Flood Risk Areas in The Rio Grande Valley Colonias

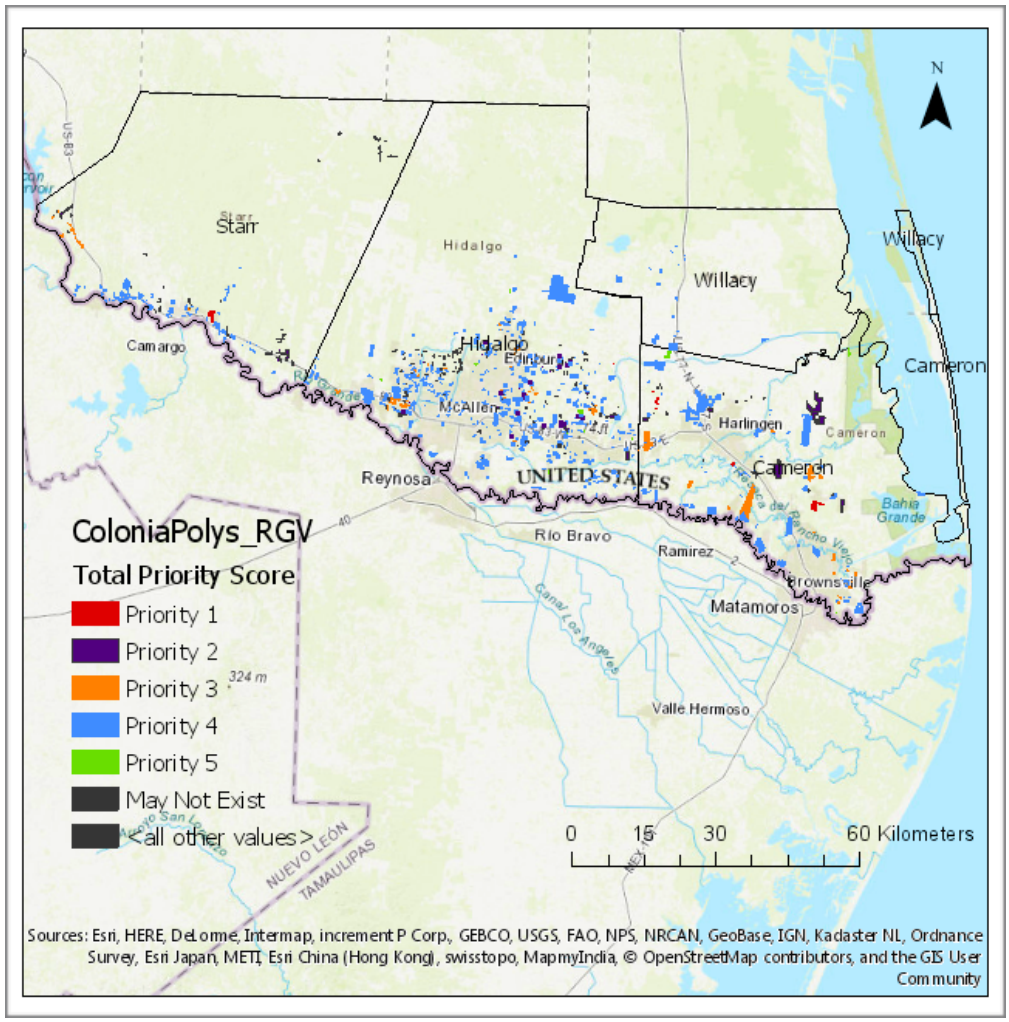

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Table of Contents

1. Introduction

The Rio Grande Valley, located in the southeastern corner of Texas, is composed of four counties; Starr, Hidalgo, Willacy and Cameron. A significant portion of The Rio Grande Valley (RGV) population lives in impoverished settlements known as colonias. Colonias started to develop around the 1920's [1] by low-income people looking for affordable housing. Land developers took advantage of the situation by selling land primarily used for agricultural purposes or located in flood plains [2] that was not incorporated to cities. The lack of incorporation to cities allowed the developers to not follow any building codes or infrastructure that is otherwise required by cities. Low-income people bought this land with little to no infrastructure such as sewer systems, paved roads, water utility connection, and potable water among others [1].

The Rural Community Assistance Partnership (RCAP) has created a GIS map containing the location and classification of colonias. Each colonia is classified as belonging to one of five Priorities Levels. These are assigned in accordance to what basic necessities they may lack; lower Priority Level (i.e. Priority 1) indicates less available necessities, greater Priority Level (i.e. Priority 4) indicates more available necessities and built infrastructure. The problems arising from lack of paved roads and sewer system is greatly exacerbated when flooding occurs, which inhibits people to travel for necessities such as food, water or medical attention. More information about this classification can be found in Annex 1.

The motivation for this study is based on an informal interview with people living in the colonias of Hidalgo County, conducted in August 2017. Interviewees reported that small to medium rains cause flooding in their colonias, and typically they wait for the water to evaporate before any assistance arrives. Dealing with flooded areas is not easy for people living in colonias with low resources. The difficulty of managing flooded areas is magnified by the low-income of the colonias residents when assistance is unreliable. Small flooded areas, as low as 1 foot (0.3 meters) caused by rainfall, can result in compounding of issues such as cars getting stuck on unpaved one-way roads impeding people to go to work, school or reach emergency services. Long-standing stationary water from flooding can cause further issues such as housing materials rotting, and health risks related to stationary water (i.e. breeding grounds for bacteria and viruses).

2. Objectives

The lack of proper storm water drainage, coupled with the low and flat elevation of The RGV makes the colonias highly susceptible to flooding. The objective of this study will be to combine ArcGIS analysis tools to assess the impacts of flooding in the Rio Grande Valley colonias. Three different analyses were combined/evaluated individually to give a representation of the physical conditions facing inhabitants of the colonias. The Height Above the Nearest Drainage (HAND) analysis will determine areas that are susceptible to inundation by creek or river overflow. The RGV land area elevations will be

mapped to show the susceptibility certain locations are to major floods. Locations of emergency services will be mapped to illustrate the existing access of the colonias. Information from the HAND, NED, and emergency services will then be used to assess if there is any relationship between flood-prone areas and colonias' Priority Level given by the RCAP.

3. Methodology

3.1 Data Description

The following table shows the data obtained in order to reach the objectives.

Table 1. ArcGIS data description and sources used in this study.

