

**FLOOD HAZARD ASSESSMENT BETWEEN 2015 AND 2019 USING  
UPDATED FEMA FLOODPLAIN DATA IN GALVESTON COUNTY,  
TEXAS**

An Undergraduate Research Scholars Thesis

by

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Dr. David Retchless

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I, Oscar Rene Cavazos Jr. , certify that all research compliance requirements related to this Undergraduate Research Scholars thesis have been addressed with my Research Faculty Advisor prior to the collection of any data used in this final thesis submission.

This project did not require approval from the Texas A&M University Research Compliance & Biosafety office.

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## **ABSTRACT**

Flood Hazard Assessment Between 2015 and 2019 Using Updated FEMA Floodplain Data in Galveston County, Texas

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Coastal flooding in America has caused large scale changes with many communities seeing increased flooding. Flooded communities, collapsed bridges, and obstructed roads are some of the lasting effects that can be devastating if communities are not well prepared for flooding disasters. The Federal Emergency Management Agency (FEMA), which releases Flood Insurance Rate Maps (FIRM) that illustrate the National Flood Hazard Layers (NFHL) across the United States, is responsible for communicating flood risks for communities across the United States. These flood hazard maps are scheduled to be routinely updated every 5 years by FEMA and are intended to help communities to properly prepare properties for their associated risk level against flooding. The following paper compares the coverage of the 2015 and 2019 FEMA flood hazard zones in Galveston County, including changes in the areal extent and parcel count for each flood hazard zone. Initial data manipulation and analysis will be conducted in ArcGIS version 10.7.1 while the statistical analysis will be finished in Microsoft Excel.

## **ACKNOWLEDGEMENTS**

### **Contributors**

I would like to thank my faculty advisor, Dr. David Retchless, for his guidance and support throughout the course of this research.

All other work conducted for the thesis was completed by the student independently.

### **Funding Sources**

This undergraduate research required no funding.

### **Data Acquisition**

This product uses the Federal Emergency Management Agency's API but is not endorsed by FEMA.

## NOMENCLATURE

A	Areas with a 1% annual chance of flooding and a 26% chance of flooding over the life of a 30-year mortgage
AE	Areas with a 1% annual chance of flooding and the base floodplain where base flood elevations are provided
AO	River or stream flood hazard areas, and areas with a 1% or greater chance of shallow flooding each year, usually in the form of sheet flow, with an average depth ranging from 1 to 3 feet. These areas have a 26% chance of flooding over the life of a 30-year mortgage.
V	Coastal areas with a 1% or greater chance of flooding and an additional hazard associated with storm waves. These areas have a 26% chance of flooding over the life of a 30-year mortgage.
VE	Coastal areas with a 1% or greater chance of flooding and an additional hazard associated with storm waves. These areas have a 26% chance of flooding over the life of a 30-year mortgage
X	Area of moderate flood hazard, usually the area between the limits of the 100-year and 500-year floods.
X5	Area of minimal flood hazard, usually depicted on FIRMs as above the 500-year flood level.
GIS	Geographic Information System
BFP	Building footprint
SFHA	Special Flood Hazard Area
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Maps
NFHL	National Flood Hazard Layers
NFIP	National Flood Insurance Program

# 1. INTRODUCTION

## 1.1 Background

America has experienced 279 weather and climate disasters over the last 40 years totaling over \$1 trillion and since 2016 the global economy has lost \$520 billion to extreme weather events (e.g., droughts, hurricanes) (The Ocean Conference, 2017). Extreme flooding, typically associated with tropical cyclones, annually displaces an average of 21.5 million people. Changes in the frequency and intensity of extreme weather events will impact human and environmental sustainability in multiple ways, agricultural practices, and developments in infrastructure that are susceptible to climate shifts (IPCC, 2019). Low lying coastal regions are particularly vulnerable to these flooding events due to sea level rise and an increase in frequency of extreme precipitation events (Kunkel, 2003). Floods are the most common natural disaster in the United States. Flood damage in the United States averaged \$2.4 billion per year for the last decade with 4 of the top ten costliest flood events happening within the last decade. Floods have three main sources: (1) river floods that encroach slowly on communities in the direct vicinity of a stream; (2) floods generated by storm surges from tropical cyclones that occur less frequently but advance more rapidly; and (3) flash floods associated to high amounts of precipitation upstream flooding areas downstream in a short amount of time.

Pursuant to their responsibility to prepare and aid communities in times of natural disaster, the Federal Emergency Management Agency (FEMA) created the National Flood Insurance Program (NFIP) to provide reasonably priced flood insurance to the public while encouraging community flood management. The NFIP is the primary source of flood insurance coverage as normal homeowners' insurance does not include flood insurance. If a residential

property is impacted by a flooding event, the owners who have purchased NFIP coverage can file a flood claim to the NFIP to receive compensation to restore the loss. The average flood claim payout from the NFIP in 2019 was \$52,000 with the average annual flood insurance policy premium sitting at \$700 (FEMA, 2020).

