Soil Resource Assessment
Station Fire
CA-ANF-3622

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EXECUTIVE SUMMARY

The Station Fire burned approximately 161,000 acres in the northeastern extent of Los Angeles Basin and adjoining basins. Vegetation is mostly shrub and chaparral vegetation, with minor inclusions of forested ecotypes. Soils are dominantly coarse textured, shallow, and occur on steep to very steep slopes, rendering them naturally erodible. Geomorphic erosion rates are high, perpetuating shallow coarse soils, especially with pulse erosion following fire as a natural long-term process in this mountain region. Cover is critical for soil stabilization, and is lacking throughout most of the fire area. Assessment found the overall soil burn severity to be 11% unburned/very low, 16% low, 62% moderate, and 11% high. Soils with low burn severity still have good surface structure, contain intact fine roots and organic matter, and should recover in the short-term once revegetation begins and the soil surface regains cover. The moderate to high classes have evidence of severe soil heating in isolated patches; these areas have long-term soil damage and high to very high erosion hazard. The most severely burned slopes occur on steep slopes at higher elevations, and predominantly on north aspects where pre-fire vegetation density and fuels accumulations were higher. Water repellency is present throughout the fire area, including unburned areas, and was only moderately exacerbated in the hotter burn areas.

General land treatments are not proposed, as the great majority of erosion source areas are untreatable (too steep with ravel hillslope process) or were not directly linked to values at risk, making treatments ineffective. Small treatment areas are proposed for point protection and stabilization of particular values at risk. There is no emergency for the soil resource itself, as on-site fire effects are expected to be within norms for this area. However, the overall scale of the fire is much larger than the historic fire regime, and downstream effects of erosion may therefore be considerable. Eroded soil, by gravity or water, provides the materials for damaging debris flows and stream bulking. Unfortunately, given the slope characteristics and active hillslope processes, extremely little in the way of land treatments can be done to moderate hazards, even if funding were unlimited.

1 RESOURCE CONDITION ASSESSMENT

1.1 GEOMORPHIC SETTING

The Station Fire occurred over a wide geographic area with significant variation in topography, vegetation, and climate. The soils therefore encompass a range of physical properties and characteristics. Much of the other background information relative to watershed composition and processes is presented in the geology and hydrology specialist reports, and will not be repeated here.

Process geomorphology is very active. Many large contiguous areas have extensive evidence of hillslope ravel processes and debris flow history, with the ravel providing continuous source material to high order channels for subsequent mobilization with rainfall. These processes increase many fold after fire. Indeed, post-fire pulse erosion and debris flow may be considered the dominant natural process of geomorphic evolution in this mountain region, with little respect for short-term consequences to proximate human habitation and development infrastructure. Some slopes are 'rock-armored' from past erosion, and pose little further erosion risk; however most areas have coarse sandy soils with weak cohesion, making them very erodible and producing high rates of natural erosion. Absence of soil cover will produce significant erosion and sediment delivery to stream systems.

1.2 SOIL INVENTORY

Soil coverage was obtained from the USDA Natural Resources Conservation Service, which incorporates Forest Service soils information and mapping in addition to other ownerships. The fire areas were covered by two separate soil surveys, with 47 soil map units within the fire perimeter. A portion of southeastern LA County within the perimeter was missing spatial data for GIS, but soils are consistent with Trigo, Chilao, and Typic/Lithic Xerorthents as assessed upslope. Soil map units are listed in Appendix A and displayed geographically in Appendix B.

Most soils are shallow to moderately deep, on a full range of slope phases. Textures are dominated by sandy loams and loamy sands, most with gravelly to very gravelly texture modifiers. Parent materials are a mix of metamorphic and granitic rocks. Extent of soil hydrologic groups are 1% A, 10% B, 34% C, and 55% D; this is a useful index reflecting a soil's inherent potential for runoff and erosion (A is best, D is worst). The deeper soils are on gentler slopes, located on toe slopes, alluvial fans, and landslide benches.

Field survey locations were prioritized using the preliminary BARC map (see next section), helicopter reconnaissance, and preliminary assessment of values at risk. Field surveys were conducted in part to verify soil map units, but also to assess other factors affecting soil hydrologic function, productivity, erosion potential, and fire effects. Such factors include vegetative burn intensity, aspect, slope gradient, slope length and profile, soil cover, duff consumption, soil heating and char, soil structure, aggregate stability, texture, porosity, organic matter, fine root condition, and water repellency. Soil map units were combined with field data and site-specific observations to generate interpretations of fire effects upon known (visited) soils, and extrapolate interpretations for unvisited areas. Subsequent erosion hazard ratings and sediment production estimates were based in part upon soil survey information.

1.3 Soil Burn Severity

Rapid assessment and mapping of soil burn severity is necessary to identify and prioritize potential source areas of flooding and erosion, and areas where critical ecosystem values may be degraded as a result of the fire. The preliminary soil burn severity map, referred to as the Burned Area Reflectance Classification or 'BARC' map, was created using satellite imagery by the USFS Remote Sensing Applications Center in Salt Lake City, Utah. Systematic and locational editing was necessary to finalize the BARC into the soil burn severity map reflecting field assessed conditions. Generalized criteria used to make field determinations of soil burn severity are included in Appendix B.

It must be emphasized that this is a rapid assessment process – the map product is not intended or expected to be 100% accurate, but it is field validated and modified for accuracy to the extent possible given the size and complexity of the fire and time allowed. The map should be 90+% accurate. This map is evaluated in combination with other site factors such as soil type, slope, hydrologic characteristics, and biological or human resource values to determine if emergency conditions exist.

The magnitude and longevity of fire effects may be generally inferred from the soil burn severity rating. A low rating indicates short-term soil effects; these areas are generally not considered significant sediment source areas, and do not constitute a potential fire-caused emergency. A high rating indicates rather severe and long-term effects, and moderate is intermediate.

The overall soil burn severity in the Station Fire is 11% unburned/very low, 16% low, 62% moderate, and 11% high. Soils with low burn severity still have good surface structure, contain intact fine roots and organic matter, and should recover in the short-term once revegetation begins and the soil surface regains cover. The moderate to high classes have evidence of severe soil heating in isolated patches; these areas have surficial char with partial destruction of structure, porosity, and roots. The most severely burned slopes occur on steep slopes at higher elevations, and mostly on north aspects where pre-fire vegetation density and fuels accumulations were higher. Soil burn severity acres by watershed are listed in Table 1 and displayed geographically in Appendix C.

1.4 Soil Water Repellency

Water repellent or 'hydrophobic' soils are present throughout the fire area, including unburned areas, and were only moderately exacerbated in the hotter burn areas. Repellency in unburned areas is primarily due to root and fungal exudates, particularly apparent when soils are very dry. Fire-induced repellency is caused by organic matter being vaporized and subsequently long-chain organic molecules are condensed onto soil particles when the vapor cools. Factors influencing extent and degree of hydrophobic soils include: soil texture, rock content, soil moisture, organic matter (amount and type), and soil heating (both peak temperature and residence time).

Very extreme or extended soil heating can actually eliminate water repellency caused at lower temperatures, by completely volatilizing or consuming the organic compounds in the soil. Fire-induced water repellency has the potential to significantly reduce water infiltration and increase runoff and erosion.

Hydrophobic soils are estimated to occupy about 80% of the fire area, and within those areas has about 50% continuity, equaling about 40% of the total area. This fire-increased repellency is confined to moderate and high soil burn severity areas. Baseline repellency is generally low to moderate severity, occurring in the surface ½ to 2 inches; increased repellency is moderate to strong in the surface 1 to 4 inches. Field data is provided in Appendix E.

