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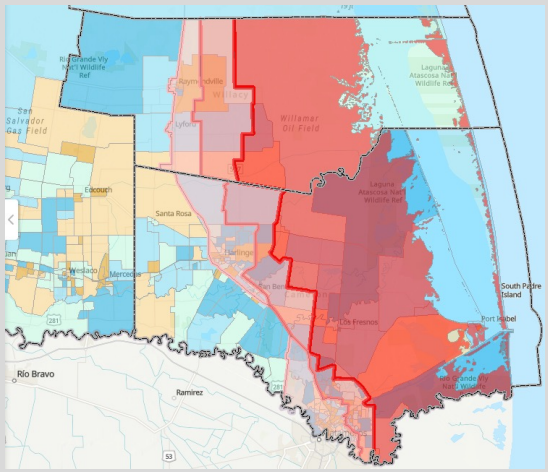
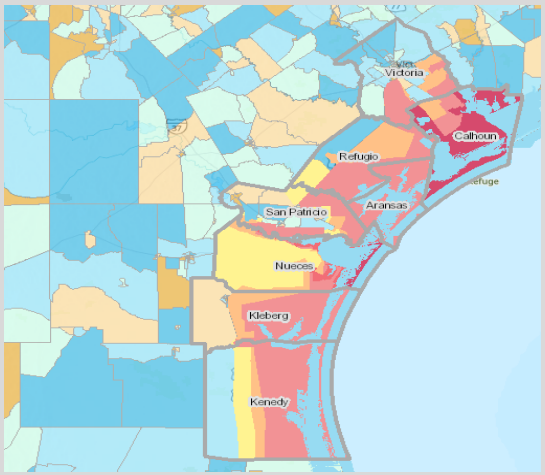
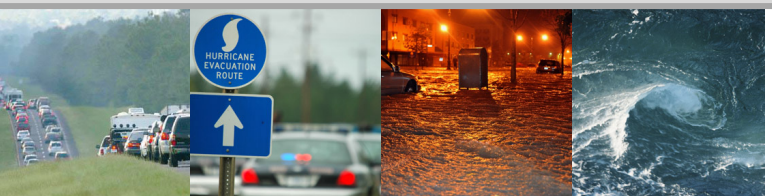
Hurricane Evacuation Studies

Risk-based evacuation zone planning for the Texas Gulf Coast



Douglas Wunneburger – HRRC
Walt Peacock – HRRC
Alexander Abuabara – HRRC
David Bierling – TTI
Darrell Borchardt – TTI





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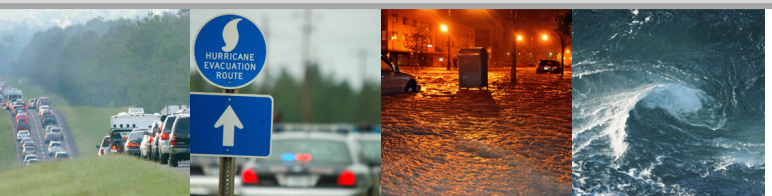
History and Justification

- Katrina (8/23/2005) – 1800 fatalities
- Rita (9/24/2005) – 107 perished during evacuation
- Ike (9/13/2008) – extreme surge, 100+ fatalities

Evacuation studies are essential for effective emergency management and community resilience.

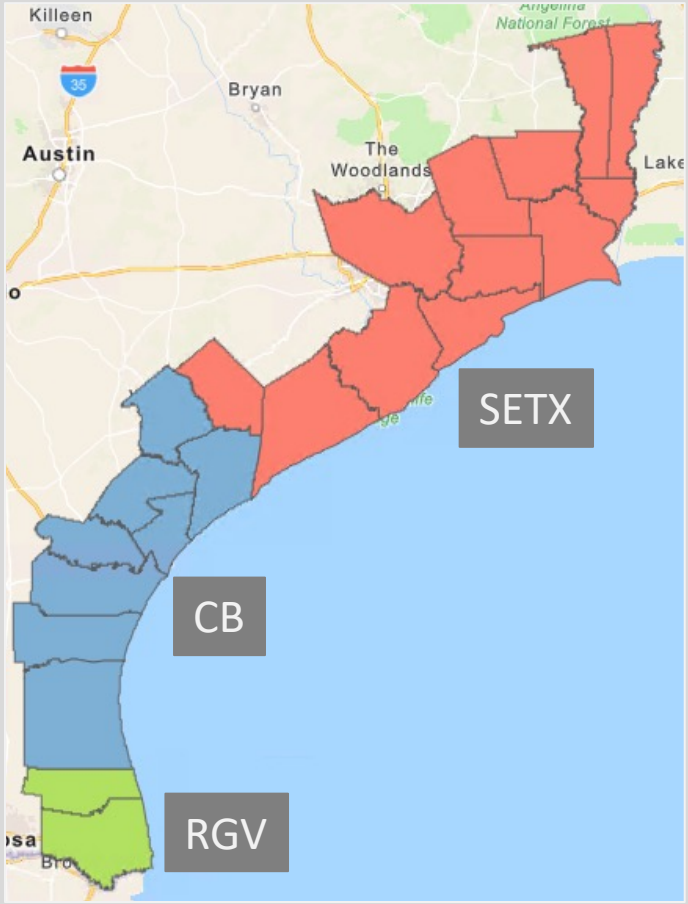
- Evidence-based decisions
- Save lives, reduce injuries
- Reduce economic loss
- Resource allocation
- Adapt to changing risks
- **Infrastructure planning, traffic management**

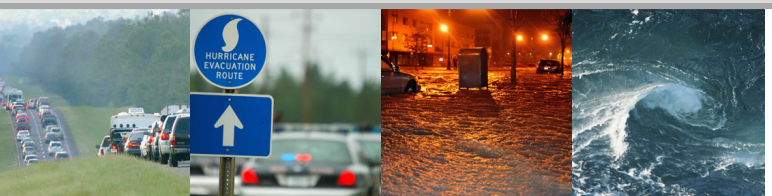
Hurricane evacuation studies provide the scientific foundation for life-saving, cost-effective, and practical emergency response plans. They are crucial for safeguarding communities, optimizing resources, and enhancing public trust and safety during hurricane events.



Hurricane Evacuation Studies

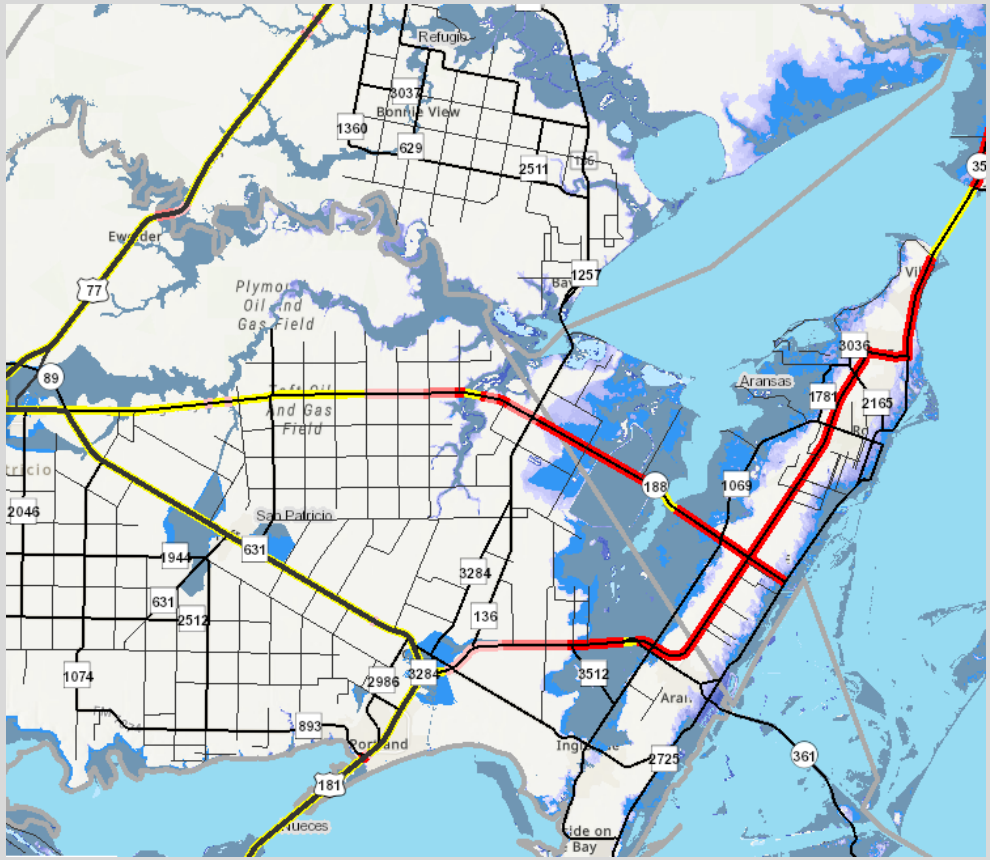
- Assemble, integrate, clean, and generate data
- Develop GIS layers and build web-based GIS platform
  - Southeast Texas – 2025
  - Coastal Bend – 2018
  - Rio Grande Valley – 2015
- Conduct vulnerability analysis
  - Physical risk
  - Socio-demographic factors
  - Critical facilities
  - Transportation infrastructure

