EXHIBIT 14 - SOIL RESOURCE ASSESSMENT

Waldo Canyon Fire – Burned Area Emergency Response

Soil Resource Assessment

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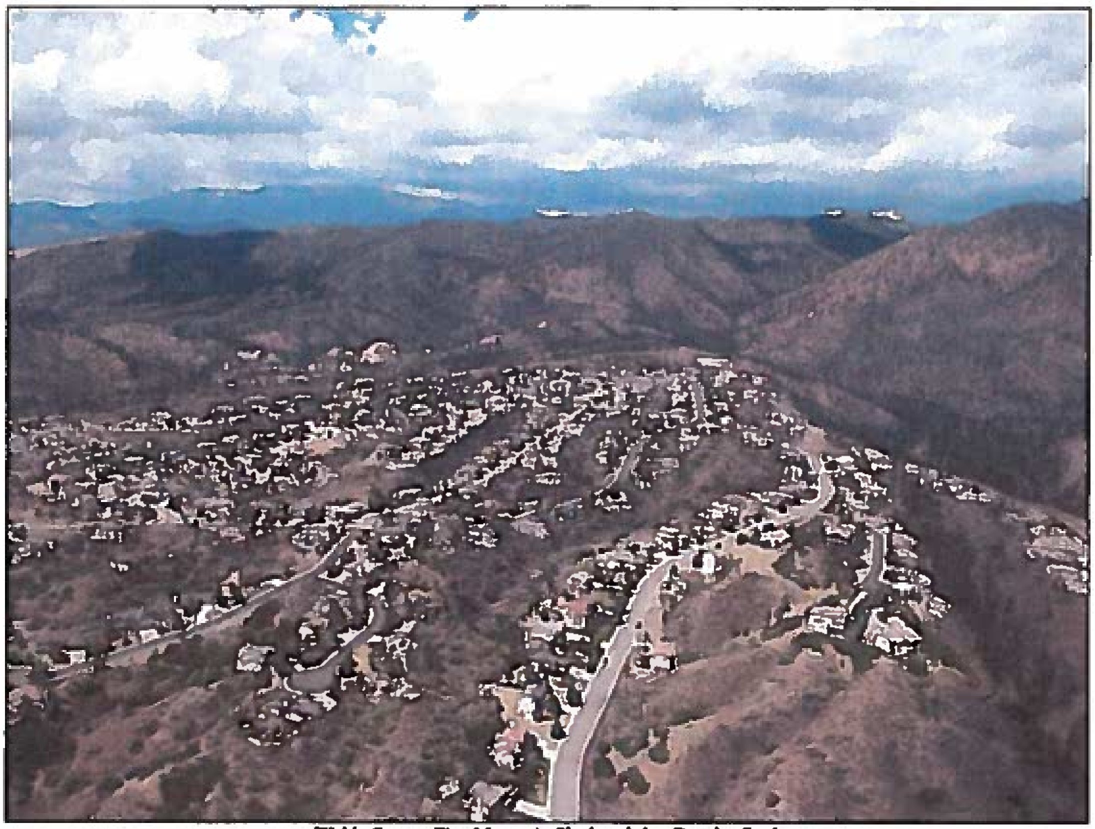

Waldo Canyon Fire, Mountain Shadows below Douglas Creek

Executive Summary – Soil Resource Condition Assessment:

The Waldo Canyon Fire burned 18,247 acres west of Colorado Springs, CO. An Inter-Agency BAER Team assessed the incident and found the overall soil burn severity to be 0.4% unburned, 41% low, 40% moderate, and 19% high. The high and moderate severity classes have evidence of severe soil heating in patches, including moderate to high water repellency; these areas have long-term soil damage and high erosion hazard. The remaining 41% 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. Vegetation is a mix of chaparral and forested ecotypes, and interaction with aspect and topography created a mosaic of burn intensity after the fires. Most moderate to severely burned slopes occurred on steep slopes and are directly linked to values at risk upon Forest Service lands and downstream. Heli-mulch treatments are proposed on 3870 acres of FS along Rampart Ridge in the headwaters of Fountain, Williams, Camp, Douglas, and Monument creeks, acting in concert with road treatments. Complementary heli-mulch treatments are also recommended on 534 acres of private lands in coordination with NRCS. Treatments are intended to reduce threats to life and off-site sediment-laden runoff affecting water quality; they are not proposed for on-site soil productivity concerns directly. Recommendations are also made regarding further evaluation needs for private landowners downslope.

1 General Situation Report

1.1 Waldo Canyon Fire Inter-Agency BAER Team

The Waldo Canyon fire burned on the Pike-San Isabel N.F. (Pikes Peak RD), including private lands within and on the downslope periphery of the fire. The fire is being described as the most damaging fire in Colorado history, because of 350 homes lost and fatalities involved. An Inter-Agency BAER team was formed to address the range of concerns, values at risk, and potential treatments across ownerships to coordinate efforts and maximize treatment effectiveness within whole watershed units at several scales. Soil Scientists working on the team include the following:

David Young, Zone Soil Scientist (Northern R5), USFS Region 5, Redding CA
Brad Rust, Forest Soil Scientist, Shasta-Trinity National Forest, Redding CA

Soil scientists focused on different fire values and worked in close cooperation daily to compare notes, concerns, values at risk, and treatment opportunities. The soils team also worked closely with other resource specialists to coordinate efforts and potential treatments.

1.2 Summary of soil conditions

The Waldo Canyon Fire occurred mostly within the Pikes Peak granite saprolyte (grus) geologic pluton, so soils are mostly gravelly to very gravelly coarse sandy loams, and are quite erodible even with the absence of fire effects. These soils are mostly shallow with moderate permeability in the substratum; despite the permeable substratum, the dominant soils are officially mapped as soil hydrologic group D. Great Basin sedimentary derived soils occur on the eastern fringe of the fire, typified as moderately deep stony clay loams, soil hydrologic group C. Soil hydrologic groups are a useful index reflecting a soil's inherent potential for flashy runoff and erosion (A is best, D is worst); overall mix is 0.4% A, 3% B, 4% C, and 92% D. Deeper soils occur on gentle slopes, located on toe slopes and landslide benches. The steeper slopes at higher elevations in the headwaters of watersheds on FS lands had the hotter burns.

