Federal GIS Conference

February 9–10, 2015 | Washington, DC

ArcGIS 3D Analyst: 3D Analysis

Brady Hoak and Gore Bolton

ArcGIS 3D helps customers to…

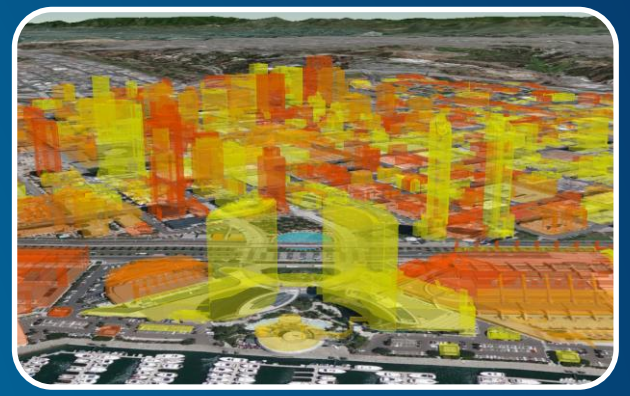
Create and Manage

Quickly and easily extract value from 2D and 3D data

Visualize and Analyze

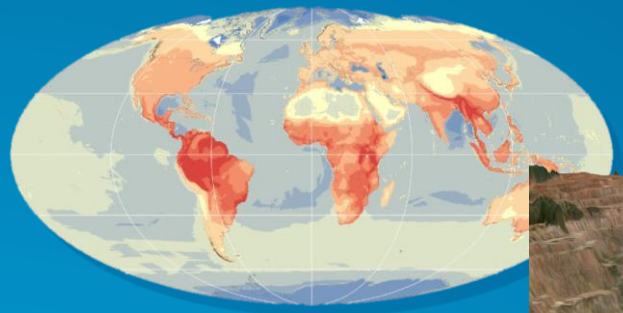
Understand and experience events and change

Design and Simulate



Manage the designed environment

Support 3D GIS across industries

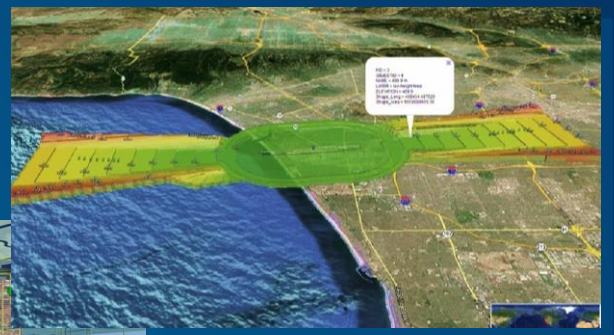


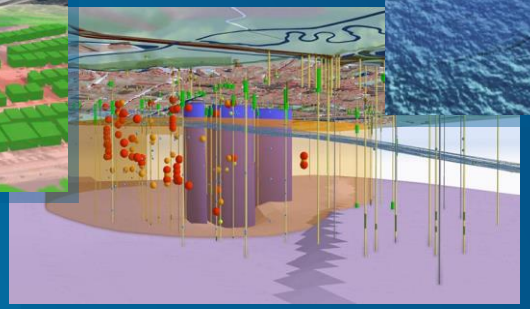
Scientific Visualization

Mining

Developing Energy resources

Transportation



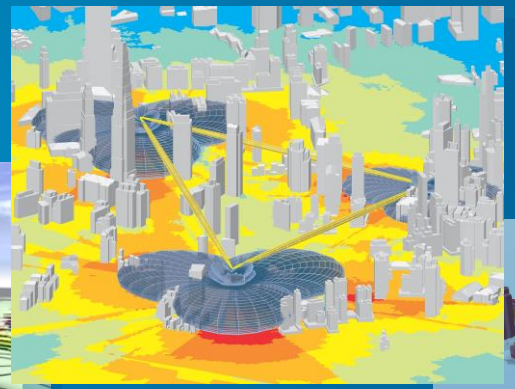


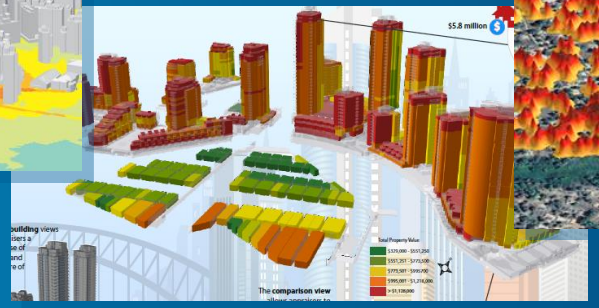
Environmental assessment

Urban Planning

Facilities Management

Utilities and Telecommunications





Land Information Management

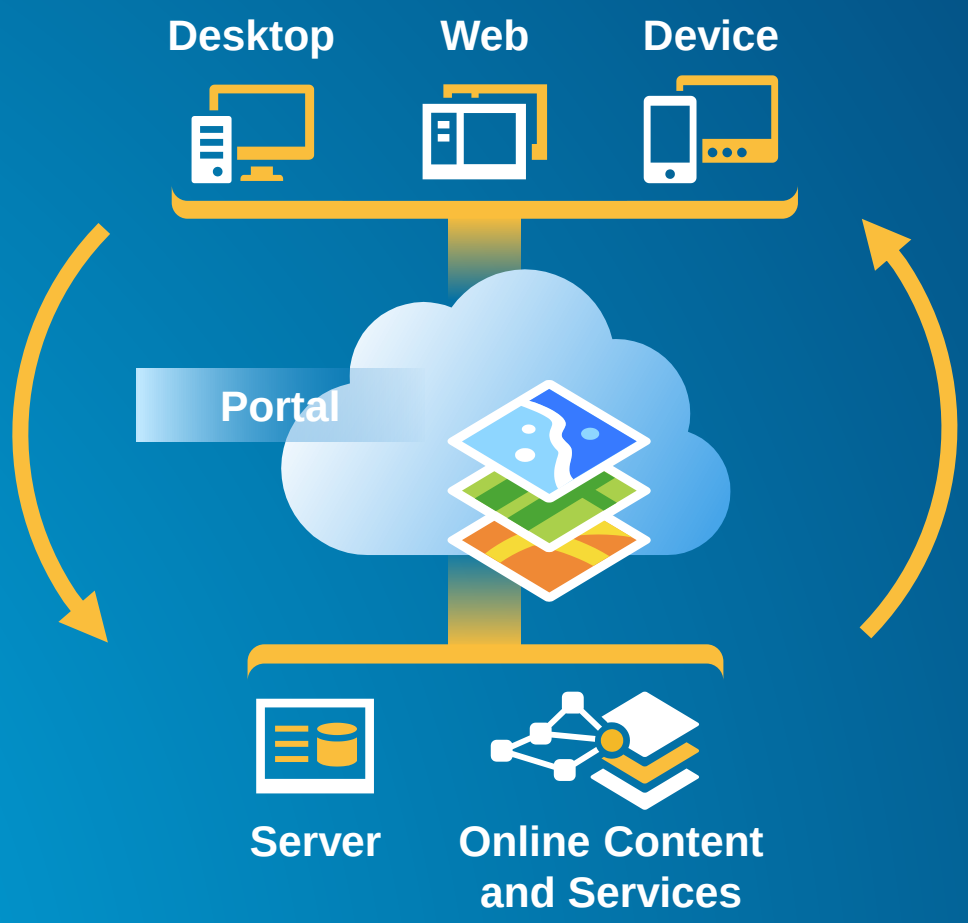
Military

3D Across the Platform

ArcGIS Pro

CityEngine

3D Analyst



ArcGIS Online

Complete workflow for editing, managing, publishing and sharing data in 3D

Key Places within the Platform for 3D Analysis

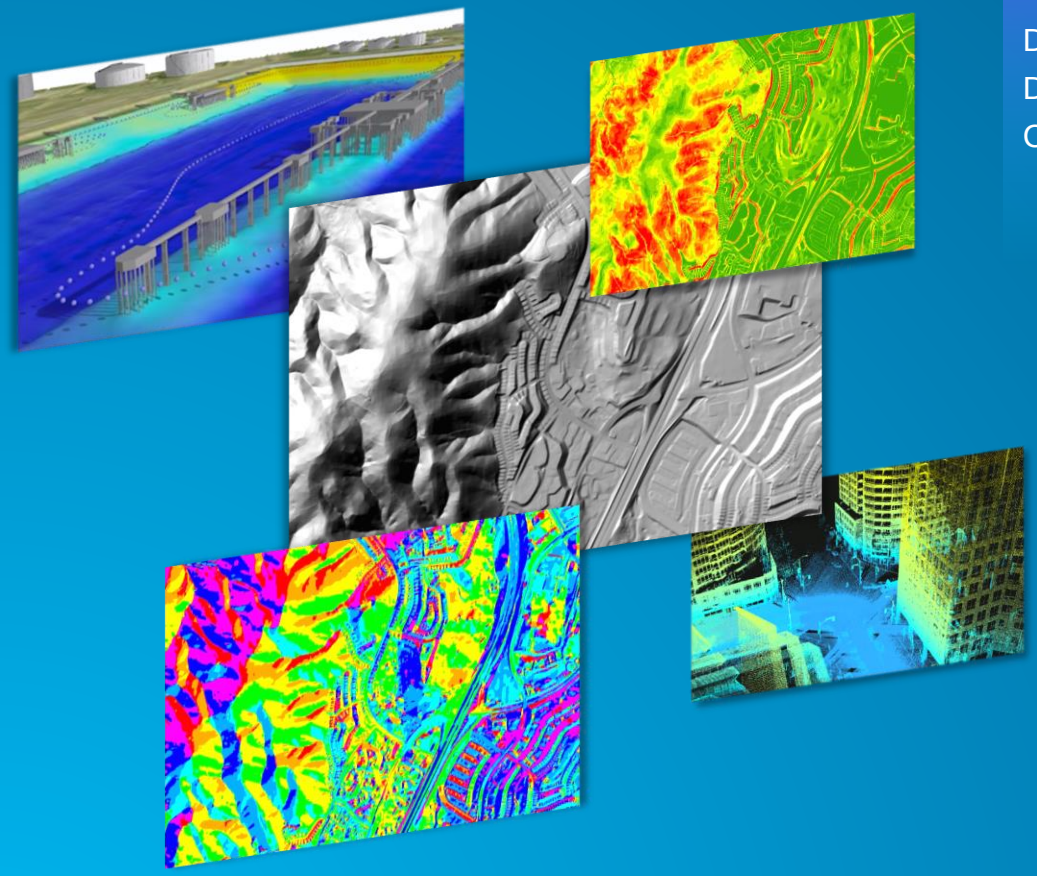
- **ArcGIS for Desktop** (ArcScene, ArcGlobe, ArcMap, ArcGIS Pro)
  - - Includes 3D Toolbars and 3D Geoprocessing Tools

- **ArcGIS for Server**
  - – 3D Published Geoprocessing Services (that use a 3D tool)

- **CityEngine**
  - - CGA rule (that transforms a 3D aspect of a building)

3D Analysis is a workflow to solve a 3D problem.

Analysis Capabilities of 3D Analyst



Area & Volume

Detect Change
Determine Cut/Fill
Calculate Surface Area & Volume

Overlay

3D Statistics
3D Proximity
3D Intersections
Visualization
Profile Graphs
Interpolate Features
Extrude Between Surfaces

Visibility

Line of Sight
Viewshed
Skyline
Shadow Modeling

Data Management

Data Creation
Data Conversion
Lidar QA/QC
Lidar Classification
Surface Interpolation

Surface Derivatives

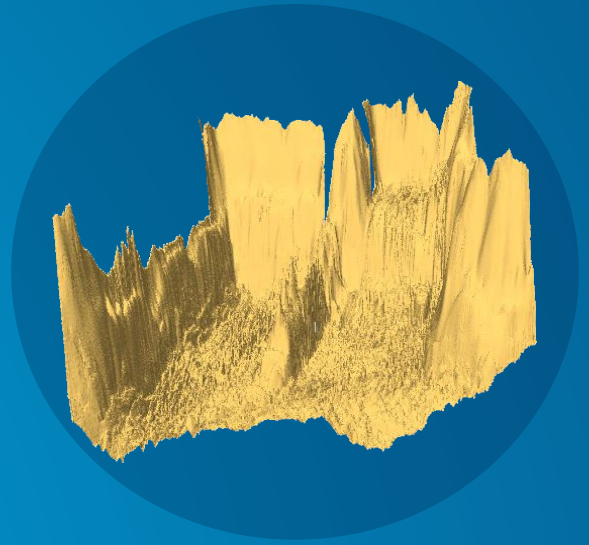
Contours
Slope
Aspect
Hillshade
Statistics
Identify Outliers
Interpolate Geometry
Perform Math Operations

Examples of 3D Feature Analysis

- Visibility Analysis
- 3D Volumetric Modeling
- Shadow Analysis

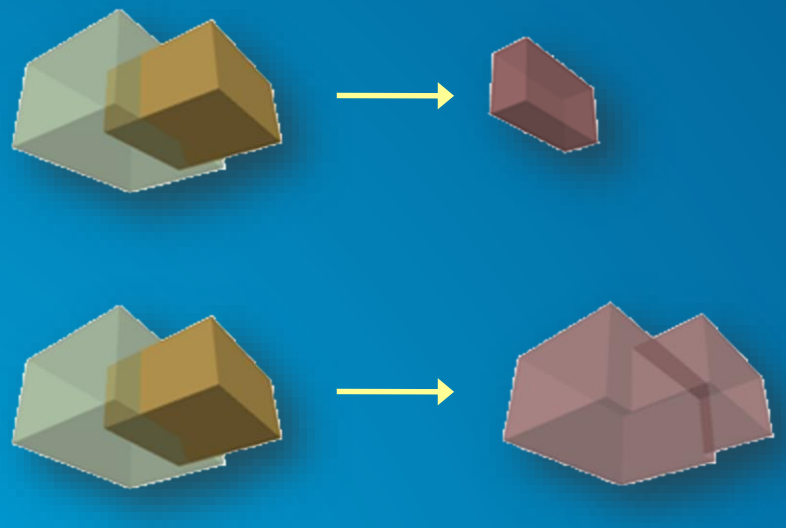
Complex 3D Features

The answer is multipatch!



3D Features Toolset

- Overlay
  - Intersect 3D
  - Union 3D
- Proximity
  - Buffer 3D
  - Near 3D



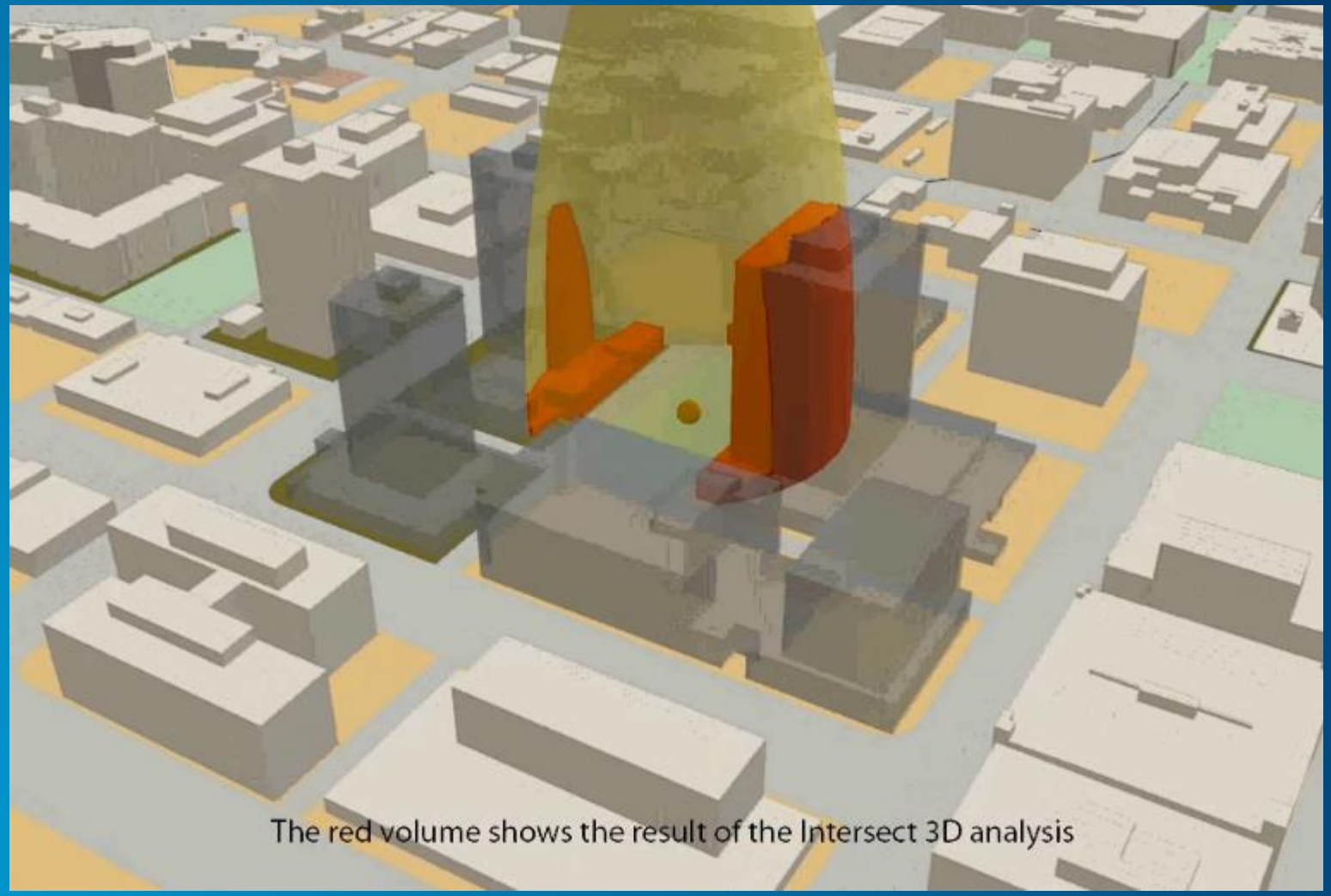
ArcToolbox

- ArcToolbox
- 3D Analyst Tools
  - 3D Features
    - Add Z Information
    - Buffer 3D
    - Difference 3D
    - Enclose Multipatch
    - Feature To 3D By Attribute
    - Inside 3D
    - Intersect 3D
    - Intersect 3D Line With Multipatch
    - Is Closed 3D
    - Near 3D
    - Union 3D
  - CityEngine
  - Conversion
  - Data Management
  - Functional Surface
  - Raster Interpolation
  - Raster Math
  - Raster Reclass
  - Raster Surface
  - Triangulated Surface
  - Visibility

