Date of Report:10/10/2010

FOURMILE EMERGENCY STABILIZATION BURNED AREA REPORT

PART I - TYPE OF REQUEST

A. Type of Report

[x] 1. Funding request for estimated funds
[ ] 2. Accomplishment Report
[ ] 3. No Treatment Recommendation

B. Type of Action

[x] 1. Initial Request (Best estimate of funds needed to complete eligible rehabilitation measures)

[ ] 2. Interim Report
[ ] Updating the initial funding request based on more accurate site data or design analysis
[ ] Status of accomplishments to date

[ ] 3. Final Report (Following completion of work)

PART II - BURNED-AREA DESCRIPTION

A. Fire Name: Fourmile Canyon Fire

B. Fire Number: CO-BLX-000321 FUL0

C. State: CO

D. County: Boulder

E. Region: Rocky Mtn (R2)

F. Forest: Arapaho-Roosevelt

G. District: Boulder

H. Date Fire Started: 9/6/2010

I. Date Fire Contained: 9/13/2010

J. Suppression Cost: $9,500,000

K. Fire Suppression Damages Repaired with Suppression Funds
1. Fireline waterbarred and rehabilitated (miles): 19.5
2. Fireline seeded (miles): 0
3. Other (identify):

L. Watershed Number: 6th Code watersheds – Fourmile Creek (WS #101900050403), Boulder Creek (WS #101900050406) and Fourmile Canyon Creek (WS #101900050405). Subwatersheds include Ingram Gulch, Melvina Gulch, Emerson Gulch, Sweet Home Gulch, Sand Gulch, Schoolhouse and Bummers Gulch.

M. Total Acres Burned: 6,179
Private (4086), BLM (1397), Boulder County/State Land Board (380), USFS Acres(306), Gold Hill OS (10)

N. Vegetation Types: Predominanately open ponderosa pine. Denser mixed douglas fir with aspen on north facing slopes. Some nonforested openings with grass, mountain mahogany and other shrubs. Major drainages and springs have riparian vegetation with narrowleaf cottonwood, Rocky mountain maple, river birch, shrubby willows and other common riparian vegetation.

O. Dominant Soils:
Soil and Terrestrial Ecological Land Units within the Fourmile Canyon Burned Area:

Map Unit	Components	Acres	% Area	General Landscape Position and Vegetative Cover
JrF	Juget-Rock outcrop complex 9-55% slopes	3539	54%	Mountain side slopes and ridges Ponderosa pine, Rocky Mt. juniper, Shrubs, Mountain Mahogany, Grasses
PgE	Peyton-Juget very gravelly loamy sands 5-20% slopes	296	4%	Open park lands, uplands Grasses, Shrubs
FcF	Fern Cliff-Allens Park-Rock outcrop complex 15-60% slopes	2116	32%	Mountain side slopes, ridges, and short fans Douglas fir, Ponderosa pine, Shrubs, Grasses
2703B	Cypher-Ratake families complex, 5 to 40 percent slopes	70	1%	Mountain slopes Pondo. Pine, Shrubs, Mountain Mahogany, Grasses
2704D	Typic Haplustolls-Cathedral family-Rock outcrop complex, 40 to 150 percent slopes	261	4%	Mountain slopes Pondo. Pine, Shrubs, Mountain Mahogany, Grasses
2705D	Ratake-Cathedral families-Rock outcrop complex, 40 to 150 percent slopes	26	.5%	Mountain slopes Pondo. Pine, Shrubs, Mountain Mahogany, Grasses
2706D	Cypher family-Rock outcrop complex, 40 to 150 percent slopes	140	2%	Mountain slopes Pondo. Pine, Shrubs, Mountain Mahogany, Grasses
4703D	Bullwark-Catamount families-Rock outcrop complex, 40 to 150 percent slopes	110	2%	Mountain slopes Lodgepole pine, Douglas Fir
5101A	Pachic Argiustolls-Aquic Argiudolls complex, 0 to 15 percent slopes	24	0.5%	Stream terraces Grasses, shrubs

P. Geologic Types: Metamorphic and igneous intrusive rocks

Q. Miles of Stream Channels by Order or Class:
Perennial – 7 miles, Intermittent – 13 miles, Ephemeral – unknown

R. Transportation System

Trails: 0.6 miles Roads: 31.5 miles Note: Because of incomplete mapping, mixed land ownership and unclear road ownership, there are unmapped roads and trails within the fire perimeter that are not included in the total.

PART III - WATERSHED CONDITION

A. Burn Severity (acres): 2,492 unburned/low 3,001 moderate 684 high

B. Water-Repellent Soil (acres): The degree and extent of water repellent soils is largely unknown due to limited collection of field data However, limited observations indicate strong repellency at a depth of 2-6 inches for some observations and no repellency for others.

C. Soil Erosion: Overall, pre-burn conditions (Figure #1) had a sediment yield at the bottom of hillslopes in the range of 0-.7 Megagrams/Hectare (0 to 0.3 tons/acre). Post-burn sediment yields increased up to 14 Megagrams/Hectare (6 tons/acre) (Figure#2).