Vegetation is a mix of Pinon pine-juniper and mixed forested ecotypes, interaction with aspect and topography created mosaic of burn intensity after the fires. Vegetation burned hotter with total consumption of vegetation at the headwalls of watersheds and lower riparian areas and draws burned cooler.

In total acreage, 41% of the burned area had unburned and low soil burn severity, showing very little evidence of significant soil heating with essentially no changes in soil color, structure, organic matter or fine root combustion. Seed source was present in most topsoils and natural regeneration is already beginning in some areas with adapted sprouting species. These areas currently have >50% soil cover, and understory growth is expected to progress rather quickly.

40% of the area was in moderate soil burn severity and 19% high. The moderate areas have observable evidence of soil heating, generally just in the surface inch of soil, but have complete lack of cover, high erosion hazards, and widespread and fairly continuous water repellency. They will therefore have a watershed response similar to a high, and will produce significantly increased flows and sediment production. Natural re-vegetation of these areas is expected to be relatively slow, with >60% canopy cover over 7-10 years, as observed in similar places such as the Hayman Fire. The areas of high soil burn severity show deeper char, discoloration, some destruction of organic matter and structure in the top 2-4 inches, and moderate to high water repellency. These areas have long-term soil damage, and natural recovery will be slow without active restoration treatments in the short to medium term (beyond BAER).

Process geomorphology is active. Many areas have extensive evidence of shallow-seated landslide and debris flow history. Old gullying and topsoil erosion is observable, and many headwall-type slopes are 'rock-armored' from past erosion, albeit natural. Most soils have high erosion hazard ratings, and with absence of cover will produce significant erosion and sediment delivery to stream systems. Elevated post-fire flows and erosion/sediment loads will persist over 5-10 or more years commensurate with rates of vegetation regrowth and soil cover establishment.

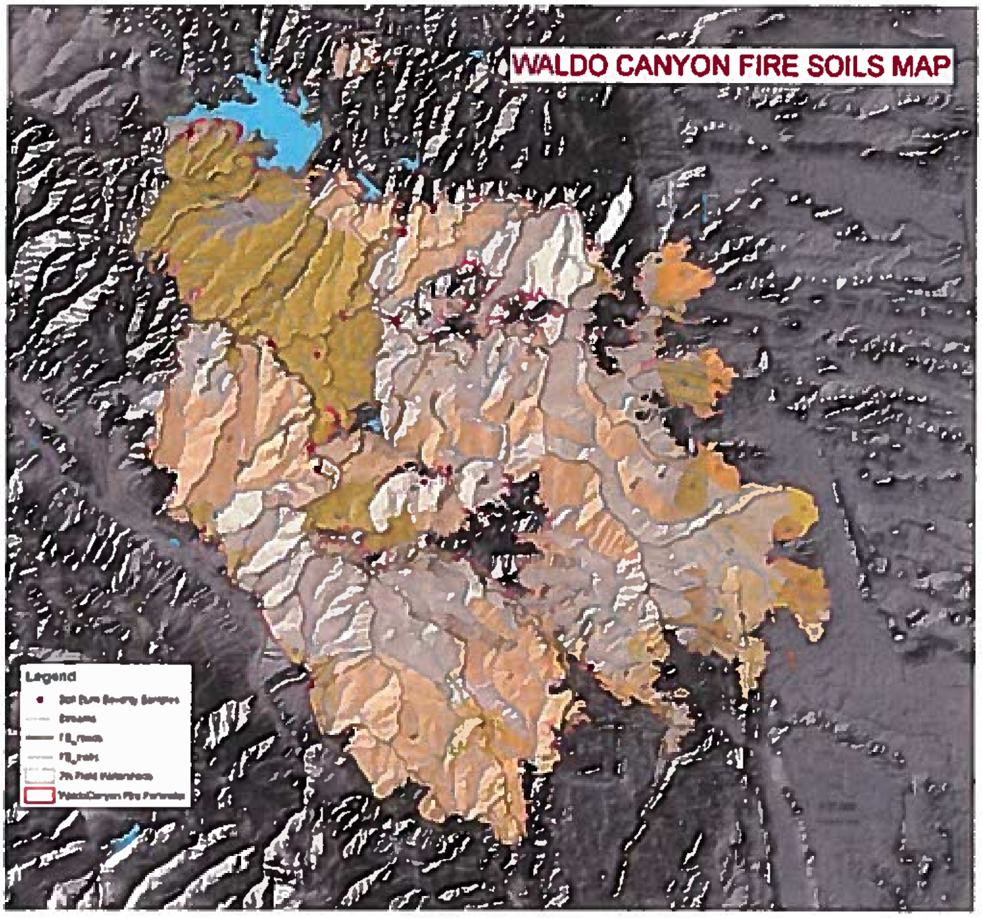

Figure 1: Soils within the Waldo Canyon Fire (Map Unit legend & acreages are in Appendix A).

2 Soil Inventory

Soil coverage was obtained from the NRCS (USDA Natural Resources Conservation Service), which incorporates soils information and mapping on all ownerships in the area. The fire area was covered by 2 soil surveys, with 29 soil map units within the fire perimeter. Corresponding map unit data and interpretations were obtained for further analyses. This provided the basic soil information for making interpretations of fire effects upon the various soils, particularly as many areas were not field visited due to access and time constraints. Soil Map Units are displayed in Figure 1, and map unit descriptions and acreage within the fire perimeter are in Appendix A.

Fire area access for field assessment was good along upper ridges, with few mid-slope roads to allow access to midslopes and upper canyon areas of several of the watersheds. 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 and slope gradient, slope length and profile, soil cover, duff consumption, soil heating and char, soil structure and aggregate stability, texture, porosity, organic matter, fine root condition, and water repellency. These more detailed and GPS-located survey points were supplemented with numerous additional spot checks between to quickly assess water repellency and soil heating characteristics in more locations along travel routes. Unburned areas were also looked at to gauge fire effects relative to natural conditions for similar soils, particularly with respect to naturally occurring water repellency without fire.

Soil map unit data was 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 modeling estimates were based in part upon soil survey information and modified using field-calibrated data where appropriate.