Data	Source	Description
Colonias Map	Rural Community Assistance Partnership	Colonias ArcGIS Online map. Information about colonias in different layers as well as information of Fire Departments and Hospitals among other services near colonias.
NLCD 2001 Land Cover (2011 Edition)	MLRC	Most recent survey of land use in the USA with spatial resolution of 30m and used as a raster
National Elevation Dataset	USGS	USA Elevation given as a raster in meters with a resolution of 1 arc-second.
Height Above Nearest Drainage	University of Illinois, CyberInfrastructure and Geospatial Information Laboratory	Raster showing the Height Above The Nearest Drainage of HUC 6 subwatersheds.
NHD Flowlines	USGS	Feature class showing the NHD Flowlines and catchments in the Rio Grande Valley

3.2 Data analyzing and processing

3.2.1 General visualization of The Rio Grande Valley colonias

Using the ArcGIS Online map completed by the RCAP, which locates colonias and their characteristics, information was first extracted into only The Rio Grande Valley counties, using the geoprocessing tool “Extract by Mask”. Giving 1,266 colonias located within The RGV shown in Figure 1.

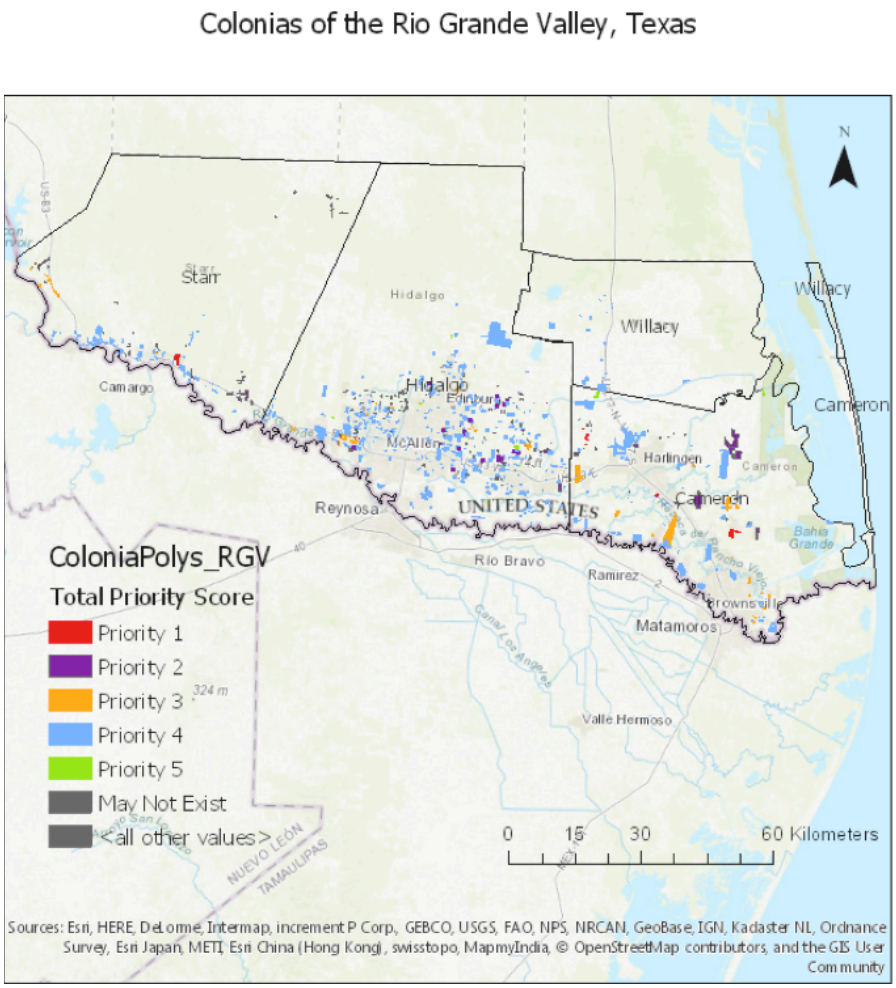


Figure 1. The Rio Grande Valley Colonias. Created by

The Land Cover Dataset was obtained from the MRLC site [4] and geoprocessed with “Extract by Mask” tool to the colonias of The Rio Grande Valley. The result can be seen in Figure 2. The information given by the Land Cover Dataset is very insightful, as it provides a visualization of the agricultural land where colonias presently exist.