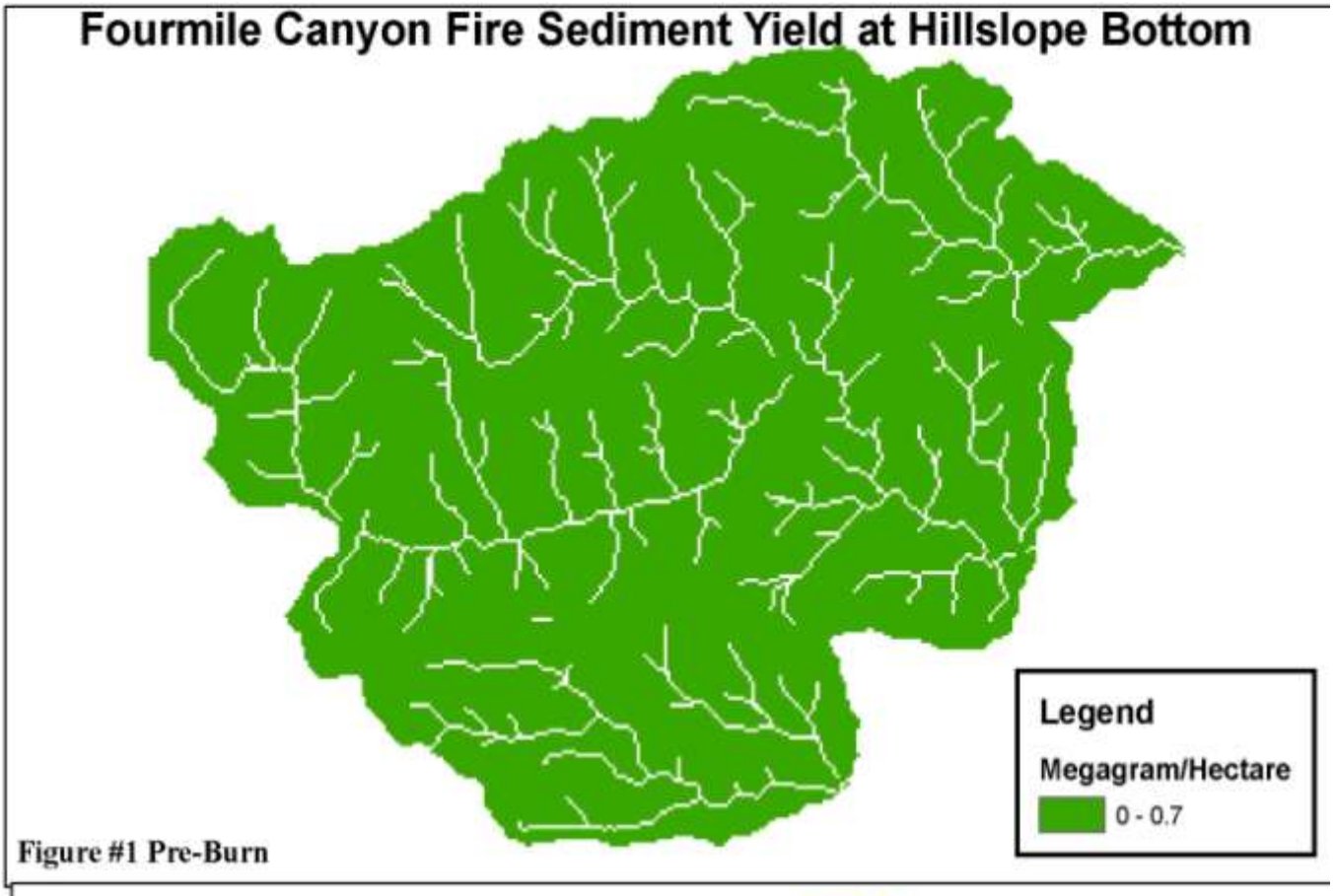

Figure #1 Pre-Burn

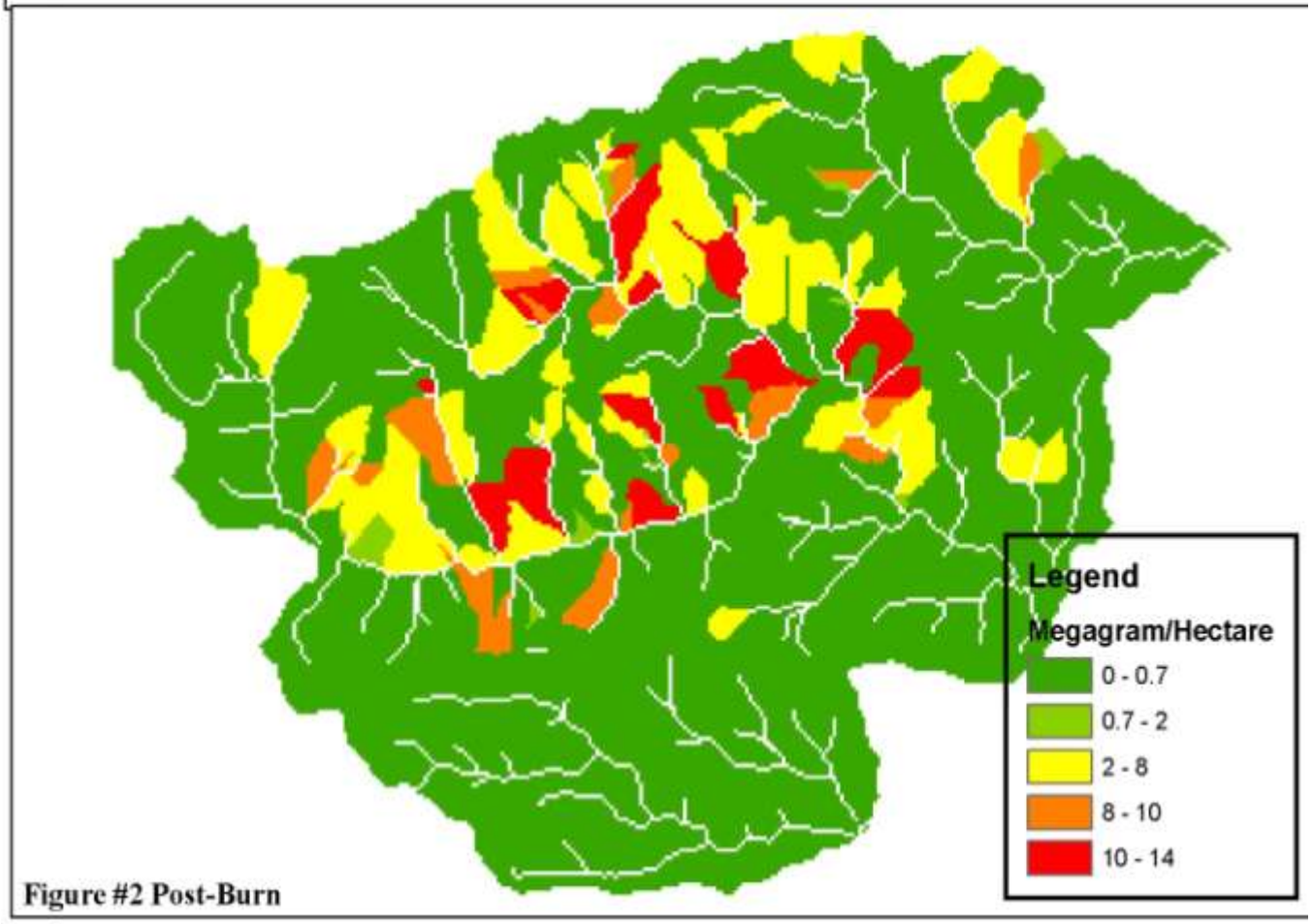

Figure #2 Post-Burn

PART IV - HYDROLOGIC DESIGN FACTORS

A. Estimated Vegetative Recovery Period, (years): 2-5 yrs grass and shrubs, 20-80 trees

B. Design Chance of Success, (percent): 80

C. Equivalent Design Recurrence Interval, (years): 10

D. Design Storm Duration, (hours): 6

E. Design Storm Magnitude, (inches): 2.0

Fourmile Canyon Fire Pre-Fire, Post-Fire, and Treated Hydrology Peak Flow Estimates

	Prefire	**Postfire**	
Watershed Name	Estimated Discharge (cfs)	Estimated Discharge (cfs)	% change
Fourmile Canyon Creek East	54	115	215%
Fourmile Canyon Creek West	78	108	140%
Packer/Sunbeam Gulches	58	63	110%
Sweet Home Gulch	51	99	195%
Fourmile Above Gold Run Composite	48	98	205%
Gold Run Creek above Fourmile Composite	54	142	265%
Unnamed Tributary between Ingram and Sweet Home	14	30	215%
Ingram Gulch	59	155	265%
Blackhawk Gulch	63	101	160%
Cash Gulch	40	63	160%
Emerson Gulch	52	140	270%
Schoolhouse Gulch	46	89	195%
Melvina Gulch	43	96	225%
Long Gulch	94	103	110%
Monument Hill/Gold Hill	5	30	600%
Upper Gold Run Creek Above Goldhill	4	11	275%
