Risk Communication of Urban Flood through Augmented Reality

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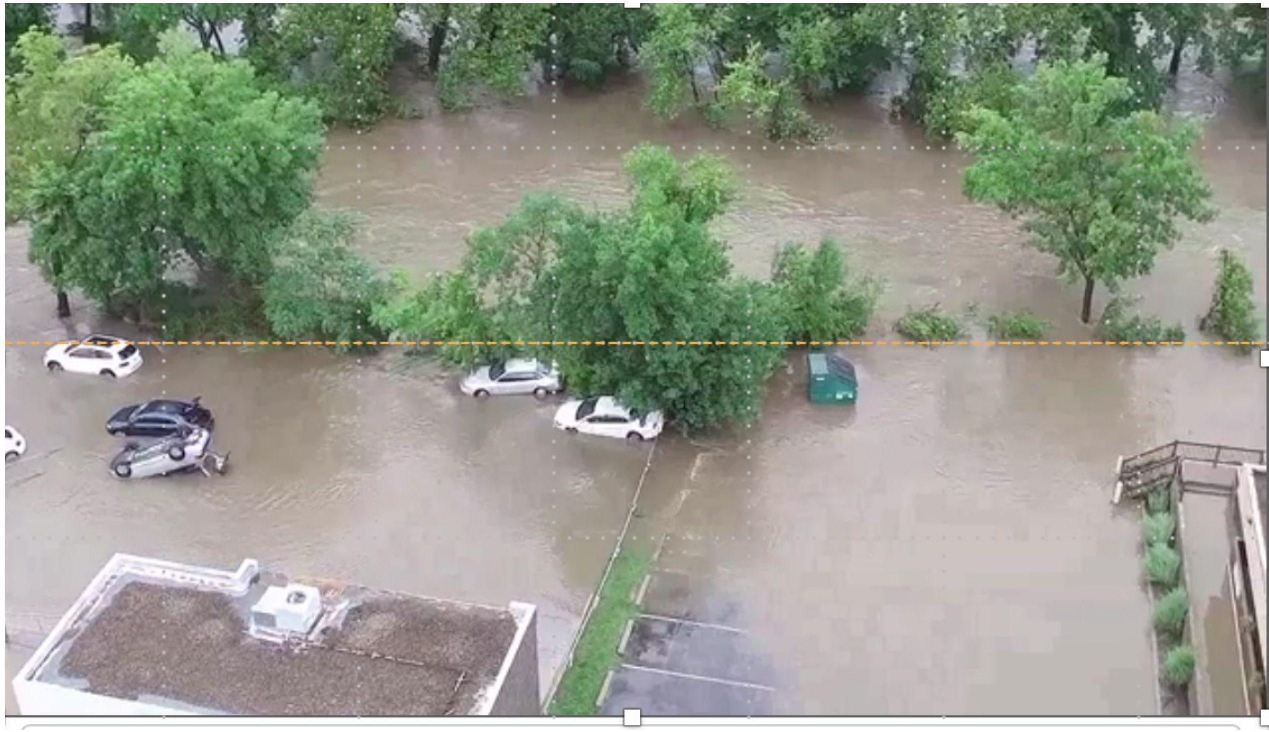
Outline

- Background:
  - 2017 Kansas City Flood and Necessity of Public Flood Risk Communication
- Risk communication through technologies
  - Why AR technology?
- Technical Implementation
- Workshop and field study (video demo).
- Conclusion remarks and future work.

2017 Indian Creek Flood, Kansas City, MO

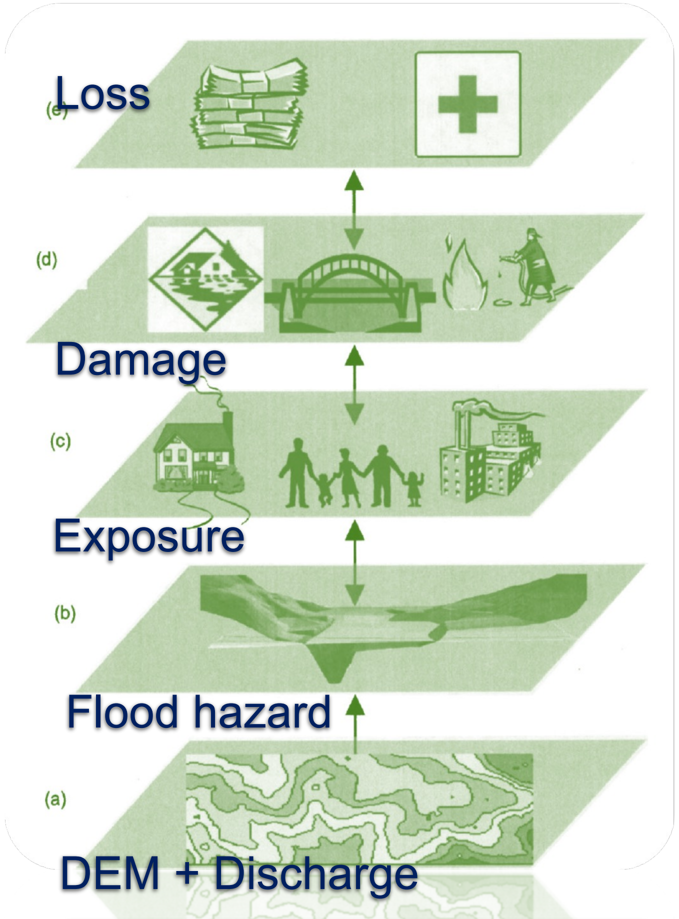
- Flooding along 103rd Street in Kansas City, MO, in 2017
- Emergency rescue of people from the roof of a commercial building.
- KC-MO purchased and demolished several business buildings to prevent future liabilities.