The premiums set for households by the NFIP are intended to reflect the flood risks for that household's location. These premiums are set by the Flood Insurance Rate Map (FIRM) created by the NFIP which communicates flood hazard areas. For coastal communities, the FIRM is based on detailed studies of storm surges flooding, storm induced erosion, wave effects and past flood activity. The FIRM depicts three specific flood hazard zones: 100-year flood plain, 500-year floodplain, and minimal risk flood plain. FEMA classifies a 100-year floodplain as areas with at least a 1% annual chance of flooding or an area that has a 26% chance of flooding over the life of a 30-year mortgage. FEMA designates high risk areas as: A (Areas with a 1% annual chance of flooding and a 26% chance of flooding over the life of a 30-year mortgage); AO (River or stream flood hazard areas, and areas with a 1% or greater chance of shallow flooding each year, usually in the form of sheet flow, with an average depth ranging from 1 to 3 feet.); and AE (The base floodplain where base flood elevations are provided). FEMA designates High risk coastal areas as: V (Areas along coasts subject to inundation by the 1-percent-annual-chance flood event with additional hazards associated with storm-induced waves.) and VE (Coastal areas with a 1% or greater chance of flooding and an additional hazard associated with storm waves; Base flood elevations derived from detailed analyses are shown at selected intervals within these zones). FEMA designates moderate risk areas identifiable as a X zone and depicts areas with a 0.2% - 1% chance of annual flooding. Minimal risk flood areas with a less than 0.2% annual chance of flooding are classified as X5.



With recent tropical cyclones inflicting damage from the Bahamas to the Texas Gulf Coast and damaging flood events expected to become more frequent, accurate flood maps that are up to date are needed more than ever (Kunkel, 2003). Communities are being put at risk if these flood maps do not reflect changing conditions (such as changing rainfall patterns or tropical cyclone activity). Accounting for these changing conditions may increase community awareness of the risk and preparedness. A 2017 investigation led by the Department of Homeland Security General Inspector revealed that 58% of all FEMA flood maps are inaccurate or out of date (Department of Homeland Security, 2017). Although FEMA's goal is to update the FIRMs for communities every 5 years, some areas are not re-analyzed that quickly, putting communities at risk and leaving homeowners with outdated flooding risk information.

Several studies have been conducted on comparing FEMA's FIRMs to observed flooding in natural disasters, third party flood risk evaluations, and other approaches to identifying flood risk areas. It is important to understand the changing FIMs for Galveston County given its significant and increasing exposure to flooding, growing population and extensive urban and industrial infrastructure. I will quantitatively compare the 2015 FEMA FIRM to the newly released 2019 FEMA FIRM for Galveston County. The goal of this study was to compare the 2015 to 2019 FIRMs in three ways: (1) by parcels counts in flood zones; (2) by property values impacted by flood hazards; and (3) by building footprints in flood zones.

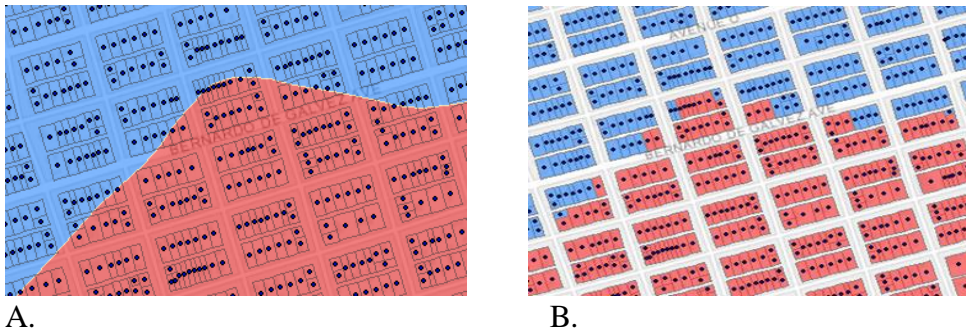
## 2. METHODS

### 2.1 GIS

The case area for this project encompasses Galveston County, located in southeastern Texas, along the Gulf Coast. Flood Hazard Data for 2019 was downloaded from FEMA's National Flood Hazard Layer repository (<https://www.fema.gov/flood-maps/national-flood-hazard-layer>). A Galveston County shapefile (updated October 25th, 2006) and parcel data (updated September 24, 2020) were acquired through the Galveston Central Appraisal District Shapefiles website (add website URL). The 2015 FEMA flood hazards data and building footprint data (last updated in 2018), was acquired through the Houston – Galveston Area Council Open GIS data website (add website URL).

In this study, ArcMap (ArcGIS version 10.7.1) was used in the manipulation of datasets. Analysis began by spatially joining each of FEMA FIRM's with parcels in Galveston county separately (based on parcel centroid, as shown in Figure 1). Following the spatial joins, I calculated the geometrical area of the parcels and inserted that in a newly formed field in the shapefile. Using join by attribute on the geo-id from the parcels, I then joined the two FEMA flood plain shapefiles (2015 and 2019) containing the parcel data and area in kilometers to each other. When this join is complete, I now have one Shapefile containing Flood hazard data for the parcels from both 2019 and 2015 layers. Six new fields were added depicting whether the parcels were included in the 100yr, 500yr, or minimal-risk areas for 2015 and 2019. A 7th field was created that depicted the flood hazard zone transition of each parcel from 2015 to 2019. The possible transitions for these parcels are as follows; 100 yr. to 100 yr., 100 yr. to 500 yr., 100 yr. to Minimal risk, 500 yr. to 100 yr., 500 yr. to 500 yr., 500 yr. to Minimal risk, Minimal risk to

100 yr., Minimal risk to 500 yr., and Minimal risk to Minimal risk. These steps were then repeated for building footprint analysis for two of the most densely-populated regions in Galveston County: Galveston Island and League City.