Unnamed tributary to Fourmile #1, West of Emerson	18	38	210%
Unnamed tributary to Fourmile #2, South of Emerson	0.8	25	3125%
Nancy Mine Gulch	30	53	175%
Unnamed Tributary to Fourmile #3, S. of Nancy Mine	1.4	15	1070%

Unnamed Tributary to Fourmile #4, S. of Melvina Gulch	1.4	10	715%
Unnamed Tributary to Fourmile #5, E. of Melvina Gulch	14	22	155%
Short Cut and Sand Gulch	84	135	160%
Fourmile Creek above Fire Perimeter	89	158	180%
Unnamed Tributary to Fourmile Above Crisman Drive	26	49	190%
Upper Bummer Gulch	6	13	220%
Unnamed Tributary east of Bummers Gulch	2	5	250%
Fourmile Creek above Gold Run	193	345	180%
Gold Run at Fourmile Creek	140	329	235%

Notes: -Short duration, high intensity summer thunderstorms are the events of greatest concern. However, no recording guage coverage is available locally and no precipitation-frequency maps for thunderstorms are available. Therefore, we used NOAA maps with the lowest duration (6 hour) storm as the closest estimate of thunderstorms.
-Because of modeling limitations, the estimated peak flow values should only be used as indicators of relative post-fire increases, rather than as absolute values.

