

FLOOD DAMAGE ESTIMATES AND THE GALVESTON BAY COASTAL ATLAS

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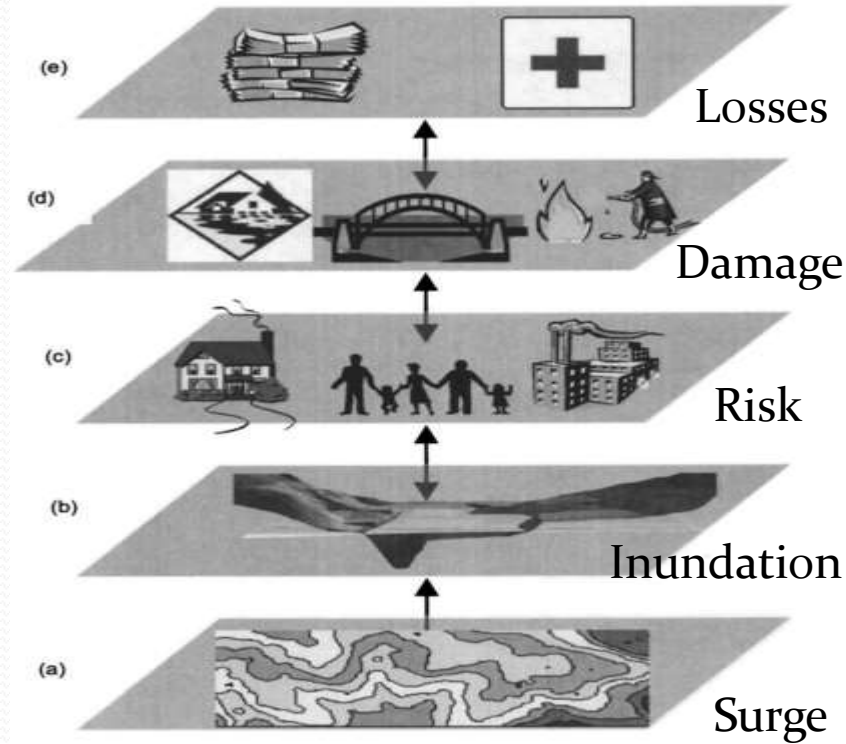
Storm Parameters

ID	Landfall	CP	Heading	Forward Speed	RMAX
FEMA 122	Galveston	900 mb	-35	11 kts	17.7 n mi
FEMA 155	Galveston	930 mb	-35	17 kts	17.7 n mi
FEMA 121	Galveston	960 mb	-35	11 kts	17.7 n mi
FEMA 561	Galveston	975 mb	-35	11 kts	17.7 n mi
FEMA 27 (100-year)	Near San Luis Pass	900 mb	-41	11 kts	21.8 n mi
FEMA 36 (500-year)	West Boundary	900 mb	-37	11 kts	21.8 n mi



