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Burned Area Emergency Response Assessment
Technical Report
Airport Fire (CA-ORC-00127883)
December 2024

Airport Fire (USDA FS)

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Overview and Process

The Airport Fire is located in Orange and Riverside Counties on the Cleveland National Forest (NF), Trabuco Ranger District as well as on state, county, and private lands. The fire started off forest on September 9, 2024, from a work crew using heavy equipment. This assessment focuses on National Forest System (NFS) lands and Forest Service (FS) critical values as defined in the FS BAER policy. The Burned Area Emergency Response BAER team coordinates with other agencies such as the US Geological Service (USGS), California State Watershed Emegency Response Team (CA WERT), National Weather Service (NWS), emergency management agencies, and others to conduct the assessment and share information. The fire was contained on October 5, 2024, having burned 23,688 acres. Approximately 91% of the burned area lies on the Cleveland NF with roughly 2,287 (9%) on county and private lands. The fire resulted in the loss of multiple structures on NFS lands, with damages to a FS-owned helibase, two recreation residence tracts, two campgrounds, picnic areas, and other small intrastructure. Other non-FS lands and private communities were also burned over resulting in damages and loss of structures.

The burned area is dominated by extremely rugged slopes, with the Santa Ana Mountain ridgeline crest reaching elevations of 1,200 to 1,700 m (3,940 to 5,580 ft). The headwaters of the Santiago and Trabuco creek watersheds form on the western side of this ridgeline, descending steeply into Orange County to the west, flowing to the Pacific Ocean. The range is deeply dissected and extensively developed, with long, linear watersheds predominantly oriented east to west. Steep tributary canyons storing sediment have formed along the flanks of the main channels.

A Forest Service (FS) Burned Area Emergency Response (BAER) team was assembled on September 22, 2024, to evaluate post-fire threats and determine the level of risk to critical values on NFS lands. The BAER assessment team's objective is to recommend potential treatments to reduce post-fire risks. The team also coordinated closely with interagency partners to identify threats to values downstream of NFS lands. This report describes the rapid characterization of post-fire watershed conditions and recommendations on NFS lands. Similar reports are being prepared by the California Watershed Emergency Response Team (CA WERT) and the counties of Orange and Riverside.

Picture 1. Burned Terrain in Modjeska Canyon Watershed (USDA FS)

Burned area emergency assessments are rapid evaluations done to determine if critical values are at risk due to imminent post-fire threats and to develop appropriate actions to manage unacceptable risks. Critical values identified by the BAER team included life and safety, recreation and transportation infrastructure, cultural and heritage sites, critical aquatic and wildlife habitat, and other natural resource values. These assessments are not intended to provide a comprehensive evaluation of all fire or fire-suppression damages, nor to identify long-term rehabilitation or restoration needs.

The first step in a burned area assessment is to identify specific values that are potentially at risk from post-fire events. Once these critical values have been identified, each is individually assessed for potential threats from post-fire conditions. To characterize post-fire threats, the BAER team makes field observations of soil and watershed conditions that are used in conjunction with analysis methods to estimate anticipated levels of post-fire damage from erosion, flooding, and geologic hazards. A post-fire emergency is identified when a critical value found to be at unacceptable risk of damage due to post-fire conditions. After defining the post-fire emergency, a response strategy that considers natural recovery is developed to mitigate the risk. The response strategy is reviewed and if approved, implemented to limit risk.

General Resource Setting

Geology

The Airport Fire occurred on the Santa Ana Mountain block, bounded by the Elsinore fault zone to the east and the Christianitos fault zone to the west. The burn area is underlain predominantly by Jurassic-aged Bedford Canyon formation, a slightly metamorphosed assemblage of marine sediments, and Cretaceous-aged heterogeneous granitic formations, and overlain by Quaternary alluvial and surficial sediments to present age (Morton and Miller, 2006). Young landslide deposits, Holocene and late Pleistocene in age, are pervasive throughout the burn area due to steep topography and highly fractured rock. These deposits are composed of displaced bedrock blocks and/or poorly sorted rubble.

Hydrology

Elevation across the Airport Fire burn area ranges from about 1,075 feet along Hot Spring Canyon to 5,687 feet at the top of Santiago Peak. At select pour points, the annual precipitation totals range between 17 and 25 inches and arrive between November and April, although summer thundershowers do occur in summer and early fall.

Damaging Storms: There are a few types of damaging storms typical for this area. Short duration, high intensity storms (such as a monsoonal thundershowers) can trigger debris flows and could cause localized flooding in small catchments. These kinds of precipitation rates can exceed infiltration rates and cause rapid runoff. Thunderstorms and effects tend to be localized and occur in summer and early fall.

Atmospheric rivers are longer duration storms and occur regularly across California and vary in size in magnitude. They deliver large amounts of warm, water vapor from the Hawaiian latitudes, typically between November and March. These warm, long duration storm events can cause major deluges and torrential rains leading to catastrophic flooding. Stream channels in the burn area have the potential to flash flood.

Picture 2. Hot Springs Canyon (USDA FS)

Functioning of hydrologic processes is connected to vegetation (type, density, litter and organic matter accumulation) and soil types. Fire causes impacts to several hydrologic processes including reduction in interception, transpiration, and infiltration, and the rate of runoff (due to lack of litter and decreased surface roughness). Removal of vegetation and changes to soil such as increases in hydrophobicity, changes in soil structure, and removal of duff and organic matter alters these processes and ultimately lead to increases in runoff, peak flows and erosion. These alterations are typical of soils classified as having incurred moderate to high soil burn severity. Trees with remaining overstory contribute to post-fire cover through needle cast. Needles remaining in trees intercept rainfall and once needles fall to the ground, offer protective cover to damaged soils, reducing erosion and providing surface roughness. Given the large percentage of moderate and high soil burn severity, widespread hydrophobicity and vegetation mortality, watershed response is expected to be significant The Airport Fire has some overlap with the Holy Fire of 2018. Between February 13-15, 2019, an atmospheric river storm event went through the Holy Fire footprint and triggered a flood event that caused damage in Trabuco Canyon. A report was conducted after the storm to determine what kind of discharge and recurrence interval of the flood event triggered the flooding. Gauges that were installed varied on the Return Interval (RI) from approximately 10 to 25 years (Fudge, 2019).

Picture 2. Overview of Airport Fire (USDA FS)

In the headwaters of Santiago, Trabuco, Bell, and Hot Springs Canyons (Picture 3), there is very little ground cover and recruitment potential from the upper canopy is mostly absent. Watershed response is expected to be higher in these canyons than those that burned patchier (e.g. Lion Canyon, drainages converging at El Cariso Campground).

Analysis and Results – Post-Fire Conditions

Soil Burn Severity

Assessment of soil burn severity is one of the first steps in the USDA Forest Service BAER process. Post-fire soil burn severity (SBS) is often mapped with the intention of identifying the degree to which the fire has affected soil characteristics that impact soil health and hydrologic function, and hence erosion rate and runoff potential. Soil burn severity is not a simple assessment of vegetation consumption, but rather an integration of vegetation loss, changes in soil structure and infiltration capacity, remaining vegetation and duff layers, ash, and soil color, all of which may indicate relative degrees of soil heating. The soil burn severity map serves at a basis for post-fire modelling and interpretations such as debris flow hazards, changes to peak flows and flood flows and hillslope erosion potential.