Significance of Risk Communication

- RC provides adequate information about an impending hazard, its potential risks, and potential mitigation steps. (Gladwin et al. 2009, Krimsky 2007).
    - Aid communities in taking preparatory actions to reduce the adverse impacts of the event.
- RC as a preparedness measure to promote community resilience (NRC 2012, UN/ISDR 2004).
    - It allows for the sharing of knowledge/information/lessons learned among stakeholders

Professional Understanding vs Public Understanding



- Risk = Loss x Probability
  (Hazard x Vulnerability)
- Through minimal education, the public may understand a ‘small-probability’ event, i.e., a 100-year flood.
- However, what is the difference between the impact of 100- and 50-year floods?

Engaging the public in understanding flood hazards and risk remains a great challenge.

Risk Communication Technologies

- VR/AR technologies have been increasingly used in recent years for disaster & hazard risk communication. [Kundu et al 2017; Mol et al. 2022; Khanal et al. 2021].

- Main advantages:
  - Virtual; gaming-engine based simulation of disaster effects
  - Immersive through augmented reality

- The Weather Channel has pioneered and widely adopted VR technologies.
- NOT AR!

AR adds digital information to a user's real-world environment, while VR completely replaces a user's real-world environment with a simulated one

Technology Implementation

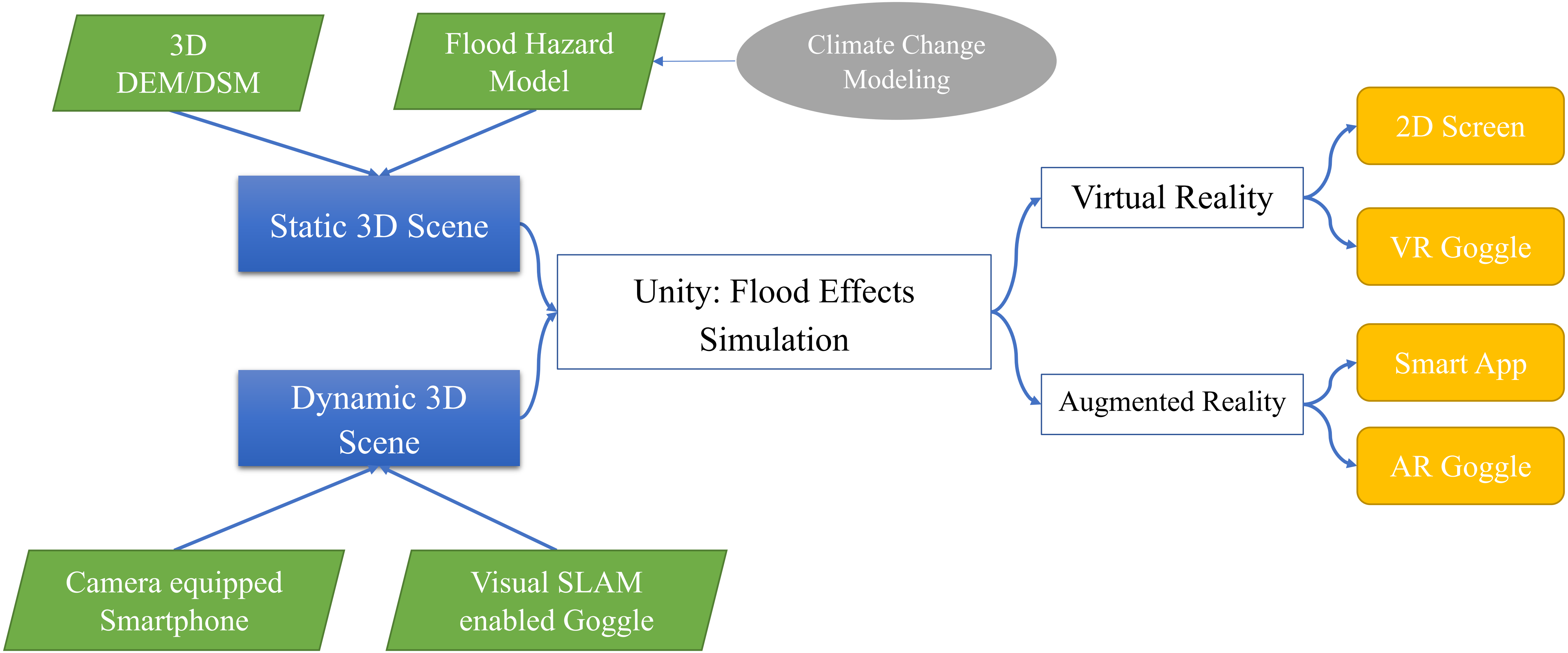
- Head-mounted AR goggles?