Table 1. Soil Burn Severity within Watershed Units (HUC6), by acres and percent

SOIL BURN SEVERITY (ACRES)				
WATERSHED	UNBURNED/VERY LOW	LOW	MODERATE	HIGH
LOS ANGELES RIVER				
Pacoima Wash	681	1,706	9,531	1,430
Lower Big Tujunga	2,087	3,888	19,193	1,018
Middle Big Tujunga	1,285	1,832	19,198	2,956
Upper Big Tujunga	3,866	3,001	11,040	3,606
Verdugo Wash	224	695	1,696	242
Arroyo Seco	1,201	2,435	9,367	1,574
Eaton Wash	134	58	392	146
SAN GABRIEL RIVER				
Upper West Fork San Gabriel	4,361	5,182	10,961	2,112
Middle West Fork San Gabriel	143	232	226	3
ANTELOPE/FREMONT VALLEYS				
Little Rock Reservoir	1,210	1,473	3,859	406
Little Rock Creek	1,195	1,575	826	31
SANTA CLARA RIVER				
Aliso Canyon	723	2,246	6,817	2,087
Soledad Canyon-Arrastre Canyon	624	539	4,058	808
Lower Soledad Canyon	465	556	3,474	517
TOTALS	**18,198**	**24,417**	**100,637**	**16,936**

SOIL BURN SEVERITY (PERCENT)				
WATERSHED	UNBURNED/VERY LOW	LOW	MODERATE	HIGH
LOS ANGELES RIVER				
Pacoima Wash	5%	13%	71%	11%
Lower Big Tujunga	8%	15%	73%	4%
Middle Big Tujunga	5%	7%	76%	12%
Upper Big Tujunga	18%	14%	51%	17%
Verdugo Wash	8%	24%	60%	8%
Arroyo Seco	8%	17%	64%	11%
Eaton Wash	18%	8%	54%	20%
SAN GABRIEL RIVER				
Upper West Fork San Gabriel	19%	23%	49%	9%
Middle West Fork San Gabriel	24%	38%	38%	0%
ANTELOPE/FREMONT VALLEYS				
Little Rock Reservoir	17%	21%	56%	6%
Little Rock Creek	33%	43%	23%	1%
SANTA CLARA RIVER				
Aliso Canyon	6%	19%	57%	18%
Soledad Canyon-Arrastre Canyon	10%	9%	68%	13%
Lower Soledad Canyon	9%	11%	70%	10%
TOTALS	**11%**	**15%**	**63%**	**11%**

1.5 SOIL EROSION HAZARD RATING

In order to assess the potential risk of soils to erode, an erosion hazard rating (EHR) was developed (R-5 FSH 2505.22). The EHR system was designed to assess the relative risk of accelerated sheet and rill erosion with land use activities, but may also be used as a comparative rating for soil burn severity effects. Many interrelated factors are evaluated in the EHR system, including soil texture, depth, infiltration and permeability, surface cover (vegetation and surface rocks), slope gradient, and climate. Risk ratings vary from low to very high. These ratings assume varying amounts of vegetation cover depending on degree of vegetative management, or similarly vegetative presence after fire.

EHR ratings were calculated for each soil map unit, with soil burn severity characteristics also factored in. Ratings thus represent a summary of inherent soil erodibility, slope gradient, soil cover, and reduced infiltration due to water repellency; field observations, soil survey data, and GIS analyses are equally relied upon to develop ratings. Summary ratings within watersheds are presented in Table 2 and presented geographically in Appendix B. Summary EHR rating for the entire fire area is 8% low, 20% moderate, 20% high, and 52% very high.

Table 2. Erosion Hazard Rating – Acres by Watershed Unit

EROSION HAZARD RATING (ACRES)				
WATERSHED	LOW	MODERATE	HIGH	VERY HIGH
LOS ANGELES RIVER				
Pacoima Wash	39	497	1,263	11,549
Lower Big Tujunga Canyon	1,425	14,687	4,282	5,711
Middle Big Tujunga Canyon	231	2,190	3,423	19,338
Upper Big Tujunga Canyon	176	2,840	8,017	10,479
Verdugo Wash	79	846	516	665
Arroyo Seco	776	2,866	4,711	5,097
Eaton Wash	170	53	161	346
SAN GABRIEL RIVER				
Upper West Fork San Gabriel River	2,467	6,458	5,171	8,461
Middle West Fork San Gabriel River	107	236	121	141
ANTELOPE/FREMONT VALLEYS				
Little Rock Reservoir	--	91	1,148	5,709
Little Rock Creek	--	165	1,185	2,276
SANTA CLARA RIVER				
Aliso Canyon	331	646	446	10,449
Soledad Canyon-Arrastre Canyon	3,695	394	585	1,354
Lower Soledad Canyon	3,563	106	132	1,211
TOTALS	**13,059**	**32,075**	**31,161**	**82,786**

EROSION HAZARD RATING (PERCENT)				
WATERSHED	LOW	MODERATE	HIGH	VERY HIGH
LOS ANGELES RIVER				
Pacoima Wash	0%	4%	9%	87%
Lower Big Tujunga Canyon	5%	56%	17%	22%
Middle Big Tujunga Canyon	1%	9%	13%	77%
Upper Big Tujunga Canyon	1%	13%	37%	49%
Verdugo Wash	4%	40%	24%	32%
Arroyo Seco	6%	21%	35%	38%
Eaton Wash	23%	7%	23%	47%

SAN GABRIEL RIVER				
Upper West Fork San Gabriel River	11%	29%	22%	38%
Middle West Fork San Gabriel River	18%	39%	20%	23%
ANTELOPE/FREMONT VALLEYS				
Little Rock Reservoir	--	1%	17%	82%
Little Rock Creek	--	5%	33%	62%
SANTA CLARA RIVER				
Aliso Canyon	3%	5%	4%	88%
Soledad Canyon-Arrastre Canyon	61%	7%	10%	22%
Lower Soledad Canyon	71%	2%	3%	24%
TOTALS	**8%**	**20%**	**20%**	**52%**

1.6 ESTIMATED EROSION RESPONSE

Approximately 160,557 acres are within the fire perimeter (with some non-soil portions removed, such as reservoirs), with 142,990 acres or 89% burned. Effects of soil burn severity will cause accelerated runoff and erosion throughout the fire areas, as well as the occurrence of shallow landslides and debris flows. Water repellency observed in these fire areas is significant, but should not be overemphasized when considering the degree of repellency in unburned areas as well. Hydrologic soil groups (a soil survey rating) are a useful indicator of potential for generation of runoff and concurrent erosion.

Quantitative erosion figures are estimated using ERMiT (Erosion Risk Management Tool), a WEPP-based modeling application by USFS Rocky Mountain Research Station (USFS, RMRS-GTR-188, April 2007) specifically developed for use with post-fire erosion modeling. The model estimates only sheet and rill erosion, which occurs when rainfall exceeds infiltration rates, and surface runoff entrains surface soil particles. The model does not account for shallow landsliding or gullying, road effects, or most notably hillslope ravel. Ravel is rather extreme in these mountains and will contribute significant additions to the following erosion estimates; the hydrologist's modeling method should better account for ravel processes in this setting and the totality of sediment delivery to streams, while ERMiT should better model sheet and rill erosion for assessing on-site soil impacts.

The ERMiT model was used with customized climate parameters to refine erosion estimates, modeling 2 separate zones – high elevation (>5000 ft) where a majority of precipitation falls as snow, and lower elevations where rain dominates. It is known and acknowledged that the northern flank of the fire is a drier rain-shadow climate, which was not modeled separately, so erosion there may be somewhat overestimated. Though not ideal, this was necessary to simplify calculations and extrapolations.

All watersheds having portions within the fire area were included in the analysis. ERMiT estimates were generated for each soil map unit and burn severity (Appendix C), and apportioned to watersheds on a per-acre basis. Model output is in tons per acre on a storm event basis, so these are *not* over-winter or annual estimates. Accuracy of model output is estimated to be +/- 50%.