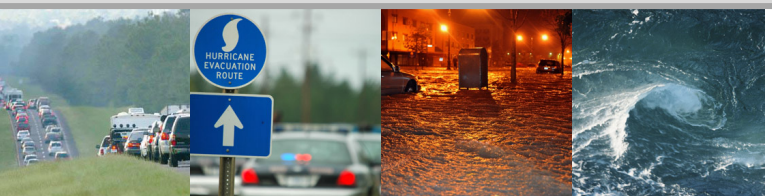




Vulnerability Assessment

- Physical risk
  - Storm surge models
  - Flood risk maps
- Socio-demographic risk
  - Vulnerable populations and household estimates
  - Total vehicles to evacuate
  - Mobile homes, RVs
  - Job locations and employee residences
  - Social vulnerability tool set
- Critical facilities
  - Health, schools, police, fire
  - Hotels, seasonal rentals
- Evacuation zones
  - Recognizable geography
  - "*Chambers County South of IH10*"
- Transportation infrastructure
  - Evacuation routes
  - Evacuation timing scenario assessment





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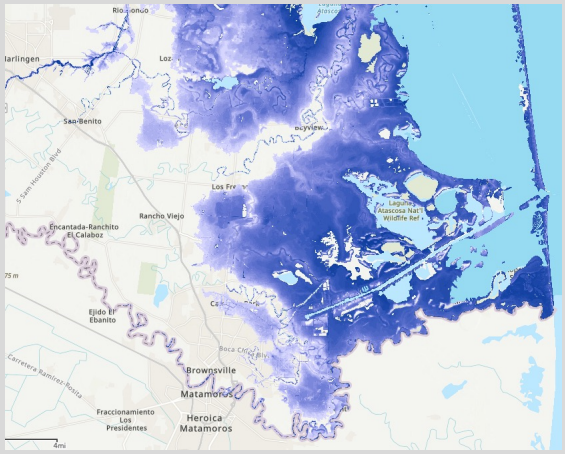
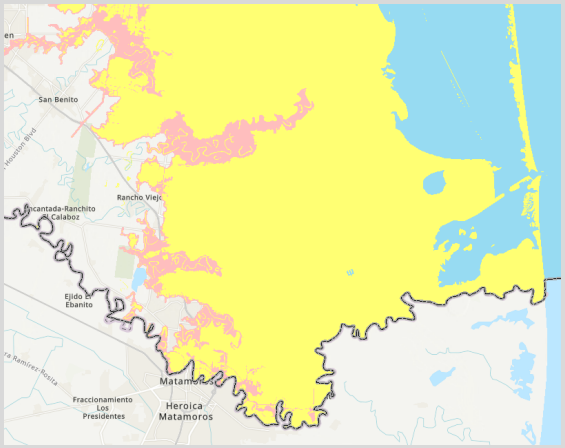
Physical Risk Model to Evacuation Zone

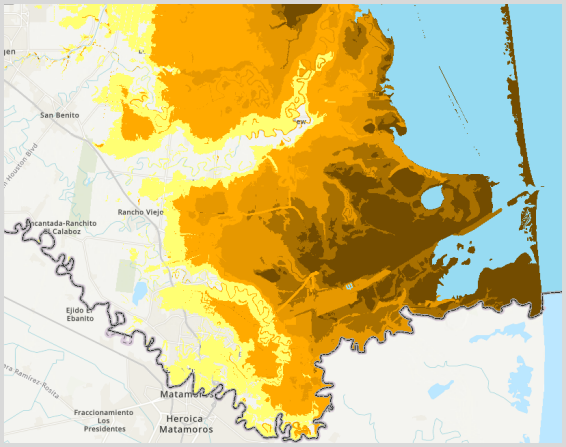
Precise Category 5 Surge



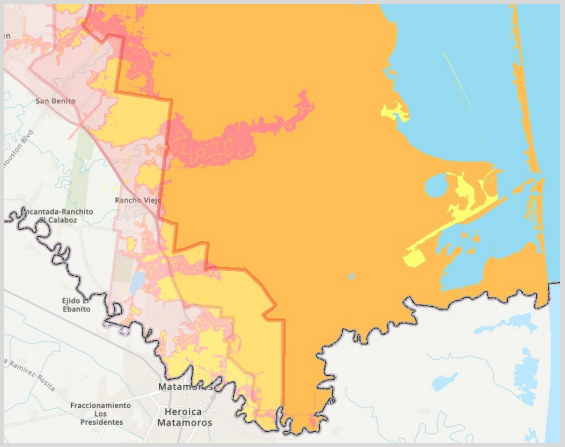
Aggregated Category 5 Surge

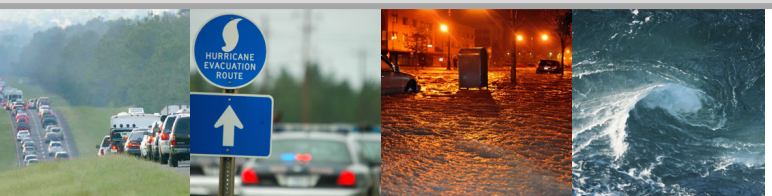


Smoothed Category 5 Surge



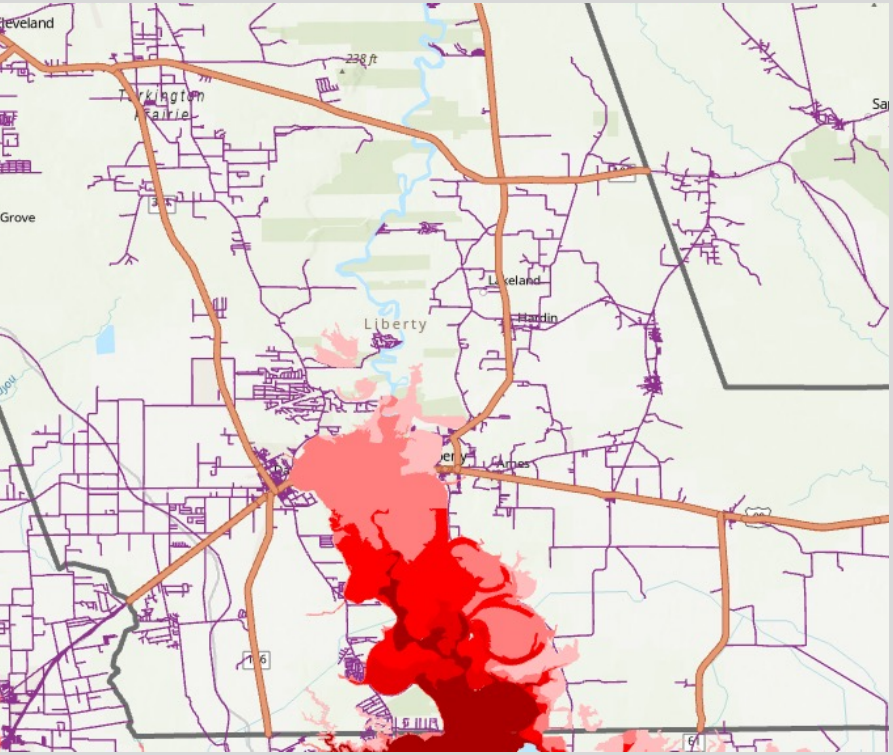
Smoothed Category 5 Surge with Evacuation Zones