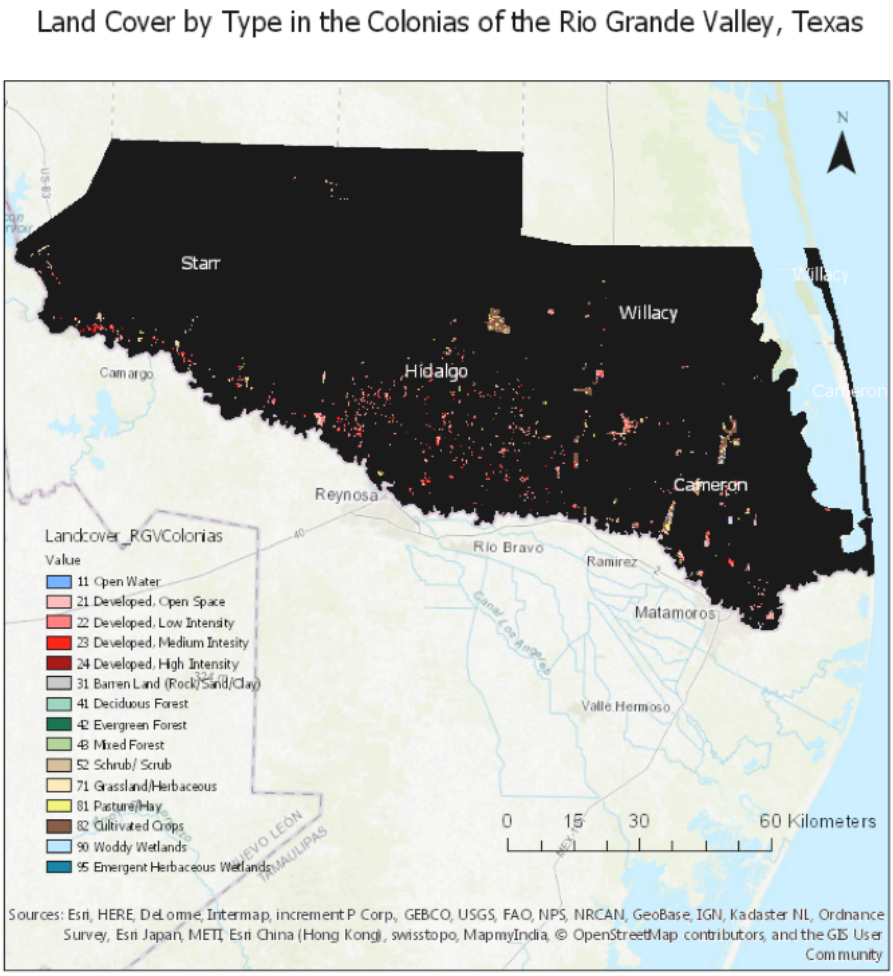


Figure 2. Land Cover Dataset for the Colonias in The Rio

The elevation of The RGV was mapped using the National Elevation Dataset [5], making the relatively uniform elevation of these counties apparent. Extracting the NED30 by Mask shows the low and flat elevation throughout the area with the exception of Starr County, which has higher elevation in some areas, shown in Figure 3.

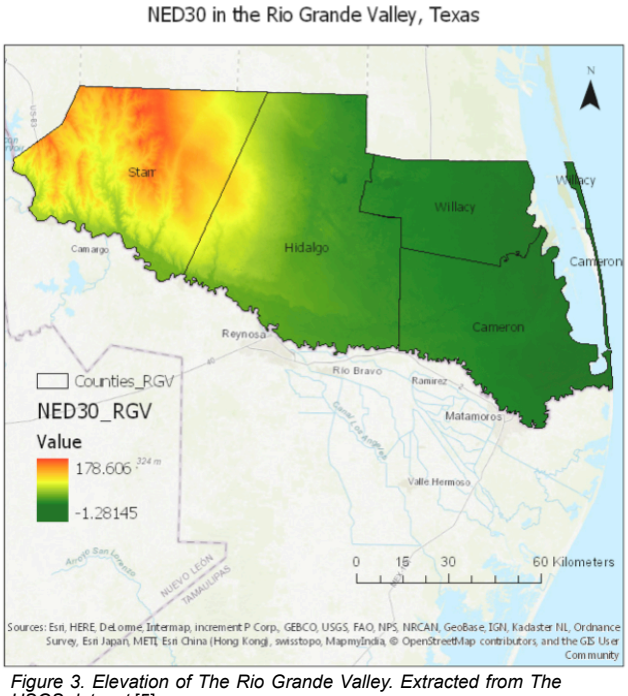


Figure 3. Elevation of The Rio Grande Valley. Extracted from The USGS dataset [5].

3.2.2 Height Above the Nearest Drainage

The Height Above the Nearest Drainage created by The University of Illinois [6] is mapped to show the natural drainage in The Rio Grande valley, located within subwatersheds HUC 130900 and HUC 121102. The HAND analyses for both subwatersheds were obtained and Extracted by Mask to Rio Grande Valley area. Shown in Figure 4 are both subwatersheds and Figure 4.1 shows the result of the Extract by Mask into The Rio Grande Valley.

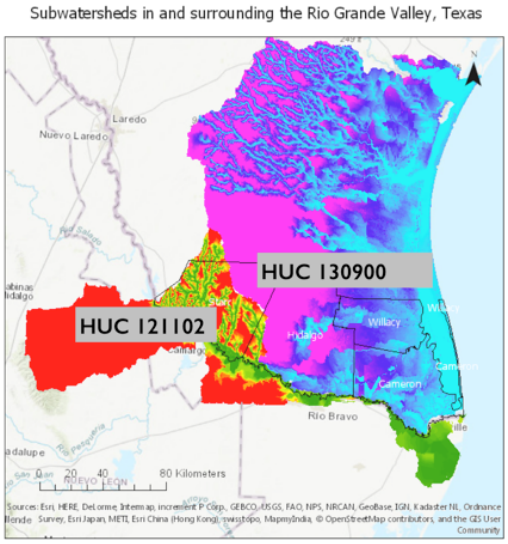


Figure 4. HAND analyses of HUC 6 subwatersheds of The Rio Grande Valley

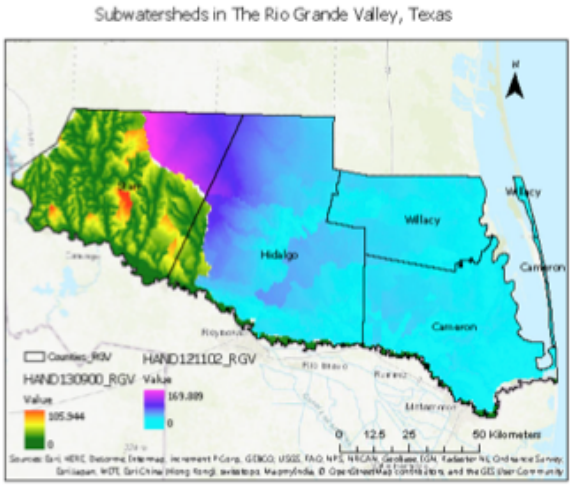
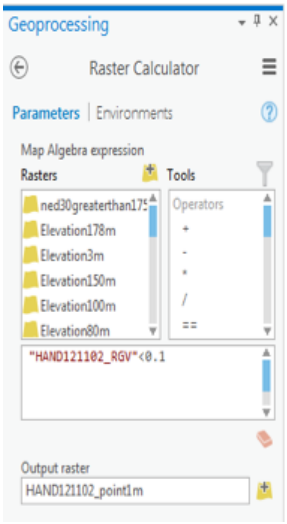


Figure 41. HAND analyses of both subwatersheds for The Rio Grande Valley

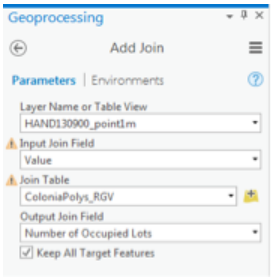
Using the Raster Calculation tool with the HAND analyses, of both subwatersheds, the areas experiencing small floods resulting from rain were analyzed under two water-level scenarios. The rise levels of water used are 0.1 m and 0.2m (approximately 0.6 ft. and 1 ft.). These values were used to determine which areas have poor natural flood drainage; the results will be discussed in the Results Section of this report.



