

Flash floods in city environments

The good, bad, and sometimes fatal judgements that motorists make

By Zack Guido

The yellow and black signs pop up throughout Tucson every summer: “flood area.” They are silent sentinels, warning motorists that a torrent of rain water is surging through a dip in the road or stretch of street, making it dangerous to pass.

Yet, every monsoon season in Tucson and throughout the Southwest sees motorists plow ahead across temporary road rapids, hoping to make it to the other side with nothing more to show for it than wet tires.

Some aren't so lucky; they misjudge the depth of the water and find themselves floating uncontrollably in their vehicles or, worse, are drowned.

Intense rains are common during the monsoon season, and so are flash floods. As of August 28, the National Weather Service in Tucson had issued 83 flash flood warnings for southeast Arizona, prompting many city planners as well as people in charge of broadcasting flash flood warnings to ask why motorists throw caution to the wind—or in this case, to the water. A University of Arizona graduate student Ashley Coles has some answers for them.

Hazardous Roads

Each year in the United States the number of deaths caused by floods is greater than all other weather-related hazards except extreme heat. Higher populations in cities give urban flash floods higher profiles, but rural areas are equally affected.

The Centers for Disease Control reports that more than half of all flood-related drownings occur when vehicles are driven into hazardous flood waters. The next highest percentage occurs when people on foot are swept into swollen



Figure 1. This photo was taken on July 28, 2008, several blocks north of Speedway Boulevard on Park Avenue in Tucson. *Source: Ashley Coles.*

and fast flowing waters. In Arizona and New Mexico, 57 people have died since 1995, and hundreds of others have needed swift water rescues, according to news sources.

In the Southwest, flooded roads often occur during the intense and short-lived monsoon storms between June and September. In Tucson, when precipitation at any of the 93 rain gauges incorporated in the Pima County Flood Control District's (Pima Flood District) monitoring network exceeds one inch per hour, the Pima Flood District alerts the Tucson Department of Transportation (T-DOT) of possible dangerous flood conditions. The monitoring data is also retrieved by the National Weather Service (NWS) in Tucson and incorporated into their decision to issue flash flood advisories or warnings.

Despite these warnings, effective communication of flash floods is virtually impossible, said Tony Haffer, meteorologist for the NWS in Phoenix. Over the air waves, Haffer continued, it is difficult to mention the specific locations of flash floods. Alerts often catch motor-

ists off-guard, and they might not reach motorists who are listening to music or people not in vehicles.

On July 26 in Ruidoso, New Mexico, a young man lost his footing and drowned in the raging Rio Ruidoso. A month later, two women were killed in Phoenix in separate incidents when flash floods swamped their cars.

“Water is typically muddy and it's difficult to judge depth. It doesn't take much water to get into trouble,” Haffer said.

The main reason for the casualties is that people underestimate the depth of water and as a result misjudge the force of the current. In fact, as little as six inches of flowing water can knock down an adult, and 18 inches is enough water to float most vehicles, including big SUVs.

Warnings are not going to reach everyone. “Thank goodness not many people die. But unfortunately we have a number of motorists who put themselves in danger and also put rescuers at risk,” Haffer said.