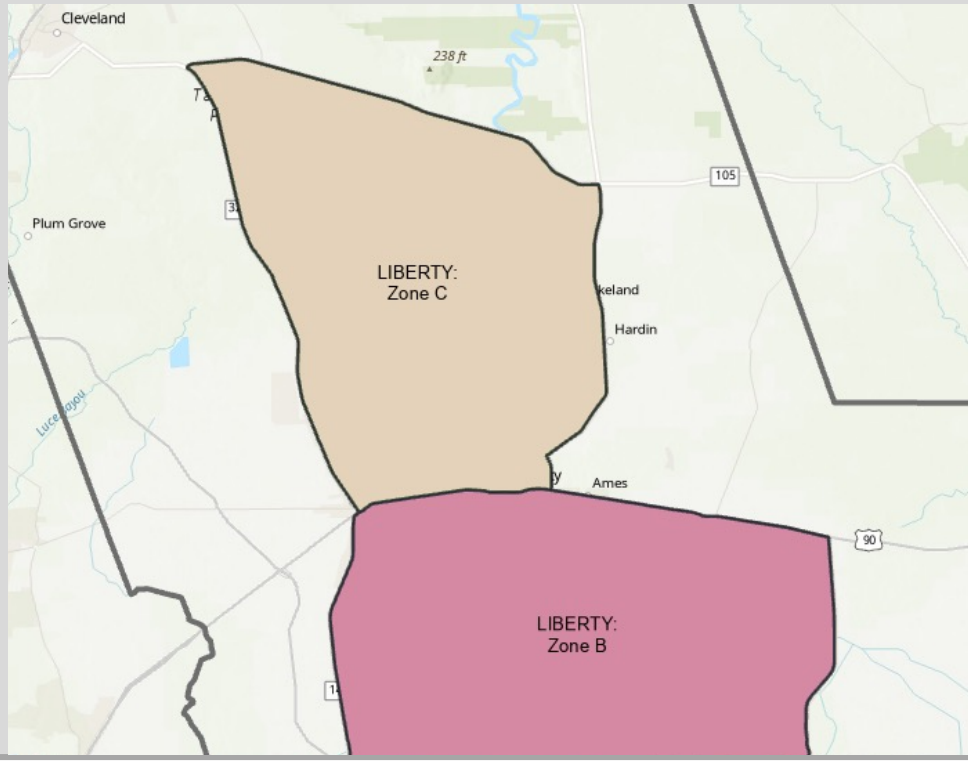


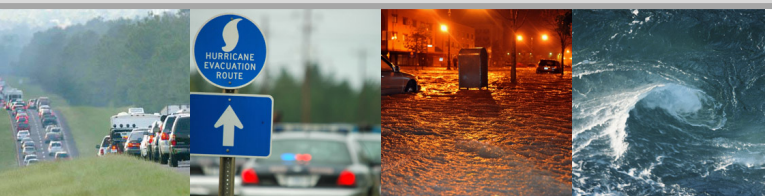
Physical Risk Assessment

Determine surge inundation limits



Identify well-known geography for first draft zone boundaries





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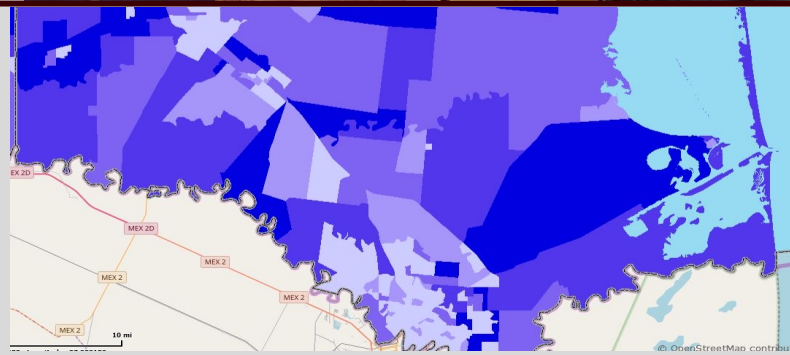
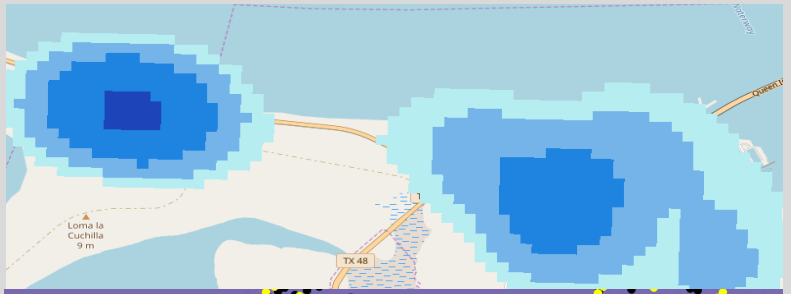
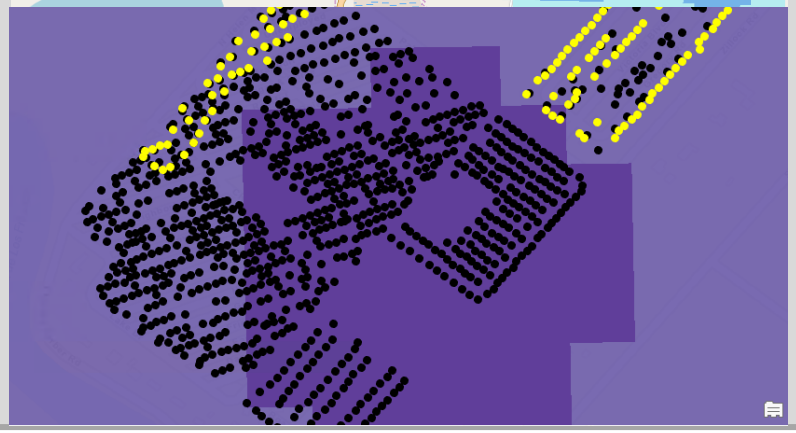
Social Risk Assessment

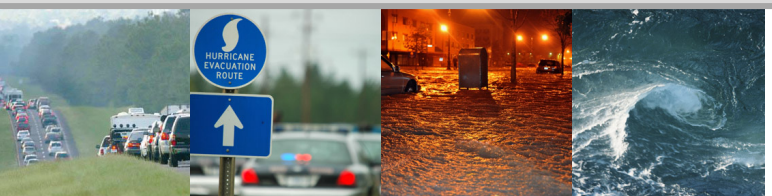
- Indices refined by fine granularity of LandScan 90M population estimates by dasymetric disaggregation
- Mobile home layer physical example of methods applied to all indices
- Kernel density heatmap

Source	Estimate
MOBILe	601 HU
MOBILEi	95.6%
LS Population	867 Pop
Digitized (blk)	978 HU
LS Structures	120 HU









