non-merchantable trees less than 10 inches dbh and lopping them into pieces in lengths short enough such that the dropped material is not stacked and has as much ground contact as practical. A minimum 50% effective ground cover is desired under both treatment techniques. A maximum of 10-20 tons/acre of fuel loading is allowed. Under Alternative 3, research would be conducted to determine the effectiveness of these ground cover treatments at reducing erosion and sedimentation. See Table 15 for a summary of WSA treatments by watershed.

Table 15 Watershed Sensitive Area (WSA) Treatments

HUC Level and Name	Mastication (ac)	Drop and Lop (ac)	Percent of Watershed with Mastication or Drop and Lop Proposed
6 - Grapevine Creek-Tuolumne River	0	0	0%
6 - Jawbone Creek-Tuolumne River	670	378	4%
7 - Corral Creek	598	149	16%
7 - Lower Jawbone Creek	0	134	2%
6 - Lower North Fork Tuolumne River	0	0	0%
6 - Lower Clavey River	53	98	1%
7 - Bear Springs Creek	53	98	2%
6 - Middle Clavey River	1	193	1%
6 - Reed Creek	354	552	4%
7 - Lower Reed Creek	354	552	12%
6 - Lower Cherry Creek	118	192	1%
7 - Granite Creek	118	175	7%
6 - Miguel Creek-Eleanor Creek	0	0	0%
6 - Poopenaut Valley-Tuolumne River	0	86	0%
6 - Lower Middle Fork Tuolumne River	93	644	5%
6 - Upper Middle Fork Tuolumne River	0	0	0%
6 - Lower South Fork Tuolumne River	20	63	0%
6 - Upper South Fork Tuolumne River	0	17	0%
6 - Bull Creek	0	0	0%
6 - Bean Creek-North Fork Merced River	0	0	0%

Erosion and Sedimentation from Treatment Activities

Salvage of Merchantable and Non-Merchantable Trees

Table 16 below describes proposed salvage treatments by watershed.

Table 16 Treatment Acreage by Watershed

HUC Level and Name	Watershed Size (ac)	Salvage Logging Units (ac)					% of Watershed Area
		Hazard Tree	Tractor	Skyline	Helicopter	Total	
6 - Grapevine Creek-Tuolumne River	23,817	1,160	42	0	0	1,202	5%
6 - Jawbone Creek-Tuolumne River	27,629	813	6,977	0	354	8,144	29%
7 - Corral Creek	4,581	49	3,515	0	26	3,590	78%
7 - Lower Jawbone Creek	5,670	174	1,501	0	235	1,910	34%
6 - Lower North Fork Tuolumne River	34,210	990	2	0	0	992	3%
6 - Lower Clavey River	17,871	1,515	2,604	51	95	4,265	24%
7 - Bear Springs Creek	7,090	604	1,214	51	95	1,964	28%
6 - Middle Clavey River	26,912	2,684	1,209	44	696	4,633	17%
6 - Reed Creek	24,526	1,306	3,327	0	611	5,244	21%
7 - Lower Reed Creek	7,495	331	2,451	0	521	3,303	44%
6 - Lower Cherry Creek	24,383	801	1,995	0	268	3,064	13%
7 - Granite Creek	4,126	98	686	0	61	845	20%
6 - Miguel Creek-Eleanor Creek	15,798	60	293	0	231	584	4%
6 - Poopenaut Valley-Tuolumne River	18,232	68	220	17	0	305	2%
6 - Lower Middle Fork Tuolumne River	14,928	1,089	6,069	76	70	7,304	49%
6 - Upper Middle Fork Tuolumne River	31,707	202	235	18	0	455	1%
6 - Lower South Fork Tuolumne River	19,989	2,833	2,879	867	596	7,175	36%
6 - Upper South Fork Tuolumne River	37,866	414	207	0	0	621	2%
6 - Bull Creek	21,064	268	24	24	6	322	2%
6 - Bean Creek-North Fork Merced River	36,739	930	143	0	109	1,182	3%

Percent of watershed treated for Alternative 3 is similar to Alternative 1for most watersheds. However, in the Jawbone Creek-Tuolumne River watershed there were timber units added for deer habitat, which increased acreage treated. The focus of this treatment was in the Corral Creek HUC 7 watershed. Granite Creek saw a large reduction in treatment acreage.

As described under Alternative 1, erosion modeling using Disturbed WEPP (Water Erosion Prediction Project) was conducted within the fire perimeter to determine both post-fire (pre-implementation) and post-implementation erosion rates. See Table 17 for modeled erosion rates in each watershed.

Table 17 Post-Fire and Post-Implementation Erosion Rates and Percent Change for Each Watershed

HUC Level and Name	Post-Fire Erosion Rate (tons/acre)	Post-Implementation Erosion Rate (tons/acre)	Percent Change Erosion Rate[1]
6 - Grapevine Creek-Tuolumne River	2.0	1.9	-5.0
6 - Jawbone Creek-Tuolumne River	3.6	3.3	-8.3
7 - Corral Creek	4.7	3.5	-25.5
7 - Lower Jawbone Creek	4.9	4.4	-10.2
6 - Lower North Fork Tuolumne River	0.9	0.9	0.0
6 - Lower Clavey River	2.9	2.7	-6.9
7 - Bear Springs Creek	3.1	2.7	-12.9
6 - Middle Clavey River	1.2	1.1	-8.3
6 - Reed Creek	1.4	1.2	-14.3
7 - Lower Reed Creek	3.2	2.5	-21.9
6 - Lower Cherry Creek	2.4	2.3	-4.2
7 - Granite Creek	3.6	3.4	-5.6
6 - Miguel Creek-Eleanor Creek	1.1	1.1	0.0
6 - Poopenaut Valley-Tuolumne River	1.4	1.4	0.0
6 - Lower Middle Fork Tuolumne River	2.8	2.4	-14.3
6 - Upper Middle Fork Tuolumne River	0.9	0.9	0.0
6 - Lower South Fork Tuolumne River	3.1	2.8	-9.7
6 - Upper South Fork Tuolumne River	0.9	0.9	0.0
6 - Bull Creek	0.6	0.6	0.0
6 - Bean Creek-North Fork Merced River	0.7	0.7	0.0

[1] A negative percent change indicates a reduction in erosion. A positive percent change indicates an increase in erosion.

As seen in Table 17, seven of the fifteen HUC 6 watersheds are anticipated to have negligible changes in erosion at the watershed scale. The eight HUC 6 watersheds with projected changes in erosion had lower erosion rates post-implementation than post-fire. This is attributed to increased ground cover in high vegetation burn severity areas due to mastication, drop and lop, and the addition of activity fuels. The modeling also indicated that all five HUC 7 watersheds would have decreased erosion rates following project implementation. The largest erosion rate change was a reduction of 1.2 tons/acre (-25.5%) in the Corral Creek watershed.

Although modeling results indicate that erosion rates either would not measurably change or would decrease as a result of Alternative 3, stream sedimentation still has the potential to occur as a result of Alternative 3, particularly in areas where logging activities create more effective sediment transport networks to stream channels. From a hydrologic standpoint, increased compaction, increased soil displacement, and changes in ground cover are most critical in the near stream areas where stream sedimentation is most likely. Knowledge of soil burn severity in these areas is important because areas of low soil burn severity have much greater potential to filter sediment than areas of high soil burn severity. See Table 18 for a description of salvage logging acres (combined timber units and hazard tree removal) within 100 feet of perennial or intermittent streams and SAFs by soil burn severity. All system types (ground-based, skyline, and helicopter) are included in this table. The table likely overestimates logging acreage in low soil burn severity areas because any green trees would not be removed unless they were an imminent hazard to a road.

Table 18 Salvage Logging Acres by Soil Burn Severity Within 100 feet of a Perennial Stream, Intermittent Stream, or Special Aquatic Feature

HUC Level and Name	Salvage Logging Acres Within 100 Feet of a Perennial Stream, Intermittent Stream, or Special Aquatic Feature		
	High Soil Burn Severity (ac)	Moderate Soil Burn Severity (ac)	Low Soil Burn Severity (ac)
6 - Grapevine Creek-Tuolumne River	0	23	34
6 - Jawbone Creek-Tuolumne River	76	234	78
7 - Corral Creek	45	92	23
7 - Lower Jawbone Creek	8	53	3
6 - Lower North Fork Tuolumne River	1	14	24
6 - Lower Clavey River	6	56	78
7 - Bear Springs Creek	6	26	31
6 - Middle Clavey River	6	49	134
6 - Reed Creek	48	105	82
7 - Lower Reed Creek	47	94	25
6 - Lower Cherry Creek	49	113	38
7 - Granite Creek	37	55	3
6 - Miguel Creek-Eleanor Creek	0	4	13
6 - Poopenaut Valley-Tuolumne River	4	4	1
6 - Lower Middle Fork Tuolumne River	47	327	137
6 - Upper Middle Fork Tuolumne River	0	12	8
6 - Lower South Fork Tuolumne River	11	169	260
6 - Upper South Fork Tuolumne River	0	3	23
6 - Bull Creek	0	7	11
6 - Bean Creek-North Fork Merced River	0	17	28

As seen in Table 18, there are four HUC 6 watersheds that have the greatest potential for stream sedimentation, based on acres of high burn severity proposed for timber harvest within 100 feet of surface water. These are the Jawbone Creek-Tuolumne River, Reed Creek, Lower Cherry Creek, and Lower Middle Fork Tuolumne River watersheds. In addition, the three HUC 7 watersheds with the greatest potential for stream sedimentation are Corral Creek, Lower Reed Creek, and Granite Creek. These HUC 6 and HUC 7 watersheds were identified as having WSAs and thus have a combination of mastication and drop and lop prescribed.

Despite implementation of BMPs and management requirements, increased stream sedimentation is anticipated as a result of Alternative 3, particularly in areas where logging activities create more effective sediment transport networks to stream channels. This is more likely to occur in the Jawbone Creek-Tuolumne River, Corral Creek, Reed Creek, Lower Reed Creek, Lower Cherry Creek, Granite Creek, and Lower Middle Fork Tuolumne River watersheds than in other HUC 6 or HUC 7 watersheds due to the larger acreages of high soil burn severity areas near streams proposed for treatment.

Mastication

Mastication is proposed on 1,309 acres of WSAs and would involve grinding or shredding dead trees less than 10 inches dbh into chunks less than 2 feet in length to create ground cover. Research in the Lake Tahoe Basin indicated that creating 25% ground cover with masticated material was effective at filtering sediment in unburned areas (Harrison 2012).

Although heavy equipment is used in the mastication treatment, it is not expected to cause measurable erosion and sedimentation. This treatment creates ground cover and thus is used to prevent erosion and filter sediment. BMPs and management requirements for ground-based mechanized equipment apply to mastication. This includes requirements such as equipment exclusion zones and restrictions on wet weather operations.

The effectiveness of BMPs at protecting water quality following mastication has been evaluated on the forest. Between 2007 and 2012, 15 mastication units were randomly selected for evaluation of BMP effectiveness. Of these, BMPs for 13 sites were found to be implemented and effective. BMPs at two sites were found to be implemented, but at risk because there was some sediment movement into the streamside management zone. However, no sediment reached stream channels at these sites, so water quality was not affected (STF 2008-2013). Therefore, risk of increased erosion and sedimentation as a result of mastication is expected to be low. Masticated materials are expected to help filter erosion and minimize sedimentation in treatment units with minimal post-fire ground cover.

Piling and Burning

The effects of piling and burning under Alternative 3 are anticipated to be similar or less than those found under Alternative 1. One difference is that dozer piling is prohibited in WSAs. In these areas, grapple piling is the only machine piling technique allowed. Because of this, there are fewer dozer piling acres proposed under Alternative 3 than Alternative 1. The effects of grapple piling on erosion and sedimentation are anticipated to be less than dozer piling because materials are picked up and moved into piles rather than pushed into piles. Another difference is that allowable fuel loading under Alternative 1 is 10 tons/acre, while it is 10-20 tons/acre under Alternative 3. This would result in the need for slightly less piling under Alternative 3.

Roads

Approximately 1 mile of new road construction, 324 miles of road reconstruction, 201 miles of road maintenance, 3.3 miles of temporary use-revert and 35 miles of temporary road construction are planned under Alternative 3. This would include 1 new permanent stream crossings along a newly constructed road.

See Table 19 for a breakdown of road related activities by watershed.

Table 19 Road Related Activities by Watershed

HUC Level and Name	Permanent Roads				Temporary Roads (mi)
	Construction (mi)	Reconstruction (mi)	Maintenance (mi)	Temporary Use – Revert (mi)	
6 - Grapevine Creek-Tuolumne River		2.24	28.01	0	0.25
6 - Jawbone Creek-Tuolumne River		43.62	11.30	0.51	8.28
7 - Corral Creek		19.18		0.22	2.28
7 - Lower Jawbone Creek		7.39	3.20	0.29	4.64
6 - Lower North Fork Tuolumne River		0.34	23.53		0.02
6 - Lower Clavey River		34.85	22.78	0.80	0
7 - Bear Springs Creek		25.70	4.68		
6 - Middle Clavey River	1.04	36.52	30.57		2.15
6 - Reed Creek		22.32	20.53		3.69
7 - Lower Reed Creek		10.72	7.88		2.88
6 - Lower Cherry Creek		30.58	8.83	1.34	0.48
7 - Granite Creek		12.28	1.09	0.10	
6 - Miguel Creek-Eleanor Creek		2.69		0.05	0.44
6 - Poopenaut Valley-Tuolumne River		1.68	0.94		0.34
6 - Lower Middle Fork Tuolumne River		52.32	10.50	0.08	11.52
6 - Upper Middle Fork Tuolumne River		3.30	1.53		0.77
6 - Lower South Fork Tuolumne River		68.47	26.53	0.48	2.82
6 - Upper South Fork Tuolumne River		7.79	1.75		0.71
6 - Bull Creek		3.95	2.00		0.51
6 - Bean Creek-North Fork Merced River		12.10	9.89		0.25

Road Construction

The effects of new road construction on erosion and sedimentation are anticipated to be less under Alternative 3 than Alternative 1. This is because only 1.04 miles of new road construction are proposed under Alternative 3, whereas Alternative 1 proposes 5.4 miles. In addition, Alternative 1 proposed 6 perennial and intermittent stream crossings, while Alternative 3 proposes only 1 intermittent stream crossing. The change in permanent road mileage as a result of Alternative 3 is a 0.65% increase in the Middle Clavey River watershed. BMPs and management requirements would limit sediment inputs to streams during road construction.