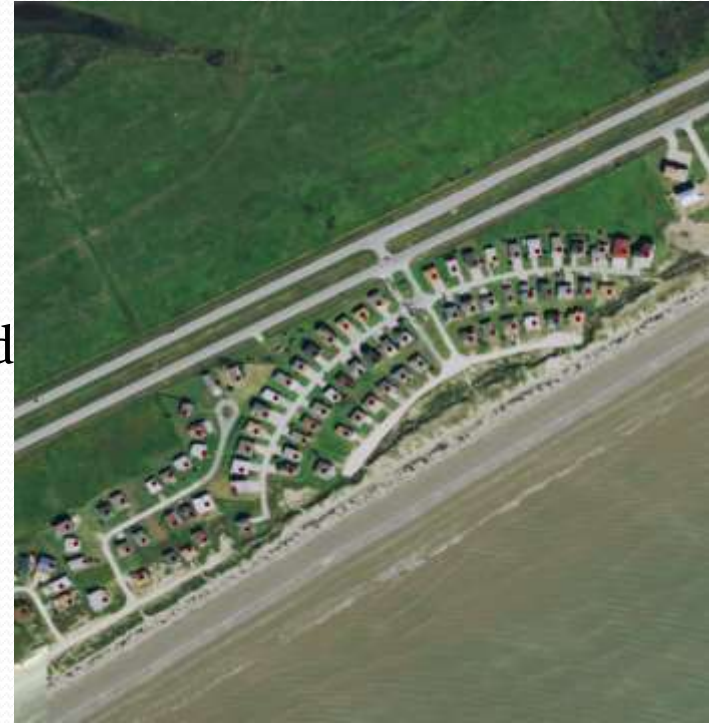
HAZUS Overview

- HAZUS is a FEMA designed tool/software for flood loss estimation
- Level 1 analysis: city/planners 'general' flood estimates
- Level 2-3 analysis: Improved data into model for projects and research



HAZUS Building Data

- Replaced default building distribution data with 2014 parcel data for all land uses
- Matched land uses with Texas State Code
- Parcel data more reliable for residential uses
- Building points for parcel centroids aggregated to census blocks



First floor Elevations

- BFE and Improvement year
- Pre or post- FIRM
- Average slab elevation based on foundation type
- Assume slab if building is outside SFHA

* Need to study average foundation heights
for our study region

Hazus Default Elevation based on foundation type

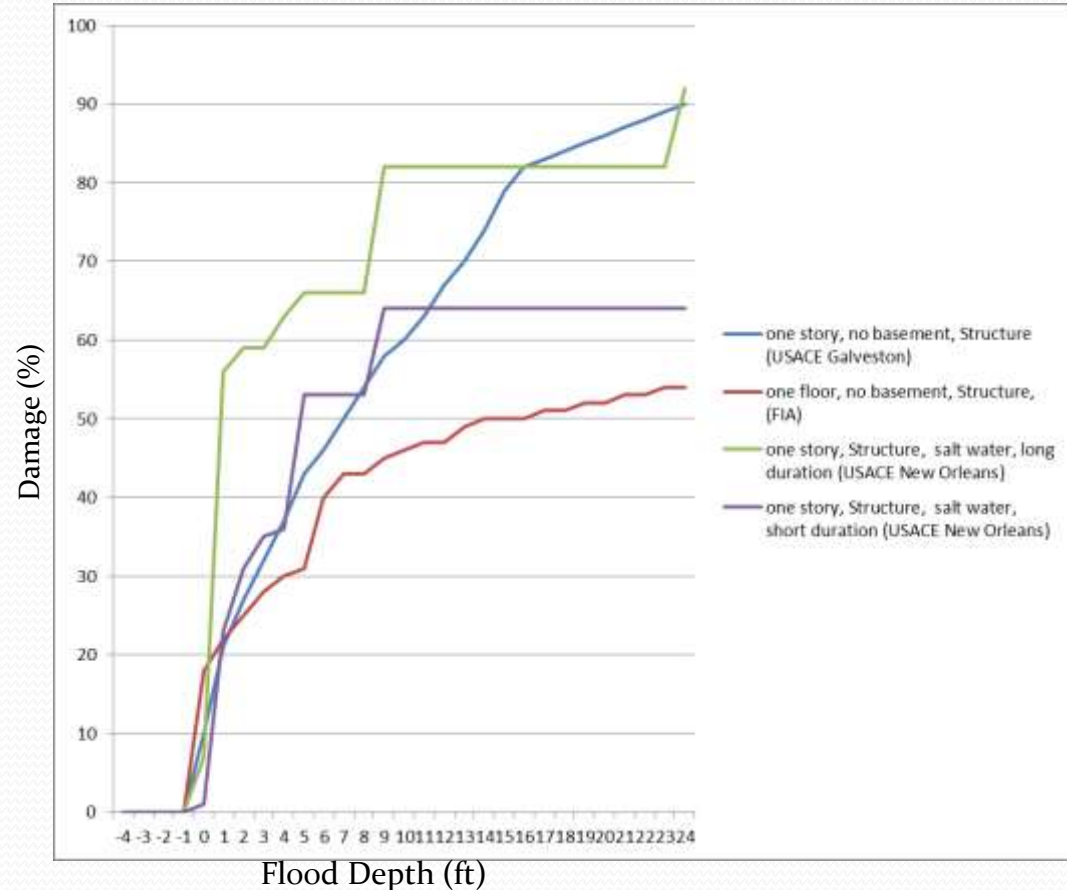
ID	Foundation Type	Pre-FIRM	Post-FIRM	
			A zone	V zone
1	Pile (or column)	7 ft	8 ft	8 ft
2	Pier (or post and beam)	5 ft	6 ft	8 ft
3	Solid Wall	7 ft	8 ft	8 ft
4	Basement (or Garden Level)	4ft	4 ft ¹	4 ft ¹
5	Crawlspace	3 ft	4 ft	4 ft ¹
6	Fill	2 ft	2 ft	2 ft ¹
7	Slab	1 ft	1 ft ¹	1 ft ¹