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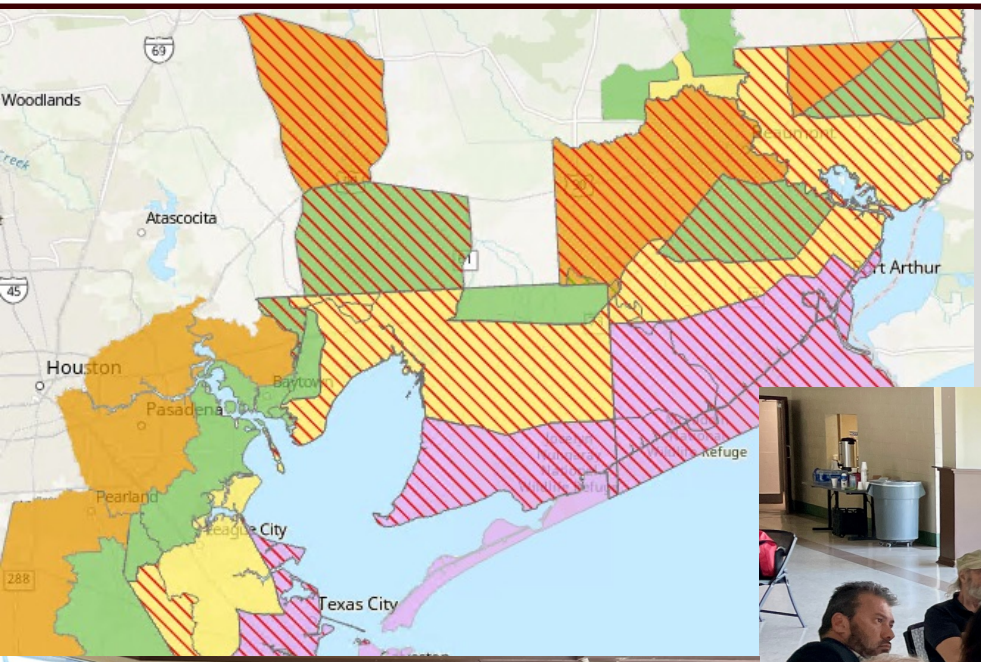

Present Draft Zones to Community Stakeholders and EOC Leaders for Comment and Markup

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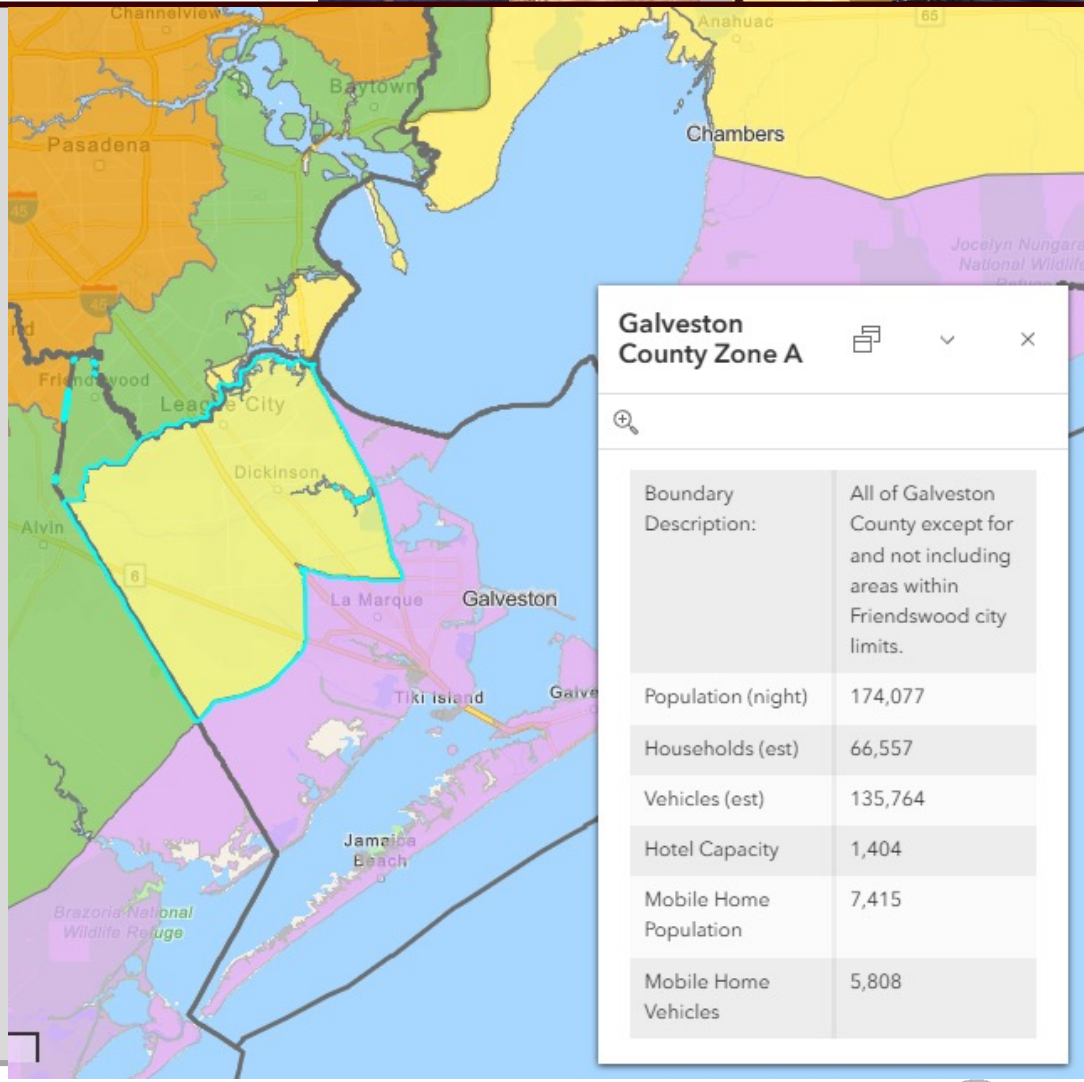
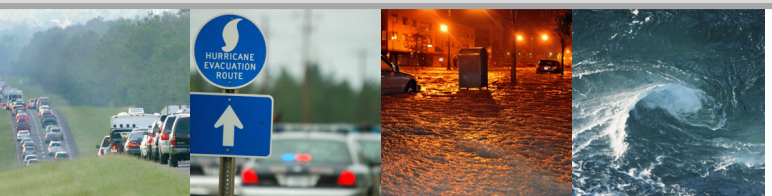
Population Characteristics by Evacuation Zone

- Sociodemographic impacts on evacuations
  - Population
  - Households
  - Vehicles
  - Seasonal population
- Boundary description
  - Identifiable geographic features
  - Zip codes
    - Not applicable in many cases
    - Harris County is exception because of population density