**Figure 1.** A. 2015 FEMA Flood hazard layer with parcel centroid and FEMA Flood plain outline; B. Spatially joined parcels to FEMA flood plains based on centroid location.

Once the transition classifications were completed the shapefile attribute table was exported as a text file and opened in Excel where the statistical analysis was completed. The sums of land values, parcel counts, and surface areas in each of the 9 transitional categories were calculated. Maps were created for Galveston county using the 2019 and 2015 classification of flood hazard areas. The transitional maps depicting the transitional classifications utilized Color Brewer 2.0 color schemes (<https://colorbrewer2.org/#type=sequential&scheme=RdPu&n=9>).

### 3. RESULTS

#### 3.1 Galveston County Parcel Analysis

Most parcels in Galveston county (59.62%, Table 1) remained zoned in the 100-year flood plain (34.47%, Table 1) or minimal hazard flood zone (25.15%, Table 1) when transitioning between 2015 to 2019 FEMA FIRM’s. From 2015 to 2019 in Galveston County, 100-year-flood-plain-zoned parcels increased by 8,543 while parcels in the minimal hazard zone decreased by 25,796 (Table 1). A substantial percentage of parcels (14.49%, Table 1) covering a large area (109.94 square kilometers, Table 2) were zoned as minimal hazard in 2015 but were rezoned as 500-year flood plain in 2019. There was an additional \$4,140,368,741 of property value rezoned to the 500-year flood plain for the 2019 FIRMs (Table 5)

*Table 1. Counts of parcel transitional changes from 2015 to 2019 FEMA SFHA in Galveston County*

		2015			
		Flood Zones	100 year	500 year	Minimal Hazard
Count	2019	100 year	59299	8324	5693
		500 year	2801	21495	24929
		Minimal Hazard	3120	2279	43272
Percentage	2019	100 year	34.4	4.84	3.31
		500 year	1.63	12.49	14.49
		Minimal Hazard	1.81	1.32	25.15

**Table 2.** Transitional changes in FEMA SFHA coverage (km<sup>2</sup>) from 2015 to 2019 in Galveston County

		2015			
		Flood Zones	100 year	500 year	Minimal Hazard
Area	2019	100 year	457.41	41.22	41.10
		500 year	24.40	70.61	109.94
		Minimal Hazard	9.60	7.48	197.23
Percentage	2019	100 year	47.69	4.30	4.29
		500 year	2.54	7.36	11.46
		Minimal Hazard	1	0.78	20.56

**Table 3.** 2015 Flood Hazard Areas; displaying parcel counts and area in square kilometers in Galveston County

		Flood Zones	Parcels	Coverage km <sup>2</sup>	Total land Value (USD)
Count/Area	100 year	64912	487.08	\$14,911,354,993	
	500 year	32615	122.65	\$6,352,960,895	
	Minimal Hazard	74467	352.08	\$20,419,157,590	
Percentage	100 year	37.72	50.78	35.60	
	500 year	18.95	12.78	15.17	
	Minimal Hazard	43.28	36.70	48.762	

**Table 4.** 2019 Flood Hazard Areas; displaying parcel counts and area in square kilometers in Galveston County

		Flood Zones	Parcels	Coverage km <sup>2</sup>	Total land Value (USD)
Count/Area	100 year	73455	534.69	\$16,583,381,854	
	500 year	49928	210.11	\$10,493,329,636	
	Minimal Hazard	48671	214.33	\$14,798,310,845	
Percentage	100 year	42.69	55.75	39.60	
	500 year	29.02	21.91	25.06	
	Minimal Hazard	28.29	22.35	35.34	

**Table 5.** Special Flood Hazard Area changes from 2015 to 2019 in Galveston County

	Flood Zones	Parcels	Coverage km <sup>2</sup>	Total land Value (USD)
Count/Area	100 year	8543	47.62	\$1,672,026,861
	500 year	17313	87.45	\$4,140,368,741
	Minimal Hazard	-25796	-137.76	\$-5,620,846,745
Percentage	100 year	4.97	4.96	3.99
	500 year	10.06	9.12	9.89
	Minimal Hazard	-14.99	-14.36	-13.42

### 3.2 Galveston Island Parcel Analysis

A vast majority of parcels on Galveston Island remained zoned in the 100-year flood plain (83.53%, Table 6) when transitioning between 2015 to 2019 FEMA FIRM’s. From 2015 to 2019 in Galveston County, 100-year-flood-plain-zoned parcels particularly increased by 1,189 parcels while minimal hazard zone parcels decreased by 1,281. A substantial percentage of parcels (83.53%, Table 6) covering a large area (101.3 square kilometers, Table 7) remained zoned as 100-year flood plain in 2019.