SiteID	Area of Fire	Ground Cover	Ash Color	Ash Depth (cm)	Soil Structure	Root Alteration	Observed Soil Burn	PreFire Veg burned	Veg Comments
1	Cascade	0 - 20 Percent	Black	3.00	SlightlyAltered	VeryFineConsumed	Moderate	High	pine q-aspen
2	Rampart williams	0 - 20 Percent	Gray	4.00	OriginalStructure	VeryFineConsumed	Moderate	High	burned poles
3	Rampart williams	0 - 20 Percent	Gray	3.00	SlightlyAltered	NoChange	Moderate	High	skeletons
4	Wellington	0 - 20 Percent	Gray	3.00	SlightlyAltered	VeryFineConsumed	Moderate	High	skeletons
5	Camp	> 50 Percent	Other	0.00	OriginalStructure	NoChange	Unburned	High	unburned
6	Eagle Camp	20 - 50 Percent	Black	2.00	OriginalStructure	NoChange	Moderate	Low	conifer aspen
7	Nichols	0 - 20 Percent	Gray	4.00	SlightlyAltered	NoChange	Moderate	High	pine
8	Eagle Camp	0 - 20 Percent	Black	4.00	SlightlyAltered	NoChange	Moderate	High	pine
9	Nichols	0 - 20 Percent	White	5.00	DegradedPowdery	VeryFineConsumed	High	High	m-conifer
10	Eagle Camp	0 - 20 Percent	Gray	2.00	SlightlyAltered	NoChange	Moderate	High	m-conifer
11	Devils Kitchen	> 50 Percent	Other	0.00	OriginalStructure	NoChange	Unburned	High	m-conifer
12	Northfield	20 - 50 Percent	Black	2.00	OriginalStructure	NoChange	Moderate	High	conifer aspen
13	Thunder Ridge	0 - 20 Percent	Gray	2.00	SlightlyAltered	NoChange	Moderate	High	m-conifer
14	Rampart Camp	20 - 50 Percent	Black	2.00	OriginalStructure	VeryFineConsumed	Moderate	Low	timber/brush
15	Sand Gulch 305	> 50 Percent	Black	0.00	SlightlyAltered	VeryFineConsumed	Moderate	Low	mixed burn

Table 1. Soil burn severity data at "detailed" site points.

3 Soil Burn Severity

Rapid assessment and mapping of areas in soil burn severity classes is necessary for incorporation with other site factors such as soil type, slope, hydrologic characteristics, and biological or human resource issues to identify source areas of potential flooding and erosion, and areas where critical ecosystem values may be degraded.

Due to smoky and/or cloudy conditions the soil burn severity map was a hand-drawn product based upon aerial reconnaissance and field validation without the benefit of a remote sensing product. Therefore map units are very generalized and do not reflect the mosaic nature and patch size characteristics of the burn. The map should be representative on a watershed scale, but may not be accurate for precise locations, and further field investigations are recommended for assessing small scale concerns.

When conditions allow, a Burned Area Reflectance Classification (BARC) map will be created by the Remote Sensing Applications Center (RSAC, Salt Lake City, Utah) using satellite imagery and standard pre-post differential processing methods (dNBR). Limited systematic and locational editing will be necessary to finalize the BARC into a map reflecting actual soil burn severity as assessed in the field. When post-fire BARC imagery becomes available for the Waldo Fire it will be processed into a final soil burn severity map by the authors using existing field soil burn severity data and information, to make it available for future assessment and modeling needs beyond the initial BAER assessment.

Soil burn severity acres are listed in table 2, and displayed geographically in Figure 2. The overall soil burn severity from direct field observations in the Waldo Fire was 0.4% unburned, 41% low, 40% moderate, and 19% high. Both moderate and high classes have high erosion hazards; both moderate and high classes had water repellency (moderate to high severity and fairly continuous).

HUC6 watershed (acres)	Unb.	Low	Mod	High	Total	
Cascade Creek-Fountain Creek		834	951	496	2,282	13%
Garden of the Gods	3	1,470	3,504	1,046	6,024	33%
Headwaters Fountain Creek	0	931	1,097	358	2,386	13%
Lower Monument Creek	67	1,443	1,204	619	3,333	18%
West Monument Creek	3	2,820	525	854	4,201	23%
Total	72	7,498	7,281	3,373	18,225	
	0.4%	41%	40%	19%		

Table 2. Soil Burn Severity- acres by 6th field watershed and corresponding percentages

Unburned areas also had low-severity water repellency in only the top 1-4 mm, and more patchy, so repellency observed in the burned area was judged to be greatly increased (in severity and continuity) by the fire, with a very significant effect on infiltration rates for watersheds as a whole. Runoff and rilling was observed and widespread following localized rain events during the assessment, even in moderate soil burn severity areas, which was attributed to the widespread water repellency.

It should be understood that **soil burn severity is NOT vegetative burn severity or mortality.** Vegetative burn severity is but one component taken into consideration – soil burn severity goes beyond aboveground vegetation impacts to belowground soil heating effects and associated impacts 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 and fire behavior during the fire, below-ground soil burn severity is related strongly to the length of time the heat is in contact with the soil (residence time).

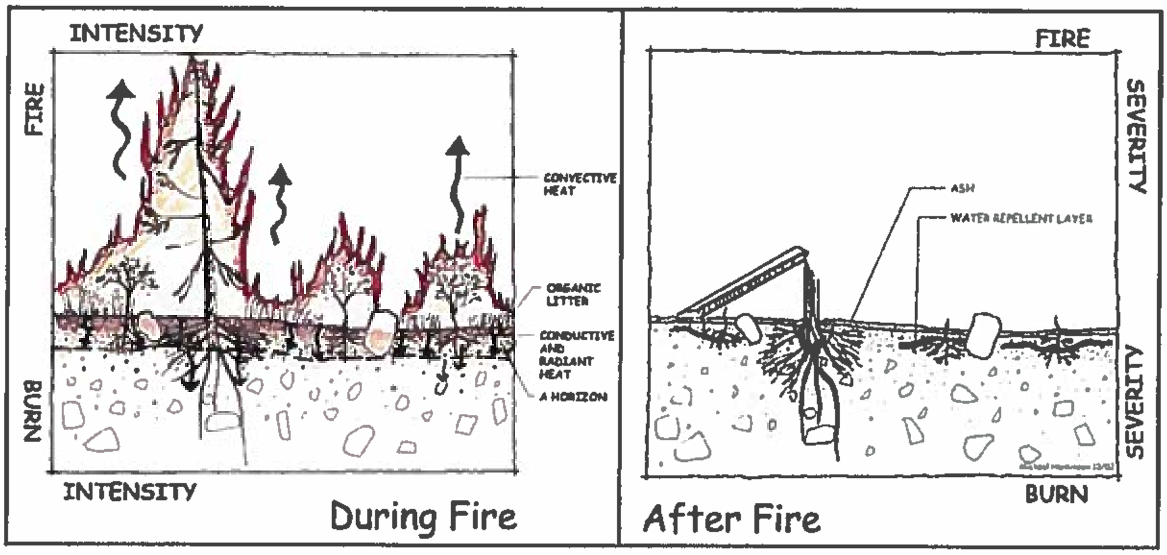

Figure 2: A graphical representation of burn severity vs. fire intensity. Residence time is not represented in the drawing but is a key factor in resulting severity (Effects of Fire-GTR WO-7).