Although some erosion and sedimentation is anticipated as a result of this activity, particularly in the first year or two following construction, overall increases in erosion and sedimentation are anticipated to be low as the percent increase in road mileage is low.

Road Reconstruction and Maintenance

Effects of road reconstruction and maintenance on erosion and sedimentation are expected to be similar to those described for Alternative 1, as the mileage proposed for these treatments are similar and the same BMPs and management requirements would be implemented.

Temporary Road Construction

Of the 32.2 miles of temporary roads identified for use under Alternative 3, 22.7 miles (70%) already exist on the ground as non-system routes. While additional traffic on these routes would cause soil disturbance and has the potential for increased erosion and sedimentation, these routes would be decommissioned following use, resulting in a net decrease of 22.7 miles of road on the landscape. The 9.5 miles of new temporary roads would reduce infiltration and lead to potential increases in erosion and sedimentation. However, decommissioning these roads after use would reduce these impacts in the long term.

Material Source Development

The effects of material source development on erosion and sedimentation are anticipated to be the same for Alternative 3 as Alternative 1 as the sites proposed for use are the same.

Water Source Development

The effects of water source development on erosion and sedimentation are anticipated to be similar for Alternative 3 as described for Alternative 1 as BMPs would be implemented the same under either alternative. However, there are 13 additional potential water sources identified under Alternative 3 that are not proposed under Alternative 1.

Fuel Loading

Fuel loading would decrease in the project area watersheds under Alternative 3. Coarse woody debris would be reduced to approximately 10-20 tons/acre in all units proposed for treatment. This is slightly higher than the 10 tons/acre prescribed under Alternative 1. Allowable tons/acre were increased under Alternative 3 to provide for increased ground cover capable of filtering erosion, and for other resource benefits. This tonnage would still result in lower flame lengths and fireline intensities, allowing for direct attack of future wildfires. Reducing fuel loading and then maintaining these fuel loads with prescribed fire has less potential for erosion and sedimentation than allowing fuel loading to increase as snags fall and having another large stand-replacing wildfire in the future.

Riparian Vegetation

The effects of Alternative 3 on riparian vegetation are similar to that described for Alternative 1. Management requirements require retention of remaining post-fire obligate riparian shrubs and trees that have live crown foliage or are resprouting. Riparian vegetation may be beneficially affected by Alternative 3 where burned overstory trees are removed.

One fen has been identified within the roadside hazard tree removal area. There are no fens within timber treatment units. Removal of hazard trees near the fen is not anticipated to affect it, as management requirements such as equipment exclusion zones would be implemented.

There are approximately 63 acres of meadows identified within the Alternative 3 treatment units. Removal of trees along meadow edges is not expected to affect meadows, as management requirements would be implemented.

Stream Condition

Stream Flow

The effects of Alternative 3 on stream flow are anticipated to be similar to those described for Alternative 1. Live trees would only be removed if they are a hazard tree and pose a risk to health and safety. Otherwise, all trees proposed for harvest would be dead and their removal would not affect soil water storage, interception, or evapotranspiration beyond the changes that already occurred as a result of the fire. Treatments that increase ground cover, such as mastication and drop and lop, or mitigate compaction, such as subsoiling, promote infiltration and reduce overland flows, leading to reduced storm peak events and total flows. Therefore, measurable changes in stream flow are not anticipated to result under Alternative 3.

Stream Morphology

The effects of Alternative 3 on stream morphology are anticipated to be similar to those described under Alternative 1. Channel incision is not expected as a result of Alternative 3, as measureable changes in stream flow are not anticipated. Management requirements and BMPs are expected to protect bank stability.

Large Woody Debris

Under Alternative 3, existing downed large woody debris (LWD) in the channel would be retained. In addition, a minimum of 5 large snags per acre would be retained within 100 feet of perennial streams to provide for future recruitment of LWD. As a result of this snag retention, large woody debris levels in streams would increase over time following project implementation. Levels would be lower, however, than if harvesting did not occur near stream channels and all snags were retained. See the Aquatics report for more information on large woody debris.

Wild and Scenic Rivers

The effects of Alternative 3 on the free-flowing condition and water quality of designated and proposed Wild and Scenic Rivers is anticipated to be similar or less than those described under Alternative 1. The total treatment acreage (timber units plus hazard trees) within the ¼ mile buffer is 614 acres less than under Alternative 1. Road maintenance and road reconstruction mileage is lower under Alternative 3. No new road construction within the ¼ mile buffer would occur.

Water Quality (Beneficial Uses of Water)

The effects of Alternative 3 on water temperature, sediment-related parameters, and water quality as a result of pesticides (registered borate compound) are anticipated to be similar to those described under Alternative 1. There is a slight increase in total unit acreage under Alternative 3, due primarily to the addition of 3,000 acres of wildlife treatment units designed to allow for improved deer passage. However, management requirements and BMPs are designed to minimize impacts. Alternative 3 also identified watershed sensitive areas for additional ground cover treatments (mastication and drop and lop), which should further mitigate impacts under this alternative.

CUMULATIVE EFFECTS

Equivalent Roaded Acres (ERAs)

ERAs were calculated for twelve HUC 6 and five HUC 7 watersheds. Results of this analysis were similar to that found under Alternative 1. See Table 20 for ERA values. Highlighted values denote watersheds over the TOC.

Table 20 Annual % ERA for each HUC 6 and HUC 7 Analysis Watershed

HUC Level and Name	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
6 - Grapevine Creek-Tuolumne River	4.31	3.50	2.51	2.36	2.18	2.00	1.83	1.69	1.56	1.43
6 - Jawbone Creek-Tuolumne River	16.56	16.08	12.96	11.41	9.78	7.91	6.15	5.05	3.96	2.87
7 - Corral Creek	21.08	25.40	21.84	19.43	16.86	13.55	10.24	8.42	6.60	4.79
7 - Lower Jawbone Creek	14.17	13.27	9.95	9.01	7.94	6.59	5.25	4.41	3.59	2.77
6 - Lower Clavey River	9.62	9.80	8.20	7.40	6.57	5.59	4.61	3.82	3.04	2.30
7 - Bear Springs Creek	12.91	12.78	10.76	9.58	8.40	7.02	5.66	4.61	3.56	2.62
6 - Middle Clavey River	4.76	5.15	4.65	5.07	5.39	5.58	4.90	4.31	3.73	3.17
6 - Reed Creek	8.20	9.40	8.40	7.96	7.06	6.02	4.94	4.22	3.51	2.79
7 - Lower Reed Creek	17.38	17.99	15.26	13.20	11.25	8.99	6.86	5.70	4.55	3.40
6 - Lower Cherry Creek	11.27	9.96	7.77	6.80	5.79	4.70	3.64	3.07	2.49	1.92
7 - Granite Creek	26.02	23.02	18.47	15.93	13.29	10.41	7.65	6.30	4.96	3.63
6 - Miguel Creek-Eleanor Creek	3.68	2.61	1.34	1.09	0.86	0.61	0.36	0.31	0.27	0.22
6 - Poopenaut Valley-Tuolumne River	4.56	3.29	1.89	1.61	1.30	0.97	0.64	0.59	0.53	0.48
6 - Lower Middle Fork Tuolumne River	12.77	15.17	13.26	12.16	10.87	9.28	7.77	6.56	5.38	4.21
6 - Upper Middle Fork Tuolumne River	3.74	2.78	1.74	1.36	0.99	0.60	0.22	0.20	0.17	0.15
6 - Lower South Fork Tuolumne River	9.12	9.83	8.50	7.87	7.42	6.44	5.52	4.81	4.10	3.40
6 - Upper South Fork Tuolumne River	3.18	2.42	1.50	1.28	1.06	0.84	0.62	0.57	0.51	0.46

HUC 6 and 7 Watersheds

ERA values for twelve of the seventeen HUC 6 and HUC 7 watersheds were equal or slightly less for Alternative 3 than Alternative 1. These values decreased by up to 0.50% for Alternative 3 in 2014. There were five HUC 6 and HUC 7 watersheds that had higher ERA values than Alternative 1. The largest increase in 2014 was 0.95% in the Corral Creek watershed. ERA increases were attributed primarily to the addition of wildlife treatment units to improve deer passage. The other substantial difference between Alternative 1 and Alternative 3 was the development of WSA treatments for increased ground cover under Alternative 3. This increased ground cover is anticipated to reduce the risk of cumulative watershed effects.

Although there are slight differences in ERA values between Alternative 1 and Alternative 3, the watersheds that exceeded the TOC were the same. Therefore, cumulative effects for Alternative 3 are anticipated to be the same as described for Alternative 1.

Grazing

The effects of grazing under Alternative 3 are expected to be the same as described for Alternative 1.

Alternative 4

DIRECT AND INDIRECT EFFECTS

Erosion and Sedimentation

Factors Affecting Erosion and Sedimentation

As described under Alternative 1, soil compaction, soil displacement, ground cover, and precipitation intensity have the potential to affect erosion and sedimentation following salvage logging activities. The potential for soil compaction and displacement are similar to Alternative 1 because there are similar acreages of mechanical treatments proposed and because management requirements and BMPs prescribed under Alternative 1 are also prescribed under Alternative 4. Precipitation intensity also has the same potential to affect erosion and sedimentation as described under Alternative 1 since that is a factor that cannot be controlled.

Alternative 4 includes site-specific requirements for increasing ground cover in watershed sensitive areas (WSAs). Two treatments are prescribed to achieve increased ground cover: mastication and drop and lop. Mastication is proposed on 1,309 acres of WSAs and would involve grinding or shredding dead trees less than 10 inches dbh into chunks less than 2 feet in length to create ground cover. Drop and lop is proposed on an additional 1,798 acres of WSAs. This treatment would involve felling non-merchantable trees less than 10 inches dbh and lopping them into pieces in lengths short enough such that the dropped material is not stacked and has as much ground contact as practical. A minimum 50% effective ground cover is desired under both treatment techniques. A maximum of 10-20 tons/acre of fuel loading is allowed. Under Alternative 4, research would be conducted to determine the effectiveness of these ground cover treatments at reducing erosion and sedimentation. See Table 21 for a summary of WSA treatments by watershed.

Table 21 Watershed Sensitive Area (WSA) Treatments

HUC Level and Name	Mastication (ac)	Drop and Lop (ac)	Percent of Watershed with Mastication or Drop and Lop Proposed
6 - Grapevine Creek-Tuolumne River	0	0	0%
6 - Jawbone Creek-Tuolumne River	670	378	4%
7 - Corral Creek	598	149	16%
7 - Lower Jawbone Creek	0	134	2%
6 - Lower North Fork Tuolumne River	0	0	0%
6 - Lower Clavey River	53	98	1%
7 - Bear Springs Creek	53	98	2%
6 - Middle Clavey River	1	18	0%
6 - Reed Creek	354	325	3%
7 - Lower Reed Creek	354	325	9%
6 - Lower Cherry Creek	118	192	1%
7 - Granite Creek	118	175	7%
6 - Miguel Creek-Eleanor Creek	0	0	0%
6 - Poopenaut Valley-Tuolumne River	0	86	0%
6 - Lower Middle Fork Tuolumne River	93	644	5%
6 - Upper Middle Fork Tuolumne River	0	0	0%
6 - Lower South Fork Tuolumne River	20	45	0%
6 - Upper South Fork Tuolumne River	0	7	0%
6 - Bull Creek	0	0	0%
6 - Bean Creek-North Fork Merced River	0	6	0%

Erosion and Sedimentation from Treatment Activities

Salvage of Merchantable and Non-Merchantable Trees

Table 22 below describes proposed salvage treatments by watershed.

Table 22 Treatment Acreage by Watershed

HUC Level and Name	Watershed Size (ac)	Salvage Logging Units (ac)					% of Watershed Area
		Hazard Tree	Tractor	Skyline	Helicopter	Total	
6 - Grapevine Creek-Tuolumne River	23,817	1,160	42	0	0	1,202	5%
6 - Jawbone Creek-Tuolumne River	27,629	813	6,976	0	354	8,143	29%
7 - Corral Creek	4,581	49	3,515	0	26	3,590	78%
7 - Lower Jawbone Creek	5,670	174	1,501	0	235	1,910	34%
6 - Lower North Fork Tuolumne River	34,210	990	2	0	0	992	3%
6 - Lower Clavey River	17,871	1,515	2,604	51	95	4,265	24%
7 - Bear Springs Creek	7,090	604	1,214	51	95	1,964	28%
6 - Middle Clavey River	26,912	2,730	1,011	44	356	4,141	15%
6 - Reed Creek	24,526	1,451	2,098	0	611	4,160	17%
7 - Lower Reed Creek	7,495	474	1,338	0	521	2,333	31%
6 - Lower Cherry Creek	24,383	967	1,552	0	175	2,694	11%
7 - Granite Creek	4,126	98	686	0	61	845	20%
6 - Miguel Creek-Eleanor Creek	15,798	104	194	0	197	495	3%
6 - Poopenaut Valley-Tuolumne River	18,232	68	220	17	0	305	2%
6 - Lower Middle Fork Tuolumne River	14,928	1,089	6,069	76	70	7,304	49%
6 - Upper Middle Fork Tuolumne River	31,707	202	235	18	0	455	1%
6 - Lower South Fork Tuolumne River	19,989	2,873	2,799	837	596	7,105	36%
6 - Upper South Fork Tuolumne River	37,866	414	181	0	0	595	2%
6 - Bull Creek	21,064	268	24	24	6	322	2%
6 - Bean Creek-North Fork Merced River	36,739	930	143	0	109	1,182	3%

Percent of watershed treated for Alternative 4 is similar to Alternative 1 for most watersheds. However, in the Jawbone Creek-Tuolumne River watershed there were timber units added for deer habitat, which increased acreage treated. The focus of this treatment was in the Corral Creek HUC 7 watershed. Granite Creek, Reed Creek, and Lower Reed Creek saw a large reduction in treatment acreage.