continued on page 4



Flash floods, continued

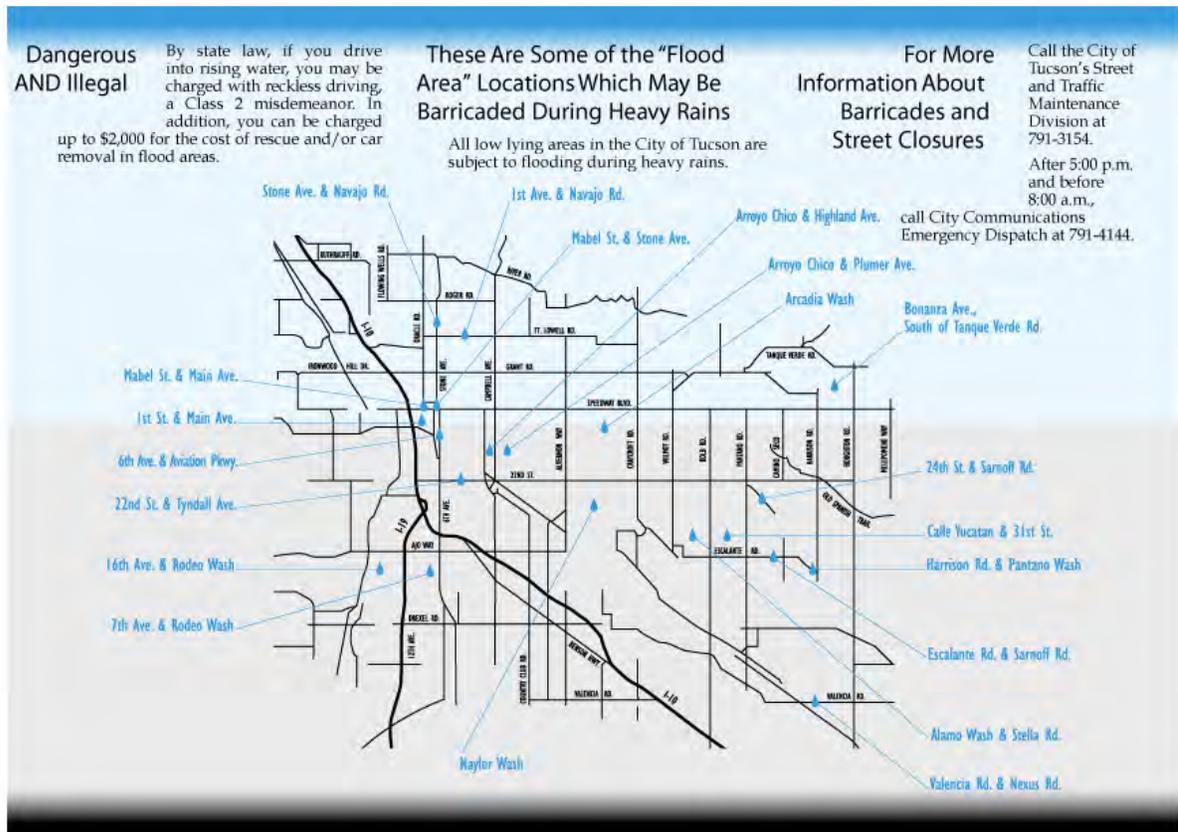


Figure 2. Map of street locations in Tucson that are prone to floods and that may be barricaded during heavy rains. This map does not include all the locations that may be flooded. *Source: This map was produced by the Tucson Department of Transportation for its public outreach campaign, "Operation Splash."*

On August 31, Tucson firefighters rescued two men who were trapped in their truck after their pick-up stalled in deeper-than-expected water and free-wheeled 1,000 feet down Arroyo Chico.

Why roads are flooded

For newcomers to the Southwest, flooded roads in downtown cities undoubtedly seem out of place. Where are the culverts, the bridges, the flood control ditches typical of other places? Even the simultaneous occurrence of rain and flooding is novel.

"Many people are transplants and they come from areas outside the Southwest; it's a whole different animal here," Haffer said. "Deserts are primed for floods because the sun bakes the soils and makes the ground more impermeable."

The hard soils and intense monsoon rains collaborate to immediately cascade

water off the landscape into a network of hundreds of natural rills and gullies that focus water into larger channels. Where the city roads overlay these waterways, roads become rivers during heavy rains.

In fact, Haffer said, "engineers and planners designed roads to carry water. When you see water on roads, that is what they were intended to do."

During flash floods in Central Tucson, for example, water flowing in Navajo Wash crosses First Avenue, creating a dangerous pool, before funneling onto Navajo Road. Navajo Road then channels the water past Euclid and Stone avenues, creating two more hazardous intersections, and several more blocks before dumping the water into a cemetery.

It would undoubtedly be safer for motorists if all the water flowed under

Tucson, but this would require a New York City-scale subway water system—a bird's eye perspective displays a city built over hundreds of washes. And although some roads perform their double duty well, too many of them flood. T-DOT has identified at least 23 locations where flooding poses a threat to motorists (Figure 1). There simply isn't enough money to dig up the roads and neighborhoods and install large diameter culverts, sometimes for miles.

"The city of Tucson alone has well over \$500 million in drainage needs," said Andrew Dinauer, city engineer for T-DOT. "Some years we receive zero dollars for flood control."