**Table 6.** Counts of parcel transitional changes from 2015 to 2019 FEMA SFHA on Galveston Island

		2015			
		Flood Zones	100 year	500 year	Minimal Hazard
Count	2019	100 year	23382	1493	194
		500 year	492	1330	1093
		Minimal Hazard	0	0	3
Percentage	2019	100 year	83.53	5.33	0.69
		500 year	1.76	4.75	3.90
		Minimal Hazard	0	0	0.010

**Table 7. Transitional changes in FEMA SFHA coverage (km<sup>2</sup>) from 2015 to 2019 on Galveston Island**

		2015			
		Flood Zones	100 year	500 year	Minimal Hazard
Area	2019	100 year	101.30	1.57	0.66
		500 year	3.26	1.43	1.49
		Minimal Hazard	0	0	0.70
Percentage	2019	100 year	89.19	1.38	0.58
		500 year	2.87	1.25	1.31
		Minimal Hazard	0	0	0.62

**Table 8. 2015 Flood Hazard Areas; displaying parcel counts and area in square kilometers on Galveston Island**

		Flood Zones	Parcels	Coverage km <sup>2</sup>	Total land Value (USD)
Count/Area	100 year		25069	103.53	\$8,222,369,156
	500 year		2915	6.18	\$1460018358
	Minimal Hazard		9	3.49	\$31652350
Percentage	100 year		89.55	91.47	84.64
	500 year		10.41	5.45	15.03
	Minimal Hazard		0.03	3.08	0.33

**Table 9. 2019 Flood Hazard Areas; displaying parcel counts and area in square kilometers on Galveston Island**

		Flood Zones	Parcels	Coverage km <sup>2</sup>	Total land Value (USD)
Count/Area	100 year		23880	107.74	\$8,059,679,023
	500 year		2823	2.99	\$722980207
	Minimal Hazard		1290	2.85	\$931380634
Percentage	100 year		85.31	94.85	82.97
	500 year		10.08	2.64	7.44
	Minimal Hazard		4.61	2.51	9.59

**Table 10.** Special Flood Hazard Area changes from 2015 to 2019 in the on Galveston Island

	Flood Zones	Parcels	Coverage km <sup>2</sup>	Total land Value (USD)
Count/Area	100 year	1189	4.20	\$8222369156
	500 year	92	3.17	\$737038151
	Minimal Hazard	-1281	-0.63	\$899728284
Percentage	100 year	4.25	3.70	84.64
	500 year	0.33	2.80	7.59
	Minimal Hazard	-4.58	-0.56	9.26

### 3.3 League City Parcel Analysis

Most parcels in League City (55.85%, Table 11) remained zoned in the minimal hazard flood when transitioning between 2015 to 2019 FEMA FIRM’s. In League City, an additional 17.72 square kilometers was rezoned in the 500-year flood plain for the 2019 FIRMs from the 2015 FIRMs. From 2015 to 2019 in League City, the number of 100-year-flood-plain-zoned parcels increased by 1,169 and parcels from the 500-year flood plain zone increased by 4,088(Table 15).

**Table 11.** Counts of parcel transitional changes from 2015 to 2019 FEMA SFHA in League City

		2015			
		Flood Zones	100 year	500 year	Minimal Hazard
Count	2019	100 year	2263	1910	1717
		500 year	559	1790	6299
		Minimal Hazard	0	860	21921
Percentage	2019	100 year	5.77	4.87	4.37
		500 year	1.42	4.56	16.05
		Minimal Hazard	0	2.19	55.85



**Table 12.** Transitional changes in FEMA SFHA coverage(km<sup>2</sup>) from 2015 to 2019 in League City

		2015			
		Flood Zones	100 year	500 year	Minimal Hazard
Area	2019	100 year	13.20	5.62	17.82
		500 year	1.06	2.88	17.72
		Minimal Hazard	0	1.51	50.91
Percentage	2019	100 year	11.44	4.87	15.43
		500 year	0.92	2.49	15.35
		Minimal Hazard	0	1.31	44.09

**Table 13.** 2015 Flood Hazard Areas; displaying parcel counts and area in square kilometers in League City

	Flood Zones	Parcels	Coverage km <sup>2</sup>	Total land Value (USD)
Count/Area	100 year	5920	37.53	\$1686836873
	500 year	8760	23.63	\$2917853682
	Minimal Hazard	24710	55.73	\$8081618384
Percentage	100 year	15.08	32.11	13.30
	500 year	22.32	20.21	23
	Minimal Hazard	62.96	47.68	63.70

**Table 14.** 2019 Flood Hazard Areas; displaying parcel counts and area in square kilometers in League City

	Flood Zones	Parcels	Coverage km <sup>2</sup>	Total land Value (USD)
Count/Area	100 year	4751	17.57	\$1200078157
	500 year	4560	10.01	\$1661243677
	Minimal Hazard	29937	86.44	\$9789993726
Percentage	100 year	12.11	15.41	9.49
	500 year	11.62	8.78	13.13
	Minimal Hazard	76.28	75.81	77.38

**Table 15.** Special Flood Hazard Area changes from 2015 to 2019 in League City

	Flood Zones	Parcels	Coverage km <sup>2</sup>	Total land Value (USD)
Count/Area	100 year	1169	19.96	\$1686836873
	500 year	4200	13.61	\$1256610005
	Minimal Hazard	-5227	-30.72	-\$1708375342
Percentage	100 year	2.98	17.29	13.31
	500 year	10.70	11.792	9.92
	Minimal Hazard	-13.32	-26.61	-13.485

### 3.4 Galveston Island Building Footprint Analysis

A majority (77.71%, Table 1) of buildings located on Galveston Island were zoned and remained zoned in the 100-year flood plain. The largest increase was in 7.2% of the buildings that were zoned as 500-year flood plain in 2015 were then zoned as 100-year flood plain in 2019 (Table 16). There was an overall increase in buildings zoned in the 100-year flood plain increasing from 79.61% to 85.88%. A loss of 435,107m<sup>2</sup> of building footprint area zoned as minimal hazard areas in 2015 occurred when transitioning to 2019 SFHAs.

