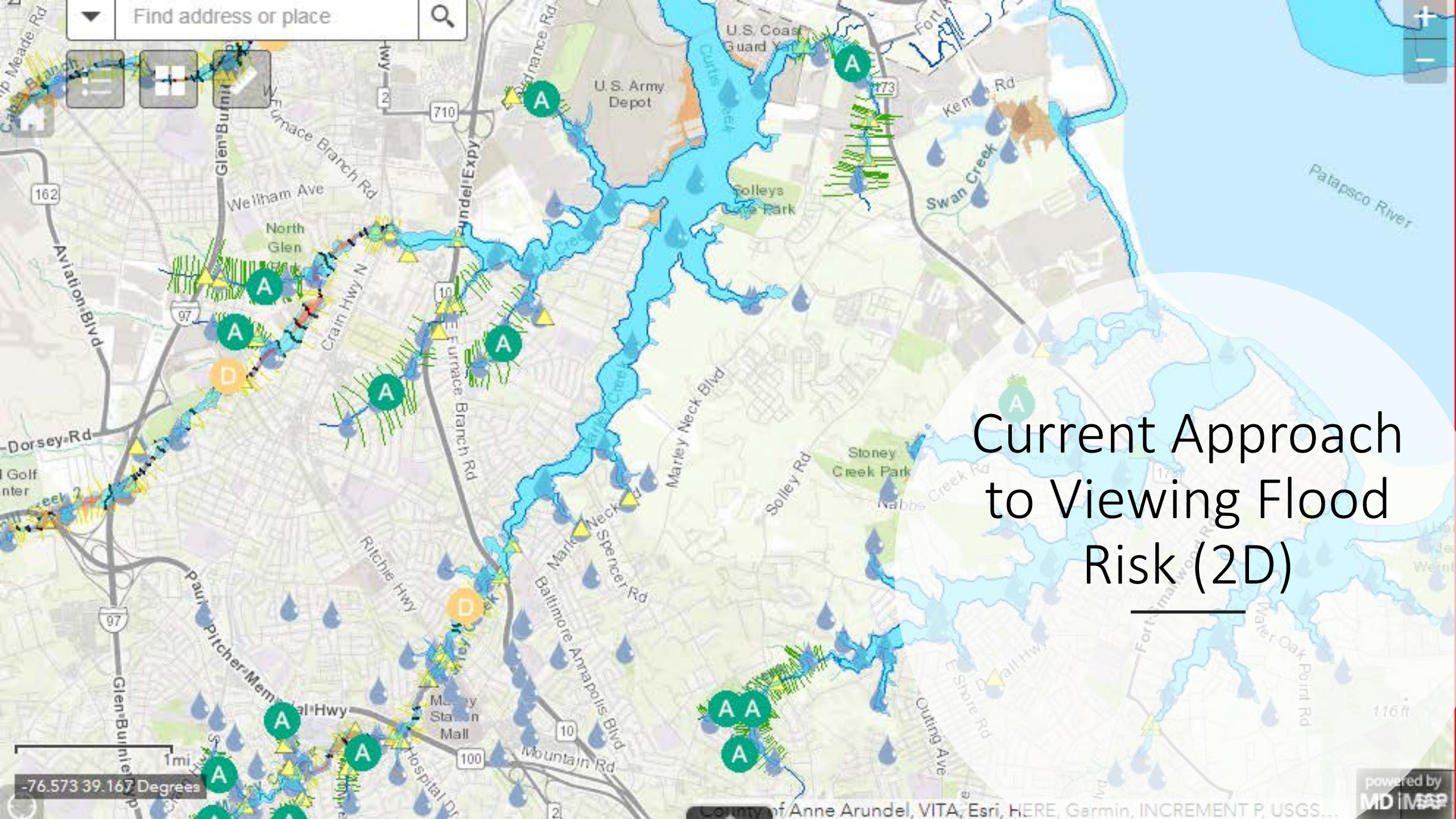
Leveraging the Power of 3D-GIS to Better Communicate Flood Risk

David Guignet
State National Flood Insurance Program Coordinator
Water and Science Administration
Maryland Department of the Environment

Michael Herzberger, GISP, CFM
Chief, Geospatial and Engineering Services
Environmental Monitoring Division
Maryland Environmental Service

Source: Google Earth

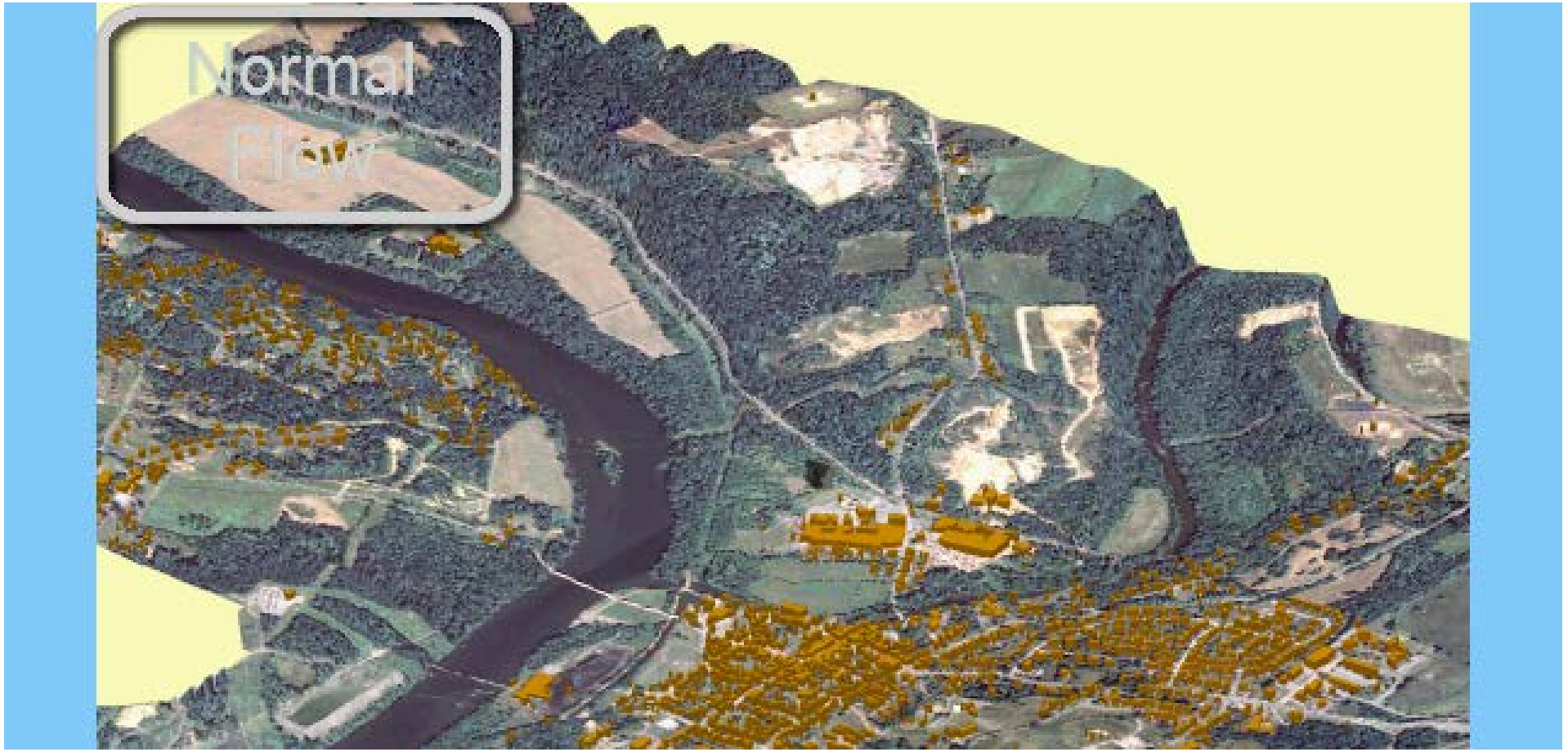


Current Approach to Viewing Flood Risk (2D)

Background

- Interacting with data in 3D is gaining popularity – Value of leveraging 3D to communicate flood risk is well known - Barriers from historic perspective include:
  - Limited availability of 3D data
  - Costs of data acquisition
  - Sharing 3D data/maps through the web required administrator rights for application installation on a given PC (Google Earth, ArcGlobe, ArcGIS Explorer)
  - Sharing outputs from ESRI ArcScene were videos (not a GIS)
  - Limitations/costs of disk storage
  - Limitations/costs of server infrastructure

Example of Flood Visualization (circa 2011)