PART V - SUMMARY OF ANALYSIS

A. Describe Watershed Emergency:

The Fourmile Canyon Fire was driven by high winds that changed directions several times. Generally, the fire was fast moving and resulted in a mosaic pattern of low, moderate, and high soil burn severities. The burned area extends from the Sugarloaf Area in the south to the Lee Hill Area in the north.

The fire was the most destructive fire in Colorado history in terms of damage to personal property with an estimated cost of $217,000,000 in losses. The fire burned through steep, heavily forested canyons just west of Boulder, Colorado destroying 166 homes. Towns within the burned area include Salina, Wallstreet and Gold Hill. While the number of homes destroyed is large, there are an estimated 300 homes within the fire perimeter that did not burn, resulting in a very large number of people living in and around the burned area. This coupled with the high population density adjacent to the fire leaves many people vulnerable to post fire effects. Many of the unburned houses lie along the canyon bottoms, making people vulnerable to flooding. The steep topography and mobile soils of the area make floods and debris flows very probable following fires. This has been seen in several nearby fires and is expected following the Fourmile Canyon Fire. Dominant vegetation in the fire area consists mainly of ponderosa pine with native shrubs and grasses on south-facing slopes and Douglas fir on north-facing slopes.

A watershed emergency exists because of the increased threat of flooding and debris flows to homes and infrastructure, the potential for noxious weeds invasion, threats to downstream community water supply, and threats to roads within the burned area. Public health and safety are also threatened due to increased flooding and debris flow potential. For the purposes of this assesment, high intensity thundershowers are the precipitation events of concern.

The single most complicating factor in the emergency stabilization of the Fourmile Canyon Fire revolves around the land ownership within the perimeter. The fire burned through a historic mining district with a mixture of land ownerships and very small parcels. Locating property lines and identifying land ownership would be very difficult and expensive. In order for stabilization techniques to be effective, close coordination

with private, county, and federal land managers will be necessary. The plan is written on a watershed basis, not on individual land ownership. The Natural Resources Conservation Service (NRCS) will work with private land owners on the implementation of this plan on private and county owned lands, while the Bureau of Land Management (BLM) and US Forest Service will work with the NRCS to get projects implemented across the landscape. Ideally, one contract could be used to treat federal, county, and private lands.

The emergency stabilization plan includes mulching the moderately and severely burned slopes between 20 and 60% gradient, seeding to prevent noxious weed invasion, culvert upsizing, storm inspection and response, channel clearing, warning signs, flood warning systems, and water diversions.

Threats to Property:

- **Homes and Driveways:** Throughout the burned area, houses and buildings located within or at the bottom of steep burned gulches or in flood-prone areas adjacent to Gold Run Creek or Fourmile Creek are at increased risk. Many houses within the burned areas have driveways that cross Gold Run or Fourmile Creeks. Post-fire sediment laden flows and/or debris flows are expected to increase as a result of the fire, increasing the risk for impacts to homes and driveways.

- **Roads:** Roads within the burned area are at increased risk for impacts from increased water, sediment, and/or debris. Impacts include damage to the road and/or loss of access due to severe erosion of the road surface, or deposition of sediment or debris. Increased risk for temporary loss of access/egress exists on Gold Run Road, Fourmile Canyon Road, and on roads in gulches within the burned area. Any damage to, or blocking of, the county road network, or private roads, could eliminate access to residents or emergency service providers. Roads within the burned area are also likely to exacerbate the risk of flooding and erosion by collecting surface water, concentrating it and delivering it to hillslopes or stream channels. Most of the roads within the burn have inadequate cross-drainage and several are bermed. The berms will contain water on the road surface rather than allowing it to drain off.

- **Irrigation:** There are 12 irrigation water supply ditches that take out of Boulder Creek downstream of the confluence with Fourmile Creek, starting with the Silver Lake ditch (0.8 miles from the confluence) to the Boulder Weld ditch (14.4 miles from the confluence). These ditches serve approximately 22,700 acres of agricultural lands in Boulder County and 13,900 acres in Weld county. There are approximately 20 large farm operations, plus several hundred small acreage producers in the service area. Each ditch has a head gate structure on Boulder Creek to control water intake. Consequently, risk to irrigation water from runoff-induced sediment and debris loading is expected to be minimal due to the ability to monitor and close the intake structures if significant runoff events occur along Fourmile Creek.

