



Assessing Flooding Hazard Exposure

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Presentation Outline

- FEMA flood hazard data
- Geoprocessing: data cleaning and reclassification
- Case study to illustrate this process and quantification of exposed elements
- Conclusions and some possible alternatives to assess flooding exposure

Flood Hazard Data Sources

- A hazard can be studied in different ways:
 - By **models** or **simulation** of extreme events (deterministically or stochastically);
 - Engineering or physics-based models (hydrological and hydraulic).
 - By **specific occurrences** (historical events, but often not well documented, even today).
 - By **local knowledge**.
- FEMA provides flood hazard data to support the National Flood Insurance Program (NFIP).
 - **National Flood Hazard Layer** (NFHL) is a **geospatial database** that contains current effective flood hazard data for a variety of official policies/programs.
 - These data establish **flood insurance requirements** (often imposed by federally backed mortgage lenders).
 - Help communities develop strategies and programs to reduce flood risk, understanding **risk exposure** and evaluating/quantifying exposure.
- NFHL data is not uniformly available, but covers the area occupied by 90% of US population.

History of FEMA Flood Maps

- In 1968 the US Congress created the NFIP.
 - FEMA has been creating and updating flood hazard maps for the program after its creation.
- These maps are based on the combination of a variety of methods:
historical occurrences and insurance claims; meteorological, hydrologic, and hydraulic data; and can incorporate assessment of land-use/land cover conditions, flood-control infrastructure, and development.
- Updates to flood maps are a collaboration between the communities and FEMA.
 - Every community that participates in the NFIP has a floodplain administrator who works with FEMA during the mapping process.
 - After their creation they are subject to public review/comment, amendment, prior to adoption.

History of FEMA Flood Maps

Over time, FEMA has produced **two** digital flood map products

Paper Maps	Q3 Flood Data	DFIRM (Digital Flood Insurance Rate Maps)
<ul style="list-style-type: none">• Flood Hazard Boundary Maps (FHBM), later Flood Insurance Rate Maps (FIRM).• Essential tool for the Mitigation Directorate (now the Federal Insurance and Mitigation Administration (FIMA), responsible for the NFIP and a range of programs designed to mitigate against future losses from all hazards including floods, earthquakes, tornadoes, and other natural disasters.	<ul style="list-style-type: none">• Started as digitization of paper maps, for the entire US.• Less precise scale 1:24,000 (±40 ft.)• Was available for over 1,300 counties• Q3 cannot be used as the official NFIP map for site design or flood risk determinations.• Last updated late 1999.	<ul style="list-style-type: none">• Started in 2000.• More precise scale 1:12,000 (±33 ft.)• NFHL (National Flood Hazard Layer) geospatial database.• New counties and updates to existing ones are an ongoing process.• Currently covers the area occupied by 90% of US population.

Current FEMA Websites

- FEMA Flood Map Service Center
 - <https://msc.fema.gov/portal/home>
 - Dynamic map
 - Document/letters of revisions, amendments, and revalidations
- National Flood Hazard Layer (NFHL) Status
 - <https://www.floodmaps.fema.gov/NFHL/status.shtml>
 - NFHL inventory: table with the most updated DFIRMs for download (by county)

Observations Regarding the NFHL Data

- Areas likely to have additional wave action (**flood with velocity** are identifiable).
- Generally speaking, **there is limited flood depth data**;
 - Some flood classifications indicate depth ranges, but mostly they reflect a dichotomous classification.
- NFHL boundaries are **not perfectly aligned** with Census TIGER shapefiles.
 - Data are presented by county, but county boundaries (and hence other geographies) can be **inconsistent** with Census boundaries.
 - Since flooding designations are distributed county by county, **neighboring**, cross-county areas, can have different flood risks.
 - This can be potentially problematic when places, cities, metro-areas, are cross counties.
- Data are presented to capture probabilities of flooding, **annual exceedance probability**.

FEMA Floodplain Designations

- Special Flood Hazard Areas (SFHA)
 - Areas subject to flood inundation at **1.0% *or greater chance*** in any given year.
 - Sometimes referred to as having a 1.0% chance of flooding per year.
 - “*100-year floodplain*”
- Moderate Flood Hazard Areas
 - Areas subject to flood inundation between the **limits of the SFHA** and **0.2%** chance of flooding in any given year.
 - “*500-year floodplain*”
- Areas of Minimal Flood Hazard
 - Areas **outside the SFHA** and higher than the elevation of the 0.2% chance of flooding in any given year.

Floodplain Reclassification

Q3 and NFHL flood zones and subtypes and our simplified recodes ...