✓ Not well suitable for outside AR=
✓ 3D sensing and visual SLAM are still problematic
✓ High-cost and not readily accessible for the public
✓ Powerful for research development

- Mobile smart-app based (Pokémon Go like AR)?

✓ Ready for outside application
✓ Mature development kits
✓ Low-cost and accessible to the public

Technology Components



Software Framework and Workflow

UI design

- User friendly
- Easy understanding

Unity 3D Scene Build

- Virtual models design
  - Water model with wave and under water animation
  - Building model
  - Ruler / sign
- AruCo code design

C# scripts

- Home page button event response
  - Game mode selection
  - Flood simulator selection (25, 50, 75 years, and 2017 flooding)
  - Return to welcome page
- Digital Earth design
  - Flag choose
  - Rotate and zoom in / out

AR response

- AruCo code target found
  - Vuforia Image Detect Model
  - Put virtual model
  - Reset global coordinate system
- Floor detected
  - Vuforia plane detect model
  - Reset y axis for global coordinate system

iOS installation packaging

- Cloud saved virtual models
- Auto fit different devices (iPad, iPhone, etc.)

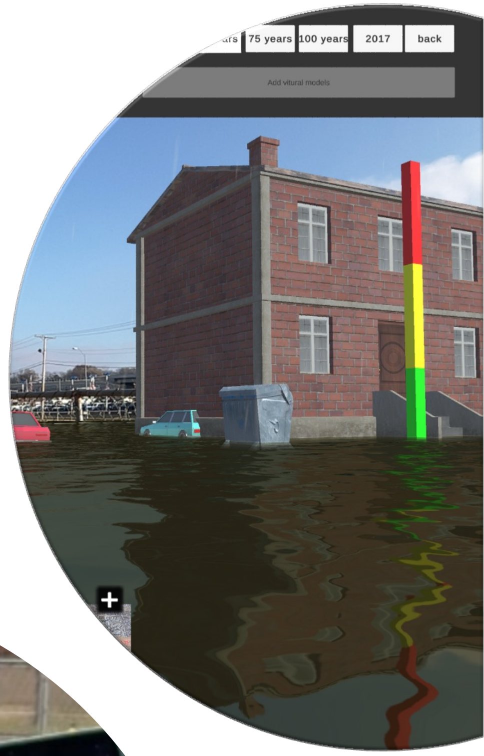
Technology Highlights

- **Truly immersive** – physical scenes, virtual scenes of floods, and landmarks are frame-by-frame updated as a user walks.

- **QR code based public AR app access and scalable to any location**

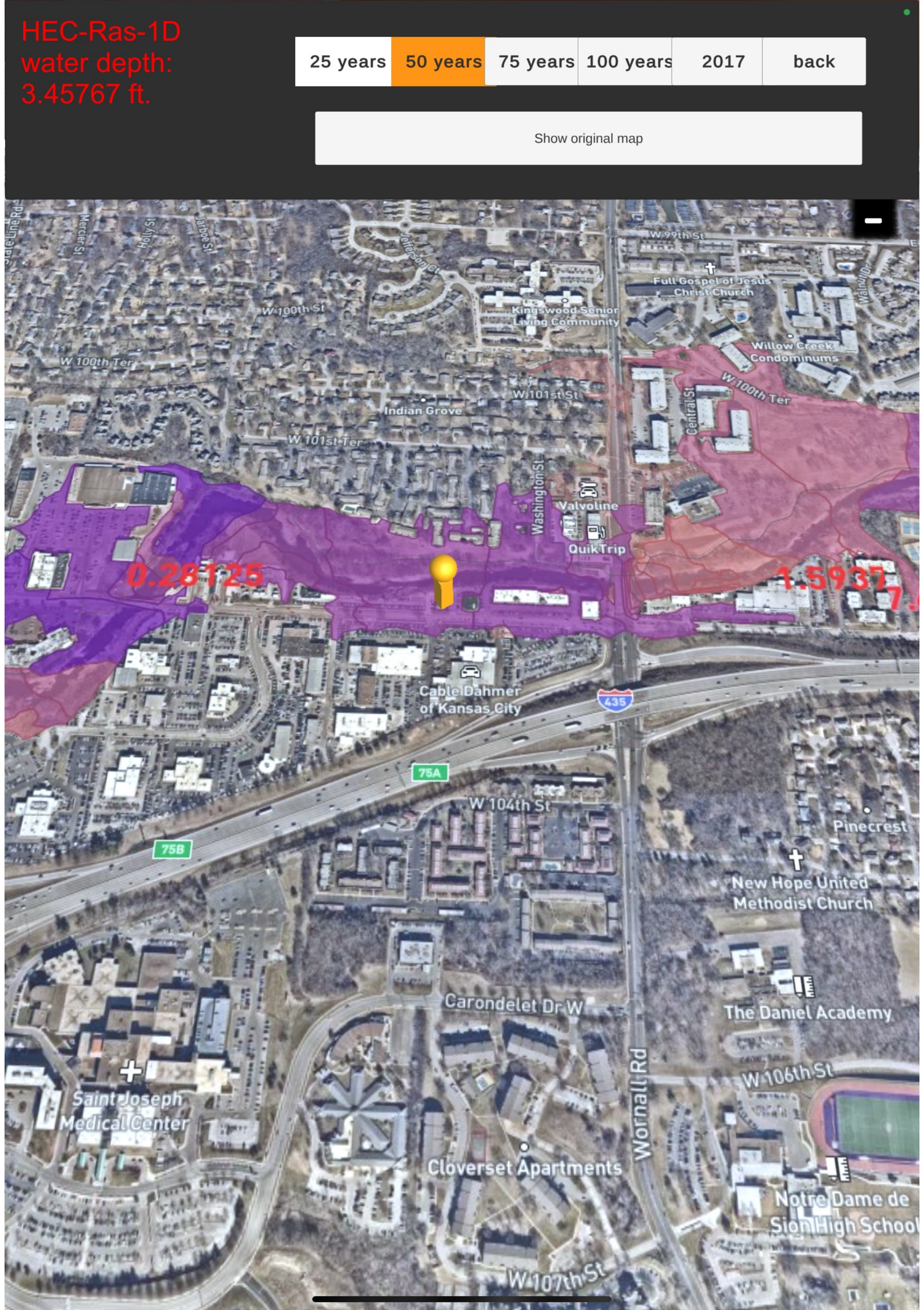
Two AR modes:

- 2D flood hazard maps with dynamic display of water depth
- 3D parametric flood effects at designated flood frequencies.



Workshop Assessment

Learning outcomes assessed through social survey studies.


HEC-Ras-1D
water depth:
3.45767 ft.
25 years
50 years
75 years
100 years
2017
back
Show original map
W 99th St
Full Gospel of Jesus Christ Church
Kingswood Senior Living Community
W 100th St
Willow Creek Condominums
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W 101st St
Indian Grove
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Central St
Washington St
Valvoline
QuikTrip
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Cable Dahmer of Kansas City
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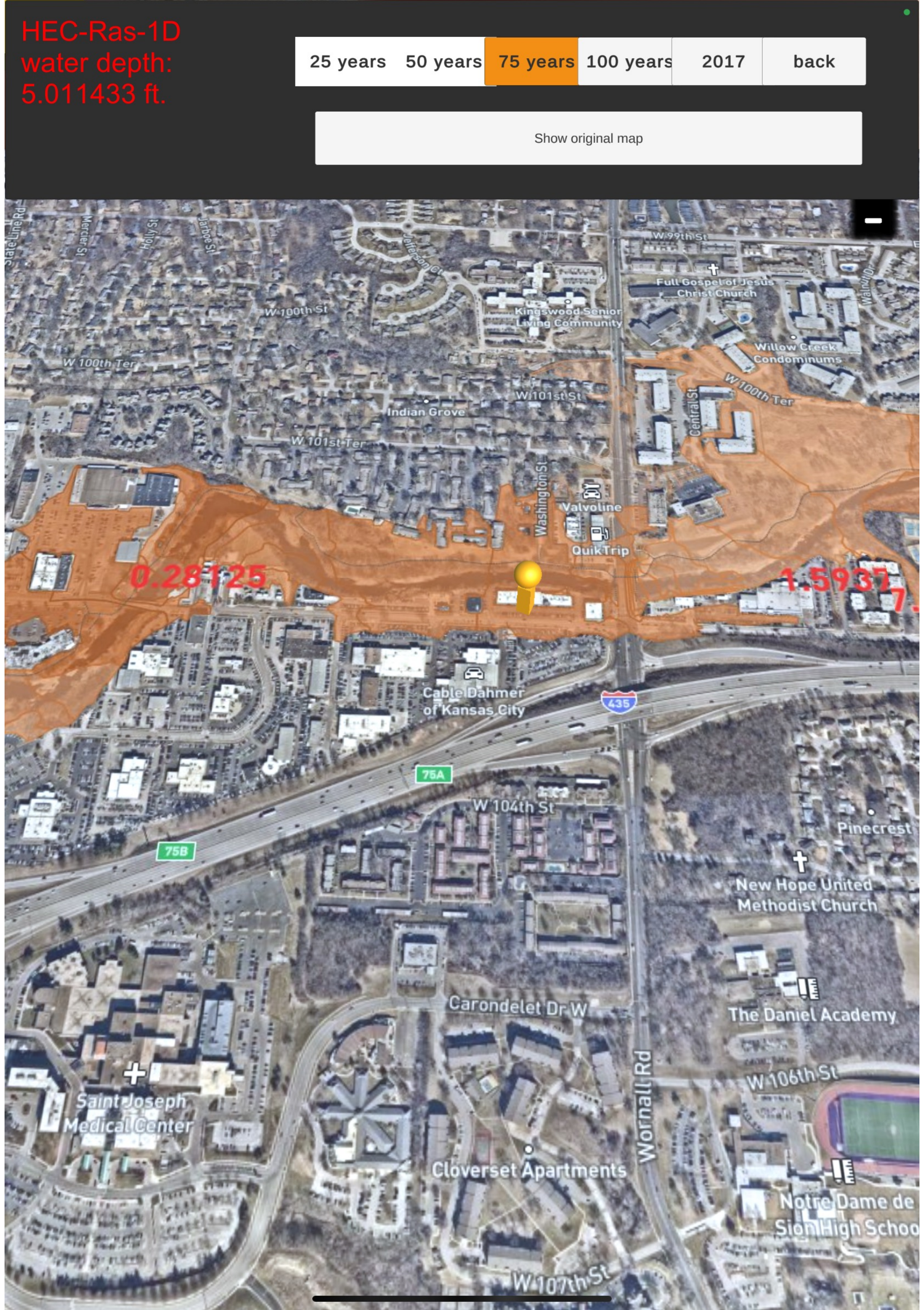
New Hope United Methodist Church
Carondelet Dr W
The Daniel Academy
W 106th St
Wornall Rd
Saint Joseph Medical Center
Cloverset Apartments
Notre Dame de Sion High School
W 107th St


