Pre-Fire Analysis of Management Alternatives: the Santa Fe Municipal Watershed

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The loss of vegetation during recent wildfires in Colorado resulted in tons of ash and debris washing into municipal water supply reservoirs, disrupting water treatment operations and reducing reservoir storage. After the 1996 Buffalo Creek Fire, 600,000 cubic yards of ash, sludge, and debris washed into Strontia Springs Reservoir. Turbidity of water coming into the treatment plant rose from 1.5 to 800 turbidity units. Based on these and other experiences following catastrophic fires in New Mexico, Arizona, and Colorado, the city of Santa Fe's water supplies likely would be seriously threatened if a fire occurred in the municipal watershed.

What effects would a catastrophic fire have on the forest health and hydrology of the Santa Fe Municipal Watershed? Which management alternatives would best protect the watershed and its sustainable water supply? These questions were the focus of studies undertaken in 2000 by Hydrosphere Resource Consultants as part of an Environmental Impact Statement to assess management alternatives for reducing the risk of catastrophic wildfire. The watershed has been closed to all uses since 1931 except fire suppression, which has led to extremely high fuel loads.

Management alternatives considered ranged from no action to various thinning alternatives with or without low-intensity prescribed (broadcast) burning. For each alternative, predictions were made for: 1) erosion and sediment yield; 2) peak flood flows on the Santa Fe River; and 3) annual water yield from the watershed following a high-intensity, stand-replacement fire. Predictions were based on a combination of mathematical models and observations from other watersheds comparable to the Upper Santa Fe River watershed.

Erosion Analyses

Post-fire effects were studied with respect to the volume of sediment that could be eroded from the watershed and deposited in the riparian zone and the city's water supply reservoirs. An engineering erosion model, the Revised Uniform Soil Loss

Alternative Summary Description (acreage treated)	Sed. Yield from Watershed (maximum acre-feet in 8 years)	10-yr Peak Flow @ Arroyo Mascaras (cfs)	Water Yield (% change after treatment)	Water Quality (relative change)	Soil Nutirent Cycling (relative change)
No Action, following catastrophic wildfire	3,148	>15,000	>+100%	Significantly adverse	Significantly adverse
Limited Manual Thinning with Broadcast Burning (2,190 acres)	86	<1,000	<+20%	Negligible changes	Minor improvement
Limited Manual Thinning with No Broadcast Burning (7,270 acres)	79	<1,000	<+20%	Negligible changes	Slight adverse effects
Manual Thinning with Broadcast Burning (4,900 acres)	86	<1,000	<+20%	Negligible changes	Minor improvement
Manual Thinning with No Broadcast Burning (7,270 acres)	79	<1,000	<+20%	Negligible changes	Negligible changes
Machine Thinning with Broadcast Burning (4,900 acres)	86	<1,000	<+20%	Negligible changes	Minor improvement
Machine Thinning with No Broadcast Burning (7,270 acres)	79	<1,000	<+20%	Negligible changes	Negligible changes

Summary of soil and water effects for each of the key issues and parameters considered.

Equation (RUSLE), was employed with analog watershed data.

Seven watersheds were identified in the western United States with similar vegetative and physical settings and that experienced high severity fires. In these analog watersheds, observed post-fire erosion rates were 25 to 448 times pre-fire rates, with an average 216-fold increase.

The RUSLE analysis was performed for current conditions (sustainable managed use) and for conditions where vegetation is completely removed (post-fire). For post-fire erosion, the hydrophobicity (water repellency) multiplier developed by the U.S. Forest Service for the 2000 Viveash Fire east of Santa Fe was incorporated. The average analog watershed post-fire to pre-fire ratio was multiplied by the RUSLE erosion rate under current conditions to predict the post-fire sediment yield. Predicted accumulated sediment yields in the first eight years following a fire ranged from 500 to 3,100 acre-feet, which could significantly impact the 4,000 acre-feet of reservoir storage in the Santa Fe watershed. The treatment alternatives all reduced the predicted sediment yield to around 80 acre-feet for the first eight years, still greater than the current eight-year accumulation of 3.52 acre-feet.

… experiences following catastrophic fires in New Mexico, Arizona, and Colorado suggest that the city of Santa Fe's water supplies would be seriously threatened if a fire occurred in the municipal watershed

Runoff / Peak Flow Analysis

To analyze the risk of post-fire flooding in the Santa Fe River, including the downtown plaza district, an SCS Curve Number approach was adapted from the Burned Area Emergency Response team's analysis of the Viveash Fire. Post-fire peak flows for analog watersheds ranged from three to 386 times higher than pre-fire peak flows, depending on fire severity. Post-fire peak flows for the Santa Fe River were predicted by multiplying estimated unregulated peak flows in the Santa Fe Watershed by the peak flow ratio from the analog watersheds.

Under current conditions, a 10-year flood results in a peak flow of approximately 1,000 cubic feet per second. However, the results of the peak-flow analysis showed that the five-year post-catastrophic fire storm flow was predicted to nearly double the *100-year* storm flow under current conditions. Peak flows following prescriptive treatments in the watershed did not significantly differ from current conditions.

Water Yield Effects Analysis

Based on gauging records for the Santa Fe River, the annual water yield of the Santa Fe Watershed has declined approximately 20 percent over the past 70 years, adversely affecting the city of Santa Fe's water supply. This yield reduction is due to the unnaturally high vegetation density in the watershed. Reducing vegetation density would reduce losses to interception and evapotranspiration and increase stream flows. For this analysis, analog watershed data of gauge-measured water yields were used to determine how much the yield could be expected to increase following fires of a range of severities. Results show that with no action, water yield would double in the years following a severe fire, and would increase by about 20 percent with thinning and low-intensity burning treatment alternatives.

Overall, the results of the study (see table above) show that any of the proposed management alternatives other than no action would reduce the risk of large-scale watershed damage. The primary differences between the results were due more to the number of acres treated than to the efficacy of an individual treatment method.

Any of the "action" treatment alternatives would impart effects that range from negligibly adverse to obviously favorable to soil and water conditions, including:

- very minor sediment yield increases,
- very minor peak flow increases, and
- slight water yield increases.

In contrast, the no-action alternative, which includes the occurrence of a catastrophic fire, would likely cause:

- increased accumulated sediment yields in the first eight years following a fire, significantly threatening the city's reservoir storage;
- much higher peak flows, greatly increasing the likelihood of flooding in the city's downtown area; and
- twice as much water yield from the watershed in the years immediately after the fire.

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Reference

Armstrong, W., 2000. Fire Effects Analysis Section, Santa Fe Watershed Draft Environmental Impact Statement, Santa Fe National Forest Open File Report.