The final soil burn severity maps were developed with *ESRI ArcGIS* software using satellite-imagery-derived Burned Area Reflectance Classification (BARC) and field survey data collected. Field work to document and confirm soil burn severity was completed from September 22 to 25, 2024. Field work included assessment of ash characteristics, ground cover, roots, soil structure, soil water-repellency, and vegetation burn severity as described in the *Field Guide for Mapping Post-fire Soil Burn Severity* (Parsons et al. 2010*)*. Hydrophobicity was measured in the field but was not used as a determining factor of soil burn severity. In some forest vegetation types, strong surface hydrophobicity was found within and outside of the burned area in unburned conditions. In burned areas, it was often present in forested sites, but its severity was variable. Field assessment sites covered as many burned conditions within each vegetation type as possible in the time available, however the process is still considered a rapid assessment and is not guaranteed to capture all variability. Field data were used to adjust the Burned Area Reflective Classification (BARC) map to produce the final soil burn severity.

Picture 3. Recovery as seen in chaparral landscapes Holy Fire (USDA FS)

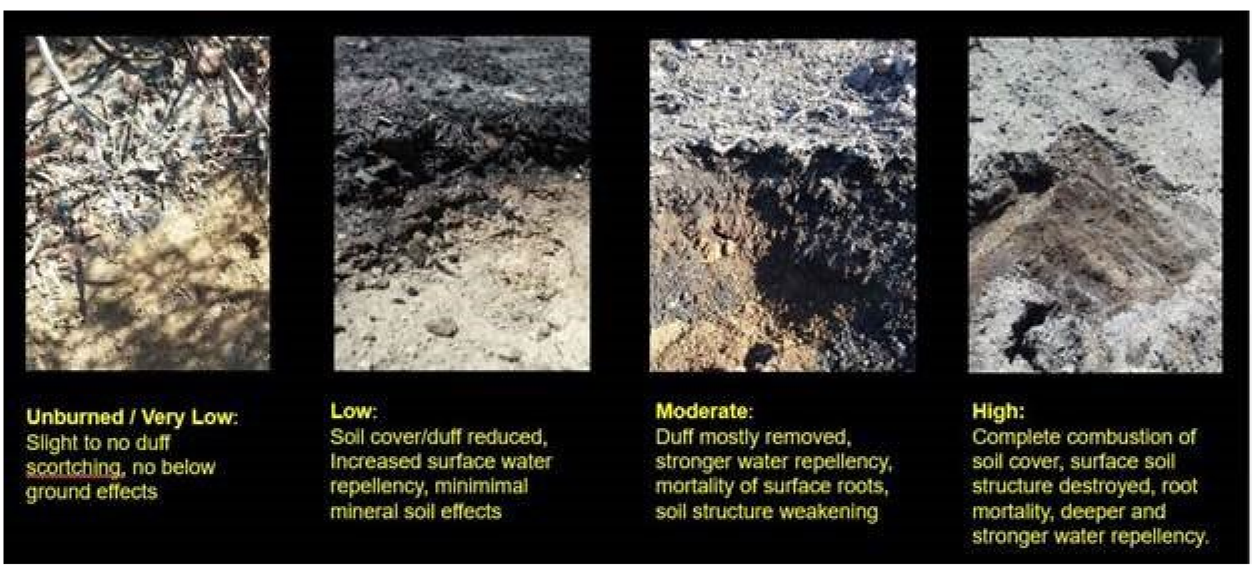
Grasses and sparse shrubs usually experience extremely rapid consumption and spread rates during wildfire events, with very little heat residence time at the soil surface. There are many other factors that lead to low soil burn severity in other vegetation types. The result is very little alteration of soil organic matter and little or no change in soil structural stability. Water repellency, occasionally present under shrubs before the fire, may or may not be exacerbated by the fire. Very low and low soil burn severity was classified in areas where the surface organic material was charred or partly consumed. Roots close to the soil surface were usually still pliable, and soil structure was mostly unchanged. Most grassland areas burned at very low to low severity; however, low severity conditions were found in all vegetation types. Vegetation recovery is anticipated to be rapid in these areas and sprouting was observed in some grasslands during the assessment. Post-fire erosion response in areas of low soil burn severity will be somewhat variable. Some low-severity areas under forest vegetation will have litter and organic material additions before the wet season; however, some of the grass and shrublands have little or no surface cover remaining except rock.

Picture 4:High burn severity in riparian oak woodland. (USDA FS)

Dense vegetation, with a deeper litter and duff layer, results in longer duration heat on the surface soils, and thus, more severe effects on soil properties. For example, deep ash after a fire usually indicates a deeper litter and duff layer prior to the fire. This results in loss of soil organic cover and organic matter, which are important for erosion resistance and the formation or exacerbation of water repellent layers at or near the soil surface. The results are increased potential for runoff and soil particle detachment, and transport by water and wind. High soil burn severity was not widespread (2.7% of the burned area), but where it occurred, effects are deep and severe. Most high burn severity had complete consumption of organic material with the surface layers of the soil resulting in a change to single-grain structure. Fine roots were commonly charred or consumed up to 3-5 cm deep. The highest-severity areas often had a loose, dusty appearance, and no longer had any cohesion or soil strength. This condition was found where forested vegetation had accumulated enough fuel on the soil surface to cause high severity, or long-duration heat impact to the soil.

The moderate class of soil burn severity is far more diverse in observed soil conditions and can include and impact various vegetation types, ranging from forests to shrub communities. In forested areas the litter layer may be largely consumed, but scorched needles and leaves often remain in the canopy and will rapidly become effective ground cover. This is important in re-establishing protective ground cover and soil organic matter. Generally, there will be less destruction of soil organic matter, roots, and structure in an area mapped as moderate compared to an area mapped as high SBS. In a shrub ecosystem, even where pre-fire canopy density was high, the litter layer is generally thin, and while the shrub canopy may have been completely consumed by the fire, the soil structure, roots, and litter layer may remain intact beneath a thin ash layer.

The Soil Burn Severity map product is used as an input for all the methods presented in this report; it is the basis for determining the anticipated level of post-fire watershed response. Unburned or very low SBS covered 3.2% of the fire perimeter, low SBS covered 16.6%, moderate SBS covered 77.5%, and high severity covered 2.7% (Figure 1).



Picture 6. Photos of the four classes of soil burn severity. On the left, unburned/very low, low soil burn severity. In the center, moderate soil burn severity. On the right, high soil burn severity. (USDA FS)

