Responding to a Flash Flood Threat When the Sky is Blue

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The September 6, 2010 Fourmile Canyon wildfire changed hydrologic conditions and increased the potential for flooding downstream. Areas impacted by the burn area are along Gold Run, Fourmile Creek, Fourmile Canyon Creek and Boulder Creek in rural areas of Boulder County, and in the City of Boulder, Colorado. The Fourmile Canyon Fire burned an area of 6,179 acres composed primarily of open ponderosa pine in the foothills approximately 5 miles west of Boulder's city limits. The wildfire also destroyed 169 structures, mostly private homes, and until 2012 was considered Colorado's most damaging wildfire. Since that fire the flash flood forecasting system which had been in place since 1979 was substantially enhanced by the Urban Drainage and Flood Control District (UDFCD).

The new flash flood forecasting system leverages a physically-based distributed hydrologic model, and inputs derived from a combination of radar and gauge measurements in real-time. Continuous forecasting of flood potential took place during the 2011 flood season and again in 2012. Predictive hydrologic information was used to generate flood threat alerts based on discharge thresholds at critical locations in downstream areas receiving runoff from the burn area. In some cases, storms over the burn area can produce potentially dangerous flood conditions in far removed locations.

Figure 1 shows conditions on July 30, 2012 on Fourmile Canyon Creek where it flows under Broadway, a main thoroughfare in the City of Boulder. This location was forecast to receive a peak of about 200 cfs arriving at 5:00 pm MDT based on operational hydrologic/hydraulic modeling with radar and rain gauge input. Onsite observations (there is no stream gauge established at this location) confirmed that it did indeed peak within a few minutes of the forecast time and that the estimated impacts were accurate.

Confidence has been gained over two flood seasons, 2011 and 2012, with a flash flood forecasting system that predicts when and where flooding is expected in diverse locations downstream of the Fourmile Burn Area (FBA). Due to the relatively quick hydrologic response of these mountainous watersheds, warning lead-times can leave little time for taking emergency actions, ranging from minutes to over an hour depending on distance downstream.

The modeling approach integrates diverse watershed characteristics, such as terrain, land use and vegetative cover along with gage-corrected radar-based rainfall to simulate the hydrologic effects of the wildfire. The model was initially deployed without calibration using physically-realistic model parameters and assuming zero infiltration in the burn area, i.e. the worst case scenario. After the first significant runoff event on July 13, 2011, the ➡

Figure 1. Forecasted flood conditions on July 30, 2012 on Fourmile Canyon Creek near the bike path and walkway passing through box culvert under Broadway in the City of Boulder.

infiltration rates were adjusted to just under 0.1 inch/hour to be more representative of the wildfire's effect on the burn area.

Flood forecasting requires a spatial and temporal rainfall distribution that is representative of how rainfall intensities evolve during a storm over a watershed. Hydraulic travel time provides an additional lead-time factor for locations downstream. The travel time of a flood wave can range from a few minutes immediately downstream of the FBA to over a half hour along Boulder Creek through the City of Boulder. Larger floods travel faster due to the hydraulic characteristics of overland and channel flow through the natural drainage network, which is taken into consideration by the model.

Radar and rain gauge data are combined to produce what is known as quantitative precipitation estimates (QPE). By contrast, future rainfall is termed quantitative precipitation forecasts (QPF) and was tested in 2012 for the FBA and is planned for continued use for real time operations in 2013. Forecast rainfall is based on projecting the path and intensity of storm cells from successive radar scans, the calculated forecast storm motion offers advanced notice of when and where flash flooding may be expected. An analysis recently completed shows that additional lead-times of approximately 40 minutes downstream of the FBA is possible by using a combination of QPE plus QPF.

These findings suggest that predicting flash floods prior to the onset of heavy rainfall holds great promise for residents and businesses downstream of the FBA. As forecasters continue to gain experience and confidence with using radar-based QPF as input for real-time hydrologic models, emergency managers, first responders, and those in harm's way will be provided with greater lead-times in which they may take the necessary actions to protect lives and property from flash floods.

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