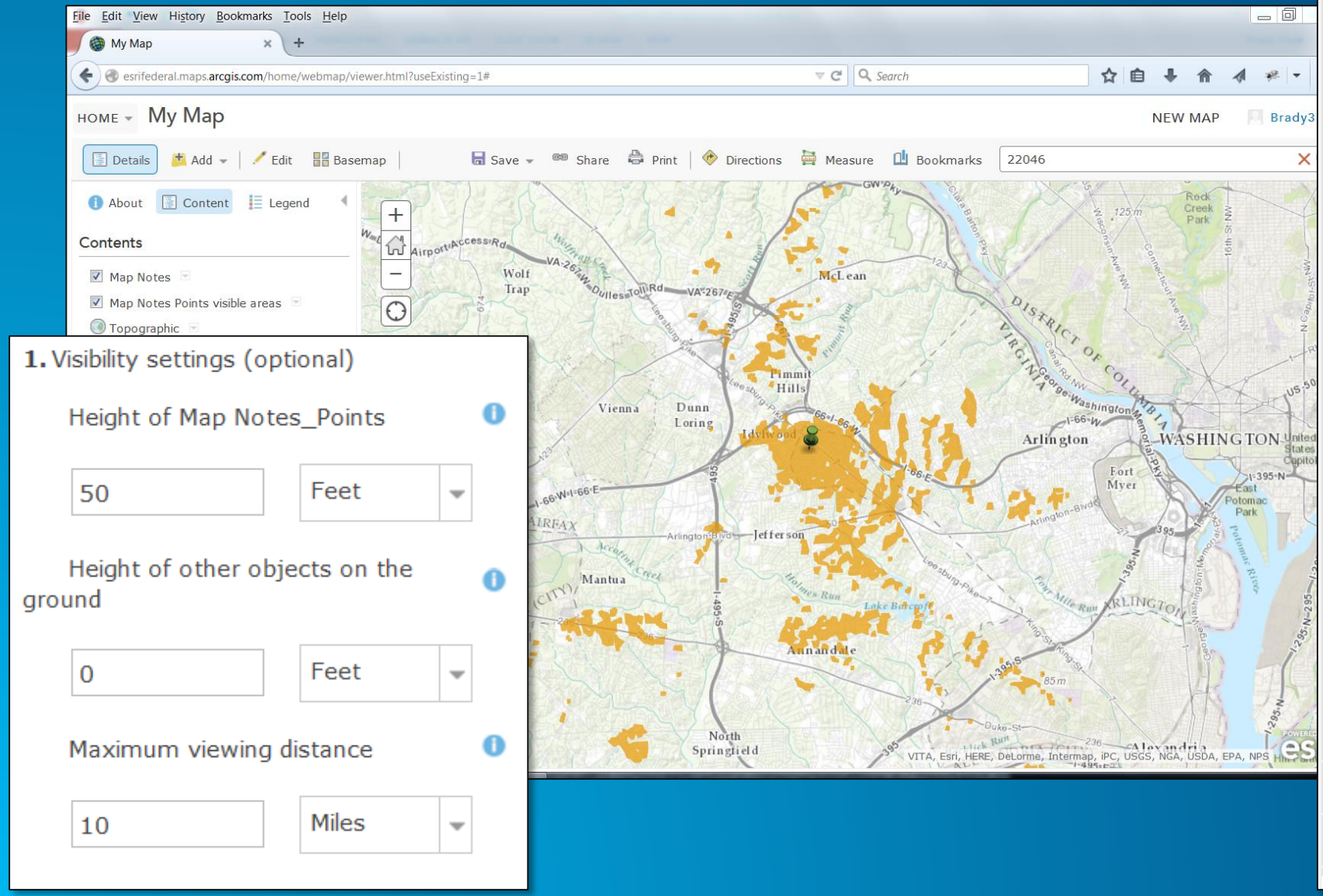
3D Feature Intersect

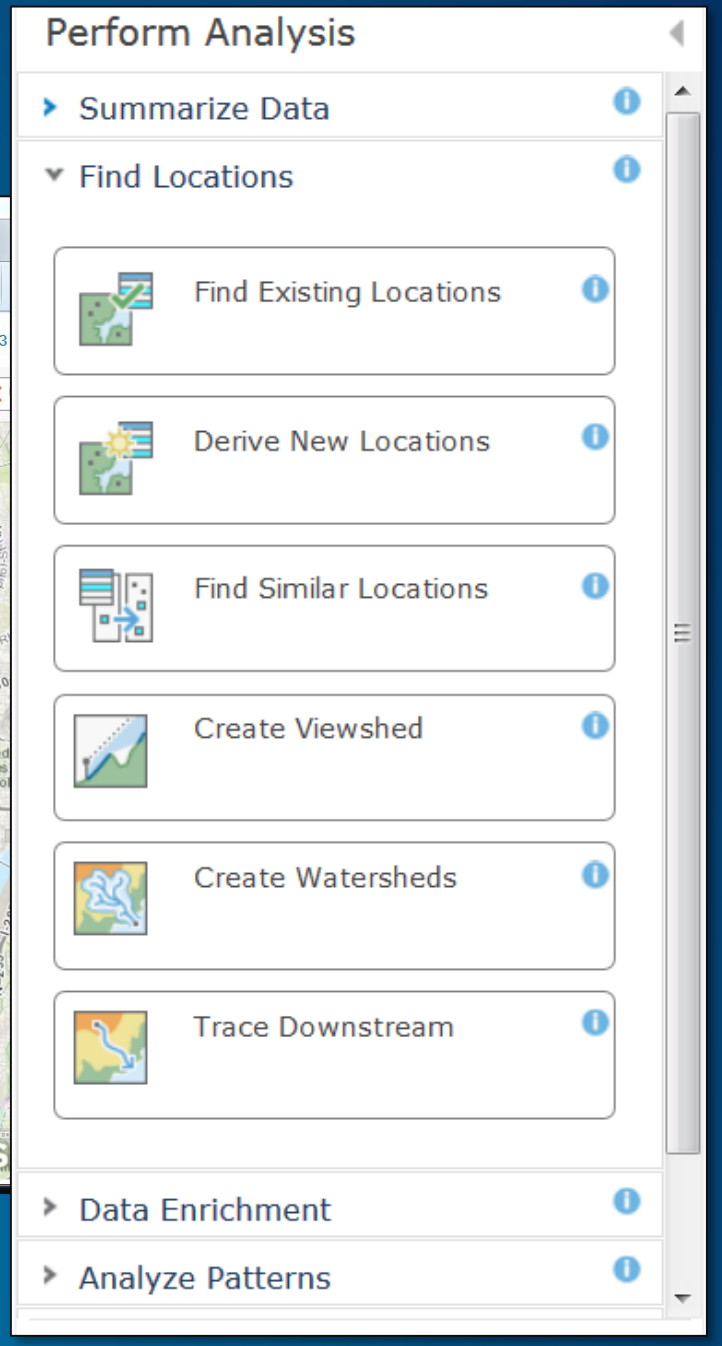
Intersect 3D Tool

Intersect two multipatches to create a new multipatch.



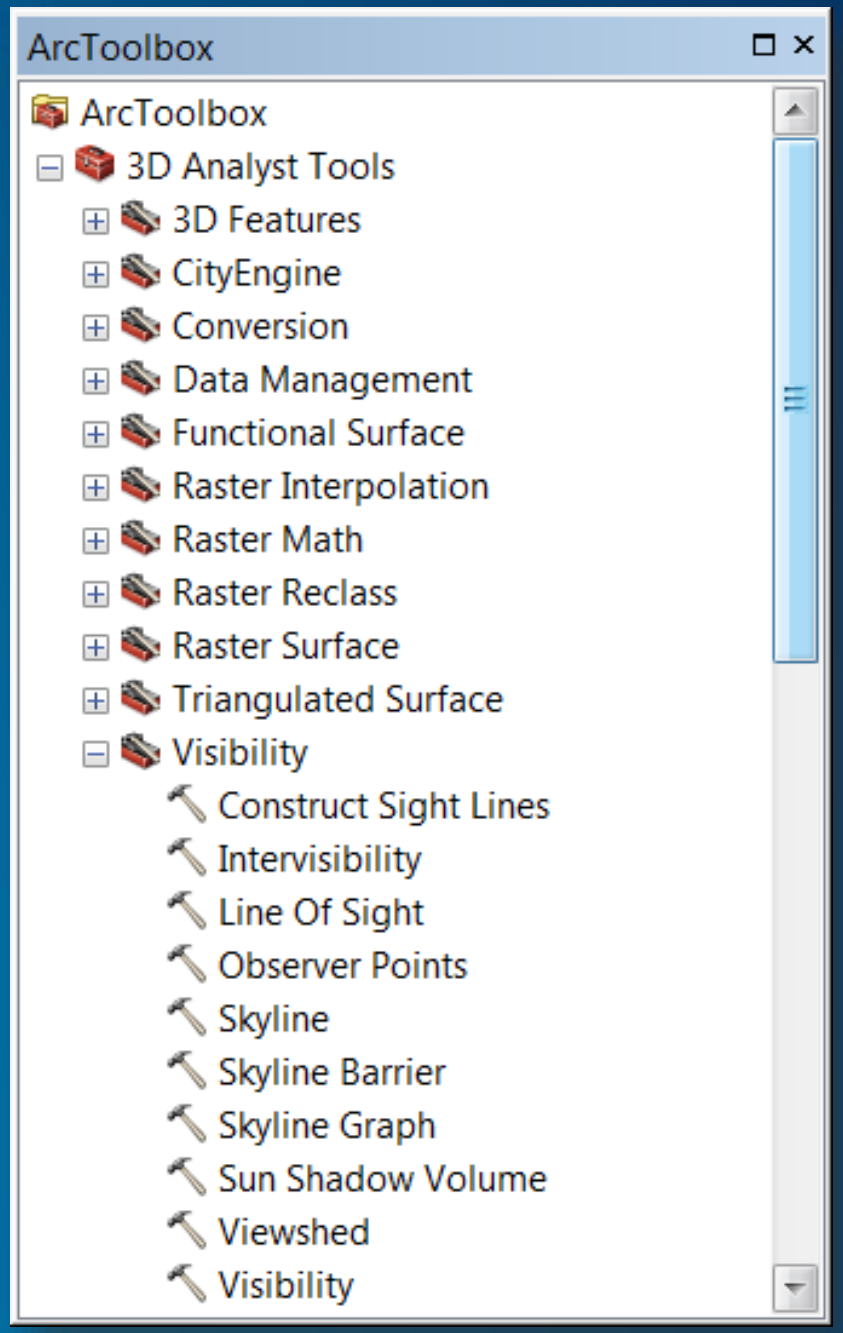
Viewshed Tool in ArcGIS Online





Visibility Toolset in Desktop

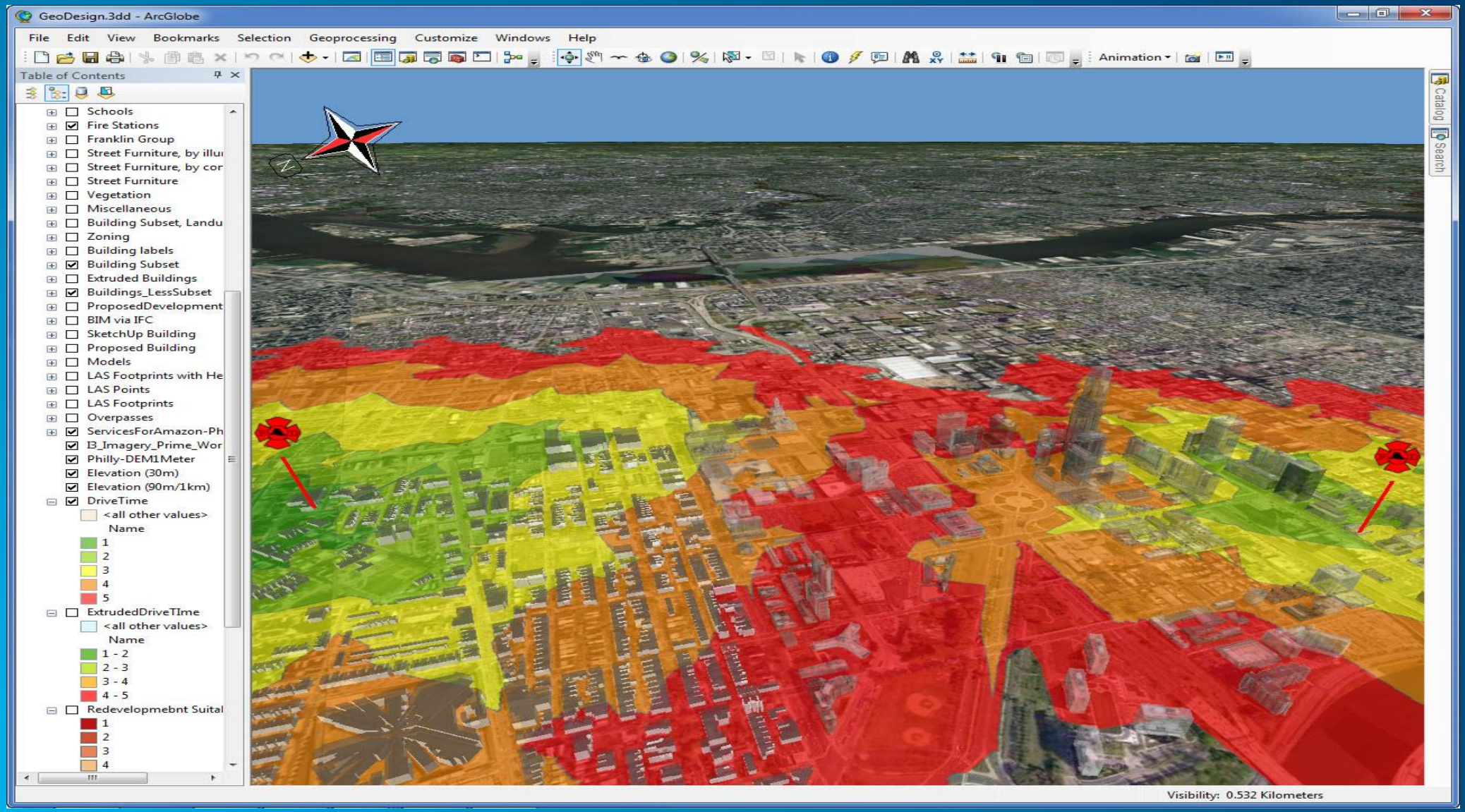
- Line of Sight
- Construct Sight Lines
- Intervisibility
- Viewshed
- Sun Shadow Volume



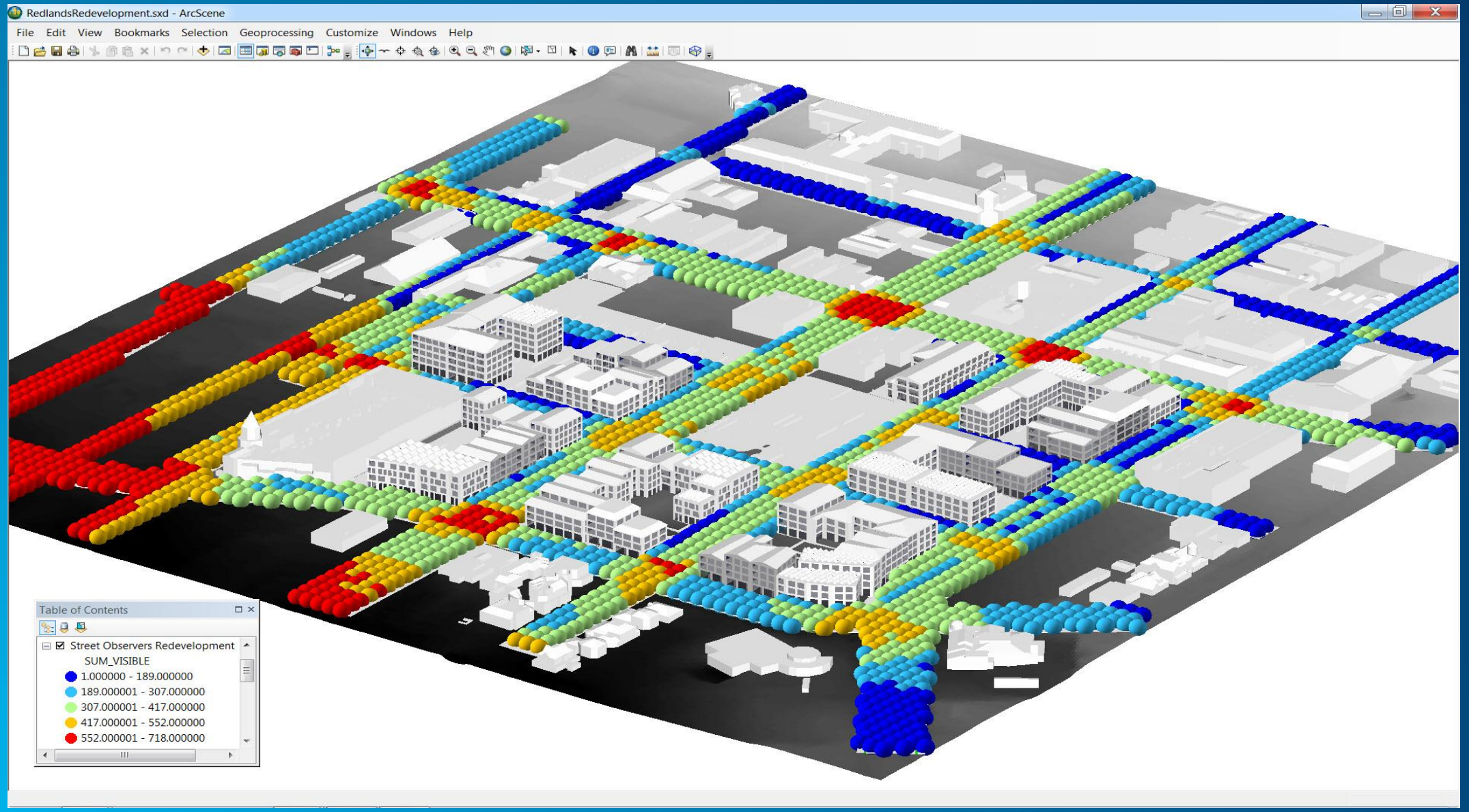
Line of Sight Examples

- Viewshed
- Line of Sight with Obstructions and distance limits
- Cumulative line of sight
- Line of sight to a polygon or line
- View assessments between objects
- Visual Prominence of a single feature

CityEngine Exports to the Geodatabase for Analysis



ArcScene Analysis with CityEngine Buildings – Visual Connectivity



Demo - Line of Sight from Proposed Tower to Airport Apron

ArcGIS FEATURES PLANS GALLERY MAP SCENE HELP Sign In

McCarran Airport Tower/Apron LOS Analysis (3D Web Scene)

3D Data of McCarran Airport with a Line of Sight Analysis from the current tower and a proposed tower 10m higher.

CityEngine Web Scene by bradyhoak

Last Modified: November 17, 2014

★★★★☆ (3 ratings, 889 views)

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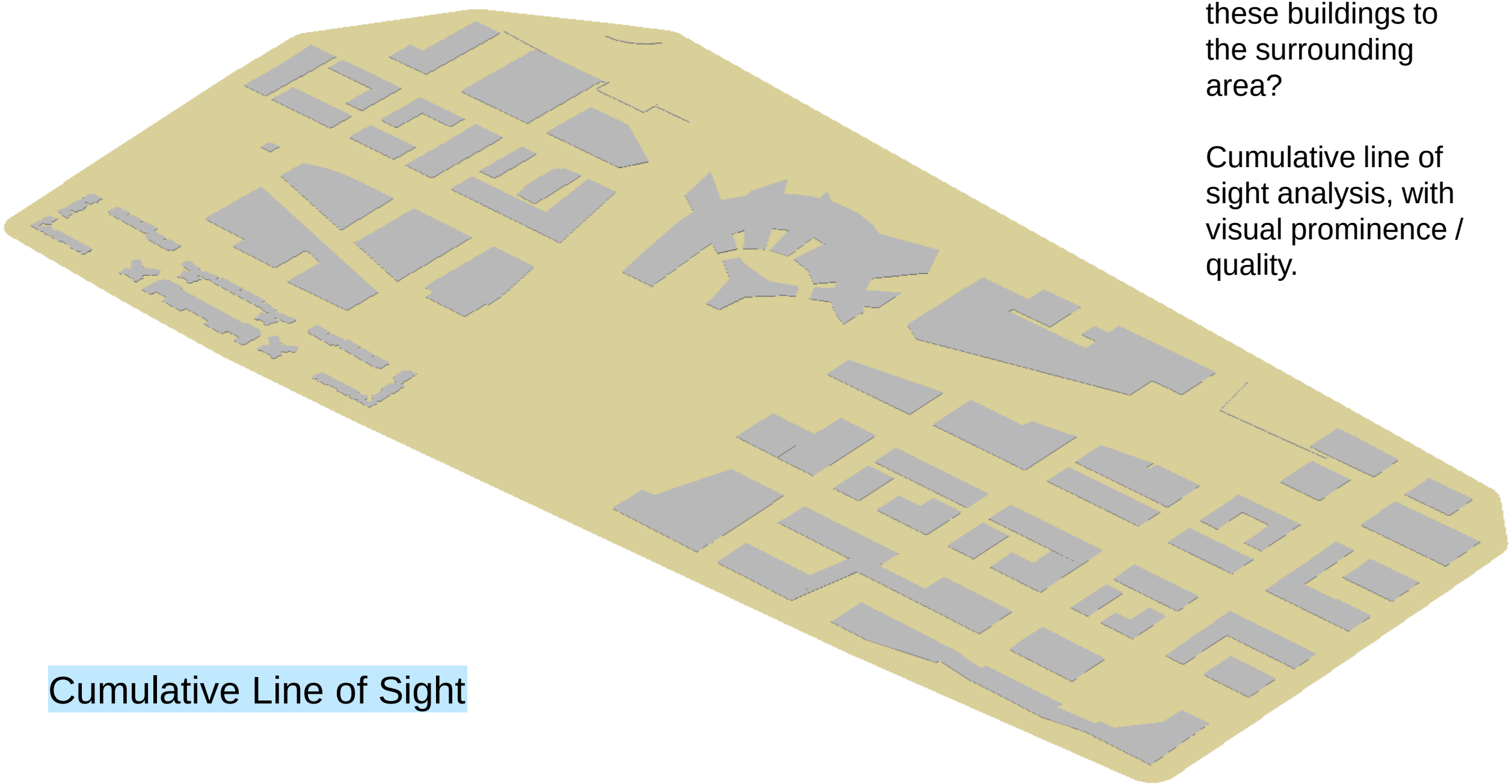
Description

ArcScene was used to perform a line of sight analysis using 3D vector (esri multipatch) data and elevation data to a grid of 5m spaced test points on the airport apron from the observation tower. The observer point was then raised 10m higher to create alternate results. One could use the interactive swipe tool to perform the comparison. Airport Incursion points on the apron show the locations of two incursions. Ideally with futher analysis incidents such as these might be prevented if they could be seen by controllers.