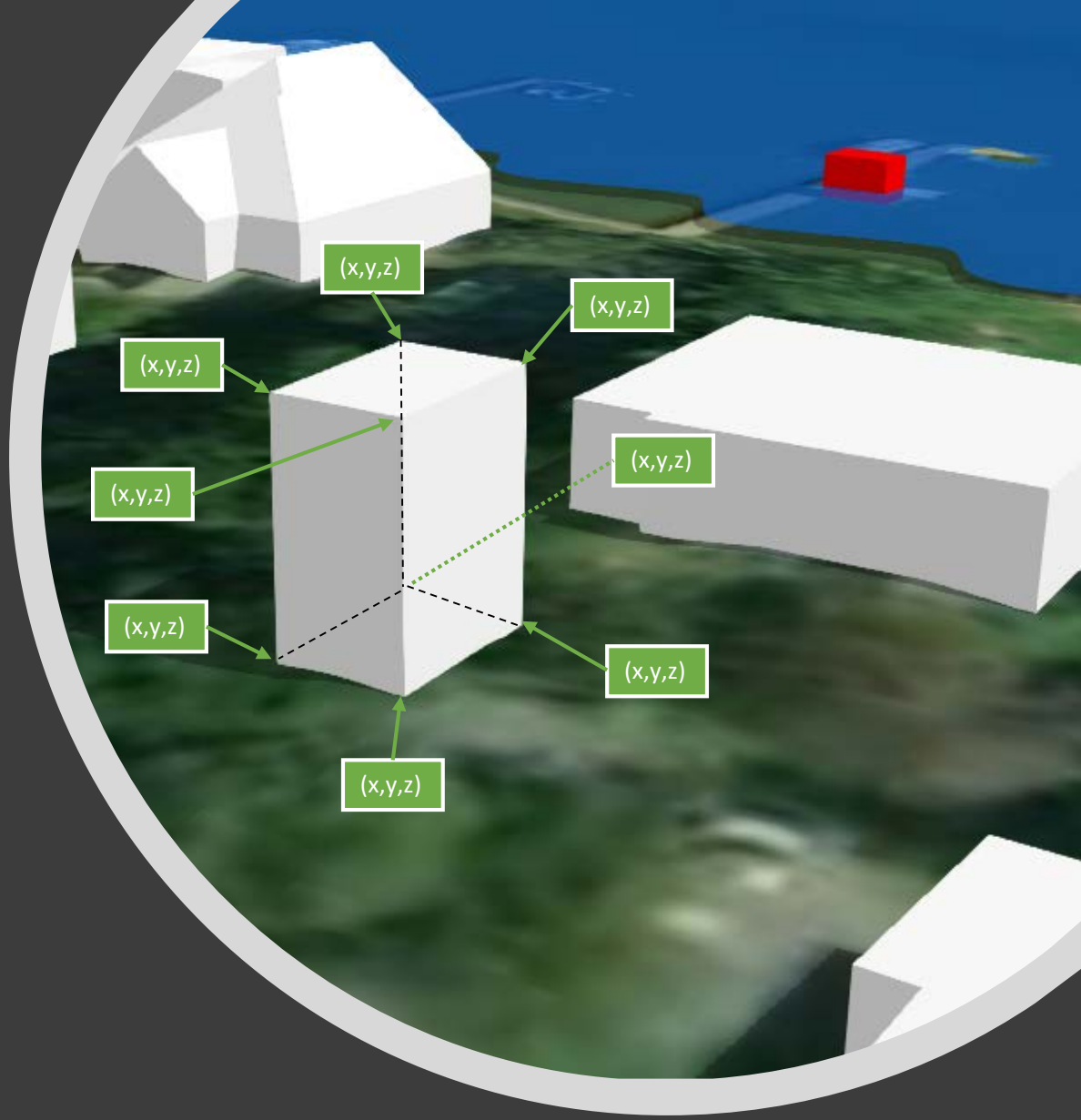


Why Now?

- ✓Availability of 3D data has increased
- ✓Costs for data acquisition decreased
- ✓Breakthrough's in 3D web-GIS offerings through ESRI
  - ✓Easier to share data/maps
- ✓Costs of disk storage have decreased
- ✓Cloud computing provides configurable horsepower at decreased costs

What is 3D GIS and AR?

- 3D GIS - 3D Geographic Information Systems (3D GIS) are systems for structuring and managing 3D spatial data and are capable of handling 3D geometry structures and performing onto them basic spatial analysis functionalities of a GIS. https://link.springer.com/referenceworkentry/10.1007%2F978-94-007-0753-5_4083
- Augmented Reality - An enhanced version of reality created by the use of technology to overlay digital information on an image of something being viewed through a device (such as a smartphone camera). https://www.merriam-webster.com/dictionary/augmented%20reality



3D GIS and Augmented Reality Technical Requirements Leveraging ESRI Platform

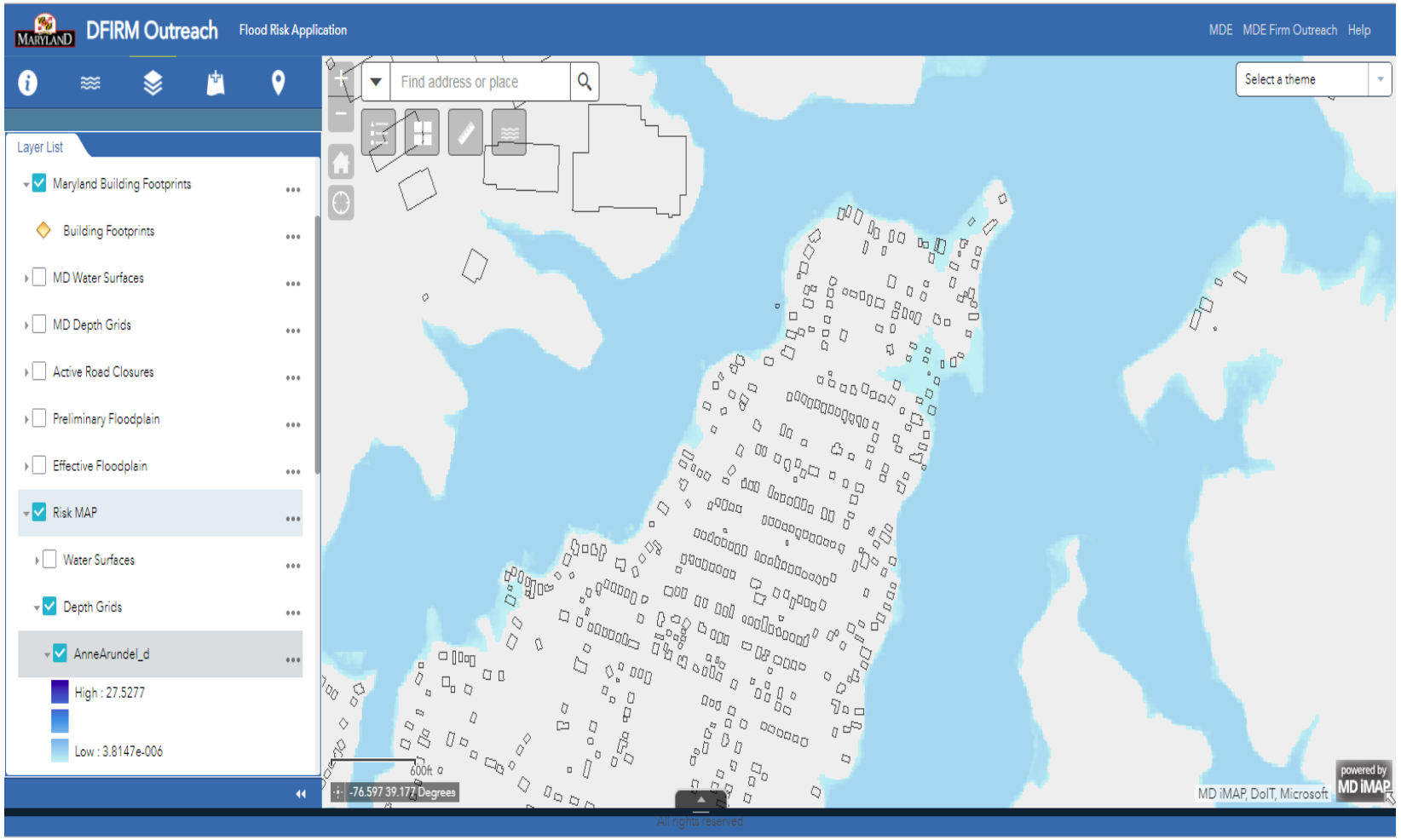
3D GIS

- ArcGIS Online Account *(Authorized to Publish Content)*
- ArcPro 2.2 or higher
- Spatial Analyst Extension & 3D Analyst Extension