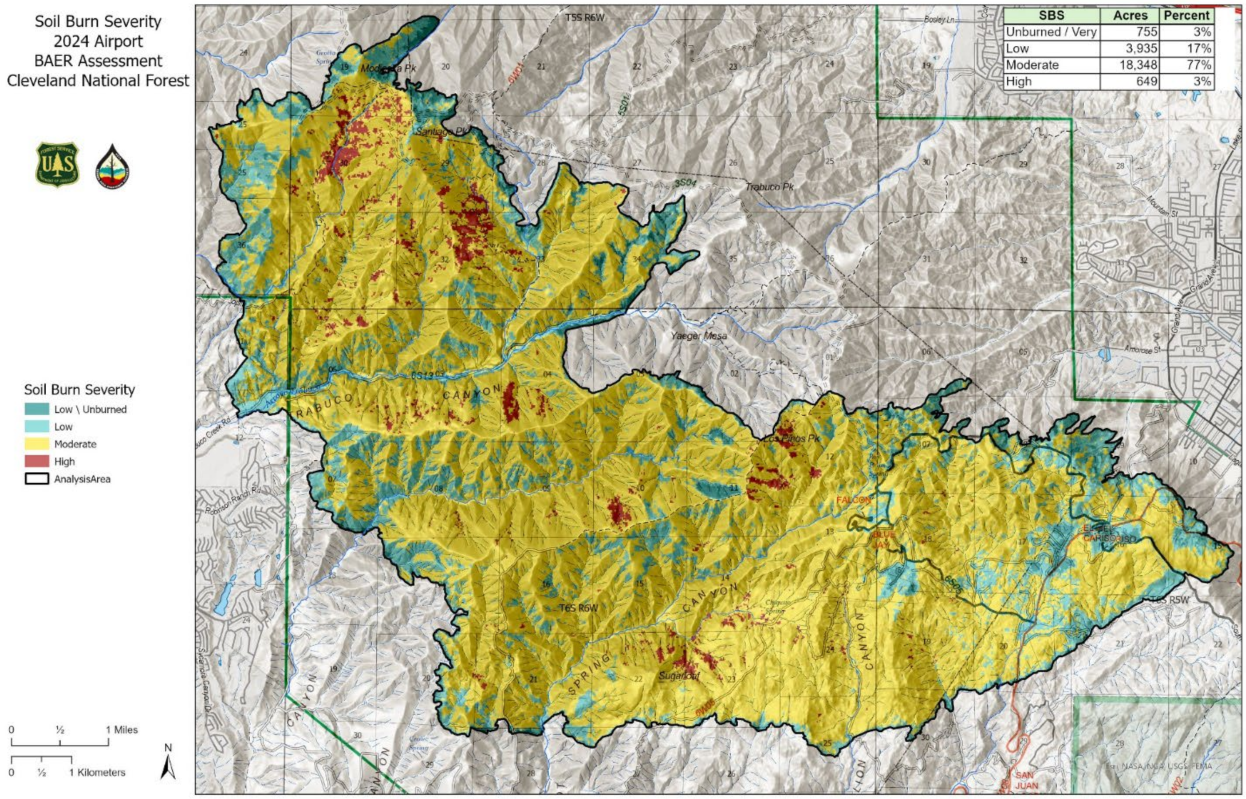


Figure 1. Soil burn severity map for the Airport Fire.

Soil Erosion

Erosion rates following wildfires are determined by several key factors, including soil burn severity (SBS), topography, soil type, precipitation, and pre-fire vegetation type. In the case of the Airport Fire, these variables interact in complex ways across different elevations, influencing the overall erosion risk and post-fire recovery. The ERMiT (Erosion Risk Management Tool) model was used to predict the erosion rates and spatially display erosion source areas (USFS, RMRS-GTR-188, 2007). (Appendix A. Map Products). Water repellency is a natural soil property, but heat from the fire vaporizes some of the compounds and they condense lower in the profile when they contact cooler soil. This tends to make the water repellency stronger, or more severe. Water repellency is exacerbated by long term drought because the microbial process that attenuates water repellency is disrupted in dry soil. In this case, decomposition of the water repellant compounds is outpaced by the deposition. In the Airport Fire, water repellency was mixed intensities throughout the fire area but was observed in nearly all soil observations across the fire. On the east side of the fire in the granitic soils, water repellency was strong at all soil burn severities. However, as the clay fraction of the soils increased moving west in the burn zone, the water repellency was variable between strong and moderate intensities. In this area, High SBS tended to have less repellency because the higher clay content reduced the depth of water repellency allowing the high heat of a High SBS to cook off the water repellent layer.

Erosion rates are determined primarily by soil burn severity, topography, soil type, precipitation and pre-fire vegetation type. In the high elevation portion of the fire, the higher erosion rates tracked consistently with increasing SBS.

As expected, the very steep slopes in the Santiago Peak area have the highest predicted erosion rates exceeding 10 tons/acre. Although not as high erosion as Santiago Peak area, Trabuco, Bell and Hot Springs Canyons are expected to generate enough sediment to contribute to flow bulking.

The ERMiT model does not factor in any soil stabilization from root regrowth following fire. Due to the intact seedbanks in the low SBS area and additional rapid resprouting in the moderate SBS areas, we expect some stabilization effect from herbaceous roots and minimally from crown growth before winter. This stabilizing effect will likely result in lower erosion rates than were modeled. In the high and moderate SBS areas, we expect sediment delivery to be less that indicated. Since these areas already lost much of the topsoil from wind and gravity erosion following the burn.

In areas of high SBS within the chaparral, coarse-textured soils are common. These soil types allow heat from the fire to penetrate more deeply, causing more extensive soil damage and higher SBS, which in turn leads to increased erosion rates.

The ERMiT model used for predicting erosion rates does not factor in the stabilizing effects of root regrowth, particularly in areas with intact seed banks. In low SBS areas, we expect some soil stabilization to occur due to the regrowth of herbaceous plants and forbs before winter arrives, as well as ground cover provided by needle cast in timbered areas. This regrowth will likely help reduce erosion in these lower SBS areas.

Table 1 below provides a summary of predicted erosion rates for several drainage basins of interest. These basins have been identified as critical for the Forest Service's post-fire response and management.

Table 1:

	Area	**Percentage SBS by Pourshed**				**Erosion Rates**		**Sediment Potential**	
Pourpoint watershed	**Acres**	**Unburned**	**Low**	**Moderate**	**High**	2 year (tons/acre)	5 year (tons/acre)	2 year event Sediment Potential (yd^3/mile^2)	5 year event Sediment Potential (yd^3/mile^2)
Bell Canyon at Fire Boundary	3231	2	15	82	1	3.2	9.7	2058	6206
Falls Canyon (confluence to Trabuco Canyon at Road)	702	0	5	90	5	3.5	10.3	2256	6593
Holy Jim Canyon (upper crossing)	1993	27	10	57	6	3.3	8.3	2081	5342
Hot Springs Canyon	5920	20	8	70	2	2.0	6.4	1297	4088
Trabuco Canyon at FS Boundary	8747	38	8	51	3	2.4	6.6	1524	4213
Airport Fire within Perimeter						**3.0**	**8.5**	1912	5426

Hydrology

Hydrologic response following wildfire in the Airport Fire burned area will include reduced interception and infiltration of precipitation, increased runoff and erosion, higher stream flow volumes for a given precipitation or snowmelt input, and a more rapid rise of stream and river levels compared with those of unburned conditions. Additionally, the probability of severe erosion, debris flows, and hillslope failure is substantially higher and will remain so for at least the next few years.

Water quality in streams that drain the burned area will be impaired during runoff events, particularly following high-intensity winter rain events. An initial flush of ash and fine sediment is likely in response to the first intense rain events of fall and winter. Suspended sediment loading and turbidity levels in streams within and below the burned area will likely be elevated in response to rainfall and in subsequent years, until groundcover becomes re-established. Even after groundcover stabilizes hillslopes in the burned area, eroded fine sediment that was deposited in draws, stream and river channels, and floodplains in the next few years will continue to move through the system for many years to come. Large woody debris will likely accompany the initial flush of fine sediments and ash, with continued downstream delivery of large debris during high-intensity rain events. Additionally, levels of some nutrients will likely be elevated in concert with higher turbidity and suspended load. Lastly, stream temperature in perennial streams is likely to increase relative to pre-fire conditions where shade has been lost. Riparian vegetation will recover in a relatively short period of time, but shading for larger channels from tall trees will take decades to recover. Changes in water quality will persist within and downstream of the burned area and will impact aquatic resources and habitat.

Picture 8. Santiago Canyon (USDA FS)

Typical USDA Forest Service BAER hydrology analytical methods include a field assessment to identify critical values vulnerable to flood and related damage, an estimation of post-fire hydrologic response to rain and snowmelt events, and evaluation of potential mitigation measures to reduce risk of damage to critical values. Prior to the field assessment, the burned area is reviewed using maps and aerial imagery, including the initial BARC data. Buildings, transportation infrastructure (e.g. roads, culverts, bridges), water developments, natural resources, and recreation areas adjacent to streams within and below the burned area are identified and prioritized for field assessment. In the field, these critical values are examined to determine their vulnerability to damage from post-fire flooding. The field survey typically includes qualitative assessments, as well as quantitative data collection where modeling is warranted.

