2006 Flood in El Paso, Texas

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Introduction

From late July to mid-September 2006 the Paso Del Norte region, consisting of El Paso City, Southern New Mexico and Ciudad Juarez, Mexico experienced several record high precipitation events. This caused severe localized and widespread flooding.

The Paso del Norte metropolitan area consists of approximately 2 million people of which El Paso comprised 736,310 during the disaster year. El Paso and ciudad Juarez are separated by the Rio Grande. El Paso is located in the Chihuahuan Desert and annual average precipitation is approximately 9 inches. Most of this rain falls within in the North American monsoon season in late summer. It is not uncommon for it to fall in short bursts that cause flash flooding in the metropolitan area. El Paso is built around the Franklin mountains and backed on the south end by Cierra de Juarez mountain. Orographic effects around the mountain lead to significant variation in storm impacts from one location to another.

The El Paso international airport rain gage measures 15.01 inches of rain during the months of July through September. From July 27 to August 4th this gage measured 6.6 inches of rain. Almost three fourths of it yearly aver average precipitation amount, with some areas receiving almost 10 inches of rain in less than 8 hours (Rogash et al 2009). Three of the 16 maximum precipitation events in the past 130 years occurred during this time period making this storm event officially the wettest monsoon on record for the Paso del Norte area (Gill and Collins 2010).

The Rio Grande that creates a natural border between El Paso and Ciudad Juarez was dammed at Elephant Butte reservoir (North of El Paso) in 1916. This reduced its base flow at El Paso from 945 cfs to 178 cfs, a reduction of 82%. During the severe rain event the Rio Grande overflowed several times in and around the city and reached its highest levels since 1912. Arroyos that had been dry for years reached flood stage (Rogash et al 2009).

Rainfall amounts were over 300% of normal levels based on 128 years of data collection. According to the national weather service the rains in the week from July 27 to August 4th were akin to a 100-150 year event. An estimated 1,500 homes were damaged, including damage to infrastructure and businesses the damage was estimated to be between 200-450 million (Collins et al 2012). The area was declared a federal disaster and although no loss of life occurred there was significant health effects.

The rainfall was due to a number of mesoscale convective systems that developed over the Santa Teresa National Weather Service Forcast Office. Since the climate of the area is often arid it is not uncommon for it to experience flash floods. However, during this event areas were affected that were at least 100 km apart within a 12 hour period. (Rogash et al 2009).

The only national weather service rain gauge in the city is located at the El Paso international airport. Its data was used during the 2006 evident for flood recurrence-interval planning for the entire city. The flood during 2006 showed that this was insufficient. It did not provide useful flash flood assessments in neighborhoods with a topographically complex urban area, such as those located near the west side of the Franklin mountains. (Gill and Collins 2010). This suggested that orographic affects were not properly considered when developing urban planning in the El Paso area.

Data

Data for the study gage, EL PASO AT RIO GRANDE was obtained from USGS. NFIE Geodatabase was used to determine the characterize the sub-watershed and basins within the study site, as well as to delineate the flowlines. The national land database was used to characterize the land cover within the sub-watershed and basins. Precipitation data for the sub-watershed and for the three rain gages within were obtained from National Oceanic and Atmospheric Administration (NOAA). All data was processed using Arc GIS pro 1.3.1 2016.

Study Site

El Paso lies within the Paso del Norte sub-watershed (Figure 1). It covers an area of 256.3 m^2. The sub-watershed is comprised of 17 HUC 10 Units, it extends 340 miles along the Rio Grande River. It irrigates approximately 200,000 acres of farmland and is impacted by the need of nearly 2 million people (including Ciudad Juarez). The NFIE Geodatabase was used to isolate the sub-watershed. Within the Paso Del Norte sub-watershed there are two distinct basins. The Mesilla basin to the North West of El Paso and the Hueco basin to the East and South.

Figure 2 was used to evaluate the land cover of the sub-watershed (Figure 2b). The majority of the sub-waterhed is shrub, scrub, and grass (~85%). El Paso and Las Cruces make up 6% in developed area and agriculture around the Rio Grande makes up another 6%. This accounts for the 200 million acres of farmland that the sub-watershed provides water for.

Looking closer at just the city of El Paso (Figure 3) it is clear that most of El Paso is highly developed. This has significant impacts on runoff as a developed area has greater runoff. This is particularly true of El Paso were the hard dry ground does not absorb too much water. This combined with the developed land lends itself to frequent and severe flash flooding. The area that is not highly developed is the Franklin mountains, and even then, there is significant development in the lower regions of the mountain (Figure 4), especially in West El Paso where a majority of the flood damage occurred.