Threats to Human Life and Safety:

- **Increased Flooding and Debris Flow Risk**: Threats to life and safety exist in valley bottom areas and in steep burned gulches throughout the burned area. Residents and road users will be exposed to increased risk of flooding and debris flow. Houses, driveways, other private property, and roads located in valley bottoms adjacent to or in the floodprone areas of Gold Run and Fourmile stream channels are at increased risk for flooding and debris flow. In several locations, structures and roads are located on debris flow fans at the outlets of severely burned gulches. Within steep, burned gulches tributary to Fourmile and Gold Run Creeks, increased threats to life, safety and property also exist as a result of the wildfire. These areas are characterized by steep burned hill-slopes, unpaved roads with poor drainage, houses and structures.

  A relatively high density of houses within the valley bottom of Gold Run and Fourmile Creeks extends from the Salina area downstream to the Crisman area. This is a zone of concern for flooding because there are several burned gulches upstream on both Gold Run and Fourmile

Creeks. There is a high risk that increased stream-flow, sediment, and/or debris will be deposited on Gold Run Road and Fourmile Canyon Drive.

- **Abandoned Mine Lands:** Abandoned mine hazards were identified throughout the burn area including Hoosier Hill, Sweet Home, Ingram, Emerson, and Melvina Gulches. These hazards include open pits, adits, and shafts, and present a high risk to human life and safety. Many of the known adits and shafts had the support structure timbers burned during the fire, and now have compromised structural integrity. There is no complete inventory of mine sites and mine waste/tailings in the affected area. It is unknown how many mine shafts and adits were exposed by the Fourmile Canyon Fire. It appears sedimentation issues due to runoff will be more directly impacted by burned and disturbed soils/vegetation than by existing mine wastes in the area of the fire. The observation team did not examine areas where significant ground cover remained, as those areas will not present a greater risk to water quality, safety or structures than they did before the fire.

- **Hazard Trees:** Hazard trees killed by the fire increase threats along the public and private roads within the burn.

Threats Natural Resources:

- **Noxious Weed establishment and/or Spread:** Based on experience from recent fires in nearby areas, noxious weeds are expected to establish and expand within the burned area. Myrtle spurge (State List A), leafy spurge, spotted knapweed, Canada thistle, musk thistle, bull thistle, Scotch thistle, yellow toadflax, oxeye daisy, scentless chamomile, and cheatgrass have been documented within the perimeter. Orange hawkweed (State List A), diffuse knapweed, dalmation toadflax, and St. John's wort are present in surrounding areas. Weed infestation is highly probable, particularly along travel corridors and riparian areas, and in areas of high and moderate burn intensity.
- **Threats to Water Used for Domestic and Municipal Supply:** Fourmile Creek, below the confluence with Gold Run Creek, serves as a source for public water supply to the community of Pine Brook Hills. The Pine Brook Water District withdraws water near the Poorman Road and pumps it up to a reservoir located in Twomile Creek. Increased risk to the water supply from impacts related to sediment laden flood flows can be avoided by ceasing diversions until the flood wave has passed. However, potential threats to this water quality, such as increase in total organic carbon (TOC), nutrients, and metals could increase treatment costs.
- **Threats to Water Quality from Mine Waste:** There are numerous mine tailings within the burn perimeter. The Evans Mine tailings are located close to the bottom of Gold Run and have the possibility of entering the drainage network. The reactivity of the tailings within the burn is unknown; however nearby tailings in the Left Hand Creek watershed are known to contain heavy metals. The risk of mine wastes within the fire perimeter entering the drainage network are expected to present a low to moderate risk to water quality.

Threats to Cultural/Heritage Resources:

- **Cultural Resources** are site specific. Potential values at risk are unique to each site. Threats to the integrity of the site and threats to public safety at the site created by the fire will have to be evaluated on an individual basis. Initial site visits proved to be time consuming, but with those few sites visited there was a wide variety of post fire conditions. Some sites were untouched by the fire, while others were completely burned over. Some sites have safety concerns that were unchanged by the fire, while others have hazards that were created by the fire (e.g. the Nancy Mine). Treatments at the sites will have to be on an individual basis.
- There might be a variety of post fire conditions occuring at the cultural resources sites. Those initially examined represent a small fraction of those to be analyzed. Efforts for the near future should focus on field visits to the sites to analyze for stabiliization efforts and mitigation for safety concerns.

Critical Values Considered but No Emergency Determined:

- No increased risk for critical habitat or suitable occupied habitat for federally listed threatened or endangered terrestrial, aquatic animal, or plant species was identified.