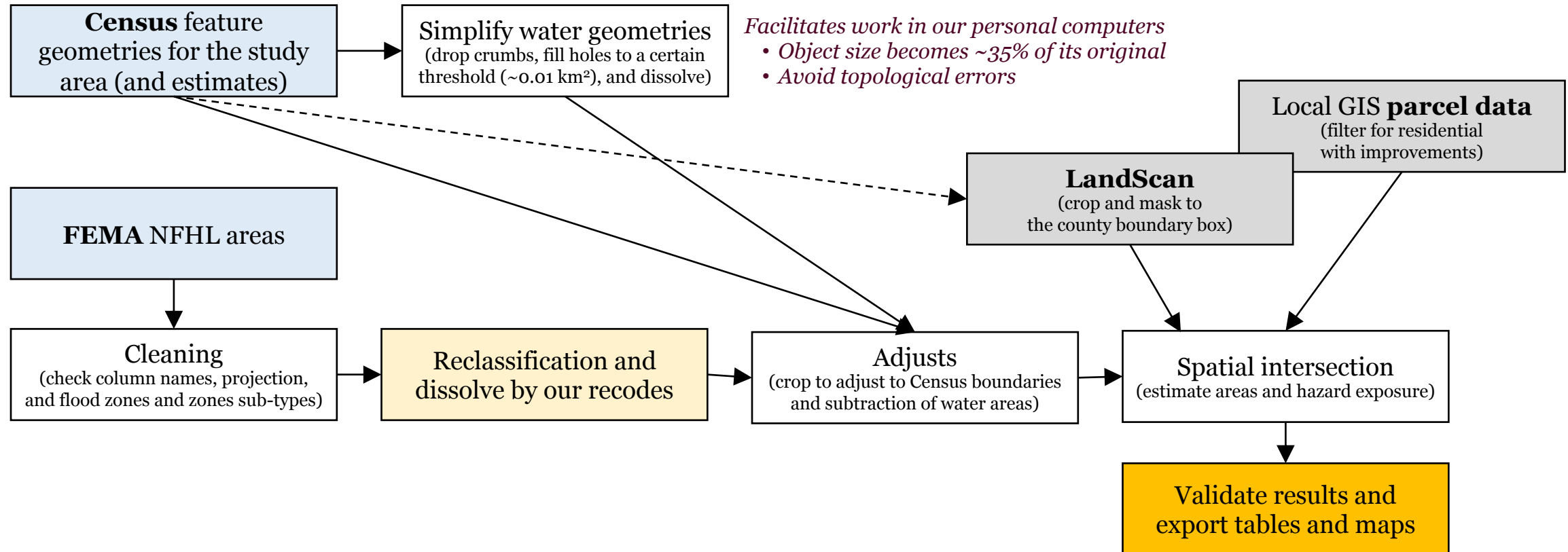
Q3 classification	NFHL classification	<i>Reclassification</i> *
V, VE	VE	100-year (with velocity)
A, A1-A30, A99, AE, AH, AO, AR	A, AE, AH, AO	100-year
B, X500, X (shaded)	X (0.2 pct annual chance flood hazard)	500-year
X (reduced flood risk due to levee)	Area with reduced flood risk due to levee	500-year (levee protected)
C, D, X, X (unshaded), UNDES	X (area of minimal flood hazard), ANI (area not included)	Out of the floodplain

Many sources ... ultimately referring to FEMA, such as:

- <https://help.riskfactor.com/hc/en-us/articles/360048256493-Understand-the-differences-between-FEMA-flood-zones>
- <http://www.floodmaps.com/zones.htm>
- <http://www.mass.gov/anf/docs/itd/services/massgis/q3floodzonescodetable.pdf>

Data Cleaning and Geoprocessing

Load, tidy, reclassify, dissolve, adjust and water subtraction, and quantification of exposure



Case Study: Flooding Hazard Exposure in Galveston Co.