HEC-Ras-1D
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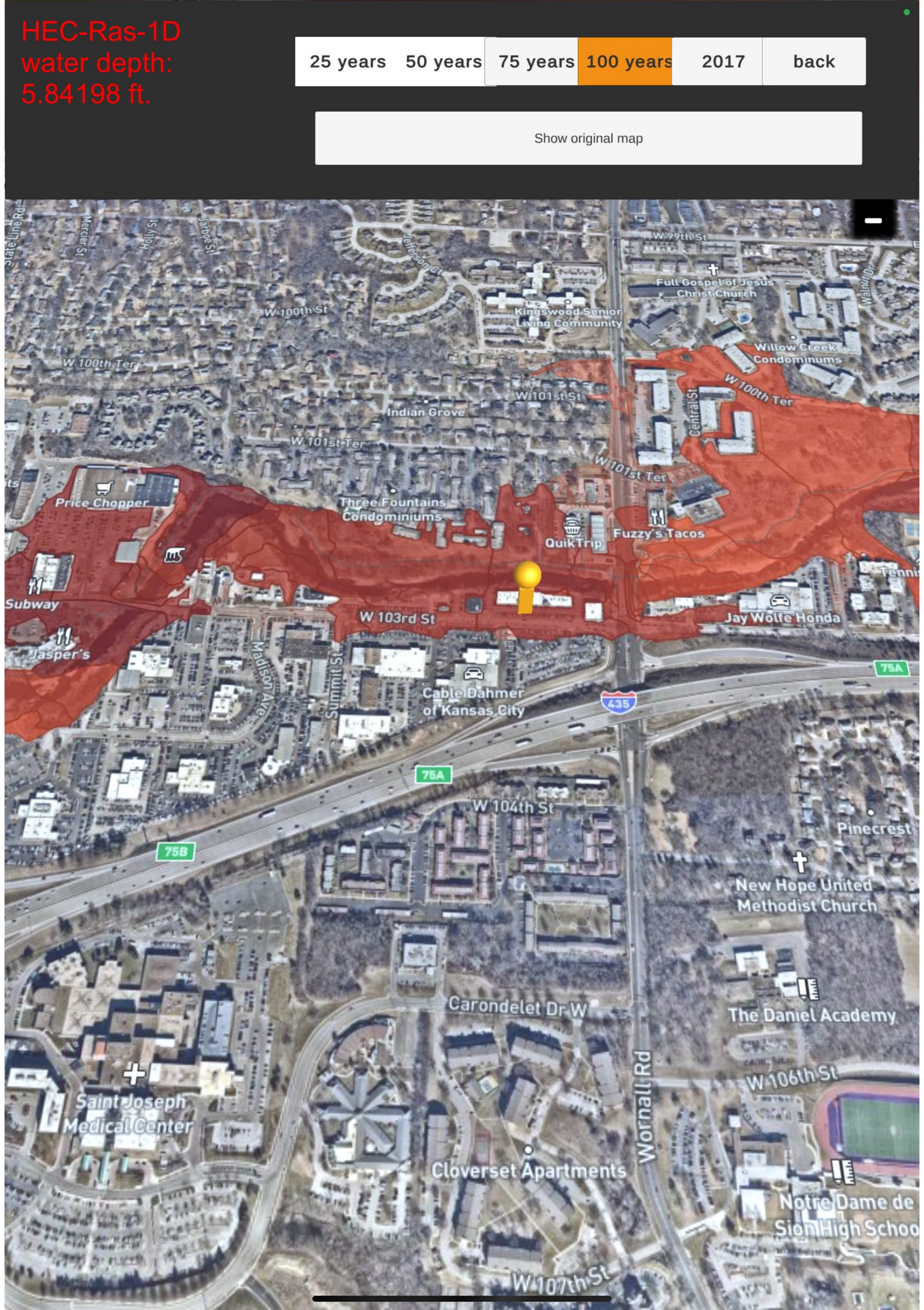
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Three Fountains Condominiums
QuikTrip
Fuzzy's Tacos
Subway
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Cloverset Apartments
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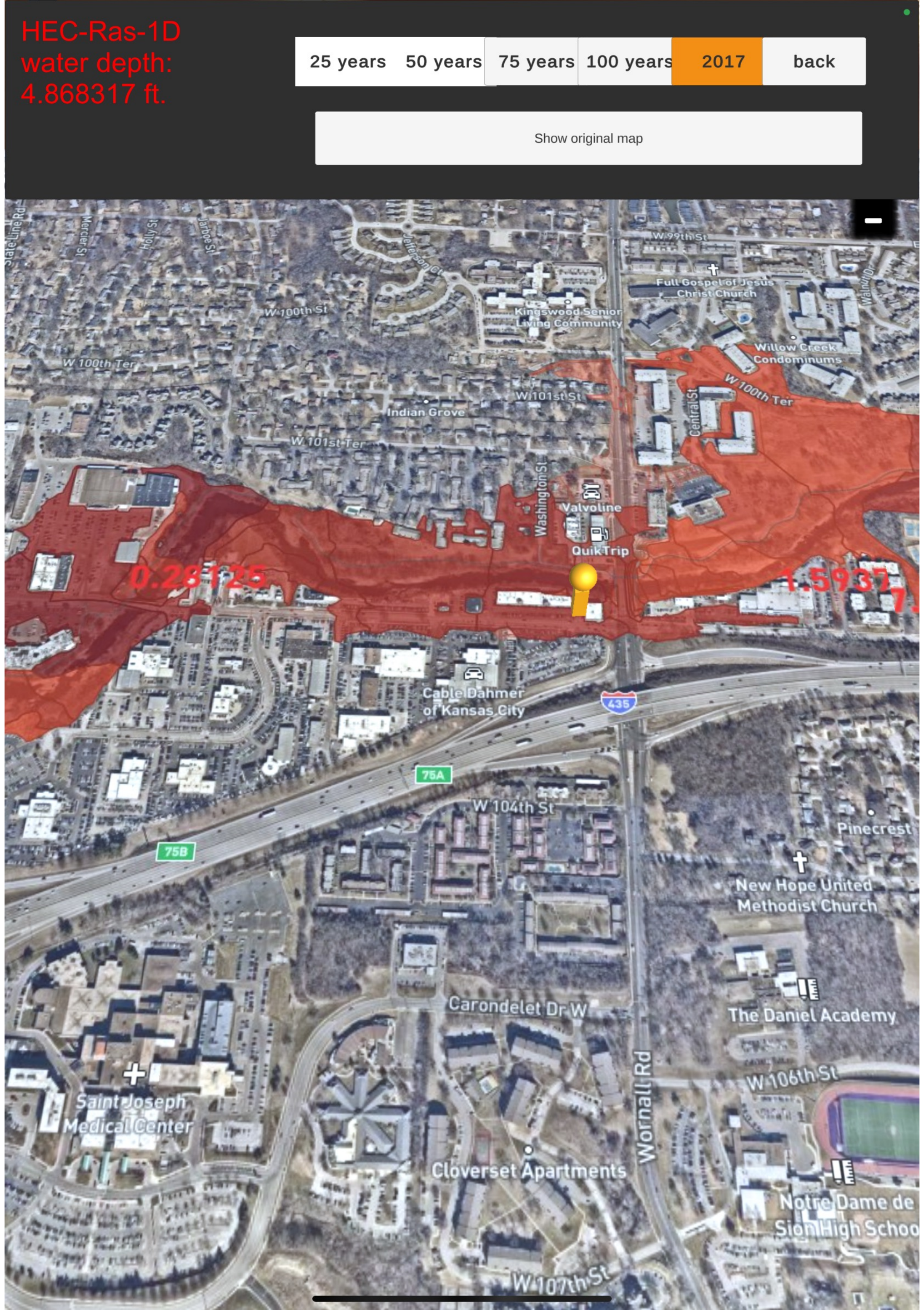