Augmented Reality

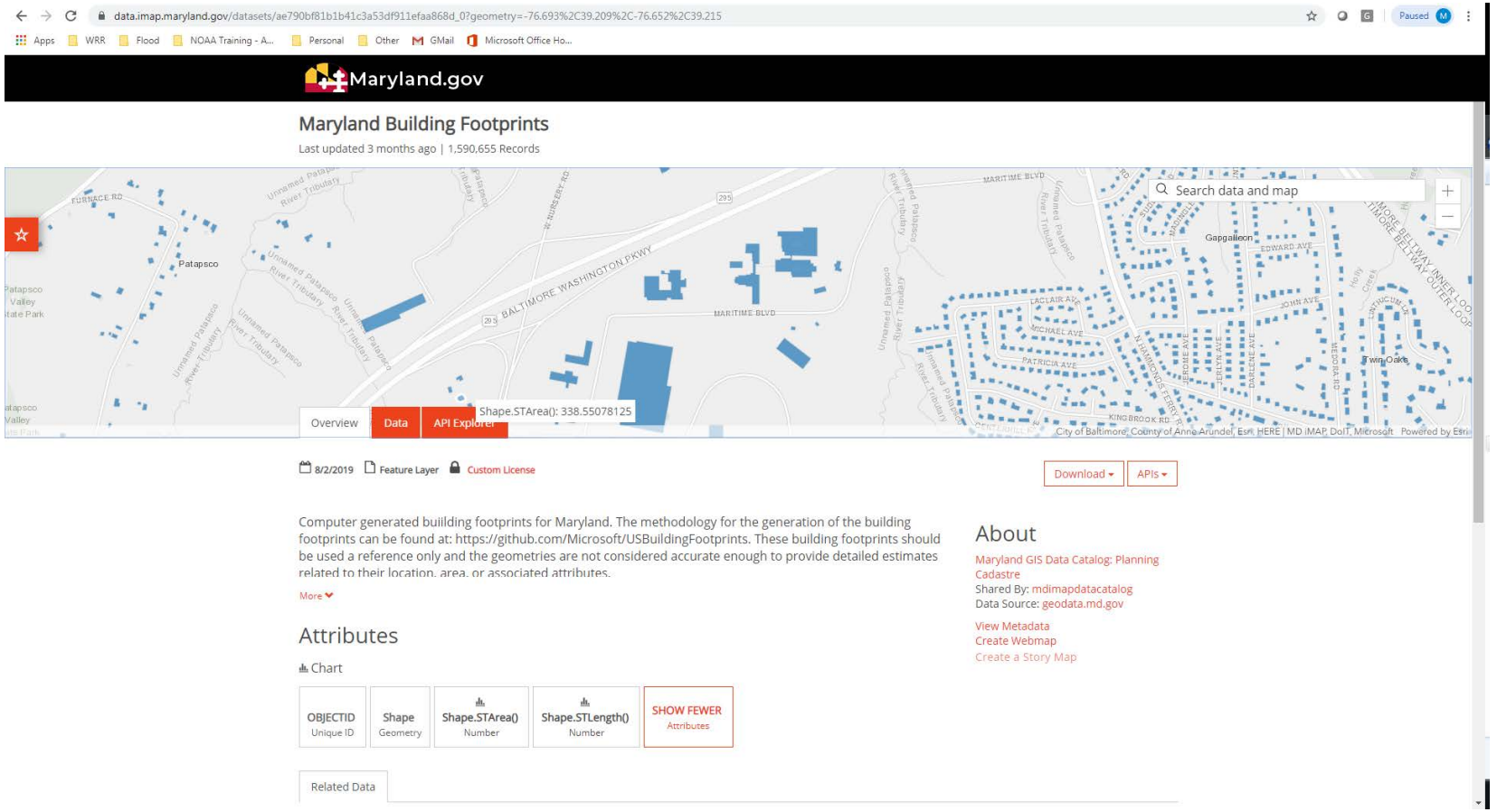
- ArcGIS Online Account *(Authorized to Publish Content)*
- ArcPro 2.2 or higher
- Spatial Analyst & 3D Analyst Extension
- Download and Install AUGEO for IOS (iPhones and iPads)

Critical Datasets for Communicating Flood Risk in 3D and AR Environments



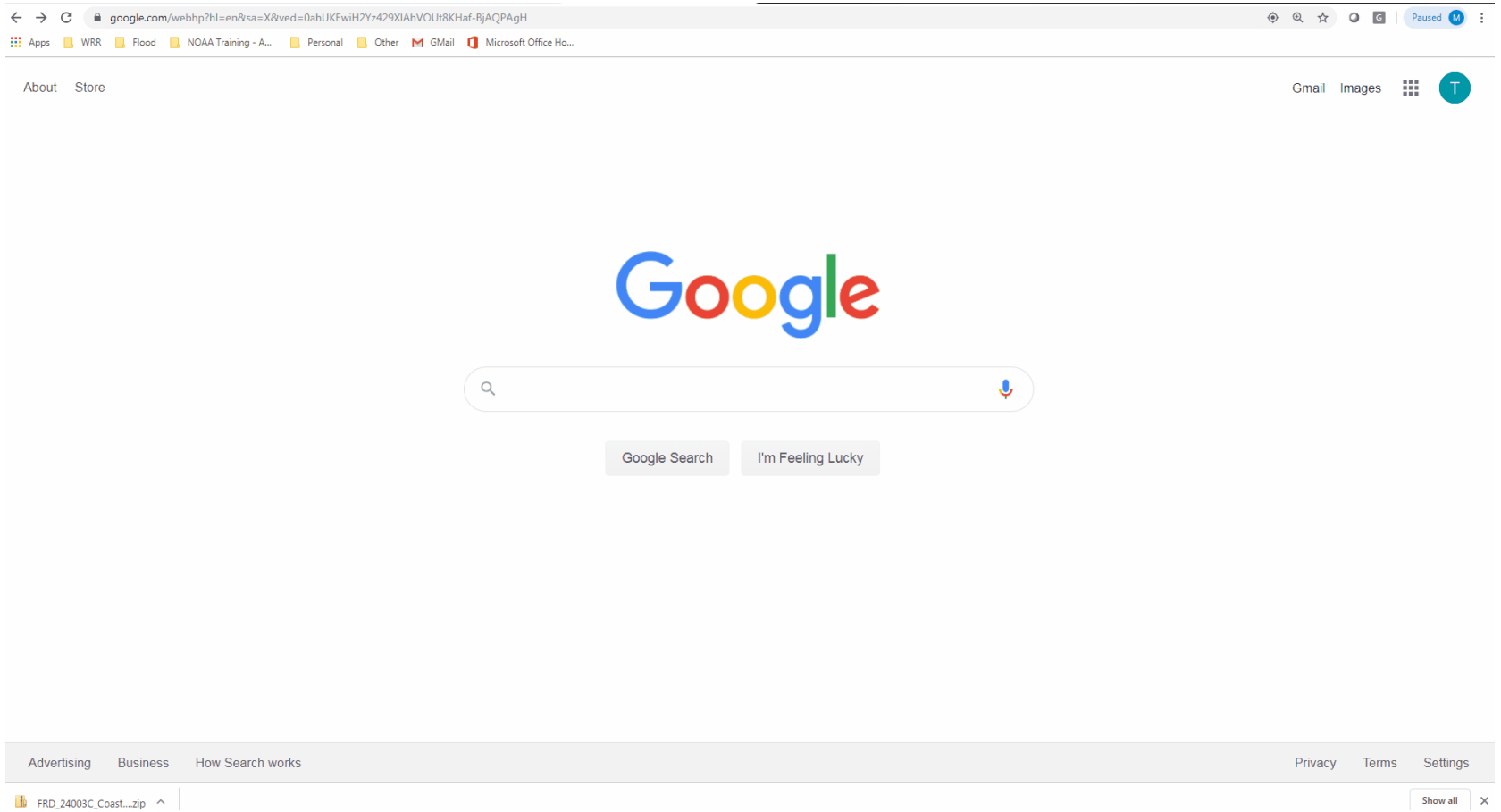
- Depth Grids – Derivative product from FEMA Special Flood Hazard Area data (i.e. DFIRM) – Raster-based GIS data product where each cell equates to a depth of flooding
- Building Footprints – Representation of building footprint locations within a particular geography, typically derived from remotely sensed data – Polygon-based GIS data product
- Elevation Data – Topographic information, typically derived from remotely sensed data – Raster-based GIS data product