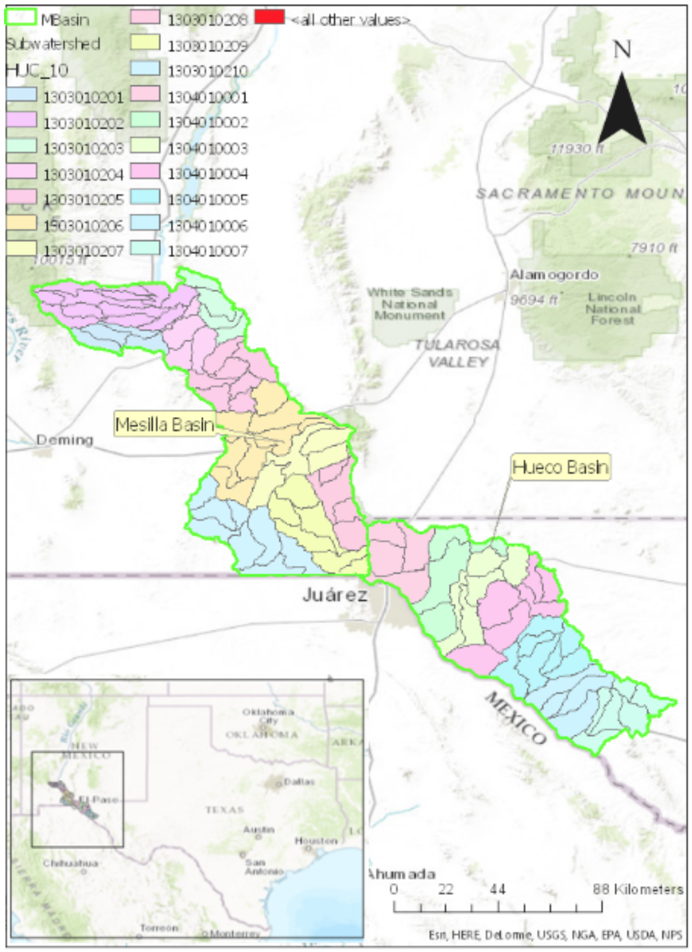


Figure 1. Paso Del Norte Subwatershed

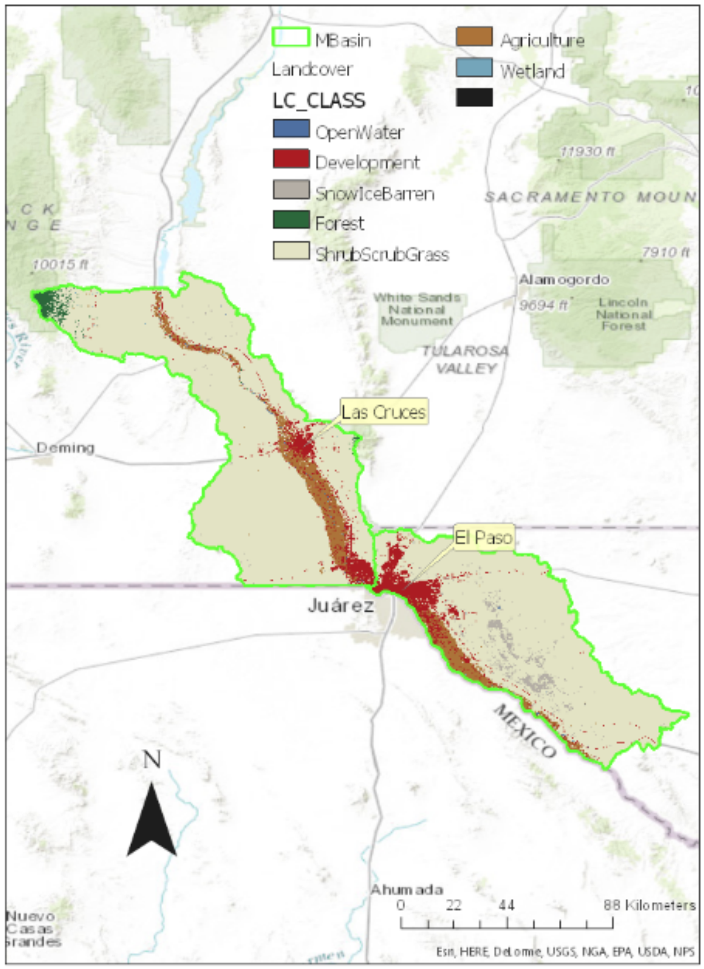


Figure 2. Land coverage in Paso Del Norte Sub-watershed.

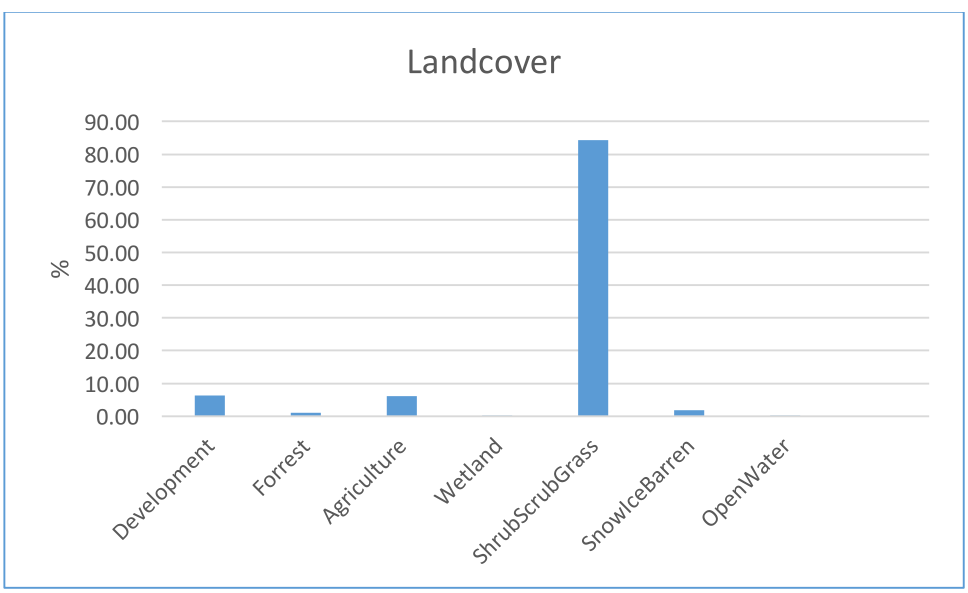


Figure 2b. Percentage of land coverage by type for Paso del Norte sub-waterhsed.