B. Emergency Treatment Objectives:

- Re-establish ground cover (mulch) to reduce threats to human life and safety, homes and infrastructure by reducing risk of flood and debris flow and/or by mitigating the effects to threatened structures.
- Coordinate with the National Weather Service and Boulder County's Office of Emergency Services existing flood warning system to provide flood warning to residents at risk of flooding and to water supply providers.
- Provide for upgraded stream crossings on County roads to better handle expected flow and debris increases.
- Reduce risk of noxious weed invasion and promote re-establishment of native vegetation.
- Augment and stabilize road drainage on roads affected by the fire.
- Reduce risk of hazard trees in the burned area.

Proposed emergency treatments to reduce threats are identified in Section A, and treatment objectives are discussed in detail in Section E:

C. Cost of Selected Alternative: $1,809,540

Treatment	BLM Costs	U.S.Forest Service Costs	Boulder County Costs	State Costs	NRCS/Private Costs	Total
Mulching	$582,800	$60,500	$122,100		$894,600	$1,660,000
Weeds	$5,000	$700	$1,048		$8,452	$15,200
Seeding	$11,443	$1,592	$2,886		$44,080	$60,000
Channel Clearing/Outreach			$1,000			$1,000
Storm Inspection Response			$19,400			$19,400
Culverts			$20,000			$20,000
Secure Mine openings				$25,000		$25,000
Flood Warning Systems			$500			$500
Warning Signs			$1,440	$500		$1,940
Debris Removal			$1,500			$1,500
Hazard Tree Removal			$5,000			$5,000
Agency Total	$599,243	$62,792	$174,874	$25,500	$947,132	$1,809,540

D. Skills Represented on Burned-Area Survey Team:

[X] Hydrology	[X] Soils	[ ] Geology	[X] Range	[X] Cultural
[X] Forestry	[X] Wildlife	[ ] Fire Mgmt.	[X] Engineering	[ ]
[ ] Contracting	[X] Ecology	[X] Botany	[X] Archaeology	[ ]
[ ] Fisheries	[ ] Research	[ ] Landscape Arch	[X] GIS	

Team Leader: Eric Schroder, Soil Scientist

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E. Treatment Narrative:

Land Treatments:

Purpose: To reduce runoff and expected increases in peak streamflows, reduce soil loss and the occurrence of debris flows. To maintain long-term ecological health by limiting the spread on noxious weeds.

Aerial Mulching: Aerially apply mulch to approximately 1800 acres of severely and moderately burned slopes in gulches tributary to Gold Run and Fourmile Creeks. Woodstraw would be preferred; however, certified weed-free cereal grain straw could be substituted if sufficient quantites of woodstraw are not available. We have identified approximately 1800 acres that are suitable for treatment. Further refining during implementation could reduce the acreage to 1200. Mulch will be applied at the rate of approximately 50-75% ground cover on slopes of 20-60%. Aerial application has been used successfully at the Overland Fire (Jamestown area) and Barnes Canyon (NV) fires, and reduces the logistical and safety problems of transporting large quantities of straw to the site and spreading by hand on steep slopes. Areas included in the mulching include stabilization of mine waste piles; however the real coverage of these areas are not known, but most fall within the mulching polygons.

Treatment cost for straw mulching is estimated at $960,000
Treatment costs for woodstraw mulch is estimated at $700,000
Total costs for mulching: **$1,660,000**

Mulching Effectiveness: Mulch effectively replaces the ground cover lost to the fire, increases infiltration and decreases runoff, and reduces the detachment of soil and transport of materials from the hill-slope. Mulching treatments have been shown to be highly effective at reducing sedimentation at the hillslope/research plot scale. While there is less documentation available about its effectiveness at reducing runoff in the watershed scale, it is believed that by replacing the ground cover formerly provided by organic matter, litter and duff, rates of runoff should be slowed, and amounts of runoff should be reduced. It is effective immediately after application and for several years thereafter. Because of the mixed land ownership, close cooperation between the Natural Resource Conservation Service, private land owners, Boulder County, and the Bureau of Land Mangement will be essential so that federal, county, and private lands can be treated.

Monitor and Treat Noxious Weeds: Treat existing known populations of weeds, including myrtle spurge, leafy spurge, and spotted knapweed, which is a very small percentage of the burned area. Since weed infestations pre-burn are largely unknown, monitoring weed establishment and spread within the burned area will be necessary. If monitoring shows that weed populations are expanding, treat weeds using an integrated weed management strategy that could include mechanical, biological, and chemical treatment. Any chemicals used would be approved by the responsible agency. We anticipate that treatment may occur in 2011 and in the two following years. The number of acres that will need treatment in years 2012 and 2013 is unknown at this time.

The estimated costs for weed treatments is **$15,200/year**.

Noxious Weed Treatment Effectiveness: With early detection, limiting the spread of weeds should be fairly effective. Because weeds are present in the burned area and in adjacent areas, we will not be able to completely prevent their establishment, but rather limit the spread and permanent establishment. Because of the intermixed land ownership, cooperation with private landowners will be critical to effectiveness.

Seeding: Manually broadcast and rake in seed on approximately 600 acres of severely and moderately burned areas with 0 to 60% slopes. Seed will be applied within a 100 foot buffer on each

side of roads and driveways. The objectives of the seeding is to prevent the introduction or spread of noxious and invasive plants. Seeding may also provide erosion control after the first year when grasses are established (Smith, unpublished paper).