Following the field assessment, the approximate change between pre-fire and post-fire runoff for one or more probable events (precipitation or runoff) is typically estimated for areas of concern. A range of models and techniques are used to estimate post-fire runoff and erosion. Each approach has its advantages and shortcomings. Given the short timeframe in which BAER assessments occur, and the challenge of modeling ungauged basins in a post-fire environment, any estimation of post-fire watershed response is imprecise at best. Therefore, BAER assessment teams generally avoid reporting stream runoff estimates as specific flow values, but instead report the estimated magnitude of change in runoff response between pre- and post-fire conditions. These estimates assist in determining where measures should be considered to reduce the risk of damage to critical values from elevated runoff response.

Flood potential will decrease as vegetation reestablishes, providing ground cover, increasing surface roughness, and stabilizing and improving the infiltration capacity of soils. Modeling for post-fire flooding was conducted on selected pour points that were associated with specific critical values and/or that might be representative of watershed response in a general area, see Map 2 (in Appendix A). Pour points are points on the landscape through which all water upslope of the point passes through.

Due to the wide variability of factors that are hard to account for (e.g., what storms may happen in the future) and approximate nature of the modeling tools, it must be noted that any results from modeling should be cautiously used, and that these values are giving us a broad look at how the watershed *may* respond.

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Due to the wide variability of factors that are hard to account for (e.g., what storms may happen in the future) and approximate nature of the modeling tools, it must be noted that any results from modeling performed should be cautiously used. These values give us a broad look at how the watershed *may* respond. Because of the lack of unregulated stream gages and size of the impacted watersheds, the USGS regression equations for South Coast (Region 5) were selected to estimate pre- and post-fire flows (Gotvald, et al., 2012).

USGS Regression Equations: Regional regression equations were developed to estimate magnitude and frequency of flows in ungaged watersheds based on analysis of discharge at gaged sites and relationship with significant basin characteristics. The South Coast (Region 5) is applicable to the burn area. South Coast regional regression equation (Gotvald, et al, 2012) uses inputs of drainage area, elevation and mean annual precipitation to estimate peak discharge for different return intervals.

Estimates of post-fire flooding are related to the acres within a pour point watershed. To determine pre-fire discharge using regression equations, no adjustments are made to calculated flows at a given pour point for the selected peak flow (Q2 for this analysis). For estimates of post-fire discharge at the same pour point, the percentage of high SBS, moderate SBS, low SBS, and unburned acres is calculated from the soil burn severity map modified from the BARC and field observations. The addition of a category for moderate soil burn severity without future needle cast potential was also added. For this analysis, runoff from unburned soil burn severity areas is assumed to be unchanged (Q2); runoff from low soil burn severity areas are assumed to respond similar to a five-year discharge (Q5); runoff from moderate soil burn severity areas are assumed to respond similar to a ten-year discharge (Q10); and runoff from high soil burn severity areas and moderate soil burn severity areas with no needle cast potential are assumed to respond similar to a twenty-five year discharge (Q25). Applicable regression equations for Q2, Q5, Q10, and Q25 are applied to each category. The sum of the flows at these various recurrence intervals estimates the response of the newly burned landscape from an event that would typically generate a 2-year peak flow.

The analysis for pre- and post- fire hydrologic response and probability of flows is based on the probability of a 2-year storm occurring in the fire area (assuming a 2-year storm event will produce a 2-year runoff event). The 2-year, 24-hour duration storm for the burn area ranges approximately between 4 to 5.5 inches based on National Oceanic Atmospheric Administration (NOAA) precipitation tables (NOAA, 2024). The storms expected to occur within the fire burned area that could produce damaging post-fire effects is a short duration, high intensity rainstorm (likely to cause localized effects), a longer duration rainstorm associated with an atmospheric river (causing flooding in large mainstems), or a rain-on-snow event (causing flooding in large mainstems). Intensity within a storm and antecedent soil moisture are both spatially variable. Ultimately, when precipitation intensity is greater than infiltration rates or exceeds infiltration capacity, runoff initiates and erosion potential increases.

Bulking factor: Post-fire flows will be bulked with sediment and woody debris increasing the volume of runoff, which could negatively impact culverts, constructed channel ways, and other infrastructure designed to pass “normal” flows. Many steeper slopes on the fire coincide with evidence of historic debris flows, especially in the Trabuco Canyon, Santiago Canyon, Bell Canyon and Hot Springs Canyon drainages. These areas contain stored sediment and will possibly be mobilized in post-fire storm events. Bulking and increased flows may cause channels to flood, divert, or migrate to areas that do not usually flood. A bulking factor of 1.25 was applied to post-fire estimates (Foltz et al., 2009).

Table 2. Comparison of pre- and post-fire peak flow related to the 2-year return interval

Critical Values Pour Point Watersheds	Drainage size (acres)	% of Mod & High SBS	Pre-Fire Discharge (cfs) Q2	Post-Fire Discharge (cfs)	Post-Fire Discharge, Bulked (cfs)	Bulked Q Compared to Pre-Fire Q (Times Increase)
Falls Canyon (confluence to Trabuco Canyon at Road)	703	95%	43	244	305	7.08
Holy Jim Canyon (upper crossing)	1,994	63%	89	502	627	7.08
Hot Springs Canyon	5,925	73%	157	931	1164	7.43
Bell Canyon at Fire Boundary	3,234	83%	111	681	852	7.69
Trabuco Canyon at FS Boundary	8,754	54%	229	1300	1625	7.11
Lion Canyon	1,972	59%	70	306	383	5.44

Santiago Canyon	2,579	53%	110	620	775	7.03
El Cariso at FS Boundary	190	42%	14	51	64	4.63
Long Canyon at Long Canyon Rd	1,259	80%	54	282	353	6.5

There are many non-Forest Service values within and downstream of the Airport Fire burned area that are at elevated risk of damage from flooding, debris flows, and increased sediment and debris deposition. People, houses, and other structures or other private property located in on fan deposits, valley bottoms adjacent to streams or in other flood-prone areas are potentially at risk of injury or loss of life in the event of post-fire runoff events. The structures and other property are also likely at increased risk of damage from post-fire flooding or debris flows. In several locations, structures and gathering areas are located on alluvial and debris flow fans or in flood-prone areas adjacent to or downstream from burned drainages. Areas of concern include but are not limited to the Recreation residences in Holy Jim, Trabuco, and Hot Springs, Santiago Canyon Road outside the fire footprint, and O'Neil Regional Park among others.

Representatives from appropriate agencies (e.g. County Disaster and Emergency Services, California Watershed Emergency Response Team, National Weather Service, USDA Natural Resources Conservation Service) have begun to determine where risk assessments and mitigation measures may be appropriate on lands outside the National Forest.

Changes in hydrologic processes can also lead to slope instability and result in post-fire debris flows, mudflows, and other mass wasting. Flat areas with diffuse channels will be depositional zones for adjacent steeper slopes. Meadows are depositional areas where flows can spread out in large runoff events, especially with sediment laden flows and woody debris. Dormant channels may be reactivated in post-fire runoff events.

Watershed response in the burn area will pose a high to very high risk to human life, safety, and infrastructure. The combination of increased flows, sediment loads, and woody debris are very likely to cause drainage control structures to fail (culverts, ditches, infrastructure crossing drainages, etc.). It is important to note that downstream areas that experience regular flooding or difficulty controlling drainage during small storms will be very likely to experience flooding and/or failure in post-fire storms.

