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Substantial Damage Estimation

Using Hazus-MH as a Screening Tool After Hurricane Harvey

Stephen Veith

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Stephen Veith, GIS Analyst

- 4 Years Experience with Hazus
  - County and City Hazard Mitigation Plans
  - Hazus H&H Studies
  - Using Climate Change Models and Hazus to Estimate Future Risk
- Graduated 2015, Master of Urban Planning from University of Washington

Overview of Presentation

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- Background on Hurricane Harvey in Fort Bend & Montgomery Counties in Texas
- Project Scope and Use of Hazus-MH
- Substantial Damage Estimation & Field Data Collection
- Hazus Inputs & Methodology
- Results
- Limitations and Improvements for Future Use
- Questions

Background on Hurricane Harvey

- Not a hurricane by the time it reached Houston area
- Record rainfall over 9 days overwhelmed reservoirs and Brazos / San Jacinto tributaries

Background on Hurricane Harvey

- Normal Brazos river height fluctuates between 10 and 20 feet
- River crests on the Brazos at Richland, TX ~55 feet
- Normal flow between 3,000 – 12,000 cubic feet per second
- Flood events reached over 110,000 cubic feet per second

Background on Hurricane Harvey

- Normal San Jacinto (West Fork) river height fluctuates around 15 feet
- River crests on the West Fork San Jacinto river at Conroe, TX ~47 feet
- Normal flow from 100 to 1,000 cubic feet per second
- Flood events reached over 80,000 cubic feet per second

Substantial Damage Estimation

- “Substantial damage” is a when the total cost to repair a structure is 50 percent or more of the structure’s market value (before the damage occurred)
- This is used for communities that participate in the National Flood Insurance Program and is a condition of purchasing flood insurance through the NFIP
- The process of inspecting properties is up to local jurisdictions
- Scope of work was to use Hazus as a screening tool to help inspectors streamline their workload and to identify priority neighborhoods and structures for inspection

What is Hazus?

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- Hazus is a risk assessment tool used to calculate damages to the structure and contents of a building.
- Can also be used for business interruption, some social impacts
- Two main components are the building inventory and hazard inputs (flood depth grid)

HAZUS®

EARTHQUAKE · WIND · FLOOD · TSUNAMI

FEMA

How was Hazus used?

- Re-create Hurricane Harvey flood scenario and compare against building inventory
- End goal is to estimate number and location of buildings that are substantially damaged (>50% to structure)

Hazus Inputs & Methodology

- Assessor Data from Fort Bend & Montgomery Counties
  - Parcel Information
  - Address
  - Occupancy Type
  - Year Built
  - Square Footage
  - # of Stories
  - Foundation Type
  - Structure Type

	LAND_SIZE_	LAND_SIZE1	LAND_SPTB_	LAND_VAL_1	LAND_TYPE	TOTAL_BU_1	BUILDING_S	BUILDING_C
	799979.4	18.365	XV	5000.272257	CP	0	XV	
	229996.8	5.28	F1	104556.818182	CS	138404	F1	AC
	220735.944	5.0674	F1	42564.234124	CP	42100	F1	BM
	696960	16	XV	60983.75	CM	64421	XV	AC
	732461.4	16.815	E1	11879.869164	RA	929	D4	RF1-
	303831	6.975	F1	37569.892473	CP	10584	F1	BM2
	115608.24	2.654	F1	421190.655614	CP	97724	F1	AC
	220735.944	5.0674	F1	42564.234124	CP	42100	F1	BM
	599755.86	13.7685	XV	241514.326179	CP	168392	XV	AC
	2559237.12	58.752	E2	11654.071351	PI	49257	D1	GAHB1
	152460	3.5	F1	72420	CP	86103	F1	SI
	220735.944	5.0674	F1	42564.234124	CP	42100	F1	BM
	348480	8	F1	185435	CP	115400	F1	AC
	239580	5.5	F1	449856.363636	CP	244182	F1	CO
	76665.6	1.76	F1	258744.318182	CP	48492	F1	AC
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	204949.8	4.705	F1	80150.903294	CM	54506	F1	C
	86536.296	1.9866	F1	213500.453035	CP	64325	F1	AC
	220735.944	5.0674	F1	42564.234124	CP	42100	F1	BM
	182603.52	4.192	F1	346622.137405	CP	155176	F1	C
	3795	0.0871	A1	298507.462687	RI	2176	A1	RA2
	230258.16	5.286	XV	89248.959516	CP	90435	XV	C
	63797.976	1.4646	F1	252942.783012	CP	42584	F1	AC
	43560	1	E1	62500	RA	8411	E1	SI
	130680	3	A1	15053.333333	RA	12732	A1	RF2+
	71882.712	1.6502	F1	290207.247606	CP	54259	F1	AC