Erosion outcomes will depend upon what the winter brings in terms of rainfall amount and intensity. Erosion rates are therefore estimated for a range of storm events that may be expected – an average 2-year event, an above average 10 year event, and a 25 year event representing a larger El Nino event, which this winter could very possibly bring according to National Weather Service forecasts. A summary of first-year erosion estimates is presented in Table 4. Erosion rates would afterward decline year by year as revegetation and natural recovery proceeds. Erosional loss of topsoil will reduce soil productivity and prolong vegetation recovery, to a degree depending upon the degree of soil loss.

Table 4. Hillslope Sediment Production – Given a Range of Storm Events

ERMiT Estimated Potential Hillslope Erosion Rates (Tons/Acre)

Watersheds	Burned Acres	Percentage of Watershed Burned	2 Year Storm			10 Year Storm			25 Year Storm		
			2 year Background	2 year	Percent of Background	10 year Background	10 year	Percent of Background	25 year Background	25 year	Percent of Background
Los Angeles River											
Pacoima Wash	12,667	95%	2.0	9.2	473%	7.8	31.1	399%	15.3	58.1	379%
Lower Big Tujunga Canyon	24,099	92%	2.5	11.8	463%	10.3	38.6	375%	17.7	64.1	361%
Middle Big Tujunga Canyon	23,986	95%	2.2	11.3	522%	7.8	38.0	489%	13.0	57.2	441%
Upper Big Tujunga Canyon	17,647	84%	2.2	11.1	495%	10.6	40.0	378%	15.5	63.6	411%
Verdugo Wash	2,633	92%	2.4	11.5	490%	11.8	40.9	347%	17.6	69.6	396%
Arroyo Seco	13,376	99%	2.8	12.4	443%	10.8	40.4	374%	19.9	67.9	342%
Eaton Wash	596	82%	2.9	13.4	466%	11.4	42.5	373%	19.3	67.8	352%
San Gabriel River											
Upper West Fork San Gabriel River	18,255	81%	2.4	11.2	466%	14.2	40.2	283%	19.3	66.3	344%
Middle West Fork San Gabriel River	461	87%	3.5	13.7	390%	15.3	35.4	232%	28.7	75.9	264%
Antelope/Fremont Valley											
Little Rock Reservoir	5,738	83%	1.9	8.6	461%	7.7	33.7	435%	13.7	58.5	426%
Little Rock Creek	2,432	74%	2.1	8.5	406%	14.6	36.4	249%	13.8	59.3	429%
Santa Clara River											
Aliso Canyon	11,150	95%	0.9	5.1	558%	4.1	25.5	621%	7.7	43.8	571%
Soledad Canyon-Arrastre Canyon	5,405	90%	1.1	5.9	528%	4.2	22.0	527%	8.9	38.1	429%
Lower Soledad Canyon	4,547	91%	1.5	7.7	526%	5.6	27.1	485%	12.0	48.5	404%
Totals	**142,990**	**89%**	**2.1**	**10.1**	**474%**	**9.6**	**35.5**	**371%**	**15.6**	**59.5**	**382%**

Hillslope Sediment Production (tons)

Watersheds	Burned Acres	Percentage of Watershed Burned	2 year Storm	10 year Storm	25 year Storm
Pacoima Wash	12,667	95%	117,031	394,389	735,765
Lower Big Tujunga Canyon	24,099	92%	283,356	929,086	1,543,796
Middle Big Tujunga Canyon	23,986	95%	270,808	911,468	1,371,810
Upper Big Tujunga Canyon	17,647	84%	195,855	705,056	1,121,946
Verdugo Wash	2,633	92%	30,305	107,591	183,230
Arroyo Seco	13,376	99%	165,412	540,725	907,607
Eaton Wash	596	82%	7,974	25,329	40,404
Upper West Fork San Gabriel River	18,255	81%	204,856	733,888	1,209,649
Middle West Fork San Gabriel River	461	87%	6,298	16,313	35,011
Little Rock Reservoir	5,738	83%	49,381	193,307	335,941
Little Rock Creek	2,432	74%	20,615	88,444	144,096
Aliso Canyon	11,150	95%	57,167	284,276	488,846
Soledad Canyon-Arrastre Canyon	5,405	90%	31,939	118,854	205,946
Lower Soledad Canyon	4,547	91%	34,881	123,207	220,351
Totals	**142,990**	**89%**	**1,434,587**	**5,042,383**	**8,445,133**

These estimates include 'background' erosion rates for unburned portions of the fires. Soil burn severity is accounted for throughout these modeled estimates; other erosional processes as mentioned above are not. The average post-burn erosion rates are expected to increase roughly four-fold for the burned areas, varying by watershed. When extrapolated to absolute sediment output, the numbers are striking. To put them in perspective, the 5 million tons generated by a single 10 year event would occupy dumptrucks parked bumper to bumper from Burbank to Detroit, Michigan.

2 EMERGENCY DETERMINATION

2.1 VALUES AT RISK – THREATS TO SOIL PRODUCTIVITY AND HYDROLOGIC FUNCTION

Threats to soil productivity and hydrologic function throughout the fire were assessed by evaluating soil burn severity, erosion hazard, erosion modeling, and other soil and site specific conditions. The combination of shallow and sandy soils, steep slopes, and lack of soil cover will create a considerable watershed response in the form of accelerated ravel and erosion, the degree depending upon geographic fire effects, the severity of the coming winters over the next 1-4 years, and rates of natural vegetative recovery.

On-site fire effects include the physical, chemical, and biological changes caused directly by soil heating, topsoil loss caused by soil cover removal, and consequences to soil productivity and hydrologic function. Some damage to soil nutrient status and microbial communities may be expected, increasing by soil burn severity class. This may pose a hazard in the form of declined soil fertility and ecosystem productivity in the short-term. However, soils are characterized as low site quality before the fires, and most soils experienced low to moderate burn severity. Therefore, effects of the fire upon soil productivity and hydrologic function are considered within the 'normal' range of variability. Soil productivity in and of itself was not identified as a value at risk, as there are no rare plants or vegetation communities present in the fire area that would raise the level of concern with on-site soil productivity to a value at risk for ecosystem stability.

That stated, the large scale of the fire is not normal, and off-site effects of hillslope sediment export will be of considerable magnitude. Off-site effects of soil erosion are downstream; sediment-laden runoff and stream water has much greater erosive power than clean water in the stream system. Eroded soil, by ravel or water, will provide the materials for damaging debris flows and stream bulking, which represent widespread hazards throughout most of this fire area. This constitutes potential adverse effects to facilities (roads, buildings, reservoirs), water quality deterioration for sensitive aquatics species and human use, and risk to human life and property from potential flooding, mudslides, and debris flows. Risks to these resources are discussed in other team members' specialist reports.

Unfortunately, given the slope characteristics and active hillslope processes, extremely little in the way of land treatments can be done to moderate soil erosion and debris flow initiation, even if funding were unlimited. Therefore an emergency determination is somewhat a semantic exercise when nothing can be done in the way of treatments. The summary determination is NO emergency to the soil resource, because of the high rates of natural background erosion and geomorphic processes taking place that are normal in the long-term. If fuels buildup and fire effects had been abnormally high, that may constitute a different determination. Fire-induced vegetative type conversion could represent a threat to the soil resource, if changes to normal levels of soil cover and root-soil interactions were a consequence of habitation by different species; these issues however are outside the scope and time scale of BAER analyses.

3 TREATMENTS TO MITIGATE THE EMERGENCY

3.1 No Treatment Proposal

Without an emergency determination, no treatments are proposed for the primary objective of soil stabilization without other collateral 'point' values at risk. That said, discussion here is warranted regarding land treatments, or more properly the lack of treatments.

The BAER Program requires that proposed treatments must be proven effective, technically feasible, justified by the values at risk, of a magnitude to make a meaningful difference to the resources, and natural recovery deemed inadequate. Proposed treatments are considered the minimum necessary response to significantly reduce the threat to the values at risk.