State, private, and county roads are located within and immediately downstream from the burned area. Potential post-fire impacts include injury or loss of life to travelers on these routes, as well as damage to the road system and/or loss of access due to increased runoff rates that overwhelm the capacity of bridges and culverts, plugging of structures by debris or sediment, erosion of the road surface, or deposition of sediment or debris on road surfaces. Responsible agencies should be encouraged to evaluate the vulnerability of their road systems in the post-fire environment and take appropriate measures to mitigate any risks identified. Based on the potential for flooding, the BAER team identified risks to the public, Forest employees, special use permittees, and cooperators in the Airport Fire affected area, especially in low-lying areas, burned drainages, and downstream of burned catchments. Several FS critical values are located on floodplains and low-lying areas that are at risk from increased runoff, floatable debris, erosion, and sedimentation. Given the variation in topography, geology, and elevation, different areas of the fire will respond differently.

In the Trabuco Canyon, Santiago Canyon, Bell Canyon, and Hot Spring Canyon drainages, there is evidence of past debris flows, rock fall, and flooding in the pre-fire environment. Risk of flooding and sediment laden flows occurring will be exacerbated by the fire.

Slope instability and increased runoff during storms could pose a very high risk to life and safety for use of trails in the burn area, especially at low-water crossings or at bridges that could become flooded. Among other hazards, channel crossings could be dangerous for hikers due to increases in volume, bedload, velocity, and woody debris until the watershed stabilizes.

Hazardous post-fire watershed responses are very likely to impact access roads (both FS and non-FS roads and highways). Impacts to access could leave forest users stranded, in areas with poor cell coverage, and/or in areas subject to rockfall, flooding, and debris flows, especially if they try to evacuate during storms.

Overall, the primary watershed responses are expected to include: 1) an initial flush of ash, 2) rill, gully, and mass wasting erosion in drainages and on steep slopes within the burned area, and 3) increased peak flows and sediment deposition. Channel crossings, valleys, meadows, and floodplains have an inherent risk of flooding which will be intensified by the fire. Increased runoff and sediment delivery may cause channel migration in flood events. Lateral channel migration can erode cut banks and undercut slopes. Aggradation can increase probability of channel migration and flooding.

Geologic Hazards

Geologic hazards commonly exacerbated by fire are debris flow and rockfall. Rockfall is most common on steeper slopes, especially along stream banks and roadcuts. Under post-fire conditions, burned watersheds with steep slopes and first-order channels that contain significant volumes of stored sediment are likely to experience increases in runoff and erosion from a lack of protective vegetation cover, soil hydrophobicity, and loss in cohesive root strength, which can generate debris flows (Kean et al., 2011; Parise and Cannon, 2012; and Kean et al., 2019). Post-fire debris flows initiate as result of progressive bulking or accumulation of slurry in stream channels (Cannon, 2000, 2001; Cannon et al., 2001a). Runoff generated slurry typically has high sediment concentrations (40–65 percent) and can scour colluvial and fluvial stream deposits. The flow can then progressively grow as it moves downstream by recruiting boulders and woody debris, resulting in destructive debris flows (Iverson, 1997). Hydrologic processes such as debris flows and hyper-concentrated flows threaten life, property, and infrastructure. They can destroy houses, block, or erode roads and cause transportation impacts, sever pipelines, damage utilities and add large quantities of sediment to stream channels that impact water resources (Schwartz et al., 2021).

Picture 9: Santiago Peak with deep debris chutes visible dropping steeply away from the road *(USDA FS).*

Reconnaissance of the burned area included ground surveys, an aerial reconnaissance flight, an analysis of the USGS debris flow model and an analysis of aerial imagery. The Geographic Information System (GIS) coverages of bedrock and geomorphology for the Cleveland National Forest were verified in the field. Assessment of the burned area included identification of critical values in and downstream of the burned area, identification of pre-fire slope failures and pre-fire slope and channel failure deposits, measurements of slopes, identification of geological units, field verification of soil burn severity, notes of observations and photography. In addition to ground surveys, a review of published geologic maps, GIS data and geoscience publications was conducted.

From ground surveys and an aerial reconnaissance flight, it is evident that pre-fire mass wasting as rock-fall, shallow landslides, and some old debris flow deposits exists throughout major portions of the burned area. Throughout the Airport Fire burn scar most slopes and drainages are loaded with unsorted, unconsolidated materials comprised of rocks of all sizes including boulders, cobbles, gravels, and fine sediments, available to be transported. This is related to the type of parent materials, the steep slopes and continues gravitational and hydrological mobilization of rocks and sediments down slopes and drainages. Scanning the burn scar from south to north, some of the drainages in the burn scar that present large amounts of unsorted, unconsolidated materials available to be transported. In most of these watersheds, in addition to the fact that large amounts of sediments are present and available to be transported, major portions of these watersheds experienced moderate to high soil burn severity. From ground surveys and aerial reconnaissance, it is evident that many of the steep shoots flowing into the major creeks in the burn scar are loaded with sediments.

Picture 10: Large dry ravel cones forming along lower Trabuco road due to high rates of erosion (USDA FS).

As a result of the fire and the removal of supportive vegetation, post-fire dry ravel and rockfall was observed on slopes, impacting roads, and further loading channels with fine sediments and rocks (Picture 10). In addition to the fact that many of these drainages impacted by the fire experienced a moderate to high soil burn severity, many of the slopes in the burn area are steep (40-60%) or very steep (60+%) slopes.

Within the Airport Fire burn scar, widespread evidence of debris flow deposits was identified in many watersheds, and creek bottoms (Picture 11). For the most case, these debris flow deposits were mobilized during storms under pre-fire conditions. Since that the Airport Fire burned such a high percentage of the landscape at the headwaters of watersheds and on steep slopes, debris flow initiation and mobilization is expected to dramatically increase due to post-fire conditions.

Picture 11. Large debris fan deposit in Trabuco Canyon, taken after the Holy Fire of 2018. Similar size and aged deposits are mapped at the headwaters of Bell and Hot Springs Canyon (USDA FS).

USGS Debris Flow Assessment

The US Geological Survey (USGS) Landslide Hazards Program has developed empirical models for forecasting the probability and the likely volume of debris flow events using ongoing research. The USGS model uses geospatial data related to basin morphometry, soil burn severity, soil properties, and rainfall characteristics to estimate the probability and volume of debris flows that may occur in response to a design storm (Staley, 2016). Estimates of probability, volume, and combined hazard are based upon a design storm with a peak 15-minute rainfall intensity of 12 – 40 millimeters per hour (mm/h) rate. The final Airport Fire soil burn severity map was used by the USGS to model debris flow probabilities and volumes of materials within the fire area.

We selected a design storm of a peak 15-minute rainfall intensity of 24 millimeters per hour (mm/h) rate to evaluate debris flow potential and volumes, since this magnitude of storm seems likely to occur in any given year. NOAA Atlas 14 indicates this is approximately a 1-2 year storm for the burn area.

Debris flow probability and volume were estimated for each basin in the burned area as well as along the upstream drainage networks, where the contributing area is greater than or equal to 0.02 km^2, with the maximum basin size of 8 km^2. (Scientific background information for Emergency Assessment of Post-Fire Debris-Flow Hazards can be found at: https://www.usgs.gov/natural-hazards/landslide-hazards/science/scientific-background?qt-science_center_objects=0#qt-science_center_objects).