Damage Curves

- Several Damage functions in Hazus Library
- Land Use
- Number of Stories
- Foundation Type

* Need to agree on appropriate damage curve for study area

RES 1, Structure, A-Zone, 1-Story, Slab damage curves



Loss Estimates

Direct Loss (\$Millions) for General Building Stock (Existing)

Existing	561	121	155	122	27	36
Residential	1,011	1,801	3,883	6,514	10,399	13,684
Commercial	349	649	1,315	2,230	3,459	4,858
Industrial	1,461	2,169	3,576	5,535	8,640	11,624
Others	83	158	311	503	705	955
Total	2,904	4,777	9,085	14,782	23,203	31,121

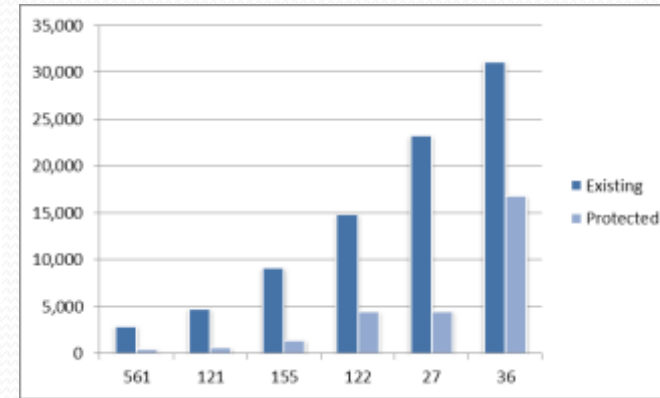
Direct Loss (\$Millions) for General Building Stock (Protected)

Protected	561	121	155	122	27	36
Residential	137	179	697	1,964	2,542	7,047
Commercial	51	61	154	560	463	2,553
Industrial	226	342	537	1,805	1,414	6,619
Others	10	9	24	137	76	519
Total	424	591	1,412	4,466	4,495	16,738

Direct Loss Avoided (\$Millions) for General Building Stock

Loss Avoided	561	121	155	122	27	36
Residential	874.00	1,621.68	3,186.27	4,550.15	7,857.03	6,637.23
Commercial	298.4	588.12	1160.64	1669.89	2996.39	2305.46
Industrial	1,235.21	1,827.19	3,038.70	3,729.44	7,226.44	5,004.89
Others	72.98	148.41	286.32	366.2	628.85	435.96
Total	2,480	4,186	7,673	10,316	18,708	14,383

Total Loss per Scenario (\$ Million)



Debris

- Simplified EPA method
- Depth based on substantial damage (50%)
- Only Structural no contents
- Based on foundation types and sq ft