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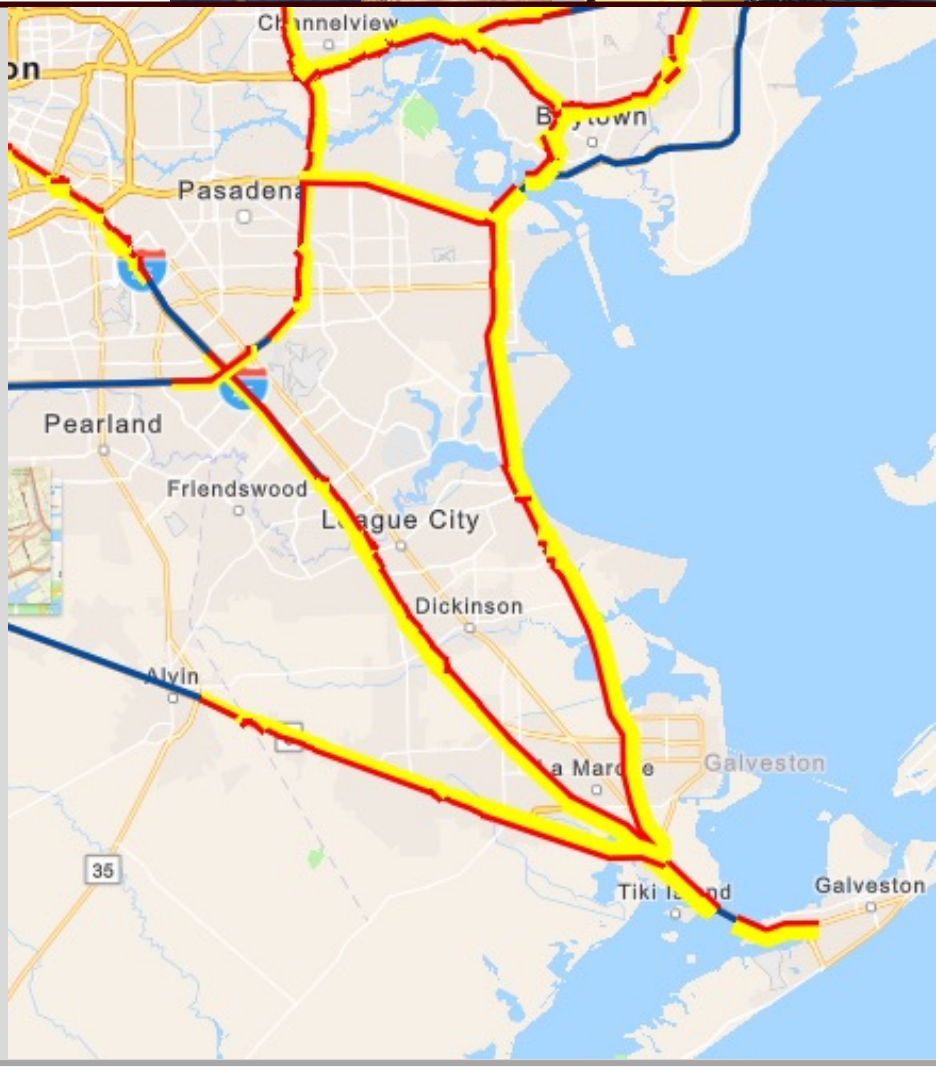
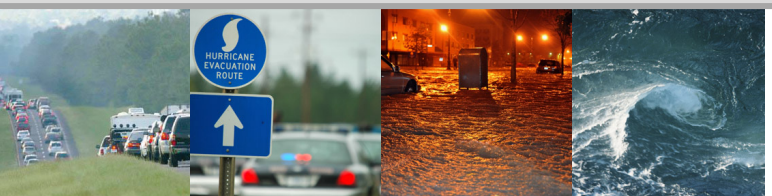
Evacuation Route Assessment

- Evacuation routes set by TXDOT
- Segments identified for special reconfiguration
  - Evaculanes
  - Contra-flow
  - Shadow evacuation





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Evacuation Timing Assessment

Real-time evacuation Planning Model (RtePM)

- Scenarios seeded by zone data
  - Population
  - Households
  - Vehicles
  - Seasonal Population
- Determines timing necessary to clear evacuation areas

County	Zone	Population [Night]	Households [est]	Vehicles [est]	Hotel Pop
Newton	**A**	**2,030**	**791**	**1,567**	
	Out of Zone	11,398	4,615	8,062	
	TOTAL	***13,428***	***5,406***	***9,629***	***0***
Jasper	Out of Zone	34,692	14,210	25,671	
	TOTAL	***34,692***	***14,210***	***25,671***	***0***
Hardin	A	3,636	1,198	2,956	2
	B	11,108	4,039	7,924	33
	Out of Zone	43,539	16,516	32,384	
	TOTAL	***58,283***	***21,753***	***43,264***	***35***
Orange	A	57,235	22,563	41,005	516
	B	15,606	5,683	12,512	387
	C	10,024	3,737	7,949	
	TOTAL	***82,865***	***31,983***	***61,466***	***903***
Jefferson	**Coastal**	**10,442**	**4,213**	**6,304**	**58**
	A	71,084	25,999	46,331	1,685
	B	47,347	14,159	26,497	1,397
	C	121,119	48,955	82,521	
	TOTAL	***249,992***	***93,326***	***161,653***	***3,140***
Upper Totals	***In Zones***	***349,631***	***131,337***	***235,566***	***4,078***
	Out of Zone	***89,629***	***35,341***	***66,117***	***0***
	TOTAL	***439,260***	***166,678***	***301,683***	***4,078***

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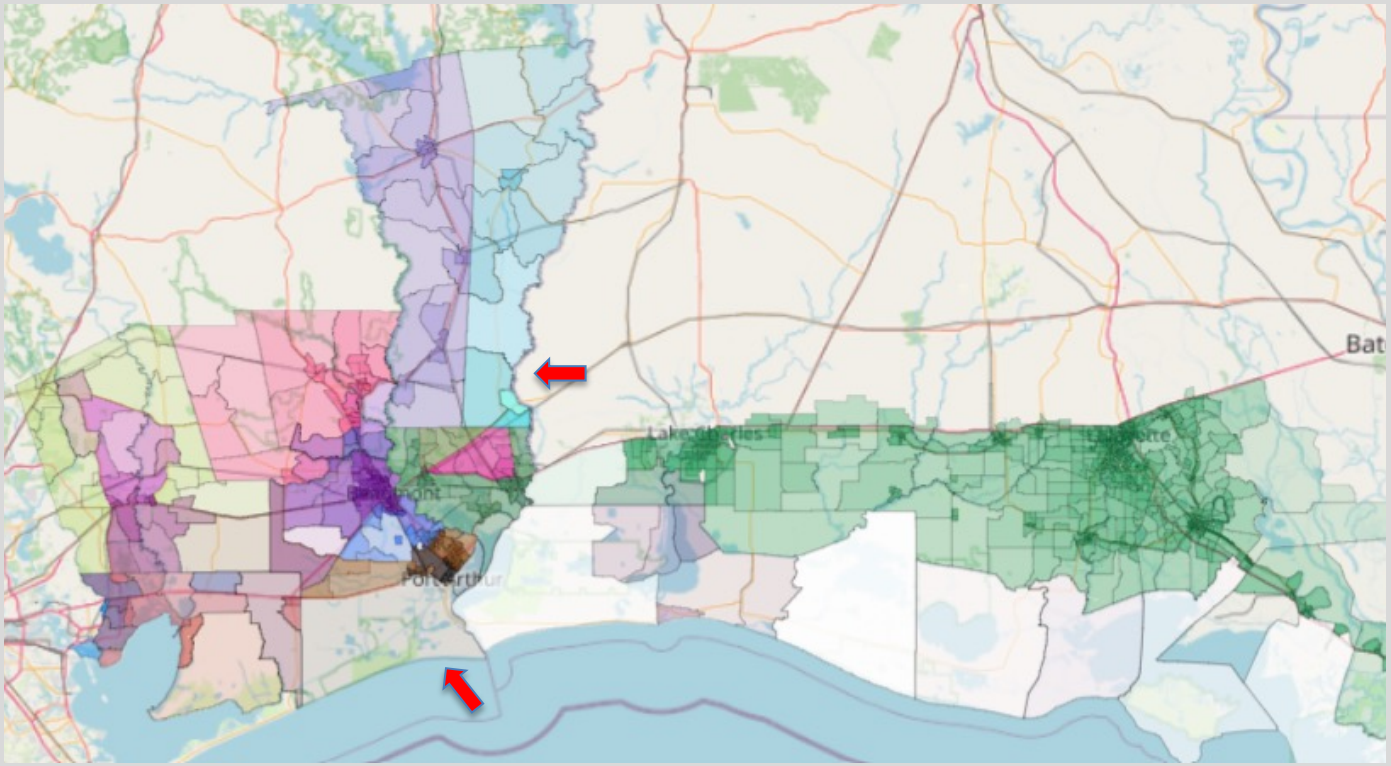
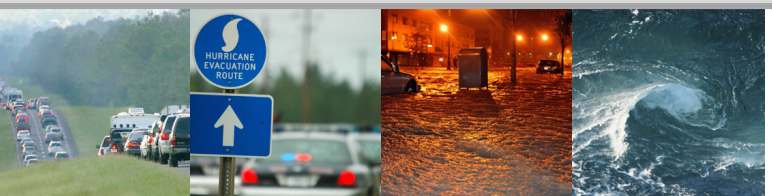
Scenario Building