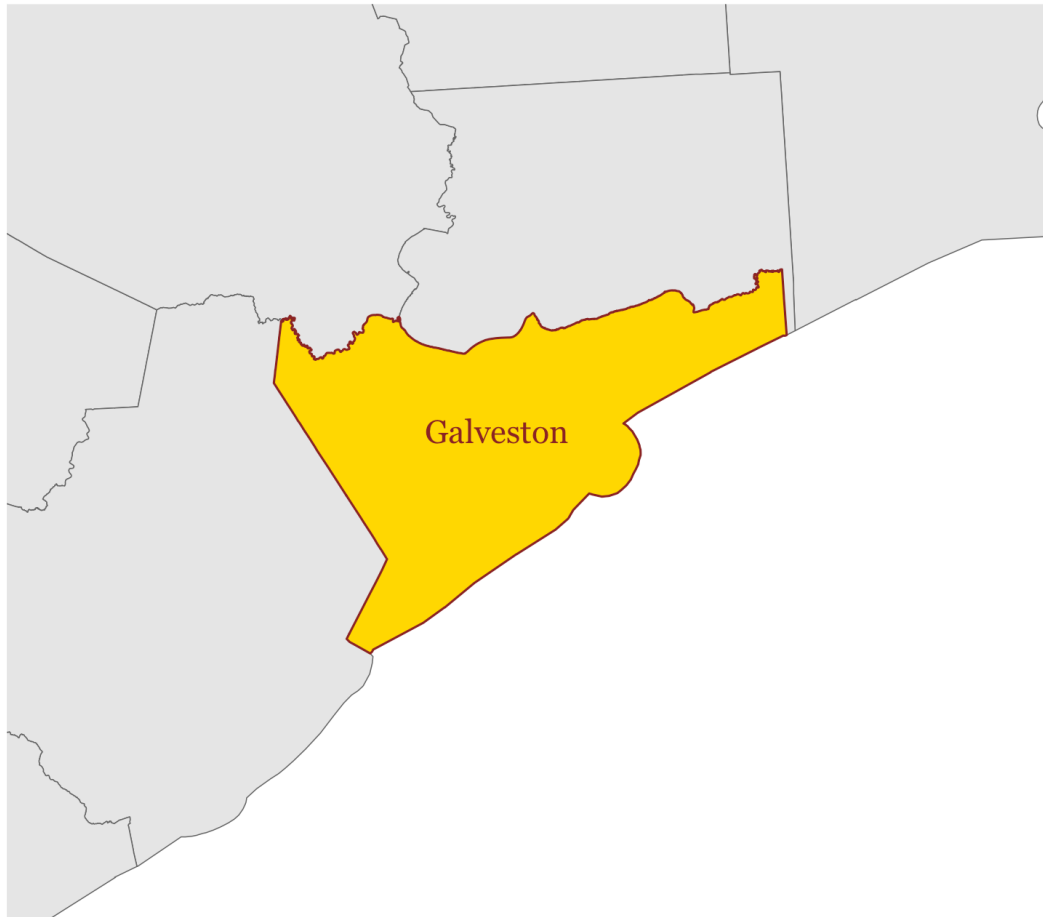
R-script for this case study: https://github.com/abuabara/flooding_hazard_exposure.git

Data sources

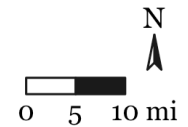
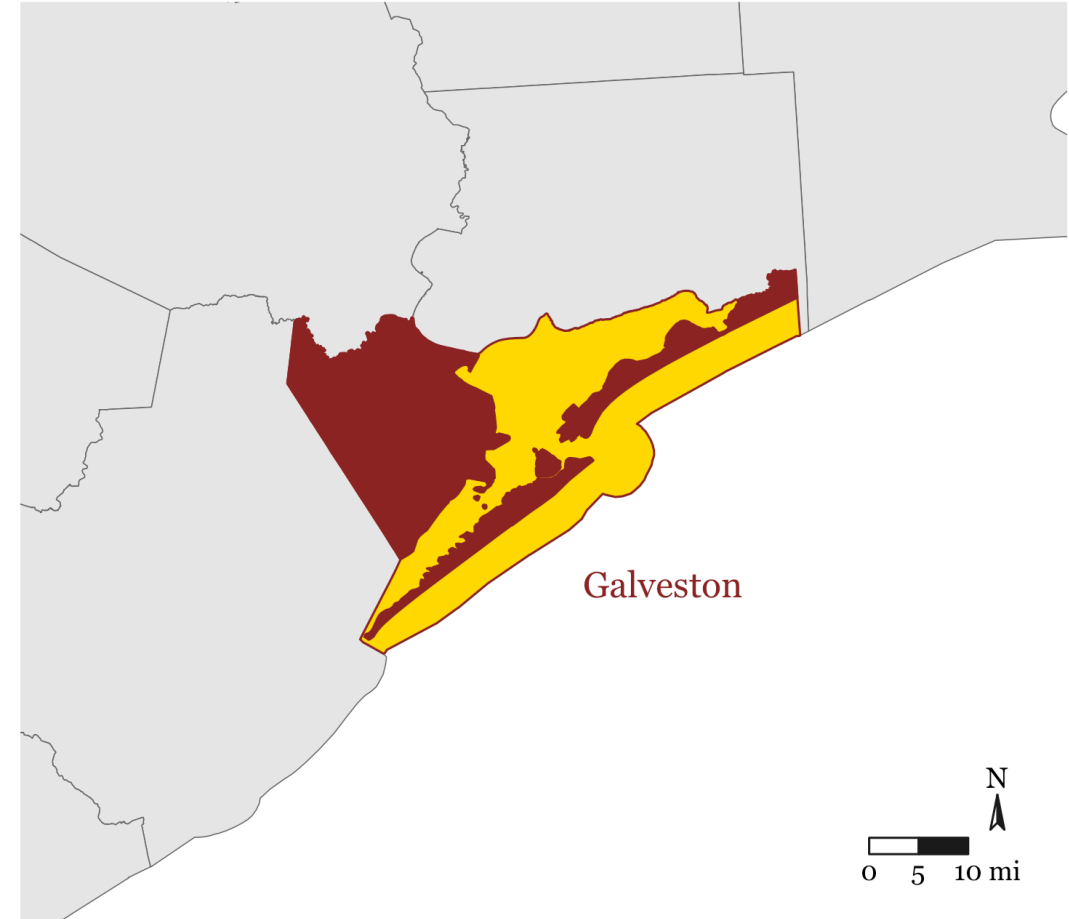
- **Census** boundaries and perennial and intermittent areas of hydrography features
 - R/tigris <https://github.com/walkerke/tigris>
- **ACS** estimates
 - R/tidycensus <https://github.com/walkerke/tidycensus/>
- **FEMA NFHL Flood Maps**
<https://www.floodmaps.fema.gov/NFHL/status.shtml>
- **ORNL LandScan USA Conus Night**
Raster dataset that provides population estimates for the Homeland Infrastructure Foundation-Level Data (HIFLD) database: <https://landscan.ornl.gov>
- **Galveston Central Appraisal District – Parcel Information**
<https://galvestoncad.org/gis-data/>