Data Sources



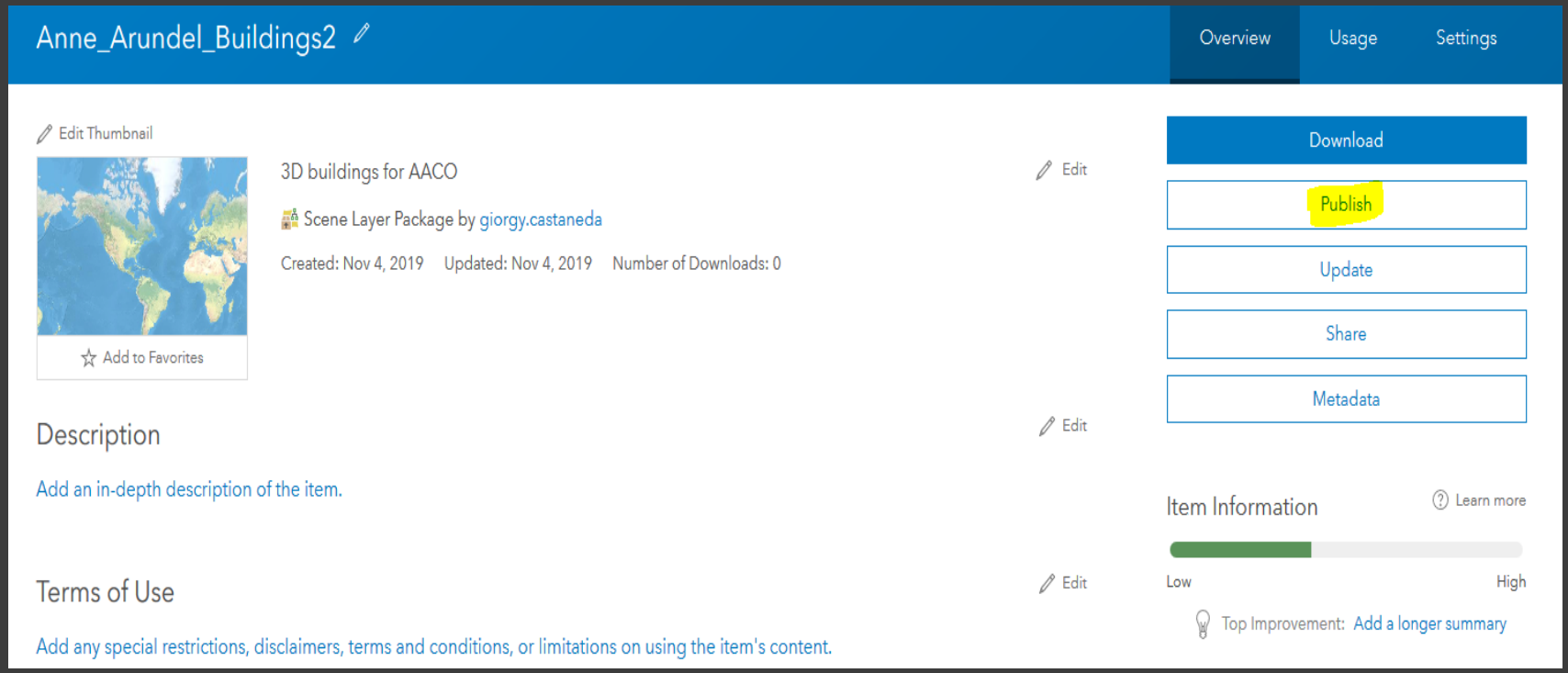
- Maryland's iMap: https://data.imap.Maryland.gov
  - Building Footprints
  - LiDAR Data
  - Aerials and Other Base Map Data

Data Sources



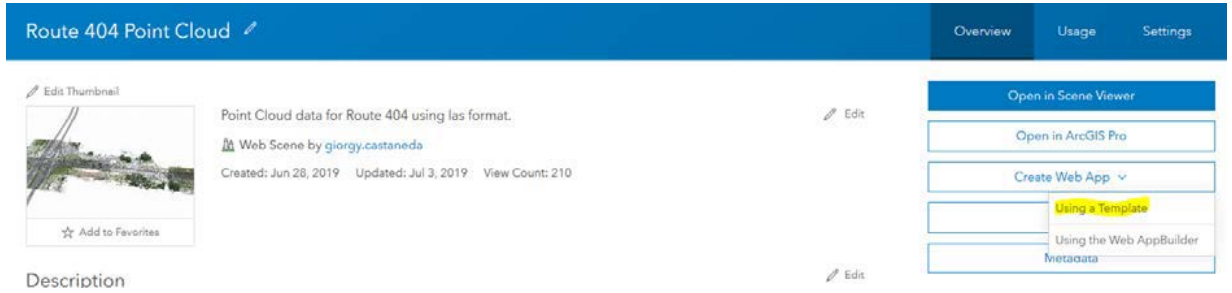
- Depth Grids for 1% Annual Chance
  - FEMA's Map Service Center: https://msc.fema.gov/portal/home

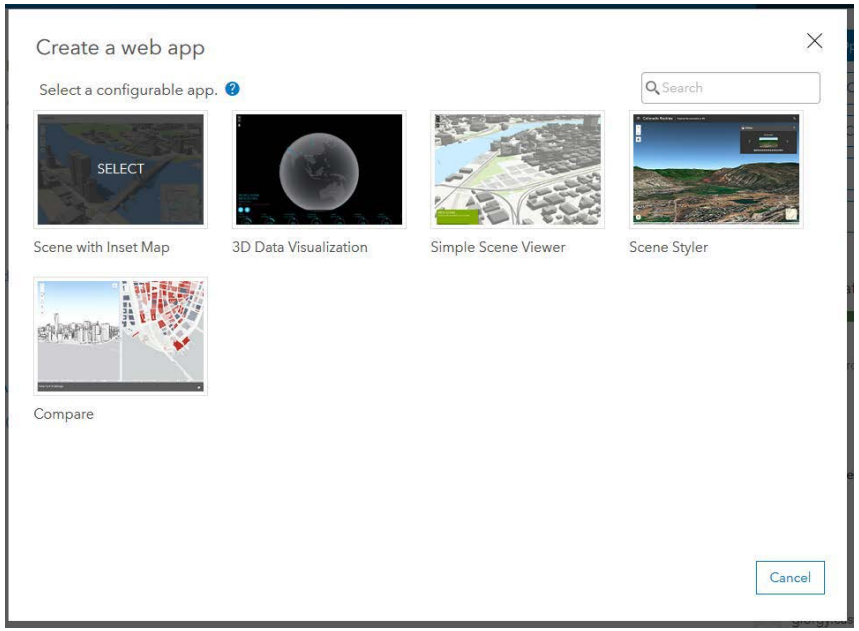
Developing a 3D View from Depth Grid Data – Data Processing & Publishing



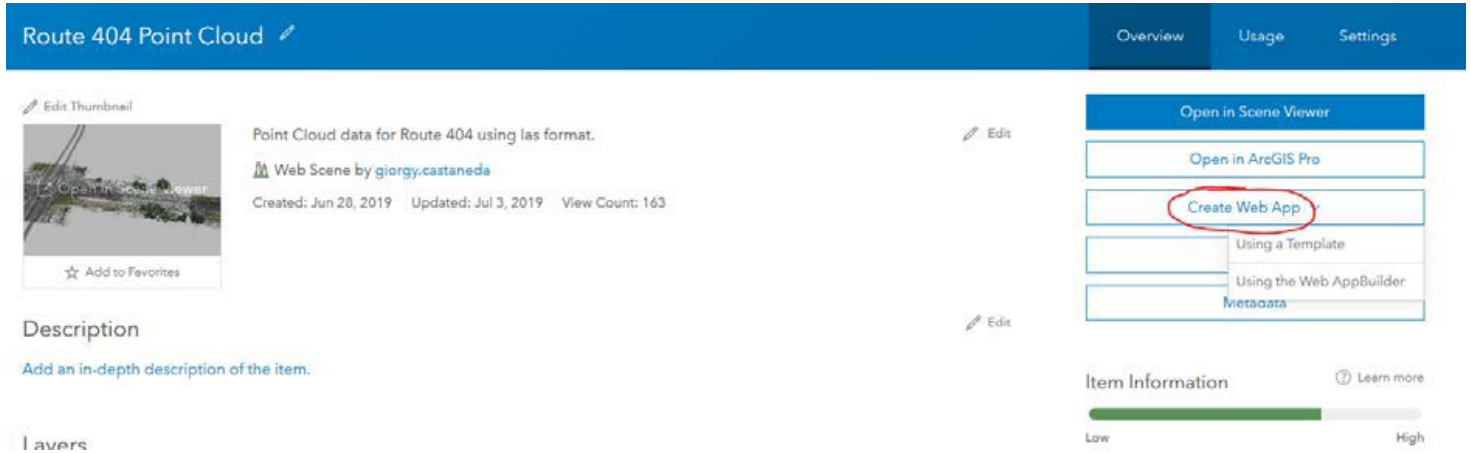
- Create 3D flood level from the raster by defining the vertical coordinate system, projecting the flood layer, and deriving a 3D flood level from the projected raster.
- Share the 3D flood level on ArcGIS Online (AGOL) by creating a scene layer package
- After sharing the scene layer to your AGOL account, go to the layer in AGOL and press the 'Publish' button
- Go to the published layer and press 'Open in Scene Viewer' to view the 3D layer in a web scene
- Step through comparable process to publish building footprints

