Differential Impacts of Flash Flooding Across the Paso del Norte

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The Paso del Norte metropolitan area of approximately 2 million people is comprised of the cities of El Paso, Texas and Ciudad Juárez, Chihuahua. This binational metropolis is separated by the Rio Grande, known in Mexico as Rio Bravo del Norte. It is located in the Chihuahuan Desert, where average annual precipitation is around 9 inches, most of which falls during the North American monsoon in late summer, often as short but intense storms that cause flash flooding in the metropolitan area. The cities are built around the Franklin Mountains, which nearly bisect El Paso, and the Sierra de Juárez that flanks Ciudad Juárez. Orographic effects around the mountains lead to significant variations in storm impacts from one location to another. And although the two cities experience the same weather systems and have similar topographic variability, their different socioeconomic characteristics result in greater relative impacts of flooding in Ciudad Juárez than in El Paso.

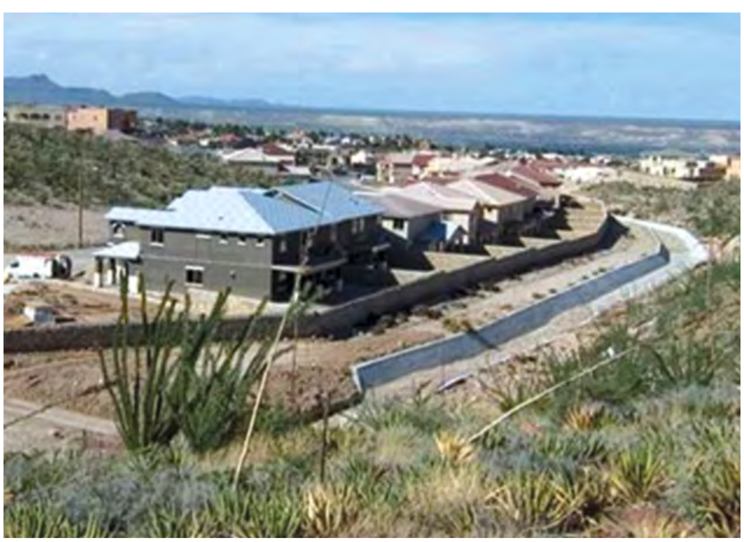
The physical and socioeconomic complexities of the Paso del Norte create dual, interacting complexities in planning for, forecasting, and responding to flash floods within the region. Weather forecasting and flood hazard planning for El Paso is the direct responsibility of the U.S. National Weather Service and other federal and state government agencies, while the Servicio Meteorologico Nacional of Mexico provides forecasts for Ciudad Juárez. Coordination during flood emergencies between these cities separated by an international frontier is mostly indirect, facilitated through local emergency management agencies.

Sharp disparities in flood-protection measures and infrastructure between the two political jurisdictions led to sharp disparities in effects and recovery from the flood.

Topographic Disparities

In "Storm 2006," from July 27 to Aug. 4, 2006, El Paso International Airport (ELP) received 6.6 inches of rain, or about three-fourths of its annual average precipitation. Some portions of El Paso's mountainous west side received around 10 inches of rain in less than eight hours during that period (Rogash and others, 2009). Heavy rains, flash flooding, and river flooding continued through the summer: three of the 16 maximum precipitation events of the prior 130 years occurred within five weeks, making July through September 2006 the wettest three months on record at ELP. Even greater amounts fell in the mountains. Large arroyos on El Paso's west side ran for the first time in decades and floodwaters caused significant damage in the urban areas (see photos).

Average recurrence intervals (ARIs) for precipitation at ELP for the 2006 floods ranged from around one year, on time scales of a few hours, to 50 to 100 years on time scales of a week to ten days. However, if the ARIs developed from airport data were applied to measurements from rain gauges in El Paso's west side, the apparent recurrence intervals for this storm would be hundreds to thousands of years (Gill and Novlan, 2007). The only National Weather Service rain gauge in the region is at ELP; its data are used for flood recurrence-interval planning for the entire city. However, the 2006



Upscale arroyo-side development (left) and flood damage due to deficient arroyo drainage system (right) on the west side of El Paso.

storm showed that inundation intensity/duration/frequency curves based on those data did not provide useful flash-flood hazard assessments in neighborhoods just a few miles away in a more topographically complex urban area. Orographic effects may not have been properly considered in developing flood-recurrence metrics for urban planning in El Paso, causing the flash-flood risk in some neighborhoods to be underassessed and exacerbating flood-related losses.

sociodemographic metrics	El Paso County, Texas	Ciudad Juárez, Chihuahua	San Diego County, California	Tijuana, Baja California
population (total)	679,622	1,218,817	2,813,833	1,210,820
housing units (total)	224,447	279,864	1,040,149	269,949
median household income (US$)	31,051	4,804	47,067	7,206
national gross domestic product, per capita (US$)	37,594	6,114	37,594	6,114

Sociodemographic characteristics of El Paso, Ciudad Juárez, San Diego, and Tijuana.