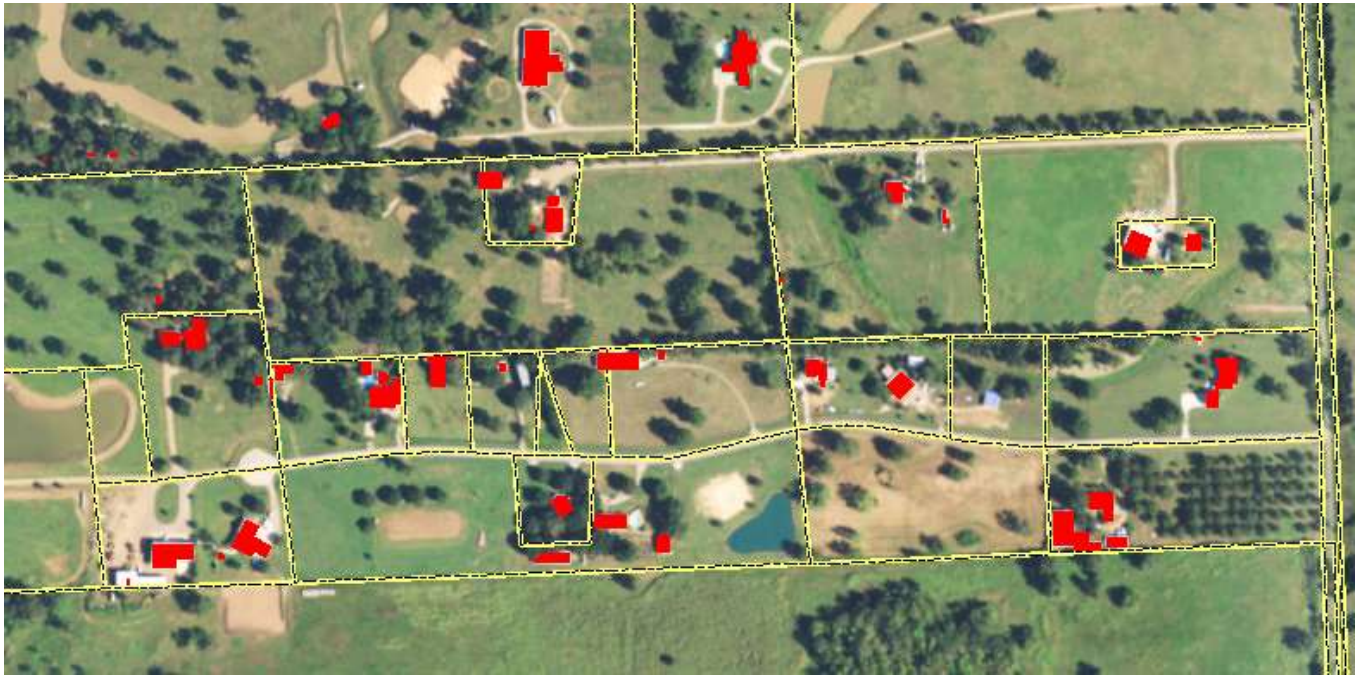
- No first floor height information, used Hazus defaults based on year of construction
- Better data, better model!

Hazus Inputs & Methodology

- LiDAR Building Footprints
  - Allow much more accurate spatial location building points within Hazus model

Hazus Inputs & Methodology

- Unfortunately, LiDAR building footprints did not have any identifying characteristics to tie directly to assessor improvement segments.