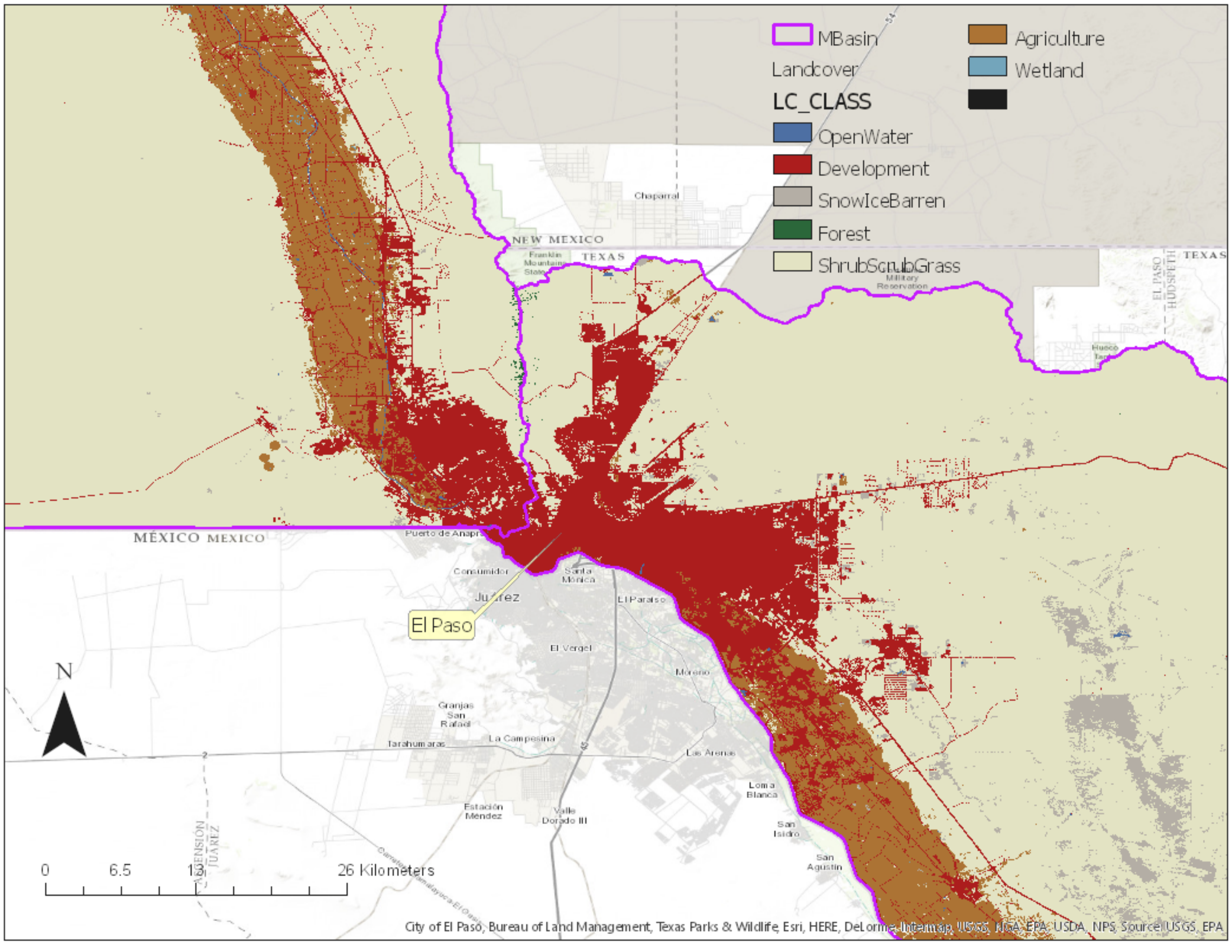


Figure 3. El Paso city land coverage data.

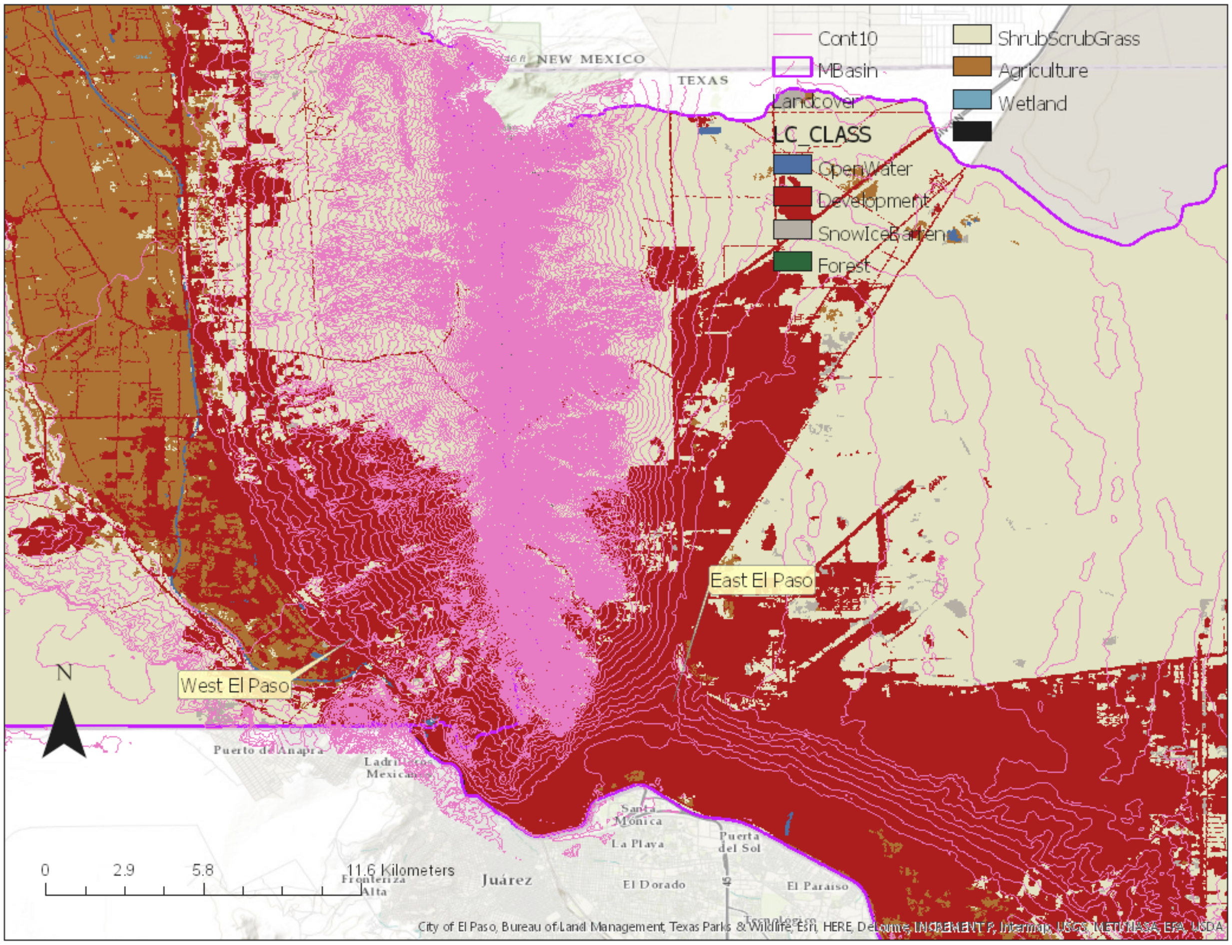


Figure 4. 10m Contour for El Paso city and surrounding area.

Study Gage

USGS only had one gage located within the study site that was recording data during the event. This gage, Rio Grande at El Paso is located within the Mesilla basin (Figure 5) and was used to obtain discharge date for the Rio Grande during the week of July 27- August 6th. Within the Mesilla basin the Rio Grande runs 173 km and there is a total stream length of 1810 km (Figure 6). Figure 7 shows the peak flow during July 27-August 6th. From this table, it is clear that the biggest impact was seen from August 1-3rd. With the largest peak on August 2nd of 7000 cfs, almost two orders of magnitude higher than base flow conditions.