HEC-Ras-1D
water depth:
4.868317 ft.
25 years
50 years
75 years
100 years
2017
back
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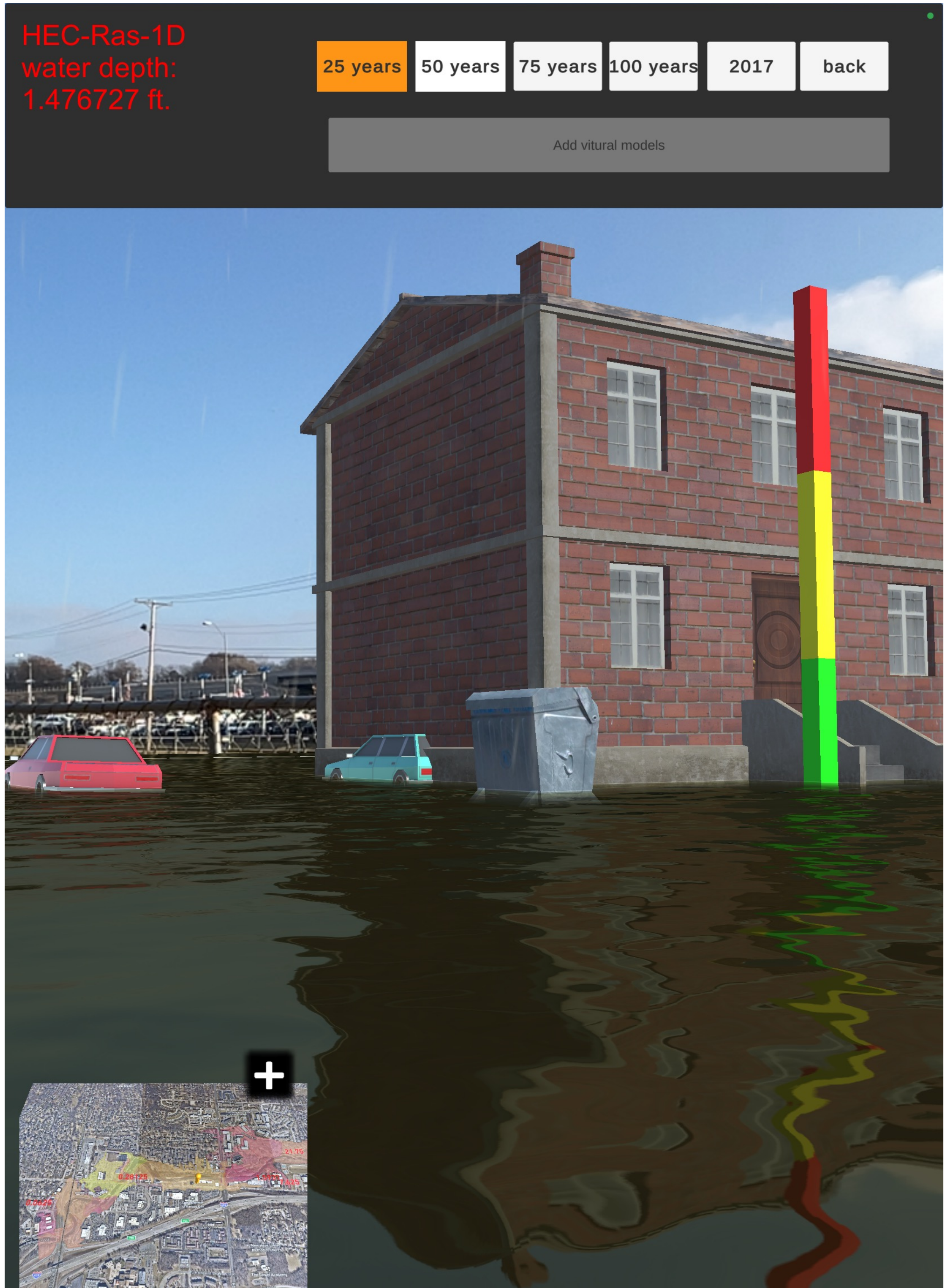
Carondelet Dr W
The Daniel Academy
W 106th St
Saint Joseph Medical Center
Cloverset Apartments
Wornall Rd
Notre Dame de Sion High Schoo
W 107th St