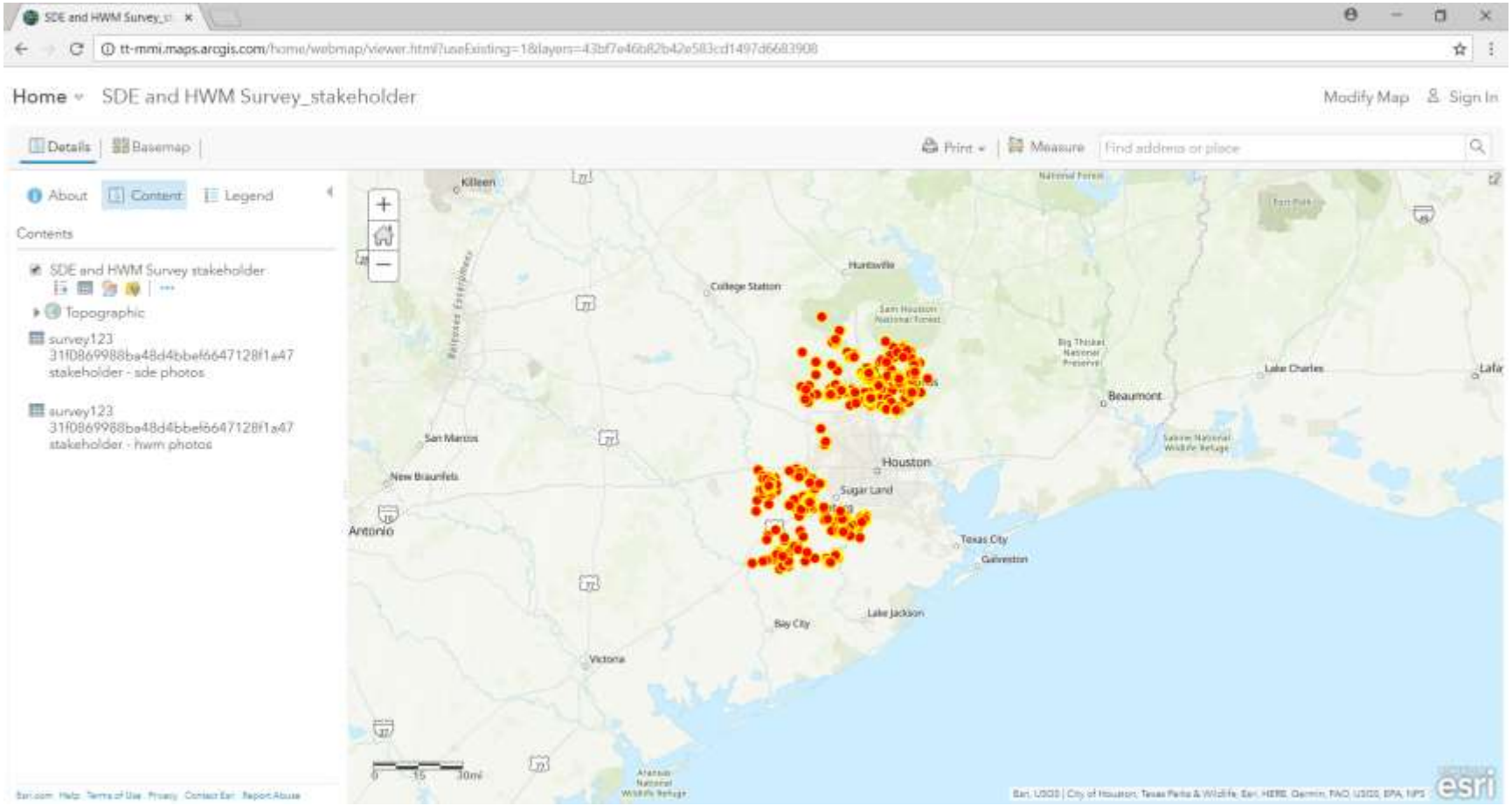
Hazus Inputs & Methodology

- Solution: Use “Main Area” improvement to tie to all building points within that parcel
- If no “Main Area” improvement, then attach highest assessed value to the parcel building points
- Focuses on generating substantially damaged estimates for the main structure/residence of a parcel
- Also add field identifying if a building is the largest structure on that parcel