As described under Alternative 1, erosion modeling using Disturbed WEPP (Water Erosion Prediction Project) was conducted within the fire perimeter to determine both post-fire (pre-implementation) and post-implementation erosion rates. See Table 23 for modeled erosion rates in each watershed.

Table 23 Post-Fire and Post-Implementation Erosion Rates and Percent Change for Each Watershed

HUC Level and Name	Post-Fire Erosion Rate (tons/acre)	Post-Implementation Erosion Rate (tons/acre)	Percent Change Erosion Rate[1]
6 - Grapevine Creek-Tuolumne River	2.0	1.9	-5.0
6 - Jawbone Creek-Tuolumne River	3.6	3.3	-8.3
7 - Corral Creek	4.7	3.5	-25.5
7 - Lower Jawbone Creek	4.9	4.4	-10.2
6 - Lower North Fork Tuolumne River	0.9	0.9	0.0
6 - Lower Clavey River	2.9	2.7	-6.9
7 - Bear Springs Creek	3.1	2.7	-12.9
6 - Middle Clavey River	1.2	1.1	-8.3
6 - Reed Creek	1.4	1.2	-14.3
7 - Lower Reed Creek	3.2	2.7	-15.6
6 - Lower Cherry Creek	2.4	2.3	-4.2
7 - Granite Creek	3.6	3.4	-5.6
6 - Miguel Creek-Eleanor Creek	1.1	1.1	0.0
6 - Poopenaut Valley-Tuolumne River	1.4	1.4	0.0
6 - Lower Middle Fork Tuolumne River	2.8	2.4	-14.3
6 - Upper Middle Fork Tuolumne River	0.9	0.9	0.0
6 - Lower South Fork Tuolumne River	3.1	2.8	-9.7
6 - Upper South Fork Tuolumne River	0.9	0.9	0.0
6 - Bull Creek	0.6	0.6	0.0
6 - Bean Creek-North Fork Merced River	0.7	0.7	0.0

[1] A negative percent change indicates a reduction in erosion. A positive percent change indicates an increase in erosion.

As seen in Table 25, seven of the fifteen HUC 6 watersheds are anticipated to have negligible changes in erosion at the watershed scale. The eight HUC 6 watersheds with projected changes in erosion had lower erosion rates post-implementation than post-fire. This is attributed to increased ground cover in high vegetation burn severity areas due to mastication, drop and lop, and the addition of activity fuels. The modeling also indicated that all five HUC 7 watersheds would have decreased erosion rates following project implementation. The largest erosion rate change was a reduction of 1.2 tons/acre (-25.5%) in the Corral Creek watershed.

Although modeling results indicate that erosion rates either would not measurably change or would decrease as a result of Alternative 4, stream sedimentation still has the potential to occur as a result of Alternative 4, particularly in areas where logging activities create more effective sediment transport networks to stream channels. From a hydrologic standpoint, increased compaction, increased soil displacement, and changes in ground cover are most critical in the near stream areas where stream sedimentation is most likely. Knowledge of soil burn severity in these areas is important because areas of low soil burn severity have much greater potential to filter sediment than areas of high soil burn severity. See Table 24 for a description of salvage logging acres (combined timber units and hazard tree removal) within 100 feet of perennial or intermittent streams and SAFs by soil burn severity. All system types (ground-based, skyline, and helicopter) are included in this table. The table likely overestimates logging acreage in low soil burn severity areas because any green trees would not be removed unless they were an imminent hazard to a road.

Table 24 Salvage Logging Acres by Soil Burn Severity Within 100 feet of a Perennial Stream, Intermittent Stream, or Special Aquatic Feature

HUC Level and Name	Salvage Logging Acres Within 100 Feet of a Perennial Stream, Intermittent Stream, or Special Aquatic Feature		
	High Soil Burn Severity (ac)	Moderate Soil Burn Severity (ac)	Low Soil Burn Severity (ac)
6 - Grapevine Creek-Tuolumne River	0	23	34
6 - Jawbone Creek-Tuolumne River	76	234	78
7 - Corral Creek	45	92	23
7 - Lower Jawbone Creek	8	53	3
6 - Lower North Fork Tuolumne River	1	14	24
6 - Lower Clavey River	6	56	78
7 - Bear Springs Creek	6	26	31
6 - Middle Clavey River	5	35	125
6 - Reed Creek	30	91	81
7 - Lower Reed Creek	29	80	25
6 - Lower Cherry Creek	49	113	38
7 - Granite Creek	37	55	3
6 - Miguel Creek-Eleanor Creek	0	4	12
6 - Poopenaut Valley-Tuolumne River	4	4	1
6 - Lower Middle Fork Tuolumne River	47	327	137
6 - Upper Middle Fork Tuolumne River	0	12	8
6 - Lower South Fork Tuolumne River	11	168	259
6 - Upper South Fork Tuolumne River	0	3	23
6 - Bull Creek	0	7	11
6 - Bean Creek-North Fork Merced River	0	17	28

As seen in Table 24, there are four HUC 6 watersheds that have the greatest potential for stream sedimentation, based on acres of high burn severity proposed for timber harvest within 100 feet of surface water. These are the Jawbone Creek-Tuolumne River, Reed Creek, Lower Cherry Creek, and Lower Middle Fork Tuolumne River watersheds. In addition, the three HUC 7 watersheds with the greatest potential for stream sedimentation are Corral Creek, Lower Reed Creek, and Granite Creek. These HUC 6 and HUC 7 watersheds were identified as having WSAs and thus have a combination of mastication and drop and lop prescribed.

Despite implementation of BMPs and management requirements, increased stream sedimentation is anticipated as a result of Alternative 4, particularly in areas where logging activities create more effective sediment transport networks to stream channels. This is more likely to occur in the Jawbone Creek-Tuolumne River, Corral Creek, Reed Creek, Lower Reed Creek, Lower Cherry Creek, Granite Creek, and Lower Middle Fork Tuolumne River watersheds than in other HUC 6 or HUC 7 watersheds due to the larger acreages of high soil burn severity areas near streams proposed for treatment.

Mastication

The effects of mastication on erosion and sedimentation are the same as described under Alternative 3, as the same acreage of treatment is proposed.

Piling and Burning

The effects of piling and burning under Alternative 4 are anticipated to be similar or less than those found under Alternative 1. One difference is that dozer piling is prohibited in WSAs. In these areas, grapple piling is the only machine piling technique allowed. Because of this, there are fewer dozer piling acres proposed under Alternative 4 than Alternative 1. The effects of grapple piling on erosion and sedimentation are anticipated to be less than dozer piling because materials are picked up and moved into piles rather than pushed into piles. Another difference is that allowable fuel loading under Alternative 1 is 10 tons/acre, while it is 10-20 tons/acre under Alternative 4. This would result in the need for slightly less piling under Alternative 4.

Roads

Approximately 315 miles of road reconstruction, 209 miles of road maintenance, 3.3 miles of temporary use-revert, and 34 miles of temporary road construction are planned under Alternative 4. No road construction is planned.

See Table 25 for a breakdown of road related activities by watershed.

Table 25 Road Related Activities by Watershed

HUC Level and Name	Permanent Roads				Temporary Roads (mi)
	Construction (mi)	Reconstruction (mi)	Maintenance (mi)	Temporary Use – Revert (mi)	
6 - Grapevine Creek-Tuolumne River		2.24	28.01		0.25
6 - Jawbone Creek-Tuolumne River		43.62	11.30	0.51	8.28
7 - Corral Creek		19.15	0.02	0.22	2.28
7 - Lower Jawbone Creek		7.39	3.20	0.29	4.64
6 - Lower North Fork Tuolumne River		0.34	23.53		0.02
6 - Lower Clavey River		34.85	22.78	0.80	
7 - Bear Springs Creek		25.70	4.68		
6 - Middle Clavey River		33.47	33.62		2.15
6 - Reed Creek		18.17	24.68		2.12
7 - Lower Reed Creek		10.72	7.88		1.76
6 - Lower Cherry Creek		29.15	9.88	1.34	0.30
7 - Granite Creek		12.28	1.09	0.10	
6 - Miguel Creek-Eleanor Creek		2.57	0.12	0.05	0.44
6 - Poopenaut Valley-Tuolumne River		1.68	0.94		0.34
6 - Lower Middle Fork Tuolumne River		52.32	10.50	0.08	11.52
6 - Upper Middle Fork Tuolumne River		3.30	1.53		0.77
6 - Lower South Fork Tuolumne River		68.16	26.84	0.48	2.82
6 - Upper South Fork Tuolumne River		7.79	1.75		0.71
6 - Bull Creek		3.95	2.00		0.51
6 - Bean Creek-North Fork Merced River		12.10	9.89		0.25

Road Construction

The increased overland flow rates and sediment yields associated with road construction (USDA 2013) would not occur under Alternative 4, as no road construction is proposed.

Road Reconstruction and Maintenance

Effects of road reconstruction and maintenance on erosion and sedimentation are expected to be similar to those described for Alternative 1, as the mileage proposed for these treatments are similar and the same BMPs and management requirements would be implemented.

Temporary Road Construction

Of the 30.5 miles of temporary roads identified for use under Alternative 4, 22.1 miles (72%) already exist on the ground as non-system routes. While additional traffic on these routes would cause soil disturbance and has the potential for increased erosion and sedimentation, these routes would be decommissioned following use, resulting in a net decrease of 22.1 miles of road on the landscape. The

8.4 miles of new temporary roads would reduce infiltration and lead to potential increases in erosion and sedimentation. However, decommissioning these roads after use would reduce these impacts in the long term.

Material Source Development

The effects of material source development on erosion and sedimentation are anticipated to be the same for Alternative 4 as Alternative 1 as the sites proposed for use are the same.

Water Source Development

The effects of water source development on erosion and sedimentation are anticipated to be similar for Alternative 4 as described for Alternative 1 as BMPs would be implemented the same under either alternative. However, there are 13 additional potential water sources identified under Alternative 4 that are not proposed under Alternative 1.

Fuel Loading

Fuel loading would decrease in the project area watersheds under Alternative 4. Coarse woody debris would be reduced to approximately 10-20 tons/acre in all units proposed for treatment. This is slightly higher than the 10 tons/acre prescribed under Alternative 1. Allowable tons/acre were increased under Alternative 4 to provide for increased ground cover capable of filtering erosion, and for other resource benefits. This tonnage would still result in lower flame lengths and fireline intensities, allowing for direct attack of future wildfires. Reducing fuel loading and then maintaining these fuel loads with prescribed fire has less potential for erosion and sedimentation than allowing fuel loading to increase as snags fall and having another large stand-replacing wildfire in the future.

Riparian Vegetation

The effects of Alternative 4 on riparian vegetation are similar to that described for Alternative 1. Management requirements require retention of remaining post-fire obligate riparian shrubs and trees that have live crown foliage or are resprouting. Riparian vegetation may be beneficially affected by Alternative 4 where burned overstory trees are removed.

One fen has been identified within the roadside hazard tree removal area. There are no fens within timber treatment units. Removal of hazard trees near the fen is not anticipated to affect it, as management requirements such as equipment exclusion zones would be implemented.

There are approximately 63 acres of meadows identified within the Alternative 4 treatment units. Removal of trees along meadow edges is not expected to affect meadows, as management requirements would be implemented.

Stream Condition

Stream Flow

The effects of Alternative 4 on stream flow are anticipated to be similar to those described for Alternative 1. Live trees would only be removed if they are a hazard tree and pose a risk to health and safety. Otherwise, all trees proposed for harvest would be dead and their removal would not affect soil water storage, interception, or evapotranspiration beyond the changes that already occurred as a result of the fire. Treatments that increase ground cover, such as mastication and drop and lop, or mitigate compaction, such as subsoiling, promote infiltration and reduce overland flows, leading to reduced storm peak events and total flows. Therefore, measurable changes in stream flow are not anticipated to result under Alternative 4.

Stream Morphology

The effects of Alternative 4 on stream morphology are anticipated to be similar to those described under Alternative 1. Channel incision is not expected as a result of Alternative 4, as measureable changes in stream flow are not anticipated. Management requirements and BMPs are expected to protect bank stability.

Large Woody Debris

Under Alternative 4, existing downed large woody debris (LWD) in the channel would be retained. In addition, a minimum of 5 large snags per acre would be retained within 100 feet of perennial streams to provide for future recruitment of LWD. As a result of this snag retention, large woody debris levels in streams would increase over time following project implementation. Levels would be lower, however, than if harvesting did not occur near stream channels and all snags were retained. See the Aquatics report for more information on large woody debris.

Wild and Scenic Rivers

The effects of Alternative 4 on the free-flowing condition and water quality of designated and proposed Wild and Scenic Rivers is anticipated to be similar or less than those described under Alternative 1. The total treatment acreage (timber units plus hazard trees) within the ¼ mile buffer is 851 acres less than under Alternative 1. Road maintenance mileage is lower under Alternative 4. No road construction or reconstruction would occur under Alternative 4.

Water Quality (Beneficial Uses of Water)

The effects of Alternative 4 on water temperature, sediment-related parameters, and water quality as a result of pesticides (registered borate compound) are anticipated to be similar or less than those described under Alternative 1. There is a slight decrease (500 acres) in total unit acreage under Alternative 4 as compared to Alternative 1. Alternative 4 also identified watershed sensitive areas for additional ground cover treatments (mastication and drop and lop), which should further mitigate impacts under this alternative.