An output raster was created with the HAND analysis value smaller than 0.1m and 0.2m. Shown to the left is the geoprocessing tool with the algebra expression "HAND121102_RGV" < 0.1. In this case 0.1 is in meters since the HAND121101_RGV is in meters. And the output in this case will be HAND121102_point1m.

The same tool and process mentioned above were used to create another output raster for the HUC 12110 watershed ("HAND121102_RGV" < 0.2) value lower than 0.2m.

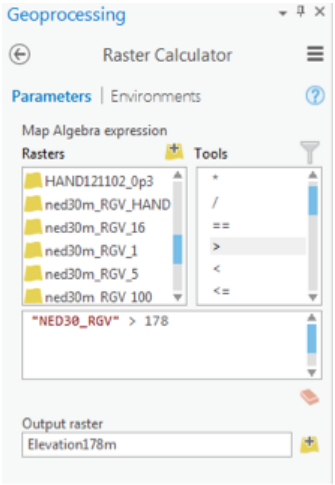
In addition to both 0.1m and 0.2m Raster Calculation, the subwatershed HUC 130900 was processed in the same manner to create two output rasters with values smaller than0.1m and 0.2m.



In order to have a table that could be easily analyzed with the colonias characteristics and the HAND analysis mentioned above, an “Add Join” was applied using the output rasters and the raster containing the colonias.

3.2.3 Elevation analysis

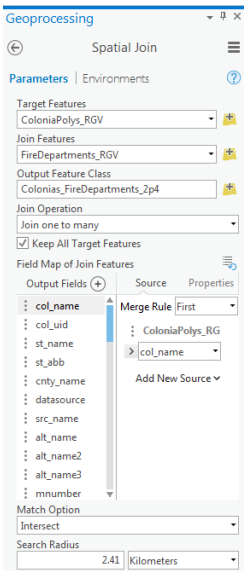
An evaluation of greater flood events (i.e. hurricanes), using the raster calculation, in The RGV was used to determine high-elevation areas to where colonias citizens should evacuate. Figures 9.0 to 9.8 show the location of the different heights within The RGV. This analysis can be used to establish emergency services as well as to where people be safer from flood risk areas.



Raster Calculations to find the highest elevation in The RGV was performed in the following order. First, the highest point was visualized in the NED30 in The Rio Grande Valley (Figure 3), which shows the highest elevation at 178.606. Secondly, to ensure finding the highest elevation point, The Map Algebra expression used is: “NED30_RGV” < 178 giving the output raster “Elevation178m” (result shown in Figure 7).

Finally, the same raster calculations were done to locate elevations higher than 150m, 100m, 80m, 50m, 30m, 10m, 5m and 3m and 1m.

3.2.4 Distance to Fire Departments and Hospitals



Fire departments and hospitals distances from colonias were calculated using the Spatial Join tool. The distances were chosen as a result from the Insurance Service Office evaluation of fire departments distribution; which states that generally a built-upon area of a community should have a first-due engine company within 1.5 road miles and a ladder-service company within 2.5 road miles [7].

This tool joins fire departments and hospitals to colonias within a given distance. In this report both hospitals and fire departments were analyzed under the recommended distances above. The results of the Spatial Joins are shown in figures 9 to 12.

4. Results

NED30 was Extracted by Mask into the colonias allowing map visualization of the natural drainage mostly lies in Cameron and Starr counties. In comparison, Hidalgo County land elevation contours are characteristically flat. Hidalgo County land elevations are generally less than 33 m and are often without rivers or streams to facilitate flood drainage. Willacy County has the lowest elevation along with Cameron County of less than 15.54 m. See Figure 1 and Figure 5 for reference on the elevations and flowlines mentioned.

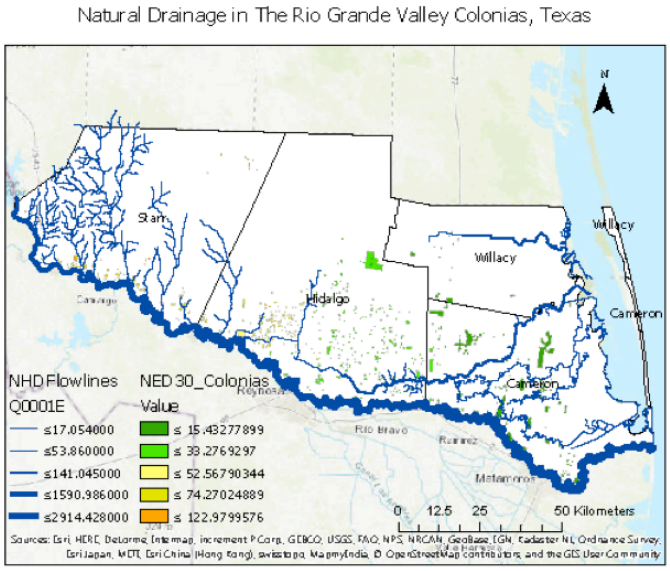


Figure 5. Natural Drainage in The Rio Grande Valley Colonias.

The NLCD 2011, shows the land use within the colonias is 49.9% of non-developed areas and 30% of the total land use is classified as “Cultivated Crops”. This shows that the colonias where low-income people are living are in great need of infrastructure.

The HAND analyses show where river growth, in the case of lesser rains, can affect the areas with lower height above the nearest drainage (i.e. a river). The areas that would be in risk of flooding at 0.1m (approximately 3.9 inches.) were calculated using the Map Algebra Equation and then using Add to Join tool to combine the result to the layer with the colonias characteristics mentioned in the Methodology. This result shows that 45% of the colonias will get flooded with this river overflow. Figure 6 shows the colonias flooded in this scenario in blue, and the colonias, which are not at risk of flooding in brown.

The same calculation was done with a water overflow value of 0.2m (approximately 7.8 inches) resulting in a 52% of colonias being flooded. The scenario of 0.2m water overflow is not presented in this report, as the visual difference is insignificant to that of 0.1m overflow.

The relationship between flooded colonias at 0.1m and 0.2m was determined by calculating the percentage of colonias that are flooded at each Priority Level. The results are as shown in the following table.