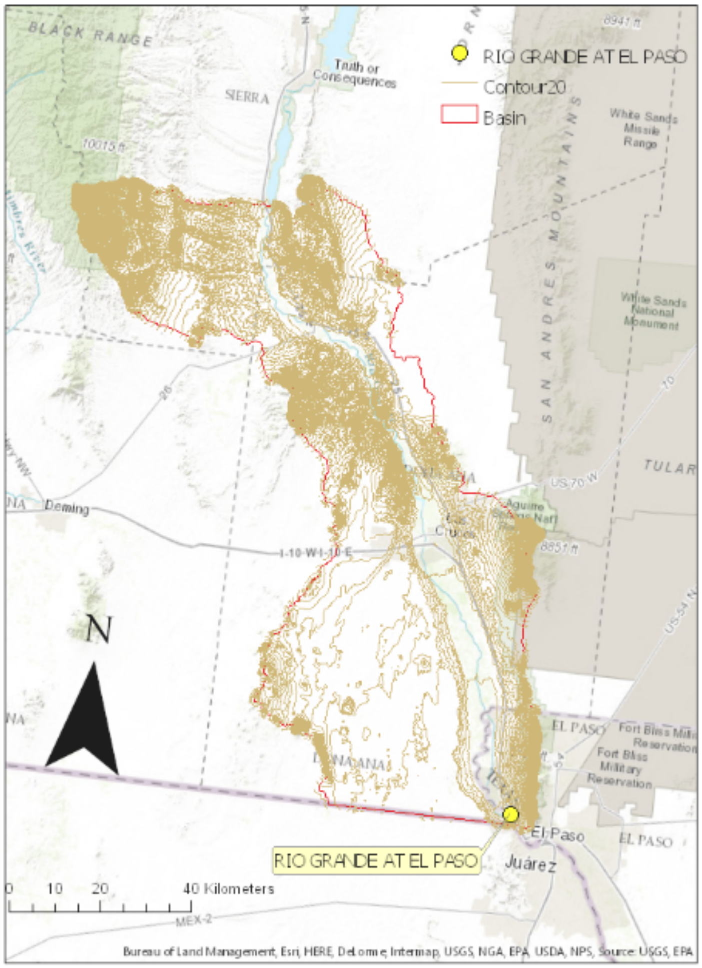


Figure 5. Rio Grande at El Paso stage gauge located in the Mesilla basin in Paso Del Norte sub-watershed.

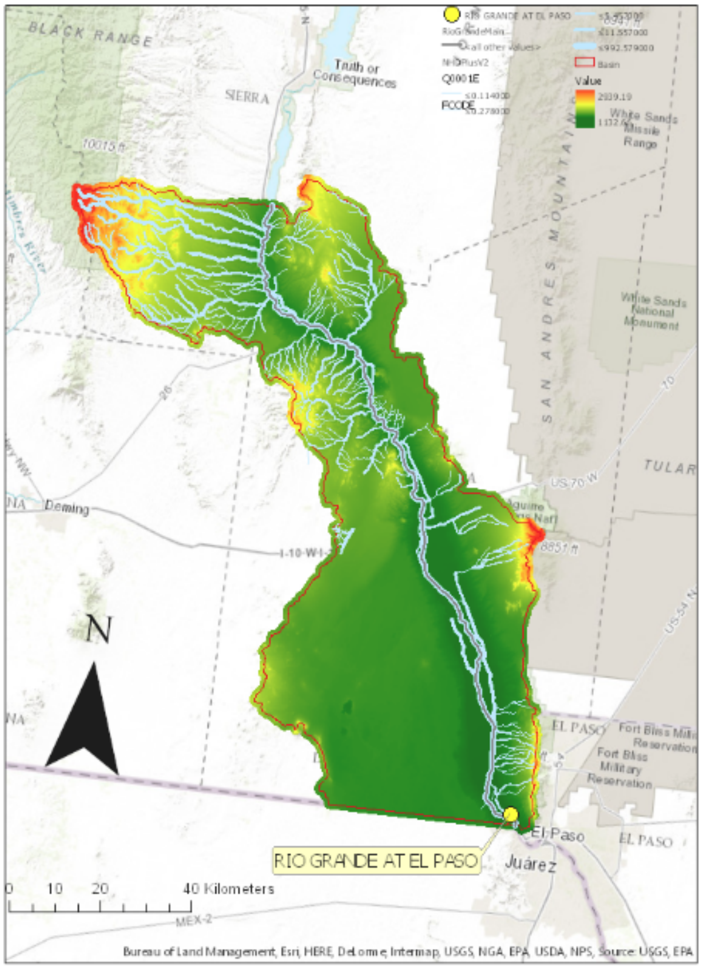


Figure 6. Stream delineation within the Mesilla basin.

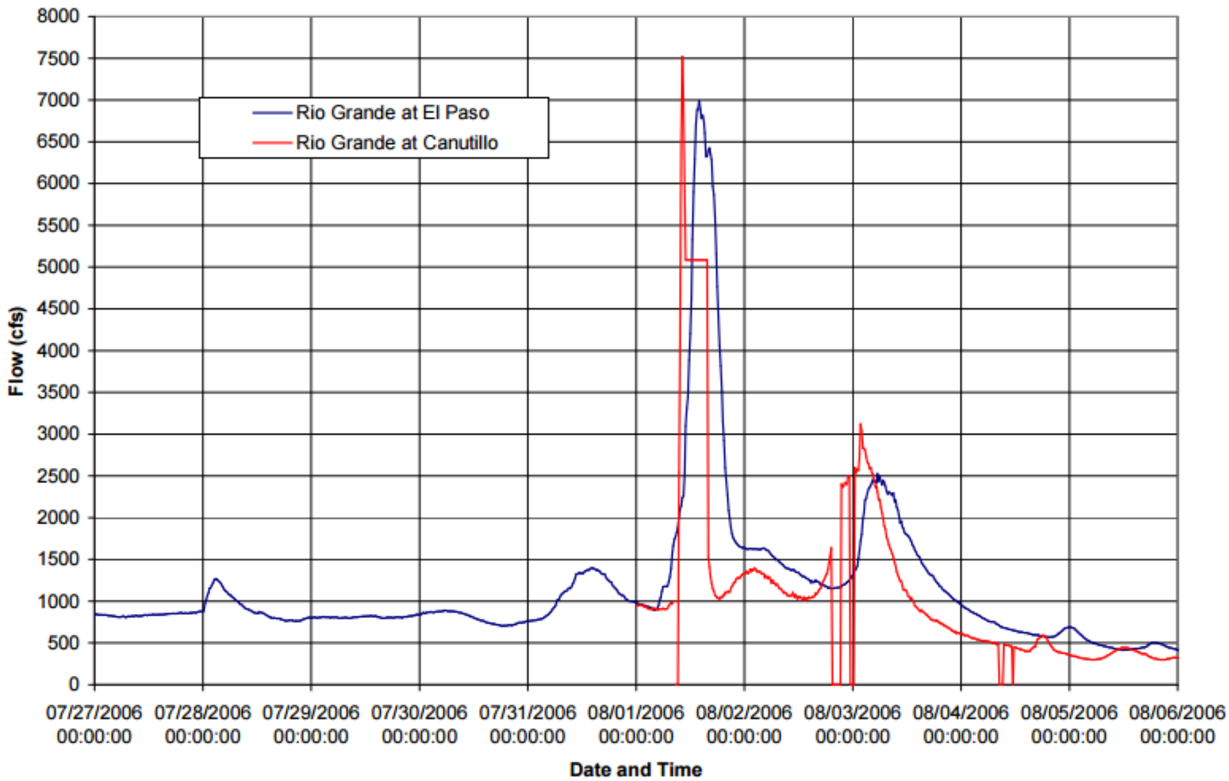


Figure 7. Peak flow for the Rio Grande from July 27-August 6th. (Source USGS)