Scenario Model Input Estimates by Census Block

- Population
- Households
- Vehicles
- Seasonal population
- Shadow evacuation





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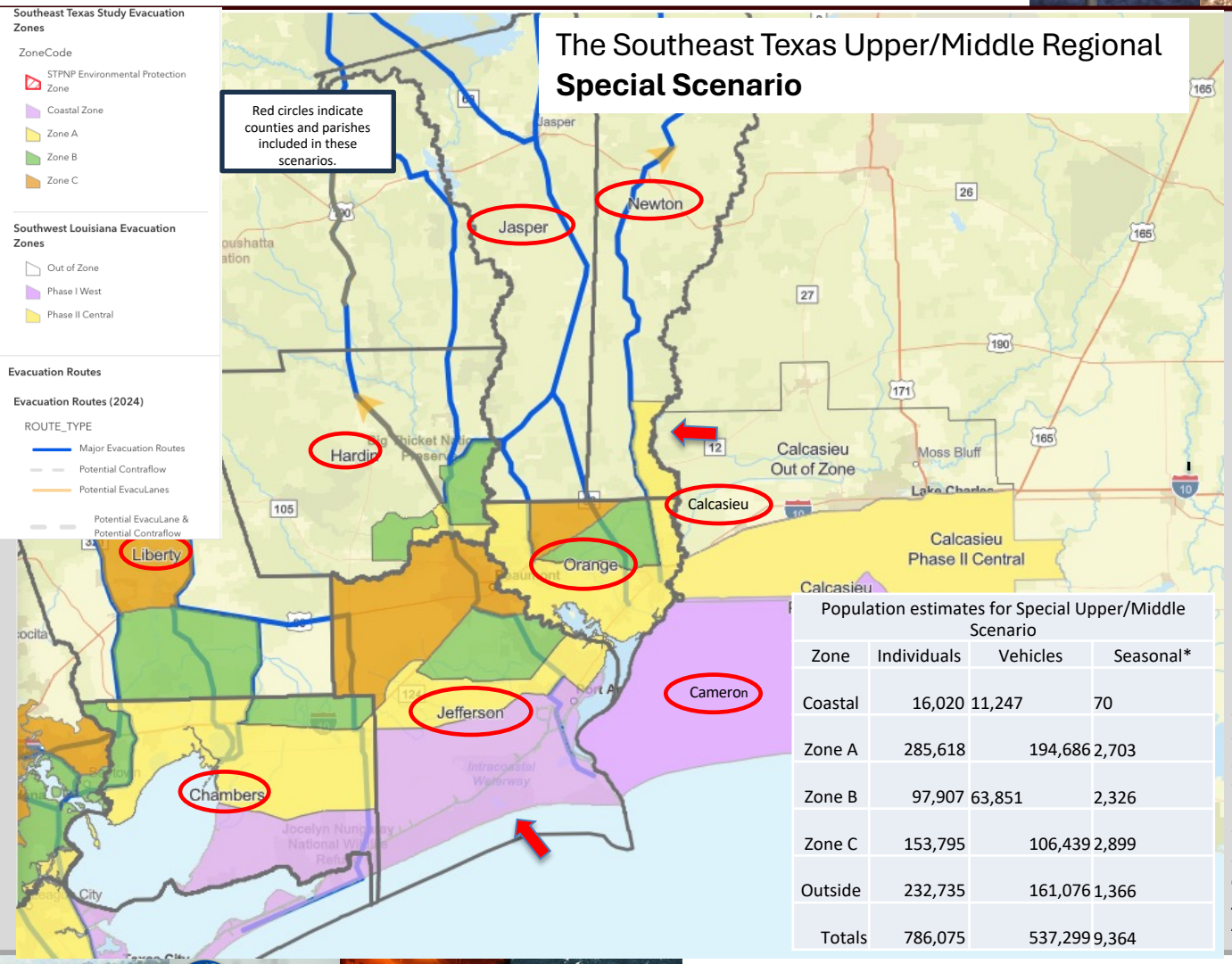
The Southeast Texas Upper/Middle Regional **Special Scenario**



Population estimates for Special Upper/Middle Scenario

Zone	Individuals	Vehicles	Seasonal*
Coastal	16,020	11,247	70
Zone A	285,618	194,686	2,703
Zone B	97,907	63,851	2,326
Zone C	153,795	106,439	2,899
Outside	232,735	161,076	1,366
Totals	786,075	537,299	9,364

1. *Significant* surge event

Significant Surge sett: Coastal, A, & B Zones (40%, 70%, & 100%);shadow evac. for Zone C at 30% & 20% for outside zones; & 8-hour and 2-days (70/30) response times. (6-runs)

25% for assumed participation rates for LA zones, moving west into Texas

Coastal Zone
Zone A
Zone B
Zone C
40, 70, & 100%
30 %
20% for out of zone areas

2. *Major* surge event

Major Surge Scenario: Coastal, A, B, & C Zones at 70% & 100% with 30% shadow evacuation rate outside zones; 8-hour and 2-days (70/30) response times. (4-runs)

25% of assumed participation rates LA zones, all moving west into Texas

Coastal Zone
Zone A
Zone B
Zone C
70% & 100%
30% for out of zone areas

1. Each scenario set will be run for two response times
   - - 8-hour Response time
   - - 2-day response time (70% day 1 & 30% day 2)
2. All Scenarios will assume
   - - Seasonal population included at full occupancy for each zone
   - - Background traffic and traffic incidents not adjusted
3. *Evacuation from Louisianna will be constrained to 25% of assumed participation rates moving west from the two zones and shadow.*
4. *Total of **10** runs*