**Table 16.** BFP transitional changes from 2015 to 2019 FEMA SFHA on Galveston Island

		2015			
		Flood Zones	100 year	500 year	Minimal Hazard
Count	2019	100 year	21930	2031	278
		500 year	547	1920	1494
		Minimal Hazard	2	0	23
Percentage	2019	100 year	77.70	7.20	0.98
		500 year	1.94	6.80	5.29
		Minimal Hazard	0.007	0	0.08

**Table 17. Transitional changes in FEMA SFHA coverage(m<sup>2</sup>) from 2015 to 2019 on Galveston Island**

		2015			
		Flood Zones	100 year	500 year	Minimal Hazard
Area	2019	100 year	4835694	321997	88448
		500 year	254208	342240	361841
		Minimal Hazard	15182	0	2847
Percentage	2019	100 year	77.71	5.17	1.42
		500 year	4.09	5.50	5.82
		Minimal Hazard	0.24	0	0.05

**Table 18. 2015 Flood Hazard Areas; displaying BFP counts and area in square meters on Galveston Island**

		Flood Zones	BFP	BFP Coverage in m <sup>2</sup>
Count/Area		100 year	22479	5105084
		500 year	3951	664237
		Minimal Hazard	1795	453136
Percentage		100 year	79.64	82.04
		500 year	14	10.67
		Minimal Hazard	6.36	7.28

**Table 19. 2019 Flood Hazard Areas; displaying BFP counts and area in square meters on Galveston Island**

		Flood Zones	BFP	BFP Coverage in m <sup>2</sup>
Count/Area		100 year	24239	5246139
		500 year	3961	958289
		Minimal Hazard	25	18029
Percentage		100 year	85.88	84.31
		500 year	14.03	15.40
		Minimal Hazard	0.09	0.29

**Table 20.** Flood hazard changes from 2015 to 2019 on Galveston Island

	Flood Zones	BFP	BFP Coverage in m <sup>2</sup>
Count/Area	100 year	1760	141055
	500 year	10	294052
	Minimal Hazard	-1770	-435107
Percentage	100 year	6.24	2.27
	500 year	0.04	4.73
	Minimal Hazard	-6.27	-6.99

### 3.5 League City Building Footprint Analysis

Most League City buildings (56.98%) remained zoned in the minimal hazard flood plain covering an approximate 6,021,563 meters squared (Tables 21, 22). A small percentage of the buildings (21.5%) that were zoned as minimal hazard zone in 2015 were then reclassified in the 500-year flood hazard zone in 2019 (Table 21). Overall, 20.14% of all buildings in League City were removed from the 2015 minimal hazard zone and reclassified to either 100 year or 500-year flood plain in 2019 FIRMs.

**Table 21.** Counts of BFP transitional changes from 2015 to 2019 FEMA SFHA in League City

		2015			
		Flood Zones	100 year	500 year	Minimal Hazard
Count	2019	100 year	1422	2127	1409
		500 year	511	2212	6604
		Minimal Hazard	1948	885	22673
Percentage	2019	100 year	3.57	5.35	3.54
		500 year	1.28	5.56	16.60
		Minimal Hazard	4.90	2.22	56.98

**Table 22.** Transitional changes in FEMA SFHA coverage(m<sup>2</sup>)from 2015 to 2019 in League City

		2015			
		Flood Zones	100 year	500 year	Minimal Hazard
Area	2019	100 year	264095	424324	358018
		500 year	129214	536335	1594376
		Minimal Hazard	426331	372536	6021563
Percentage	2019	100 year	2.61	4.19	3.54
		500 year	1.28	5.30	15.74
		Minimal Hazard	4.21	3.68	59.46

**Table 23.** 2015 Flood Hazard Areas; displaying BFP counts and area in square meters in League City

		Flood Zones	BFP	BFP Coverage in m2
Count/Area		100 year	3881	819640
		500 year	5224	1333195
		Minimal Hazard	30686	7973957
Percentage		100 year	9.75	8.09
		500 year	13.13	13.17
		Minimal Hazard	77.12	78.74

**Table 24.**2019 Flood Hazard Areas; displaying BFP counts and area in square meters in League City

		Flood Zones	BFP	BFP Coverage in m2
Count/Area		100 year	4958	1046437
		500 year	9327	2259925
		Minimal Hazard	25506	6820430
Percentage		100 year	12.46	10.33
		500 year	23.44	22.32
		Minimal Hazard	64.10	67.35