Rain Gages and Precipitation

NOAA was used to obtain rain gage data and satellite precipitation data for the area. The three gages used for this analysis were State university at Las Cruces, Santa Teresa Airport and EL Paso International Airport (Figure 8). The precipitation data was added to ArcGIS pro then converted to a raster. This raster was then used to extract the information for just the sub-watershed. Figure 9 shows the progression of the storm precipitation over the sub-watershed during the same time period as the stage gage (July 27-August 6th). From these images, you can see that it correlates with the observed peak river discharge from Figure 7, where the biggest discharge happened on August 2nd. This is also the day that El Paso Experienced its heaviest rain fall with some areas on the west side seeing 6 inches of rain in a single day (Figure 9, 8-02). The animated version of Figure 9 is located at the following link: https://drive.google.com/open?id=0B-42Sf917H4SMVZSZ2hlSjV6VzA

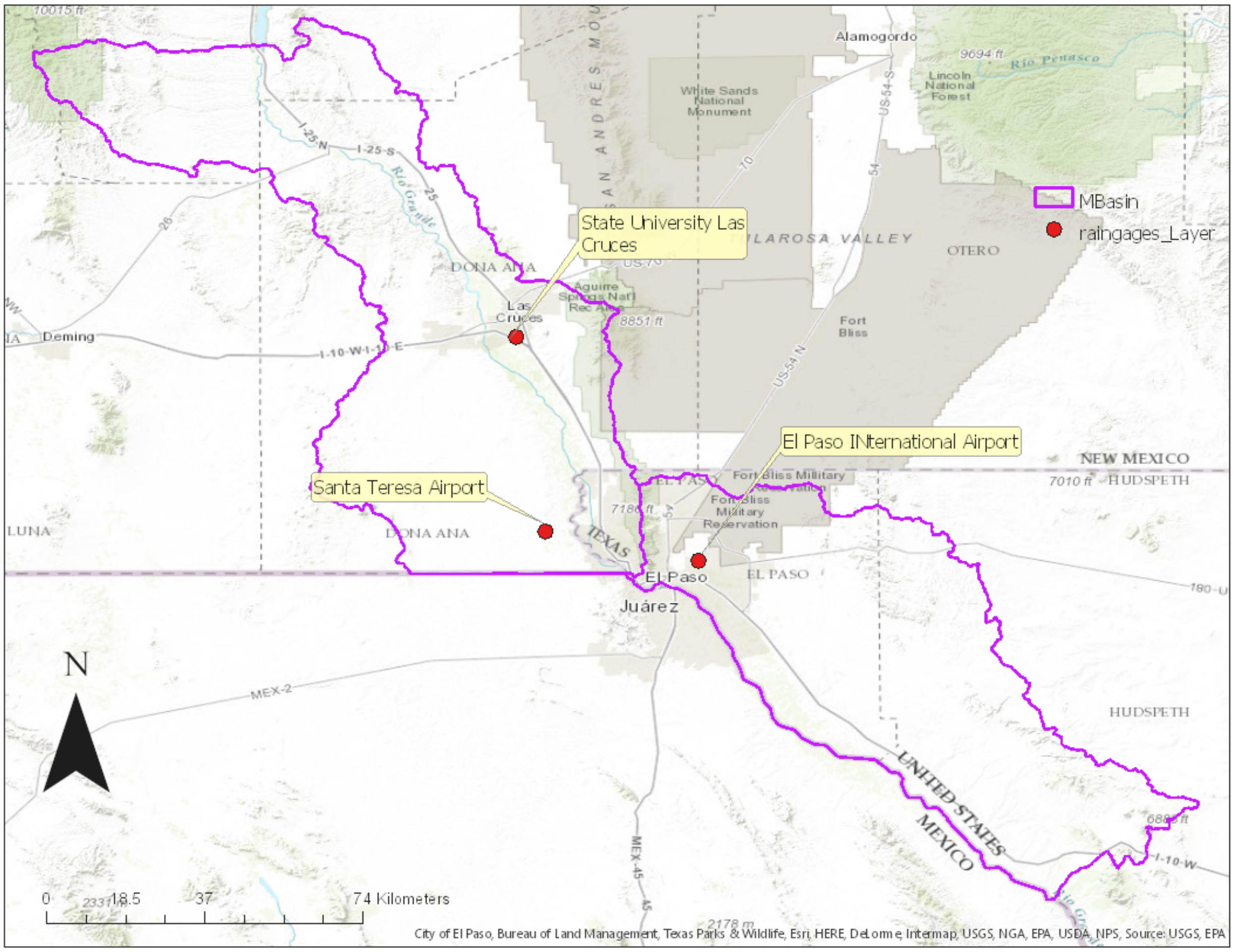
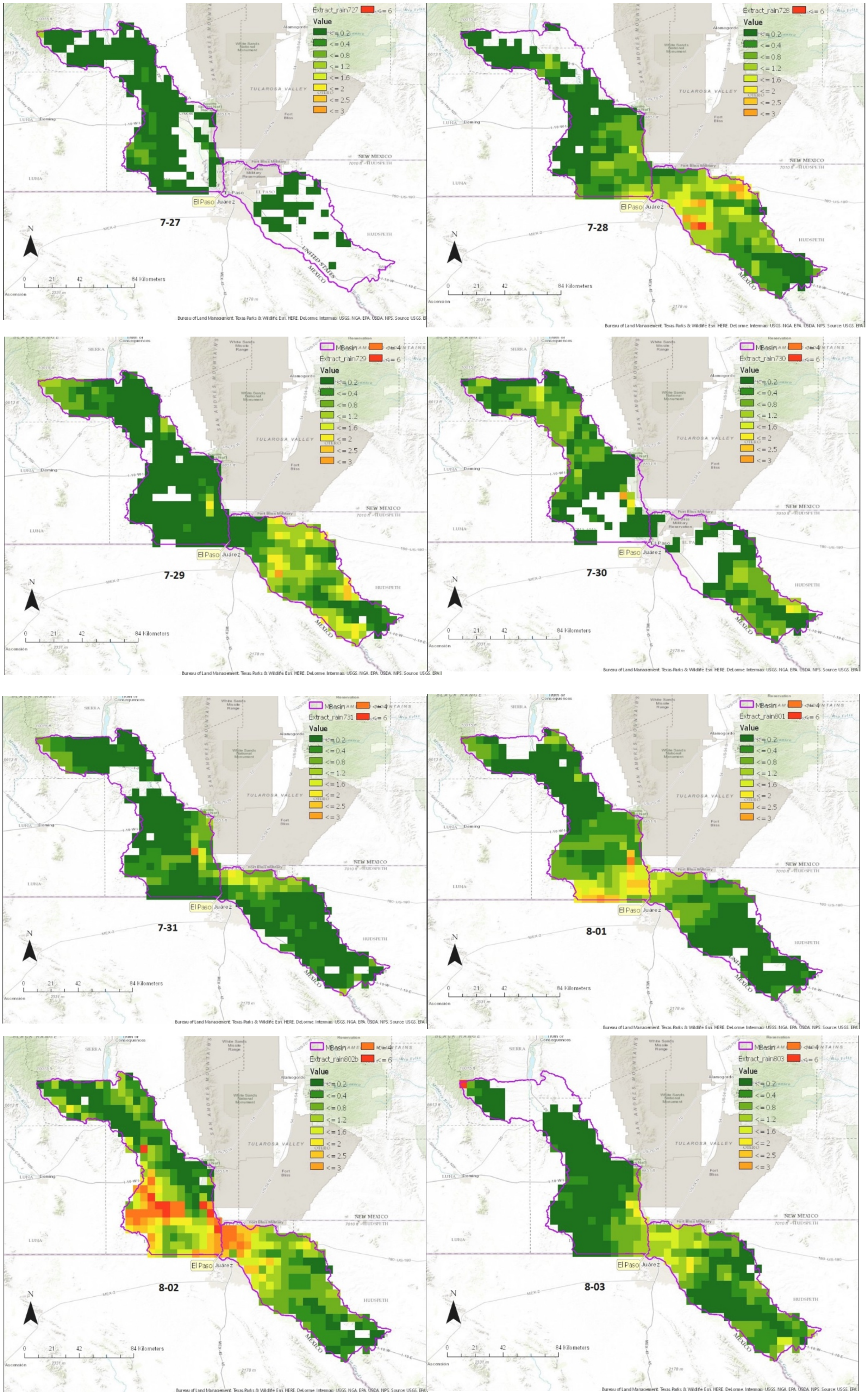