CUMULATIVE EFFECTS

Equivalent Roaded Acres (ERAs)

ERAs were calculated for twelve HUC 6 and five HUC 7 watersheds. Results of this analysis were similar to that found under Alternative 1. See Table 26 for ERA values. Highlighted values denote watersheds over the TOC.

Table 26 Annual % ERA for each HUC 6 and HUC 7 Analysis Watershed

HUC Level and Name	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
6 - Grapevine Creek-Tuolumne River	4.31	3.50	2.51	2.36	2.18	2.00	1.83	1.69	1.56	1.43
6 - Jawbone Creek-Tuolumne River	16.56	16.08	12.96	11.41	9.78	7.91	6.15	5.05	3.96	2.87
7 - Corral Creek	21.08	25.40	21.84	19.43	16.86	13.55	10.24	8.42	6.60	4.79
7 - Lower Jawbone Creek	14.17	13.27	9.95	9.01	7.94	6.59	5.25	4.41	3.59	2.77
6 - Lower Clavey River	9.62	9.80	8.20	7.40	6.57	5.59	4.61	3.82	3.04	2.30
7 - Bear Springs Creek	12.91	12.78	10.76	9.58	8.40	7.02	5.66	4.61	3.56	2.62
6 - Middle Clavey River	4.66	5.02	4.54	4.98	5.30	5.50	4.83	4.26	3.69	3.14
6 - Reed Creek	8.01	8.70	7.58	7.19	6.34	5.41	4.43	3.81	3.19	2.57
7 - Lower Reed Creek	16.77	15.93	12.93	10.99	9.19	7.22	5.37	4.50	3.64	2.77
6 - Lower Cherry Creek	11.22	9.71	7.49	6.54	5.54	4.49	3.46	2.92	2.38	1.84
7 - Granite Creek	26.02	22.93	18.29	15.69	12.98	10.14	7.41	6.10	4.79	3.50
6 - Miguel Creek-Eleanor Creek	3.66	2.54	1.26	1.02	0.79	0.55	0.30	0.27	0.23	0.20
6 - Poopenaut Valley-Tuolumne River	4.56	3.29	1.89	1.61	1.30	0.97	0.64	0.59	0.53	0.48
6 - Lower Middle Fork Tuolumne River	12.77	15.17	13.26	12.16	10.87	9.28	7.77	6.56	5.38	4.21
6 - Upper Middle Fork Tuolumne River	3.74	2.78	1.74	1.36	0.99	0.60	0.22	0.20	0.17	0.15
6 - Lower South Fork Tuolumne River	9.11	9.76	8.41	7.79	7.35	6.38	5.47	4.77	4.07	3.38
6 - Upper South Fork Tuolumne River	3.18	2.41	1.48	1.27	1.04	0.83	0.61	0.56	0.51	0.45

HUC 6 and 7 Watersheds

ERA values for twelve of the seventeen HUC 6 and HUC 7 watersheds were equal or slightly less for Alternative 4 than Alternative 1. These values decreased by up to 0.50% for Alternative 4 in 2014. There were five HUC 6 and HUC 7 watersheds that had higher ERA values than Alternative 1. The largest increase in 2014 was 0.95% in the Corral Creek watershed. ERA increases were attributed primarily to the addition of wildlife treatment units to improve deer passage. The other substantial difference between Alternative 1 and Alternative 4 was the development of WSA treatments for increased ground cover under Alternative 4. This increased ground cover is anticipated to reduce the risk of cumulative watershed effects.

Although there are slight differences in ERA values between Alternative 1 and Alternative 4, the watersheds that exceeded the TOC were the same. Therefore, cumulative effects for Alternative 4 are anticipated to be the same as described for Alternative 1.

Grazing

The effects of grazing under Alternative 4 are expected to be the same as described for Alternative 1.

Summary of Effects Analysis across All Alternatives

Erosion and Sedimentation

Under Alternative 1, erosion rates as a result of timber harvest are anticipated to have negligible change in most HUC 6 watersheds. Two HUC 6 watersheds are projected to have decreased erosion and one watershed is projected to have increased erosion. Sedimentation increases due to timber harvest are anticipated to be highest in HUC 6 watersheds with treatments proposed within 100 feet of streams in high soil burn severity areas (Jawbone Creek-Tuolumne River, Reed Creek, Lower Cherry Creek, and

Lower Middle Fork Tuolumne River). Of the piling and burning activities, dozer piling has the highest potential for sedimentation and could occur in any of the treatment units. This alternative has the highest mileage of road construction, leading to the largest potential for road related erosion and sedimentation. While road reconstruction and maintenance cause disturbance, improving and maintaining drainage features can reduce erosion from current levels. Temporary road construction would involve the construction of new temporary roads and the use of existing non-system roads, all of which would be decommissioned following use. This decommissioning would result in fewer roads on the landscape post-project than pre-project. Some sedimentation could occur as a result of material source and water source development.

Under Alternative 2, erosion rates in HUC 6 watersheds are anticipated to be similar to those watersheds under Alternative 1 and similar to or higher than those watersheds under Alternatives 3 and 4 due to a lack of ground cover. New sediment transport networks would not be created. However, reductions in soil compaction on existing skid trails would not occur, so these sediment transport networks would remain in place. There is no risk of erosion and sedimentation from piling and burning, road construction, material source development, or water source development. Road reconstruction and maintenance would not occur, so hydrologic connectivity of roads and streams would remain. Temporary road construction would not occur, so temporary roads already existing on the landscape would not be decommissioned.

Under Alternatives 3 and 4, erosion rates for HUC 6 watersheds are anticipated to have either negligible change or reduced erosion rates. Sedimentation increases due to timber harvest are anticipated to be highest in HUC 6 watersheds with treatments proposed within 100 feet of streams in high soil burn severity areas (Jawbone Creek-Tuolumne River, Reed Creek, Lower Cherry Creek, and Lower Middle Fork Tuolumne River). Watershed sensitive areas (WSAs) were delineated for these alternatives and ground cover treatments were prescribed (mastication and drop and lop) to reduce the risk of sedimentation. Of the piling and burning activities, dozer piling has the highest potential for sedimentation. These alternatives have restrictions that prohibit dozer piling in WSAs. Alternative 3 has only 1 mile of permanent road construction and Alternative 4 has no permanent road construction. While road reconstruction and maintenance cause disturbance, improving and maintaining drainage features can reduce erosion from current levels. Temporary road construction would involve the construction of new temporary roads and the use of existing non-system roads, all of which would be decommissioned following use. This decommissioning would result in fewer roads on the landscape post-project than pre-project. Some sedimentation could occur as a result of material source and water source development.

Fuel Loading

Under Alternative 1, fuel loading would be reduced to 10 tons/acre of surface fuels, allowing for direct attack of future wildfires and maintenance of reduced fuel loading with prescribed fire.

Under Alternative 2, fuel loading would increase over time, to an estimated 98 tons/acre of surface fuels in 30 years. This would not allow for direct attack of wildfires or use of prescribed fire. A future reburn under such extreme fuel loading conditions would likely lead to soil erosion and sedimentation more severe than that caused by fuel reduction treatments.

Under Alternatives 3 and 4, fuel loading would be reduced to 10-20 tons/acre of surface fuels, allowing for direct attack of future wildfires and maintenance of reduced fuel loading with prescribed fire.

Riparian Vegetation

Under Alternatives 1, 3, and 4, removal of burned overstory trees may provide slight increases in sunlight, benefitting regrowth of riparian obligate trees and shrubs. Management requirements would prevent disturbance to riparian vegetation, including at a fen and numerous meadows.

Under Alternative 2, there would be no removal of burned overstory trees, so no benefits of slight increase in sunlight. There would be no disturbance to riparian vegetation.

Stream Condition

Under Alternative 1, measurable changes in stream flow or channel incision are not anticipated. Stream banks in high soil burn severity areas may receive increased cover as part of ground cover treatments, resulting in improved bank stability. Snags would be felled into stream channels for increased LWD.

Under Alternative 2, no changes in stream flow or channel incision are anticipated. There would initially be less ground cover along stream banks than the action alternatives because no ground cover would be added. Over time, some near-stream snags would fall into streams, leading to increased levels of LWD.

Under Alternatives 3 and 4, measurable changes in stream flow or channel incision are not anticipated. Stream banks in high soil burn severity areas may receive increased cover as part of ground cover treatments, resulting in improved bank stability. Snags would be left adjacent to stream channels, allowing for natural recruitment of LWD, but at levels much less than Alternative 2.

Wild and Scenic Rivers

Under Alternative 1, 3, and 4, activities within the ¼ mile buffer of eligible and designated Wild and Scenic Rivers are not anticipated to affect their free-flowing condition. While some sedimentation could occur, it is anticipated to be minimal and of short duration and is not expected to affect the Outstandingly Remarkable Values of these rivers.

Under Alternative 2, the free flowing condition and high water quality needed to maintain wild and scenic values would be maintained.

Water Quality (Beneficial Uses of Water)

Under Alternatives 1, 3, and 4, water temperature is not expected to be affected. Some sedimentation would likely occur, particularly in areas which have high soil burn severity adjacent to streams. The potential for the registered borate compound to contaminate surface water is limited. Effects to beneficial uses are not anticipated.

Under Alternative 2, no changes to water temperature, stream sedimentation, or water quality related to pesticide applications are anticipated. Effects to beneficial uses are not anticipated.

Compliance with the Forest Plan and Other Direction

Standards and Guidelines

Table 27 lists Standards and Guidelines (S&Gs) applicable to watershed resources, as well as how the S&Gs would be met under the action alternatives.

Table 27 Standards and Guidelines Applicable to Watershed Resources

Standards and Guidelines	Supporting Information/Discussion
Design projects to reduce potential soil erosion and the loss of soil productivity caused by loss of vegetation and ground cover. Examples are activities that would: (1) provide for adequate soil cover in the short term; (2) accelerate the dispersal of coarse woody debris; (3) reduce the potential impacts of the fire on water quality; and (4) carefully plan restoration/salvage activities to minimize additional short-term effects.	Ground cover treatments are prescribed to reduce soil erosion and allow for filtering of sediment.
Implement water quality Best Management Practices (BMPs) as needed for all Forest management activities. BMPs are a system of nearly 100 practices designed to minimize or prevent water pollution from Forest management activities. They cover such activities as timber harvest, road construction, mining, recreation, fire management and grazing. See Appendix K of the EIS for a discussion and listing of the water quality BMPs.	Applicable BMPs are described in the Management Requirements section of the Watershed Report (Appendix B).

Standards and Guidelines	Supporting Information/Discussion
Monitor the implementation and effectiveness of BMPs in selected areas to determine if they are being carried out and if they are accomplishing their objectives.	The implementation and effectiveness of BMPs would be monitored following the Regional BMPEP and National Core BMP monitoring guidelines.
Analyze cumulative watershed effects (CWE) on all applicable proposed Forest management activities to determine off-site effects on the beneficial uses of water.	A CWE analysis was conducted.
Implement the following watershed recovery practices following major wildfires, except in Wilderness in most cases: (1) Restore ground cover as soon as possible when necessary to reduce flood flows to protect life and property, to maintain soil productivity and/or to minimize stream sedimentation and cumulative watershed effects. (2) Conduct reforestation activities in a manner which reduces the potential for cumulative watershed effects, such as dispersing site preparation adequately over time and space and/or using techniques which minimize land disturbance.	Ground cover treatments are prescribed to maintain soil productivity, minimize stream sedimentation, and minimize cumulative watershed effects. Reforestation activities are outside the scope of this project.
Designate riparian conservation area (RCA) widths as described above. The RCA widths displayed may be adjusted at the project level if a landscape analysis has been completed and a site-specific RCO analysis demonstrates a need for different widths.	RCA widths for the Rim Fire Recovery Project were designated based on direction from the STF Forest Plan Direction (2010) and were used in the analysis of each alternative.
Evaluate new proposed management activities within CARs and RCAs during environmental analysis to determine consistency with the riparian conservation objectives at the project level and the AMS goals for the landscape. Ensure that appropriate mitigation measures are enacted to (1) minimize the risk of activity-related sediment entering aquatic systems and (2) minimize impacts to habitat for aquatic- or riparian-dependent plant and animal species.	Proposed management activities were developed as part of an interdisciplinary process. Management requirements incorporate a range of BMPs and were designed to ensure consistency with AMS/RCOs during project implementation.
As part of project-level analysis, conduct peer reviews for projects that propose ground-disturbing activities in more than 25 percent of the RCA or more than 15 percent of a CAR.	Ground-disturbing activities do not exceed these thresholds, so no peer review is required. Percentages of ground disturbing activities in RCAs and CARs are displayed in the project record.
Ensure that management activities do not adversely affect water temperatures necessary for local aquatic- and riparian-dependent species assemblages.	Water temperatures are not expected to be affected by removal of near-stream dead conifer trees as they create little shade.
Limit pesticide applications to cases where project level analysis indicates that pesticide applications are consistent with riparian conservation objectives.	The project proposes the application of a registered borate compound. The Watershed report includes BMPs and Management Requirements specific for this activity that would achieve consistency with RCOs.
Prohibit storage of fuels and other toxic materials within RCAs and CARs except at designated administrative sites and sites covered by a Special Use Authorization. Prohibit refueling within RCAs and CARs unless there are no other alternatives. Ensure that spill plans are reviewed and up-to-date.	Fuels and other toxic materials would not be stored in any RCAs or CARs. Servicing and refueling would be only at designated and approved sites. BMP 2.11 Equipment Refueling and Servicing would address handling of fueling and servicing operations. A spill plan would be provided where applicable.
Maintain and restore the hydrologic connectivity of streams, meadows, wetlands, and other special aquatic features by identifying roads and trails that intercept, divert, or disrupt natural surface and subsurface water flow paths. Implement corrective actions where necessary to restore connectivity.	Road maintenance and reconstruction activities are designed to enhance hydrologic function of roads within the project area.
Ensure that culverts or other stream crossings do not create barriers to upstream or downstream passage for aquatic-dependent species. Locate water drafting sites to avoid adverse effects to in stream flows and depletion of pool habitat. Where possible, maintain and restore the timing, variability, and duration of floodplain inundation	BMP 2.8 Stream Crossings addresses barriers to aquatic-dependent species. BMP 2.5 Water Source Development and Utilization addresses the location of water drafting sites and methods of water removal, including limits on drafting based on stream flows. Ground cover treatments and compaction mitigations are