Understanding these differences is crucial to meeting the objectives of the BAER assessment. A high intensity fire (high flame lengths, rapid rate of spread, crown fire, etc) in a stand-replacement event can result in a moderate (or even low) soil burn severity, if the residence time is short and soil characteristics are not altered significantly. Conversely, a slow-moving fire with complete consumption of accumulated surface fuels can leave trees alive, but heat the soil severely with predictable negative consequences to soils and streams. Soil burn severity, used in this context, is a much better index of soil damage, watershed response, and potential for natural vegetative recovery after the fire.

Soil Burn Severity Indicators used for the Waldo Canyon fire are generalized best in Parsons et al., 2010:

Low soil burn severity: Surface organic layers are not completely consumed and are still recognizable. Structural aggregate stability is not changed from its unburned condition, and roots are generally unchanged because the heat pulse below the soil surface was not great enough to consume or char any underlying organics. The ground surface, including any exposed mineral soil, may appear brown or black (lightly charred), and the canopy and understory vegetation will likely appear "green."

Moderate soil burn severity: Up to 80 percent of the pre-fire ground cover (litter and ground fuels) may be consumed but generally not all of it. Fine roots (~0.1 inch or 0.25 cm diameter) may be scorched but are rarely completely consumed over much of the area. The color of the ash on the surface is generally blackened with possible gray patches. There may be potential for recruitment of effective ground cover from scorched needles or leaves remaining in the canopy that will soon fall to the ground. The prevailing color of the site is often "brown" due to canopy needle and other vegetation scorch. Soil structure is generally unchanged.

High soil burn severity: All or nearly all of the pre-fire ground cover and surface organic matter (litter, duff, and fine roots) is generally consumed, and charring may be visible on larger roots. The prevailing color of the site is often "black" due to extensive charring. Bare soil or ash is exposed and susceptible to erosion, and aggregate structure may be less stable. White or gray ash (up to several centimeters in depth) indicates that considerable ground cover or fuels were consumed. Sometimes very large tree roots (> 3 inches or 8 cm diameter) are entirely burned extending from a charred stump hole. Soil is often gray, orange, or reddish at the ground surface where large fuels were concentrated and consumed.

4 Soil Erosion Hazard Rating

In order to assess the potential risk of a given soil to erode, an erosion hazard rating (EHR) system was developed in R-5 (FSH 2505.22). The EHR system is designed to assess the relative risk of accelerated sheet and rill erosion. Many interrelated factors are evaluated to determine whether land use activities would cause accelerated erosion. This rating system is based on soil texture, depth, clay content, infiltration, amount of rock fragments, surface cover (vegetative and surface rocks), slope gradient, and climate. Risk ratings vary from low to very high, with low ratings meaning low probability of surface erosion occurring. Moderate ratings mean that accelerated erosion is likely to occur in most years and water quality impacts may occur for the upper part of the moderate numerical range. High to very high EHR ratings mean that accelerated erosion is likely to occur in most years and that erosion control measures should be evaluated. For BAER purposes, fire induced changes to soil infiltration and ground cover can be factored in to determine changes in erosion hazard.

Colorado does not have an equivalent EHR system that we are aware of, so we utilized the CA system as a tool to rate soils relative to one another, and we believe it is applicable for this purpose in the fire area.

For EHR purposes, the 29 soil map units were evaluated using information for texture, rock content, slope phase, and soil hydrologic group, which are in turn used to rate characteristics relating to infiltration, permeability, and depth of the soil. EHR ratings were calculated for each soil with soil burn severity characteristics also factored in. Ratings thus represent a summary of soil physical characteristics, slope gradient, soil cover present, and level of hydrophobicity (water repellency) as observed in the field. EHR ratings for soil groups are presented in Appendix B, Table B1. Summary EHR rating for the entire fire area is 19% low, 10% moderate, 56% high, and 15% very high. Notably, several of the soils rate as moderate to high even in unburned or low burn severity condition (Appendix A), due to the erodible nature of soils derived from the Pikes Peak saprolytic granite substrate. In other words, the soils are naturally very erodible, and erosion rates will be increased after the fire, to varying degrees based upon soil burn severity and topography.

HUC6 watershed	Low	Mod	High	V. High	Total	
Cascade Creek-Fountain Creek	153	52	1,582	496	2,282	13%
Garden of the Gods	679	816	3,636	892	6,024	33%
Headwaters Fountain Creek	199	17	1,867	303	2,386	13%
Lower Monument Creek	740	727	1,308	557	3,333	18%
West Monument Creek	1,733	193	1,858	406	4,190	23%
Total	3,505	1,804	10,251	2,654	18,214	
('water' removed from total acreage)	19%	10%	56%	15%		

Table 3. Erosion Hazard Rating- Acres (within the fire perimeter) by 6th-Field watershed, and corresponding percentages. Note that "water" was removed from total acreage figures.

Figure 3 displays geographically the areas of greatest soil erosion risk with soil burn severity factored in. Areas with high and very high EHR would represent priority areas for potential land treatments where erosion and sediment production pose a threat to values at risk. These areas would further be examined for treatment feasibility and suitability considering factors such as accessibility (including distance to aircraft staging areas), slope gradient, existing soil cover including rock, stream density, and down-slope values at risk.