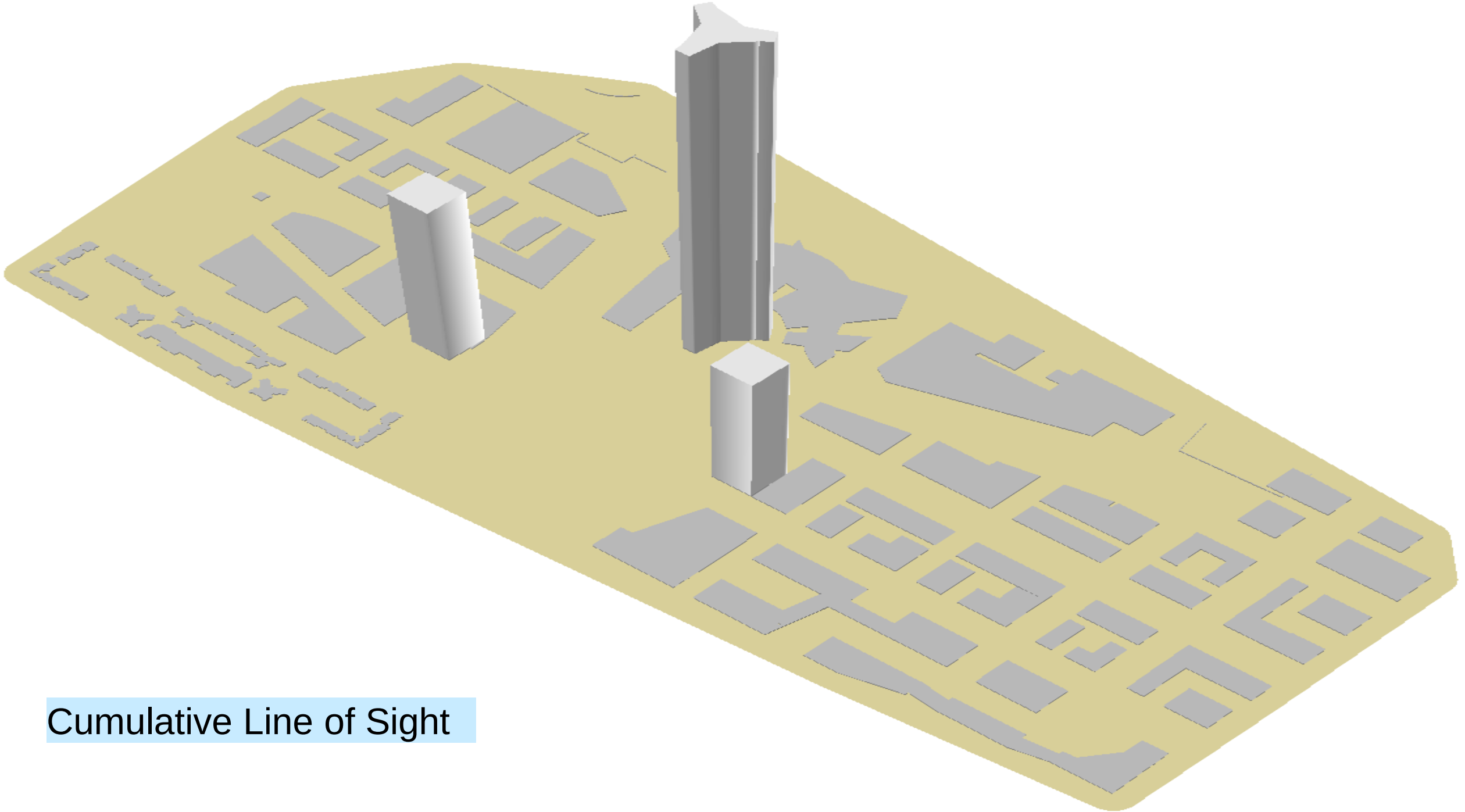
Las Vegas McCarran Airport Buildings from CyberCity 3D

How visible are these buildings to the surrounding area?

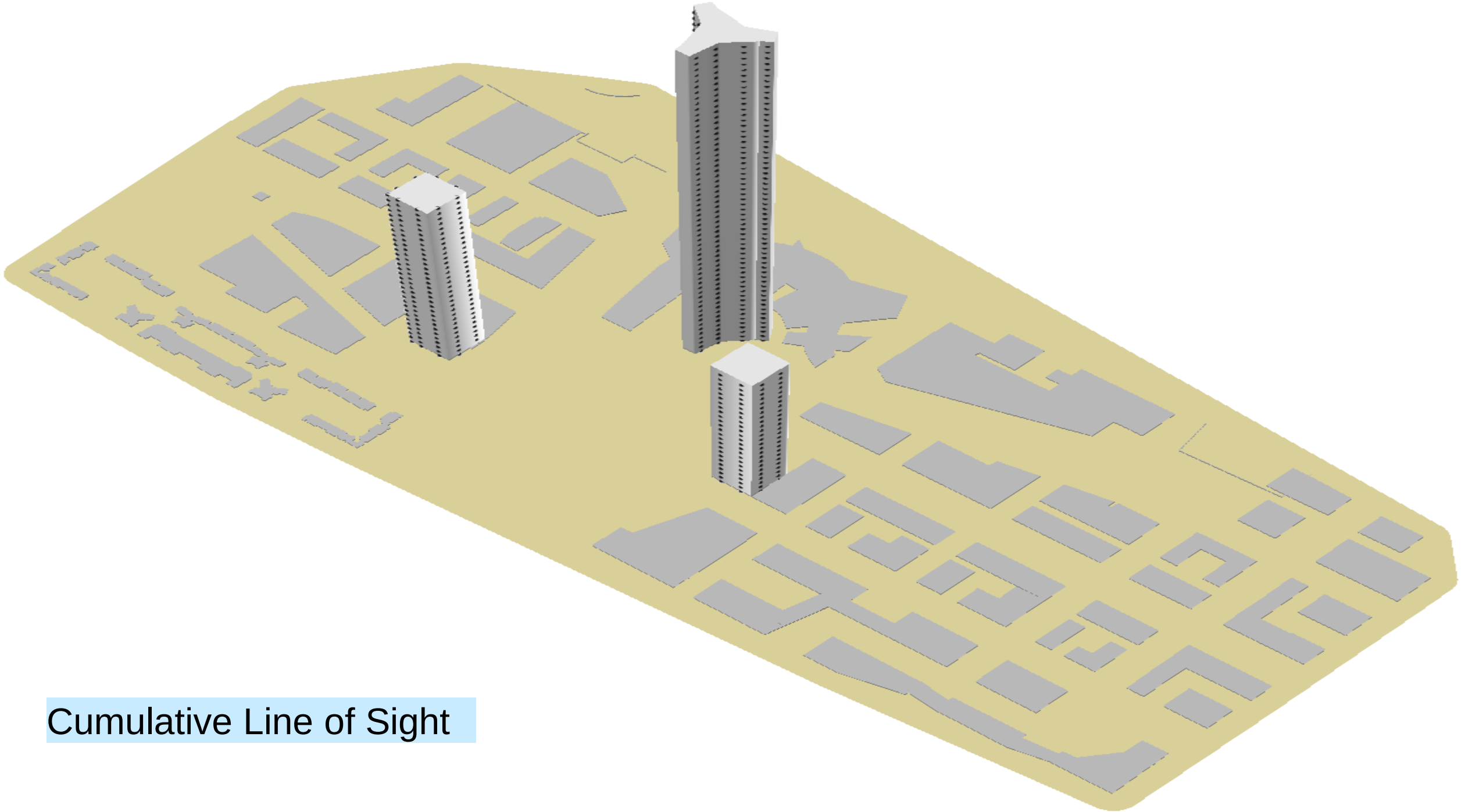
Cumulative line of sight analysis, with visual prominence / quality.