Standards and Guidelines	Supporting Information/Discussion
and water table elevation in meadows, wetlands, and other special aquatic features.	designed to maintain/restore flood flows.
Prior to activities that could adversely affect streams, determine if relevant stream characteristics are within the range of natural variability. If characteristics are outside the range of natural variability, implement mitigation measures and short-term restoration actions needed to prevent further declines or cause an upward trend in conditions. Evaluate required long-term restoration actions and implement them according to their status among other restoration needs.	This project is within the Rim Fire area and due to the wildfire some areas are near or out of the range of natural variability. The project has included numerous BMPs and Management Requirements to mitigate or prevent further declines or cause an upward trend in conditions, including the addition of ground cover. Long term restoration actions are outside the scope of the project.
Prevent disturbance to streambanks and natural lake and pond shorelines caused by resource activities (for example, livestock, off-highway vehicles, and dispersed recreation) from exceeding 20 percent of stream reach or 20 percent of natural lake and pond shorelines. Disturbance includes bank sloughing, chiseling, trampling, and other means of exposing bare soil or cutting plant roots. This standard does not apply to developed recreation sites, sites authorized under Special Use Permits and designated off-highway vehicle routes.	The project includes BMPs and Management Requirements for mechanized equipment operation activities within RCAs, including exclusion zones and restrictions on the number of stream crossings.
At either the landscape or project-scale, determine if the age class, structural diversity, composition, and cover of riparian vegetation are within the range of natural variability for the vegetative community. If conditions are outside the range of natural variability, consider implementing mitigation and/or restoration actions that will result in an upward trend. Actions could include restoration of aspen or other riparian vegetation where conifer encroachment is identified as a problem.	This project is within the Rim Fire area and due to the wildfire some areas are near or out of the range of natural variability. The project has included numerous BMPs and Management requirements to mitigate effects, including equipment exclusion zones. Long term restoration actions are outside the scope of the project.
Cooperate with Federal, Tribal, State and local governments to secure in stream flows needed to maintain, recover, and restore riparian resources, channel conditions, and aquatic habitat. Maintain in stream flows to protect aquatic systems to which species are uniquely adapted. Minimize the effects of stream diversions or other flow modifications from hydroelectric projects on threatened, endangered, and sensitive species.	The project does not propose to create flow modifications. The project does propose to use approved water sources for watering roads, dust abatement, and road surface protection. Management requirements for water drafting are designed to maintain in stream flows needed to protect riparian resources, channel conditions and aquatic habitat.
Determine if the level of coarse large woody debris (CWD) is within the range of natural variability in terms of frequency and distribution and is sufficient to sustain stream channel physical complexity and stability. Ensure proposed management activities move conditions toward the range of natural variability.	Based on stream survey data and visual observations of stream channels within the project area, levels of CWD appear to be adequate and within the range of natural variability. This project is designed to retain an adequate recruitment source for CWD by retaining snags in near-stream areas as well as by leaving in place existing downed trees that are in perennial or intermittent stream channels.
Design prescribed fire treatments to minimize disturbance of ground cover and riparian vegetation in RCAs. In burn plans for project areas that include, or are adjacent to RCAs, identify mitigation measures to minimize the spread of fire into riparian vegetation. In determining which mitigation measures to adopt, weigh the potential harm of mitigation measures, for example fire lines, against the risks and benefits of prescribed fire entering riparian vegetation. Strategies should recognize the role of fire in ecosystem function and identify those instances where fire suppression or fuel management actions could be damaging to habitat or long-term function of the riparian community.	Although this project does not propose to use broadcast burning, pile burning and jackpot burning is proposed. BMPs and Management Requirements specific to pile burning include restrictions on pile placement to protect riparian vegetation.

Standards and Guidelines	Supporting Information/Discussion
Post-wildfire management activities in RCAs and CARs should emphasize enhancing native vegetation cover, stabilizing channels by non-structural means, minimizing adverse effects from the existing road network, and carrying out activities identified in landscape analyses. Post-wildfire operations shall minimize the exposure of bare soil.	All proposed actions are designed to minimize impacts to aquatic- and riparian-dependent resources while meeting project objectives. The post-wildfire management activities in this project have been designed to minimize adverse effects of roads via numerous BMPs in the watershed management requirements. Bare soil would be minimized by use of ground cover treatments. Restoration activities are outside the scope for this project.
Allow hazard tree removal within RCAs or CARs. Allow mechanical ground disturbing fuels treatments, salvage harvest, or commercial fuelwood cutting within RCAs or CARs when the activity is consistent with RCOs. Utilize low ground pressure equipment, helicopters, over the snow logging, or other non-ground disturbing actions to operate off of existing roads when needed to achieve RCOs. Ensure that existing roads, landings, and skid trails meet Best Management Practices. Minimize the construction of new skid trails or roads for access into RCAs for fuel treatments, salvage harvest, commercial fuelwood cutting, or hazard tree removal.	Logging systems have been designed to minimize ground disturbance. Low ground pressure equipment such as feller bunchers, or non-ground disturbing methods such as helicopters would be employed. Numerous BMPs have been included in the project to minimize effects of the transportation system, as well as for landings and skid trails.
Prohibit or mitigate ground-disturbing activities that adversely affect hydrologic processes that maintain water flow, water quality, or water temperature critical to sustaining bog and fen ecosystems and plant species that depend on these ecosystems. During project analysis, survey, map, and develop measures to protect bogs and fens from such activities as trampling by livestock, pack stock, humans, and wheeled vehicles. Criteria for defining bogs and fens include, but are not limited to, presence of: (1) sphagnum moss (Spagnum spp.), (2) mosses belonging to the genus Meessia, and (3) sundew (Drosera spp.)	There is one identified fen within a treatment unit. This site would be protected by implementing mechanized equipment exclusion zones around special aquatic features.

Beneficial Uses of Water

All alternatives are expected to result in maintenance of the applicable beneficial uses of water in the Water Quality Control Plan (Basin Plan) for the California Central Valley Water Quality Control Board (CVRWQCB 2011). Water temperature, sediment, and water quality following pesticide use are not expected to be adversely altered. Domestic and municipal water supplies and power are not adversely affected by the proposed action or alternatives. Recreational contact and non-contact waters are suitable for human use. Warm and cold freshwater habitat and wildlife habitat are not adversely affected by the proposed action or alternatives.

Water Quality Best Management Practices (BMPs)

Alternatives 1, 3 and 4 comply with the intent and procedural requirements of BMPs (USDA 2011, USDA 2012). If any of the action alternatives are implemented, or a combination thereof, applicable BMPs would be followed. BMPs would not be implemented under Alternative 2 (No Action), as no recovery activities would occur under this alternative.

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Appendix A: Cumulative Watershed Effects Analysis Methodology

The process for analyzing cumulative watershed effects (CWE) consists of two steps: (1) an office evaluation which consists of determining the risk of cumulative effects using a predictive model and researching watershed history, and (2) field evaluation of streamcourse indicators of cumulative effects.

Step 1, the risk of cumulative effects, is evaluated using the Forest Service equivalent roaded acreage (ERA) methodology, which has been adopted by Region 5 as a method of addressing cumulative watershed effects (USDA Forest Service 1990). ERA values are calculated using a computer model developed on the Stanislaus National Forest (Rutten and Grant 2008). The model is designed as a preliminary indicator for managers to determine whether or not past and present land management disturbances in a given watershed approach or exceed a threshold of concern (TOC). The TOC for each watershed was determined based on the watershed's relief ratio, geology, precipitation regime, and stream channel classification. The ERA model is intended to predict risk of cumulative effects, not actual effects. As such, it is an initial screen for focusing field evaluation priorities.

Understanding watershed history (i.e. past management activities, hydrologic events, wildfire) is important to build a temporal context of past impacts, current condition and potential future effects. Analysis of watershed history, including land disturbance history, is essential to help predict effects of future management activities on water quality and watershed condition. This history is considered in the ERA model spreadsheets. The temporal scope analyzed is based upon the estimated time of recovery from each past activity or event. It varies by activity and ranges from 1 to 10 years. The temporal scope for known future activities also varies by activity and ranges from 1 to10 years into the future. Not all future activities used to calculate ERA values have a defined proposed action. Therefore, assumptions were made about when and where activities would likely occur. These assumptions were documented in this appendix.

Step 2, field evaluation, is necessary for comparing the modeled ERA prediction with actual and expected future field conditions. Project-related water quality parameters and watershed condition are evaluated via in-stream and near-stream indicators of condition. This evaluation is essential to help interpret cumulative effects of past projects and potential cumulative effects given proposed activities and other reasonably foreseeable future activities. Field review was used to verify that the geographic and temporal extent of analysis was adequate for evaluation of cumulative watershed effects (Connaughton 2005).

The CWE ERA analysis for the Rim Fire Recovery EIS was conducted on all lands within the affected watersheds (public and private lands). GIS analysis was used to calculate acreages of activities in the watersheds. CalFire was contacted regarding timber harvest activities on private land and maps of activities on private lands were digitized for the GIS analysis (Frese 2013-2014). ERA values for all activities described below were summed and then were compared to a TOC. These TOCs were determined for each individual watershed based on the natural watershed sensitivity (USDA Forest Service 1990, USDA Forest Service 1998).

Watersheds Analyzed

The Rim Fire Recovery project area includes 15 HUC 6 analysis watersheds. The percent of watershed acres proposed for treatment varies greatly between watersheds. Table 1 displays the soil burn severity and percent of watershed acres proposed for treatment (combined timber units and hazard tree removal) for each action alternative.

Table 1 Percent of HUC 6 Watershed Acres Burned at High or Moderate Soil Burn Severity and Percent of Watershed Acres Proposed for Treatment by Alternative

HUC 6 Watershed Name	Percent of Watershed Burned at High or Moderate Soil Burn Severity[1]	Percent of Watershed Acres Proposed for Treatment		
		Alternative 1	Alternative 3	Alternative 4
Grapevine Creek-Tuolumne River	27%	5%	5%	5%
Jawbone Creek-Tuolumne River	70%	23%	30%	30%
Lower North Fork Tuolumne River	7%	3%	3%	3%
Lower Clavey River	49%	22%	23%	23%
Middle Clavey River	13%	20%	17%	15%
Reed Creek	23%	21%	21%	17%
Lower Cherry Creek	53%	14%	12%	11%
Miguel Creek-Eleanor Creek	35%	4%	3%	3%
Poopenaut Valley-Tuolumne River	39%	2%	1%	1%
Lower Middle Fork Tuolumne River	63%	49%	49%	49%
Upper Middle Fork Tuolumne River	29%	1%	2%	2%
Lower South Fork Tuolumne River	46%	36%	36%	35%
Upper South Fork Tuolumne River	25%	2%	2%	1%
Bull Creek	2%	1%	1%	1%
Bean Creek-North Fork Merced River	4%	4%	4%	4%

[1] This includes Forest Service and non-Forest Service lands.

As seen in Table 1, three of the fifteen analysis watersheds had a maximum of 6% of their watershed acreage burned at high or moderate soil burn severity. These watersheds (Lower North Fork Tuolumne River, Bull Creek, and Bean Creek-North Fork Merced River) also all had a maximum of 4% of their acreage proposed for treatment under any action alternative. Therefore, these watersheds were not analyzed in detail following the ERA methodology. The effects of the small acreage of high or moderate soil burn severity and the small acreage of proposed treatments on these watersheds made it very unlikely to have measurable cumulative watershed effects, leading to the determination that ERA calculations were unnecessary.

The focus of the ERA evaluations is on the following HUC 6 watersheds:

- Grapevine Creek-Tuolumne River
- Jawbone Creek-Tuolumne River
- Lower Clavey River
- Middle Clavey River
- Reed Creek
- Lower Cherry Creek
- Miguel Creek-Eleanor Creek
- Poopenaut Valley-Tuolumne River
- Lower Middle Fork Tuolumne River
- Upper Middle Fork Tuolumne River
- Lower South Fork Tuolumne River
- Upper South Fork Tuolumne River

Land Ownership in the Watersheds

The CWE ERA analysis for the Rim Fire Recovery EIS was conducted on both public (US Forest Service, National Park Service, or Bureau of Land Management administered) and private lands in the watersheds. While it is harder to know activities on private land, GIS analysis can cover constant features such as roads and activities such as wildfire. In addition, CalFire was contacted regarding timber harvest activities on private land (Frese 2013-2014). Ownership patterns in the watersheds appear to be relatively stable.

Land ownership in the watersheds is as follows:

- Grapevine Creek-Tuolumne River: 74% USFS, 4% BLM, 22% Private
- Jawbone Creek-Tuolumne River: 73% USFS, 27% Private
- Lower Cherry Creek: 81%USFS, 2%NPS, 17% Private
- Lower Clavey River: 85% USFS, 15% Private
- Lower Middle Fork Tuolumne River: 95% USFS, 5% Private
- Lower South Fork Tuolumne River: 96% USFS, 4% Private
- Middle Clavey River: 91% USFS, 9% Private
- Miguel Creek-Eleanor Creek: 6% USFS, 94% NPS
- Poopenaut Valley-Tuolumne River: 28% USFS, 70%NPS, 2% Private
- Reed Creek: 90% USFS, 10% Private
- Upper Middle Fork Tuolumne River: 3% USFS, 97% NPS
- Upper South Fork Tuolumne River: 8% USFS, 91% NPS, 1% Private

ERA Coefficients

The Annual ERA value is calculated in Excel using a linear decay of the ERA coefficient. The basic equation is:

ERA = Acres*(ERACoef-((Year-ActivityYear/Recovery)*ERACoef)))

However, if the activity is in the future, no ERA will be calculated until the first year of the activity. Also, if Year-ActivityYear is greater than or equal to the Recovery, then the Annual ERA is zero because the recovery time has been exceeded.