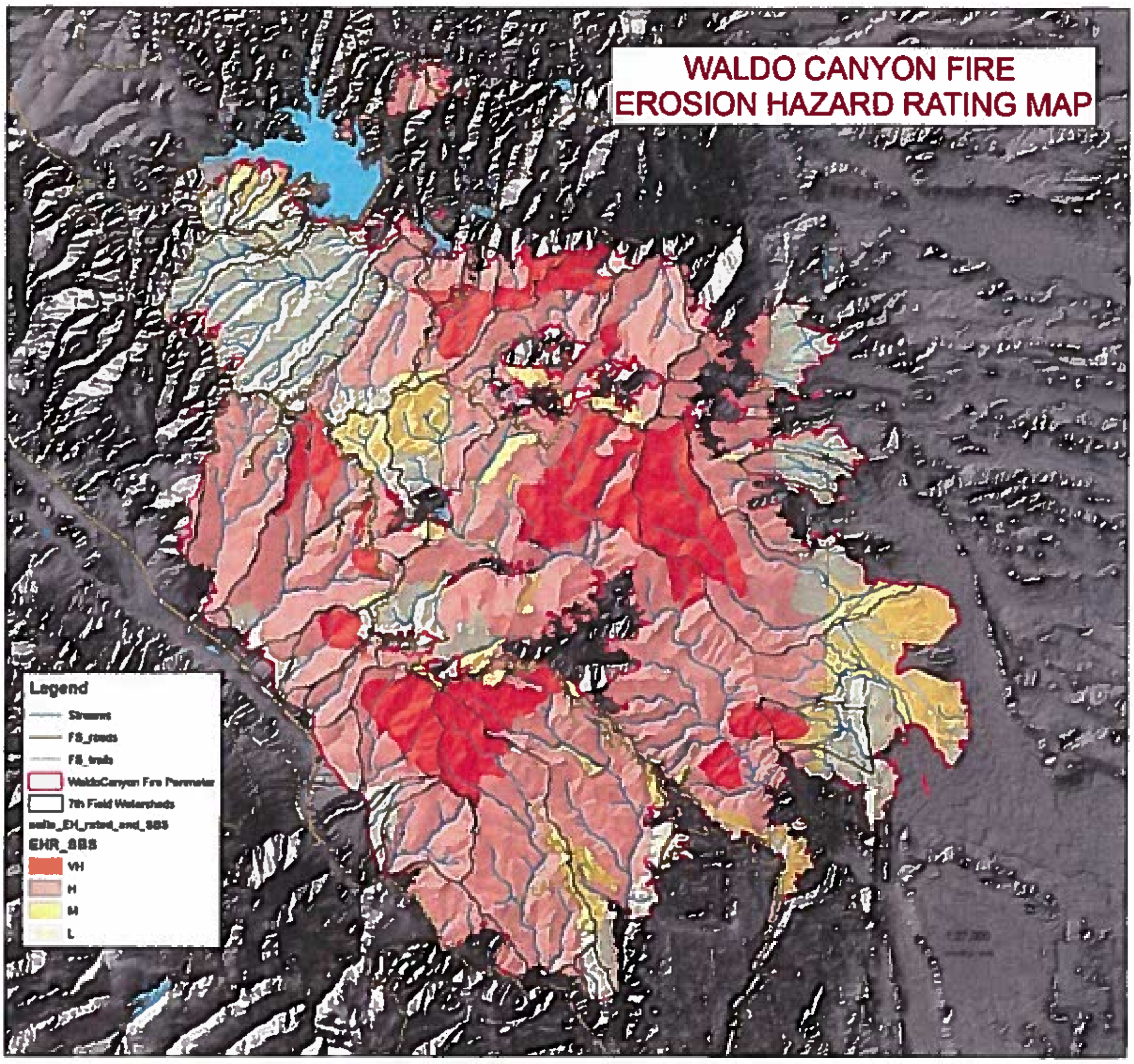

Figure 3. Post-Fire Soil Erosion Hazard Rating Map.

5 Estimated Erosion Response

Approximately 18,227 acres are within the burn perimeter, with approx. 18,155 acres burned. Hydrologic soil groups are a useful indicator of potential for runoff generation and subsequent erosion. The great majority of soils have a hydrologic soil group D, indicating a high potential for runoff and erosion, regardless of soil burn severity. Additional effects of soil burn severity will cause more runoff, accelerated sheet and rill erosion throughout the fire areas (Table 4), as well as accelerated occurrence of shallow landslides and debris flows. The water repellency observed in these fire areas is slight to moderate in moderate soil burn severity areas, and high in areas of high soil burn severity; the repellent layer generally begins about 1 inch beneath the surface and extends to 3-4 inches deep.

Hydrologic Soil Group	Percent of Fire Perimeter
A	0.44
B	3.25
C	4.21
D	92.10

Table 4. Hydrologic Soil Group- Percentage of Acres

Quantitative erosion figures were estimated using the new batch-module of the ERMiT (Erosion Risk Management Tool) model. ERMiT is a WEPP-based application developed by USFS Rocky Mountain Research Station (USFS, RMRS-GTR-188, 2007) specifically 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 fire-line erosion and gullying, which could pose large additional sources of sediment entering the stream systems.

ERMiT models erosion potential based on single hillslopes, single-storm "runoff events," and post-fire soil burn severity. Hillslopes include soil and topography inputs. Soil information was based upon soil map unit information, which was field verified in many areas of the fire as part of the assessment. Generalized hillslope gradients and profiles were developed in GIS by soil map unit, sub watershed, and soil burn severity class to account for fairly site specific differences in topography. 479 such hillslopes were generated for model inputs for the Waldo fire.

As input for storm events, ERMiT uses PRISM to generate climatic input parameters; a customized climate interpolated from Canyon City to the SE was generated to refine erosion estimates (Colorado Springs data was not available). A single set of climate parameters was used for the fire area. Modeled sediment production may be over- or under-estimated somewhat to the extent that the climate parameters may vary from the actual site-specific climate. Various storm runoff-event magnitudes may be chosen in ERMiT for erosion response estimates; 2-year, 5-year, and 10-year events were run for the Waldo fire analysis, and most of the reported results are based on the 10-year runoff event to be consistent with hydrologic modeling and modeling efforts on other fires for comparative purposes.

ERMiT model output is then extrapolated and re-apportioned on a per-acre basis in sub-watersheds to generate totals (Appendix B), which can also then be spatially displayed to identify areas with the higher sediment source potential. All 6th field watersheds having portions within the fire area were included in the analysis, but only acres within the fire perimeter were run through the model; custom sub-watersheds were modeled to assist in more detailed analyses regarding specific values at risk.