The probability model was designed to predict the probability of debris-flow occurrence at a point along the drainage network in response to a given storm. The volume model was designed to estimate the volume (m^3) of material that could issue from a point along the drainage network in response to a storm of a given rainfall magnitude and intensity. Debris-flow hazards from a given basin can be considered as the combination of both probability and volume. For example, in each setting, the most hazardous basins will show both a high probability of occurrence and a large, estimated volume of material. Slightly less hazardous would-be basins that show a combination of either relatively low probabilities and larger volume estimates or high probabilities and smaller volume estimates. The lowest relative hazard would be for basins that show both low probabilities and the smallest volumes.

Kean et al. (2013) and Staley et al. (2016) identified that rainfall intensities measured over durations of 60 minutes or less are best correlated with debris-flow initiation. It is important to emphasize that local data (such as debris supply) influence both the probability and volume of debris flows. Unfortunately, local specific data are not presently available at the spatial scale of the post-fire debris-flow hazard assessment done by the USGS. As such, local conditions that are not constrained by the model may serve to dramatically increase or decrease the probability and (or) volume of a debris flow at a basin outlet.

Within the burned area of the Airport Fire, some drainages show a great deal of past mass wasting such as landslide, debris flow, and rockfall activity that will be increased during future storms. Dry ravel is common in steep canyons such as Trabuco Canyon in unburned conditions. Fire will further weaken these slopes and increase erosion. Old landslide and debris flow deposits in canyon headwaters indicate the mass wasting potential of these canyons, and as conditions have changed due to the fire, erosion and new mass wasting might be initiated.

Several high potential debris flow, landslide, and rock-fall hazard areas were identified in the Airport Fire, based on ground observations and the US Geological Survey (USGS) Debris Flow Model. The USGS - Landslide Hazards Program, has developed empirical models for forecasting the probability and the likely volume of post-fire debris flow events. To run their models, the USGS uses geospatial data related to basin morphometry, burn severity, soil properties, and rainfall characteristics to estimate the probability and volume of debris flows that may occur in response to a design storm (Staley, 2016). Estimates of probability, volume, and combined hazard are based upon a design storm with a peak 15-minute rainfall intensity of 12 – 40 (mm/h) rate.

The magnitude of storm that was chosen for analysis was a peak 15-minute rainfall intensity storm of 24 mm/hr rate (0.94 in/hr), equivalent to the accumulation of 6 mm (0.24 inches) in 15 minutes. Based on NOAA Atlas 14, the 1-hr storm at this intensity has a 1-year recurrence interval (RI) within the burn area. The 15-minute peak intensity has been shown to be the most predictive metric for debris flow initiation as post-fire debris flows are most often triggered by high-intensity, short-duration bursts of rain (USGS).

The USGS debris flow model estimates high probabilities of debris flows forming in over 60% of the Airport burn area. The largest watersheds within the burn (Santiago, Holy Jim and Trabuco, Bell, Hot Springs Canyon) have modeled debris flow likelihoods of 80-100% in a 1-year recurrence interval (RI) storm. Model results are supported by observations of significant flooding and debris flow responses at the outlet of Trabuco Canyon following the 2018 Holy Fire and at the base of the burned tributary following the 2016 Holy Fire.

There will be a significant geologic response to post-fire rainfall for several years. This will include debris slides and significant hillslope erosion, debris flows forming in the headwaters and routing into main channels, and increased rockfall and landslides.

Summary of Post-Fire Watershed Response:

- Soil burn severity was moderate to high across roughly 80% of the burned area.
- Erosion will be elevated in most of the burned areas, and substantially elevated on and near areas of moderate and high soil burn severity on roughly the southern third of the fire.
- Ash and fine sediment will likely be transported to stream channels and washed downstream during the first fall rainstorms.
- The Airport Fire in general has modeled higher percent increases in a 2-year flood event discharge when compared to the Holy Fire. The post-fire 2-year discharge for the Airport Fire is comparable to a 10–25-year pre-fire discharge. A 2-RI storm event is likely to cause flooding in low-lying areas and downstream due to the Airport Fire landscape
- Mobile woody debris in many of the stream channels throughout the burned areas will likely be entrained in flood flows.
- Water quality in streams and the nearshore environment will be impaired by ash, fine sediment, nutrients, and dissolved organic carbon during and following rainfall on the burned areas.
- The USGS debris flow model estimates high probabilities of debris flows forming in the Airport burn area in over 60% of the burn area. The largest watersheds within the burn (Santiago, Holy Jim and Trabuco, Bell, Hot Springs Canyon) have modeled debris flow likelihoods of 80-100% in a 1-year recurrence interval (RI).
- Debris flows in headwater draws and canyons will add material to floodwaters in the larger streams draining the burned area, and have the potential to temporarily dam larger streams, causing backwater effects as well as flood surges when the temporary dams fail.
- Debris-laden flood waters and debris flows threaten anyone in or near streams and rivers within and downstream of the burned area.
- The threat of damage from flooding and debris flows extends to in-channel structures such as culverts, bridges, and diversions, as well as any structures or improvements located on existing debris fans, runout zones, and other flood-prone areas. Areas of concern include the recreation residences in Holy Jim, Trabuco and Hot Springs, Los Pinos Conservation Camp, and state and county roads.
- Rockfall and hillslope instability on steeper slopes throughout the burned area are threats to life and safety as well as infrastructure.

Recommended Treatments on National Forest Lands

- Roads - stabilization
- Hazardous Materials – clean up and stabilization
- Trails - stabilization
- Weeds Suppression and Burn Related
- Safety
- Implementation Team
- Interagency Coordination

Capacity and Collaboration

This BAER assessment was a coordinated, shared response, including close coordination with the California Watershed Emergency Response Team (CA WERT) and Orange and Riverside Counties. The BAER team reached out to many non-Forest Service entities (e.g., USGS, CAL-OES, CalFire, NWS, National Resources Conservation Service (NRCS), etc.) to ensure cross boundary coordination and information sharing during the BAER assessment. These partners can assist in establishing a post-fire assessment and response process.

Many non-forest entities, and partners have infrastructure in and adjacent to the fire area and are actively repairing damaged infrastructure and/or implementing mitigations to reduce post-fire runoff damage. The BAER team continues to share results and findings with non-Forest entities so that they can develop appropriate response plans to properly inform public safety, protect/prepare infrastructure, and critical natural resources from anticipated post-fire watershed response events. These partners can assist in establishing a post-fire assessment and response process.

The BAER team participated in Orange County led interagency “Debris Flow Task Force” meetings with other key partners including CA WERT, County DPW, NWS and NRCS. The Cleveland NF is a key partner to prepare for winter runoff events. Currently, meetings are held weekly and will continue into the rainy season.

The Forest Service BAER team will continue to participate in interagency coordination efforts to assist in interpreting BAER information and prepare response plans. We also welcome further collaboration and learning through professional exchange including refining the model of the federal BAER team working with CA WERT and county personnel during the assessment and response phases of post-fire recovery.

Monitoring

Monitoring burned area conditions and recovery can assist managers in planning for public safety as of watershed conditions recover. We recommend recurring evaluation of recovery over time in conjunction with monitoring of runoff response to rainstorms and snowmelt, especially after heavy rainstorms. Informal implementation and effectiveness monitoring is an important part of the BAER process with results linked back to refining processes and recommendations.

State of California Watershed Emergency Response Team (CA WERT) often completes more quantitative debris flow and flood flow monitoring in conjunction with other partners to gain furthering understanding of and refinement of debris flow and flood flow models.

References

Foltz, R.B., Robichaud, P. R., and Rhee, H. 2009. A synthesis of post-fire road treatments for BAER teams: methods, treatment effectiveness, and decision-making tools for rehabilitation. Gen. Tech. Rep RMRS-GTR-228 Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, 152 p.