In this fire are several locations having serious long-term soil damage – the high soil burn severity class and some of the moderate areas – coupled with high+ erosion hazard ratings and downstream values at risk of a very serious nature (life and homes, valuable road, reservoir, and energy infrastructure). The stakes are high given the scale of the fire. Many of these locations where treatments would be desirable were either on very steep slopes (slopes >50% are considered 'untreatable' with land treatments), not in connected proximity to values at risk (no emergency justification), or had a high proportion of untreatable ground such that treatment efforts would not be meaningful or effective. No locations were identified as having emergency threats to values at risk with feasible hillslope treatment opportunities beyond point protection.

3.2 Hillslope Morphology and Process

Steep denuded hillslopes respond to water in a rather predictable nature. Water comes down from the top, gaining energy and momentum as it collects in concave headwall basins and high gradient channels, until it develops sufficient erosive energy to mobilize soil particles. Sediment-laden water then dramatically increases its erosive power, and an ever increasing 'snowball effect' takes place. These flows will mobilize more sediment, initiate debris flows, and have the power to overtop or redirect stream channels until low gradient stream segments are reached to dissipate momentum and settle sediments. Any homes, roads, and infrastructure caught in the middle may experience severe damage or complete destruction.

Hillslopes in the fire area are almost exclusively extremely steep in the headwall basins, with long linear steep slopes collecting in canyons, and leading down to bottom slopes with relic alluvial fans where flow could disperse and sediments deposit; this is a very normal and repeated landscape pattern in this region. In the last century, very many of these alluvial fans have been incised by the streams and homes built upon them as convenient and accessible habitation sites. However, any large flow events with the potential to escape incised channels on these fans have the potential to put homes upon them and their inhabitants at great risk.

Several flow events in the last century have put homes in such locations at risk and caused fatalities, notably in unburned watershed condition. Burned watersheds will produce dramatically higher response to similar rainfall events. Many homes were lost to the fire emergency; many of the surviving homes built upon alluvial fans and floodplains are at risk to flooding, mudslides, and debris flows with the coming emergency of prolonged or intense rain events.

3.3 Treatment Limitations

Land treatments in the form of hillslope 'mulch' treatments are proven effective at mitigating sheet erosion and rill erosion processes on slopes less than 50% gradient; they are proven ineffective on steeper slopes and slopes dominated by ravel and debris flow processes, as present in this fire area. The forces moving the soil overwhelm the treatment, and the mulch just moves downslope with the soil. Conversely, treating low gradient slopes less than 20-25% is inadvisable, as they are usually not active erosion surfaces or source areas of significant sediment volume, so widespread or costly treatments are not warranted.

It is further proven that treating upper slopes is more effective than treating lower slopes. Mulch treatments on upper slopes interrupt water momentum and dissipate energy before it becomes erosive, effectively shortening slope length, increasing infiltration, and preventing the 'snowball effect' from beginning. Treatments on lower slope position are inundated and overwhelmed by already energized water flows, making them ineffective.

The values at risk in this area are generally built at the base of such slopes, with adverse slope gradients above, meaning the connected source areas are untreatable. These hillslopes are also dominated by ravel and debris flow processes, which treatments are ineffective at mitigating. Therefore, potential treatments are considered absolutely ineffective to protect values at risk, regardless of funding available or significance of values at risk. The best treatment is to insure that people are not in the path of the next emergency, which is greatest in the next 1-2 winters, but will persist until natural vegetation recovery restores soil cover and landscape scale water use.

4 RECOMMENDATIONS

4.1 POINT PROTECTION AND STABILIZATION

While not land treatments for the soil resource, some particular values at risk have proposed treatments in consultation with the soil science team with objectives of soil stabilization for other resource protection needs. These values at risk and treatments are described in the other pertinent specialist reports.

4.2 FIRELINES

The network of constructed firelines created on the fire was a necessary part of fire suppression operations. Suppression repair is underway that provides for constructing waterbars to limit sediment movement downslope. However, suppression repair typically has quite variable outcomes. The firelines are prone to both surface erosion and gullying, and require approximately 10-15 years to naturally re-vegetate, as observed on other older fires in the vicinity. These firelines may be chronic sources of sediment production, for a longer time period than general burned hillslopes.

It is recommended that firelines be further evaluated in 2010 for additional repair work and/or longer term rehabilitation needs. Erosion control structures should be maintained as best management practices for reducing cumulative watershed effects.

5.0 REFERENCES

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Appendix A – Soil Map Units

Map Unit Name	Acres
Rock outcrop-Chilao family-Haploxerolls, warm association, 15 to 120 percent slopes	22,469
Pismo-Chilao-Shortcut families complex, 45 to 80 percent slopes	21,934
Caperton-Trigo, granitic substratum-Lodo families complex, 50 to 85 percent slopes	12,354
Pismo-Trigo, dry-Exchequer, dry families complex, 30 to 70 percent slopes	9,463
Pacifico family-Xerothents complex, 50 to 90 percent slopes	8,030
Chilao family, 20 to 60 percent slopes	7,313
Pismo family-Rock outcrop complex, 50 to 80 percent slopes	6,944
Stukel-Sur-Winthrop families complex, 60 to 100 percent slopes	6,917
Tollhouse-Stukel-Wrentham families complex, 60 to 90 percent slopes	6,373
Typic Xerorthents, warm, 55 to 90 percent slopes	5,711
Trigo, granitic substratum-Green Bluff-Supan families association, 15 to 60 percent slopes	5,360
Chilao-Trigo, granitic substratum-Lodo families complex, 55 to 85 percent slopes	5,184
Waterman-Springdale-Pacifico families complex, 30 to 70 percent slopes	5,153
Shortcut family, dry-Lithic Xerorthents, warm-Rock outcrop complex, 50 to 85 percent slopes	4,090
Tollhouse-Knutsen-Stukel families complex, 30 to 70 percent slopes	3,831
Trigo, granitic substratum-Modjeska families association, 5 to 60 percent slopes	3,137
Olete-Kilburn-Etsel families complex, 50 to 80 percent slopes	3,072
Rock outcrop-Lithic Xerorthents-Rubble land association, 60 to 120 percent slopes	3,024
Green Bluff-Hohmann families-Xerorthents complex, 15 to 60 percent slopes	2,996
Xerorthents-Green Bluff family-Rock outcrop complex, 15 to 50 percent slopes	2,834
Pacifico-Preston families complex, 15 to 50 percent slopes	2,797
Modesto, moderately deep-Trigo families complex, 25 to 75 percent slopes	1,247
Trigo family, granitic substratum, 60 to 90 percent slopes	1,088
Haploxerols, shallow-Lithic Xerorthents, warm complex, 45 to 75 percent slopes	1,048
Trigo-Modesto-San Andreas families association, 15 to 70 percent slopes	778
Hanford family, 3 to 25 percent slopes	715
Trigo, granitic substratum-Exchequer families-Rock outcrop complex, 60 to 100 percent slopes	596
Stukel-Olete families association, 50 to 100 percent slopes	583
Winthrop family, very stony-Lithic Xerorthents-Rock outcrop association, 15 to 70 percent slopes	550
Riverwash	467
Typic Haploxeralfs, 3 to 50 percent slopes	466
Mollic Haploxeralfs, 2 to 50 percent slopes	310
Trigo family-Calcixerollic Xerochrepts-Vista family complex, 30 to 70 percent slopes	307
Vista family, 5 to 30 percent slopes	270
Vista-Trigo, granitic substratum-Modesto families complex, 40 to 70 percent slopes	251
Stonyford-Millsholm families complex, 30 to 70 percent slopes	244
Amargosa rocky coarse sandy loam, 9 to 55 percent slopes, eroded	228
Vista coarse sandy loam, 30 to 50 percent slopes, eroded	171
Ramona gravelly sandy loam, 2 to 9 percent slopes	136
Tujunga-Capistrano families association, 2 to 20 percent slopes	112
Hanford coarse sandy loam, 2 to 9 percent slopes	108
Terrace escarpments	100
Haploxerolls, shallow-Trigo family, dry-Haploxeralfs complex, 90 percent slopes	98
Trigo family, dry-Lithic Xerorthents, warm complex, 50 to 80 percent slopes	76
Hanford coarse sandy loam, 9 to 15 percent slopes	43
Vista coarse sandy loam, 15 to 30 percent slopes, eroded	17
Greenfield sandy loam, 9 to 15 percent slopes, eroded	4