Occupancy	Depth of Flooding	Debris Weight (Tons/1000 sq. ft.)			
		Finishes	Structure	Foundations	
				Footing	Slab on Grade
RES1 (without basement)	0' -4'	4.1			
	4' to 8'	6.8			
	8'+	6.8	6.5	12.0	25.0
RES1 (with basement)	-8' to -4'	1.9			
	-4' to 0'	4.7			
	0' to 6'	8.8			
	6'+	10.2	32.0	12.0	25.0
RES2	0' to 1'	4.1			
	1'+	6.5	10.0	12.0	25.0
RES3 (small 1 to 4 units)	0' to 4'	4.1			
	4' to 8'	6.8			
	8'+	10.9	6.5	12.0	25.0

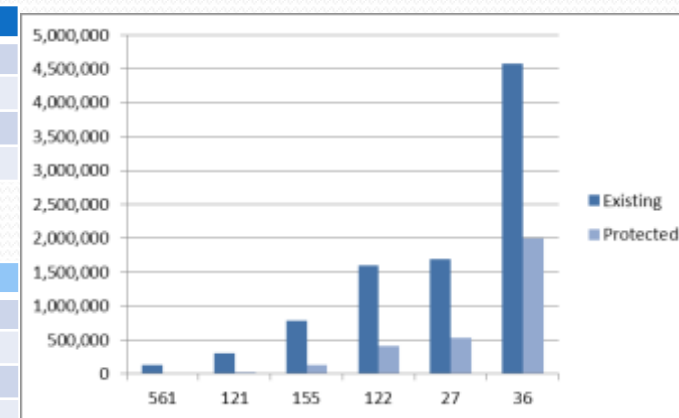
Debris (Tons)

Existing	561	121	155	122	27	36
Finishes	96,527	195,474	437,339	756,414	1,100,528	1,492,821
Structures	17,208	65,792	200,813	484,990	926,388	1,789,385
Foundations	16,791	46,962	150,405	354,812	669,802	1,296,818
Total	130,525	308,228	788,557	1,596,216	1,696,718	4,579,023

Debris (Tons)

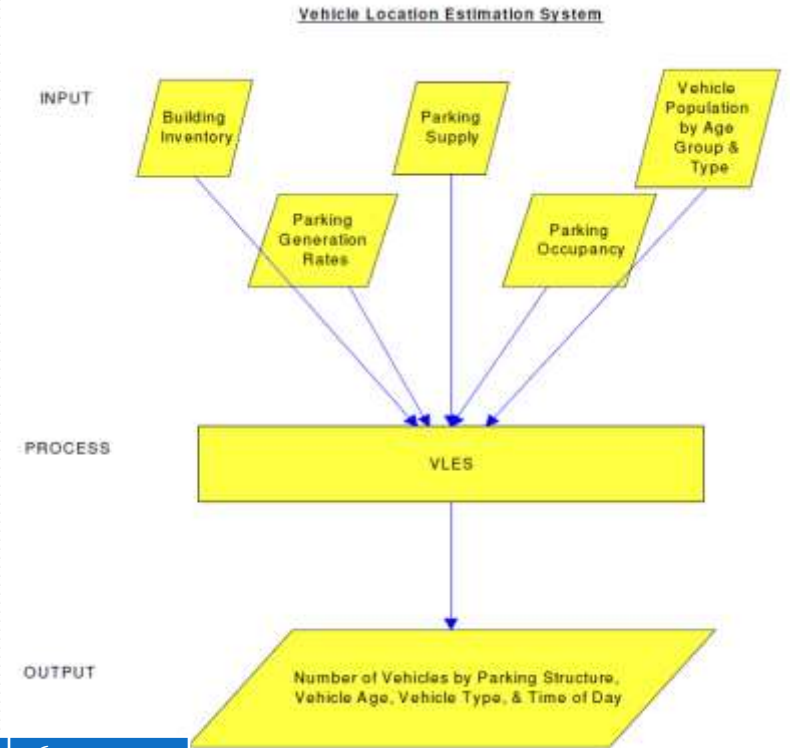
Protected	561	121	155	122	27	36
Finishes	11,477	16,527	71,910	214,809	276,551	944,586
Structures	1,125	3,259	36,154	110,008	142,281	614,680
Foundations	1,360	2,975	27,144	84,660	106,256	440,074
Total	13,963	22,761	135,209	409,477	525,089	1,999,340