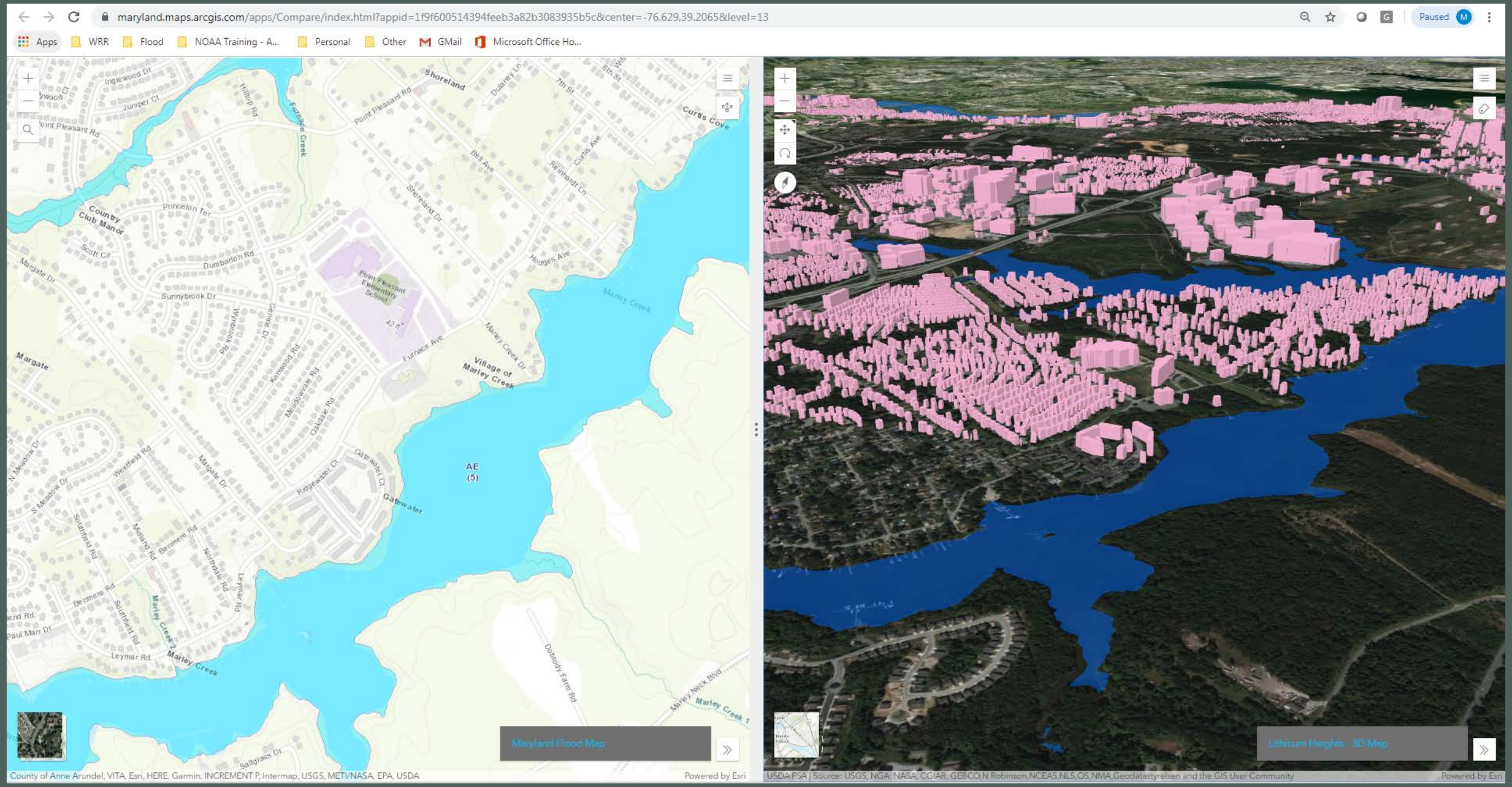
Developing a 3D View from Depth Grid Data – Publishing the Application



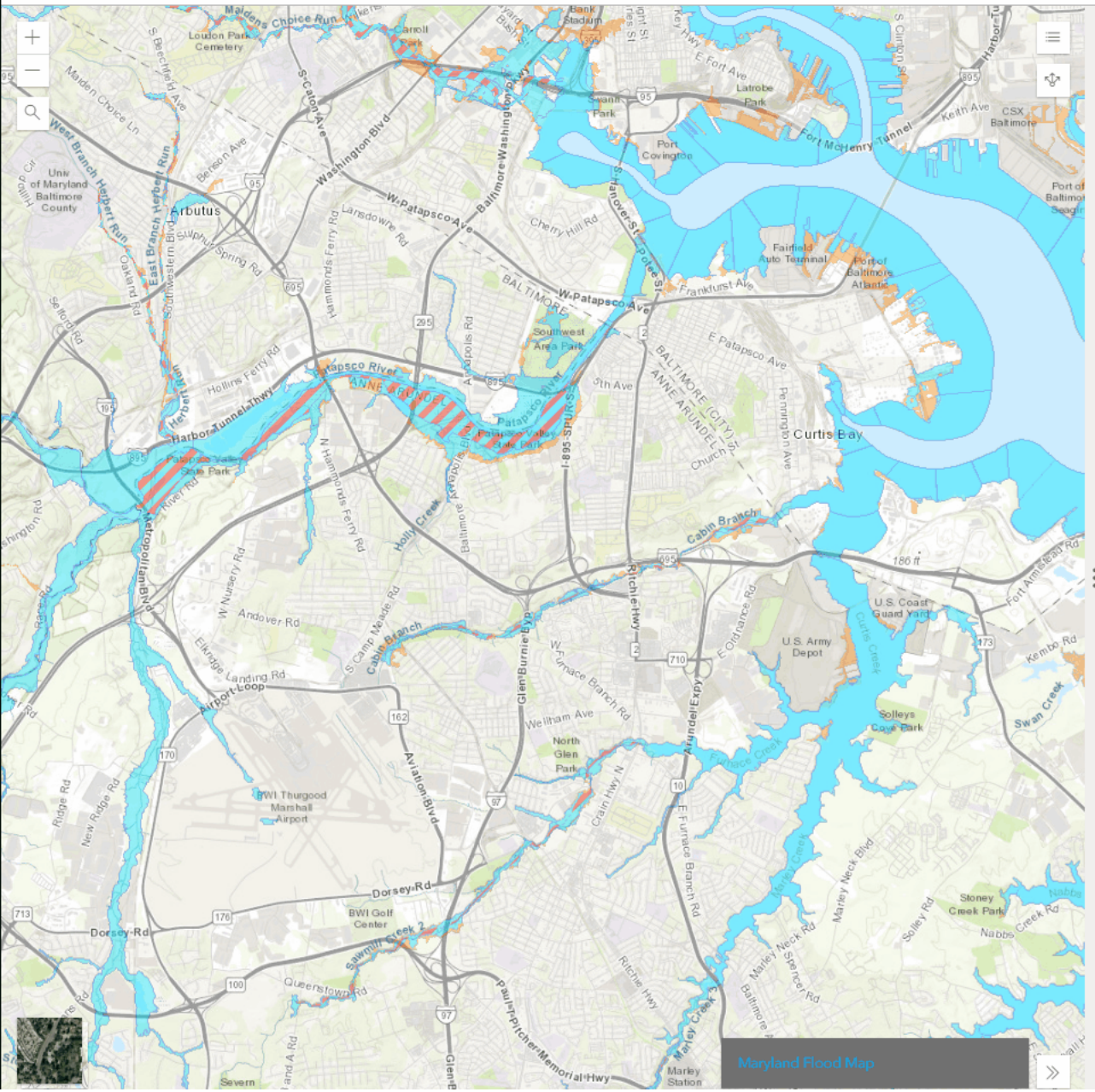


- Open web scene in AGOL
- Click on the Create Web App Option
- Click on ‘Using a Template’ for pre-defined apps





