

# THE HYDROLOGIC AND HYDRAULIC METHODOLOGY USED TO ESTIMATE POST-BURN FLOODPLAIN HAZARDS

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Due to the October, 2003 California Fires, the hydrological conditions of the watersheds in the burned areas were significantly altered causing the flooding potential of these areas to drastically increase. As part of FEMA's effort to assess the post-fire flood hazards, a number of flooding sources throughout San Diego, San Bernardino, Riverside, Ventura and Los Angeles Counties were identified for hydrologic and hydraulic restudy and floodplain mapping. This document provides a brief summary of the hydraulic methodology that was used to develop the post-burn floodplain boundaries.

## **Hydrologic Methodology**

The first step in the process was to estimate the peak runoff rates under post-burn conditions. The following is a brief description of the methodology developed to estimate post-burn peak flows.

### ***The Need for a Simple Technique to Estimate Post-burn Discharges***

Given the short timeframe of the project (10 days), development of rainfall runoff models was deemed impractical, and a simplified method for estimating the post-burn needed to be developed. The California Regional Regression Equations, available through the National Flood Frequency (NFF) program web site (<http://water.usgs.gov/osw/programs/nffp.html>) provided a quick approximation of the peak flows with various frequencies. However, the regression equations only provide estimates of the natural or pre-burn peak flows. There are no parameters in these equations that can be reasonably adjusted to reflect the changes in the hydrologic conditions caused by the fire. Therefore, a method was developed to capture the post-burn runoff properties and incorporate them as a multiplier to the standard regression equations.

### ***Development of the Simple Methodology***

The main concept behind the simple method is to develop post-burn adjustment factors to be applied to pre-burn flows calculated by the regression equations.

### **Clear Water Adjustment Factors**

To develop the peak flow post-burn adjustment factors for clear water (without the bulking effect of sediments), ratios were established between values provided by the regression equations and by the NRCS CN Method using post-burn CN values for typical local land use conditions. For each burn intensity, a representative ratio was then selected

as the adjustment factor to be applied to the peak flow generated by the regression equation. The following are the steps taken in this approach:

1. Consider the post-burn CN values from URS/Dewberry studies of the 2000 Cerro Grande Fire (New Mexico) as follows:

| <b>Burn Intensity</b>           | <b>CN</b> |
|---------------------------------|-----------|
| Low Burn<br>No Hydrophobic      | 77        |
| Low Burn<br>Hydrophobic         | 83        |
| Moderate Burn<br>No Hydrophobic | 85        |
| Moderate Burn<br>Hydrophobic    | 89        |
| High Burn<br>No Hydrophobic     | 90        |
| High Burn<br>Hydrophobic        | 95        |

The dominant land cover in the Southern California burn areas was assumed to be Chaparral. For the typical mixture of the hydrological soils in the area, the typical CN of the project area is 83. This CN is larger than Low Burn CN values from above. Since the SCS CN calculations should be compatible with regression equations, the 100-year peak flow was calculated by the NFF Equation for California South Coast (assuming P=25") for various basin areas and slopes. By back solving for the resulting peak flows, a CN=82 was determined as the typical equivalent pre-burn CN value for the regression equations in this area. However, this value also seems too high to be used in conjunction with the "No Hydrophobic" CN values from the above table. Therefore, various CN, basin area and slopes were examined to find reasonable combination of factors to be used. This resulted in selection of the results for the hydrophobic CN values for a typical 1- square-mile-watershed with a 10% slope.

2. For the conditions selected, as explained above, the 100-year peak flows were calculated by the NRCS CN method as well as the regression equations. The ratio of the two provided the adjustment factors as listed below:

| <b>Burn Condition</b> | <b>Adjustment Factor</b> |
|-----------------------|--------------------------|
| Pre-burn              | 1.00                     |
| Low Burn              | 1.76                     |
| Moderate Burn         | 2.20                     |
| High Burn             | 2.62                     |

The areas classified as "Very Low/ Unburned" in Burned Area Reflectance Classification for the California fires were treated as essentially "Unburned" and so no adjustment factors were used for these areas. For areas where the burn intensity

maps were not available it was determined to assume a “Moderate” burn classification.

The adjustment factors provided in the table above were used for both the 5-year and the 100-year peak flows.

### **Sediment Bulking Adjustment Factors**

Under post-fire conditions runoff carries an excessively large load of sediments, resulting in bulking of the flow volume. Based upon past experience and engineering judgement, it was recommended to use bulking factors related to the basin area and the flood frequency as follows:

| <b>A (sq miles)</b> | <b>5-yr Q</b> | <b>100-yr Q</b> |
|---------------------|---------------|-----------------|
| <b>0-3</b>          | 50            | 40              |
| <b>3-10</b>         | 30            | 20              |
| <b>Above 10</b>     | 20            | 10              |

The numbers in this table are percentage of increase in the peak flow rates to account for sediment bulking.

### **Overall Adjustment Factors**

The overall adjustment factors for the pre-burn 5-year and 100-year peak flows were determined by multiplying the clear water adjustment and bulking factors.

$$Q_{post-burn} = Q_{regression} \times \text{Clear Water Adjustment Factor} \times \text{Bulking Adjustment Factor}$$

Consequently, the overall adjustment factors depend on the basin area, flood frequency and the distribution of areas with various burn intensities.

### **Hydraulic Methodology**

Both the 5-year and 100-year (or Advisory) post-burn floodplains were developed and mapped. Where available, FEMA’s Q3 data was included as the pre-burn 100-year floodplain. Where FEMA Q3 data was not available, the 100-year pre-burn floodplain was developed and mapped so the change in pre- and post-burn flood hazards could be assessed.

HEC-GeoRAS was used to build hydraulic models of the flooding sources. Where digitally available, an effort was made to use the hydraulic models (e.g. HEC-2, HEC-RAS) from the effective Flood Insurance Study. The models used pre- and post-burn discharges, as described above..

Teams performed a cursory site visit to the studied streams to obtain existing conditions data, such as channel physical conditions, structure data and overbank landuse, which could be used in the hydraulic analyses. Cross-sections for the hydraulic models were developed using USGS 10-meter Digital Elevation Models (DEMs). These DEMs were

also used to map the floodplains. The DEMs were supplemented with more detailed terrain data if the data existed and was readily available.

When structure data was readily available, structures were incorporated into the hydraulic models. Structure data was derived from effective information (e.g. FISs and related models) and field reconnaissance. If structure information was not available and it was evident that the structure would result in a significant head-loss, structures were approximated as inline weirs. The crest of each weir was determined using available terrain data and engineering judgment.

Starting conditions for the hydraulic models were based on normal depth. Manning's  $n$ -values were determined from effective information, field reconnaissance, and available land use information (e.g. USGS National Land Cover Data for California – South Version, 4-28-02).

Floodplains were mapped using HEC-GeoRAS or similar tools and cleaned-up manually in ArcView GIS. All floodplains were delivered in ArcView GIS shapefile format. In areas where urban development did not reflect existing topology, Q3 data was used as a guide to estimate the 5-year and 100-year post burn floodplains. The floodplains were then overlain on the USGS 1:24000 Quadrangles.