Table 2. Percentage of Priority level colonias at flood risk at 0.1 m and 0.2 m water overflow

Priority Level	Flood risk at 0.1 m of water overflow	Flood risk at 0.2 m of water overflow
Priority 1	0%	0%
Priority 2	14.28%	16.53%
Priority 3	10.72%	11%
Priority 4	75%	72.47%
Priority 5	0%	0%

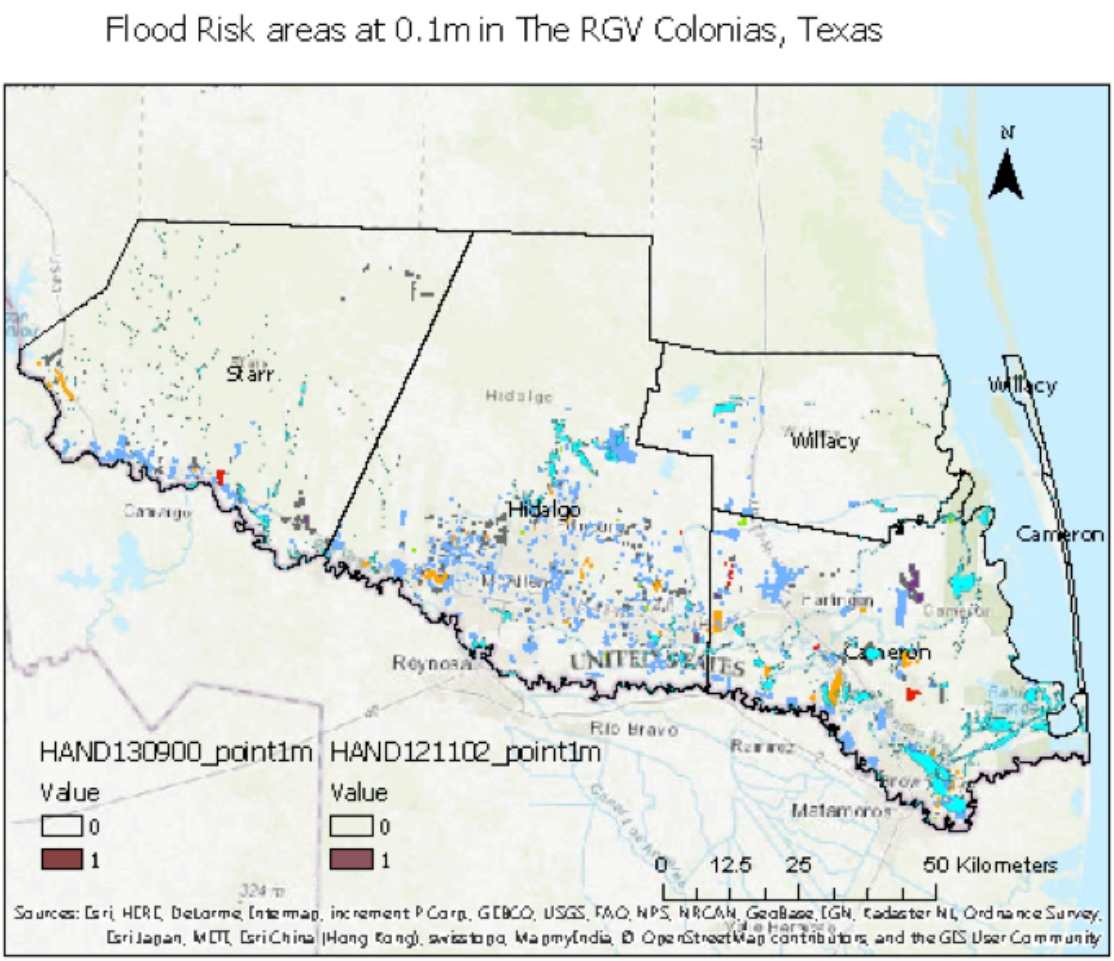


Figure 6. Flood Risk areas at 0,1 m in The Rio Grande Valley. Blur dots represent the flooded colonias at 0.1m water overflow

Mapping the highest elevation point may help establish where the inhabitants of the colonias and The Rio Grande Valley should evacuate and where emergency services should be located in the case of major floods (i.e. caused by a hurricane or other natural phenomena). The highest point of The RGV is illustrated in Figure 7.

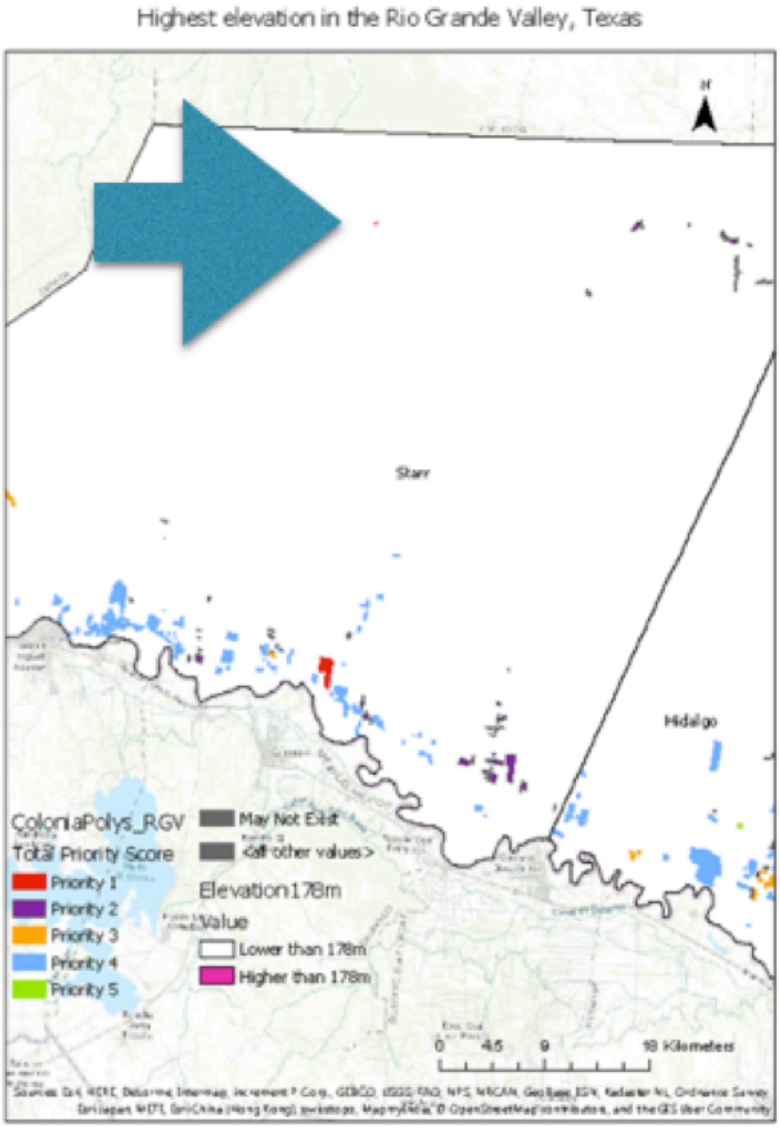


Figure 7. Highest elevation in The Rio Grande

Additional elevation contours were mapped in order to visualize different areas at risk of flooding during straining weather (i.e. during hurricanes and storms of different categories). This elevation visualization can also help, as mentioned before, to plan evacuations and emergency services.