Appendix B – Soil Burn Severity Primer

Soil burn severity is NOT vegetative burn severity or mortality. Soil burn severity goes beyond above-ground vegetation impacts to below-ground soil impacts; vegetative burn severity or mortality is but one component taken into consideration. It is important to appreciate the differences between *fire intensity* or *burn severity* as discussed by fire behavior, fuels, or vegetation specialists, and *soil burn severity* as defined for watershed evaluation in BAER analyses. Fire intensity or burn severity as defined by fire, fuels, or vegetation specialists may consider such parameters as flame height, rate of spread, fuel loading, thermal potential, canopy consumption, tree mortality, etc. For BAER analysis, mapping is not simply above-ground effects of the fire, which is why it is essential to validate and modify satellite BARC imagery.

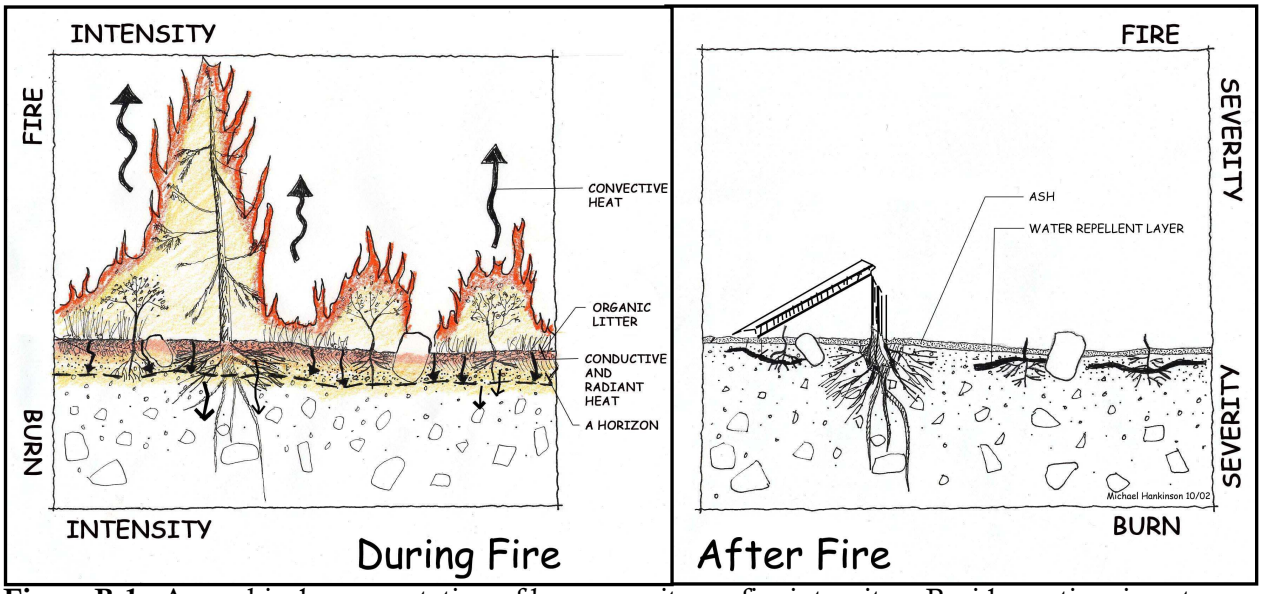


Figure B-1: A graphical representation of burn severity vs. fire intensity. Residence time is not represented in the drawing but is a key factor in resulting severity (Effects of Fire-GTR WO-7).

Soil burn severity as defined for BAER rapid assessment purposes is partially related to above-ground factors, but also considers additional surface and below-ground factors that relate to soil hydrologic function, runoff and erosion potential, and vegetative recovery. Such additional factors include amount and condition of residual ground cover, viability of native seed banks, condition of residual fine roots, degree of fire-induced water-repellency, soil physical factors (texture, structural stability, porosity, restricted drainage), soil chemical factors (oxidation, altered nutrient status), and topography (slope gradient, length, and profile). While above-ground burn severity is more related to peak temperatures during the fire, below-ground soil burn severity is strongly related to the length of time the heat is in contact with and permeates the soil (residence time).

Understanding these differences is crucial to meeting the objectives of BAER analysis. A high intensity fire (high flame lengths, rapid rate of spread, crown fire, etc) in a stand-replacement scenario can result in a low or moderate soil burn severity, if the residence time is short and soil characteristics are not altered significantly. Soil burn severity, used in this context, is a much better index of soil damage, watershed response, and vegetative recovery after the fire.

FSH 2509.23.31,32 contains guidelines discussing site indicators to use in determining these classes. The Interagency BAER/ESR Handbook also contains some definition guidelines. These are only guidelines, and each fire/ecosystem situation can be different. Familiarity must be developed with the specific ecosystems of the burned area, and key characteristics indicating the level of soil burn severity.

Soil Burn Severity Criteria generally follows Parsons (2002):

UNBURNED/VERY LOW: The polygon has not been burned, or is lightly burned at a scale that can not practically be mapped.

LOW: The majority of the polygon has not been significantly altered by the fire. Significant amount of remaining intact or singed leaf litter and duff remain, ash is sparse, small unburned fuels remain, canopy is largely intact, grass and shrub root crowns are intact. Areas where pre-fire vegetation was sparse, and/or bare soil and rock fragments dominate should be classified as Low severity, since there was little fuel to burn to begin with. Low severity burn areas do not contribute to an emergency watershed condition, but they may act as buffer areas to mitigate flood hazards that originate on more severely burned areas. Overstory mortality is generally minimal but can be significant in some cases.

MODERATE: This class is the most difficult to define, but think of it as intermediate between LOW and HIGH. Its specific characteristics may vary depending on the ecosystem types involved in the fire area. Less than 40 percent of the area exhibits high severity characteristics. During triage, areas of MODERATE severity are not as likely to be prime candidates for emergency stabilization treatments, but a rating of moderate alerts the team to the possibility that the area may be a potential flood source area. The site is somewhat altered by fire. Over-story mortality may be moderate to high, where brown needles remain but trees are dead.

In forested areas, generally litter is consumed and duff deeply charred or consumed, but recognizable char and some unburned remnants of leaf or needle litter and duff may remain. Ash and char are present. Soil characteristics are not significantly visibly altered. Fine and very fine roots and soil structural aggregates are still intact in the soil surface. On shrub or grassland sites, canopy is consumed and ash may replace the usually sparse pre-fire leaf litter. Evidence of unburned litter is found under a thin ash or char layer. Shrub skeletons remain but leaves and fine twigs are consumed. Water repellency may be observed in places, but other factors such as remaining ground cover or needle cast potential, or rapidly re-sprouting vegetation will help to mitigate runoff to some extent. Generally, runoff response is significantly accelerated as a result of the fire for the first year only on moderate severity shrub sites. Runoff in subsequent years is mitigated by vegetation recovery.

A situation that often causes confusion in burn severity mapping is an area where you may find forested areas where duff and litter have mostly been consumed, but small fuels and needles remain in the canopy. Even though these needles may be brown and dead, they will quickly fall and create a natural mulch, or ground cover. This natural mulch will act to moderate soil surface temperature and moisture, add native organic matter, and protect the soil from raindrop splash and runoff. Replenishing ground cover is the least expensive and single most effective treatment we can implement on a burned area, and during triage for treatment recommendations, these areas with natural mulch potential are not likely to be high priority for treatment. It will usually be classified as "Moderate", especially if you can identify intact soil structure or fine roots, and at least some remnants of charred duff and litter.

