Appendix D

Flash Flood Potential Index (FFPI) Description

In the western United States flash floods frequently occur in canyon areas of very small drainage basins and are the product of isolated storms. In short distances, land characteristics change significantly from areas where flash flooding is unlikely to where there always is a threat for flash flooding regardless of the recent rainfall history.

In the (mostly) arid West, efforts to accurately determine the flash flood threat for each basin (and grid cell) are currently hampered by the state of development of distributed models as noted in Chapter 5, and also by non-representative Flash Flood Guidance (FFG) values for areas with highly variable geographic features. In these areas the FFG values are often thought to be too high because of questionable ThreshR values. This can result from incorrect return frequency assumptions (measures of the average interval between floods of a given size), questionable unit hydrograph results, or poor resolution digital elevation model (DEM) data.

FFG takes into account a storm's rainfall properties (intensity, volume, location) and runoff properties (routing, volume, timing) but does not completely address geographic parameters (slope, vegetation, soils, land use) that contribute to the flash flood threat for a particular basin. Currently, radar technology is utilized as one of the main sources of flash flood information in the west. Flash Flood Monitoring and Prediction (FFMP) inputs radar-based precipitation estimates and maps those estimates to small river basins. Those basins are then color coded to indicate precipitation estimates and flash flood potential. The great unknown with this process are the characteristics of those color coded basins. Different rainfall intensities will cause varying amounts of flash flooding depending on basin characteristics. FFMP maps precipitation data to basins whose hydrologic characteristics are unknown to the forecaster. Are there large amounts of impermeable surfaces? Are the basins devoid of vegetation, or are they hosting lush forests? Are the basins steep walled/floored, or flat pans? Have wildfires altered basin hydrologic characteristics? The answers to these questions are crucial in the thought process to issue a flash flood warning.

One approach to deriving a meaningful flash flood threat for basins with highly variable geographic parameters is the Flash Flood Potential Index (FFPI) developed by the Western Region of the National Weather Service. The FFPI approach addresses three questions:

- Can the physiographic properties that make an area susceptible to flash flooding be identified?
- What changes in these features or properties increase or decrease an area's susceptibility to flash flooding?
- Can areas susceptible to flash flooding be identified relative to one another based solely on these properties?

As noted by Smith (2003) several physiographic factors that contribute to the possibility a flash flood will occur in any particular drainage area. Soil texture and structure are important in determining water holding and infiltration characteristics. Slope and basin geometry determine such behavior as the speed and concentration of runoff. Vegetation and forest canopy affect precipitation interception. Land use practices, particularly urbanization, can play a significant role in water infiltration, concentration, and runoff behavior. Together these somewhat static characteristics yield information about the hydrologic response and flash flood potential inherent to a specific area. However, as other features change the flash flood potential may take on a more dynamic nature. For example, changes in vegetation or seasonal changes in a deciduous forest may decrease or increase the hydrologic response associated with similar rainfall events. Perhaps the greatest effect is that of forest fire where a hydrophobic soil layer, impervious to water infiltration, may result due to the burning of organic material. In this case the flash flood potential may increase dramatically on an event-by-event basis.

A static FFPI was derived for each basin in the western United States by performing GIS map algebra on four raster (composed of pixels, e.g. bitmaps) datasets linked to hydrologic response, and re-sampled to a somewhat coarse 400-meter grid:

- Percent Slope Grid (terrain steepness factor)
- Rock Volume Grid (percent rock fragments – affecting infiltration)
- Fractional Soil Grid (percent clay, sand, etc.)
- Forest Density Grid

Slope grids come from the USGS Digital Elevation Model (DEM) dataset. The rock and soil grids came from the National Resources Conservation Service (NRCS) STATSGO (State Soil Geographic Database), while the forest grid comes from the NOAA AVHRR (Advanced Very High Resolution Radiometer) dataset. The datasets were all geo-registered prior to manipulation and re-sampled to consistent resolution using a bilinear (nearest neighbor) method. Equal weighting was given to each data layer, and unit-less Flash Flood Indicators (numeric values from 1 to 10) were assigned. Without observed event information it is difficult to know how to weigh each layer. Until these observed data layers are generated the input layers were weighed equally with the exception of the slope layer. This layer was weighed slightly more than the others due to the significant influence of slope on flash flood development. A more robust weighting scheme is anticipated when observed flash flood event data is included in the analysis. An example of the relative FFPI around the Virgin River in southern Utah produced by the NWS Colorado Basin River Forecast Center in Salt Lake City, Utah, is shown in Figure D.1 from Smith (2002).