The steep rise in building materials in recent years has worsened the budget crunch. The price of concrete, steel, and other materials have nearly doubled in

continued on page 5



Flash floods, continued

the last three to four years. Project budgets approved in the past now only buy half the project. It's becoming cheaper to purchase entire blocks of houses than to install the needed drainage control for specific neighborhoods, Dinauer said.

As a result, city engineers and planners are beginning to rethink drainage control and floodplain management. Out of necessity, they now perceive runoff as a resource rather than a nuisance and are researching adaptation strategies, such as storm water harvesting. Some managers are also contemplating engineering flood control structures for the 500-year storm instead of the 100-year storm to protect against increases in flood magnitude that may result from climate change; with the deficient financial resources, this may be a pipe dream.

No amount of money can change the fact that Tucson and other desert cities are built upon an arroyo-rich landscape. During extreme weather some roads will flood. It ultimately becomes the responsibility of the motorist to use good judgment.

Why people cross flooded roads

At the end of July 2007, Ashley Coles found herself living her research. At the time, she was a second year graduate student in The University of Arizona's Department of Geography. As part of a Climate Assessment for the Southwest-funded project, she was researching the factors that led people to either drive through flooded roads or compelled them not to. On that rainy afternoon, she drove north on Park Avenue and was several blocks from Speedway Boulevard when the road was swallowed by water. Exercising good judgment, Coles pulled her car to the curb. A white sports car driven by a young man, however, passed her and plowed into the road-come-river. The water choked off his engine. Seconds later he emerged from his car, standing in ankle deep water, undoubtedly regretting his decision. Meanwhile, a big-wheeled truck pulled

alongside to fashion a tow, while a sedan spun around on the far side (Figure 2).

Had Coles brought her research papers with her, she would have handed the three drivers the same survey questionnaire that she sent to 1,000 residents of Tucson in an attempt to understand the motives of "crossers" and "non-crossers."

Coles crafted the survey in collaboration with risk managers and personnel from agencies such as T-DOT, NWS, and Pima County Regional Flood Control District. Their participation was essential for Coles because "if the results were going to be used, managers needed to be on board from the beginning. I didn't want to hand them a product and then ask if it was useful," she said.

Coles' analyzed the 160 returned surveys and concluded that more people admitted that they had crossed flooded roads without knowing the water depth than did not cross—97 people responded that they had at least once in their life driven across a flooded road, while 63 said they had never crossed.

Coles discovered that the main motive behind "crossers" was the prior successful crossing of another vehicle. She also found that, not surprisingly, the size of the vehicle mattered. Of the respondents with trucks and SUVs, 84 and 73 percent were "crossers," respectively, while only 57 percent of the people in cars had crossed a flooded road.

Coles' effort to reach out to management agencies highlights a growing desire in the academic community to conduct research with practical uses. Coles' research not only gave her a degree, but more importantly it helped risk managers understand why people make bad decisions in spite of many efforts to improve their decisions, including the threat of a fine of up to \$2,000 on people who are rescued from a barricaded flooded road and stigmatizing

them for breaking the "Stupid Motorists Law."

Perhaps the most important result of Coles' research is the knowledge that warning signs and barricades confuse motorists by not conveying the degree of danger. "The fact that the signs remain in place when the roads are dry or when the flow is 'a trickle' leaves the motorist to assess the hazard based on environmental cues, such as water flowing over the curb level, or perhaps the behavior of other motorists," Coles wrote in her study. "However, as motorists become accustomed to the presence of signs at flood-prone intersections, the lack of a sign creates a false sense of security for those who trust the signs and will not cross when they are present."

Several solutions exist for improving the communication of flood risk: signs that flash only during hazardous conditions, alternative route maps that become common knowledge, and use of new technologies like car-mounted Global Positioning Systems that help illuminate alternative routes. Unfortunately, these solutions are expensive. And since most participants in the survey responded that they seek advice from others during flash floods, perhaps the best solution is continued education so that social networks better protect motorists.

Although there are few casualties of flash floods in the Southwest, most people are affected by them. Looking toward the future, Coles envisions that the impact of flash floods on society will increase. More extreme events may be in store in the future, she said, and the population in the Southwest will continue to grow, increasing the number of people caught on the wrong side of a flooded road. Also, Coles said, as cities expand, additional washes become roads, boosting the number of hazardous areas, while a growing number of impermeable surfaces increases the magnitude of flash floods.