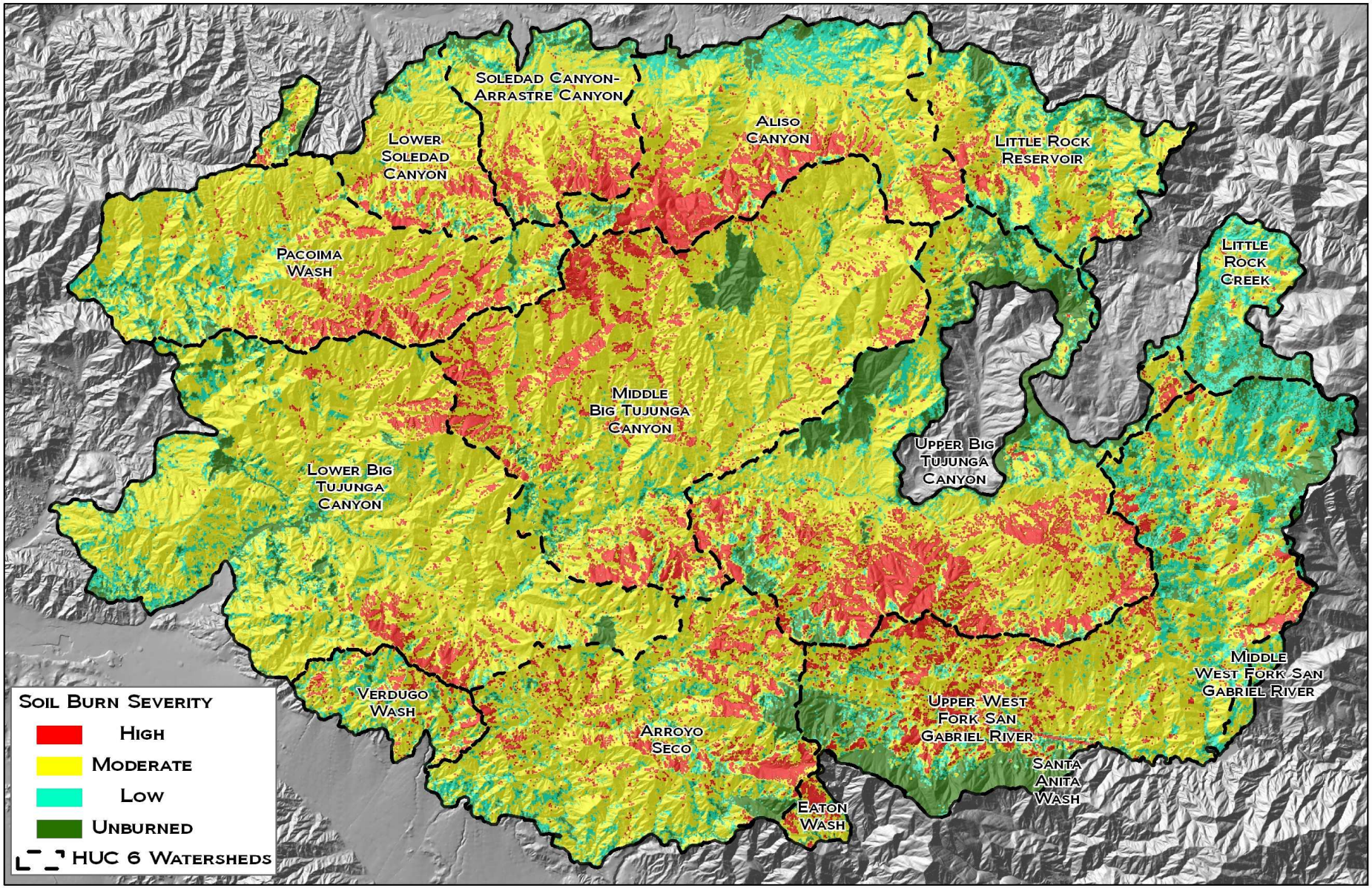
HIGH: The site has been significantly affected by the fire. In general, areas where pre-fire vegetation, ladder fuels, and litter layers are thick, heat residence time is often long. More than 40 percent of the area exhibits characteristics of high severity. The area is classified as high burn severity if duff and litter layers have been completely consumed to ash such that little or no effective ground cover remains, surface soil is often loose, single grained with little sign of intact structure or fine roots. (It is important to compare to unburned areas, since sometimes this is the natural condition.) Soil structure is often destroyed, and fine roots in surface soil have been consumed. Surface soil which, prior to the fire, may have had stable granular structure can, after a high severity burn, be loose and single grained, due to volatilization of roots and binding organic compounds. Water repellency may or may not be significant, but is often increased after a high severity burn. (Water repellency alone is not

necessarily an indicator of high severity, nor is it required for a classification of HIGH severity.) Use multiple indicators rather than just one or two. The size of fuels remaining is generally large - all fine fuels have been consumed. In other words, the only stuff remaining is big stuff. The soil hydrologic function has been significantly altered. Little or no ground cover or litter remains, and trees are black sticks with no needlecast/mulch potential. Runoff and erosion will be significant. Canopy and small to medium or even large fuels are usually consumed. Natural recovery of vegetation may be inhibited. Over-story mortality is generally high, up to 100%.

The appearance and characteristics of high severity may vary from ecosystem to ecosystem, thus it is difficult to give a precise definition. Sometimes ash color can indicate heat of consumption; white ash may indicate more complete consumption, but some vegetation species tend to produce white ash as well, so ash color by itself is not a reliable indicator. Plenty of areas with black or gray ash are high severity. Grass or shrub root crowns may have been consumed and natural re-sprouting and revegetation may be inhibited.