Post-fire summary erosion rates are shown in table 5, which includes all soil burn severity classes combined. For the total fire area, erosion rates are modeled at 13 tons per acre (range 0.4 to 40) for a single 10-year runoff event. Total sediment production by sub-watershed, both pre-fire and post-fire, are included in Appendix B (table B2). More detailed information is available and on file with the authors. Note: Fairly localized data in the same geologic terrane were utilized for building the ERMiT model; these hillslope materials are notably under-predicted by the generalized model. Stated model accuracy is +/- 50%; therefore +50% may be more representative for this area, but the regular model output is reported in the tables.

ERMiT Output (tons/acre):	2 year runoff event			5 year runoff event			10 year runoff event		
HUC6_Name	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave
Headwaters Fountain Creek	0.0	7.5	1.7	0.3	16.4	6.7	0.4	26.4	11.5
Cascade Creek-Fountain Creek	0.3	13.7	3.1	2.8	26.6	9.4	6.3	39.6	15.7
Garden of the Gods (Camp Creek)	0.0	10.6	2.5	0.3	23.6	7.8	0.4	34.4	12.8
West Monument Creek	0.0	7.4	1.8	0.6	15.8	6.4	0.9	26.3	11.0
Lower Monument Creek	0.0	6.1	2.1	1.3	15.8	7.5	3.2	28.3	12.8
Average	0.0	13.7	2.3	0.3	26.6	7.5	0.4	39.6	12.7

Table 5. Hillslope Sediment Production Rates by 6th field watershed, given a 2, 5, or 10-year storm "runoff event"

The post-fire erosion rates for all burned areas are 0-14 tons/acre for a single 2-year runoff event, 0.3-27 tons/acre for a 5-year event, and 0.4-40 tons/acre for a 10 year event. Regardless of the accuracy of the absolute numbers, the model is utilized here for relative rating of different areas within the fire for relative potential as sediment source areas, prioritize areas for potential treatments in later steps of the assessment process, and determine the efficacy of possible treatments in reducing sediment rates and total sediment loads downstream.

6 Values at Risk – Threats to Life, Property, and Water Quality

Soil quality and hydrologic function throughout the fire was assessed by determining soil burn severity, soil erosion hazard, and evaluating potential on- and off-site effects of topsoil loss and sediment production. The combination of soil types, steep slopes, and lack of soil cover will create watershed responses with elevated erosion and sedimentation, the degree depending upon the severity of the coming winters over the next 3-5 years at least. On-site effects include the physical, chemical, and biological response of the soils to the fires, and likely recovery rates. Off-site effects due to sedimentation and stream bulking are downstream, and include potential adverse effects to life and 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, both on and off of FS lands.

On-site effects of the fire will be some loss of topsoil via accelerated erosion, and some damage to soil nutrient status and microbial communities. This may pose a hazard in the form of declined soil fertility and ecosystem productivity in the short-term. Soils are generally characterized as low site quality before the fires, so soil productivity in and of itself was not identified as a value at risk. Likewise, there are no rare plants or vegetation types 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.

Off-site effects of the fire will be accelerated sediment production into stream systems, stream bulking, downstream deposition of sediment in streams, and increased landslide and debris-flow potential. Sediment-laden ("bulked") runoff and stream water has much greater erosive power than similar flows of clean water in the stream system. Several off-site values are at risk, threatened by increased sedimentation and debris flow activity. Risks to roads exist throughout the fire area which are necessary to the transportation systems (see Engineering Report) and represent valuable infrastructure investments. Hazards to these values at risk can be substantially reduced by targeted upslope land treatments to reduce hillslope runoff and sediment delivery into stream waters.

Erosion and sedimentation would contribute to debris flows and mudflows, which would have a high potential to threaten life and property, as well as water quality. Anticipated sediment production will be elevated from 300 to 400% of pre-fire sediment movement.

Additional values at risk are present regarding archaeological sites, critical habitat and threatened & endangered species. This information is sensitive in nature, and is not discussed here.

7 Emergency Determination

Effects of the fire on the soils have created emergency conditions, posing hazards to critical values at risk. These soils are naturally prone to flashy runoff and erosion, and have been affected by the fire with complete removal of soil cover and moderate to high levels of water repellency. This will significantly increase peak flows, runoff, stream bulking, flooding and debris flow hazard, and downstream sedimentation. These conditions pose unacceptable threats to values at risk, specifically to life, property, and water quality.

Natural recovery and administrative closure will be inadequate to reduce threats to values at risk, including life. Therefore, targeted land treatments are proposed to mitigate on and off-site effects of soil erosion, in conjunction with other treatments to fully address emergency conditions for specific values at risk.

8 Treatments to Mitigate the Emergency

It is possible to have emergency conditions without the ability or justification to do something about it. The BAER Program requires that proposed mitigative treatments must be proven effective, technically feasible, justified by the values at risk, and of a magnitude to make a meaningful difference in reducing risk levels. Proposed treatments are considered the minimum necessary response to significantly reduce the threat to the values at risk. In this context the suite of possible treatments and treatment locations are scrutinized and narrowed to the minimum necessary response to manage and reduce risk levels to acceptable levels, or as close as we can feasibly achieve toward that objective given reasonably expectable magnitudes of damaging events.

In these fires there were several locations having serious long-term soil damage coupled with high erosion hazard ratings – the high soil burn severity class and some of the moderate areas. Many of these locations were either on steep slopes (considered 'untreatable' with land treatments on slopes >60%), 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 in achieving risk reduction objectives.

Proposed treatments were developed in conjunction with geology, hydrology, wildlife, archaeology, and engineering specialists to target specific threats to values at risk in specific locations. A GIS layer of treatment units was developed using constraints of slope, soil burn severity, location and amount of treatable ground within watersheds, direct linkage to values at risk, as well as other operational feasibility considerations. Treatments as proposed should provide some measure of mitigation of short-term hazards; implementation of some treatments but not others intended to have additive effects would compromise the effectiveness of treatments as a whole. Forest Service treatments in conjunction with NRCS treatments are intended to provide complementary protection measures. ERMiT estimates indicate about a 20% reduction in sediment potential as a result of treatments as proposed (Appendix B, table B3). Thus, despite the proposed treatments, flow and erosion rates will still be elevated for several years, so threats to life and property will still exist, just at lower risk levels for less than "worst-case" storm scenarios. Several downstream communities outside of the burn area will need to remain vigilant and aware of the potential for flash floods with certain size rain events.