Timber Harvest/Fuels Treatment

The ERA coefficient and recovery timeframe vary depending on the logging system. All coefficients are additive. For example, two entries of ground based salvage plus biomass would equal an ERA of 0.26 (0.14+0.08+0.04). See Table 2 for a description of ERAs.

Table 2 ERA Values for Timber Harvest/Fuels Treatments

Treatment	Coefficient	Recovery (Years)	Notes
Ground-based salvage (1st entry)	0.14	10	
Ground-based salvage (2nd entry)	0.08	10	This assumes that less of the treatment unit would be accessed and that existing features such as skid trails would be re-used, so lower coefficient than first entry.
Biomass	0.04	10	This would occur in units with ground-based salvage proposed.
Machine pile and burn	0.04	10	This assumes use of a dozer
Grapple pile and burn	0.02	10	
Helicopter salvage	0.04	3	Trees hand felled and lifted out of units.
Skyline Harvesting	0.08	5	Some units may utilize feller bunchers to drop the trees
Roadside Hazard Trees (1st entry)	0.08	10	Shorter skid trail distances than other ground-based salvage units.
Roadside Hazard Trees (2nd entry)	0.04	10	This assumes that less of the treatment unit would be accessed and that existing features such as skid trails would be re-used, so lower coefficient than first entry.
Mastication burned trees and brush	-0.02	-	Coefficient is negative because it is a treatment used to increase groundcover and

Treatment	Coefficient	Recovery (Years)	Notes
			filter erosion. Treatment is only taking place in ground-based salvage units, so the effects of heavy equipment are already being considered.
Drop and lop	-0.02	-	Treatment involves dropping and lopping sub-merchantable trees. Coefficient is negative because it is a treatment used to increase groundcover and filter erosion.
Jackpot burning	0.02	2	Burning of fuel concentrations
Green tree sale on private land – clearcut	0.18	10	
Green tree sale on private land – non-clearcut	0.15	10	This includes shelterwood seed cut, shelterwood removal cut, shelterwood prep cut, seed tree seed cut, seed tree removal cut, group selection, selection, commercial thin, sanitation salvage, rehab understocked, alternative prescription, transition, fuelbreaks
Green tree sale on private land – conversion	0.22	10	Conversion of land to a different use
Salvage sale on private land – clearcut	0.22	10	Assumes ground based salvage + biomass + machine pile and burn (0.14+0.04+0.04)
Salvage sale on private land – clearcut with subsoiling	0.18	10	Coefficient was reduced due to erosion control benefits of subsoiling.
Helimulch burned area	-0.02	2	Coefficient is negative because it is a treatment used to increase groundcover and filter erosion. Straw degrades quickly, so recovery period is short.
Green tree - shred/mastication	0.03	3	Shred trees and brush
Green tree – tractor thin	0.15	10	
Prescribed burn	0.02	2	
Herbicide site prep and release	0.01	2	
Hand pull and dig weeds	0.03	2	

Due to unknowns in implementing this large project, the following assumptions were made:

- All helicopter and skyline logging would occur in the 1st year of implementation (2014).
- Approximately 1/3 of the ground-based logging acreage would be completed in 2014 and the remaining would occur in 2015. The units which burned the hottest would be treated first because the economic value of the trees may be lost more quickly in these areas.
- Ground-based salvage units with <75% canopy cover mortality (determined in GIS) would have a 2nd entry to treat future die off. This 2nd entry would occur in 2016.
- Ground-based salvage units with >75% canopy cover mortality would only have one entry because it is assumed that the first entry would be comparable to a clearcut.
- No 2nd entries would occur on helicopter or skyline logging units (cost prohibitive).
- Roadside hazard trees would be treated in 2014.
- Roadside hazard trees with <50% canopy cover mortality (determined in GIS) would have a 2nd entry to treat future die off. This 2nd entry would occur in 2015.
- Roadside hazard trees with >50% canopy cover mortality (determined in GIS) would only have 1 entry because it is assumed that the first entry would be comparable to a clearcut. This percentage is different from the salvage units because the salvage units require the trees to be 100% dead, whereas the roadside hazard trees have different marking standards.
- Subsequent entries (beyond the second entry) were not evaluated for. It is assumed that after two entries any remaining die off would be treating scattered isolated trees and would not significantly affect ERA calculations.

- Pile and burn fuels treatments include machine piling and burning (dozer or grapple piling), jackpot burning, and hand piling and burning. All of these fuel treatment acres were assumed to be treated by dozer piling because this would cause the greatest ground disturbance. The exception is the areas where dozer piling is prohibited. In these areas, grapple piling was assumed.
- Pile and burn fuels treatments would require an additional entry into the units.
- Pile and burn treatments would occur from 2015-2018 and are evenly distributed in time and space.
- Biomass treatments would occur in 2015.
- In helicopter units, either lop and scatter or jackpot burning is prescribed to treat fuels. Jackpot burning is assumed for all of these treatment acres because this treatment would cause greater disturbance than lop and scatter.
- Mastication treatments would occur in 2014.
- All salvage harvesting on private land was assumed to be clearcuts.
- On SPI land, it was assumed that subsoiling for site prep and erosion control was completed following salvage harvesting.
- In Yosemite National Park, 50% of hazard tree acreage was treated in 2013 and 50% will be treated in 2014. Second entries to treat future die off were calculated the same as hazard trees on National Forest lands.

Engineering

The ERA coefficient and recovery timeframe vary depending on the activity proposed. See Table 3 for a description of ERAs.

Table 3	ERA Values for Engineering

Treatment	Coefficient	Recovery (Years)	Notes
New road construction	1	-	Road kept on the system, so no recovery (new constant feature)
Temporary road construction	1	7	Road would be closed (decommissioned) following use.
Skid Zone	1	7	This is area where skidding would occur outside of treatment units.
Material Source	1	10	Use of new of existing material source, followed by source closure. Sources not closed are considered constant features (no recovery).

Activities such as road maintenance and road reconstruction are not assigned ERA values because these activities are on existing roads which already have ERA values assigned to them (constant features).

Wildfire/Suppression Activities

The ERA coefficient and recovery timeframe vary depending on the activity and the fire soil burn severity. See Table 4 for a description of ERAs.

Table 4	ERA Values for Wildfire

Treatment	Coefficient	Recovery (Years)	Notes
High Soil Burn Severity	0.33	7	
Moderate Soil Burn Severity	0.1	3	
Low Soil Burn Severity	0.02	1	
Dozer Lines	1.00	7	All dozer lines rehabbed

Constant Features

Constant features in a watershed are considered as part of the ERA analysis. This includes features such as roads, trails, power lines, buildings, campgrounds, dispersed recreation sites, etc. See CWE analysis spreadsheets for constant features and ERA coefficients for each watershed. Since they are constant features, they have no recovery timeframes assigned.

Future Activities

Reasonable foreseeable future land management activities were considered in the ERA calculations. This included all items listed in the January 2014 SOPA that had the potential for ground disturbance as well as any other known likely future activities on public or private lands. Similar equations to those described above were used to calculate ERAs for future activities. See CWE analysis spreadsheets for each future activity, ERA coefficient, and recovery timeframe.

Grazing

Previous analyses on the forest have indicated that the effects of livestock grazing at the watershed scale are low. For example, in the BEH DEIS, differences in ERA values between the No Action alternative and the Current Management alternative ranged from an increase of 0.02% to an increase of 0.45% in eight HUC 6 watersheds analyzed. These calculations assumed 100% ground disturbance in meadows and lesser disturbance in capable/suitable range outside of meadows (USDA 2013). Therefore, ground disturbance from livestock grazing is essentially a site issue rather than a watershed scale issue. This is because impacts of livestock grazing tend to be higher in low gradient stream channels through meadows than in upland areas, and these low gradient areas make up a small percentage of the watershed acreage. This results in little change to ERA values. Because of this, impacts of grazing are considered narratively for this project, but not quantitatively.

ERA Analysis Results

Table 5 summarizes ERA results for the twelve HUC 6 analysis watersheds and compares them to a TOC of 12-14%. See the CWE analysis spreadsheets in the Project Record for specific activities in each watershed as well as details on how the TOC was determined.

Table 5 Highest Percent ERA by Watershed and Alternative

HUC 6 Watershed Name	Highest % ERA Alternative 1	Highest % ERA Alternative 2	Highest % ERA Alternative 3	Highest % ERA Alternative 4	TOC Exceeded? (Y/N)
Grapevine Creek-Tuolumne River	4.31	3.91	4.31	4.31	N
Jawbone Creek-Tuolumne River	16.24	14.68	16.56	16.56	Y (Alt 1,2,3,4)
Lower Clavey River	9.59	8.41	9.80	9.80	N
Middle Clavey River	5.77	4.28	5.58	5.50	N
Reed Creek	9.47	7.06	9.40	8.70	N
Lower Cherry Creek	11.36	10.58	11.27	11.27	N
Miguel Creek-Eleanor Creek	3.69	3.47	3.68	3.66	N
Poopenaut Valley-Tuolumne River	4.56	4.45	4.56	4.56	N
Lower Middle Fork Tuolumne River	15.13	9.96	15.17	15.17	Y (Alt 1,3,4)
Upper Middle Fork Tuolumne River	3.74	3.66	3.74	3.74	N
Lower South Fork Tuolumne River	9.91	7.01	9.83	9.76	N
Upper South Fork	3.19	3.07	3.18	3.18	N

Tuolumne River					

The results of the HUC 6 ERA analysis indicated that one HUC 6 watershed, Jawbone Creek-Tuolumne River, exceeded the TOC under all alternatives, including the no action alternative. The Lower Middle Fork Tuolumne River exceeded the TOC under all action alternatives. There were an additional four watersheds that approached, but did not exceed, the TOC. These were the Lower Clavey River, Reed Creek, Lower Cherry Creek, and Lower South Fork Tuolumne River watersheds.

The six HUC6 watersheds which approached or exceeded the TOC were then evaluated more closely to determine if ERAs should be calculated at the HUC 7 level. See Table 6 for a description of soil burn severity and treatment acres for these HUC 7 watersheds.

Table 6 Percent of HUC 7 Watershed Acres Burned at High or Moderate Soil Burn Severity and Percent of Watershed Acres Proposed for Treatment by Alternative

HUC 6 Watershed Name	HUC 7 Watershed Name	Percent of Watershed Burned at High or Moderate Soil Burn Severity[1]	Percent of Watershed Acres Proposed for Treatment		
			Alternative 1	Alternative 3	Alternative 4
Jawbone Creek-Tuolumne River	Gravel Range-Tuolumne River	72%	8%	16%	16%
	Corral Creek	89%	58%	78%	78%
	Lower Jawbone Creek	85%	32%	34%	34%
	Middle Jawbone Creek	69%	15%	17%	17%
	Upper Jawbone Creek	40%	12%	13%	13%
Lower Clavey River	Bull Meadow-Lower Clavey River	47%	17%	22%	22%
	Quilty Creek-Lower Clavey River	55%	13%	19%	19%
	Bear Springs Creek-Lower Clavey River	50%	27%	28%	28%
Reed Creek	Lower Reed Creek	62%	43%	44%	31%
	Bourland Creek	10%	4%	4%	4%
	Reynolds Creek	13%	19%	19%	18%
Lower Cherry Creek	Plum Flat-Lower Cherry Creek	83%	2%	2%	2%
	Granite Creek	92%	27%	20%	20%
	Kibbie Ridge-Lower Cherry Creek	45%	16%	16%	10%
	Cherry Lake	31%	14%	16%	15%
Lower Middle Fork Tuolumne River	Lower Middle Fork Tuolumne River West	75%	44%	45%	45%
	Lower Middle Fork Tuolumne River East	50%	54%	53%	53%
Lower South Fork Tuolumne River	Lower South Fork Tuolumne River West	49%	40%	38%	38%
	Lower South Fork Tuolumne River East	46%	34%	34%	34%

[1] This includes Forest Service and non-Forest Service lands.

In the Jawbone Creek-Tuolumne River HUC 6 watershed, there are five HUC 7 watersheds. Of these, Corral Creek and Lower Jawbone Creek had the highest percentage of moderate and high soil burn severity and the highest percentage of acreage treated under the action alternatives. These two HUC 7 watersheds were therefore evaluated using the ERA methodology.

In the Lower Clavey River HUC 6 watershed, there are three HUC 7 watersheds. All had similar soil burn severity. Bear Springs Creek-Lower Clavey River had the highest percentage of watershed proposed for treatment, so this HUC 7 watershed was evaluated using the ERA methodology.

In the Reed Creek HUC 6 watershed, there are three HUC 7 watersheds. Of these, Lower Reed Creek had by far the highest percentage of moderate and high soil burn severity as well as the highest percentage of acreage proposed for treatment. Therefore, Lower Reed Creek was evaluated using the ERA methodology.

In the Lower Cherry Creek HUC 6 watershed, there are four HUC 7 level watersheds. Granite Creek had the highest percentage of moderate and high soil burn severity and the highest percentage of the watershed proposed for treatment. In addition, much of this watershed is on private land and the private land was being salvage logged. Therefore, Granite Creek was evaluated using the ERA methodology.

In the Lower Middle Fork Tuolumne River HUC 6 watershed, there are two HUC 7 watersheds. Both soil burn severity and treatment area percentages were fairly well distributed between these two watersheds. Because the HUC 6 watershed was over the threshold of concern for each action alternative and impacts appeared to be well distributed, TOC was not calculated for either HUC 7 watershed. It was assumed that both HUC 7 watersheds would exceed the TOC.

In the Lower South Fork Tuolumne River HUC 6 watershed, there are two HUC 7 watersheds. Both soil burn severity and treatment area percentages were fairly well distributed between these two watersheds. Because the impacts of the action alternatives appeared to be well distributed, TOC was not calculated for either HUC 7 watershed. It was assumed that neither HUC 7 watershed would exceed the TOC.