Case Study: Flooding Hazard Exposure in Galveston Co.

Case Study

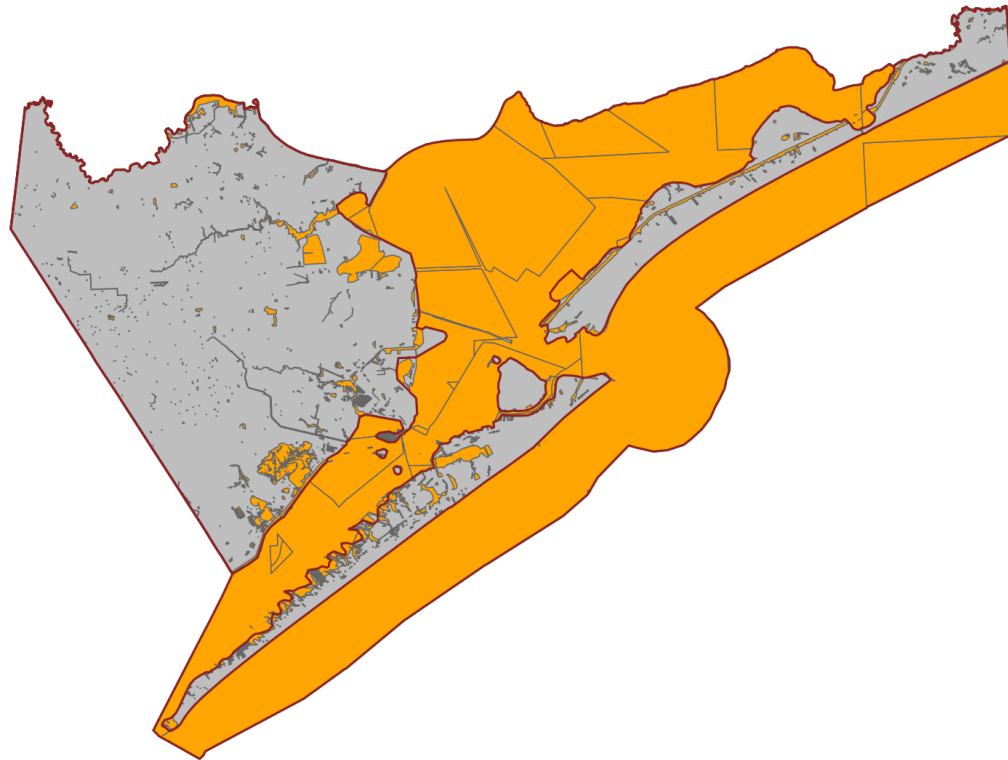


Cartographic Boundary

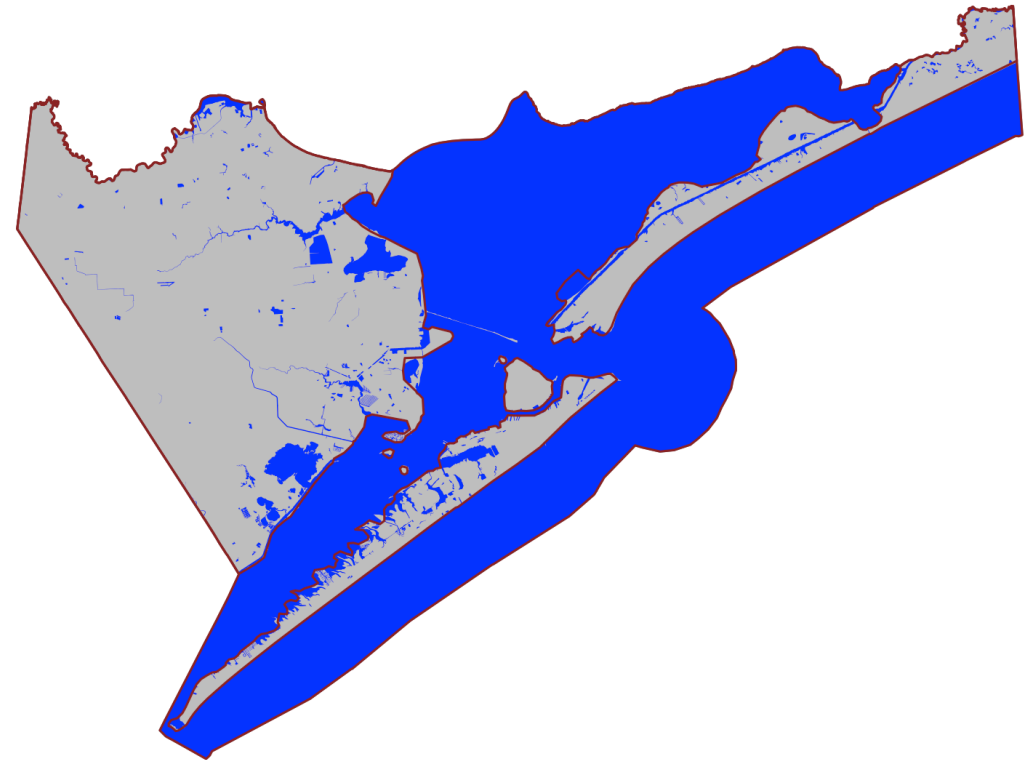


Case Study: Flooding Hazard Exposure in Galveston Co.