Debris generated (Tons)



Vehicles

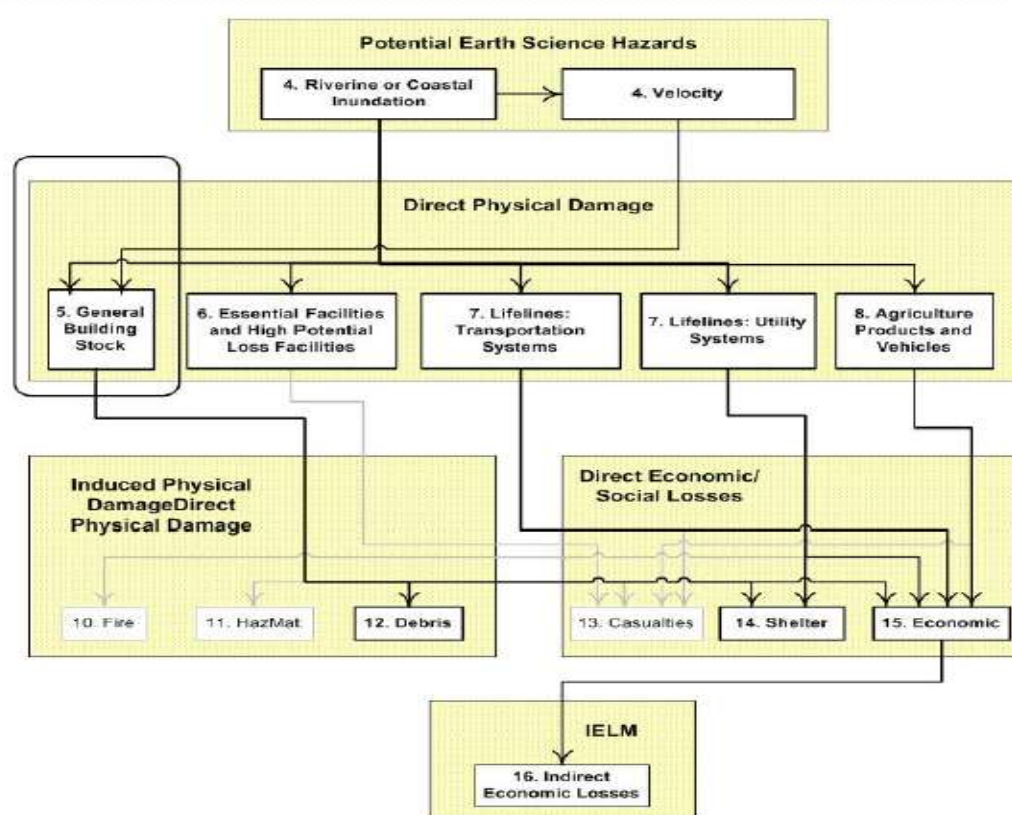
- Daytime estimates
- Hazus default distribution of vehicles based on American Planning Association Occupancy parking rates
- Institute of Transportation Engineers parking general study
- Does not incorporate Evacuation etc.



Vehicle Loss (\$Millions)

Scenario	561	121	155	122	27	36
Existing	319.36	582.25	964.57	1,396.37	1,944.68	2,460.39
Protected	42.91	52.12	143.41	507.08	389.03	1,411.48
Avoided	276.45	530.13	821.16	889.29	1555.65	1048.91

Future Extensions





Galveston Bay Coastal Atlas