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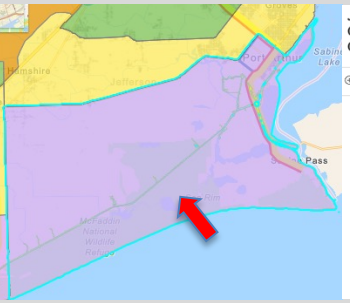
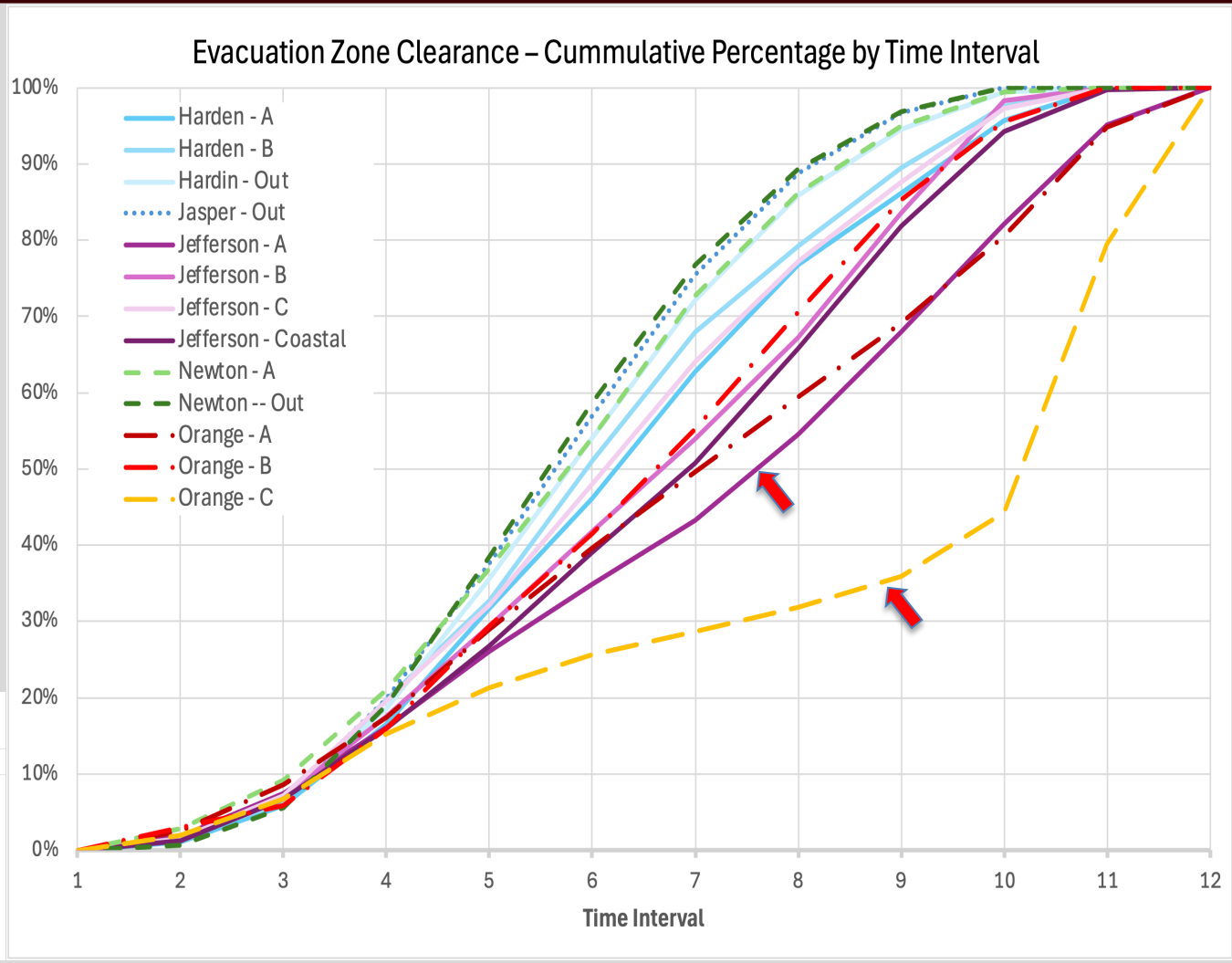
Evacuation Zone Clearance Scenarios

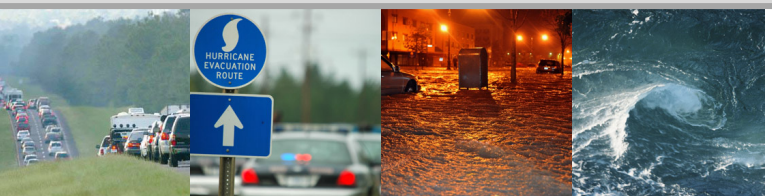
- Results of RtePM model
- Clearance time estimates
- Example (12 hr evac):
  - Jefferson Coastal Zone 50% clear at ~7.6 hrs



Jefferson County Coastal Zone

Boundary Description:	All areas south of SH 73 from western county boundary to US 69 (Memorial Blvd).
Population (night)	10,442
Households (est)	4,213
Vehicles (est)	6,304
Hotel Capacity	58





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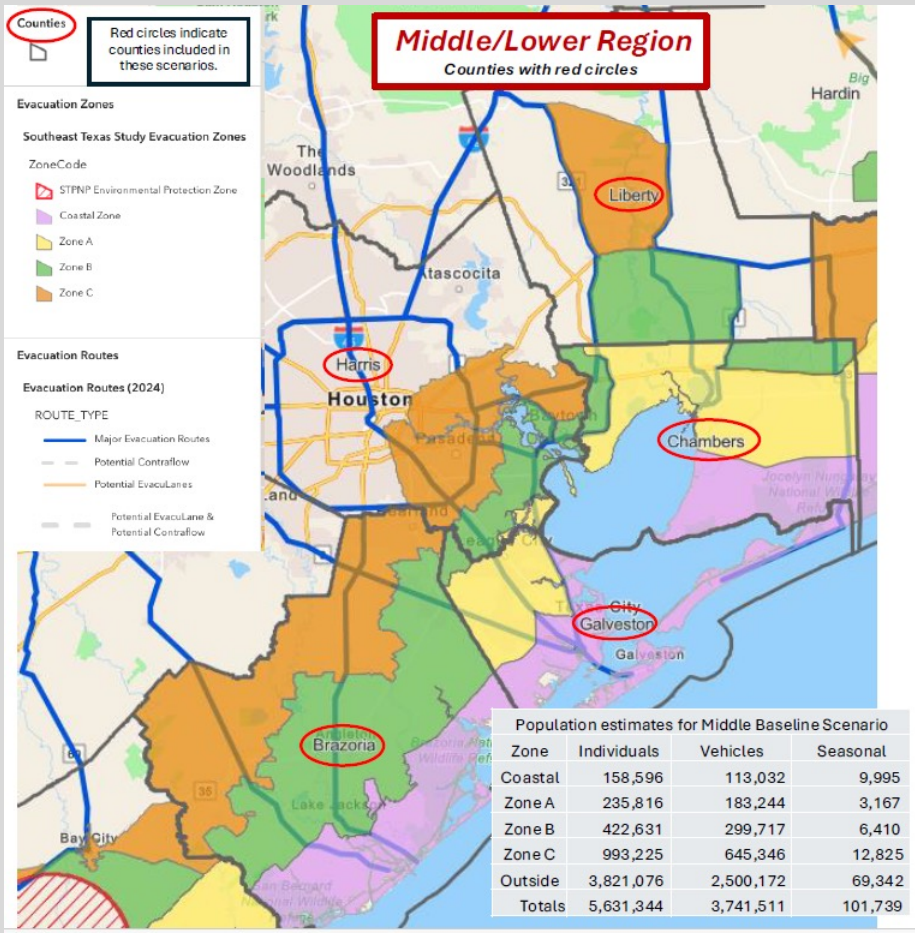


Population estimates for Middle Baseline Scenario

Zone	Individuals	Vehicles	Seasonal
Coastal	158,596	113,032	9,995
Zone A	235,816	183,244	3,167
Zone B	422,631	299,717	6,410
Zone C	993,225	645,346	12,825
Outside	3,821,076	2,500,172	69,342
Totals	5,631,344	3,741,511	101,739

Middle/Lower Region
Baseline Evacuation Scenarios

Scenario one (*limited* surge event)

Scenario one set: Coastal Zones, at 3 participation rates (40%, 70%, and 100%), with 10% shadow evacuation for Zone A, and run for 12-hour &2-day (70/30) response times. (6-runs)

Coastal Zone 40, 70, & 100%
Zone A 10%
Zone B
Zone C

Scenario two (*moderate* surge event)

Scenario two set: Coastal &A Zones, at 3 participation rates (40%, 70%, and 100%) with shadow evacuation for Zone A& B at 20% & 10% respectively and run for 12-hour and 2-days (70/30 response times. (6 runs)

Coastal Zone, Zone A 40, 70,& 100%
Zone B 20%
Zone C 10%

Third scenario (*significant* surge event)