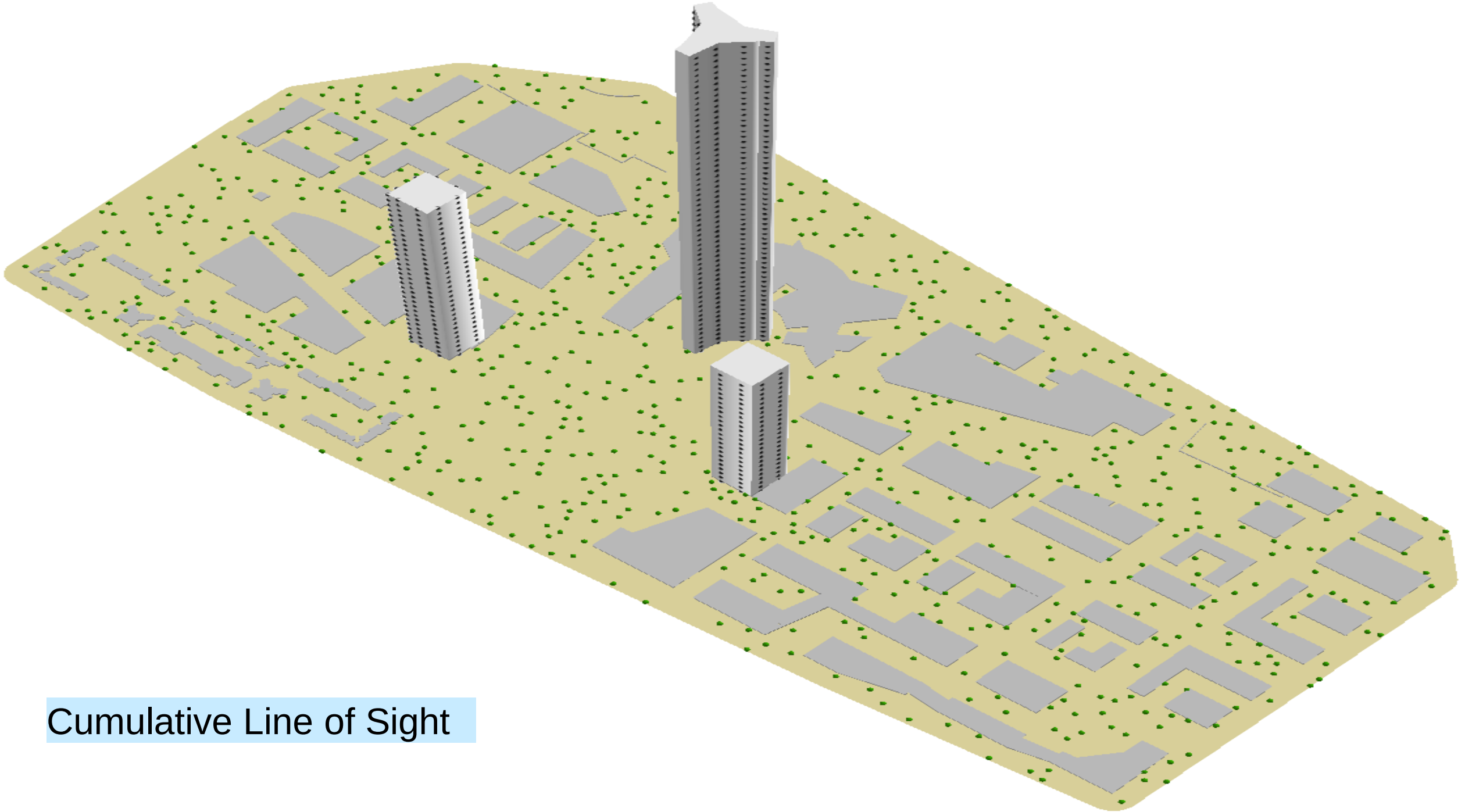
Cumulative Line of Sight



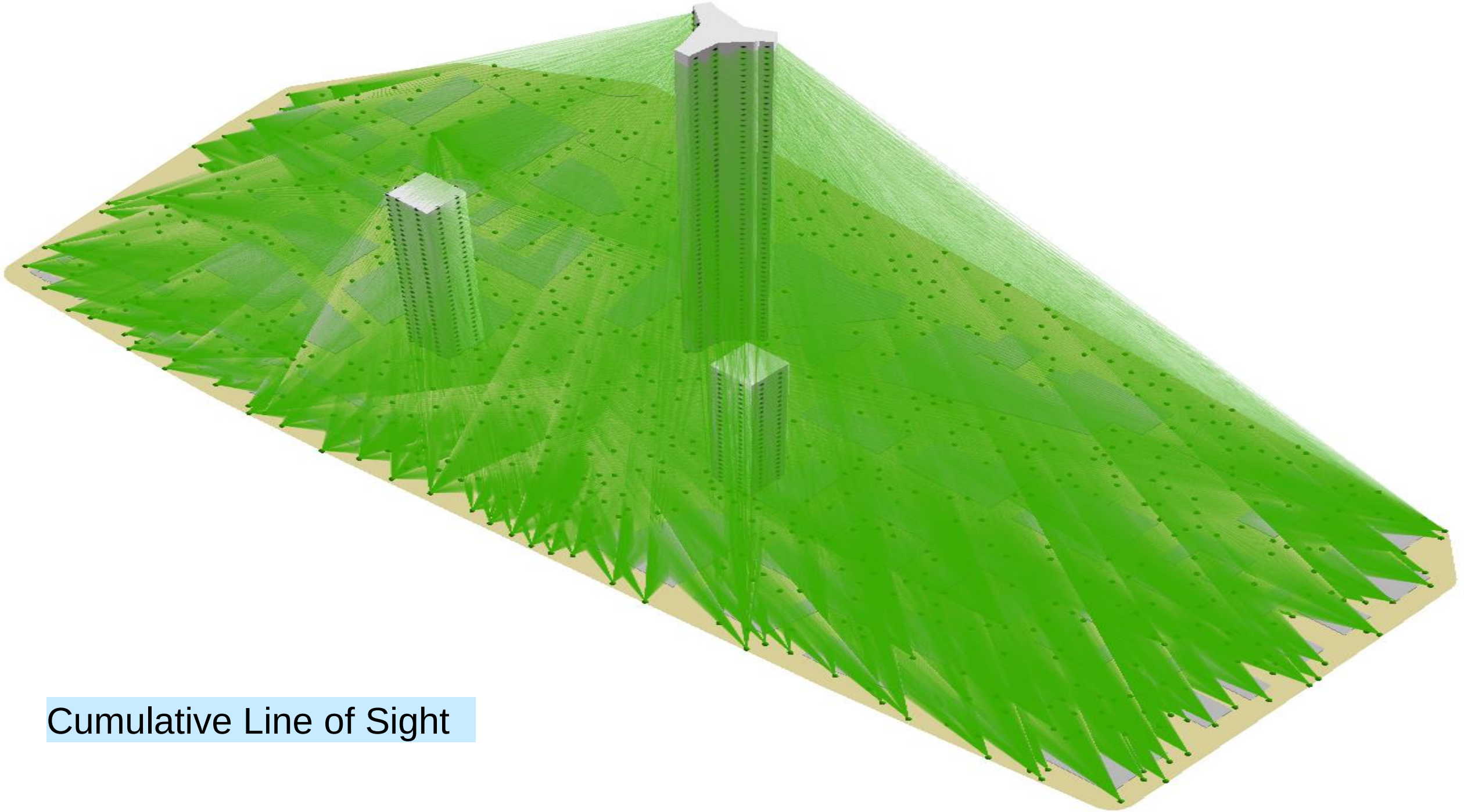
Cumulative Line of Sight



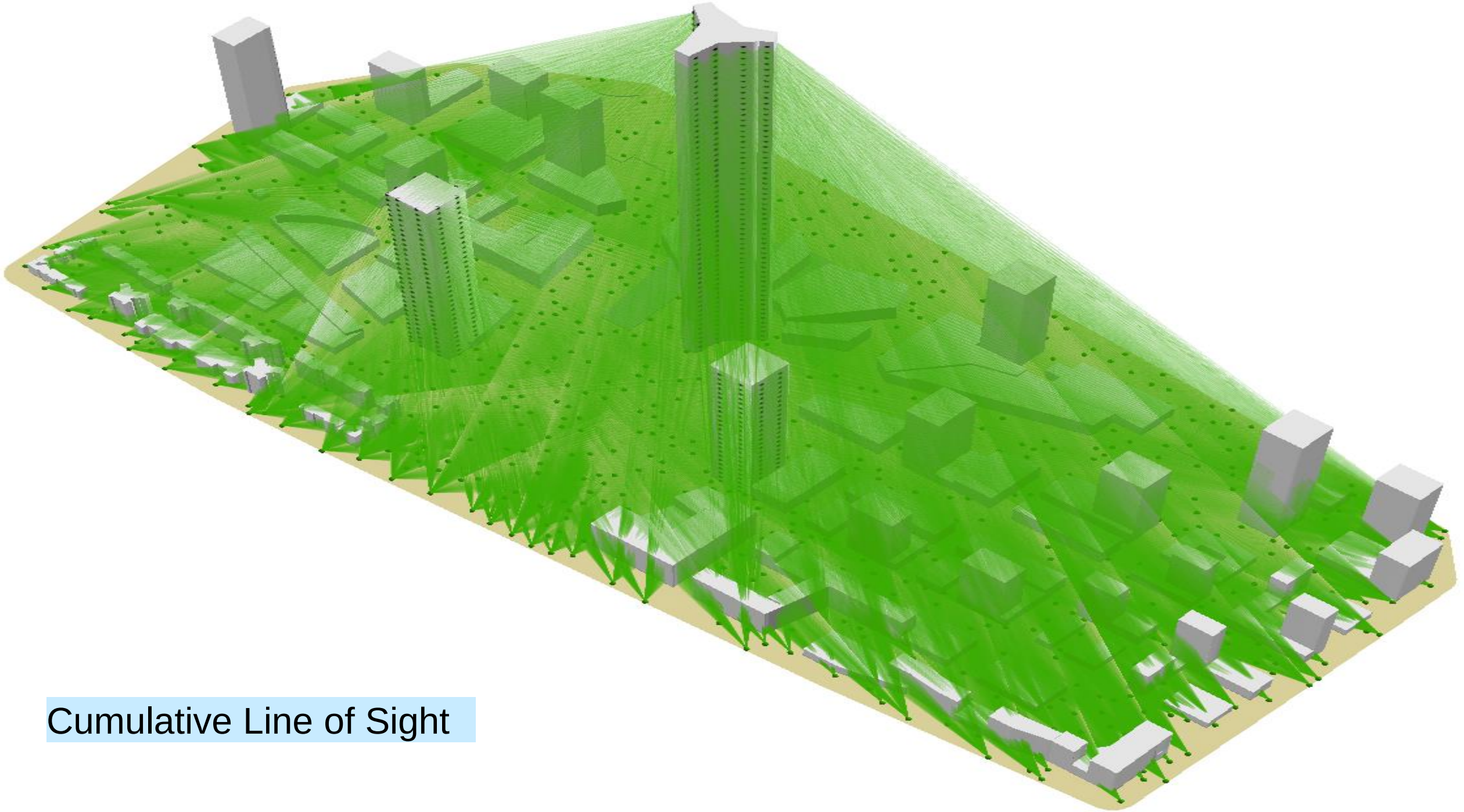
Cumulative Line of Sight



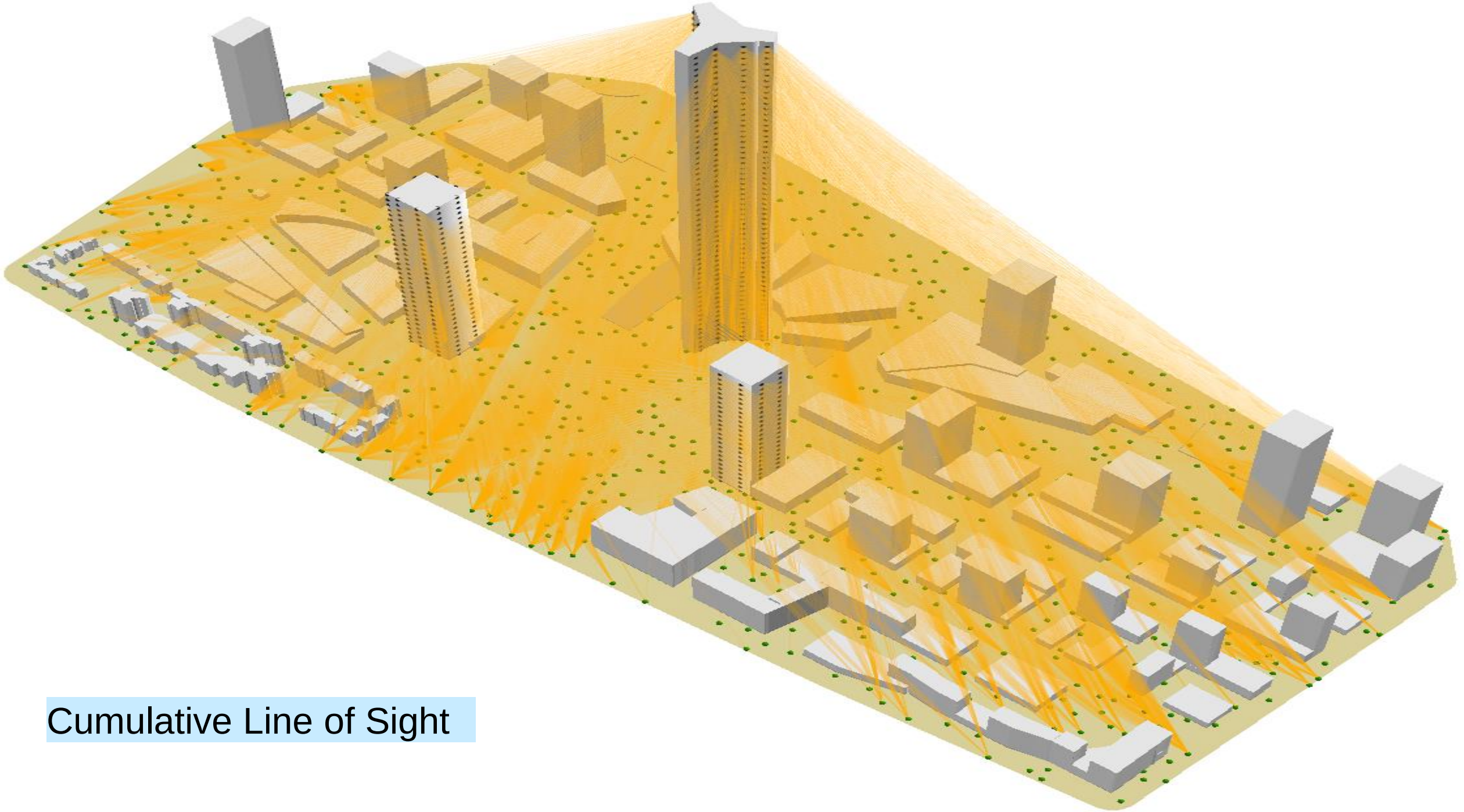
Cumulative Line of Sight



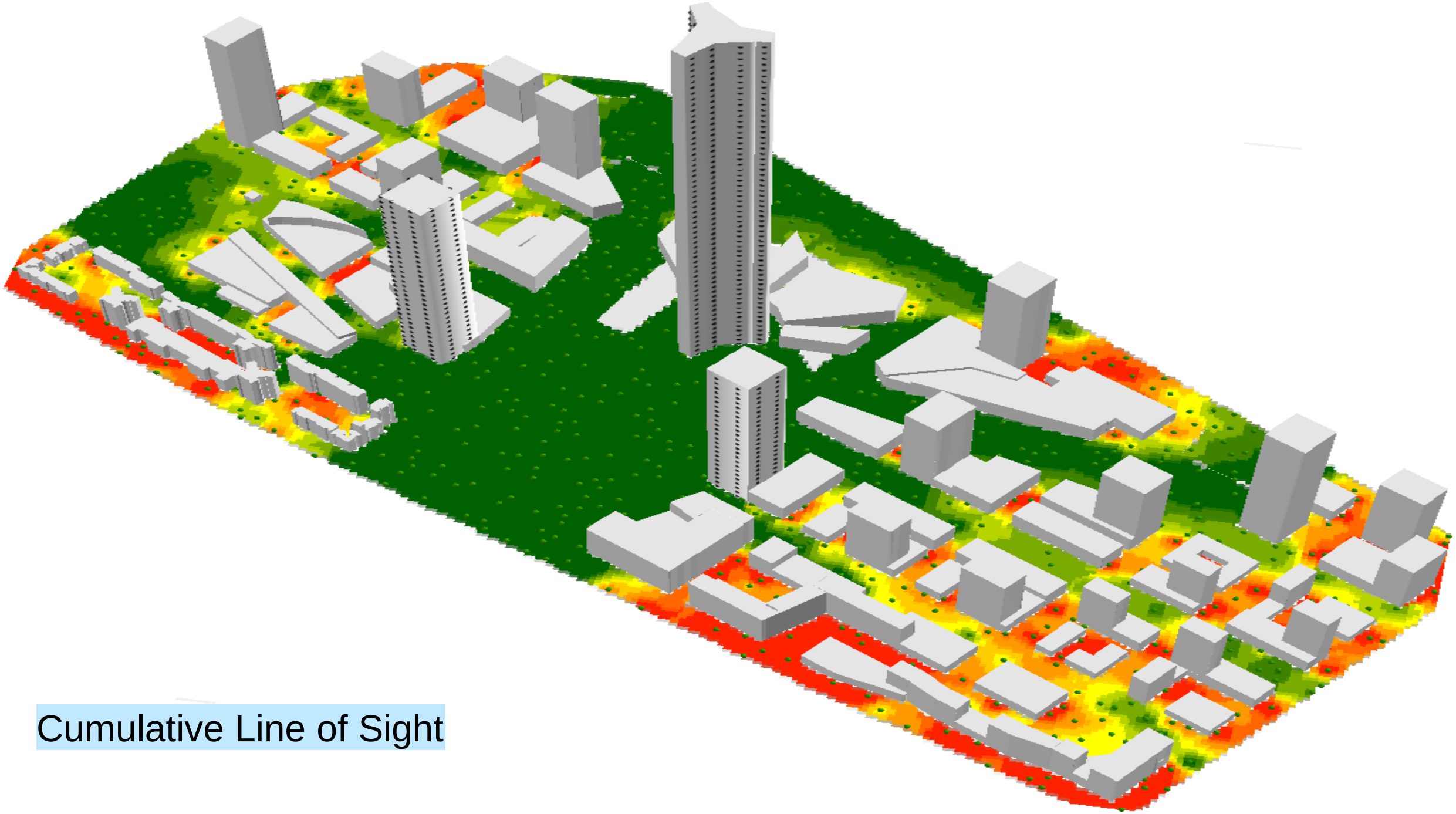
Cumulative Line of Sight



Cumulative Line of Sight



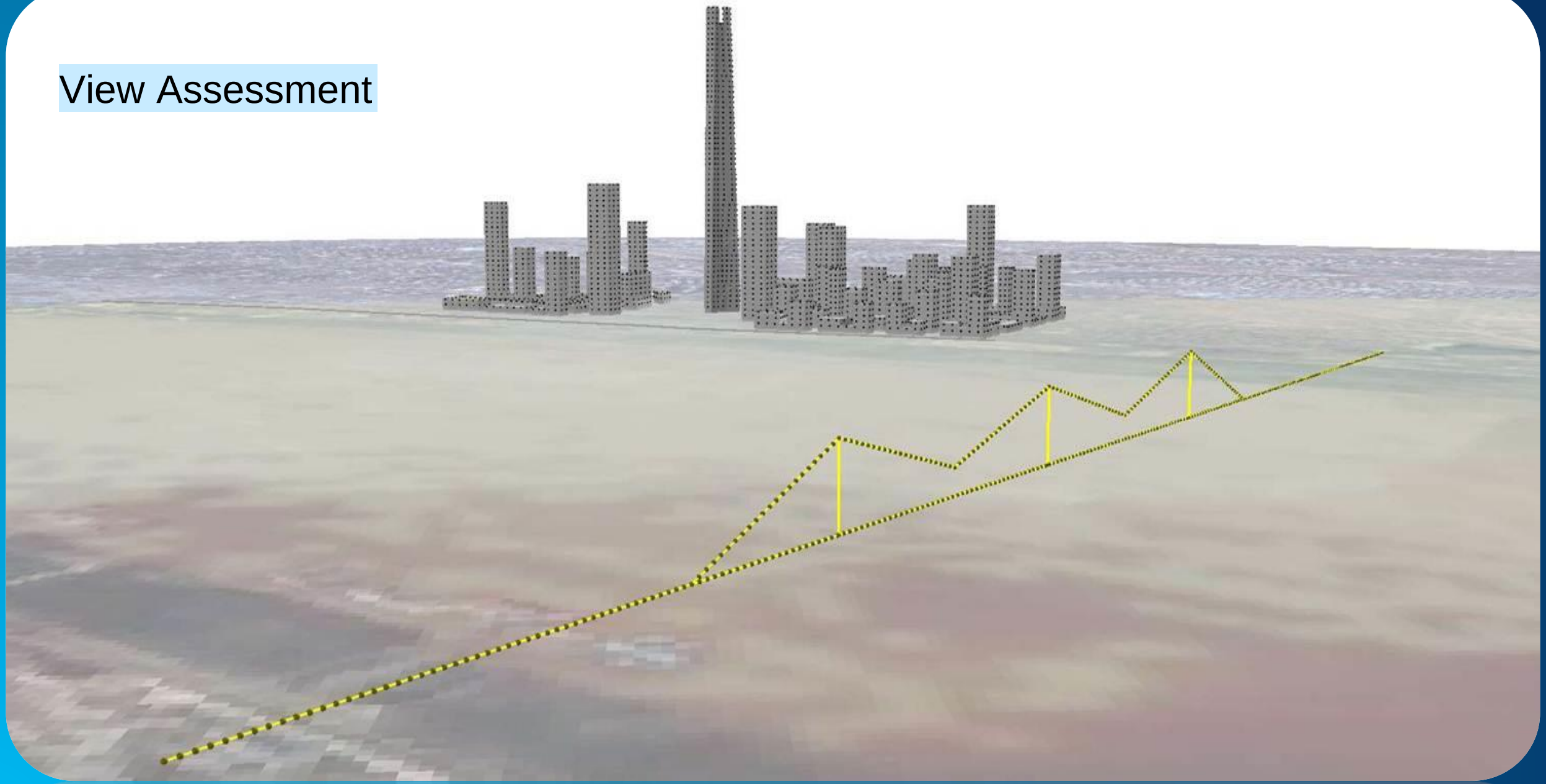
Cumulative Line of Sight

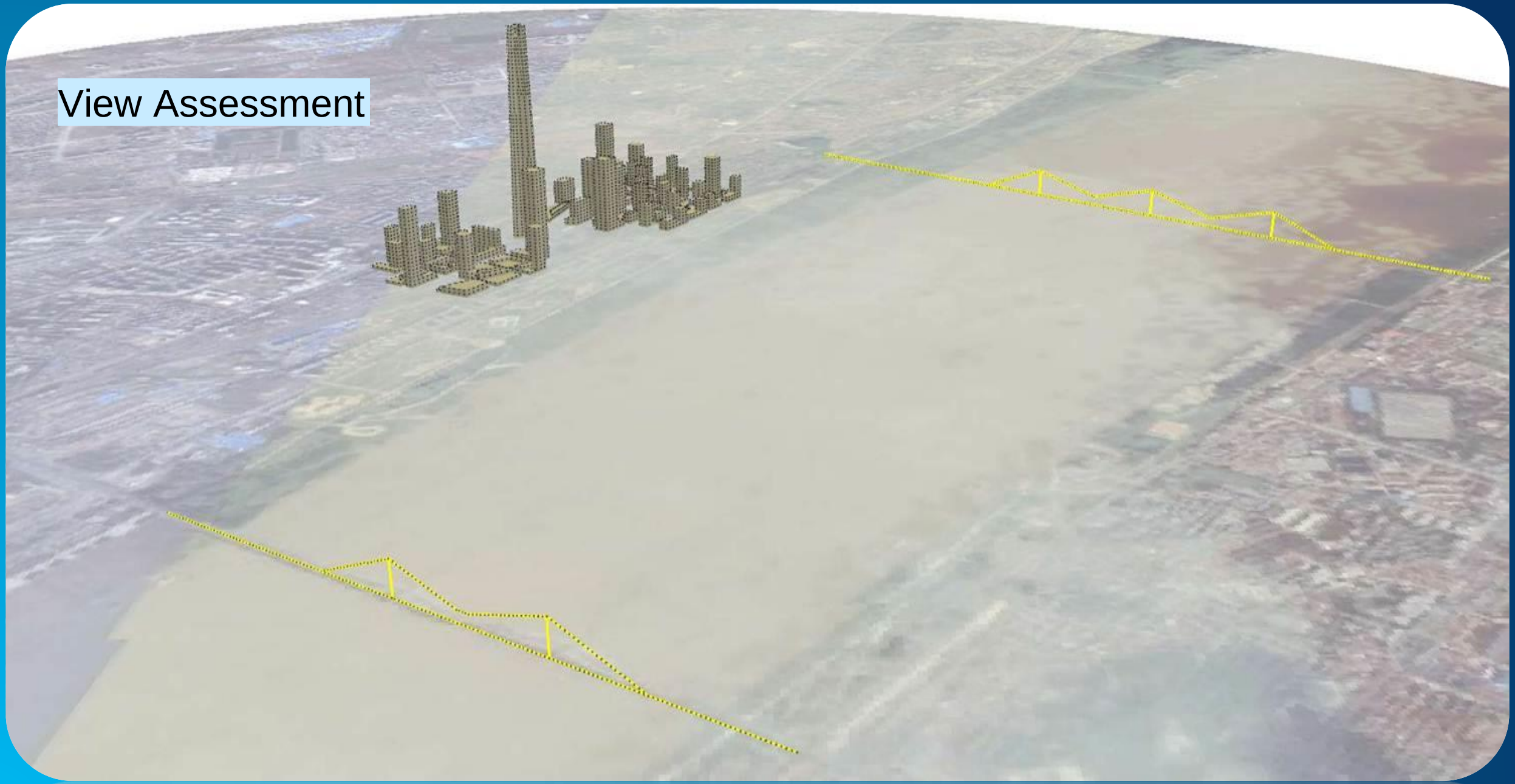


Cumulative Line of Sight

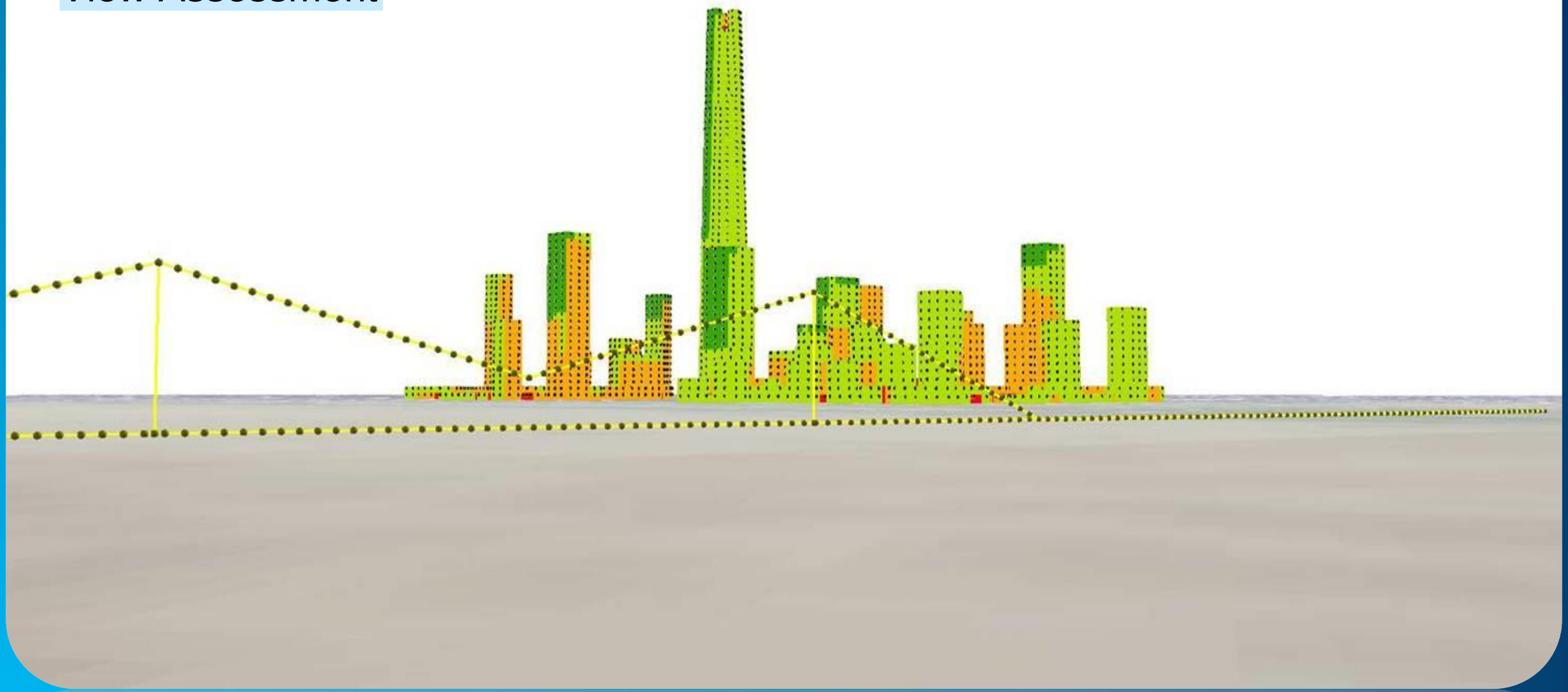
View Assessment