FFMP software takes advantage of the ability of the WSR-88D NEXRAD Doppler Radar Digital Hybrid Scan Reflectivity precipitation algorithm to sample rainfall amounts and rate at a fine resolution (1 degree by 1 km polar grid resolution) and the High Resolution Precipitation Estimator (HPE) to estimate rainfall on a 1x1 Km grid resolution. This gridded precipitation

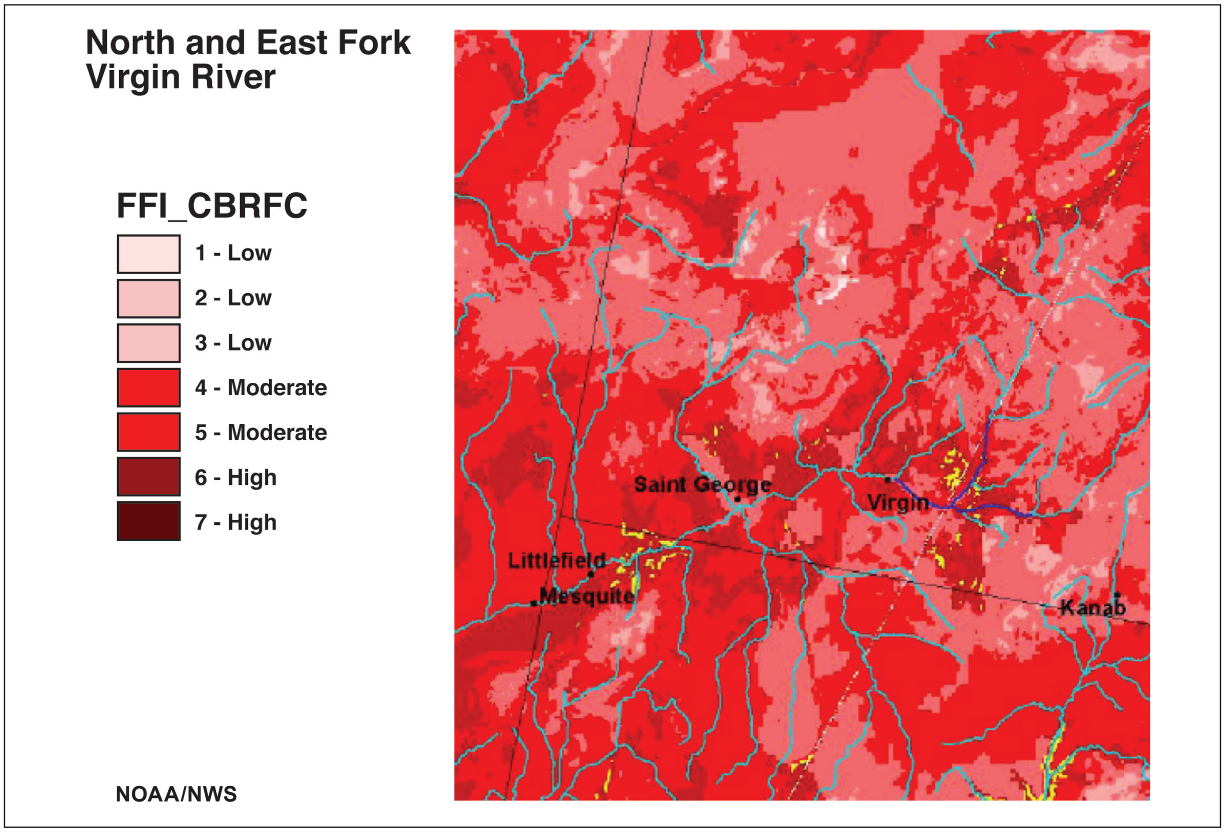

Figure D.1 Example of static relative FFPI for portions of southern Utah

is then converted to an Average Basin Rainfall (ABR) for a predefined set of watershed boundaries. FFPI endeavors to supplement FFG by incorporating information about the relative flash flood potential of each of the FFMP basins. Revised FFG will result in better products from FFMP.

References

Smith, Greg, (2002): Unpublished presentation at Severe Weather/Flash Flood Warning Decision Making workshop, COMET Sep. 2002.

Smith, Greg, (2003): Flash Flood Potential: Determining the Hydrologic Response of FFMP Basins to Heavy Rain by Analyzing Their Physiographic Characteristics. A white paper available from the NWS Colorado Basin River Forecast Center web site at http://www.cbrfc.noaa.gov/papers/ffp_wpap.pdf, 11 pp