The cost of seeding is estimated at $100/acre for 600 acres or **$60,000** total

Seeding Effectiveness: Seeding alone has become less popular as a treatment due to its limited effectiveness at providing any effective cover the first year after a wildfire. In a review of existing studies on post-fire seeding, few studies demonstrate statistically significant decreases in sediment movement (Beyer 2004, MacDonald and Larsen 2009). However, seeding is effective at preventing or reducing the spread of noxious weeds (Johnston 2008). Species were chosen to provide quick cover to compete with aggressive weeds, particularly cheatgrass. In addition, these species are not expected to persist beyond ten years, allowing native species to establish later without competition from aggressive annual weeds.

Channel Treatments

Purpose: The purpose of channel treatments is to help convey runoff through the drainage system and remove debris that may plug channels and culverts resulting in water being diverted and causing damage outside of the stream channel itself. Implementation will be conducted by the county through public outreach, asking residents to remove debris and keep channels clear. Costs will be covered with the public information treatment.

Channel Debris Clearing: Channel-debris clearing removes debris from the channel and flood-prone areas that could dislodge and plug culverts downstream. High priority areas for treatment would include areas in close proximity to houses and directly upstream from culverts. Debris may include burned wood from trees and debris from burned structures. Generally, this treatment would be done manually with a focus on small debris considered likely to be transported downstream.

Estimated costs for the outreach is **$1,000**

Channel Debris Clearing Effectiveness: The removal of material that could become flotsam during a runoff event greatly reduces the chances of the channel becoming clogged and water being diverted out of the channel.

Roads Treatments:

Purpose: The purpose of road treatments is to reduce the risk of transportation system drainage failure which could compromise access/egress, damage the road surface, increase erosion, sedimentation, and cause downstream damage. Road and trail treatments mitigate the fire's effect on the transportation infrastructure and protect life, safety, property, and critical natural or cultural resources. These treatments work in conjunction with land, channel, and protection/safety.

Storm Inspection and Response: Storm inspection and response keeps culvert and drainage structures functional by cleaning sediment and debris from the inlet between or during storm events on roads where access is required. Typically, crews drive the roads during or immediately after storms, checking sediment and debris accumulations and performing thorough, rapid inspection of road-drainage features, culverts, and other structures. The crew is responsible for maintaining culvert function by opening culvert inlets and removing debris. Within the regular duties of Boulder County road maintenance crews, routine road, culvert and infrastructure inspections are performed. Additional inspections within the burn area will be added to regularly scheduled inspections. Crews will inspect culverts and ditches for debris prior to storm event runoff, and remove any accumulated debris or sedimentation from those locations. Crews will also monitor high risk areas during storm events to immediately identify areas at risk of flooding or debris sedimentation. Following a storm event, crews will identify areas that have been impacted and respond by initiating a cleanup effort to remove accumulated sediment and debris from roadways, or repair damaged infrastructure. Cost for this

treatment will vary by storm event and the response required following that event. Total cost for response to a 20 cubic yard event is $1941 per event with an anticipated 10 events per year.

Total Estimated Costs = **$19,410**

Effectiveness of Storm Inspection and Response: No formal effectiveness monitoring data exists on storm inspection and response. Informal observations indicate that the treatment is cost effective because many road problems are avoided with timely clearing and cleaning of road crossings. Effectiveness can be reduced when a dedicated team is not made available to conduct the storm inspection and response. In some cases, the patrol area is too large for the responsible agency to cover effectively and contracting may be a solution. In accessible areas, some agencies have used storm patrols instead of installing trash racks or larger culverts.

Increase culvert diameters at drainage crossings, remove berms, add drainage, and armor drainage outlets: There are approximately 15.8 miles of maintained county roads (2.7 paved, 13.1unpaved) and 15.7 miles of unmaintained county roads within the burned area. Several more miles of private roads exist in the burn area. Ownership of all the roads is unclear at this time, but there are private, county, and National Forest roads within the burn. Culverts that are used for roadway drainage (ditch relief culverts) and channel crossings contribute to the watershed emergency when they are damaged in a fire or when their hydraulic capacity is marginal. Stream diversion potential may exist along insloped roads with a continuous road grade. Post-fire sediment and debris flow in channels may plug culverts and increase the diversion-potential risk. Increased storm runoff due to the fire's effects can cause the failure of undersized culverts and lead to erosion of the road fill, thereby deteriorating water quality. Boulder County will upgrade or replace culverts located within high-risk areas, or add features to alleviate sediment deposition on the county road, within the culverts, or downstream. Larger culverts, flared end sections, or rip rap aprons will be installed to increase the efficiency of flow through the culverts, prevent overtopping, or reduce erosion and sedimentation at the culvert locations. At this time, the Boulder County Transportation Department will require additional research to identify locations for culvert replacement or other upgrades. Research will include identifying likely areas of high-risk, culverts that are undersized for expected base flow from burn areas, and effects downstream of the upgrades.