Land treatments are proposed as one large element of complementary risk mitigation prescriptions. Only land treatments are described here; other specialists have described their respective treatment portions separately, but all treatments are intended to work in concert to attain effective risk mitigation.

Specific land treatments are as follows:

1. Mulching with straw (rice straw or certified weed free straw), wood shred, or wood straw aerial application. Ownership is primarily USFS with smaller portions of private. Cost estimates will be priced for contracting the work; cost could be reduced significantly by FS or cooperative cost share agreement administration.

9 Recommendations for Further Evaluation

9.1 Soil Burn Severity Mapping – BARC Imagery

BARC imagery was not available for production of the soil burn severity map utilized for all modeling and analyses pursuant to this assessment; it was hand-mapped based upon helicopter reconnaissance and field review, and "simplistic" polygons do not reflect the patch size and mosaic nature of the burn at small scale. RSAC is pursuing further imagery acquisition; when it becomes available it can and should be modified to provide a better product that is accurate at smaller scales; the authors will be available to complete this from our home unit to make it available for future analyses by the Forest and cooperators involved in emergency management.

9.2 Rampart Reservoir Shoreline Burn

The Rampart Reservoir trail 700 below Thunder Ridge campground was burned resulting in a moderate soil burn severity located on granitic terrain, creating high to very high erosion hazard rating. Slopes are predominantly moderate gradient and treatable. The lands are in a special use permit for Colorado Water Resources. This area will contribute sediment to the reservoir and woody material. Due to other higher priority treatment areas threating life and property, this area is recommended for other funding mechanisms to treat. This area should be further evaluated for values at risk and potential treatments.

10 References

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APPENDIX A: Soil Map Unit Inventory

Table A1. Soil Map Unit Descriptions and Erosion Hazards

Map Unit	Name	Acres	Percent	Erosion Hazard		
				Soil Burn Severity		
				low	mod	high
2	Aquolls, 1-10% slopes	96	0.5	L	M	M
12	Fortwingate-Rock Outcrop complex, 15-60% slopes	0.4	0.0	M	H	H
13	Garber very gravelly coarse sandy loam, 2-15% slopes	86	0.5	L	L	L
14	Garber very gravelly coarse sandy loam, 15-40% slopes	4.3	0.0	M	H	H
16	Guffey very gravelly sandy loam, 40-60% slopes	117	0.6	M	H	H
17	Herbman very gravelly sandy loam, 15-40% slopes	435	2.4	M	M	H
18	Herbman-Rock Outcrop complex, 15-40% slopes	152	0.8	M	M	H
22	Kassler very gravelly coarse sandy loam, 5-35% slopes	80	0.4	L	M	M
25	Legault very gravelly coarse sandy loam, 40-65% slopes	863	4.7	M	H	H
29	Pendant cobbly loam, 15-40% slopes	312	1.7	L	M	M
31	Pendant cobbly loam-Rock Outcrop complex, 15-70% slopes	179	1.0	L	M	M
32	Perrypark coarse sandy loam, 1-15% slopes	1.0	0.0	L	L	L
36	Rock Outcrop-Sphinx warm complex, 15-80% slopes	128	0.7	H	H	H
38	Security very gravelly coarse sandy loam, 40-65% slopes	279	1.5	L	L	M
42	Sphinx gravelly coarse sandy loam, 15-40% slopes	2753	15.1	L	M	H
43	Sphinx gravelly coarse sandy loam, 40-70% slopes	88	0.5	H	H	VH
44	Sphinx gravelly coarse sandy loam, warm, 15-40% slopes	128	0.7	L	M	H
45	Sphinx gravelly coarse sandy loam, warm, 40-70% slopes	2.6	0.0	H	H	VH
46	Sphinx-Rock Outcrop complex, 15-80% slopes	6341	34.8	H	H	VH
46b	Kutler-Broadmoor-Rock outcrop complex, 25-90% slopes	15	0.0	L	M	M
47	Sphinx, Warm-Rock Outcrop complex, 15-80% slopes	5194	28.5	H	H	VH
48	Tecolote very gravelly sandy loam, 15-30% slopes, very stony	499	2.7	L	L	L
50	Tomah sandy loam, 2-15% slopes	2.7	0.0	L	L	L
52	Manzanola clay loam, 1 to 3 percent slopes	65	0.4	L	L	L
63	Paunsaugunt-Rock outcrop complex, 15 to 65 percent slopes	79	0.4	L	L	L
64	Penrose-Manvel complex, 3 to 45 percent slopes	30	0.2	L	L	L
73	Razor clay loam, 3 to 9 percent slopes	0.1	0.0	L	L	L
74	Razor stony clay loam, 5 to 15 percent slopes	280	1.5	L	L	L
75	Razor-Midway complex	27	0.1	L	L	L
W	Water	12	0.1	NA	NA	NA

The EHR system is designed to assess the relative risk of accelerated sheet and rill erosion: L = low, M = Moderate, H = High, VH = Very High. Soil burn severity is factored in using estimated changes in infiltration and soil cover.

Appendix B: Soil Burn Severity and Modeled Erosion Estimates by Watersheds

Table B1. Soil Burn Severity by Watershed and modeled custom Sub-Watersheds. Top 3 sub-watersheds are larger in scale, and may include other sub-watersheds below.