See Table 7 for a summary of the ERA results for the five HUC 7 watersheds analyzed.

Table 7 Highest Percent ERA by Watershed and Alternative

HUC 7 Watershed Name	Highest % ERA Alternative 1	Highest % ERA Alternative 2	Highest % ERA Alternative 3	Highest % ERA Alternative 4	TOC Exceeded? (Y/N)
Corral Creek	21.39	16.33	25.40	25.40	Y (Alt 1,2,3,4)
Lower Jawbone Creek	14.00	11.80	14.17	14.17	Y (Alt 1,3,4)
Bear Springs Creek-Lower Clavey River	13.00	11.36	12.91	12.91	Y (Alt 1,3,4)
Lower Reed Creek	18.10	14.98	17.99	16.77	Y (Alt 1,2,3,4)
Granite Creek	26.52	24.68	26.02	26.02	Y (Alt 1,2,3,4)

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Appendix B: Watershed Management Requirements

Management requirements, designed to protect water quality and watershed conditions, are derived from Regional and National Best Management Practices (BMPs) (USDA 2011a, USDA 2012) and Riparian Conservation Objectives (RCOs) (USDA 2004). Riparian resources within Riparian Conservation Areas (RCAs) and the Critical Aquatic Refuge (CAR) will be protected through compliance with the RCOs outlined in the Forest Plan (USDA 2010). Best Management Practices (BMPs) protect beneficial uses of water by preventing or minimizing the threat of discharge of pollutants of concern. BMPs applicable to this project are listed below with site-specific requirements and comments. Project planners and administrators (e.g., layout, Sale Administrator, Contracting Officer Representative) are responsible for consulting with a hydrologist and/or soil scientist prior to or during project implementation for interpretation, clarification, or adjustment of watershed management requirements.

Mechanized Equipment Operations within RCAs/CAR

On the Stanislaus National Forest, ground-based mechanized equipment operations in RCAs are divided into three zones. The exclusion zone, at the edge of streams or wetlands, prohibits mechanized equipment use. Next, the transition zone allows light mechanized activity. Last, the outer zone allows activity to increase to standard operations beyond the RCA. Together, these zones comprise a wide, graduated RCA buffer zone intended to achieve Riparian Conservation Objectives as well as vegetation management objectives.

The purpose of mechanized RCA operations is to reduce fuel loading and improve riparian vegetation community condition close to streams and wetlands. These operations are carefully conducted to prevent detrimental soil impacts and retain a high percentage of ground cover in the RCA. Where ground cover is minimal in an RCA, such as following wildfire, specialized low ground pressure vehicles become the primary type of equipment used. They minimize disturbance during timber removal operations and can be used to increase ground cover by chipping and distributing woody debris.

Forest guidance for Mechanized Equipment Operations in RCAs (Frazier 2006) as summarized above was developed for RCA vegetation management operations in unburned areas. It has since been revised to include post-wildfire operations.

Table 1 provides a summary of the operating requirements for mechanical operations in RCAs.

Table 1 Operating requirements for mechanized equipment operations in RCAs

Stream Type[1]	Zone	Width (feet)	Equipment Requirements	Element	Operating Requirements
Perennial/ Intermittent and Special Aquatic Features (SAFs)	Exclusion	0 - 15	Mechanical Harvesting/ Shredding[2]: Prohibited		
		0 - 50	Skidding[3]: Prohibited		
	Transition	15 - 100	Mechanical Harvesting/ Shredding: Allowed	Streamcourse Debris	Remove activity-created woody debris to above the high water line of stream channels
				Vegetation	Retain remaining post-fire obligate riparian shrubs and trees that have live crown foliage or are resprouting (e.g. willows, alder, dogwoods and big leaf maples)
				Streambanks	Do not damage streambanks with equipment.
		50 - 100	Skidding: Allowed	Skid Trails	Use existing skid trails except where unacceptable impact would result. Do not construct new primary skid trails within 100 feet of the stream
				Stream Crossings	The number of crossings should not exceed an average of 2 per mile
	Outer (Perennial/SAFs)	100 - 300	Mechanical Harvesting/ Shredding/ Skidding: Allowed	Skid Trails	Allow skid trail density and intensity to gradually increase with distance from the Transition Zone
	Outer (Intermittent)	100 - 150	Mechanical Harvesting/ Shredding/ Skidding: Allowed	Skid Trails	Allow skid trail density and intensity to gradually increase with distance from the Transition Zone
Ephemeral	Exclusion	0 - 15	Mechanical Harvesting/ Shredding: Prohibited		
		0 - 25	Skidding: Prohibited		
	Transition	15 - 50	Mechanical Harvesting/ Shredding: Allowed		
		25 - 50	Skidding: Allowed	Stream Crossings	The number of crossings should not exceed an average of 3 per mile

1 Perennial streams flow year long. Intermittent streams flow during the wet season but dry by summer or fall. Ephemeral streams flow only during or shortly after rainfall or snowmelt. Special aquatic features (SAFs) include lakes, meadows, bogs, fens, wetlands, vernal pools and springs.

2 Low ground pressure track-laying machines such as feller bunchers and masticators.

3 Rubber-tired skidders and track-laying tractors.

Management Requirements Incorporating BMPs and Forest Plan S&Gs

Table 2 presents management requirements pertaining to: erosion control plans; operations in RCAs, road activities; stream crossings; log landings, skid trails; suspended log yarding; water sources, rock borrow pits/quarries, slope and soil moisture limitations, servicing and refueling of equipment, burn piles; application of registered borate compound; water quality monitoring; and, cumulative watershed effects.

Table 2 Management requirements incorporating BMPs and Forest Plan S&Gs

Management Requirements	BMPs/Forest Plan[1]/Locations
Erosion Control Plan - Prepare a project area Erosion Control Plan (USDA 2011a) approved by the Forest Supervisor prior to the commencement of any ground-disturbing project activities. Prepare a BMP checklist before implementation.	**Regional BMPs** 2-13 Erosion Control Plans (roads and other activities) 1-13 Erosion Prevention and Control Measures During Operations 1-21 Acceptance of Timber Sale Erosion Control Measures before Sale Closure **National Core BMPs** Veg-2 Erosion Prevention and Control **Forest Plan S&Gs** 194 (RCO 4) **Locations**: all areas where ground-disturbing activities occur.

Operations in Riparian Conservation Areas
- Delineate riparian buffers along streams and around special aquatic features within project treatment units as described above in Table 1.
- Fell trees harvested within RCAs directionally away from stream channels and SAFs unless otherwise recommended by a hydrologist or biologist. Fall hazards trees that cannot be removed either parallel to the contour of the slope or into the channel, as recommended by a hydrologist or biologist.
- Maintain or provide ground cover (e.g., maintain post-fire conifer needle cast; provide logging slash, straw, wood chips, felled or masticated small burned trees) within 100 feet of perennial and intermittent streams and SAFs to the maximum extent practicable to minimize erosion and sedimentation. A minimum of 50% well distributed ground cover is desired.
- Minimize turning mechanical harvesters/shredders in the RCA Transition Zone to limit disturbance.
- Exclude mechanized equipment between the near-stream roads that closely parallel both sides of Corral Creek (1N01, 1N08 on the west and 1N74 (south of junction with 1N74C) and 1N74C on the east) unless otherwise recommended by a hydrologist or soil scientist. Smooth out all end lining ruts within this area. The maximum mechanized equipment exclusion width is the RCA width (300 feet).
- The Sale Administrator shall coordinate with a hydrologist prior to operating around Scout Spring Gully (Unit T22).
- The Sale Administrator shall coordinate with a hydrologist prior to operating in unit T27B to protect the Bear Gully restoration site, the stream channel downstream of the site, and the alluvial flat.
- In high vegetation burn severity areas (defined as complete combustion of needles) with slopes greater than 15%, the following requirements apply:
  - From 0-50 feet from perennial and intermittent stream banks, smooth out feller buncher or end lining ruts greater than 4 inches in depth.
  - From 50-100 feet from perennial and intermittent stream banks, smooth out feller buncher or end lining ruts greater than 4 inches in depth or waterbar these ruts following the waterbar spacing guidelines for a very high erosion hazard rating.
- Increase the ground-based equipment exclusion zone in RCAs to 100 feet on slopes greater than 25% with slope lengths greater than 100 feet, high burn severity, and immediately adjacent to perennial and intermittent channels within the following units: D04B, D12, E01B, E02, E03B, F11, G01, G03B, L02D, M01, M05A, M15, N01I, R16, S02, S04, T04B, T04C, T27B, U03, V13, V14B, V14C. Prior to implementation, these sites will be evaluated in the field by a hydrologist or soil scientist to identify on the ground areas where exclusion is required.
	Regional BMPs
	1-4 Using Sale Area Maps and/or Project Maps for Designating Water Quality Protection Needs
	1-8 Streamside Zone Designation
	1-10 Tractor Skidding Design
	1-18 Meadow Protection During Timber Harvesting
	1-19 Streamcourse and Aquatic Protection
	5-3 Tractor Operation Limitations in Wetlands and Meadows
	5-5 Disposal of Organic Debris
	7-3 Protection of Wetlands
	National Core BMPs
	Aq Eco-2 Operations in Aquatic Ecosystems
	Plan-3 Aquatic Management Zone Planning
	Veg-1 Vegetation Management Planning
	Veg-2 Erosion Prevention and Control
	Veg-3 Aquatic Management Zones
	Veg-4 Ground-Based Skidding and Yarding Operations
	Forest Plan S&Gs
	193 (RCO 2)
	194 (RCO 3)
	194 (RCO 4)
	195 (RCO 5)
	Locations: All units containing RCAs and SAFs, and specifically the portions of units mentioned in this section of Table 2.

Road Construction and Reconstruction - Maintain erosion-control measures to function effectively throughout the project area during road construction and reconstruction, and in accordance with the approved erosion control plan. - Stabilize disturbed areas with certified weed free mulch, erosion fabric, vegetation, rock, large organic materials, engineered structures, or other measures according to specification and the erosion control plan. - Set the minimum construction limits needed for the project and confine disturbance to that area. - Adjust surface drainage structures to minimize hydrologic connectivity by: discharging road runoff to areas of high infiltration and high surface roughness; armoring drainage outlets to prevent gully initiation; and increasing the number	**Regional BMPs** 2-2 General Guidelines for the Location and Design of Roads 2-3 Road Construction and Reconstruction 2-8 Stream Crossings 2-13 Erosion Control Plans (roads and other activities) **National Core BMPs** Road-3 Road Construction and Reconstruction **Forest Plan S&Gs** 62 193 (RCO 2)

Management Requirements	BMPs/Forest Plan[1]/Locations
drainage facilities within RCAs. - Minimize diversion potential by installing diversion prevention dips that can accommodate overtopping runoff. Place diversion prevention dips downslope of crossing, rather than directly over the crossing fill, and in a location that minimizes fill loss in the event of overtopping. Armor diversion prevention dips when the expected volume of fill loss is significant. - Locate and designate waste areas before operations begin. Deposit and stabilize excess and unsuitable materials only in designated sites. Do not place such materials on slopes with a high risk of mass failure, in areas subject to overland flow (e.g., convergent areas subject to saturation overland flow), or within the RCA. Provide adequate surface drainage and erosion protection at disposal sites. - Do not permit side casting in RCAs. Prevent excavated materials from entering water or RCAs. - Schedule operations during dry periods when rain, runoff, wet soils, snowmelt or frost melt are less likely. Limit operation of equipment when ground conditions could result in excessive rutting, soil compaction (except on the road prism or other surface to be compacted), or runoff of sediments directly to streams. - Stabilize project area during normal operating season when the National Weather Service predicts a 50% or greater chance of precipitation. - Keep erosion-control measures sufficiently effective during ground disturbance to allow rapid closure when weather conditions deteriorate. - Complete all necessary stabilization prior to precipitation that could result in surface runoff. - Scatter construction-generated slash on disturbed areas. Ensure ground contact between slash and disturbed slopes. Windrow slash at the base of fills to reduce sedimentation. Ensure windrows are placed along contours with ground contact between slash and disturbed slope. - Monitor contractor's plans and operations to assure contractor does not open up more ground than can be substantially completed before expected winter shutdowns, unless erosion-control measures are implemented. - Install erosion-control measures on incomplete roads prior to precipitation or the start of winter (November 16 through March 31) and in accordance with the Erosion Control Plan. Remove ineffective temporary culverts, culvert plugs, diversion dams, or elevated stream crossings leaving a channel at least as wide as before construction and as close to the original grade as possible. Install temporary culverts, side drains, cross drains, diversion ditches, energy dissipaters, dips, sediment basins, berms, dikes, debris racks, pipe risers, or other facilities needed to control erosion. Remove debris, obstructions, and spoil material from channels, floodplains, and riparian areas. Do not leave project areas for the winter with remedial measures incomplete. Provide protective cover for exposed soil surfaces.	194 (RCO 4) **Locations**: all new road construction and reconstruction.
Road Maintenance and Operations - Clean ditches and drainage structure inlets only as often as needed to keep them functioning. Prevent unnecessary or excessive vegetation disturbance and removal on features such as swales, ditches, shoulders, and cut and fill slopes. - Maintain road surface drainage by removing berms, unless specifically designated otherwise. - Accompany grading of hydrologically connected road surfaces and inside ditches with erosion and sediment control installation. - Divert springs across roads to prevent them from pooling and diverting on or along the road. A layer of coarse rock with geotextile fabric or other treatments may be necessary. - Ensure that after road maintenance activities (i.e., grading/earthwork activities) the final road surface drainage system will remove water from the road surface with the purpose to minimize concentrated runoff to an area. Ensure that existing metal/drain gutters are in working condition and /or install them as needed. - Conduct road watering for road maintenance, dust abatement, and road surface protection using approved existing water sources locations. (See Water Sources Development and Use below)	**Regional BMPs** 2-4 Road Maintenance and Operations 2-13 Erosion Control Plans (roads and other activities) **National Core BMPs** Road-4 Road Operations and Maintenance Veg-2 Erosion Prevention and Control **Forest Plan S&Gs** 193 (RCO 2) 194 (RCO 4) **Locations**: all roads with maintenance or project use.
Stream Crossings **Design of New or Reconstructed Crossings** - Design permanent stream crossings (new road construction and replacement culverts) to pass the 100-year flood flow plus associated sediment and debris; armor to withstand design flows and provide desired passage of fish and other aquatic organisms. - Locate and design crossings to minimize disturbance to the water body. Use	**Regional BMPs** 2-8 Stream Crossings 2-13 Erosion Control Plans (roads and other activities) **National Core BMPs** AqEco-2 Operations in Aquatic Ecosystems Road-7 Stream Crossings