Original Census County Water

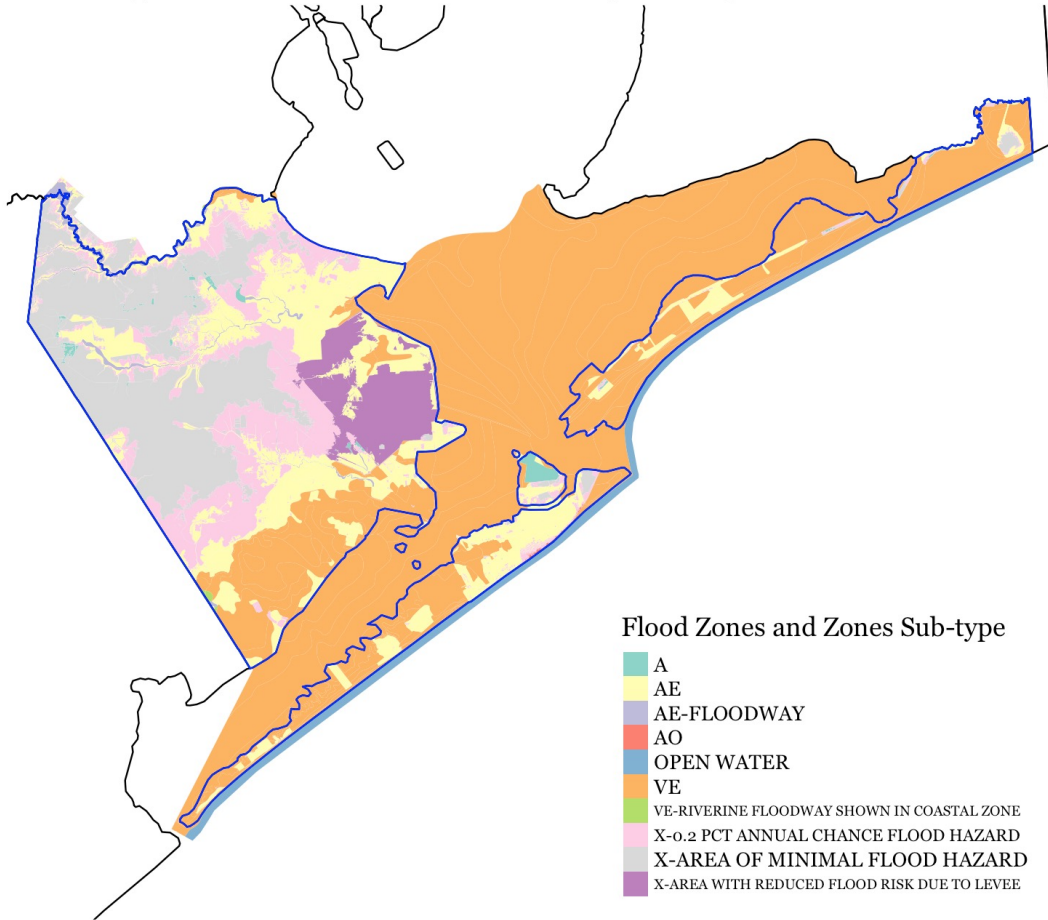


Simplified County Water



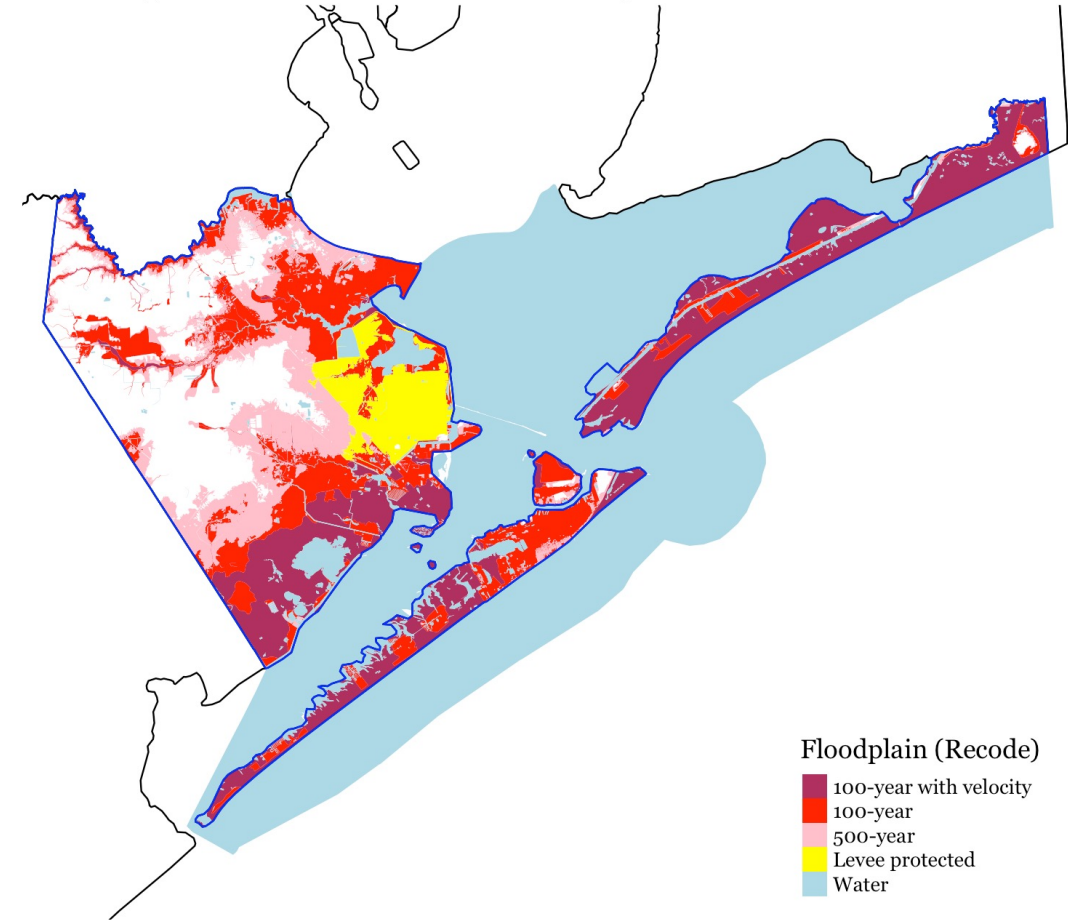
Case Study: Flooding Hazard Exposure in Galveston Co.

Floodplain in Galveston County (Original)