Field Collection Tool

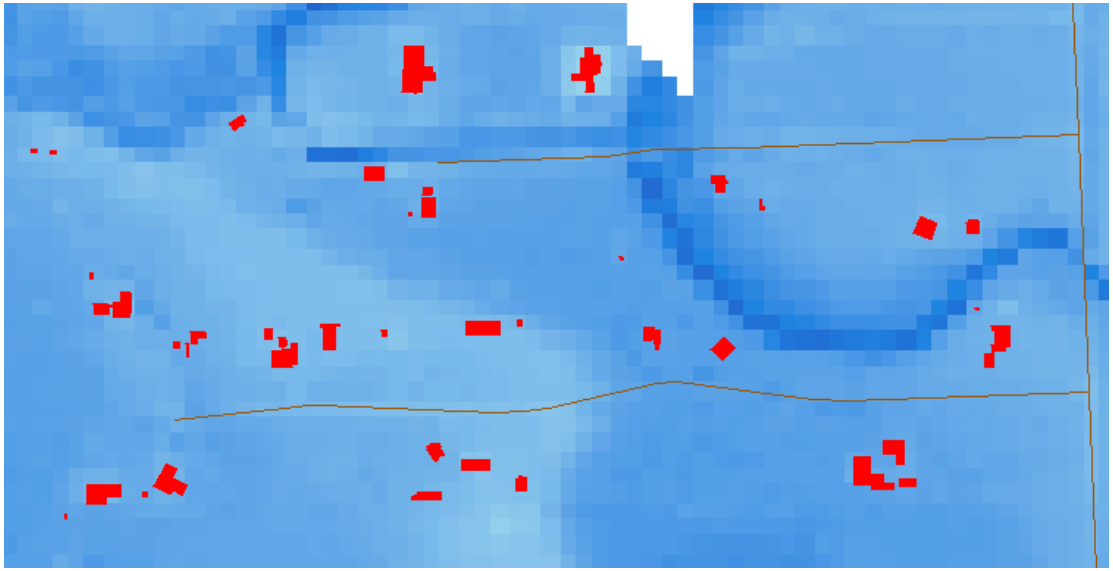
- Used ArcGIS Online to develop an inspection and high water mark collection database
- Easily accessible by the teams on the ground and clients
- Used Survey 123 to record information

Field Collection Tool



Hazus Inputs & Methodology

- Depth Grid calibrated using observed USGS high water mark data from Harvey event and through field data collection
- Fort Bend Drainage District created using HEC-RAS model of Brazos River & surrounding tributaries calibrated to those high water marks
- Depth Grid 5m
- Montgomery County depth grid generated from DFIRM data, calibrated using