Foltz, R.B., and Wagenbrenner, N.S. 2010. An evaluation of three wood shred blends for post-fire erosion control using indoor simulated rain events on small plots. Catena 80, 86-94.

Fortini, L.B., Kaiser, L.R., Perkins, K.S., Xue, L., and Wang, Y., 2023. Estimating the Impact of Climate and Vegetation Changes on Runoff Risk across the Hawaiian Landscape. Conservation 2023, 3 291-302. https://doi.org/10.3390/conservation3020020

Parsons, A., Robichaud, P., Lewis, S., Napper, C., Clark, J., and Jain, T. 2010 Field Guide for Mapping Post-Fire Soil Burn Severity. Gen. Tech. Rep. RMRS-GTR-243. Moscow, ID: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

Gotvald, A.J., Barth, N.A., Veilleux, A.G., and Parrett, Charles,2012, Methods for determining magnitude and frequency of floods in California, based on data through water year 2006: U.S. Geological Survey Scientific Investigations Report 2012–5113, 38 p., 1 pl.

Kean, J. W., S. W. McCoy, G. E. Tucker, D. M. Staley, and J. A. Coe (2013), Runoff-generated debris flows: Observations and modeling of surge initiation, magnitude, and frequency, *J. Geophys. Res. Earth Surf.*, **118**, 2190–2207, doi:**10.1002/jgrf.20148**

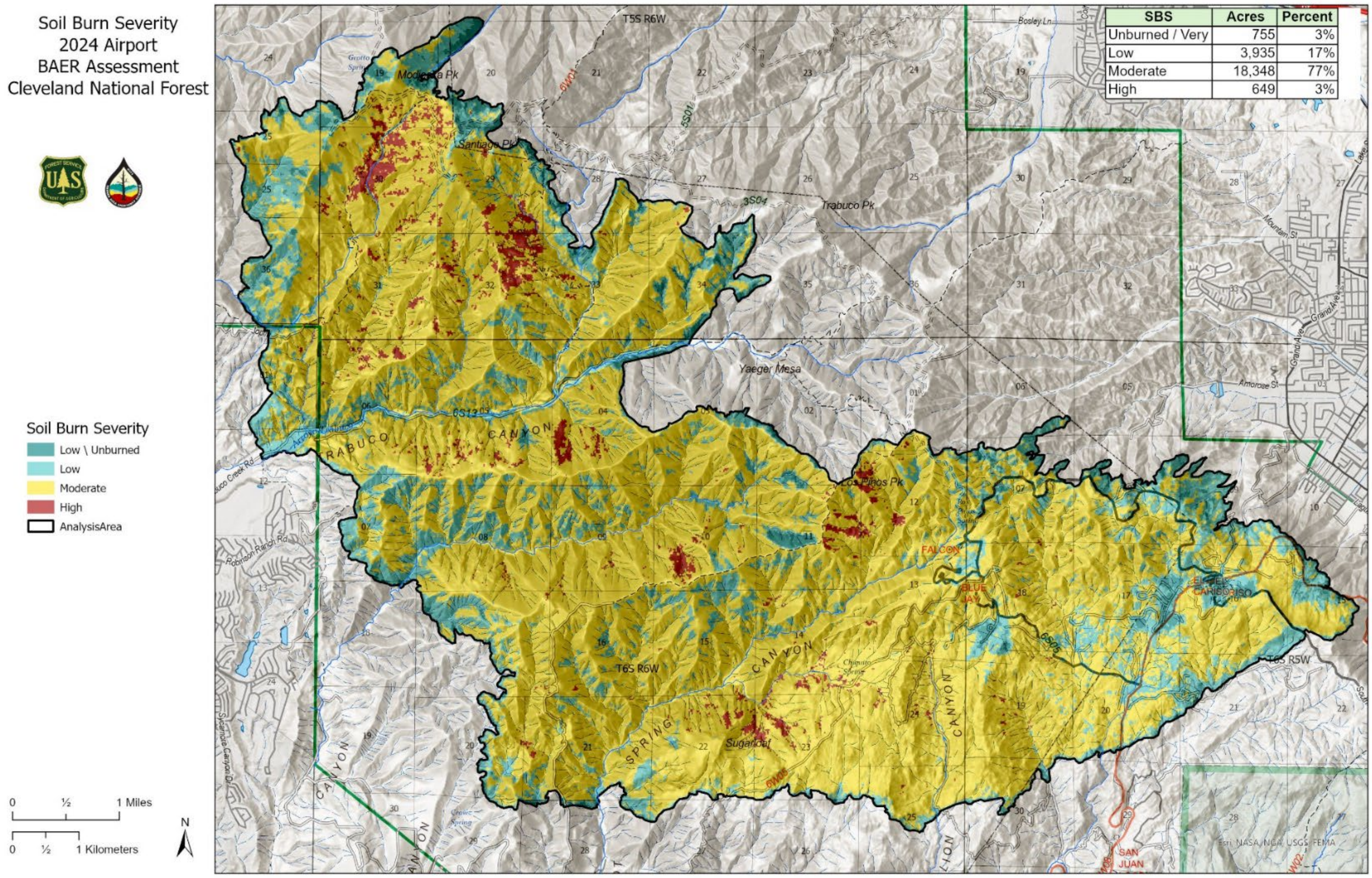
Robichaud, P. R., Ashmun, L.E., Foltz, R.B., Showers, C.G., and Groenier, J.S. 2013. Production and aerial application of wood shreds as a post-fire hillslope erosion mitigation treatment. General Technical Report RMRS-GTR-307, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, CO.

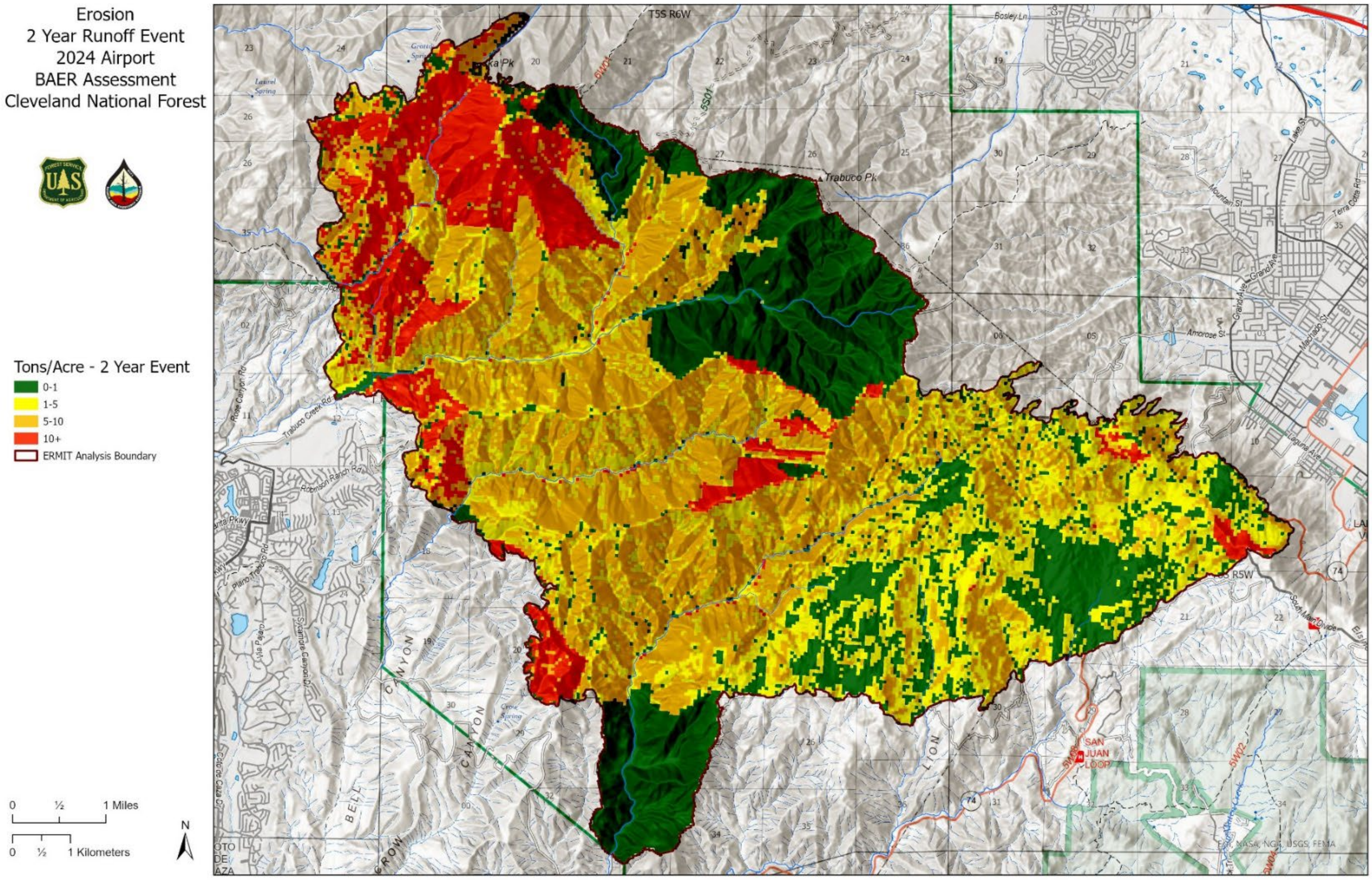
Robichaud, P.R., Elliot, W.J., Pierson, F.B., Hall, D.E., Moffet, C.A., and Ashmun, L.E. 2007. Erosion Risk Management Tool (ERMiT) user manual (version 2006.01.18). Gen. Tech. Rep. RMRS-GTR-188. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 24 pages. https://forest.moscowfsl.wsu.edu/fswepp/