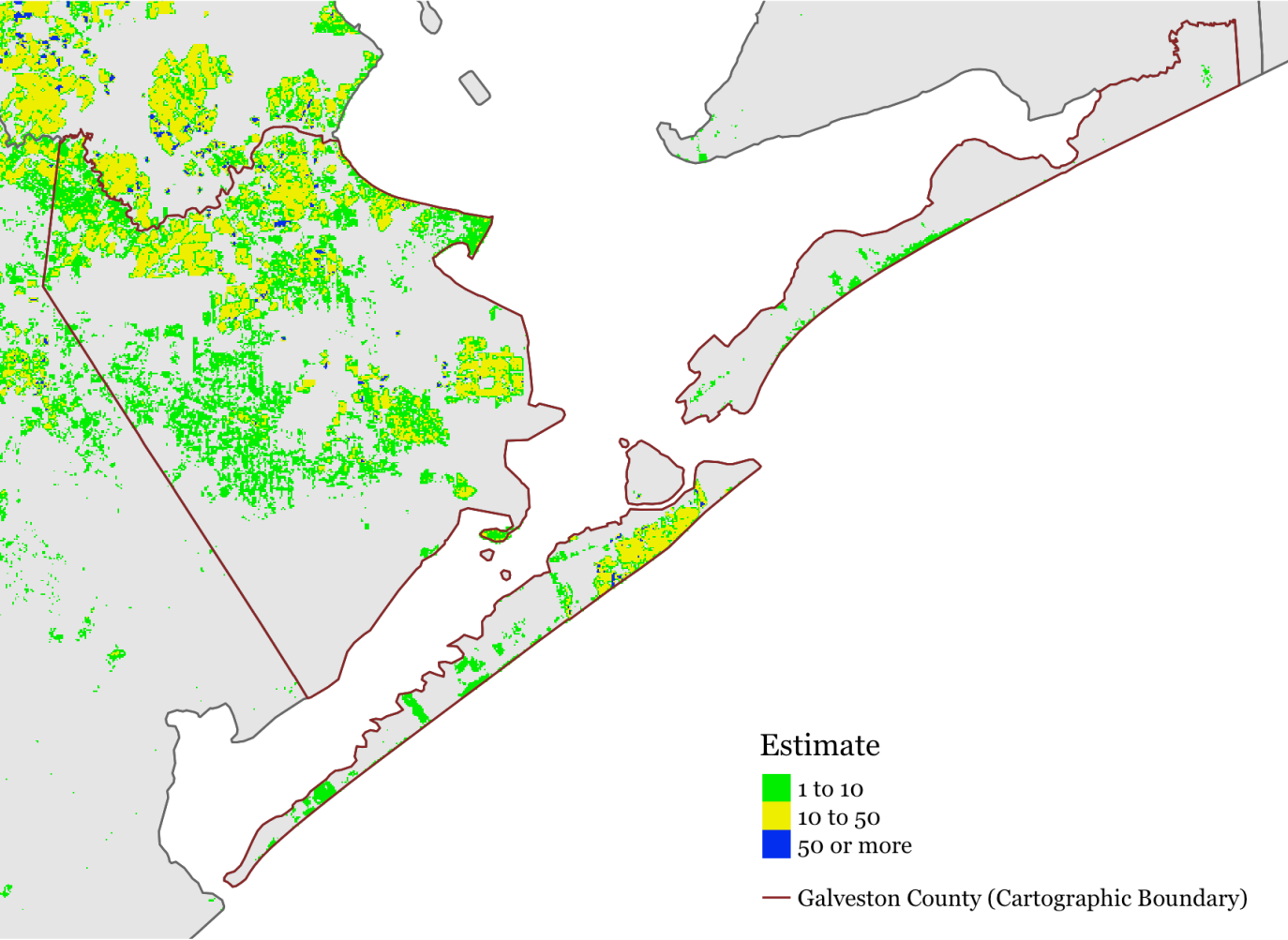
NFHL update date: 2022-11-20

Floodplain in Galveston County (Reclassified)



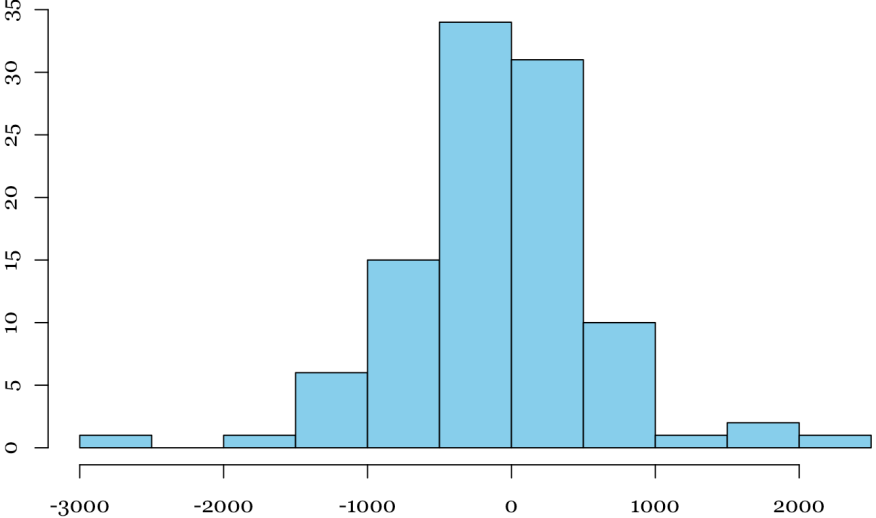
PS: need to use LandScan that is the mid-year of the 5-year ACS estimate

Landscan 2019 Population Counts (Conus Night)



Census Tracts

Histogram for Census Estimate - Landscan Counts



Paired t-test

Data: Census Estimate and Landscan Counts (Population)

t = -1, df = 101, p-value = 0.3

Alternative hypothesis: true mean difference is not equal to 0

95 percent confidence interval: **-203.28 65.55**

Sample estimates: mean difference **-68.87**

	Census 2021-2017 ACS 5-Year	Landscan 2019
Total County Population	347,084 (MOE 38,817)	354,112

Galveston County

(–Illustrative Estimates–)

Floodplain	Population Count* 2019 LandScan	Residential Parcels** Appraisal District	Area*** (sq mi)
Water	–	–	493.0
100-year (with velocity)	12,854	5,289	103
100-year	99,136	27,387	93.9
500-year	81,637	24,867	61.1
500-year (levee protected)	40,243	11,540	24.8
Out of floodplain	120,242	42,795	171.6
Total	354,112	111,878	775.8

* Landscan pixel is **aerial weighted** to estimate the population estimate in the area covered by the flood category.
 ** Total of **parcel centroids** that are within the floodplain category area. Land use coded as **residential (R) with improvement value greater than \$0 in 2022**.
 *** Projection used **EPSG:3081** NAD83 / Texas State Mapping System