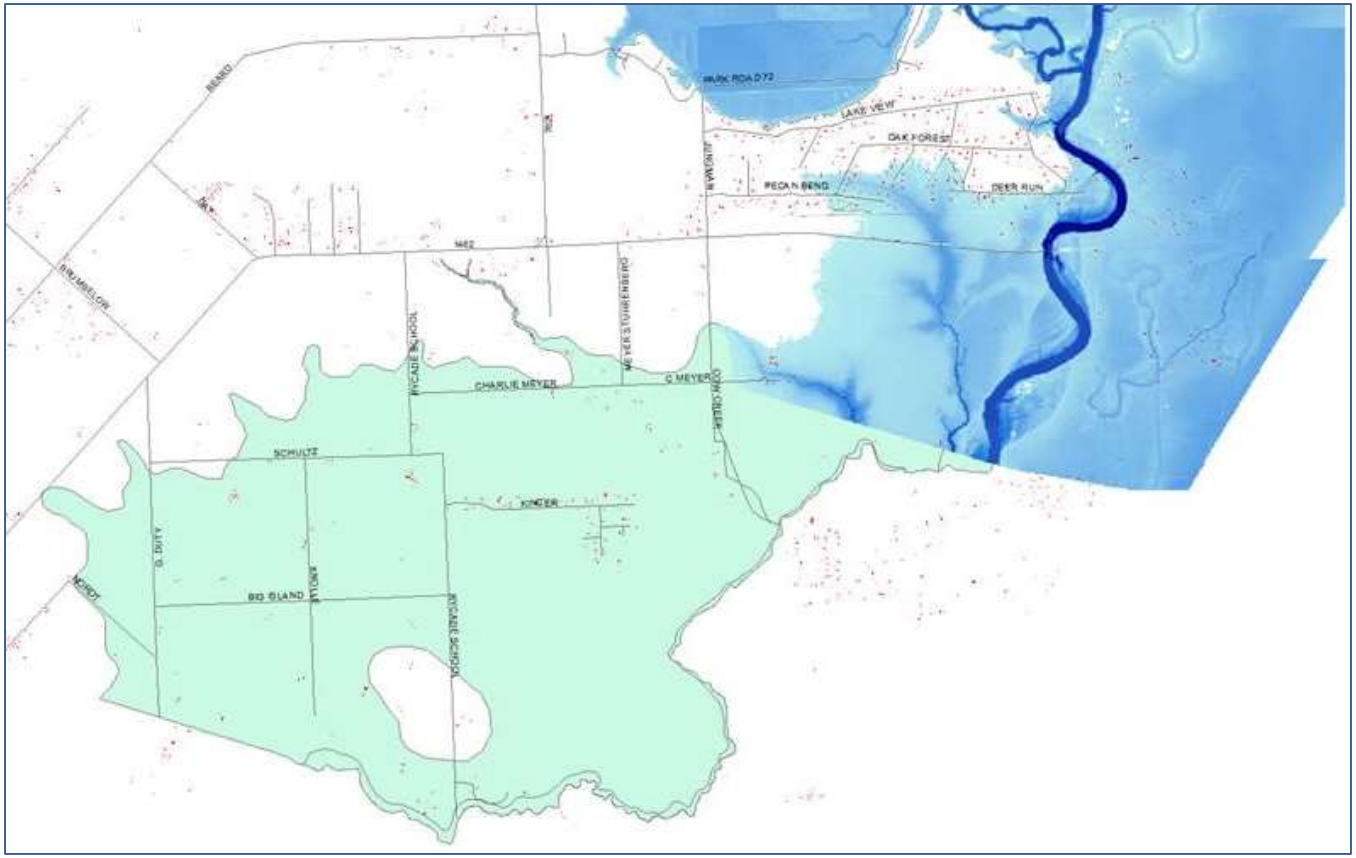


Hazus Inputs & Methodology

- HEC-RAS outputs occasionally produce incomplete grids based on original river channel model
- Enhanced the Depth Grid from HEC-RAS by using:
  - FEMA Floodplain Boundaries
  - Water Surface Elevations from HEC-RAS depth grid
  - FEMA Cross Sections and Base Flood Elevation Lines
  - 1 Meter LiDAR Digital Elevation Model of Fort Bend & Montgomery Counties
  - Observed Hurricane Harvey High Water Mark Data
- End result shows a more complete depth grid for both counties