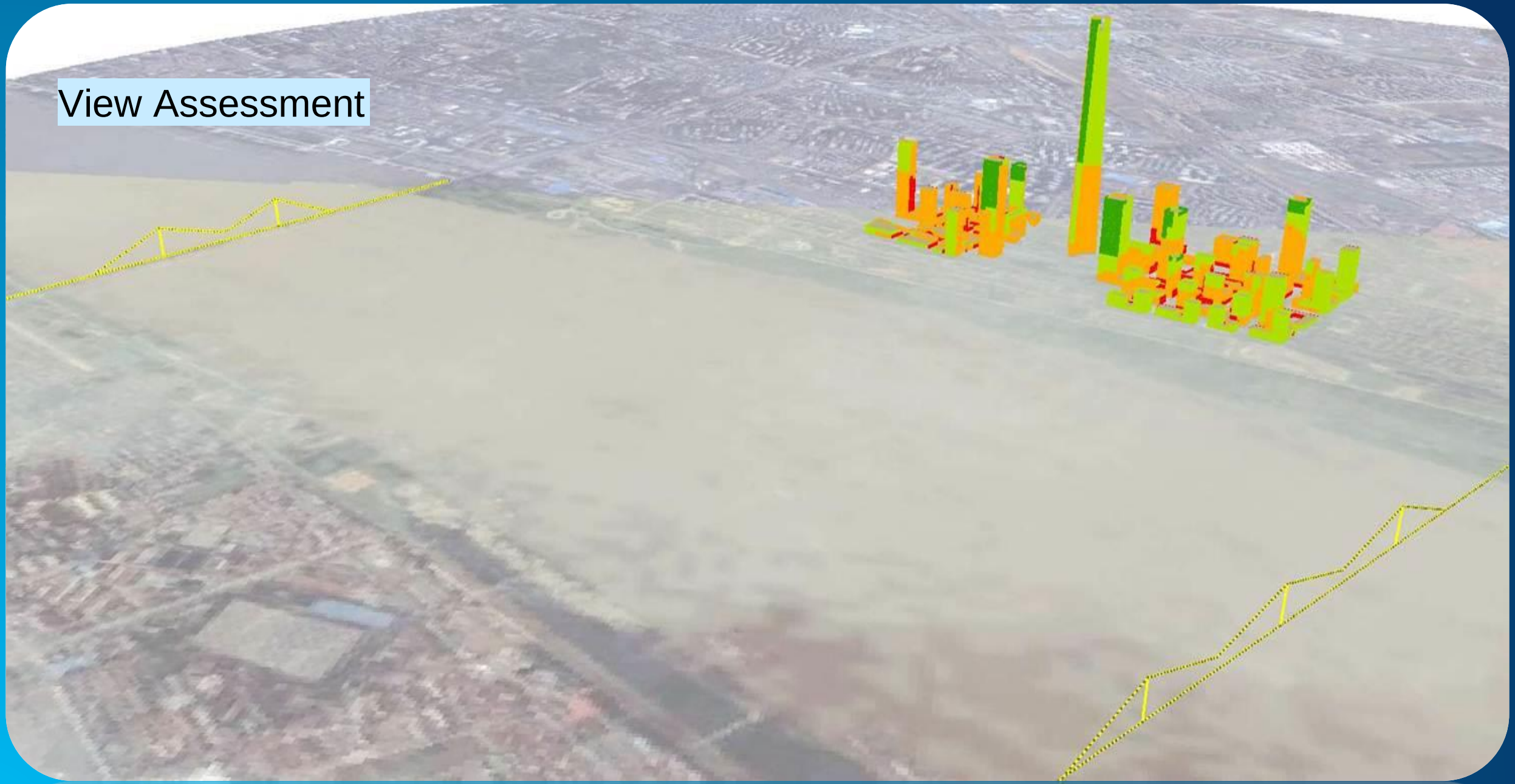
View Assessment




View Assessment

View Assessment




View Assessment

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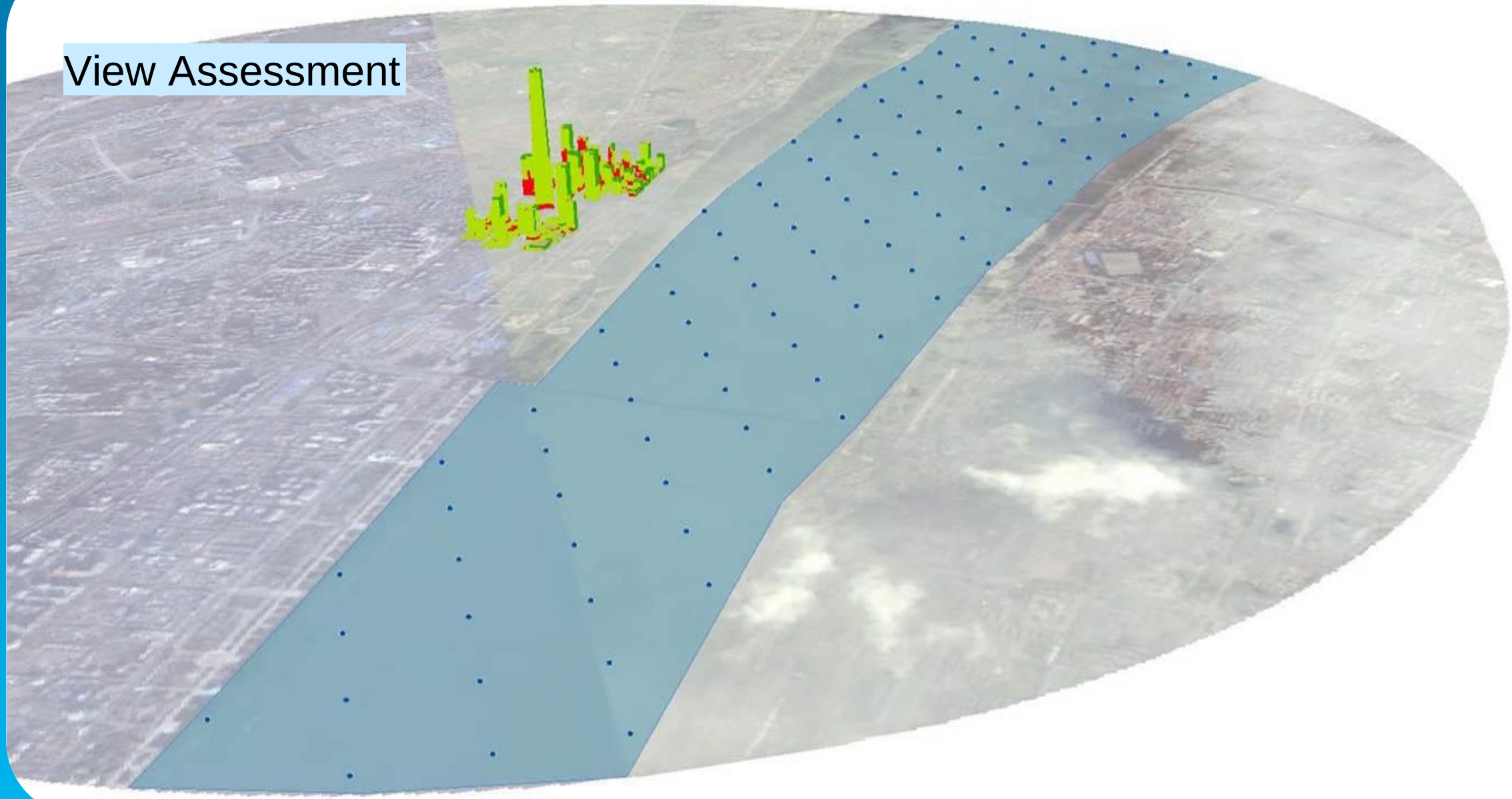

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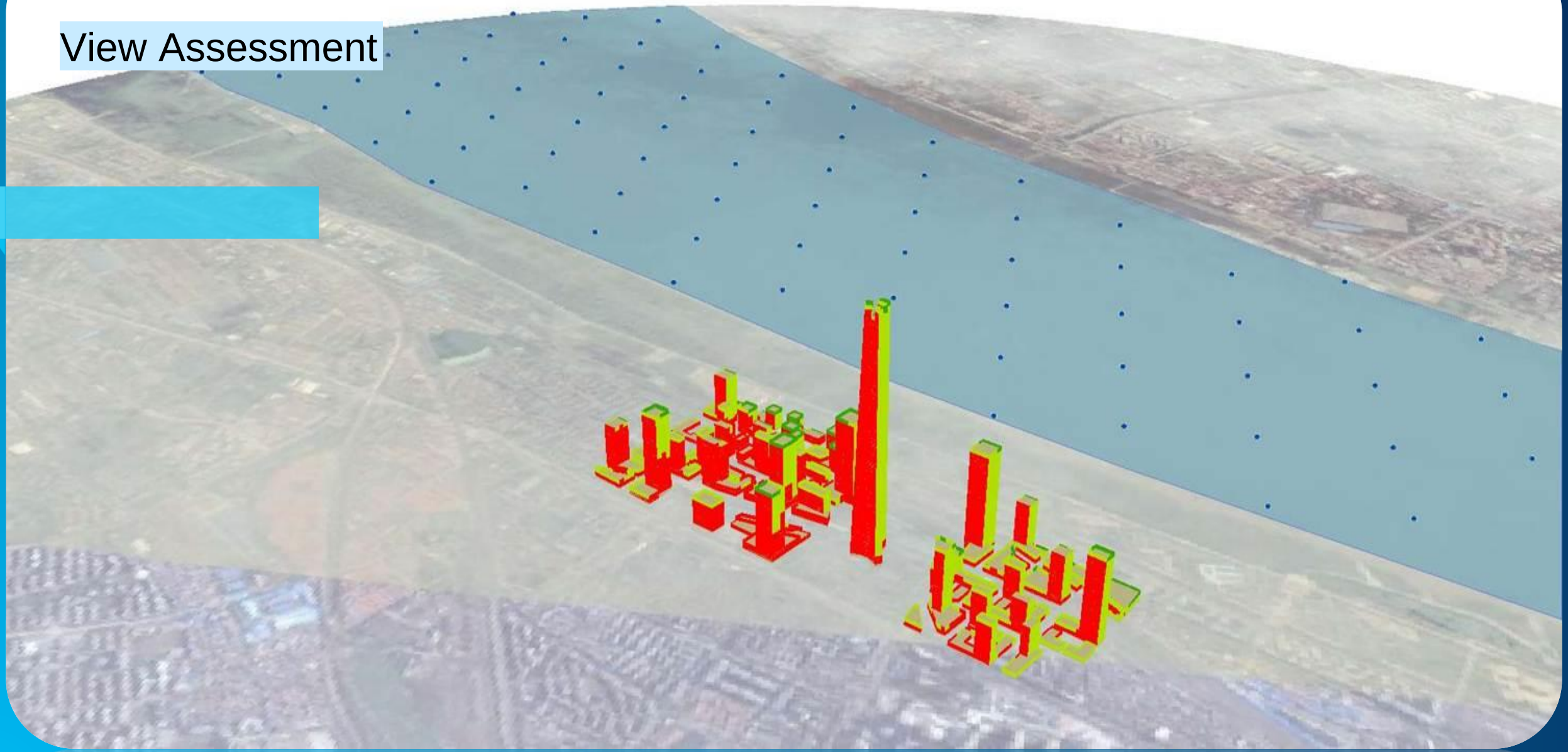

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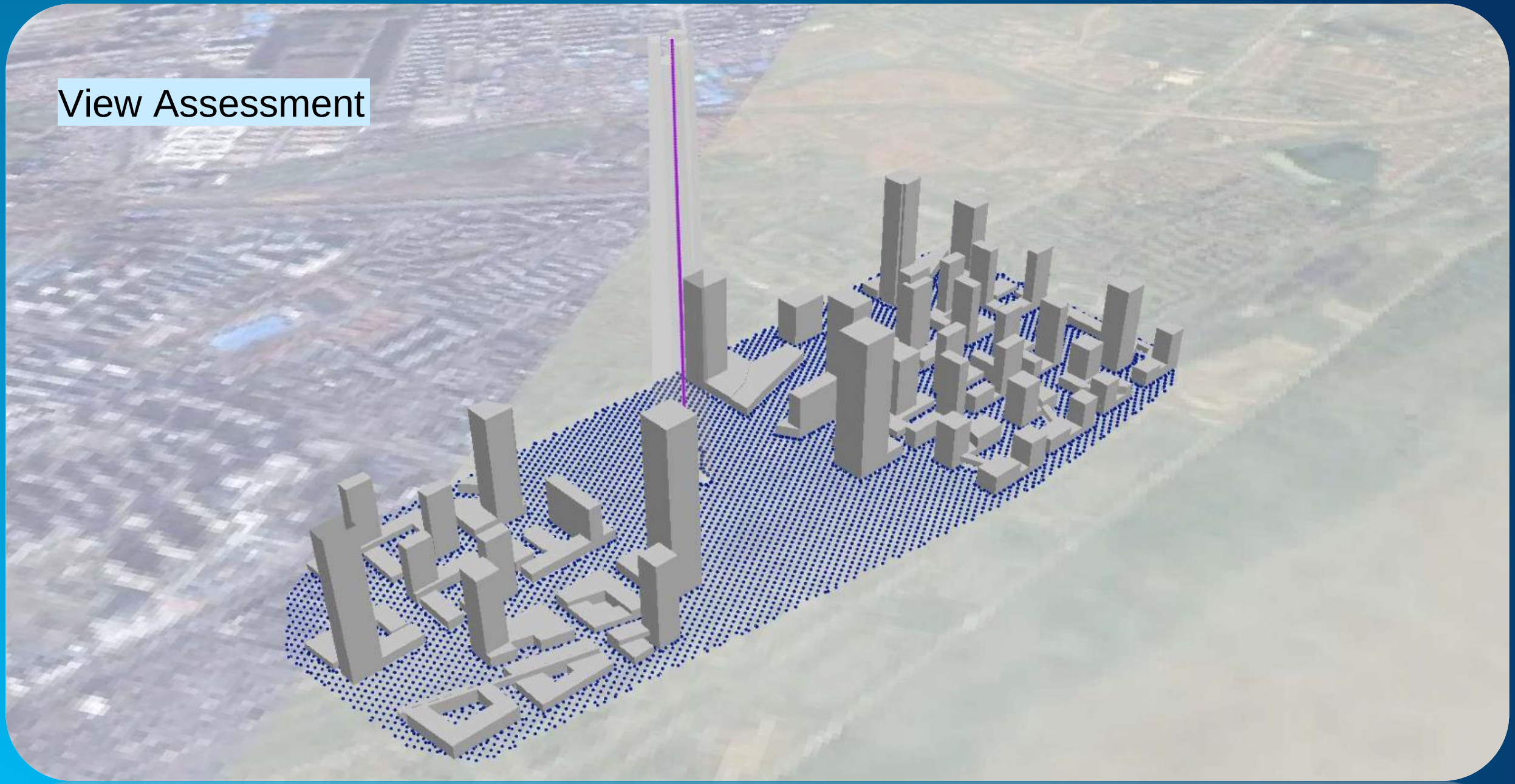

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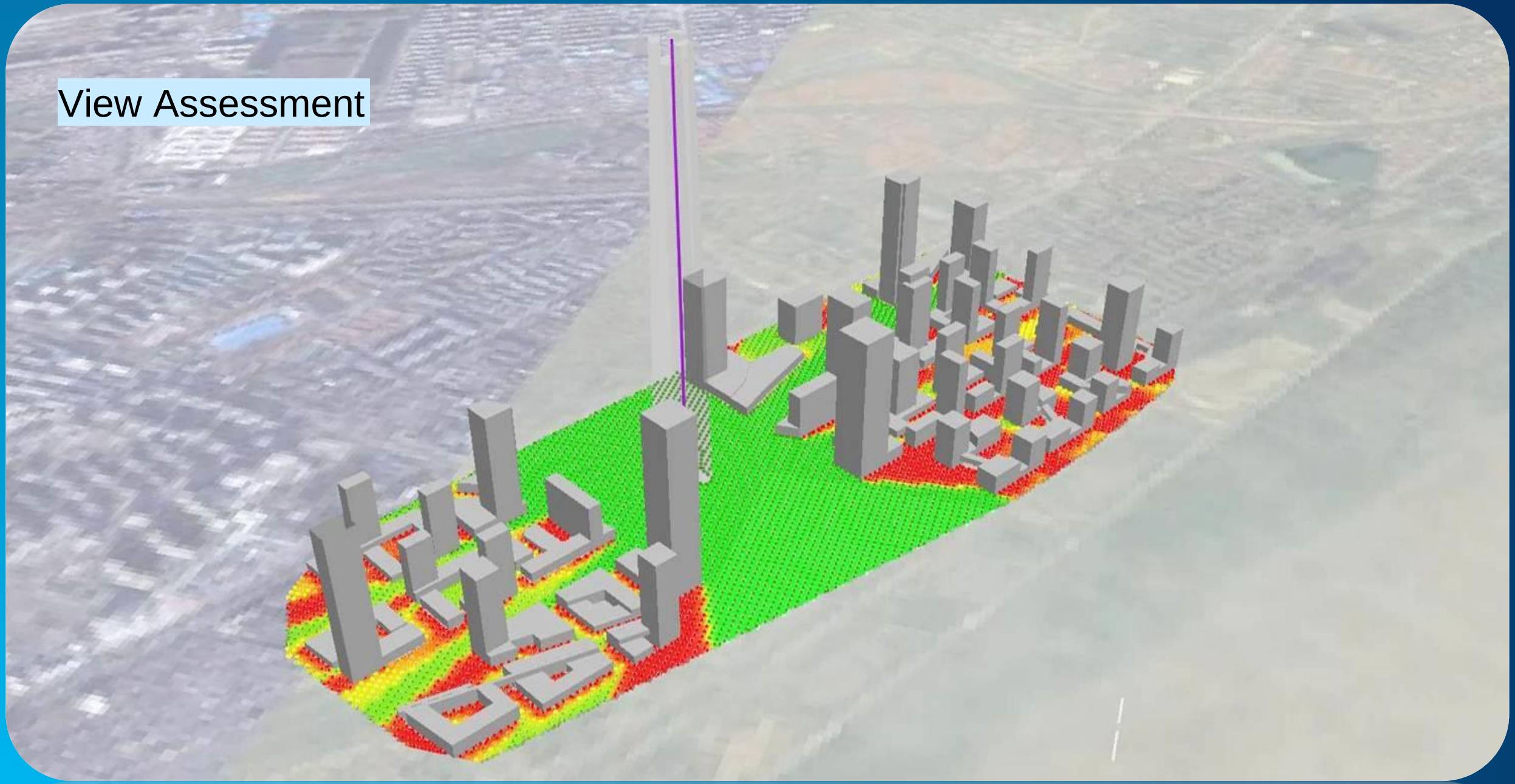

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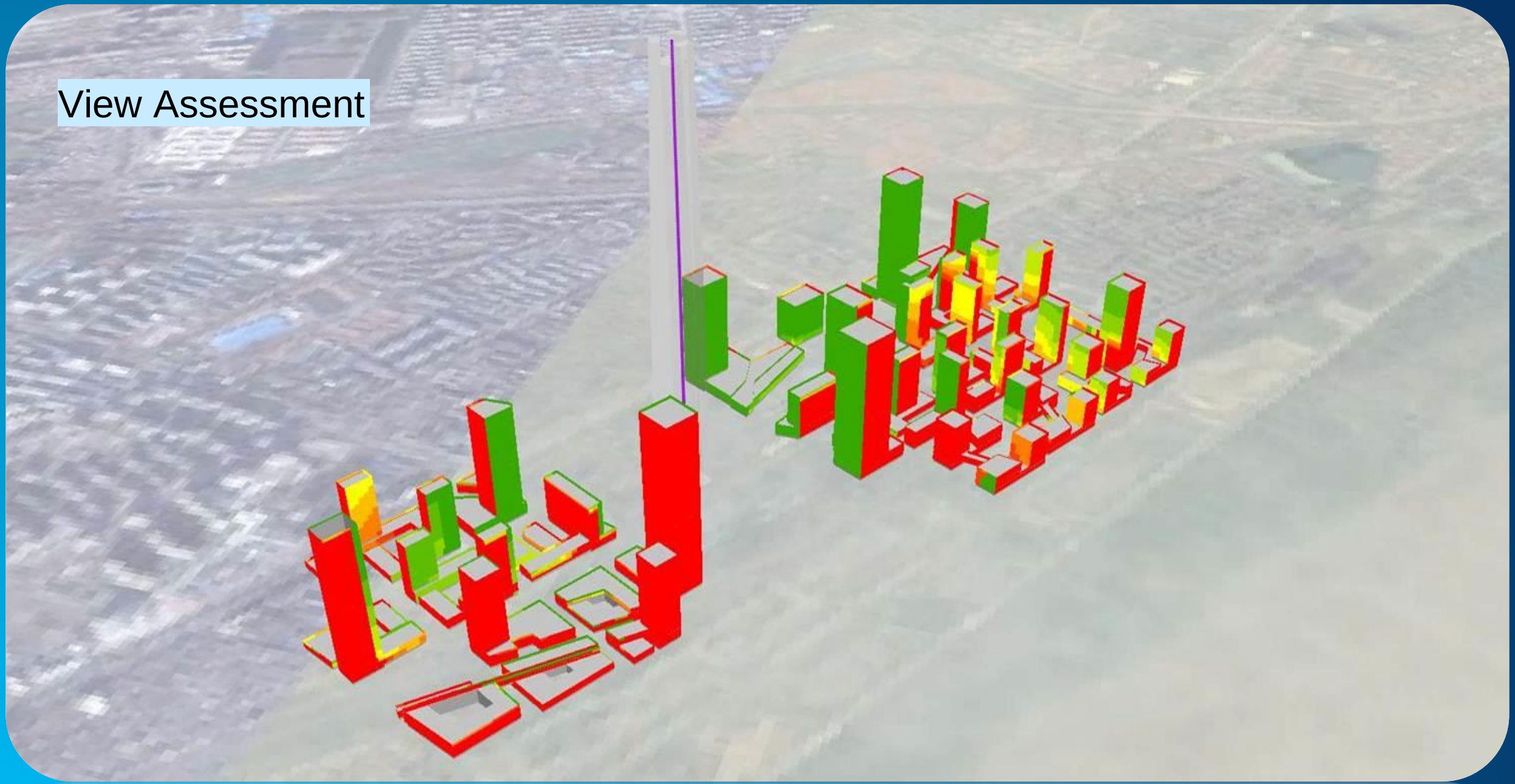