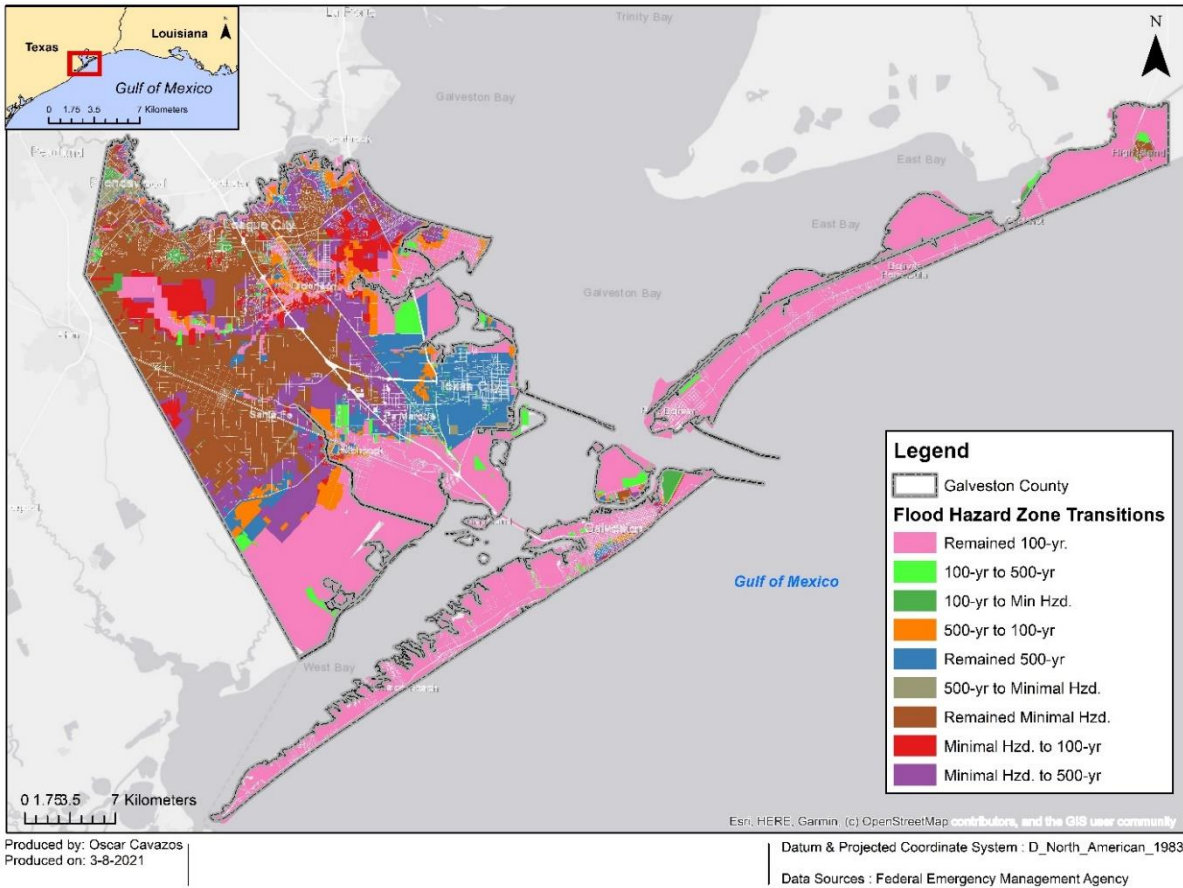
**Table 25.** Flood hazard changes from 2015 to 2019 in League City

	Flood Zones	BFP	BFP Coverage in m2
Count/Area	100 year	1077	226797
	500 year	4103	926730
	Minimal Hazard	-5180	-1153527
Percentage	100 year	2.70	2.24
	500 year	10.31	9.15
	Minimal Hazard	-13.02	-11.39

### 3.6 Maps

Low lying areas, most susceptible to coastal flooding by storm surge or intense rainfall, can be seen in Figure 2 represented in pink are parcels that remained in the 100-year flood plain when transitioning from 2015 to 2019 FIRMs throughout Galveston County. A large area deep within Galveston County is seen to remain in the minimal flood hazard zone shown in a dark brown. Neighboring the parcels remaining in the 100-year flood zone (pink), are blue and purple symbolized parcels showing a large area of parcels remaining and rezoned into the 500-year flood plain, respectively. A majority of Galveston Island is within the 100-year floodplain with the exception of some points of higher elevation on the East end of Galveston Island.