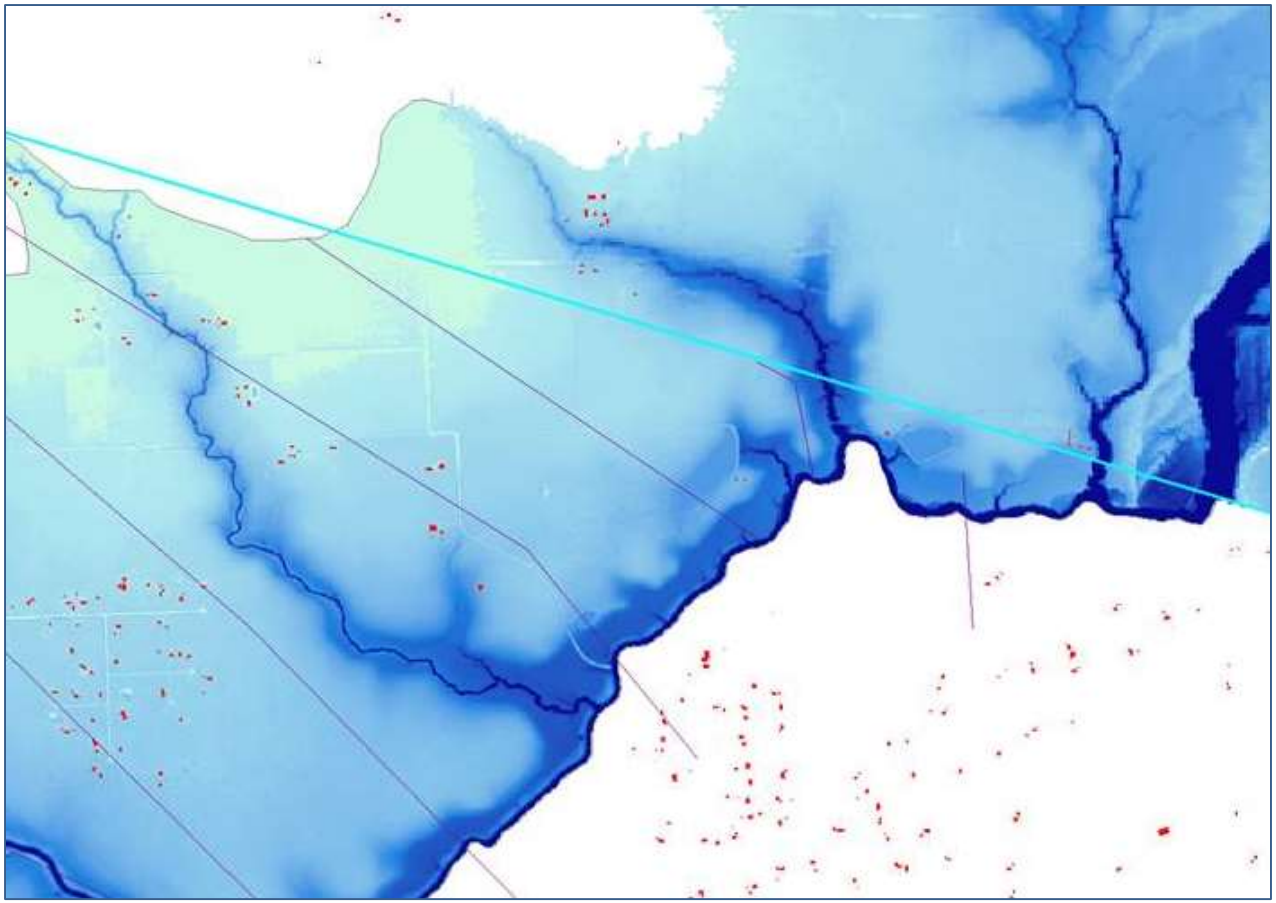
Hazus Inputs & Methodology

- Original Depth Grid from HEC-RAS:

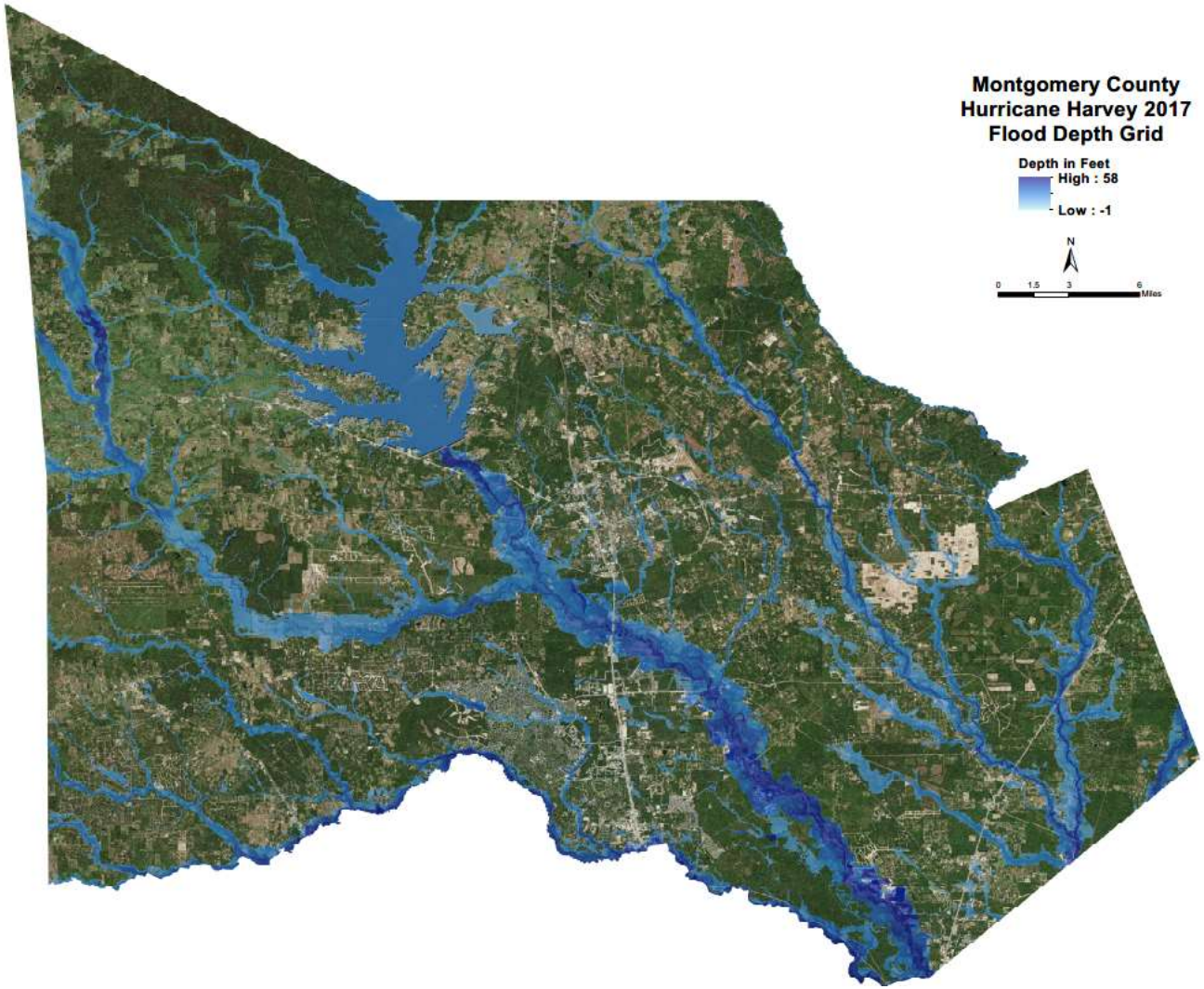


Hazus Inputs & Methodology

- Enhanced Depth Grid from HEC-RAS:



Hazus Inputs & Methodology



Hazus Inputs & Methodology

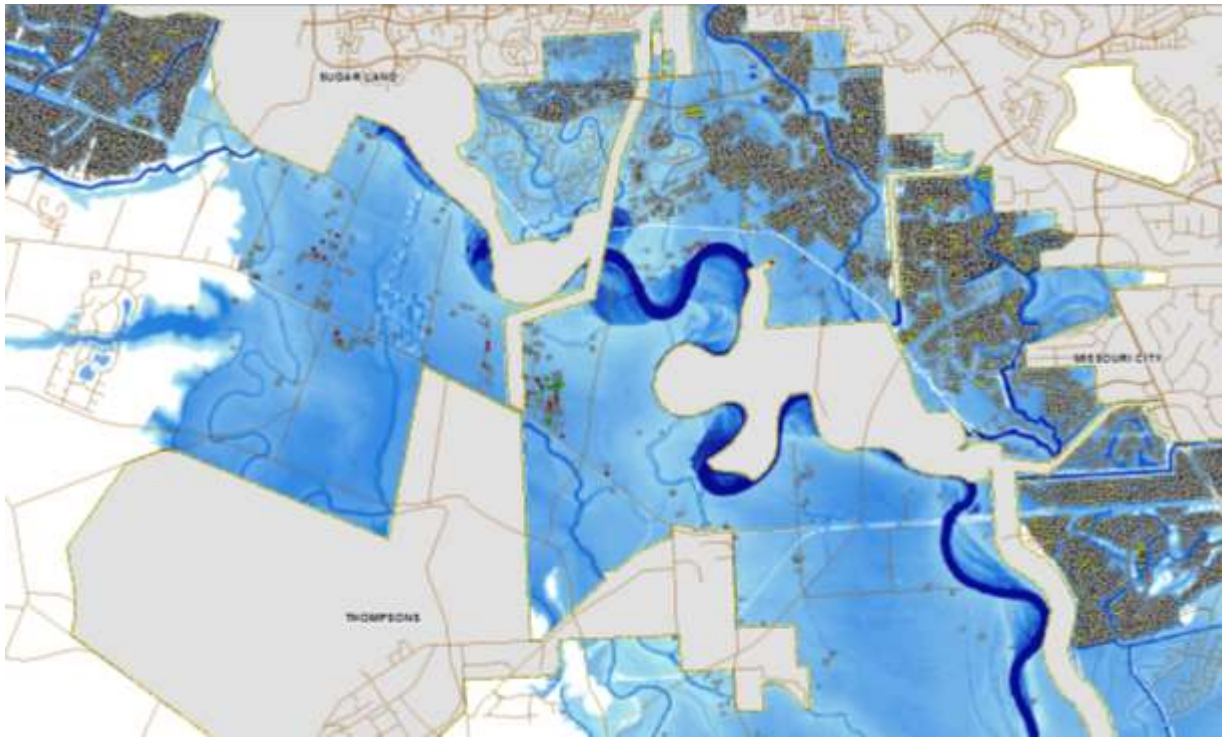
- All building footprint data with joined assessor information converted into building points
- These points converted into a Hazus compatible format for a User Defined Facility Analysis
  - Crosswalk tables for Hazus occupancy classes, structure type, foundation type, etc.
- Analysis was for unincorporated section of both counties, ended up with over 40,000 UDF's analyzed.
- Assessment done in Hazus 4.0

Results

- Categorized damage results into five categories:
  - GRAY – Properties that were exposed to the hazard, but did not show above 40% damage
  - GREEN – Properties already inspected by linking to active database of parcel ID's inspected
  - YELLOW – Structures showing over 40% damage, but reside in FEMA designated X zones behind protective levees or minimal flood areas with no observed flooding (local knowledge)
  - ORANGE – Structures that may be substantially damaged: they show over 40% damage to the structure but are not the largest building in their parcel and sit in a designated FEMA A or AE flood zone
  - RED – Structures most likely to be substantially damaged: they are estimated to have over 40% structure damage, sit in the special flood hazard area, are the largest buildings in their parcel and have not already been inspected
- This was done to streamline inspection process

Results

- Out of 45,000 properties in the flood zones of both counties, ended up with ~3000 fit for priority inspection (orange and red coded structures)
- Of those 3000 identified structures, approximately half were correctly identified as substantially damaged



Limitations & Improvements for Future Use

- Temporal Data Incongruency
  - LiDAR Footprints and Assessor Data were compiled in October 2016, 10 month gap between assessor table and actual damaged structures
- Assessor Data Individual Improvements not uniquely linked to LiDAR Building Footprints
- Depth Grid was calibrated to observed high water marks, but still had many other areas of water depth that had no observed flooding (behind levees)
- First floor height elevations for each structure were not available

Key Takeaways

- Model did point to some neighborhoods that were not yet inspected that warranted a look
- “I think the model has done a pretty decent job as we have gotten further along into this… we send [the inspectors] out and they come back with SDE’s now and most of those are under 3 feet.”
- Constant refinement of the depth grid with field collected data improved accuracy.
- Better data, better model, better performance.
- Relatively cost effective solution when considering the timeframe and project goals.

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Questions?

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Photos sourced from Houston Chronicle 2016, Youtube, User Famous Texas, 2015, KTRK ABC News, 2016 and Google Streetview June 2016, Community Impact Newspaper/Jesse Mendoza October 2017