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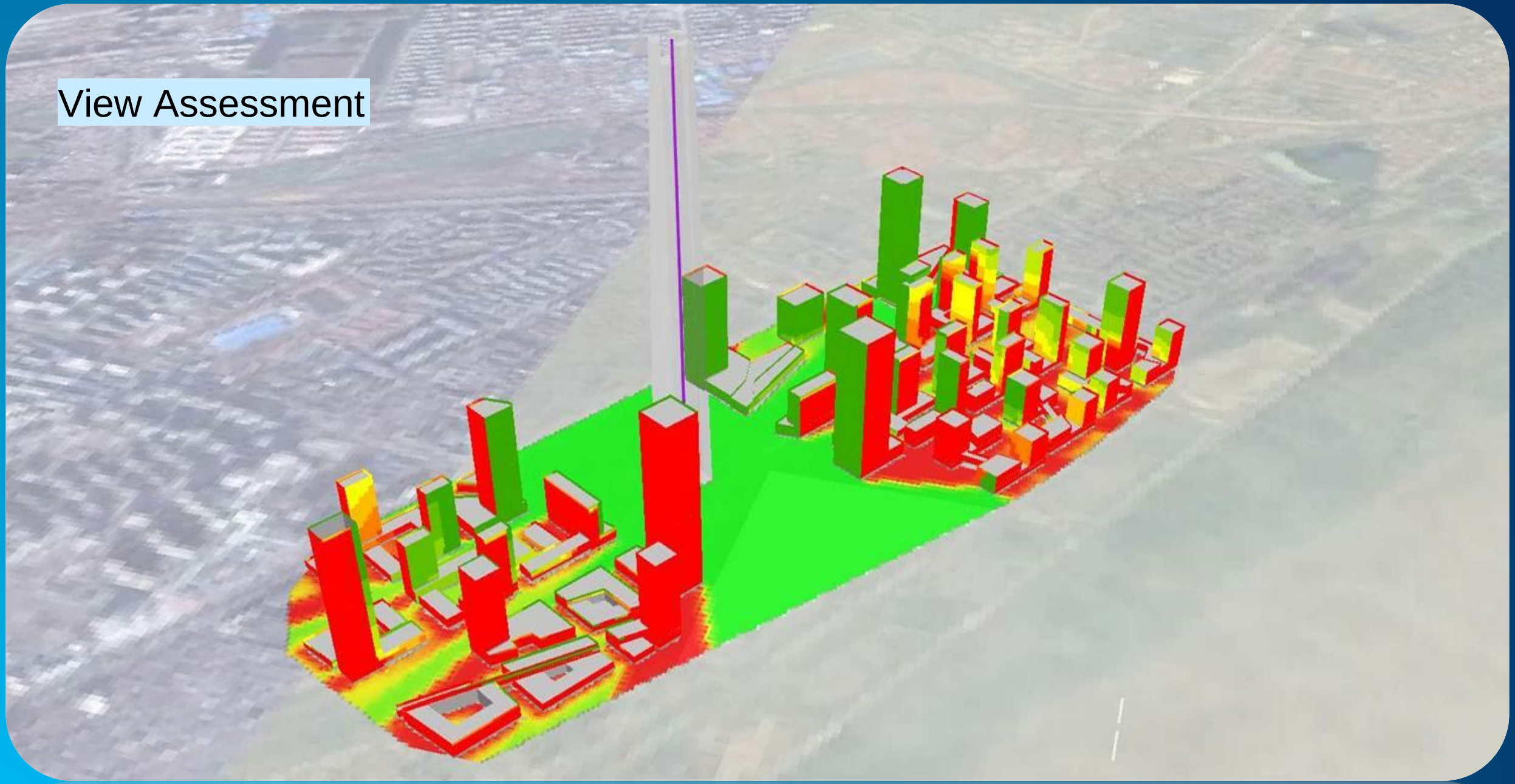

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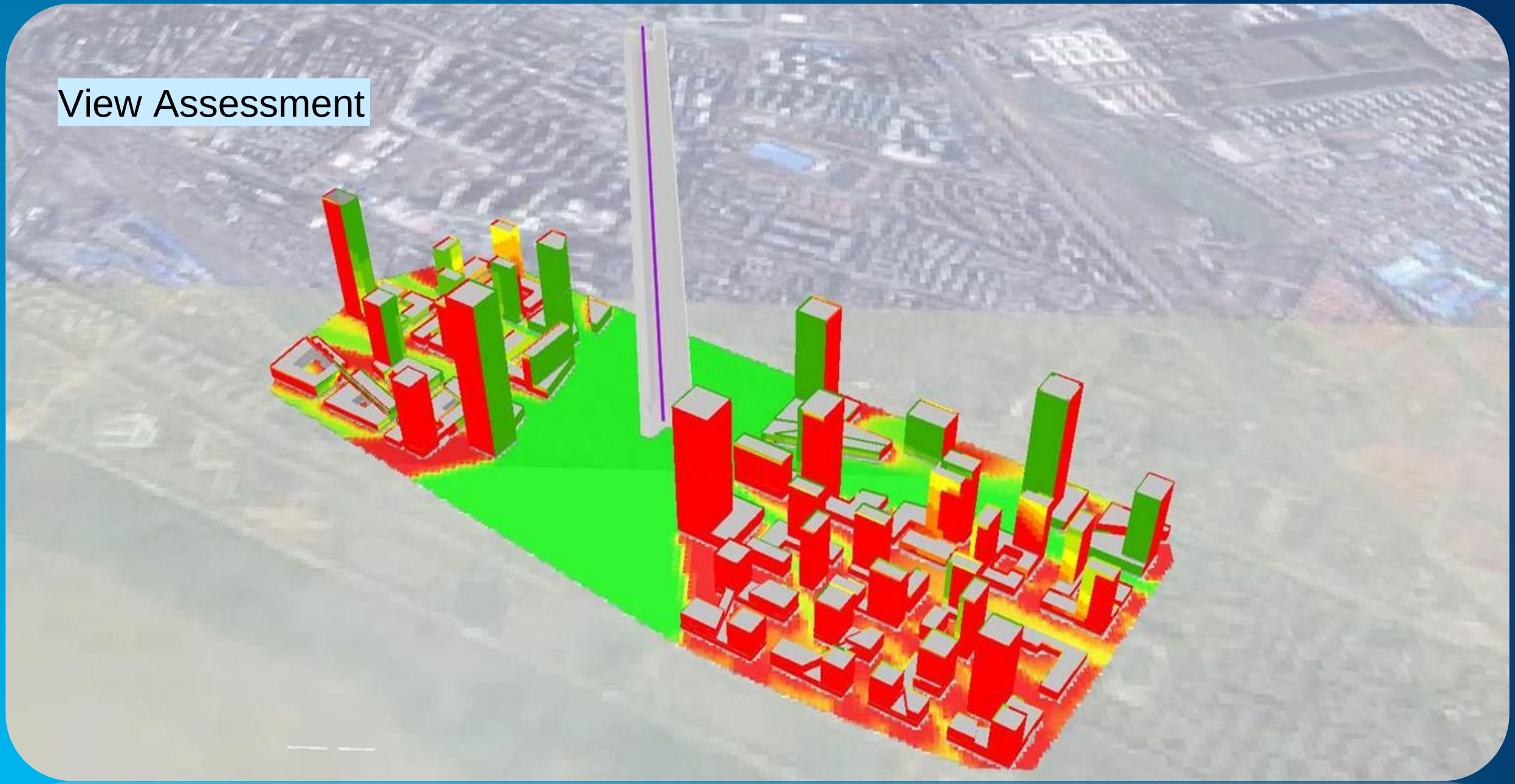
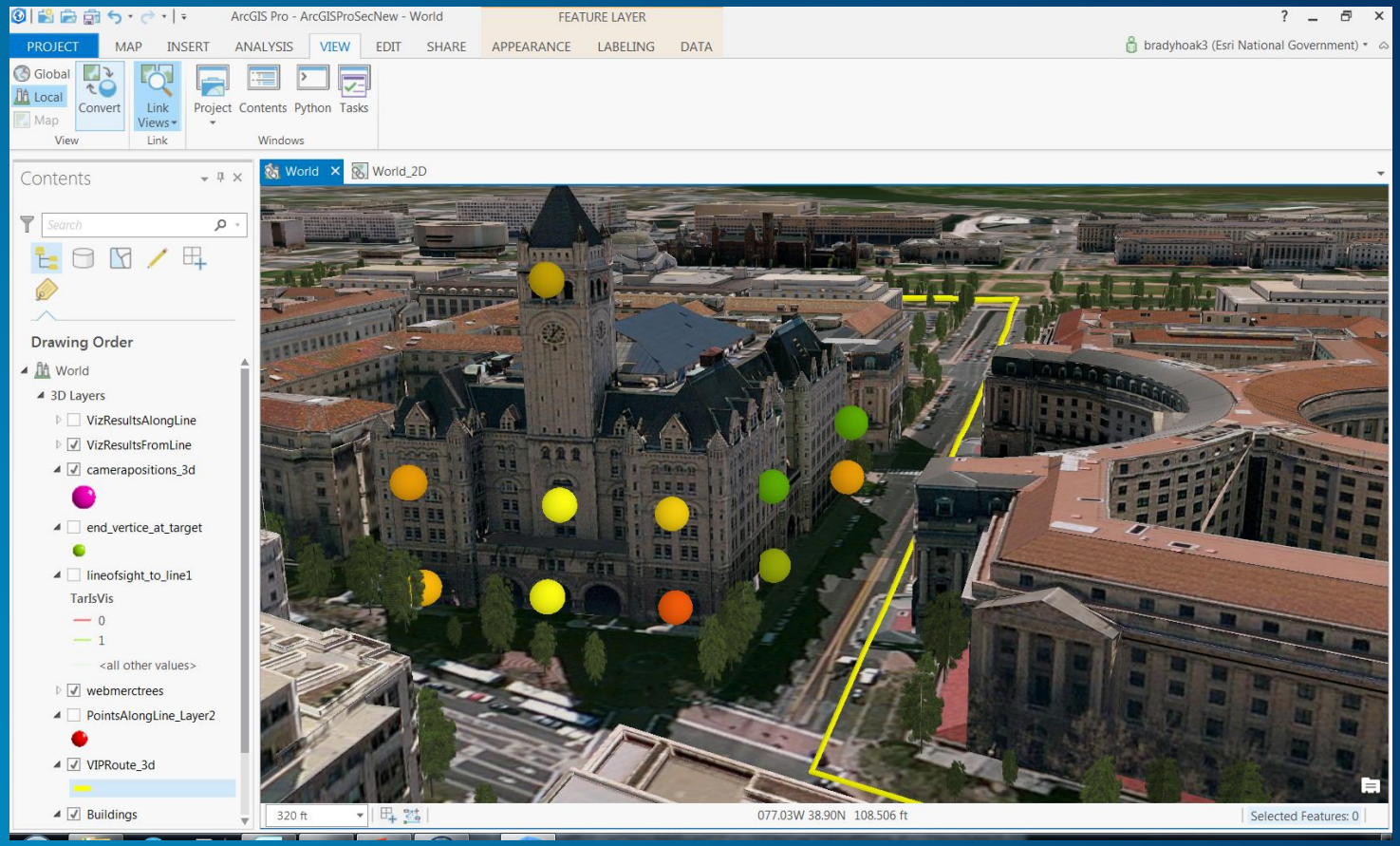


Demo –Line of Sight Analysis – Camera Visibility to Route

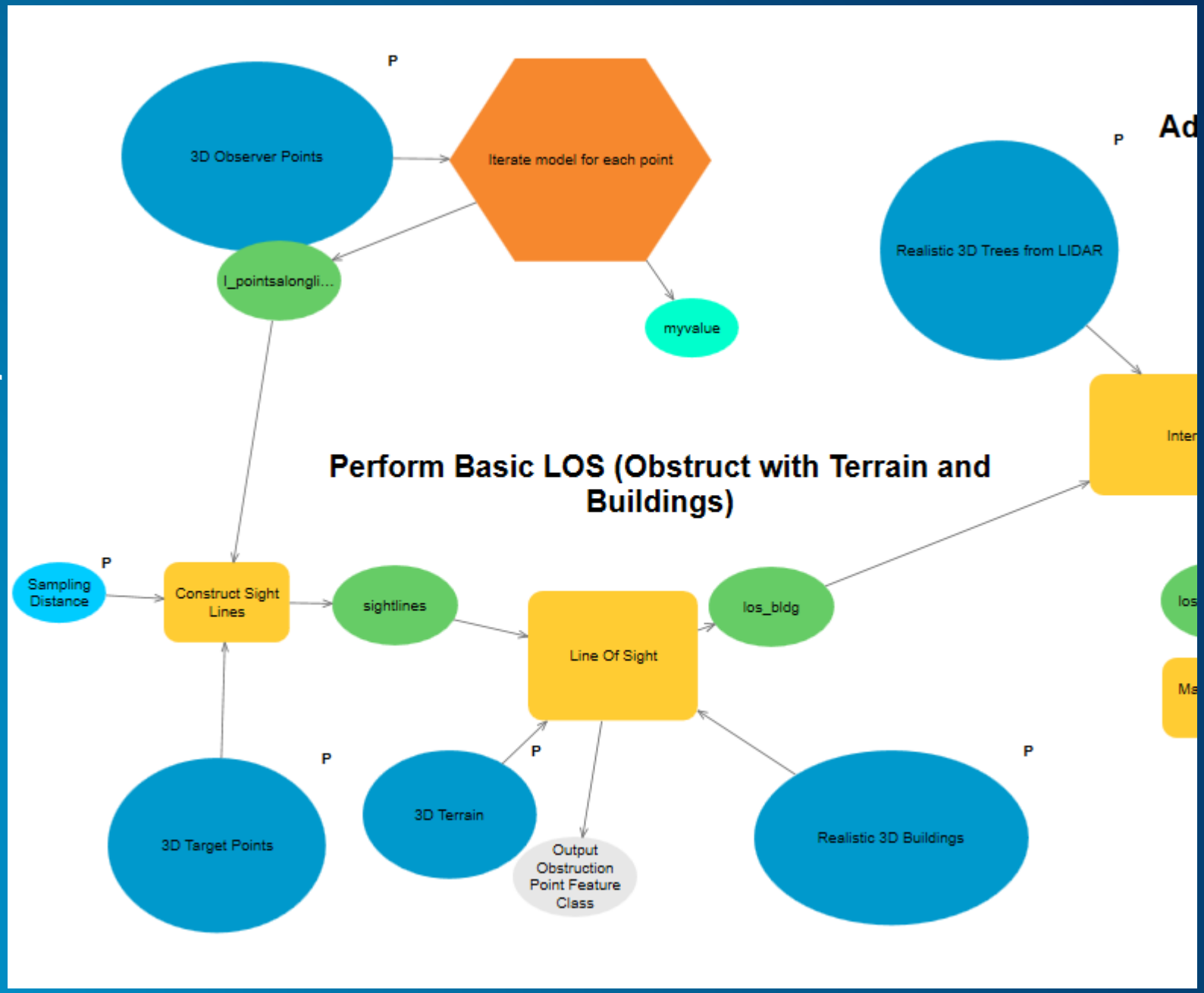
- ArcGIS Pro
- Realistic Buildings
- Tree and Bldg Obstructions
- Cumulative Line of Sight
- Bidirectional



Credit - Pictometry Buildings

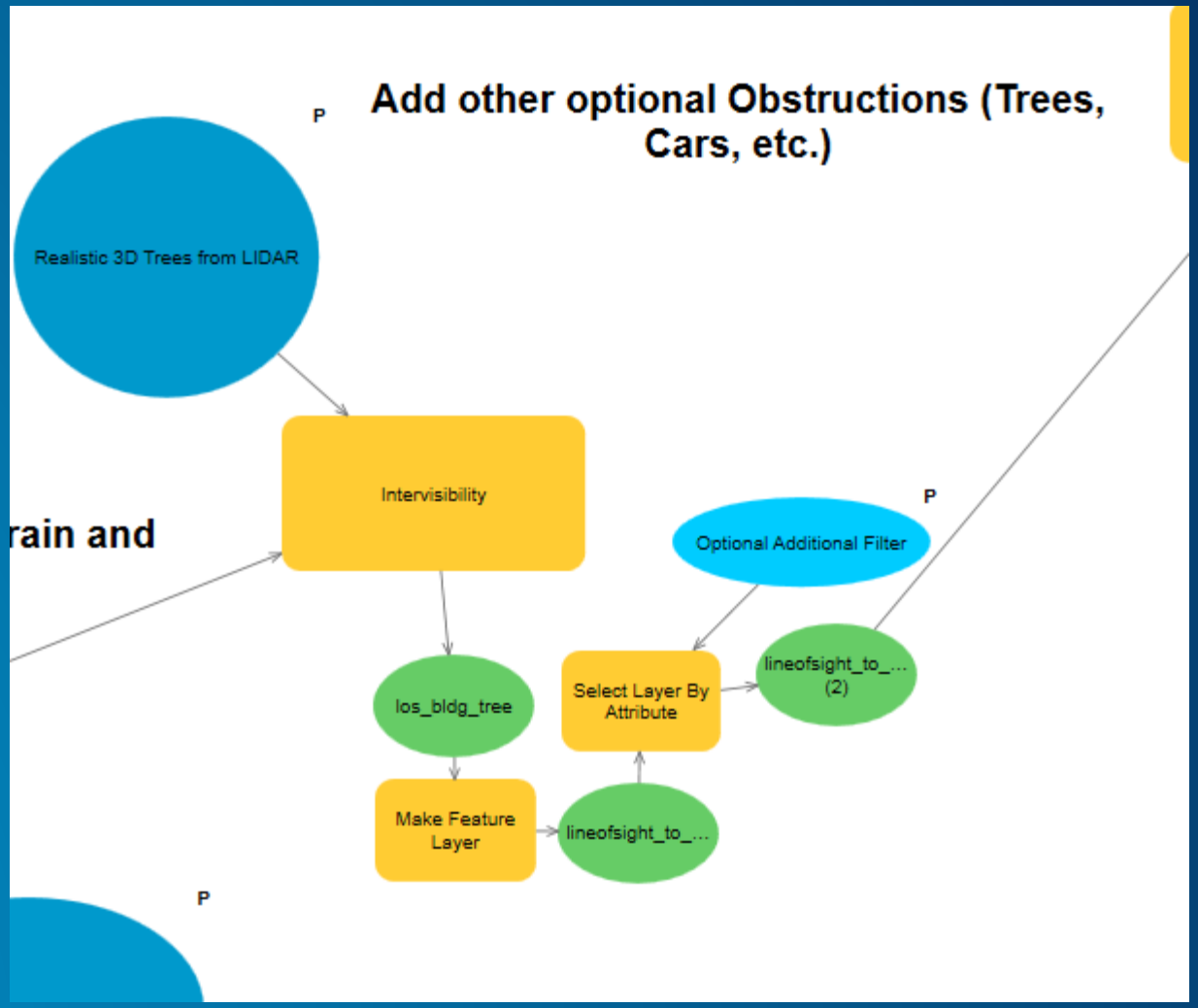
Demo – Cont.

- Construct Sight Line
- Line of Sight
- Interate Model for each observer
- Multipatch Buildings obstruct



Demo – Cont.

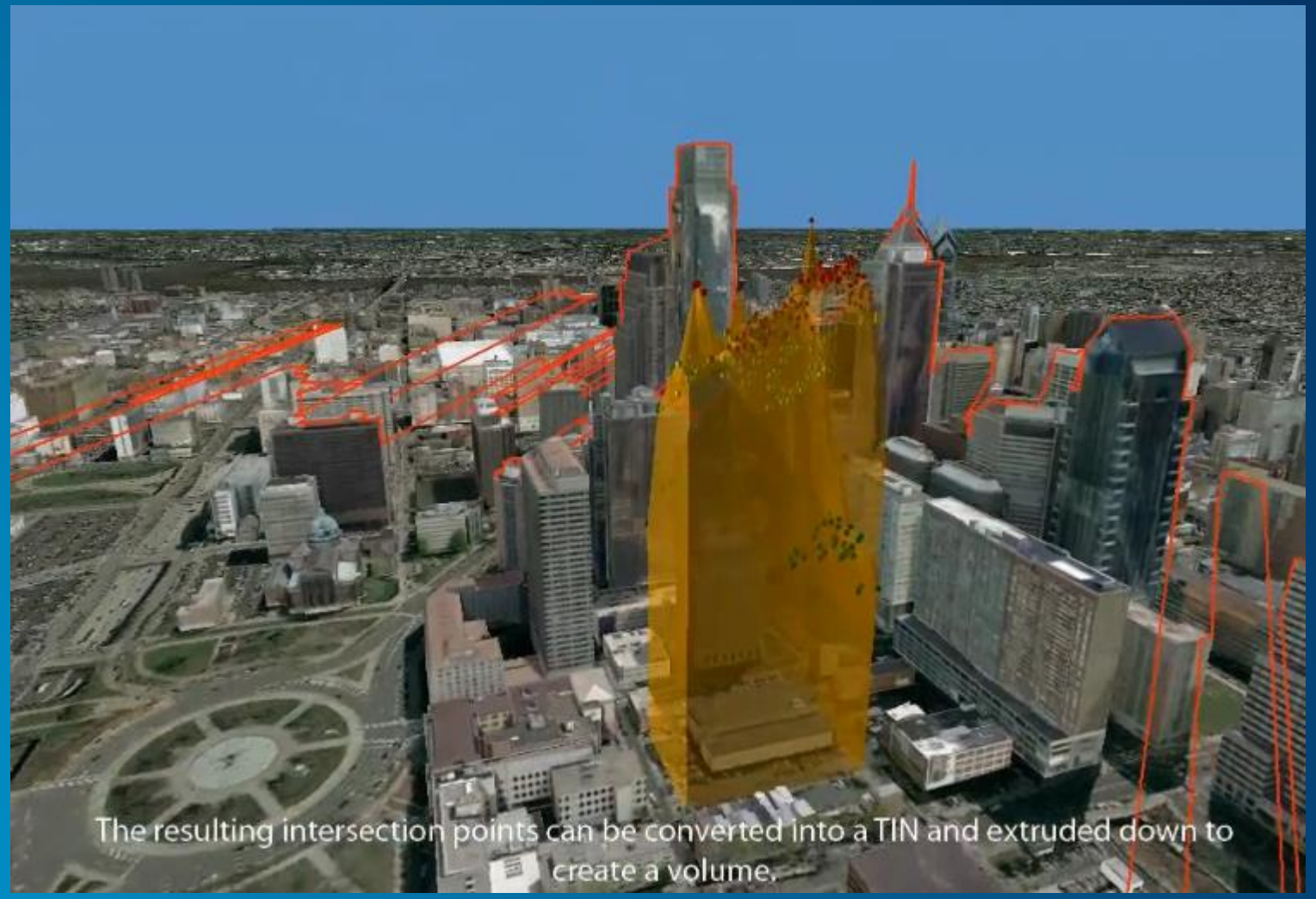
- Use Intervisibility for Multipatch Trees
- Perform on only the visible targets
- Filter out the result



Skyline and Skyline Barrier

- Which buildings define our skyline? How high can we build without changing our skyline?