https://arcg.is/1iiC4P

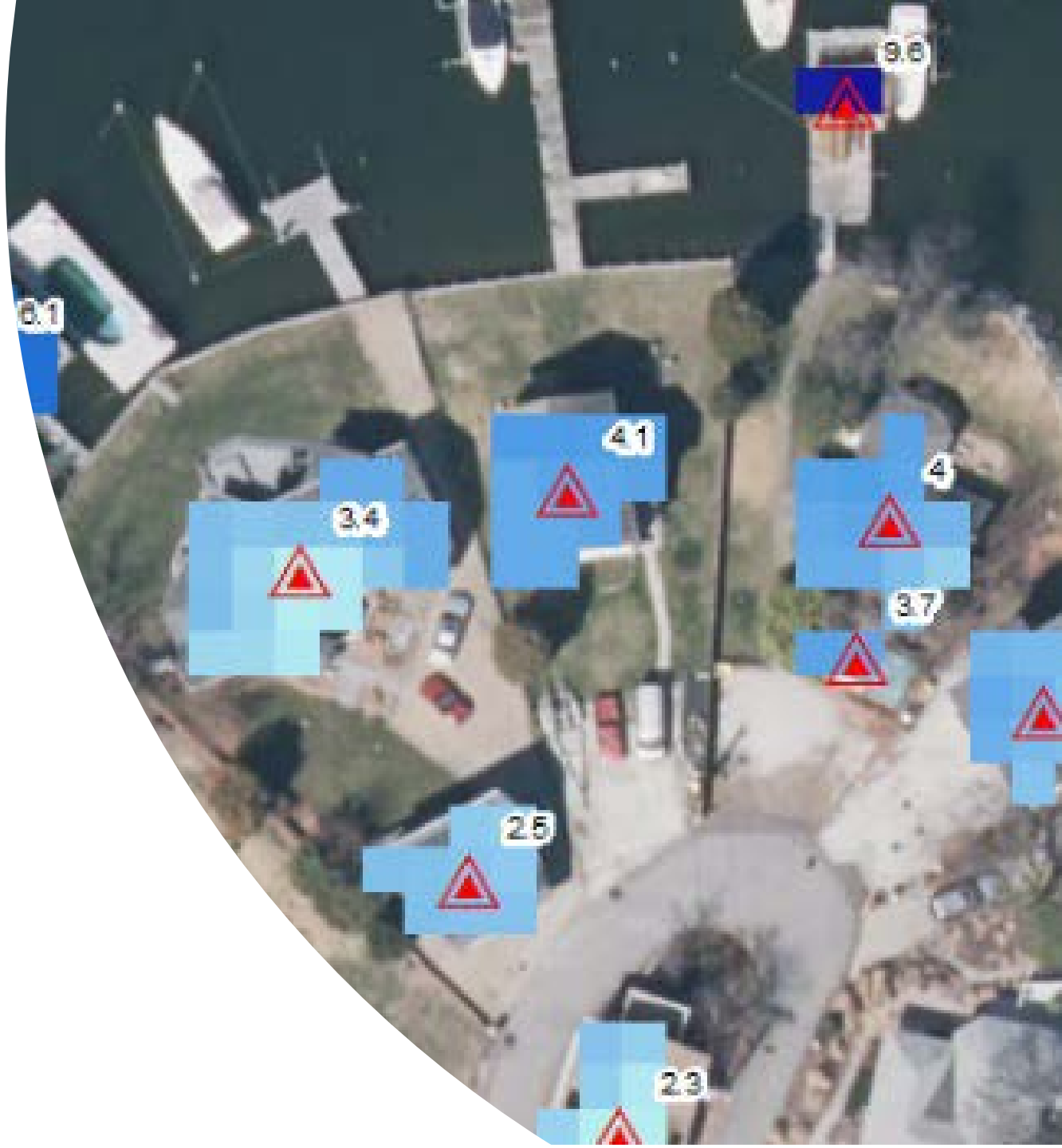


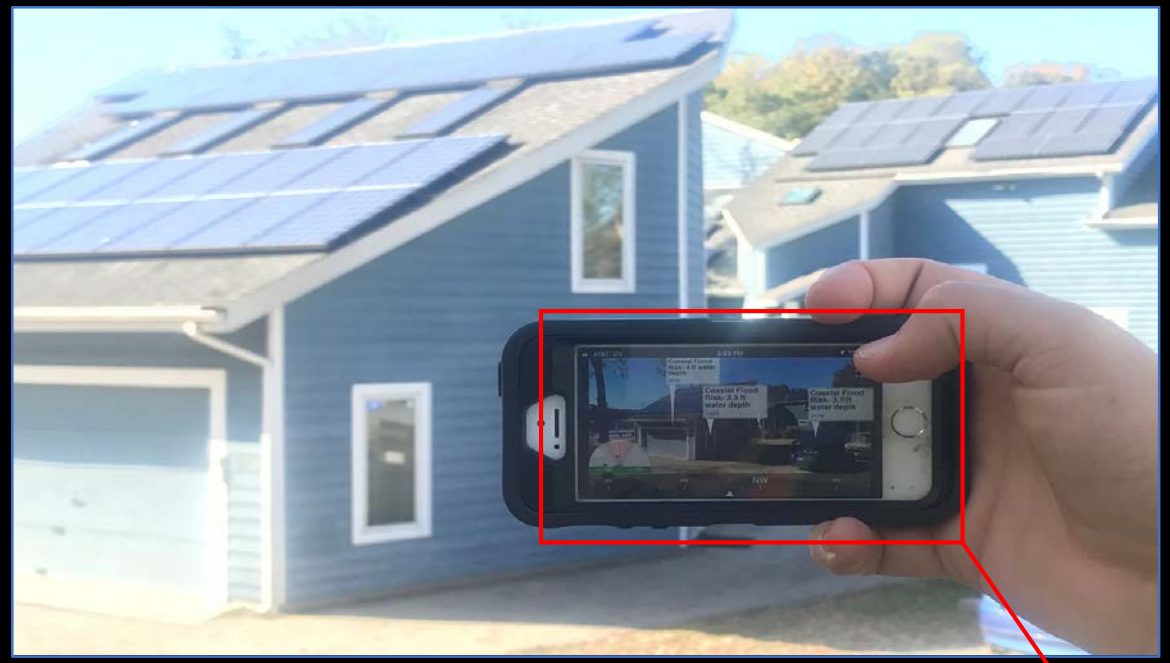
Developing an Augmented Reality View from Depth Grid Data – Data Processing