Figure 8. Rain gage location within Paso Del Norte sub-watershed.


7-27
7-28
7-29
7-30
7-31
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Extract_rain727
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Extract_rain731
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Extract_rain802b
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Value
<= 0.2
<= 0.4
<= 0.8
<= 1.2
<= 1.6
<= 2
<= 2.5
<= 3
<= 4
<= 6
0
21
42
84 Kilometers
El Paso
Juárez
TULAROSA VALLEY
NEW MEXICO
HUDSPETH
Fort Bliss
Deming
Alamogordo
White Sands National Monument
Bureau of Land Management, Texas Parks & Wildlife, Esri, HERE, DeLorme, Intermap, USGS, NGA, EPA, USDA, NPS. Source: USGS, EPA

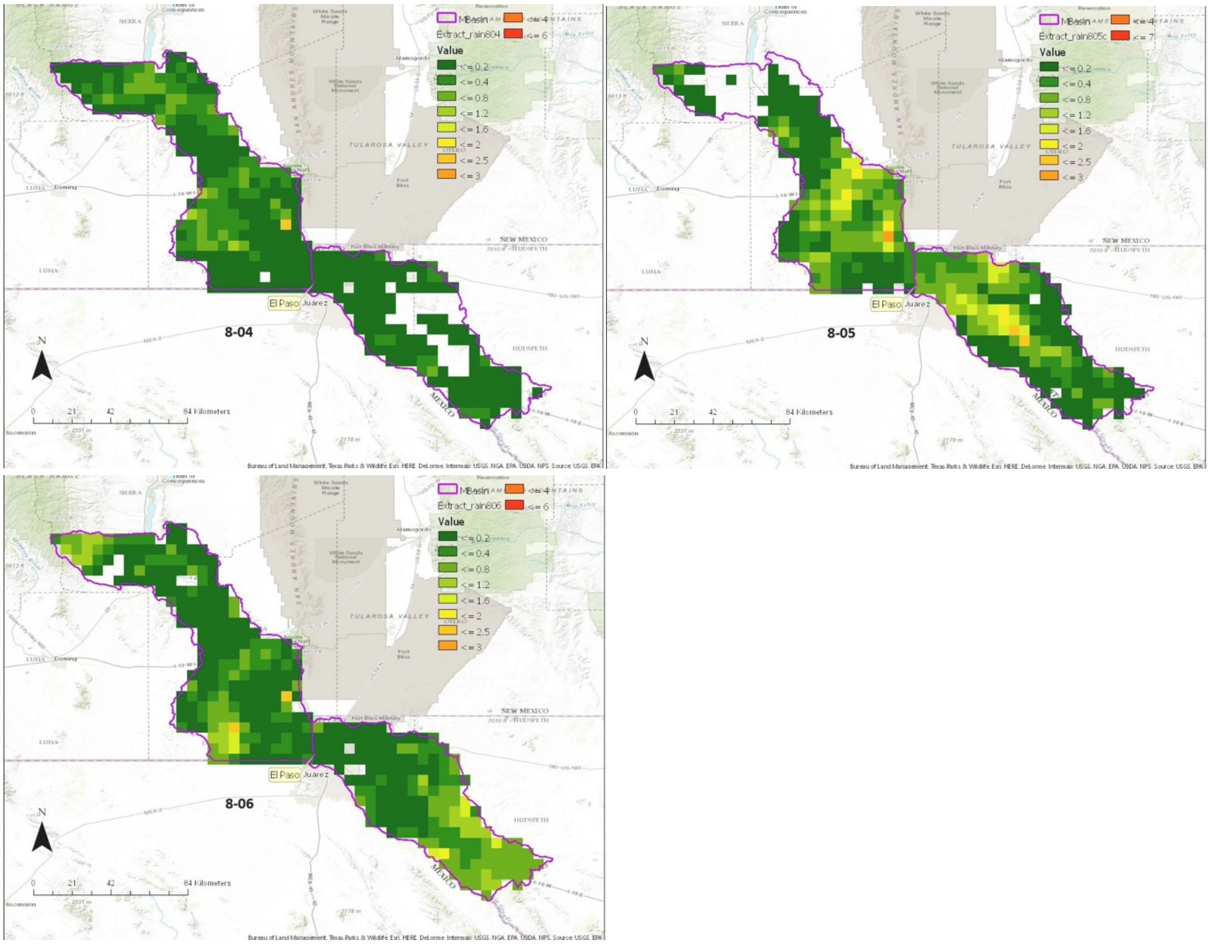


Figure 9. Precipitation data for from July 27 to August 6th in Paso Del Norte sub-watershed.

Flow Direction

By analyzing the terrain in ArcGIS, it is possible to determine the flow direction of the precipitation along with the areas that are most likely to flood during heavy storm events. Figure 10 shows the percentage drop of the El Paso area. From this figure, you can see that the east side has a sharper drop with less elevated area. The west side in contrast has less percentage drop but has a larger area with diverse topographic effects. When comparing it to figure 4 It also shows that this area is further developed than the east side. Figure 11 shows the flow direction of precipitation using the D8 model along the franklin mountains. Figure 12 can be used to determine the direction of flow on the mountains. On the eastside, the direction is predominantly towards 1 and on the west, side the direction is towards 8 and 16. This indicates that on the eastside the flow is generally towards a less urbanized area than on the west side. Again, this accounts for the greater damage seen on the west side of El Paso. We can then look at the lowest points on the surrounding area to see where water would tend to localize in (Figure 13). This suggest that these areas are more prone to flooding.