Socioeconomic Disparities

The Paso del Norte covers two nations with greatly differing capacities to respond to flash floods. For the same storm, Ciudad Juárez experiences much greater flood risks and impacts and longer-lasting effects than El Paso, largely due to socioeconomic disparities as shown in the table at right (Jenkins and Iturralde, 2008; Collins, 2009). In the 2006 floods, more than 1,500 homes and dozens of drainage facilities and roads were impacted in El Paso, with damage estimates of $200 million to $300 million; a federal disaster was declared. But in Ciudad Juárez, some 5,000 homes were damaged or destroyed and losses exceeded $600 million, more than twice the city's annual budget (Collins, 2009). Relative to local economic productivity, the flood's severity was arguably an order of magnitude greater in Ciudad Juárez than in El Paso.

Flood insurance had not been maintained among the generally lower socioeconomic status households in Ciudad Juárez, while 58 percent of El Paso's households experiencing home-site damage were insured (Collins, 2009). Thus recovery was generally facilitated in El Paso, although disparities were evident even within the city. Impacted high-income households were virtually 100 percent covered by flood insurance. In comparison, recovery was more difficult for low-income El Paso households experiencing damage: only 18 percent of the city's low-income households maintained flood insurance to compensate for losses (Collins, 2009).

These differing risks and responses are further illustrated by looking at the 2006 flood impacts on residents of heavily damaged mountainside neighborhoods in each city. Neighborhoods in the Franklin Mountains of western El Paso experienced the greatest absolute monetary damage from the floods. Yet these residents are relatively affluent: nearly 95 percent of those experiencing flood damage maintained flood insurance (Collins, 2009). In contrast, Ciudad Juárez's Poniente neighborhood on the slopes of the Sierra de Juárez—which also received severe storm impacts—has some of the most socioeconomically vulnerable residents of the Paso del Norte. Many lack legal title to their homes, and few if any had flood insurance or assets to invest in flood-hazard reduction, mitigation, and recovery efforts.

Lessons for the Southwest

The Paso del Norte example illustrates several key issues for flood-hazard planning, management, and recovery and has strong implications for other Southwest cities. In these topographically complex regions where precipitation is spatially variable, uneven rain-gauge density, airport data, or any single-station-based rainfall climatology may be inappropriate for flood recurrence/intensity planning and flood-hazard assessment across a metropolitan area. Neighborhoods in or below mountainous catchments may be more vulnerable to flooding than predictions indicate. The same weather system that caused the Paso del Norte flood brought rainfall with an apparent recurrence interval

see Paso del Norte, page 33

Paso del Norte, continued from page 21

of hundreds of years in Sabino Canyon in the Santa Catalina Mountains near Tucson, Arizona, causing record flash flooding and debris flows, washing out roads, and destroying recreational facilities (Magirl and others, 2007).

Mexico's urban areas experience more severe flash-flood impacts than adjacent cities in the United States due to Mexico's reduced capacity for social protection. These impacts are likely to be experienced in other binational watersheds in the Southwest, such as along the Tijuana River between California and Baja California. Although water-quality issues are the prime concern there, an extreme event such as occurred in the Paso del Norte would likely have similarly disparate socioeconomic effects on different sides of the border (see table, page 21).

Both socioeconomic and physical factors create variable risks for and capacities to respond to flash-flood hazards within a single metropolitan area. Impact-based, rather than purely hazard-based, flood forecasting and planning would be especially effective for urban areas with high spatial variabilities in meteorology and/or socioeconomic development. Assessments incorporating GIS and spatially variable risks and impacts, now used to evaluate other natural hazards such as tornadoes, earthquakes, and winter storms, are appropriate tools for management and mitigation of urban flooding in such areas. ■

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