Total cost for this treatment is not known at this time, but is estimated at **$20,000**.

Effectiveness: Roads are both values at risk and sources of problems because they collect and concentrate water and then eventually drain it across the road prism where it can erode the road surface and fill slopes as well as cause problems downslope. The proposed treatment is effective at reducing road effects immediately after installation and into the future. Effectiveness will be increased if private, as well as public roads are treated.

Protection and Safety Treatments:

Purpose: Treatments to protect life, safety, and critical natural and cultural resources include flood-warning systems, warning signs, barriers, facility safety work, enforcement protection, and hazard removal. Flood-warning systems are used when there is a direct and substantial threat to life and a high probability of significant storms capable of producing floods or mass failure. Flood-warning treatments include early warning systems that are collaboratively identified with the local jurisdiction responsible for public safety. Warning signs alert drivers and recreational users of existing or potentially hazardous conditions created by wildfire incidents. Warning signs should use universal symbols.

Secure Mine Openings: The Colorado Division of Reclamation, Mining and Safety-Abandoned Mine Lands (AML) Program is initiating a post fire survey in conjunction with the US Forest Service and the BLM to identify open abandoned mine openings to include in upcoming projects. The survey will start the beginning of October 2010. Two options to safe guard a hazardous mine site are:

1. Sites can be included for safe guarding in a grant application prepared by the AML Program, which may take up to two years to process.
2. Colorado statute states the landowner is responsible for adequately safe guarding mine openings. The landowner can pay to have the site safe guarded. The AML Program will provide a list of contractors and technical assistance/oversight.

At this time the inventory of mine sites and how the fire affected them is unknown along with the ownership. Continued surveys will be conducted.

Costs are estimated at **$25,000** for continued mine surveys. Closures are estimated at $4,000 each.

Flood Warning Systems: The Fourmile Creek watershed provides public water supply to Pine Brook Hills and is also tributary to Boulder Creek upstream of multiple irrigation ditches located above and within the City of Boulder. Use of existing flood warning systems provided by the National Weather Service and the Boulder County Office of Emergency Services would notify water providers that sediment laden floodwaters may be approaching. They can then make an informed decision about whether to close intake headgates to avoid taking sediment laden water into their systems.

> **Effectiveness of Flood Warning Systems:** This method has been used with success on the Bobcat and Overland Fires to provide warning to water providers. However, the method is not likely to be effective for people living within or immediately downstream of the burned area. Because of the close proximity to flood generation areas (the burned gulches) and the rapid movement of flood flows, flood warning is unlikely to provide adequate response time so that effective action could be taken.

Warning signs: Warning signs will inform the public of the risks associated with travel within the burn area that include excess stormwater runoff, possible high water or flash floods and debris that may create a hazard along the County road. Warning signs will be installed along major County roads at the edge of the burn area. Additional signs will be installed in high-risk areas. In these areas, access may be cut-off by high water, debris, or other hazards. Warning signs will also be posted in areas of known mine hazard areas. The Colorado Division of Reclamation, Mining and Safety-AML Program can provide mine hazard warning signs.

Total cost for this treatment is **$1,440**.

> **Effectiveness of Warning Signs:** No formal effectiveness information is known for warning signs; however it can be expected that by notifying visitors of dangers created by the fire that people will be aware of the hazards.

Debris Structures: Debris structures, including jersey barriers, will be used to divert flood waters and debris around other values at risk, such as residential structures in critical locations. Debris structures will be installed in areas where culverts are expected to overtop with excessive stormwater runoff and where other values at risk, such as residential structures, are located within the drainage path. Debris structures will divert high water and debris around these structures.

Total cost for this treatment is **$1,500**.

Hazard Tree Identification and Removal: To protect life and safety of residents, visitors, and emergency stabilization implementation workers; identify and remove hazard trees within the burned area.

> **Hazard Tree Removal Effectiveness:** Identification and removal of hazard trees is believed to be a very effective means to provide for public safety. We recognize that it is not feasible to remove all trees that may eventually fall (all of the burned trees). We will remove only those trees that are judged to be high risk and that occur along roads and trails.

Public Information: Public information will be dispersed in many ways, including public meetings, leaflets, and other outlets. Due to the large amount of private land and hundreds of land owners within the burn area, there are limited ways to get work done on large areas of the burn. Public information will attempt to educate property owners on the new environment that can be expected after the fire and things that they can do about it. This includes driveway maintenance, flood danger, debris clearing in channels, mine hazards, seed mixtures, restoration options and procedures, etc. The Colorado Division of Reclamation, Mining and Safety-AML Program can also provide mine hazards education and awareness materials for distribution to the public, and, on request, work with schools to educate children on mine hazards as part of the Mine Safety Awareness Program.

Public information Effectiveness: No formal effectiveness information is known for public information; however it can be expected that notifying and educating residents and visitors of the new environment created by the fire will increase public awareness.

References

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