Figures 8.1 to 8.3 show the areas with different elevation and Figure 8.4 shows all elevation in one map for easier visualization.

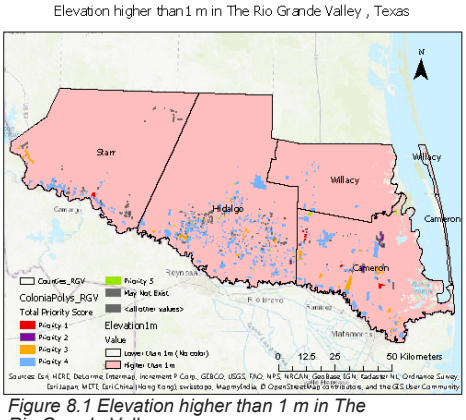


Figure 8.1 Elevation higher than 1 m in The Rio Grande Valley

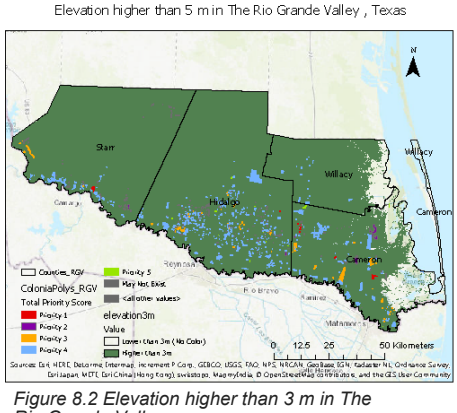


Figure 8.2 Elevation higher than 3 m in The Rio Grande Valley

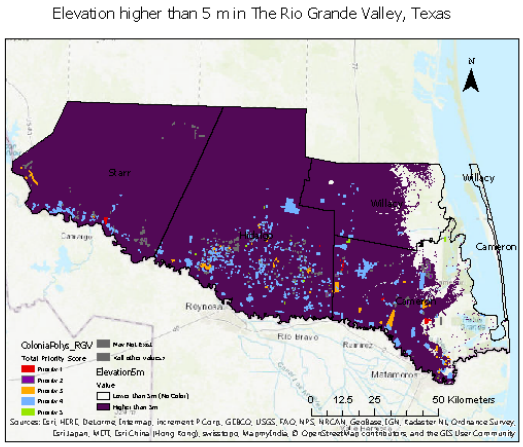


Figure 8.3 Elevation higher than 5 m in The Rio Grande Valley

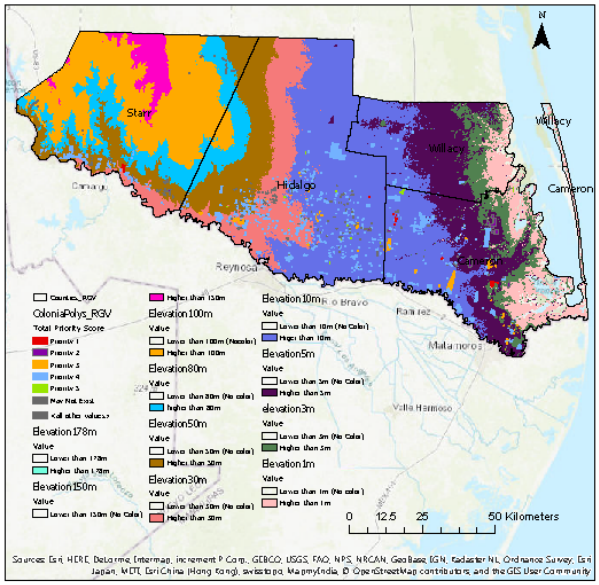


Figure 8.4 Different elevation n The Rio Grande Valley

Fire departments within a distance of 2.41km and 4km of colonias are represented as blue dots in figures 10 and 11. Fire departments located outside of the ISO recommended distance of 2.41 km and 4km in these Counties are 8.05% and 50.4%, respectively.