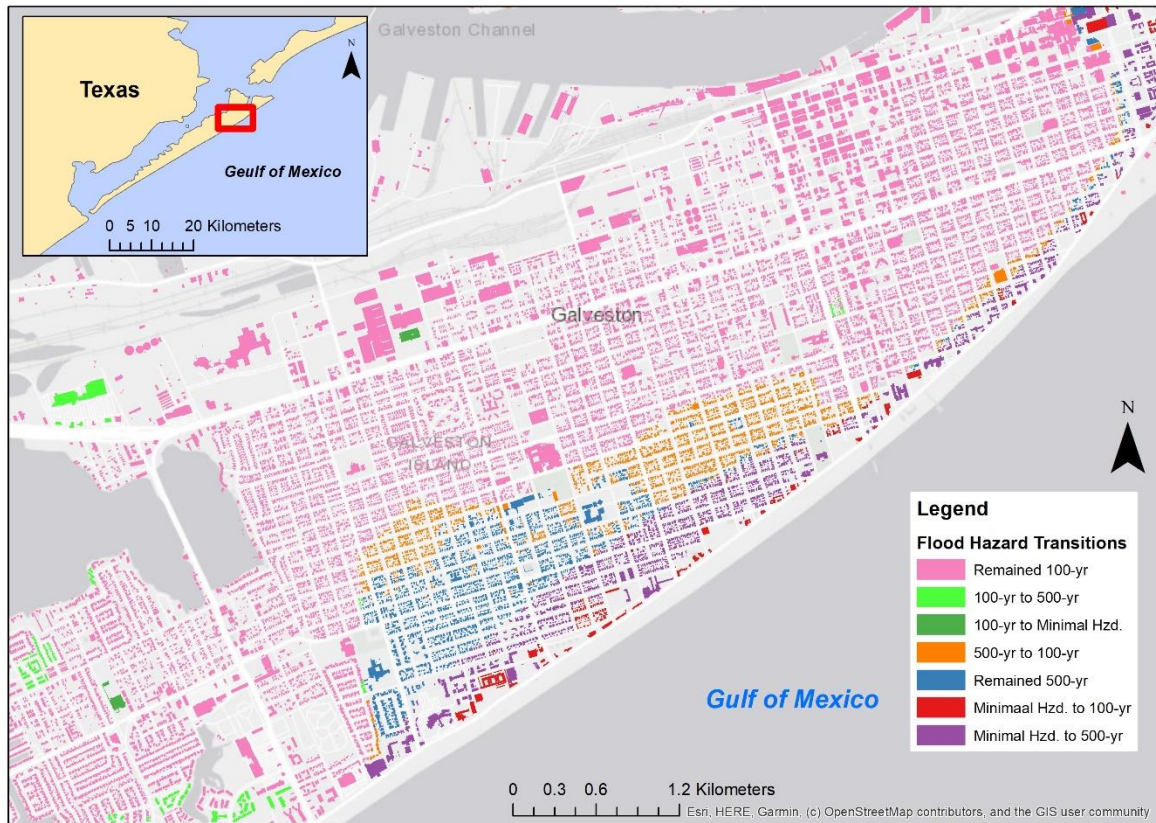
Parcel transitions from 2015 to 2019 FEMA Flood Hazard zones in Galveston County, Texas



**Figure 2.** Map of parcel transitions from 2015 to 2019 FEMA flood hazard zones in Galveston County, Texas

Figure 3 shows most building footprints on the East end of Galveston Island remained zoned in the 100-year flood plain when comparing the 2015 and 2019 FEMA SFHAs. With a higher building density on the East side of the island, more buildings would be displaced if a flood reached the 100-year or greater threshold. Buildings along Seawall Blvd. seemingly are better zoned out of the high risk 100-year flood plain.

Building footprint transitions from 2015 to 2019 FEMA Flood Hazard Zones in Galveston, Texas



Produced by: Oscar Cavazos

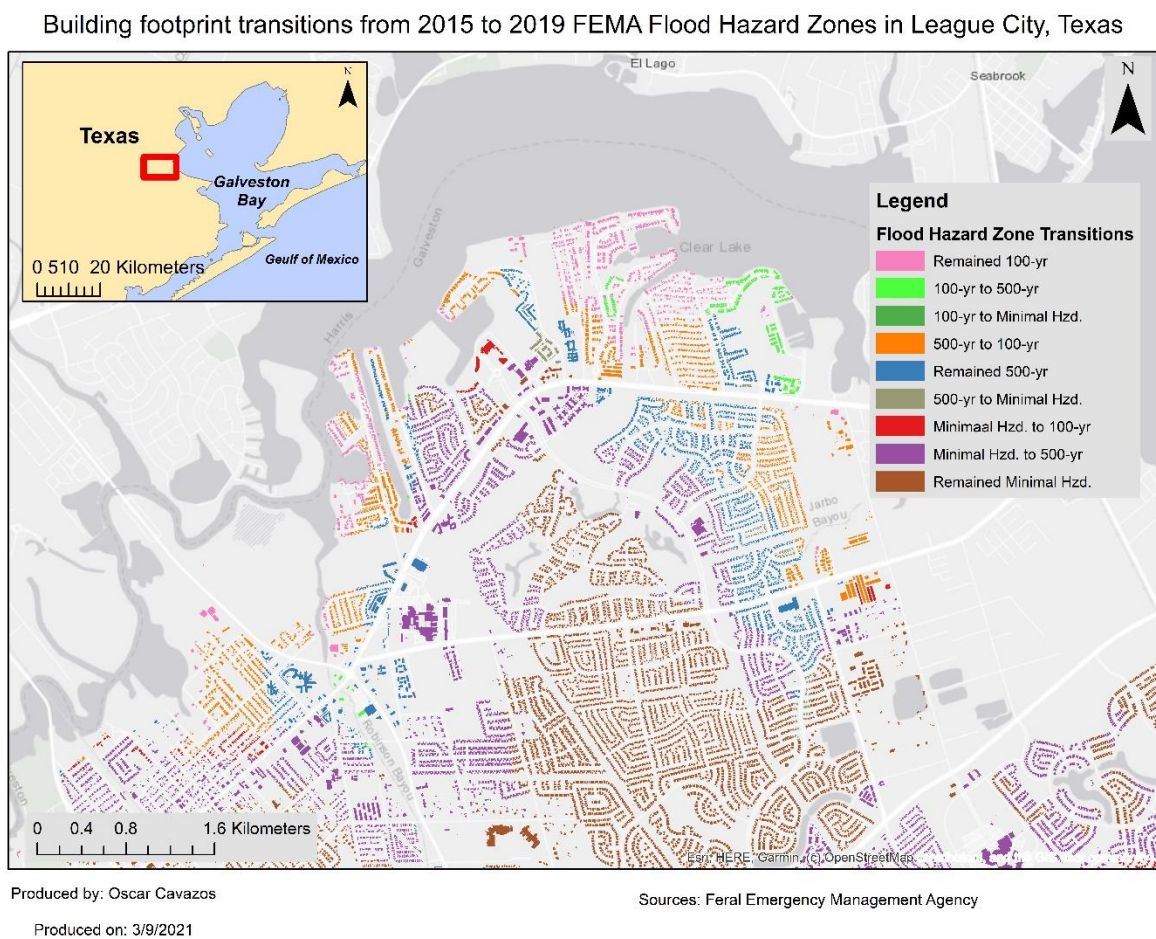
Sources: Feral Emergency Management Agency