After the flooding in 2006 FEMA reassessed the flooding potential of el Paso and updated its floods zone map for the area. Comparing the generated image in ArcGIS that considers the topography, flow lines and lowest sinks it can be seen that the two images are very similar (Figure 14 & 15).

Figure 10. Percentage drop for the Franklin mountains in El Paso city.

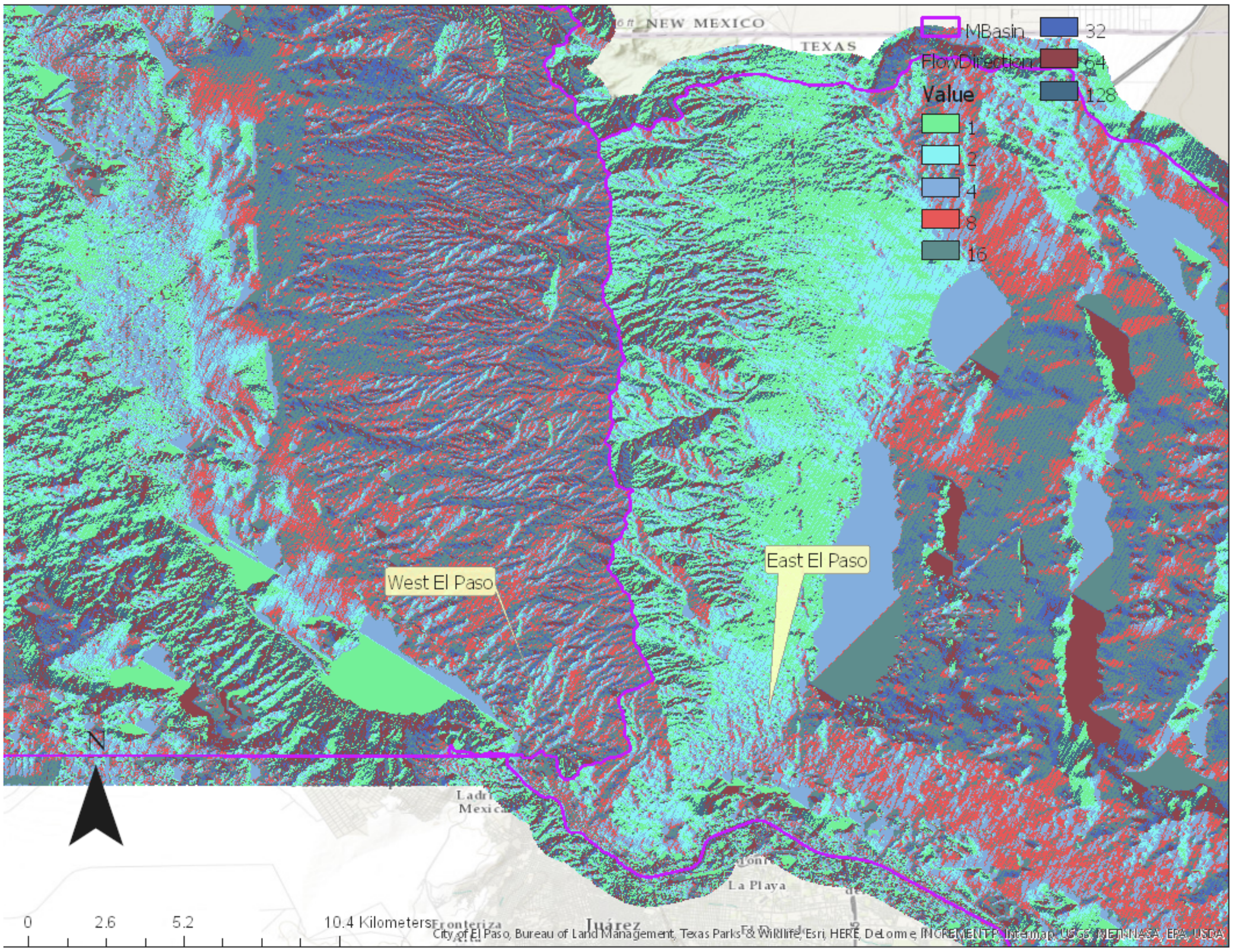


Figure 11. Precipitation flow direction for El Paso city and the Franklin mountains.

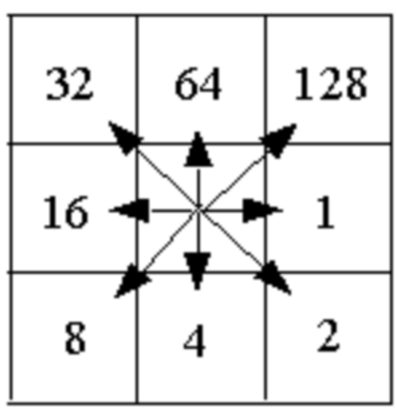


Figure 12. D8 flow direction grid.