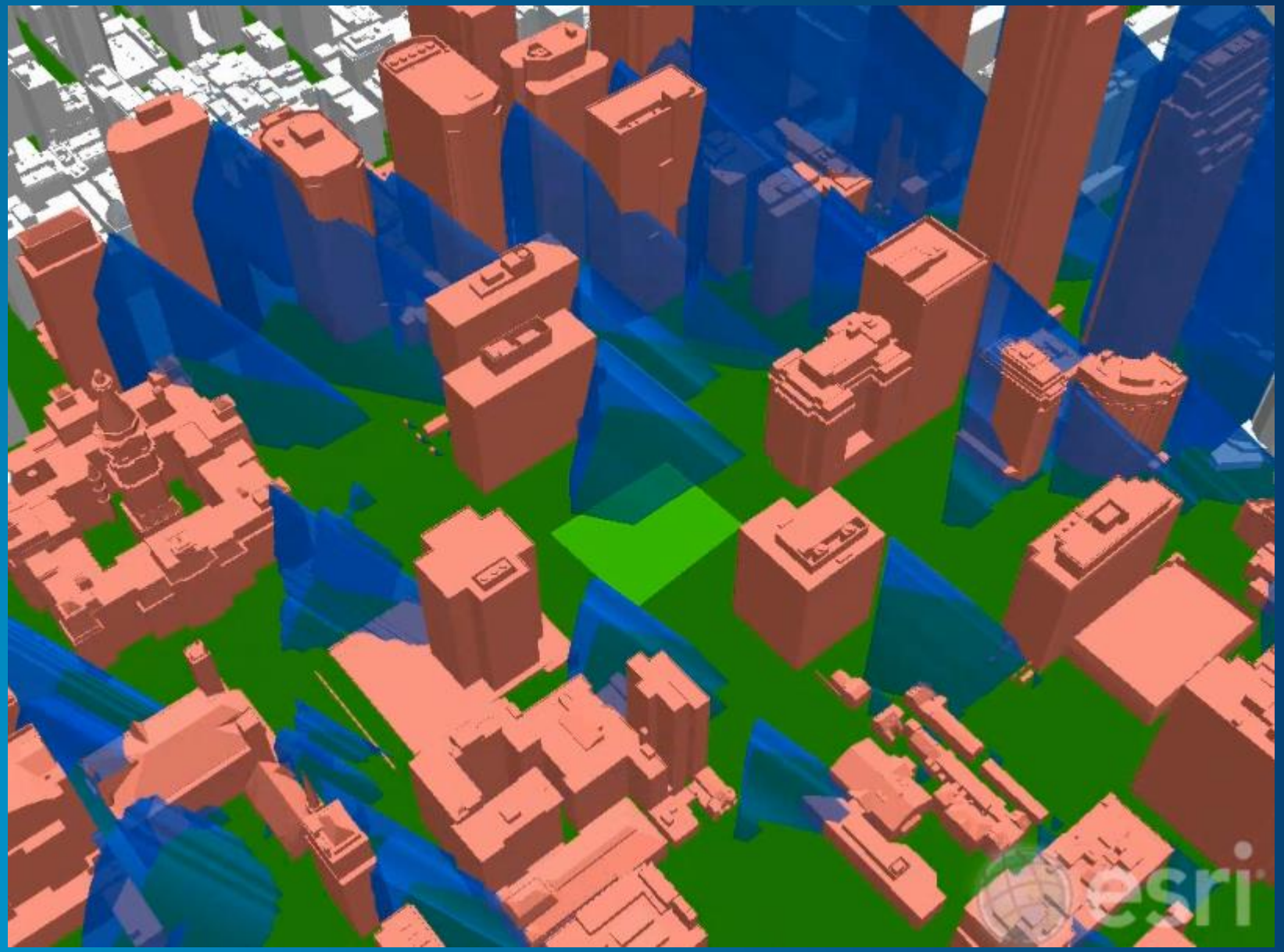
- Intersect sample points with a surface created using skyline barrier, then using it to generate a buildable volume.



Shadows and Shadow Maps

- Where do shadows fall? How can we quantify their impact over time?

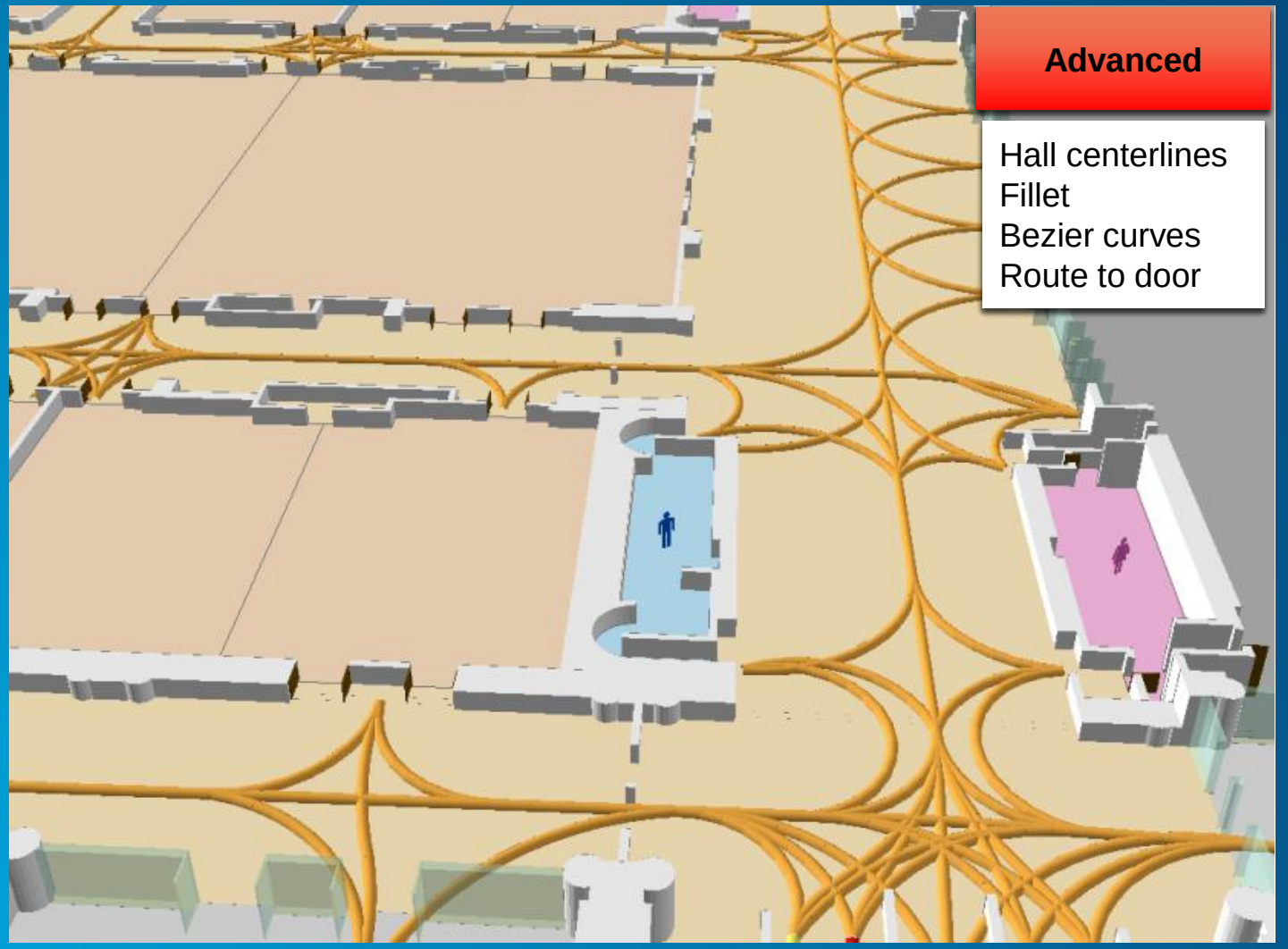
- Intersection of shadows, at specified time intervals, for specified days in the year, on a park polygon.



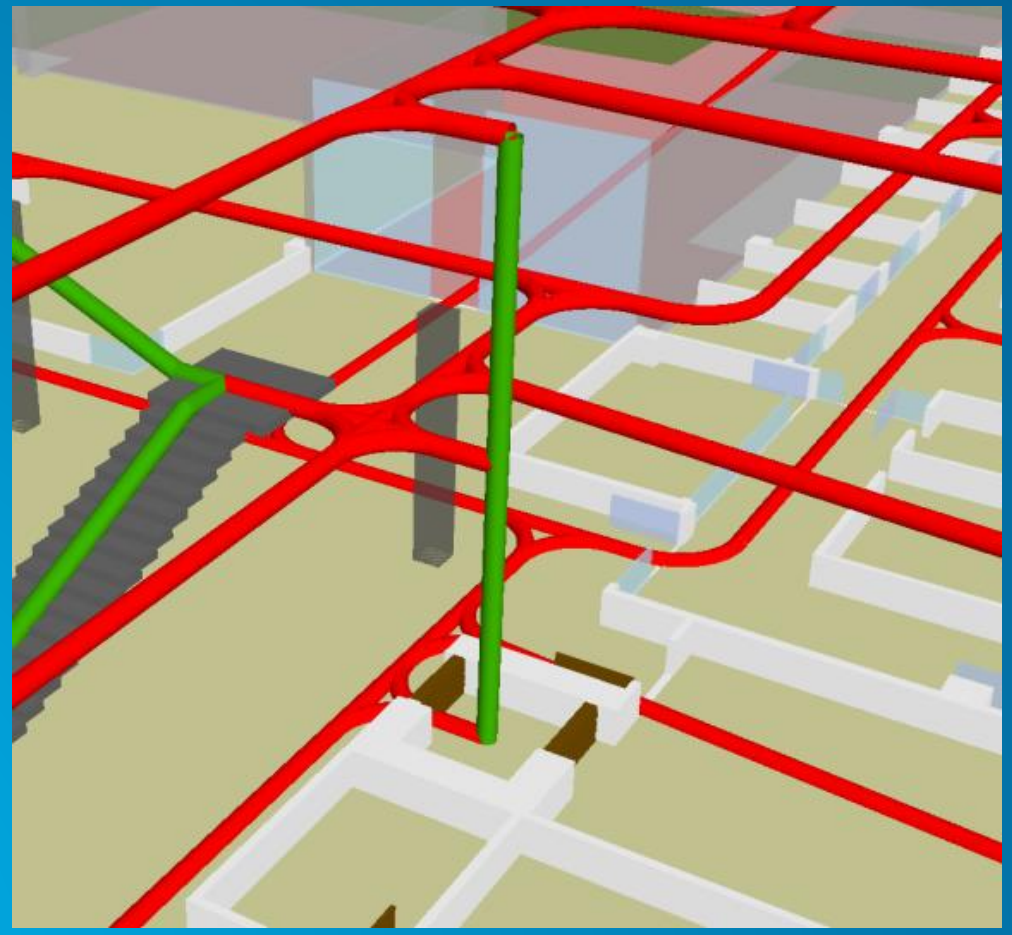
3D Routing

- Release of ArcGIS 10 provided support for 3D Transportation networks
- Building Interior Space Data Model (BISDM) v3.0 supports the development of the required data components

Creating Data – Floor Lines



Creating Data – Floor Transitions



Floor 1 plan
Add z-values to vertices
Floor 2 plan
Add z-values to vertices
Floor 3 plan
Check in 3D
Elevators

#	X	Y	Z	M
0	481...	376...	3.657	NaN
1	481...	376...	3.657	NaN
2	481...	376...	5.486	NaN
3	481...	376...	5.486	NaN
4	481...	376...	5.486	NaN
5	481...	376...	7.315	NaN
6	481...	376...	7.315	NaN

Understanding the Surface

What is it & when should it be used?

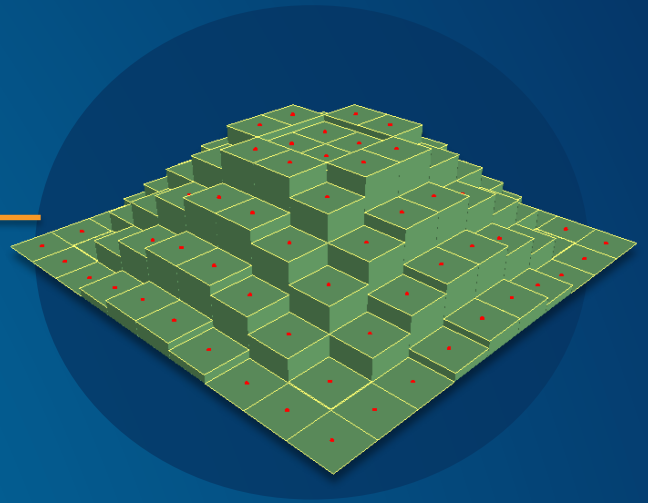
Any continuous measurement with one value for a given x-y location $z = f(x,y)$

- **Temperature**
- **Gravity**
- **Soil studies**
- **Epidemiology**
- **Chemical concentrations**
- **Many diverse applications…**

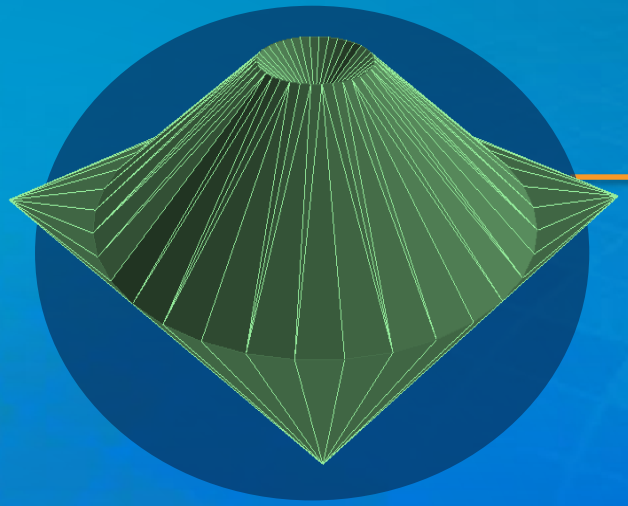
More than just topography!

Surface Data Types

Raster Surface



- Made by interpolation, generalize source measurements to cell size
- Supports robust mathematical operations

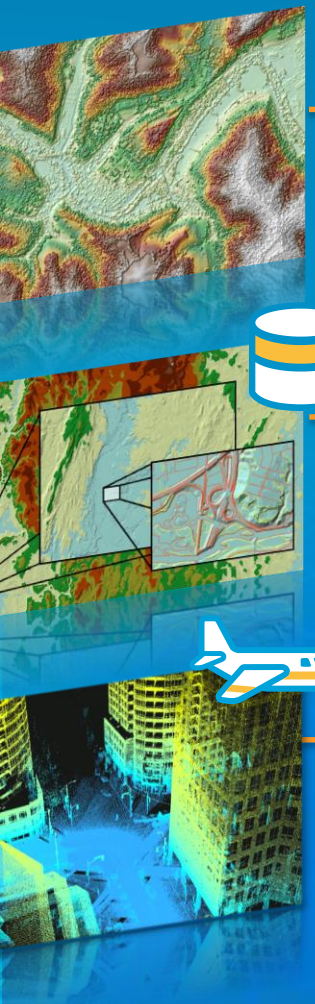


TIN Based Surfaces

- Created by triangulation, maintain source measurements
- Support robust surface definitions & data

Triangulated Irregular Network (TIN) Based Surfaces

Overview of Data Types



TIN

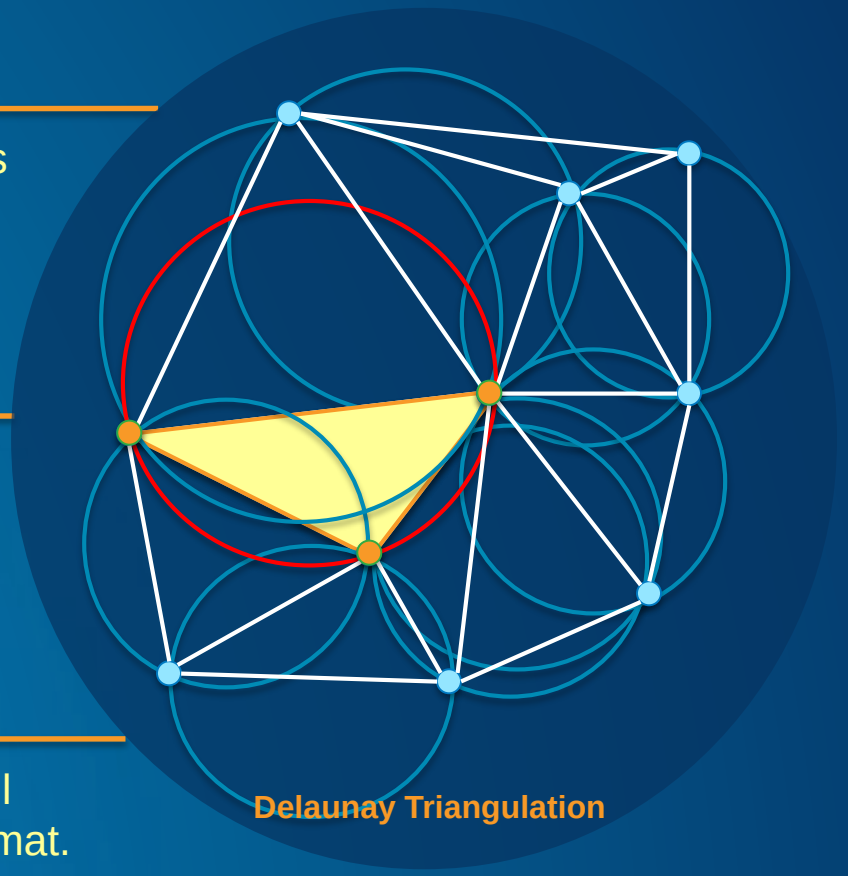
Well-suited for engineering applications and analysis of study areas that are not exceedingly large, provides interactive editing options.

Terrain

Multi-resolution, scalable, offers robust support for handling large amounts of data.