Scenario three set: Coastal, A, & B Zones at 3 participation rates (40%, 70%, & 100%) with shadow evacuation for Zone C at 30% & 20% for out of zones and run for 12-hour and 2-days (70/30) response times. (6-runs)

Coastal Zone, Zone A, Zone B 40, 70, & 100%
Zone C 30%
20% for out of zone areas

Fourth scenario (*major* surge event)

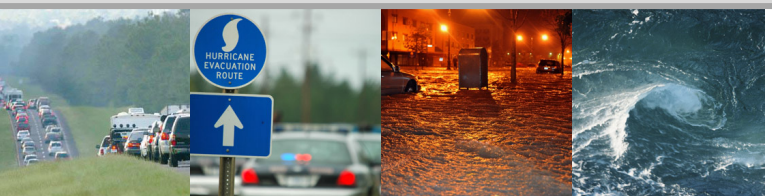
Scenario four set: Coastal, A, B, & C Zones, at 2 participation rates (70% & 100%) with 30% shadow evacuation rate for out of Zone areas and run for 12-hour and 2-days (70/30) response times. (4-runs)

Coastal Zone, Zone A, Zone B 70% & 100%
Zone C
30% for out of zone areas

1. Each scenario will be run for two response times (22 runs)
   - 12-hour response time
   - 2-day response time (70% day 1 & 30% day 2)
2. Scenarios 3 & 4 will be run with/without evaculanes for 2-day response (+5 runs)
3. Scenario 4 will be run with/without evaculanes & contra flow for 2-day resp. (+2 runs)

All Scenarios will assume
- Seasonal population at full occupancy for each zone
- Background traffic and traffic incidents not adjusted

4. A total of **29 runs** for the Upper/middle Region



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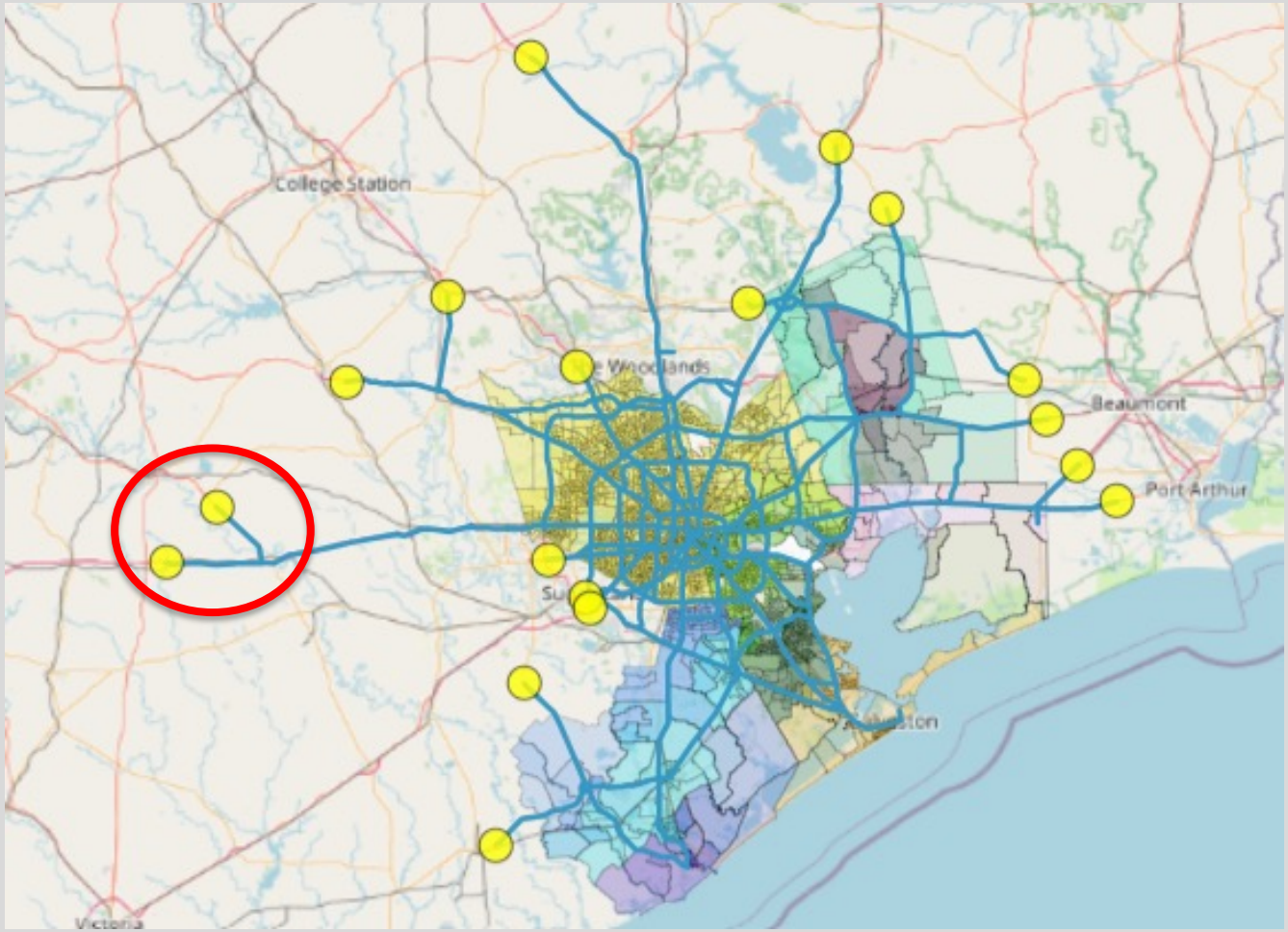
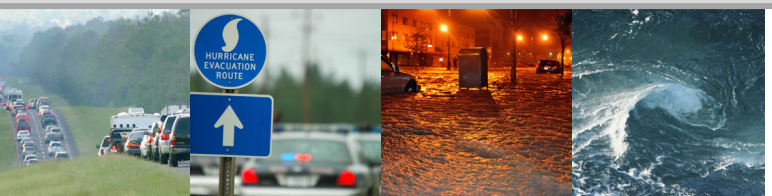
Contraflow Scenario

Evacuation Route Endpoints

- Set outside limits of surge impact
- Contraflow endpoints set at end of lane modifications



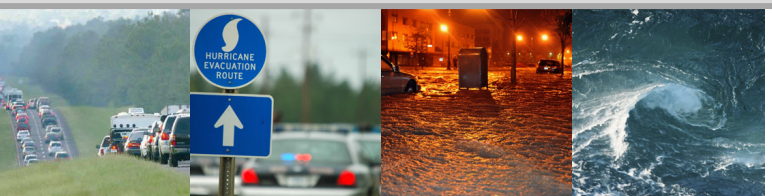


Summary

Regularly updating hurricane evacuation plans is essential due to the dynamic nature of risk factors and response needs. Evacuation studies face significant challenges, including constantly changing data and the need for analysis of:

- Physical and social risk,
- Human factors,
- Infrastructure,
- Limited resources,
- Unpredictable nature of hurricanes and public response.

Addressing these challenges requires ongoing collaboration, sustained investment, adaptation to changing conditions, and robust community engagement. Only through regular review and improvement can evacuation plans remain effective, ensuring the safety and resilience of communities in the face of hurricane threats.



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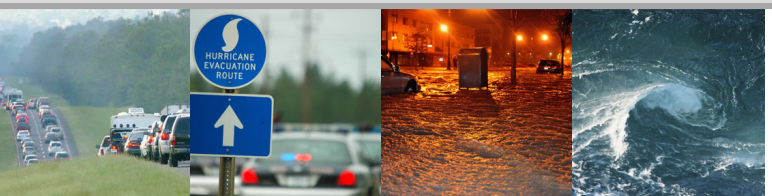
Thank You



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