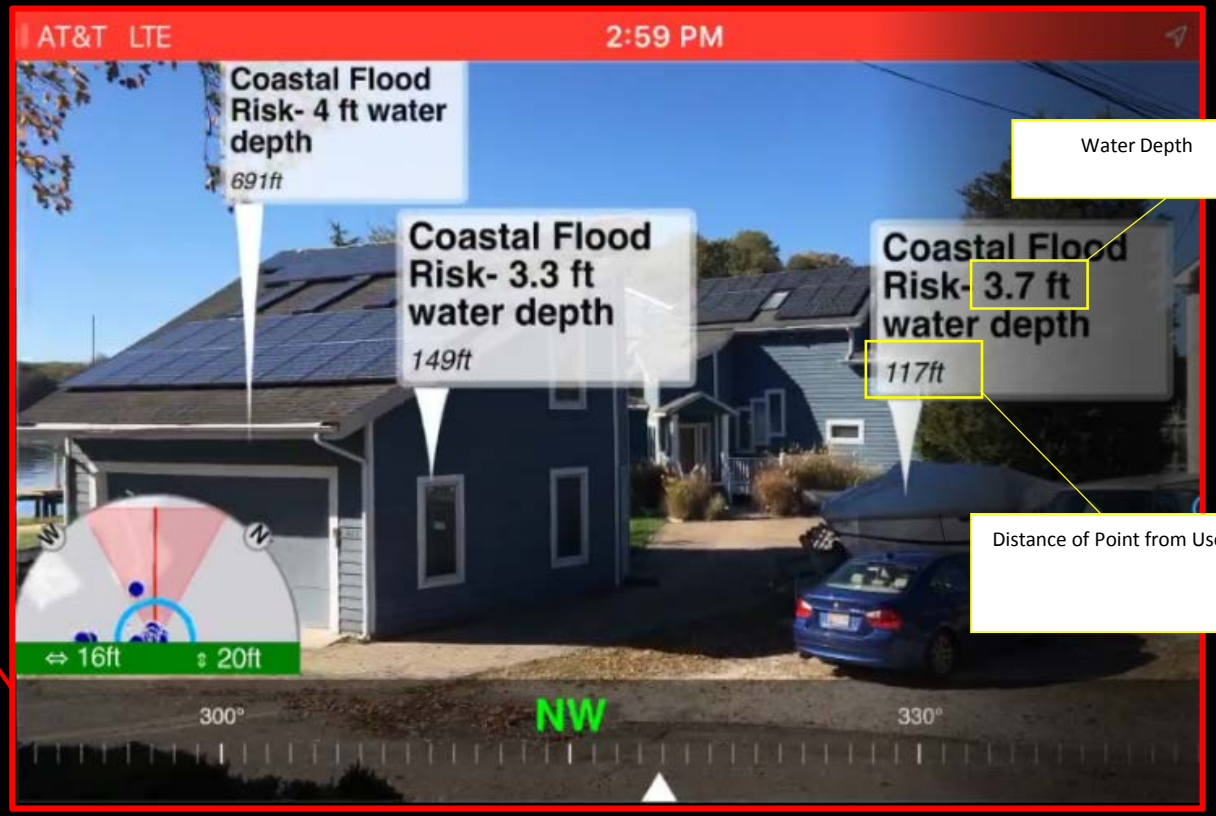
- Create a depth grid point for each building footprint.
  - Using the Extract by Mask tool, create a new raster that reflects the overlap between the building footprint polygon and the depth grid raster.
  - Using the Raster to Point tool, create an array of points that represent depth values of water elevation throughout the building footprint (retain the water depths via the GRID_CODE field).
  - Using the Spatial Join tool, create one point per building reflecting the maximum height of water along the building, as per the 1% annual chance floodplain.

Developing an Augmented Reality View from Depth Grid Data – Publishing the Data

- Prepare depth grid points for AuGeO
  - Using the Feature to 3D by attribute tool, the point layer was converted to a 3D layer with Z-values enabled.
  - Publish the point layer to ArcGIS online as a feature service and made publicly available.






AT&T LTE
2:59 PM
Coastal Flood Risk- 4 ft water depth
691ft
Coastal Flood Risk- 3.3 ft water depth
149ft
Coastal Flood Risk- 3.7 ft water depth
117ft
⇔ 16ft
⇕ 20ft
300°
NW
330°
Water Depth
Distance of Point from User

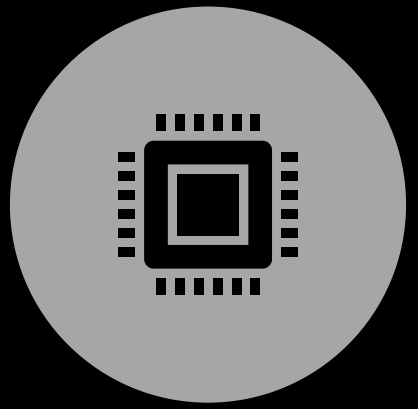

4'
3.7'
3.7'
3.6'
3.2'
3.3'
1.9'
3.2'
2.9'
2.6'

Lessons Learned

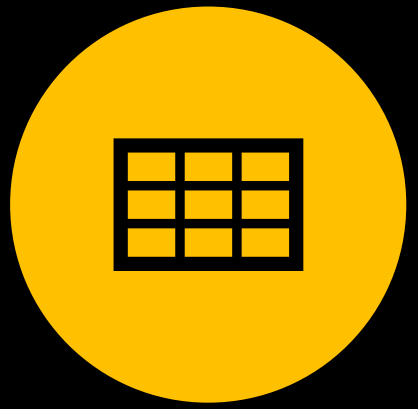
- Depth Grid data developed as part of non-regulatory risk map products can be integrated into 3D and augmented reality applications with relative ease
- COTS software exists that's capable of building 3D web applications viewable through a web browser, no installation required, no programming required
- Becomes an effective means of communicating the potential severity of flood risk to the public, beyond "I'm in or I'm out" 2D or Plan View
- Using ESRI platform – 3D data and applications can be published via ArcGIS Online and do not have to consume internal system resources
- Solution does require understanding of principles and concepts of Geographic Information Systems (GIS). Best to start basic and scale up with more data and increased functionality over time

Limitations of Data/Applications

THE DATA AND APPLICATIONS DEVELOPED FROM DEPTH GRIDS SHOULD BE USED FOR RELATIVE LOCATION ONLY AND SHOULD NOT BE THE SOLE REFERENCE FOR DETERMINING ONE'S MANDATORY PURCHASING REQUIREMENT FOR FLOOD INSURANCE AS PART OF THE NFIP



AUGEO – THE ACCURACY OF THE GPS PRESENT ON THE MOBILE DEVICE/TABLET WILL EFFECT HOW WELL THE DATA RENDERS INSIDE THE APPLICATION. IT CAN ONLY DISPLAY POINT FEATURES, NO LINES OR POLYGONS



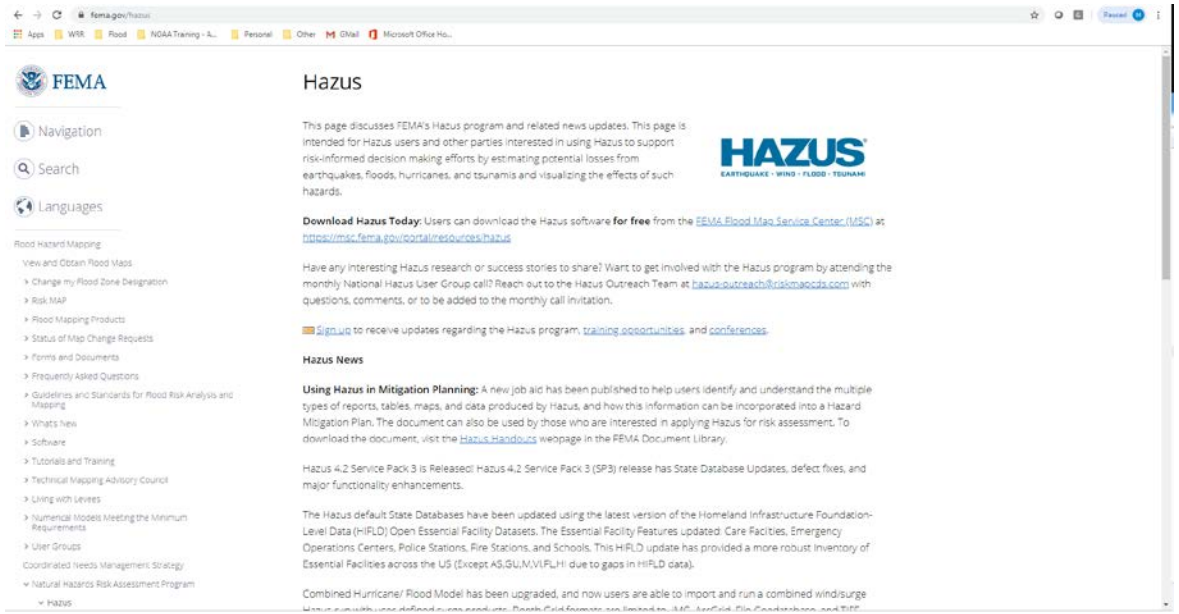
DEPTH GRID DATA IS VARIABLE BETWEEN COMMUNITIES (NOT ALL COUNTIES ARE COMPLETE COVERAGES). TERRAIN DATASETS CAN CAUSE RENDERING OF 3D VIEWS TO BE MISLEADING