Management Requirements	BMPs/Forest Plan[1]/Locations
structures appropriate to the site conditions and traffic. Favor armored fords for streams where vehicle traffic is seasonal or temporary, and where the ford design maintains the channel pattern, profile and dimension. - Install stream crossings according to project specifications and drawings. Design should sustain bankfull dimensions of width, depth and slope, and maintain streambed and bank resiliency. - Construct diversion prevention dips to accommodate overtopping of runoff if diversion potential exists. Locate diversion prevention dips downslope of the crossing rather than directly over crossing fill; armor diversion prevention dips based on soil characteristics and risk. Install cross drains (e.g., rolling dips; waterbars) to hydrologically disconnect the road above the crossing and to dissipate concentrated flows. **Construction, Reconstruction and Maintenance Operations** - Keep excavated materials out of channels, floodplains, wetlands and lakes. Install silt fences or other sediment- and debris-retention barriers between the water body and construction material stockpiles and wastes. Dispose unsuitable material in approved waste areas outside of the RCA. - Inspect and clean equipment; remove external oil, grease, dirt and mud and repair leaks prior to unloading at site. Inspect equipment daily and correct identified problems before entering streams or areas that drain directly to water bodies. Remove all dirt and plant parts to ensure that noxious weeds and aquatic invasive species are not brought to the site. - Remove all project debris from the stream in a manner that will cause the least disturbance. - Minimize streambank and riparian area excavation during construction. Stabilize adjacent disturbed areas using mulch, retaining structures, and or mechanical stabilization materials. - Ensure imported fill materials meet specifications, and are free of toxins and invasive species. - Divert or dewater stream flow for all live streams or standing water bodies during crossing installation and invasive maintenance.	Veg-2 Erosion Prevention and Control **Forest Plan S&Gs** 62 193 (RCO 2) 194 (RCO 4) **Locations**: all stream crossings on constructed, reconstructed and maintained roads.
Closure of Temporary and ML 1 Roads - Remove road stream crossings and other culverts identified at high risk of failure and posing a threat to water quality before a road is closed. - Block closed roads to prevent vehicle access. - Road-stream crossings deemed safe to leave in place will be treated to remove the potential for streamflow diversions in the event of a crossing failure or blockage, and, where needed, will have rock armor added to downstream crossing fill to prevent erosion. - Ensure that the road, culvert, and all hydrologically connected drainage structures are cleaned, and sediment and erosion controls are intact and functioning prior to closure. - Ensure road is effectively drained (e.g. waterbars, dips, outsloping) and treated to return the road prism to near natural hydrologic function. - Treat and stabilize road surfaces through subsoiling, scattering slash, and/or revegetation. Reshape and stabilize side slopes as needed.	**Regional BMPs** 2-6 Road Storage 2-7 Road Decommissioning 2-13 Erosion Control Plans (roads and other activities) **National Core BMPs** Road-6 Road Storage and Decommissioning Veg-2 Erosion Prevention and Control **Forest Plan S&Gs** 57 193 (RCO 2) **Locations**: all roads post-project closed or ML1 status.
Log Landings - Re-use log landings to the extent feasible. Existing landings within RCAs may be used when sedimentation effects can be mitigated by erosion prevention measures. - Do not construct new landings within 100 feet of perennial or intermittent streams and SAFs and 50 feet of ephemeral streams. - See the Soils Report for subsoiling requirements.	**Regional BMPs** 1-12 Log Landing Location 1-16 Log Landing Erosion **National Core BMPs** Veg-6 Landings Veg-2 Erosion Prevention and Control **Forest Plan S&Gs** 194 (RCO 4) **Locations**: all landings.
Skid Trails - Design and locate skid trails to best fit the terrain, volume, velocity, concentrations and direction of runoff water in a manner that would minimize erosion and sedimentation. - Locate new primary skid trails at least 100 feet from perennial and intermittent streams and SAFs and new secondary skid trails at least 50 feet from perennial and intermittent streams and SAFs. Locate all skid trails at least 25 feet from ephemeral streams. Primary skid trails typically have 20 or more passes and result in detrimental compaction or displacement of soils. Secondary skid trails have fewer passes and result in minor compaction or displacement.	**Regional BMPs** 1-10 Tractor Skidding Design 1-17 Erosion Control on Skid Trails **National Core BMPs** Veg-2 Erosion Prevention and Control Veg-4 Ground-Based Skidding and Yarding Operations **Forest Plan S&Gs** 194 (RCO 4) **Locations**: all ground-based yarding system units.

Management Requirements	BMPs/Forest Plan[1]/Locations
- Use existing skid trails wherever possible except where unacceptable resource damage may result. Existing skid trails <100 feet from streams may be used if they are rehabilitated following use to improve infiltration from their current state. - Skid trails within 100 feet of steams will be given priority for subsoiling. - See Soils report for additional requirements on rehabilitating skid trails	
Suspended Log Yarding - Fully suspend logs to the extent practicable when yarding over RCAs and streams. - Locate skyline corridors to minimize damage to live streamside trees or resprouting streamside burned trees and shrubs. - Install skyline corridor erosion control measures prior to each winter season to ensure runoff will be well dispersed and not concentrated down corridors. Measures may include water bars constructed in alternating directions, smoothing of ruts, and/or logging slash lopped to contract specifications.	**Regional BMPs** 1-11 Suspended Log Yarding in Timber Harvesting 2-13 Erosion Control Plans (roads and other activities) **National Core BMPs** Veg-2 Erosion Prevention and Control Veg-5 Cable and Aerial Yarding Operations **Locations**: all units using skyline yarding systems.
Water Sources - For water drafting on fish-bearing streams: do not exceed 350 gallons per minute for streamflow greater than or equal to 4.0 cubic feet per second (cfs); do not exceed 20% of surface flows below 4.0 cfs; and, cease drafting when bypass surface flow drops below 1.5 cfs. - For water drafting on non-fish-bearing streams: do not exceed 350 gallons per minute for streamflow greater than or equal to 2.0 cfs; do not exceed 50% of surface flow; and, cease drafting when bypass surface flow drops below 10 gallons per minute. Water sources designed for permanent installation, such as piped diversions to off-site storage, are preferred over temporary, short-term-use developments. Locate water drafting sites to avoid adverse effects to in-stream flows and depletion of pool habitat. - Do not allow water drafting from streams by more than one truck at a time. - Do not construct basins at culvert inlets for the purpose of developing a waterhole, as these can exacerbate plugging of the culvert. - Gradually remove temporary dams when operations are complete so that released impoundments do not discharge sediment into the streamflow. - When diverting water from streams, maintain bypass flows that ensure continuous surface flow in downstream reaches, and keep habitat in downstream reaches in good condition. - Locate approaches as close to perpendicular as possible to prevent stream bank excavation. - Treat road approaches and drafting pads to prevent sediment production and delivery to a watercourse or waterhole. Armor road approaches as necessary from the end of the approach nearest a stream for a minimum of 50 feet, or to the nearest drainage structure (e.g., waterbar or rolling dip) or point where road drainage does not drain toward the stream. - Armor areas subject to high floods to prevent erosion and sediment delivery to water courses. - Install effective erosion control devices (e.g., gravel berms or waterbars) where overflow runoff from water trucks or storage tanks may enter the stream, - Check all water-drafting vehicles daily and repair as necessary to prevent leaks of petroleum products from entering RCAs. Water-drafting vehicles shall contain petroleum-absorbent pads, which are placed under vehicles before drafting. Water-drafting vehicles shall contain petroleum spill kits. Dispose of absorbent pads according to the Hazardous Response Plan.	**Regional BMPs** 2-5 Water Source Development and Utilization 2-13 Erosion Control Plans (roads and other activities) **National Core BMPs** WatUses-3 Administrative Water Developments AqEco-2 Operations in Aquatic Ecosystems **Forest Plan S&Gs** 193 (RCO 2) 194 (RCO 4) **Locations**: all water drafting sites.
Rock Borrow Pits/Quarries - Limit the area of disturbance to the minimum necessary for efficient operations. - Rehabilitate and stabilize sites after operations are complete to minimize risk of off-site movement. - Where appropriate, install temporary barriers between the extraction area and surface waters to prevent sedimentation. - Obliterate or decommission temporary access roads unless other treatment is required. - Maintain system roads to quarries or borrow pits.	**Regional BMPs** 2-12 Aggregate Borrow Areas 2-13 Erosion Control Plans (roads and other activities) **National Core BMPs** Min-5 Mineral Materials Resource Sites **Locations**: all borrow pits.
Slope and Soil Moisture Limitations - See Soils report for specific slope limitations for operation of ground-based equipment.	**Regional BMPs** 5-2 Slope Limitations for Mechanical Equipment Operation 5-6 Soil Moisture Limitations for Mechanical

Management Requirements	BMPs/Forest Plan[1]/Locations
- See Soils report for wet weather operating restrictions.	Equipment Operations **National Core BMPs** Veg-2 Erosion Prevention and Control Veg-4 Ground-Based Skidding and Yarding Operations **Locations**: all ground-based equipment units.
Servicing, Refueling, and Cleaning Equipment and Parking/Staging Areas - Allow temporary refueling and servicing only at approved sites located outside of RCAs. - Rehabilitate temporary staging, parking, and refueling/servicing areas immediately following use. - A Spill Prevention and Containment and Counter Measures (SPCC) plan is required where total oil products on site in above-ground storage tanks exceed 1320 gallons or where a single container exceeds 660 gallons. Review and ensure spill plans are up-to-date. - Report spills and initiate appropriate clean-up action in accordance with applicable State and Federal laws, rules and regulations. The Forest hazardous materials coordinator's name and phone number shall be available to Forest Service personnel who administer or manage activities utilizing petroleum-powered equipment. - Remove contaminated soil and other material from NFS lands and dispose of this material in a manner according to controlling regulations. - Install temporary wash sites only in areas where the water and residue can be adequately collected and either filtered on site or conveyed to an appropriate wastewater treatment facility.	**Regional BMPs** 2-10 Parking and Staging Areas 2-11 Equipment Refueling and Servicing **National Core BMPs** Road-9 Parking and Staging Areas Road-10 Equipment Refueling and Servicing Fac-7 Vehicle and Equipment Wash Water **Forest Plan S&Gs** 193 (RCO 1) **Locations**: designated temporary refueling, servicing and cleaning sites and parking/staging areas.
Burn Piles - Place burn piles a minimum of 50 feet away from perennial and intermittent streams and SAFs and 25 feet from ephemeral streams. Locate piles outside areas that may receive runoff from roads. Avoid disturbance to obligate riparian vegetation. - Do not dozer pile in sensitive watershed areas (areas where mastication or drop and lop have been prescribed). Grapple piling is allowed in these areas, but is subject to the mechanized equipment restrictions for RCAs. When grapple piling in sensitive watershed areas, consult a hydrologist or soil scientist if less than 70% ground cover would be retained. - Minimize effects on soil, water quality, and riparian resources by appropriately planning pile size, fuel piece size limits, spacing, and burn prescriptions in compliance with state or local laws and regulations if no practical alternatives for slash disposal in the RCA are available.	**Regional BMPs** 6-2 Consideration of Water Quality in Formulating Fire Prescriptions 6-3 Protection of Water Quality from Prescribed Burning Effects **National Core BMPs** Fire-1 Wildland Fire Management Planning Fire-2 Use of Prescribed Fire **Forest Plan S&Gs** 194 (RCO 4) **Locations**: all pile burning areas, sensitive watershed areas.
Application of Registered Borate Compound - Do not apply fungicide within 10 feet of surface water, when rain is falling, or when rain is likely that day (i.e., National Weather Service forecasts 50% or greater chance). - Follow all State and Federal rules and regulations as they apply to pesticides.	**Regional BMPs** 5-7 Pesticide Use Planning Process 5-8 Pesticide Application According to Label Directions and Applicable Legal Requirements 5-11 Cleaning and Disposal of Pesticide Containers and Equipment 5-12 Streamside Wet Area Protection During Pesticide Spraying **National Core BMPs** Chem-1 Chemical Use Planning Chem-2 Follow Label Directions Chem-3 Chemical Use Near Waterbodies Chem-5 Chemical Handling and Disposal **Forest Plan S&Gs** 193 (RCO 1) **Locations**: portions of units with applications in RCAs.
Water Quality Monitoring - Conduct implementation and effectiveness monitoring using the Best Management Practices Evaluation Program (BMPEP) (USDA 2002) and the National Core Monitoring Protocols (FS-990b) (USDA 2012). - Conduct project-level in-channel monitoring as required in the Water Quality Management Handbook (USDA 2011).	**Regional BMPs** 7-6 Water Quality Monitoring **Locations**: Monitoring locations will be detailed in a project monitoring plan.
Cumulative Watershed Effects (CWE) Analysis - CWE analysis will be conducted for the project.	**Regional BMPs** 7-8 Cumulative Off-Site Watershed Effects **Locations**: All activities within the project

Management Requirements	BMPs/Forest Plan[1]/Locations
	watersheds will be analyzed

[1] Forest Plan S&Gs indicate page number from Forest Plan Direction (USDA 2010).