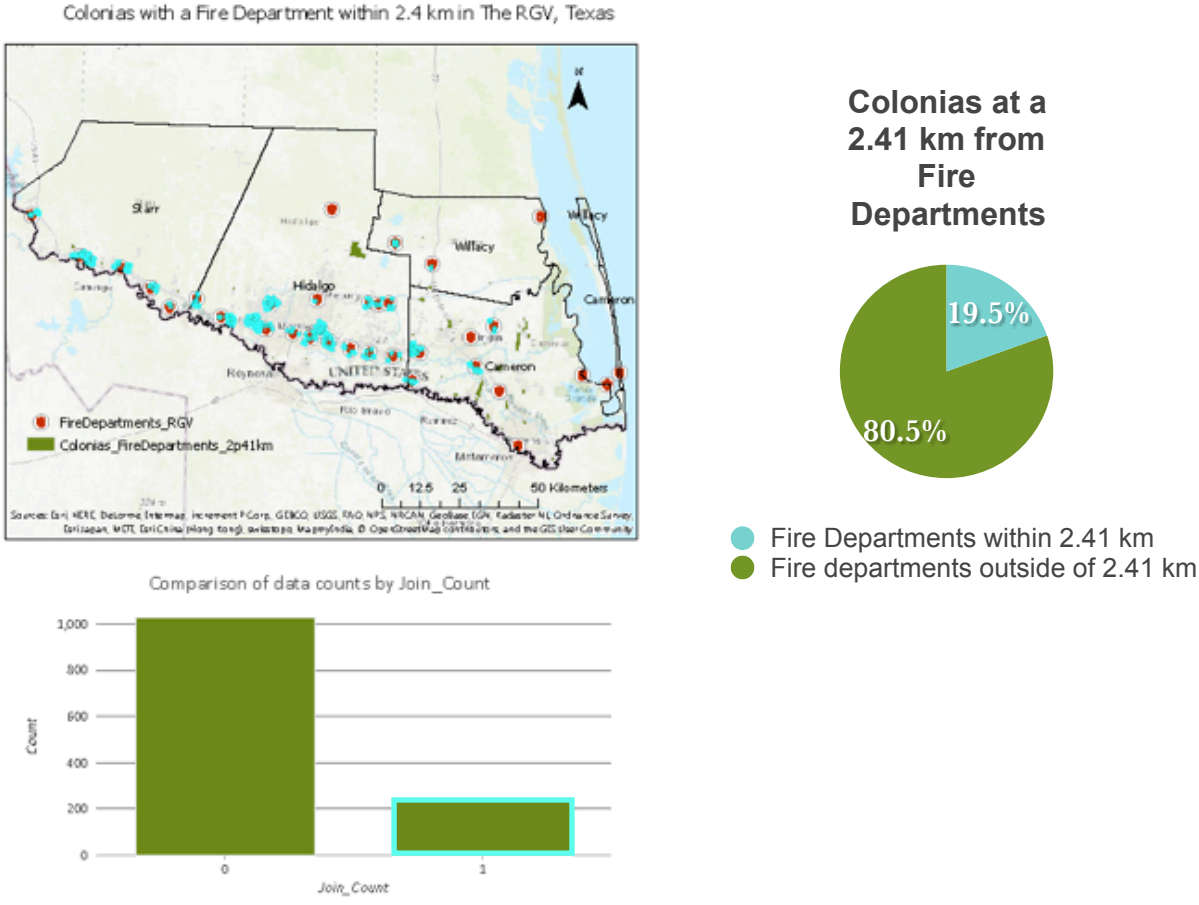
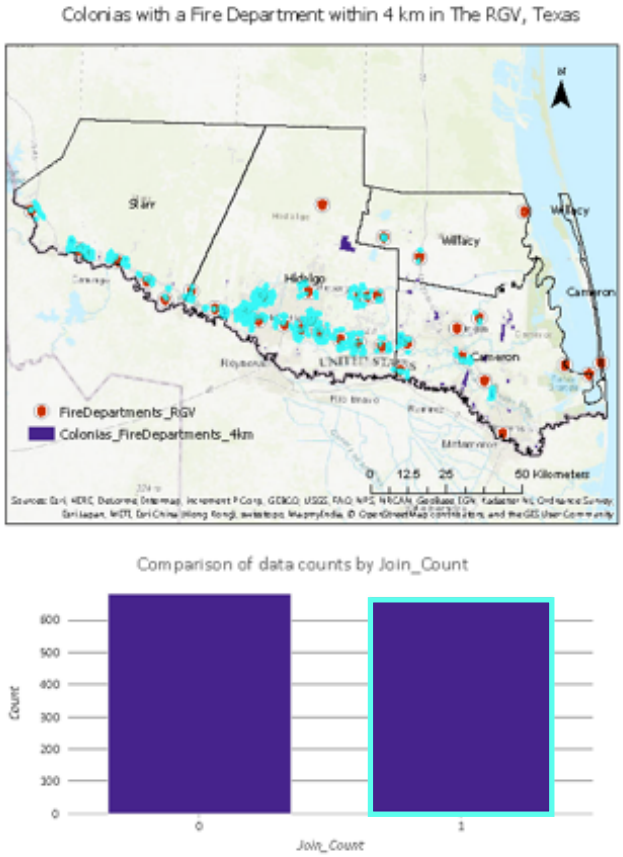


Figure 9. Spatial Join of Fire Departments within 2.41 km of colonias



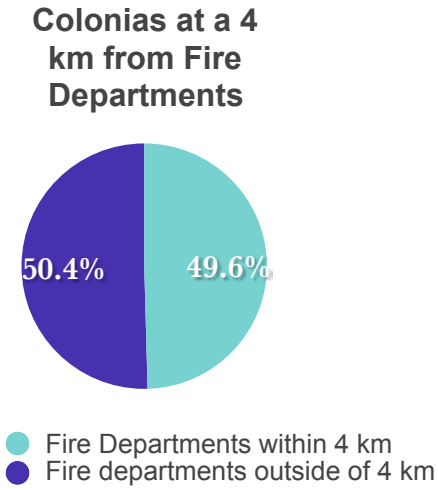
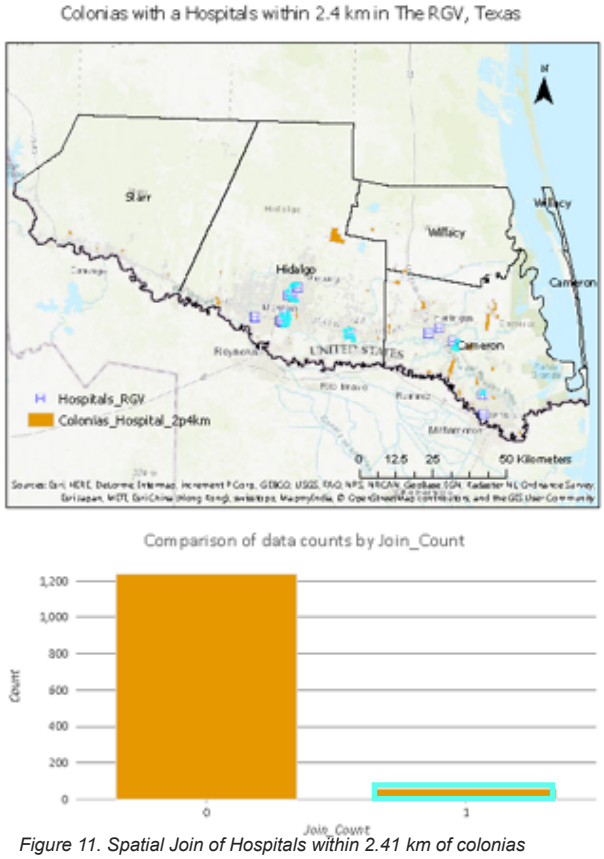


Figure 10. Spatial Join of Fire Departments within 4 km of colonias

Hospitals located within a distance of 2.41km and 4km of colonias are represented as blue dots in figures 12 and 13 are represented as blue dots. Hospitals located outside of the distance evaluated are 81% and a 95% respectively.