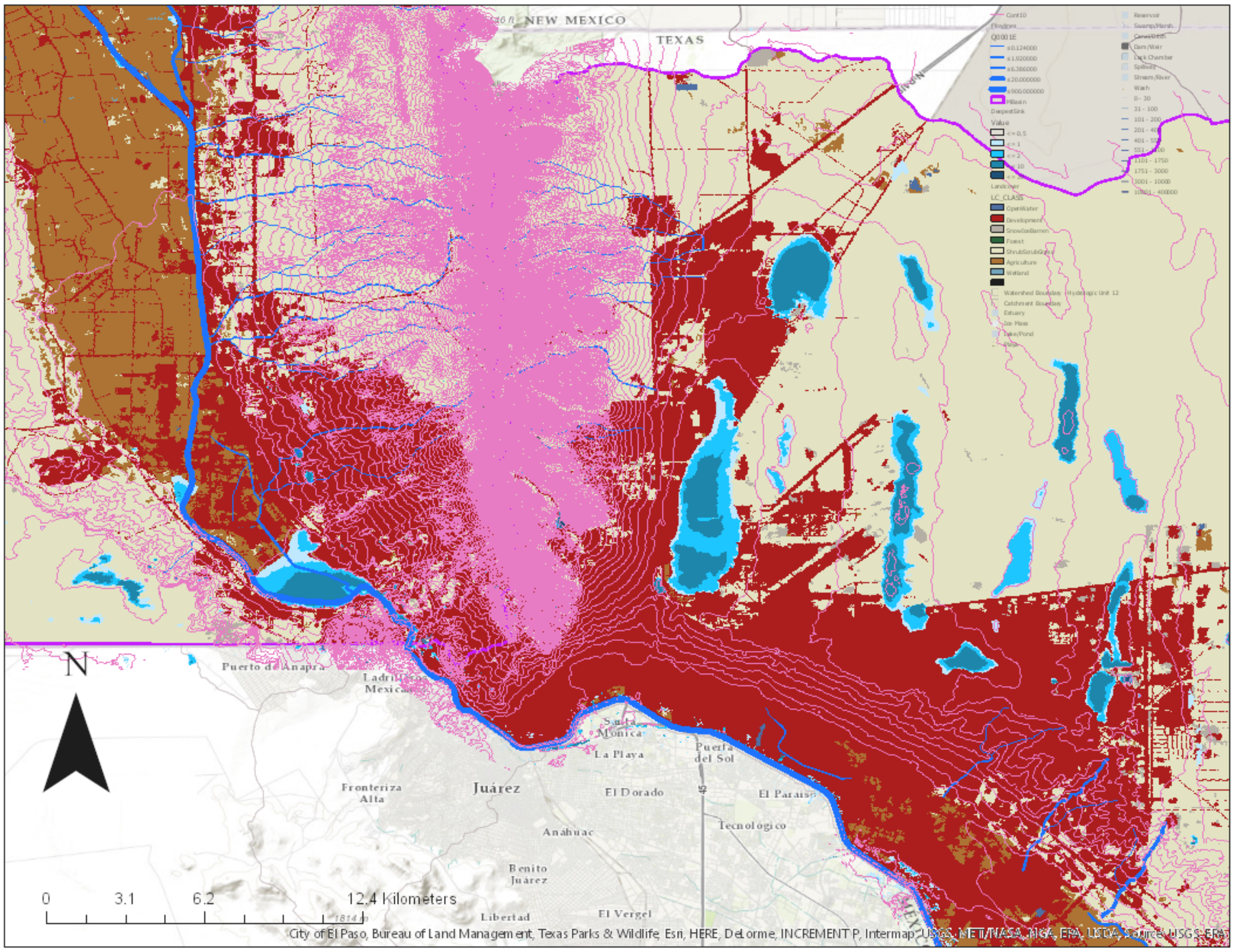
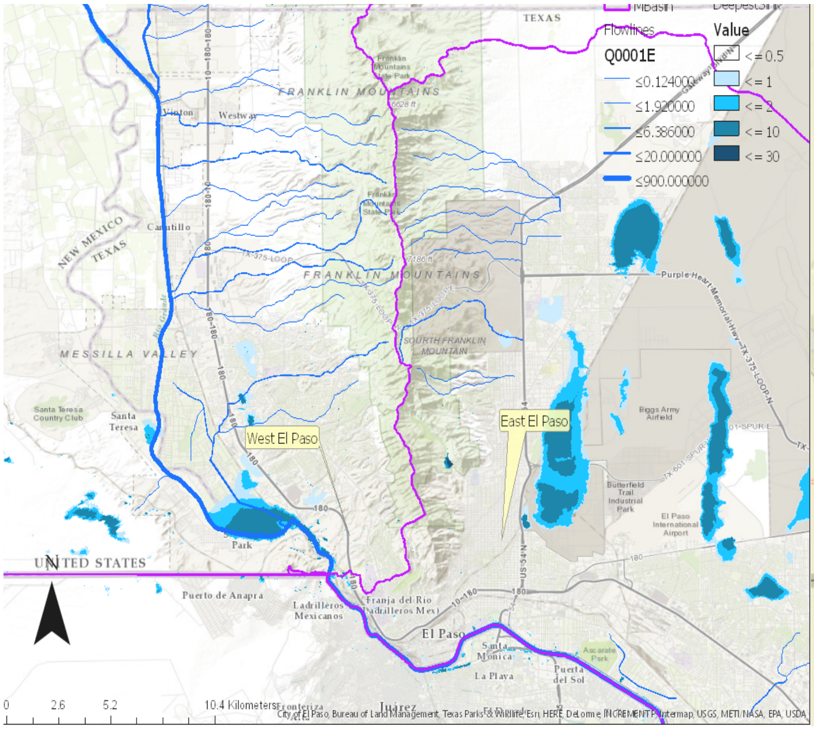


Figure 13. 10m contour map of El Paso city showing developed areas and deepest sinks.



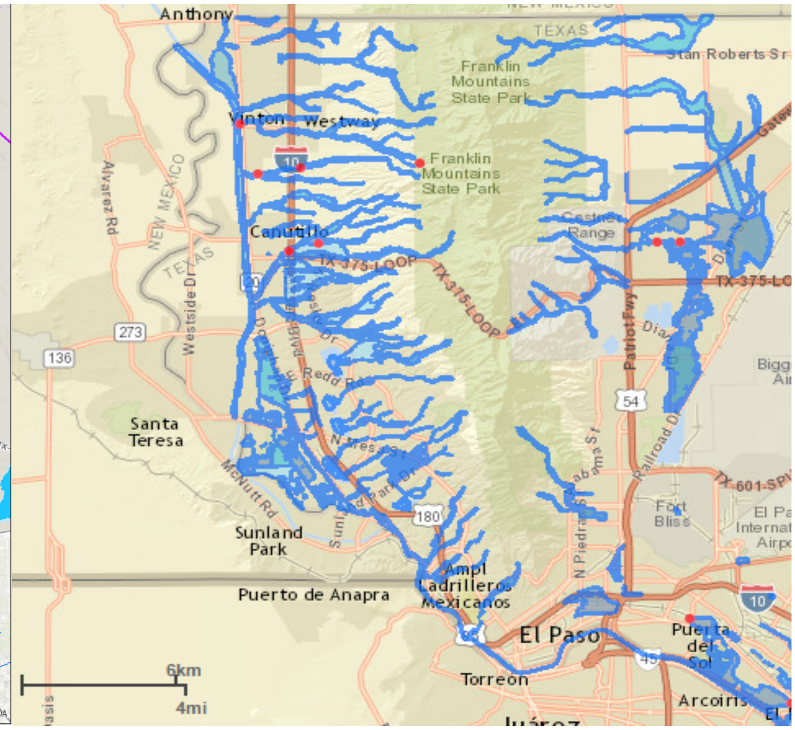


Figure 14. Flow lines and sinks in El Paso city. Figure 15. FEMA updated flood zones in El Paso

Summary

Little data was gathered during the 2006 El Paso flood due to the lack of sufficient rain gages, stage recorders and stream gages in the watershed. Since the severe storm event in El Paso USGS has set up more stage gages and rain gages in the area to better asses flood risk and to be able to give accurate flash flood warning. Weather station placed in key areas could provide accurate measurements and appropriate warnings in order to minimize loss of life and property. Using ArcGIS, it was possible to see that west El Paso is located in a more topographically complex area with a larger percentage of land that is urbanized. Furthermore, on the west side we have more flowlines and a larger area that accumulates rain fall. This resulted in the west of El Paso receiving greater damage to businesses and homes. It could be possible that orographic effects were not properly considered during urban development in El Paso Texas. This resulted in flash flood risk being under assessed in specific neighborhoods and increasing the cost of damage.

References

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