Please select flood level.
25 years
50 years
75 years
100 years
2017
back
Add vitural models


HEC-Ras-1D
water depth:
1.476727 ft.
25 years
50 years
75 years
100 years
2017
back
Add vitural models


HEC-Ras-1D
water depth:
2.91098 ft.
25 years
50 years
75 years
100 years
2017
back
Add vitural models


HEC-Ras-1D
water depth:
4.372658 ft.
25 years
50 years
75 years
100 years
2017
back
Add vitural models


HEC-Ras-1D
water depth:
5.092925 ft.
25 years
50 years
75 years
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2017
back
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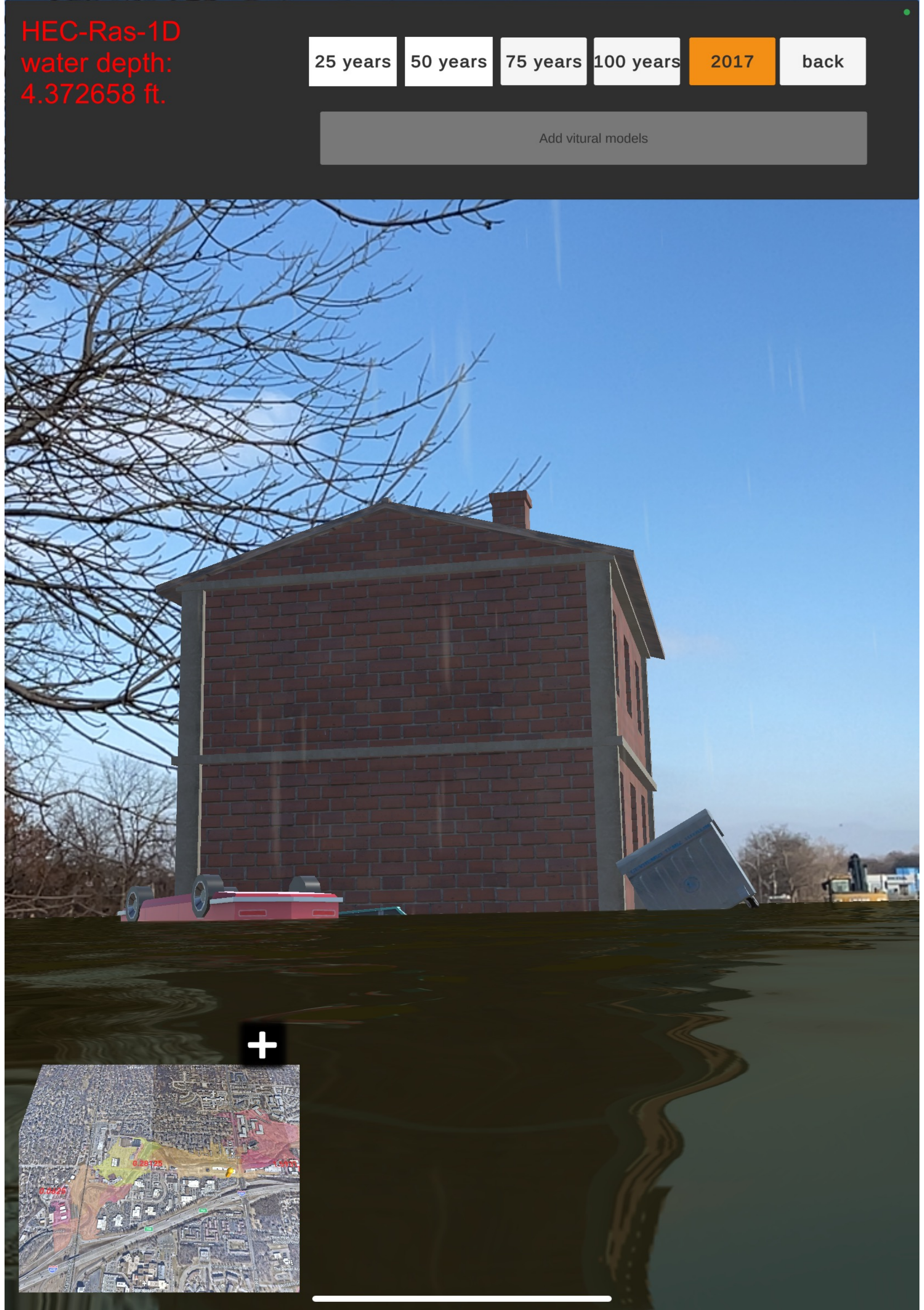