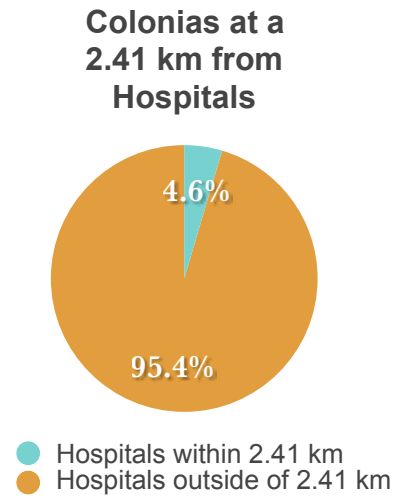


Figure 11. Spatial Join of Hospitals within 2.41 km of colonias

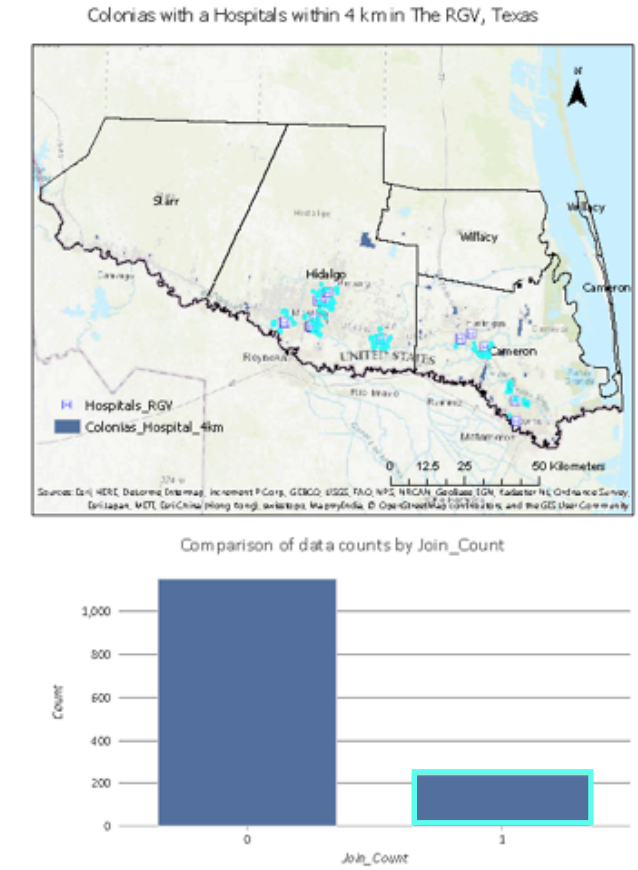
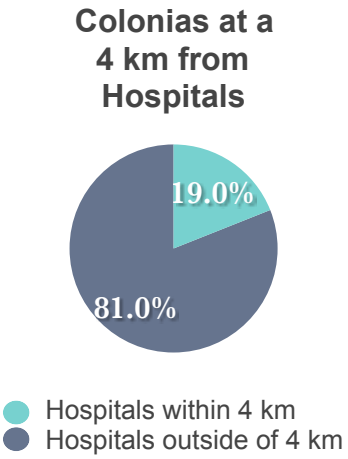


Figure 12. Spatial Join of Hospitals within 4 km of colonias



5. Conclusion

The results of this study illustrate the flood risk areas created by an array in rising water levels in The Rio Grande Valley colonias. Using water levels of 0.1 and 0.2, the HAND Map Algebraic Equation calculation, 45% and 52% respectively, of colonias are affected when rivers overflow. Colonias that experience the most flooding are Priority Level 4 colonias. These colonias have the most built in infrastructure and any recurrence in flooding might indicate that the colonias are located near a river or elevations do not allow for proper drainage.

Elevation in The Rio Grande Valley colonias varies approximately by county. As mentioned before, Starr County has the highest elevation followed by Hidalgo County and then Cameron and Willacy counties. Elevation mapping within The Rio Grande Valley can be used to help create strategies for emergency situations such as natural disasters caused storms, tsunamis or hurricanes.

Vast majorities of colonias are located far away from fire departments and hospitals adding strain to people in need of emergency services. Emergency-response -time for inhabitants of the colonias compounds the severity of flooding events, as these responders are more often than not located at distances greater than recommended by ISO.

6. Discussion And Recommendations

This report was intended to develop mapping and evaluate flood zones, which may encompass colonias in The Rio Grande Valley. Simplifications regarding the colonias characteristics and allocation in this study, in order to create a more accurate evaluation, surveys regarding flooding should be conducted within the colonias. In many cases, online data sources used for this report had not been updated in several years. More accurate evaluation of these flood-prone colonias and the availability of built in drainage would benefit from having more recent data. FEMA flood analysis has not been considered for this report since there are no FEMA flood projections for Hidalgo and Cameron counties.

Further work to assess high-risk flood areas in The Rio Grande Valley should include the creation of a map that connects precipitation with built drainage and HAND analyses. This will allow for a better visualization of the impact precipitation has on flood risk areas. Further work should also include elevation, HAND analysis of the area surrounding The Rio Grande Valley, i.e. northern Mexico and the rest of Texas, to determine the best evacuation areas in case of great catastrophes. Finally, further work in data collection and upgrade of colonias characteristics and infrastructure should be conducted to better plan future upgrades to the colonias built infrastructure.

7. Bibliography

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[9] R. Stewart, A. Neumann, and B. Detwiler, “Rural Community Assistance Partnership (RCAP),” 2015.

Annex 1

Colonias Priority Level Classification According to The RCAP [9]

Priority 1: Communities NOT served by a public water and/or wastewater facility AND A health hazard is (or may) be present

Priority 2: Colonia residents are NOT served by a public water system —no health hazard indicated OR Colonia residents are NOT served by a publicly owned wastewater disposal system, and existing onsite wastewater treatment system is not adequate—no health hazard indicated OR Colonia residents ARE served by publicly owned water and wastewater facilities but one or both are in serious violation of regulations

Priority 3: Some residents are NOT served by a publicly owned water AND/OR Some residents do NOT have access to wastewater service AND Plans are in development and proceeding for financing new water or wastewater services to all areas affected or are currently under construction

Priority 4: Residents ARE served by public water facilities AND Residents are NOT served by public wastewater service, BUT Individual onsite wastewater disposal systems appear to be adequate OR Residents ARE served by BOTH public water service and publicly owned wastewater facilities

Priority 5: The identified colonia does not have any occupied residences, i.e. there are no inhabitants.