Staley, D.M., Negri, J.A., Kean, J.W., Tillery, A.C., Youberg, A.M., 2016, Updated logistic regression equations for the calculation of post-fire debris-flow likelihood in the western United States: U.S. Geological Survey Open-File Report 2016-XXXX, 20 p., available at http://pubs.usgs.gov/of/2016/XXXX/

United States Department of Agriculture, Soil Conservation Service, 1973. *Engineer Field Manual for Conservation Practices.* Chapter 2: Peak Rates of Discharge for Small Watersheds.

Appendix A. Airport Fire BAER Map Products

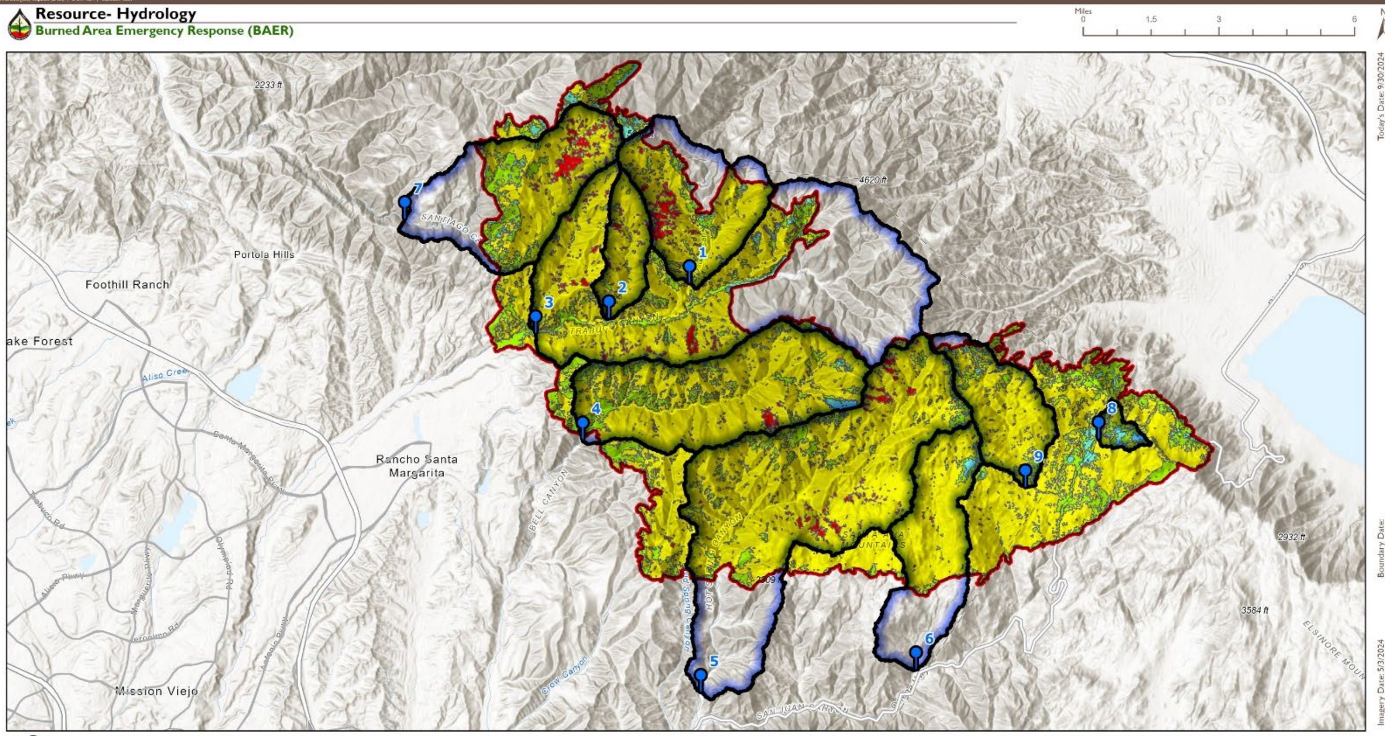



Erosion
2 Year Runoff Event
2024 Airport
BAER Assessment
Cleveland National Forest
Tons/Acre - 2 Year Event
0-1
1-5
5-10
10+
ERMIT Analysis Boundary
0 ½ 1 Miles
0 ½ 1 Kilometers
N
NASA, NGA, USGS, FEMA

Forest Service
US Department of Agriculture

Burned Area Emergency Response (BAER) | BAER Team | September 2024

Resource- Hydrology
Burned Area Emergency Response (BAER)



- Pour Points
- Pour Point Watersheds
- Aiport Fire Perimeter

Soil Burn Severity

- High
- Moderate
- Low
- Unburned / Very Low

Pour Point Number	Pour Point Watershed Name
1	Holy Jim Canyon (upper crossing)
2	Falls Canyon (confluence to Trabuco Canyon at Road)
3	Trabuco Canyon at FS Boundary
4	Bell Canyon at Fire Boundary
5	Hot Springs Canyon
6	Lion Canyon
7	Santiago Canyon
8	El Cariso at FS Boundary
9	Long Canyon at Long Canyon Rd

Airport Fire
Combined Hazard
Peak 15 Minute Rainfall
Intensity of 24 mm/h rate
Cleveland National Forest
September 2024

Debris Flow Combined Hazard

24mmh

- Low
- Moderate
- High
- <all other values>
- AnalysisArea

0 ½ 1 Miles

0 ½ 1 Kilometers

N

General risks and probabilities of debris flow, flooding and erosion hazards were evaluated by the US Forest Service BAER Team. Site specific risks were not evaluated in this assessment.