View of Galveston Island Downtown Area

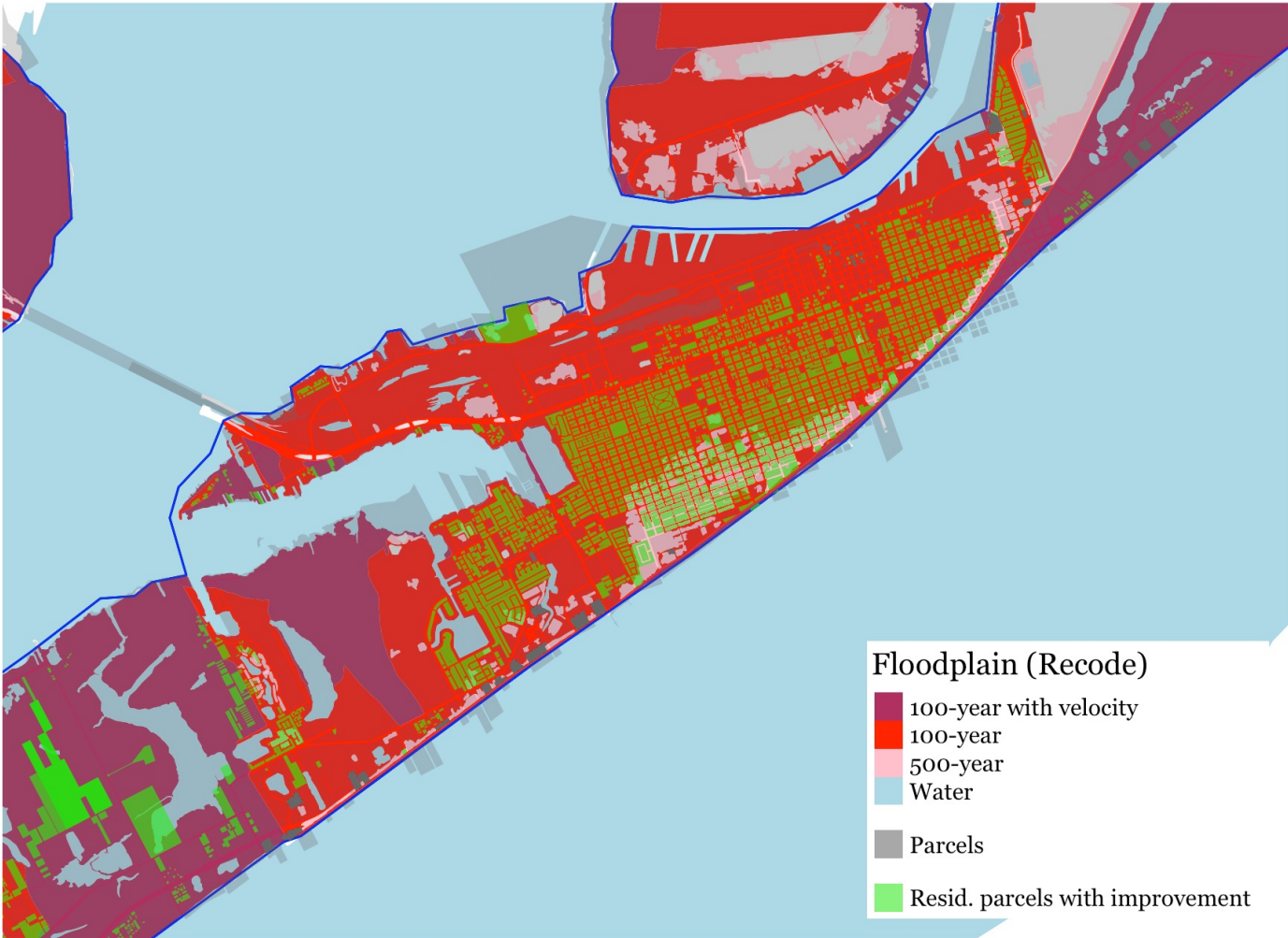


Image features part of Galveston Island to illustrate the location of parcels and residential parcels with improvement.

Possible Alternatives to Assess Flooding Risk

Commercial

- *Katrisk*
 - <https://www.katrisk.com/hazard-data>
 - Inland flood data at **multiple return periods**.
 - 2-d hydraulic **modeling** of pluvial (surface water) and fluvial (riverine) flooding.
 - Resolution varies by region dependent on available DTMs, down to 10 meters in the US.

Academic

- Wing, O. E., Bates, P. D., Smith, A. M., Sampson, C. C., Johnson, K. A., Fargione, J., & Morefield, P. (2018). Estimates of present and future flood risk in the conterminous United States. *Environmental Research Letters*, 13(3), 034023.
 - https://www.unisdr.org/preventionweb/files/57470_wing2018environ.res.lett.13034023.pdf
 - 30 m resolution **model** of the entire conterminous US with a 2-d representation of flood physics to produce estimates of flood hazard.
 - Match to within **90% accuracy** the skill of local models built with detailed data.