Data Availability

County	Enhanced Coastal Flood Risk Report - UDF Analysis Only	Enhanced Riverine Flood Risk Report - UDF Analysis Only	Enhanced Coastal Flood Risk Report - UDF, Debris Generation, Shelter Needs, Essential Facilities, State Assets Analyses	Enhanced Riverine Flood Risk Report - UDF, Debris Generation, Shelter Needs, Essential Facilities, State Assets Analyses
Allegany County	N/A	N/A	N/A	State Of Maryland Flood Risk Report Allegany County, Maryland MM/DD/2019
Anne Arundel County	Flood Risk Report Anne Arundel County, Maryland Coastal Study 09/09/2015	N/A	State Of Maryland Flood Risk Report Anne Arundel County, Maryland MM/DD/2019	State Of Maryland Flood Risk Report Anne Arundel County, Maryland MM/DD/2019
City of Annapolis	Included in Anne Arundel FRR	N/A	Included in Anne Arundel FRR	Included in Anne Arundel FRR
Baltimore City	Flood Risk Report Baltimore City, Maryland Coastal Study 05/30/2014			
Baltimore County	Flood Risk Report Baltimore County, Maryland Coastal Study 12/16/2014			
Calvert County	Flood Risk Report Calvert County, Maryland Coastal Study 07/08/2015			
Caroline County	Flood Risk Report Caroline County, Maryland Coastal Study 07/17/2015		State Of Maryland Flood Risk Report Caroline County, Maryland MM/DD/2019	State Of Maryland Flood Risk Report Caroline County, Maryland MM/DD/2019
Carroll County	N/A		N/A	
Cecil County	Flood Risk Report Cecil County, Maryland Coastal Study 11/02/2015			
Charles County	Flood Risk Report Charles County, Maryland Coastal Study 11/04/2015	N/A	State Of Maryland Flood Risk Report Charles County, Maryland MM/DD/2019	State Of Maryland Flood Risk Report Charles County, Maryland MM/DD/2019
Dorchester County	Flood Risk Report Dorchester County, Maryland Coastal Study 01/20/2016	N/A	State Of Maryland Flood Risk Report Dorchester County, Maryland MM/DD/2019	State Of Maryland Flood Risk Report Dorchester County, Maryland MM/DD/2019
Frederick County	N/A		N/A	
Garrett County	N/A	N/A	N/A	State Of Maryland Flood Risk Report Garrett County, Maryland MM/DD/2019
Harford County	Flood Risk Report Harford County, Maryland 11/03/2015	Flood Risk Report Harford County, Maryland 11/03/2015		
Howard County	N/A		N/A	
Kent County	Flood Risk Report Kent County, Maryland Coastal Study 11/14/2014			
Montgomery County	N/A		N/A	
Prince George's County	Flood Risk Report Prince George's County, Maryland Coastal Study 12/17/2015			
Queen Anne's County	Flood Risk Report Queen Anne's County, Maryland Coastal Study 06/30/2015	N/A	State Of Maryland Flood Risk Report Queen Anne's County, Maryland MM/DD/2019	State Of Maryland Flood Risk Report Queen Anne's County, Maryland MM/DD/2019
St. Mary's County	Flood Risk Report St. Mary's County, Maryland Coastal Study 04/21/2015			
Somerset County	Flood Risk Report Somerset County, Maryland Coastal Study 05/04/2016	N/A	State Of Maryland Flood Risk Report Somerset County, Maryland MM/DD/2019	State Of Maryland Flood Risk Report Somerset County, Maryland MM/DD/2019
Talbot County	Flood Risk Report Talbot County, Maryland Coastal Study 08/03/2016			
Washington County	N/A	Flood Risk Report Washington County, Maryland 1/31/2017	N/A	State Of Maryland Flood Risk Report Washington County, Maryland MM/DD/2019
Wicomico County	Flood Risk Report Wicomico County, Maryland Coastal Study 09/30/2015			
Worcester County	Flood Risk Report Worcester County, Maryland Coastal Study 12/30/2015	N/A	State Of Maryland Flood Risk Report Worcester County, Maryland MM/DD/2019	State Of Maryland Flood Risk Report Worcester County, Maryland MM/DD/2019
Ocean City	Included in Worcester County FRR	N/A	Included in Worcester County FRR	Included in Worcester County FRR

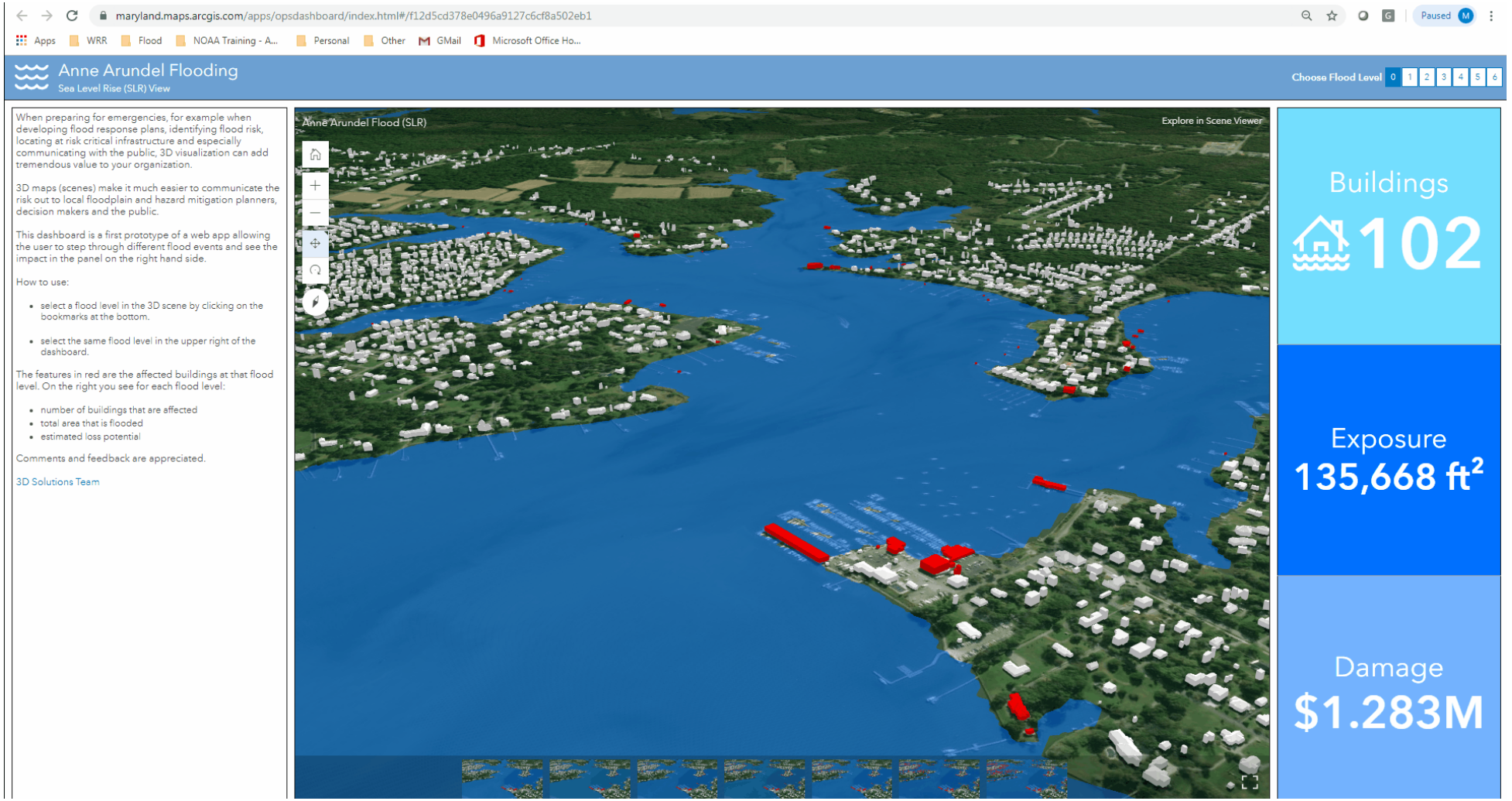
What if Depth Grids aren't available for your Community

FEMA's Hazus - https://www.fema.gov/hazus



https://www.youtube.com/watch?v=8CNtSAXoRIk

What's Next?



Prototype only, not real data - https://maryland.maps.arcgis.com/apps/opsdashboard/index.html#/f12d5cd378e0496a9127c6cf8a502eb1

Summary

Data, systems, and applications are enhanced for 3D and AR using ESRI platform

Leverage GIS Analysts to support the lift

Start basic, a small study area as a pilot, then scale up

- Expanded Freeboard Data
- Sea Level Rise
- Critical Facilities
- Other HMP Data

Links

FEMA Flood Map Service:

https://msc.fema.gov/portal/home

Local Government 3D Basemaps:

https://solutions.arcgis.com/local-government/planning-and-development/basescenes/

Flood Impact Analysis:
https://community.esri.com/people/GvanMaren-esristaff/blog/2019/02/06/beta-release-of-3d-flood-impact-solution

3D GIS Overview from ESRI:

https://www.esri.com/en-us/arcgis/3d-gis/overview

Blog on 3D from ESRI:

https://www.esri.com/arcgis-blog/products/3d-gis/3d-gis/ar-for-your-gis/