Produced on: 3/8/2021

*Figure 3. Map of building footprint transitions from 2015 to 2019 FEMA flood hazard zones in Northern Galveston, Texas*



For Clear Lake (Figure 4), most of the buildings can be seen to have remained in the minimal hazard zone when transitioning between the 2015 and 2019 SFHAs. Areas surrounding Clear Lake, North of League City transitioned from minimal hazard and 500-year flood plains to 100-year flood plains and 500-year flood plains. A large portion of BFP's in the bottom left section of Figure 4 transitioned from the minimal hazard zone to the 2019 500-year flood plain zone.



**Figure 4.** Map of building footprint transitions from 2015 to 2019 FEMA flood hazard zones in Northern League City, Texas

## **4. DISCUSSION AND CONCLUSIONS**

### **4.1 Galveston Island vs. Galveston County Parcel Data**

There was a larger majority (83.53 %) of parcels in The City of Galveston that remained zoned in the 100-year flood plain when transiting from the 2015 to the 2019 FEMA FIRMs in comparison to Galveston County as a whole (34.47%). This conclusion is understandable as the City of Galveston is situated on the barrier island, Galveston Island, where the highest points of elevation barely top 2 meters above sea level (compared to League City's elevation averaging around 6 meters above sea level). Although the City of Galveston is large, it only accounted for 32.5% of the 100-year flood zone parcels zoned in 2019 and 20% of land area zoned in the 100-year flood plain in Galveston County. Galveston County retained more parcels that either remained or were rezoned in minimal hazard zones in comparison to the City of Galveston. The City of Galveston kept only about 0.010% of its parcels in the minimal hazard area when transitioning to the 2019 FEMA FIRMs from 2015.

### **4.2 League City vs Galveston County Parcel Data**

A higher percentage of parcels in League City remained zoned in the minimal hazard zone (55.85%) when compared to Galveston County, where a lower percentage of parcels remained in the 100 year flood zones (34.47%) when transitioning between 2015 and 2019 FEMA FIRM's. League City saw a rezoning of 1.42% of its parcels compared to Galveston County's 1.63% parcels zoned in 2015 FEMA 100 year flood plains to the 500 year flood plain in 2019.

### **4.3 League City vs Galveston Island Parcel Data**

Geographically, League City is situated next to Clear Creek nestled in the West side of Galveston Bay which is roughly 35.5 km away from Galveston Island. League City (116.89 km<sup>2</sup>) and the Galveston Island (113.2 km<sup>2</sup>) parcels cover relatively close to the same aerial extent giving a quite close comparison. Due to League City's higher average elevation (~19ft.), it is not nearly as susceptible to storm surges as Galveston Island. With Clear Creek bordering League City, this area would be more susceptible to inland flooding due to either flash flooding upstream or storm surge reaching upstream causing damage to homes not properly prepared. Despite the creek's associated risks in League City, most parcels (55.85%) remained classified in the minimal hazard zones when rezoning from FEMA's 2015 to 2019 FIRMs, unlike Galveston Island's 0.01% of parcels. 83.53% of Galveston Islands parcels remained zoned in the 100-year flood plain whilst League City kept about 5.77% of its parcels classified in the 100-year flood zone. Based on the amount parcels contained in the 100-year flood plain, Galveston Island contained parcels that are at higher risks of flooding when compared to League city.

### **4.4 Galveston Island vs League City BFP Data**

Similarly to the parcel analysis, League City has a majority of its building footprints within the minimal flood hazard zone (56.98%) whilst Galveston Island has a majority of its buildings in the 100 year flood plain (77.71%) when transitioning from the 2015 to the 2019 FEMA FIRMs. League City had a larger increase in transitions to the 500-year floodplain when compared to Galveston Island, with a 16.6% transitional change from minimal hazard zones to the 500-year floodplain in League City. Observed flooding from 2017's Hurricane Harvey might have accounted for this change as the storm dropped an average of 49 inches of rain in the span

of just a couple of days, flooding many areas in League City where flooding had never been previously recorded. The largest loss was on Galveston Island was losing 435,107m<sup>2</sup> (-6.99%) of building from minimal hazard zones from 2015 to 2019, most of which was rezoned to the 500-year flood plain.

#### **4.5 Conclusion**

After the fairly recent extreme rainfall event Hurricane Harvey (2017), that flooded thousands of homes in the Houston-Galveston area, the support of communicating flooding risks to households has been rising amongst issues. Overall the case areas including Galveston Island, League City and Galveston County were observed to have a uniform trend in the decrease of minimally hazard zoned BFP and parcels from 2015 to 2019 FEMA FIRMs. Analysis like this one can be taken into account in future development plans to ensure structures zoned in higher risk areas are capable of withstanding the associated flooding risks.

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