HEC-Ras-1D
water depth:
4.372658 ft.
25 years
50 years
75 years
100 years
2017
back
Add vitural models

Youtube demo link:

https://www.youtube.com/watch?v=d9KFQyFL3SM&ab_channel=ImagingUmkc

Future Collaborative Effort:

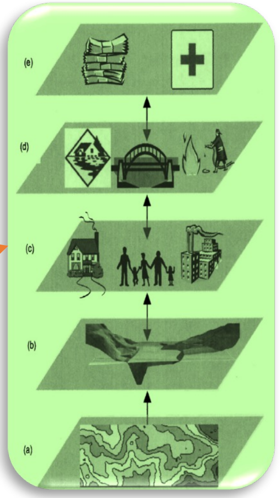
- **Climate change and regional downscaling**
- **Physics-based Urban Flood Digital-Twinning,**
- **AR-enabled Decision-making and Risk Communication**

✓ Real-time flood hazard, vulnerability, and loss/risk modeling in a cloud-based computing infrastructure to enable real-time on-demand services.

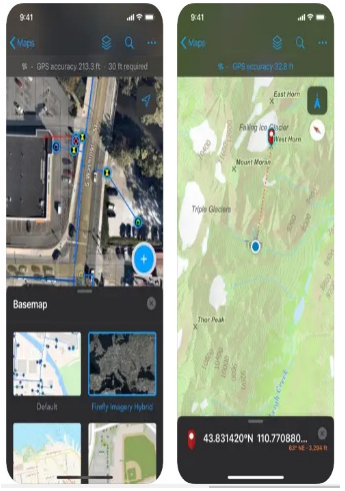
✓ Advanced AI-enabled physical scene understanding and virtual effects generation

✓ Interactive and real-time data collection and crowdsourcing at the AR front ends

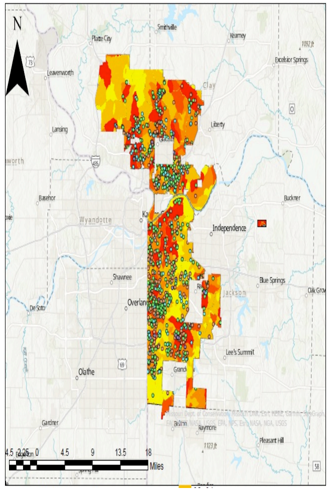
✓ On-demand AR-based flood risk communication at any location of interest



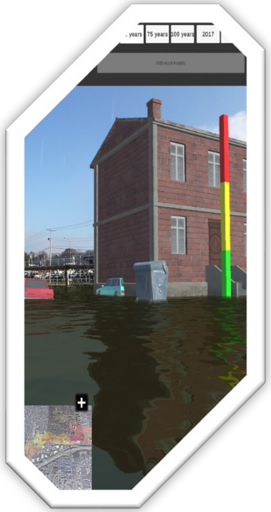
Baseline modeling



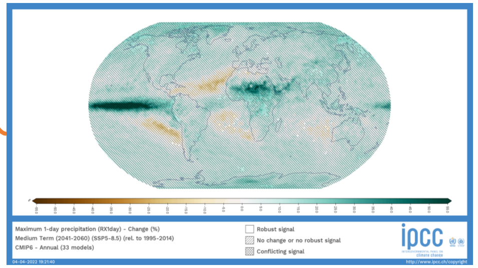
Field data collection



Mapping and Analytics



Immersive field AR



Thank you!

Acknowledgment

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