Appendix C – Maps

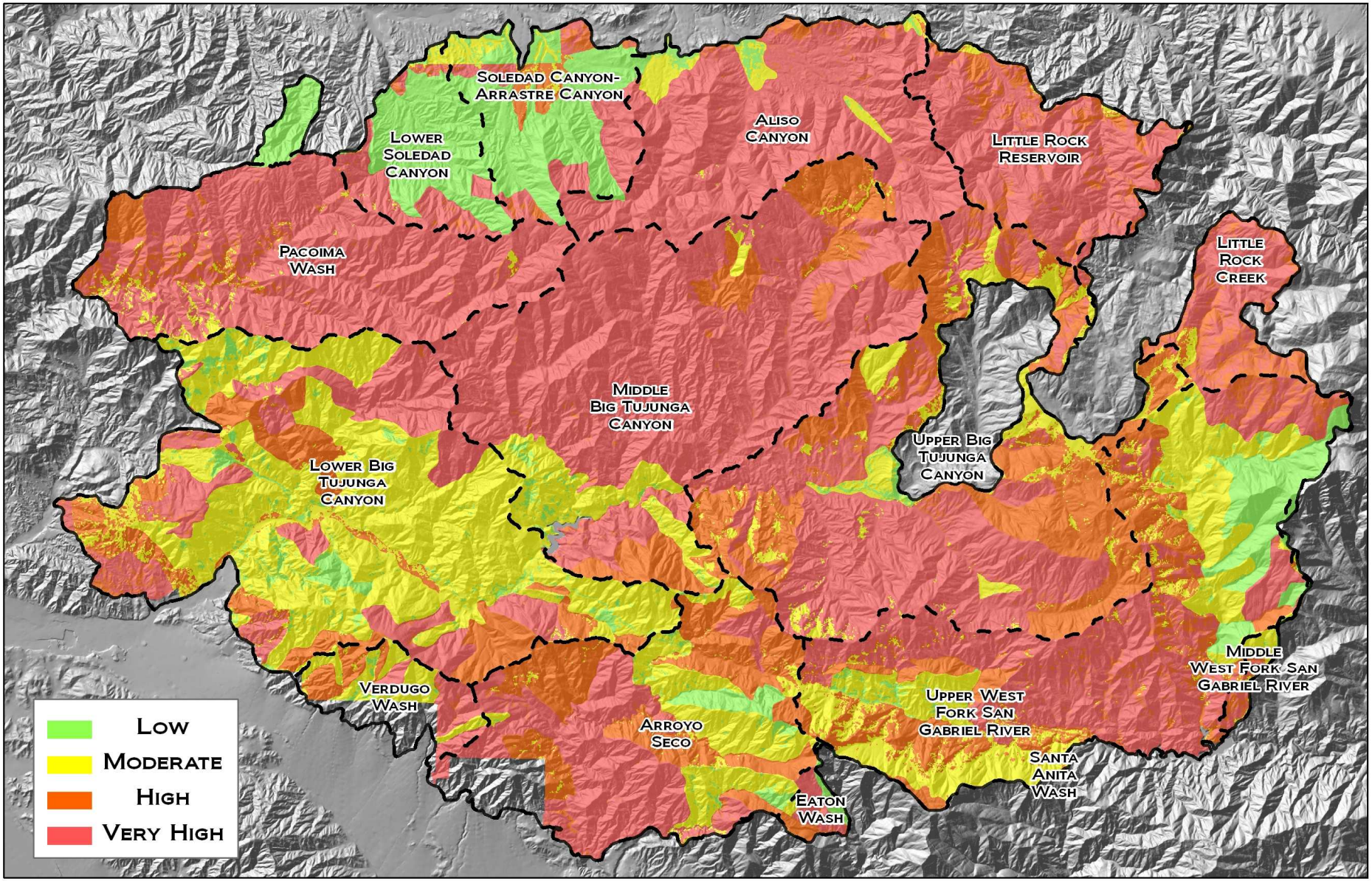
Map C-1 Soil Burn Severity Map
Map C-2 Erosion Hazard Rating Map
Map C-3 Soil Map Units and Hydrologic Group Map



1:150,000
1 inch equals 2 miles
Miles
0 0.5 1 2 3 4

STATION FIRE
Soil Burn Severity

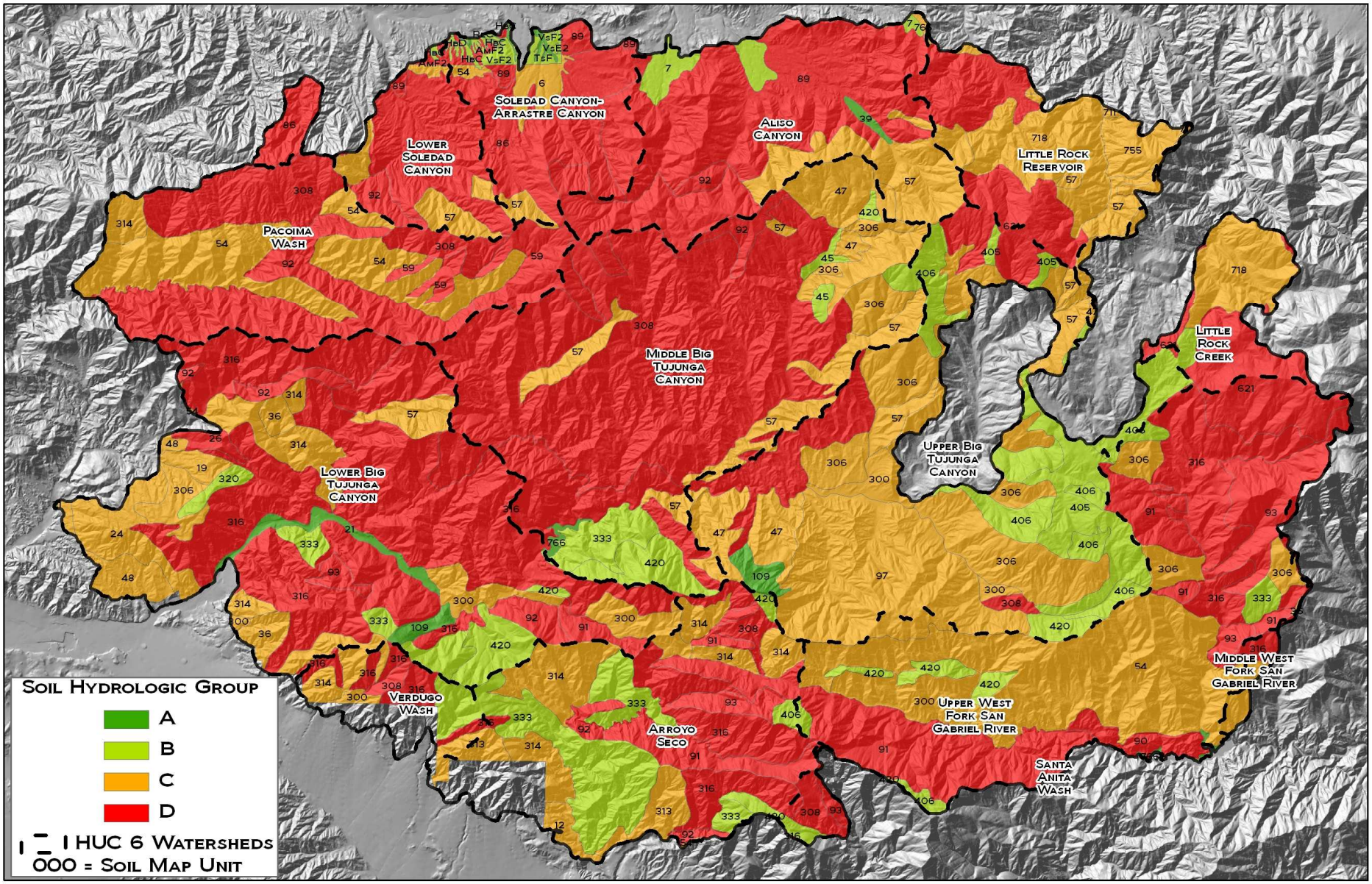
J. Jimenez - BAER Soils - 9/20/2009



1:150,000
1 inch equals 2 miles
0 0.5 1 2 3 4 Miles

STATION FIRE
Soil Erosion Hazard Rating

J. Jimenez - BAER Soils - 9/20/2009



1:150,000
1 inch equals 2 miles
Miles
0 0.5 1 2 3 4

STATION FIRE
Soil Map Units by Soil Hydrologic Group

J. Jimenez - BAER Soils - 9/20/2009

Appendix D – Photos

Aboveground: Burned, but duff has incomplete consumption with recognizeable organic structure intact.

Belowground: Soil structure, porosity, and roots intact; very little char or discoloration.

Moderate Soil Burn Severity Example

Aboveground: Near to complete duff consumption, but some recognizeable organic structure in the ash. These areas often look worse aboveground than they are belowground.

Belowground: Surficial char and discoloration with partial change to soil structure, porosity, and roots; affected zone is not very thick.

High Soil Burn Severity Example

Aboveground: Thicker ash layer with complete duff consumption, often looking very similar to moderate.

Belowground: Deeper char layer with fine roots burned out; soil is like powder with destroyed structure and porosity; may or may not be water repellent.