Waldo Canyon BAER -- Soil Burn Severity by Watershed

6th Field Watershed	Unb.	Low	Mod	High	Total	% Low	% Mod	% High	% M + H
Headwaters Fountain Creek	0	931	1,097	358	2,386	39%	46%	15%	61%
Cascade Creek-Fountain Creek		834	951	496	2,282	37%	42%	22%	63%
Garden of the Gods	3	1,470	3,504	1,046	6,024	24%	58%	17%	76%
West Monument Creek	3	2,820	525	854	4,201	67%	12%	20%	33%
Lower Monument Creek	67	1,443	1,204	619	3,333	43%	36%	19%	55%
Total	**72**	**7,498**	**7,281**	**3,373**	**18,225**	**41%**	**40%**	**19%**	**58%**

Sub Watersheds (pour points)	Unb.	Low	Mod	High	Total	% Low	% Mod	% High	% M + H
wsJ - Fountain Creek above Manitou Springs		1,707	2,032	852	4,590	37%	44%	19%	63%
wsL - Camp Creek (Queens Canyon)	3	1,020	2,616	838	4,477	23%	58%	19%	77%
wsQ - W. Monument Creek above Filtration Plant	3	2,591	529	854	3,977	65%	13%	21%	35%
wsA - Sand Gulch		391	261	1	653	60%	40%	0%	40%
wsB - Wellington Gulch		267	560	273	1,100	24%	51%	25%	76%
wsC - Unnamed		59	90	73	222	26%	41%	33%	74%
wsD - Unnamed (Mud across Hwy)		30	105	10	145	20%	73%	7%	80%
wsE - Cascade		47	143	255	445	11%	32%	57%	89%
wsF - Marygreen Pines		41	34	3	78	53%	43%	3%	47%
wsG - Unnamed		58	274	0	333	17%	82%	0%	83%
wsH - Waldo Canyon		404	473	236	1,112	36%	42%	21%	64%
wsI - Cavern Gulch		61			61	100%	0%	0%	0%
wsK - Williams Canyon	0	337	808	214	1,359	25%	59%	16%	75%
wsM - Unnamed (Alpine)		1	178	60	238	0%	75%	25%	100%
wsN - S. Douglas Creek	66	220	411	491	1,188	19%	35%	41%	76%
wsO - N. Douglas Creek		130	0		130	100%	0%	0%	0%
wsP - Dry Creek		68	38	4	109	62%	34%	3%	38%
wsR - N. Blodgett gulch	2	394	154	33	584	68%	26%	6%	32%
wsS - Devils Kitchen gulch	1	168	234	117	520	32%	45%	22%	67%
wsT - Northfield Res. gulch		43	27	197	267	16%	10%	74%	84%
wsU - Nichols Res. gulch		368	22	377	766	48%	3%	49%	52%
wsV - Wildcat Gulch		881			881	100%	0%	0%	0%
wsW - Rampart Res. shore 1		255			255	100%	0%	0%	0%
wsX - Rampart Res. shore 2		18	41		59	30%	70%	0%	70%
wsY - Camp Creek above Eagle Camp 1	0	53	160	64	277	19%	58%	23%	81%
wsZ - Camp Creek above Eagle Camp 2		100	323		423	24%	76%	0%	76%

Table B2. Sediment Production by Watershed – Changes from Pre- to Post-Fire

Waldo Canyon BAER -- Sediment Production by Watershed (Fire Effects)

"Correct" GIS-derived ERMiT Figures using geospatially-weighted averages

10 year runoff event 6th Field Watershed	Pre-Fire tons/ac	Post-Fire tons/ac	increase	Pre-Fire total tons	Post-Fire total tons	increase
Headwaters Fountain Creek	2.1	11.5	+ 440%	9,253	39,422	+ 326%
Cascade Creek-Fountain Creek	2.9	15.7	+ 442%	9,717	41,709	+ 329%
Garden of the Gods	2.7	12.8	+ 372%	23,685	103,928	+ 339%
West Monument Creek	2.3	11.0	+ 385%	12,041	53,013	+ 340%
Lower Monument Creek	2.6	12.8	+ 399%	10,222	48,420	+ 374%
Total	**2.5**	**12.7**	**+ 401%**	**64,917**	**286,492**	**+ 341%**

10 year runoff event Sub Watersheds (pour points)	Pre-Fire tons/ac	Post-Fire tons/ac	increase	Pre-Fire total tons	Post-Fire total tons	increase
wsJ - Fountain Creek above Manitou Spgs	2.5	13.6	+ 437%	18,590	79,496	+ 328%
wsL - Camp Creek (Queens Canyon)	2.5	11.6	+ 369%	16,751	73,605	+ 339%
wsQ - W. Monument Creek above Filtration Plant	2.2	10.9	+ 382%	11,393	50,701	+ 345%
wsA - Sand Gulch	2.3	10.5	+ 353%	2,325	9,009	+ 287%
wsB - Wellington Gulch	2.1	11.9	+ 469%	4,300	19,512	+ 354%
wsC - Unnamed	2.8	14.9	+ 435%	1,007	4,389	+ 336%
wsD - Unnamed (Mud across Hwy)	2.5	13.9	+ 450%	694	2,576	+ 271%
wsE - Cascade	2.1	12.0	+ 483%	2,085	9,724	+ 366%
wsF - Marygreen Pines	2.3	13.7	+ 507%	140	1,013	+ 622%
wsG - Unnamed	2.4	15.5	+ 556%	1,244	5,286	+ 325%
wsH - Waldo Canyon	3.7	19.0	+ 410%	4,767	20,277	+ 325%
wsI - Cavern Gulch	5.3	21.3	+ 304%	382	1,531	+ 301%
wsK - Williams Canyon	3.3	16.4	+ 391%	6,304	27,610	+ 338%
wsM - Unnamed (Alpine)	2.5	12.9	+ 410%	661	3,688	+ 458%
wsN - S. Douglas Creek	2.9	12.7	+ 344%	4,785	22,519	+ 371%
wsO - N. Douglas Creek	2.4	12.6	+ 437%	294	1,949	+ 563%
wsP - Dry Creek	2.4	17.1	+ 597%	484	1,853	+ 283%
wsR - N. Blodgett gulch	2.2	9.6	+ 332%	2,400	8,840	+ 268%
wsS - Devils Kitchen gulch	2.5	12.2	+ 381%	1,599	7,508	+ 369%
wsT - Northfield Res. gulch	2.0	12.3	+ 513%	709	4,222	+ 495%
wsU - Nichols Res. gulch	1.9	9.5	+ 411%	1,994	10,384	+ 421%
wsV - Wildcat Gulch	2.1	7.7	+ 264%	2,198	8,630	+ 293%
wsW - Rampart Res. shore 1	1.8	7.0	+ 286%	611	2,436	+ 299%
wsX - Rampart Res. shore 2	1.4	8.7	+ 506%	95	530	+ 459%
wsY - Camp Creek above Eagle Camp 1	1.6	9.6	+ 502%	463	2,837	+ 513%
wsZ - Camp Creek above Eagle Camp 2	1.9	8.3	+ 333%	867	4,161	+ 380%