Appendix E – Field Data

FIELD DATA FOR PRIMARY SAMPLE POINTS

				Ground Cover		Slope					Soils								Water Infiltration			Burn Severity	H20 Shed Response
Point #	Grid	Date	Observer	Effective %	Potential %	Slope	Aspect	Length	Profile up/m/dn	Veg Type	Ash Color	Ash Depth	Horizon	Texture	Porosity	Roots	Structure Altered	Rock Content	Depth (cm)	Infiltration	Continuity		
DT1		9/11/2009	DNY/TAH	<5	0	10	w	250	70/10/10	chap	w	1 cm	1	SL	ok	ok	ok	<5	0-1	w	5	L	L-H
DT2	Long Fan	9/11/2009	DNY/TAH		0																		
DT3	Side by Side	9/11/2009	DNY/TAH		0																		
DT4	Clay Mining Flat	9/11/2009	DNY/TAH	<5	0	10	w	600	15/10/10	chap	w/b	3mm	1	SL	ok	ok	ok	5	0-4	m-s	5	L	L
DT5	Moody Cyn	9/11/2009	DNY/TAH	5	0	20	n	450	40/20/20	chap	w/b	5mm	1	vfSL	ok	3 ok	y	10	none	none	none	M	M
DT6	Indian Cyn 2yr unburned	9/11/2009	DNY/TAH	85	0	55	55	300	linear	grass w/sparse chap	0	0	1	SL	ok	ok		25	2cm	w-m	100		
DT7	Indian Cyn 2yr burn	9/11/2009	DNY/TAH	50	0	40	40	50		grass w/sparse chap	b	2mm	1	SL	ok	ok		15	0-1	w	25	L	L
Dave	Gabrielino	9/12/2009	DNY/TAH	90	90	5	w	30		riparian alder	w	3cm	1	S	ok	1 cm char		55	10	s	90	M-	L
J1	Santa Clara Divide	9/11/2009	JJ	25	25	40	5	500		Chap w/yucca	w-g	2cm		SL			1cm	15	none	none	none	M	M
J2	Santa Clara Divide	9/11/2009	JJ	55	55	40	320	200		Live Oak	w-g	2cm		SL		below 2cm	4cm	15	surface st		25	H-	H
E1	Santa Clara Divide	9/11/2009	EN	65	65	65	230	200		Big Cone douglasii	g	1cm		LCoS		4cm	no	50	1cm	st		M-	H
E2	Santa Clara Divide	9/11/2009	EN	25	25	50	230	200			g	.5cm		LCoS		1cm	no	35	1cm	st		M	H
E3	Mendenhall Ridge Road	9/12/2009	EN/JJ	60	100	65	340	500		oak woodland	b-w			LCoS		1cm	no	50	0-2cm	st	80	L	M
E4	Mendenhall Ridge Road	9/12/2009	EN/JJ	80	80	65	340	500		oak woodland	n/a			LCoS		1cm	no	50	4cm	st	80	U	M
E5	Mendenhall Ridge Road	9/12/2009	EN/JJ	80	80	65	65	500	linear	oak woodland	w	2mm		LCoS				50	0-1 cm	st	70	M-	M
E6	Mendenhall Ridge Road	9/12/2009	EN/JJ	80	80	75	30	500	90/75/60	chapparel, oak	w-b	8mm		LCoS		2-5 cm	no	25	2-7cm	st	80	M	H
E7	Mendenhall Ridge Road	9/12/2009	EN/JJ	80	80	70	338	500	85/70/70	chapparel, oak	w	1cm		LCoS		7cm	0-3cm	25	7-10 cm	st	50	H	H
E8	Mendenhall Ridge Road	9/12/2009	EN/JJ	60	80	80	340	1000	65/80/85	chapparel, oak	g-b	1mm		LS		3cm	no	35	0-8cm	st	80	M-	H
BT1		9/13/2009	TH	15	60	20	S	300		pine plantation	b	1cm	A	CoSL	H	NC	no	10	0-8cm	m		M	H
BT2		9/13/2009	TH	20	20	50	N	500		oak	g	1cm	A	CoSL	H	S	y	5	0-10cm	m		H	H
BT3		9/13/2009	TH	10	50	40	SW	400		camise/chapparel	w	2cm	A	SL	H	VFC	y	5	0-4cm	m		M	H
BT4		9/13/2009	TH	35	35	40	E	250		chamise	b	1cm	A	gr SL	H	S	no	25	0-10cm	w		L	M
BT5		9/13/2009	TH	15	15	45	N	500		oak	g	4cm	A	gr SL	H	VFC	y	25	0-2cm	st		H	H
BT6		9/13/2009	TH	60	60	50	N	400		oak	g	2cm	A	gr SL	H	VFC	y	40	0-6cm	st		H	H
BT7		9/13/2009	TH	40	40	40	N	500		oak	g	4cm	A	gr SL	H	VFC	y	30	0-5cm	st		H	H
JJ4		9/13/2009	JJ	60	60	20	35	100		mixed conifer/sage	n/a			LCoS			no	15	2-8cm	m	50	U	L
JJ5		9/13/2009	JJ	95	100	10	35	100			n/a			LCoS			no	15	0-8cm	m	75	U	L
JJ6		9/13/2009	JJ	50	50	10	200	35		mixed chapparel	b	1cm		SL			1cm	20	0-1cm	st	80	M	M
JJ7		9/13/2009	JJ	20	20	25	270	250		mixed chapparel	w-g	4cm		SL			5cm	15	0-12cm	st	80	H	H
JJ1		9/13/2009	JJ	90	90	25	220	200	5/45/15	grass	b	2cm		SL		1cm	no	15	0-2cm	m	75	L	L
JJ2		9/13/2009	JJ	60	60	5		200		chapparel	w-b	0.5cm		SL		1cm	yes	5	0-2cm	st	50	M	M
JJ3		9/13/2009	JJ	65	65	70	200	200	70/65/85	yucca, chapparel		2mm		grv SL		0.5cm	no	45	0-6cm	st	50	M	H
B1		9/12/2009	BR	15	15	15		100		chapparel	b		A	CoSL	H	m	n	15	0-4in			M	H
B2		9/12/2009	BR	10	10	5		1000		chapparel	b		A	SL	H	f	y	10	0-5in			M	VH
B3		9/12/2009	BR	10	10	35		1000		chapparel	g		A	gr SL	H	m	n	30	0-6in			M	VH
B4		9/12/2009	BR	25	35	25		300		plantation	g		A	SL	M	m	n	25	surface			M	H
B5		9/12/2009	BR	10	10	45		1000		oak/brush	g		A	SL	H	m	y	15	0-2in			MH	VH
B6		9/12/2009	BR	5	35	5		100		plantation	b		A	fSL	M	m	n	5	surface			M	H
B7		9/12/2009	BR	15	15	65		1000		oak/chapparel	w		A	gr SL	H	m	y	30	0-4in			MH	VH
B8		9/12/2009	BR	20	30	50		100		p. pine	g		A	gr SL	H	m	y	20	0-4in			M	H
B9		9/13/2009	BR	20	80	30	S	300		p. pine	b	1in	A	gr SL	H	m	n	15		h		M	MH
B10		9/13/2009	BR	5	5	65	W	200		chapparel	g	1in	A	fSL	H	m	y	5		m		H	H
B11		9/13/2009	BR	5	5	95	W	1000		chapparel	g	1in	A	gr SL	H	l	y	15		m		M	H
B12		9/13/2009	BR	5	5	45	NW	1000		oak/chapparel	g	2in	A	gr SL	M-H	c	y	15		m		H	H
B13		9/13/2009	BR	5	10	65	NE	200		oaks	w	2in	A	gr SL	H	c	y	15		j		M	H
B14		9/13/2009	BR	10	10	25	E	400		oak/chapparel	w-g	2in	A	SL	MH	m	n	10		m		M	H
B15		9/13/2009	BR	15	5	50	N	600		oak/chapparel	w-g	3in	A	gr SL	H	c	y	20		m		M	H
B16		9/13/2009	BR	45	45	80	SW	800		chapparel	g	3in	A	VC SL	H	m	y	60		ms		MH	VH
B17		9/13/2009	BR	35	35	75	S	1000		chapparel	g	4in	A	VC SL	H	c	y	65		ms		MH	VH
MT1		9/12/2009	MT	5	40	30	N	300		oak	b	1cm		gr CoSL		scorched	n	15	0-2cm	m	50	M	H