LAS Dataset

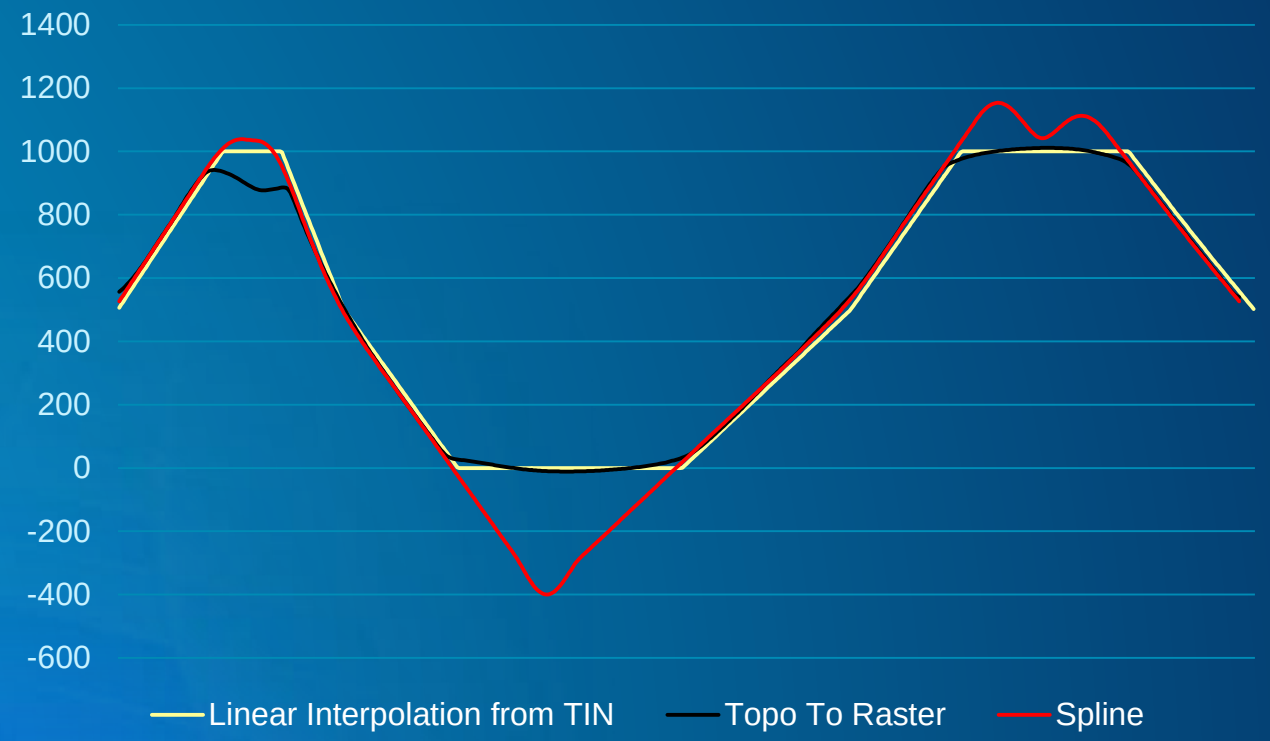
Rapidly visualize, filter, perform QA/QC and analyze lidar data. Well suited for aerial collections, supports compressed lidar in ZLAS format.



Delaunay Triangulation

Choosing the Most Appropriate Surface Model

- What is the nature of data being modeled?
- How is the data distributed?
- How will the data be used?

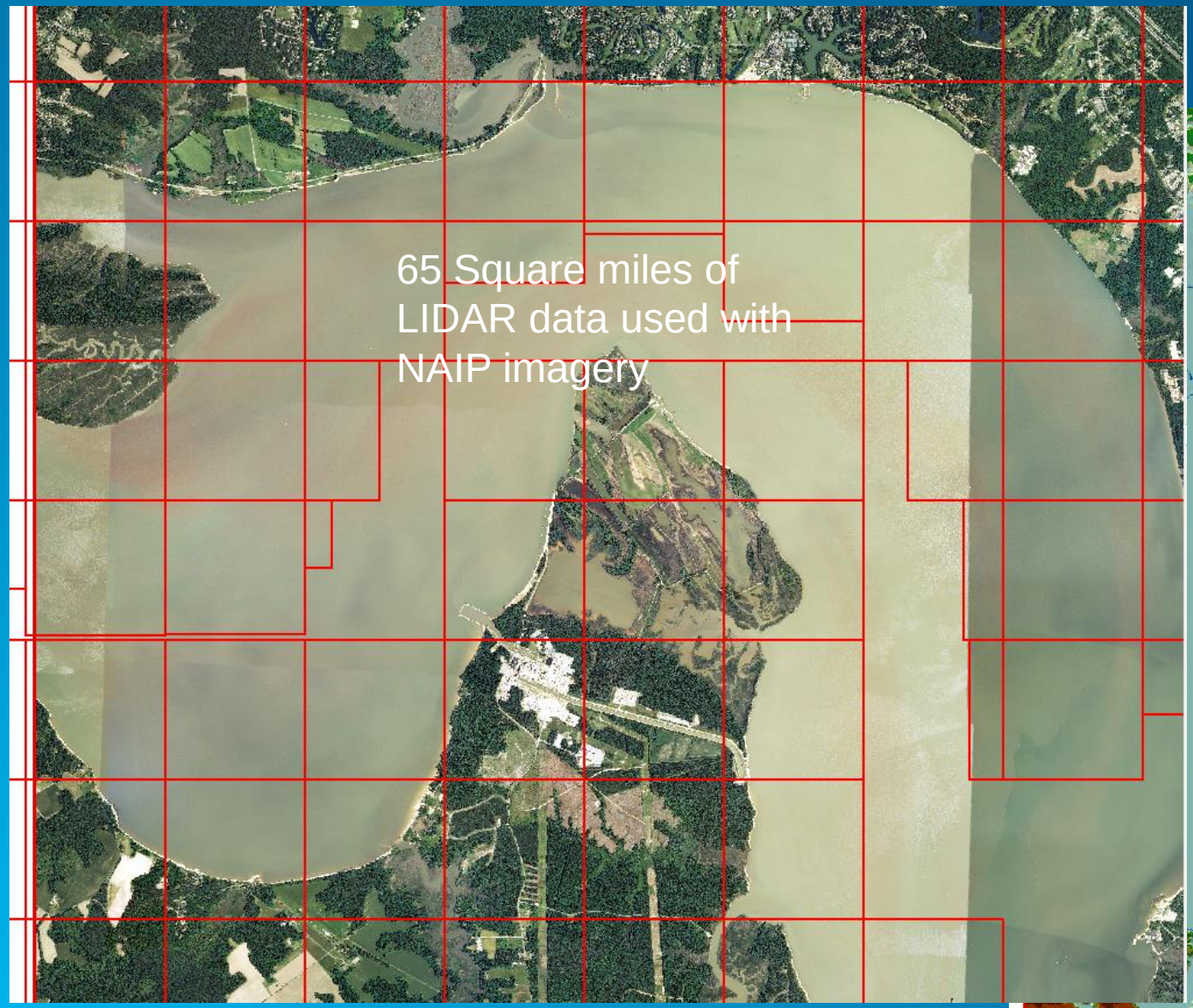


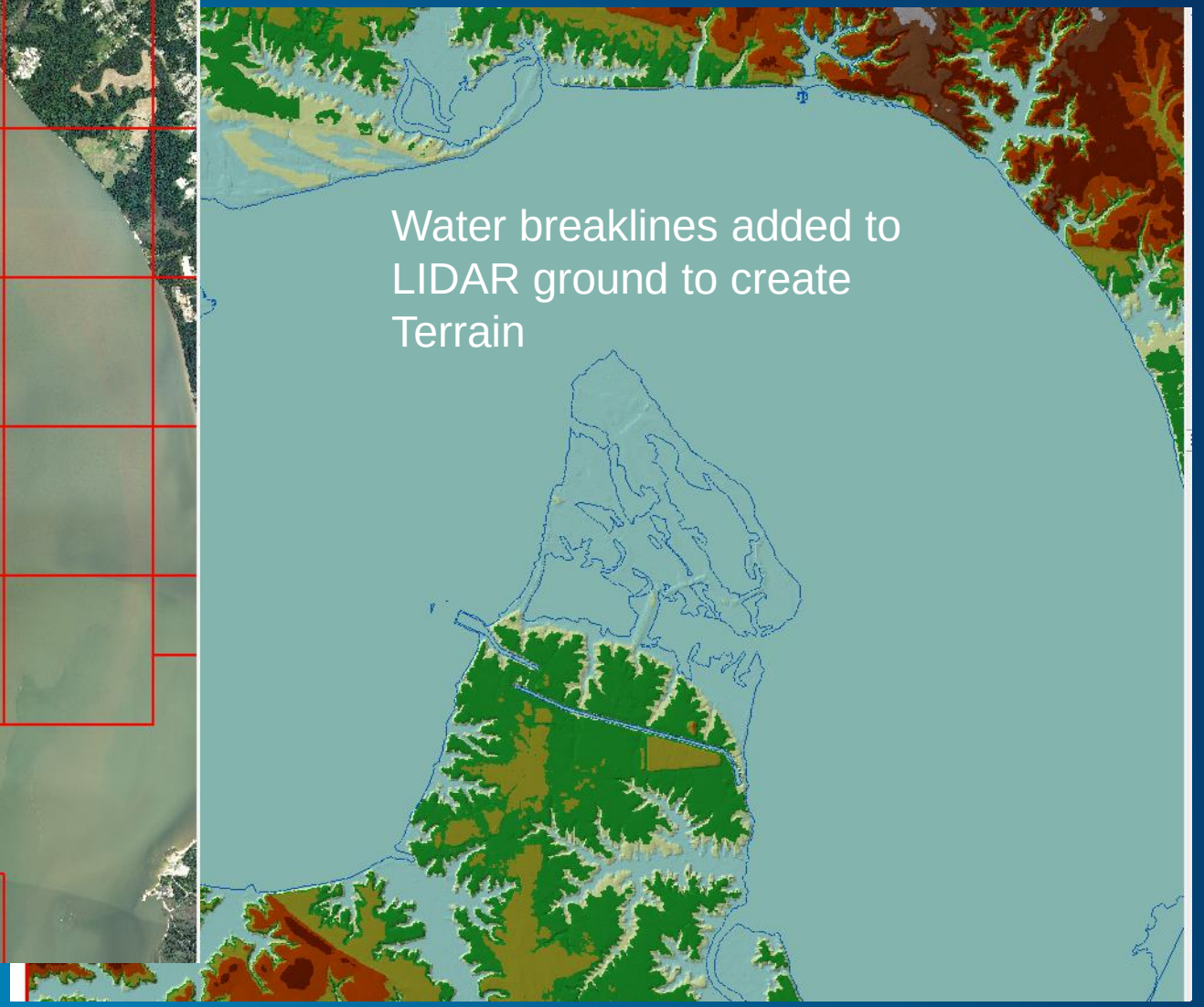
3D Scene Creation – James River Example

James River Project

- Decided on 65 mile study area extent
- Obtained lidar for entire area from source site
- Digitized water polygon to enforce breaklines and affect tree placement
- Processed lidar to create elevation
- Processed imagery and lidar to create tree points with height
- Created rotated towers with realistic model using CityEngine rule
- Digitized building footprints for power structure facility
- Hand modeled historic plantation building as collada ‘as-built’ models
- Created webscene in order to show reflective water
- Determined animated path to tell a story
- Created .mp4 video capture of story path

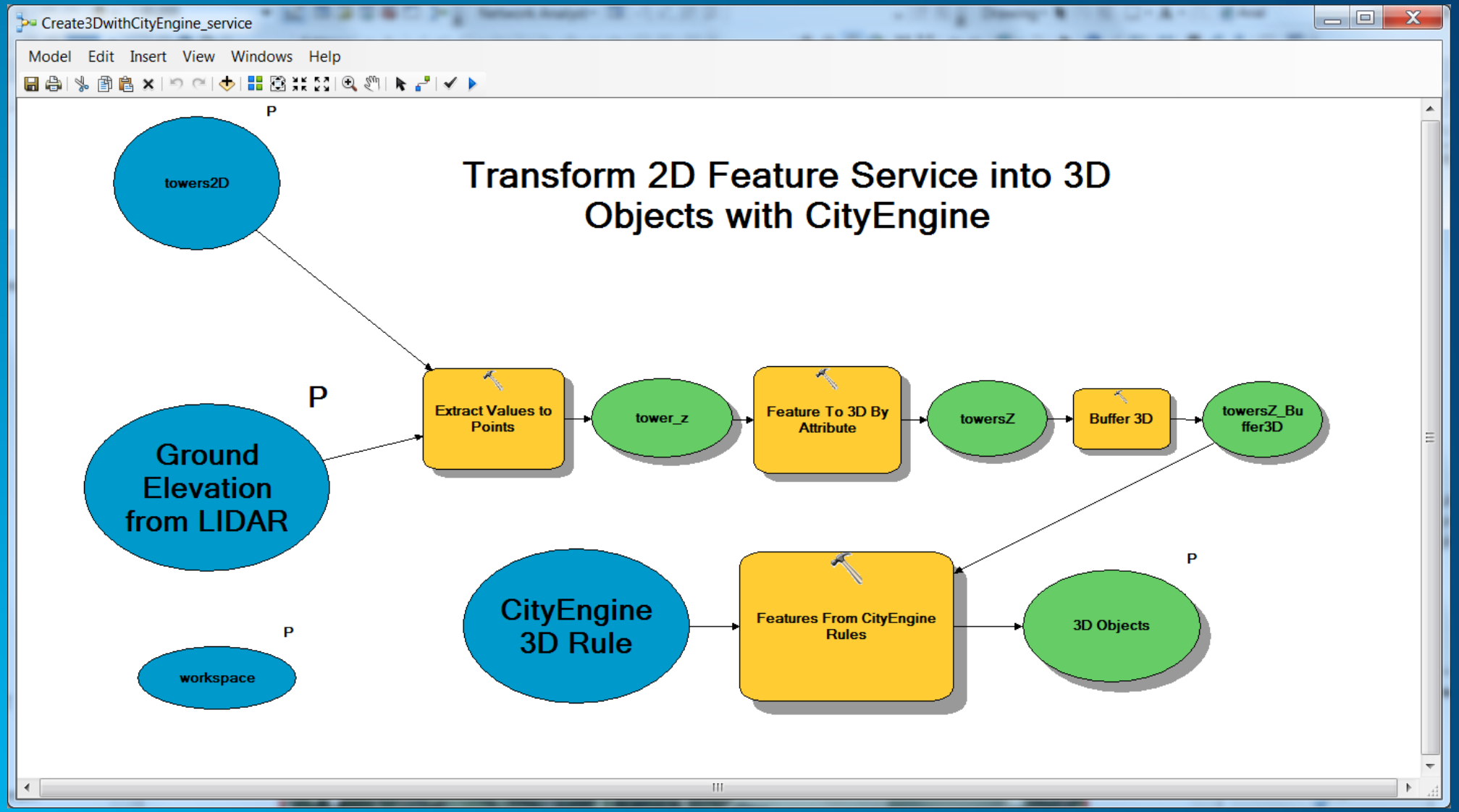

Proposed Tower
locations


65 Square miles of
LIDAR data used with
NAIP imagery

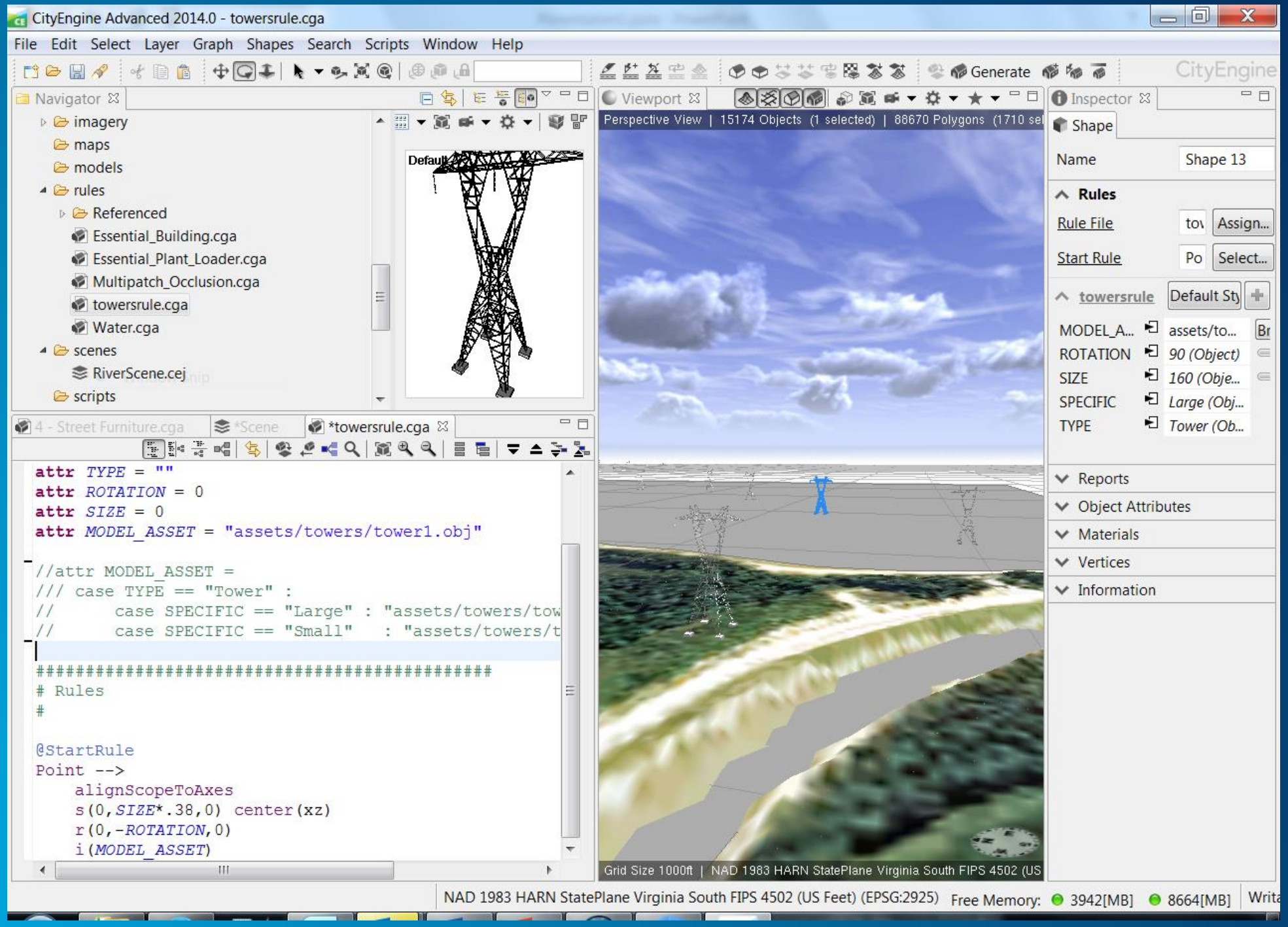

Water breaklines added to
LIDAR ground to create
Terrain

DEM and Trees (Height, Placement) – Derived from Lidar

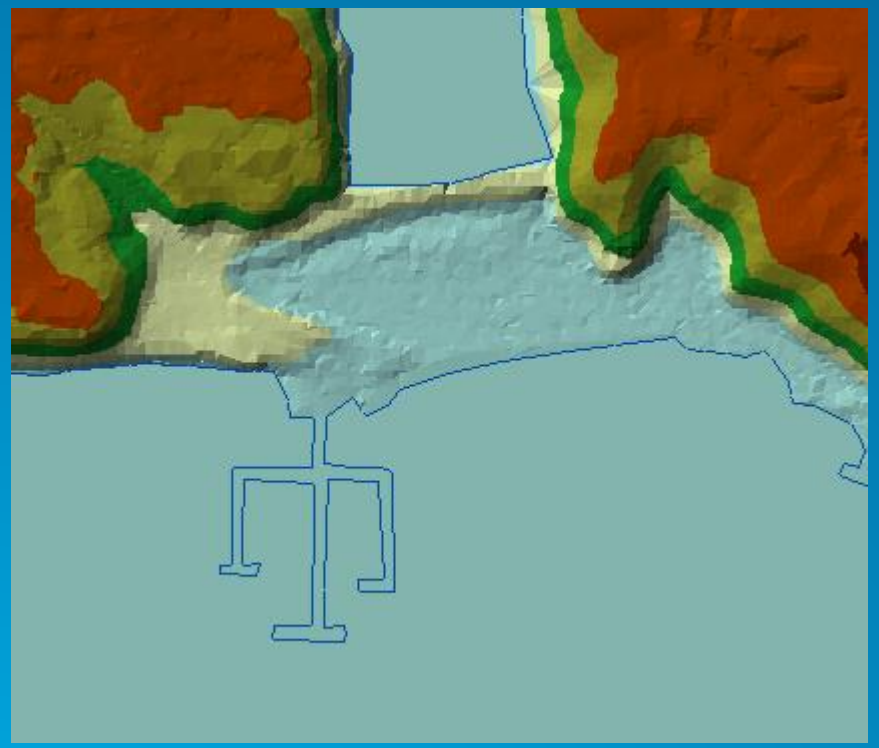
Position and Scale 3D Towers Using Lidar Elevation and Feature Attributes

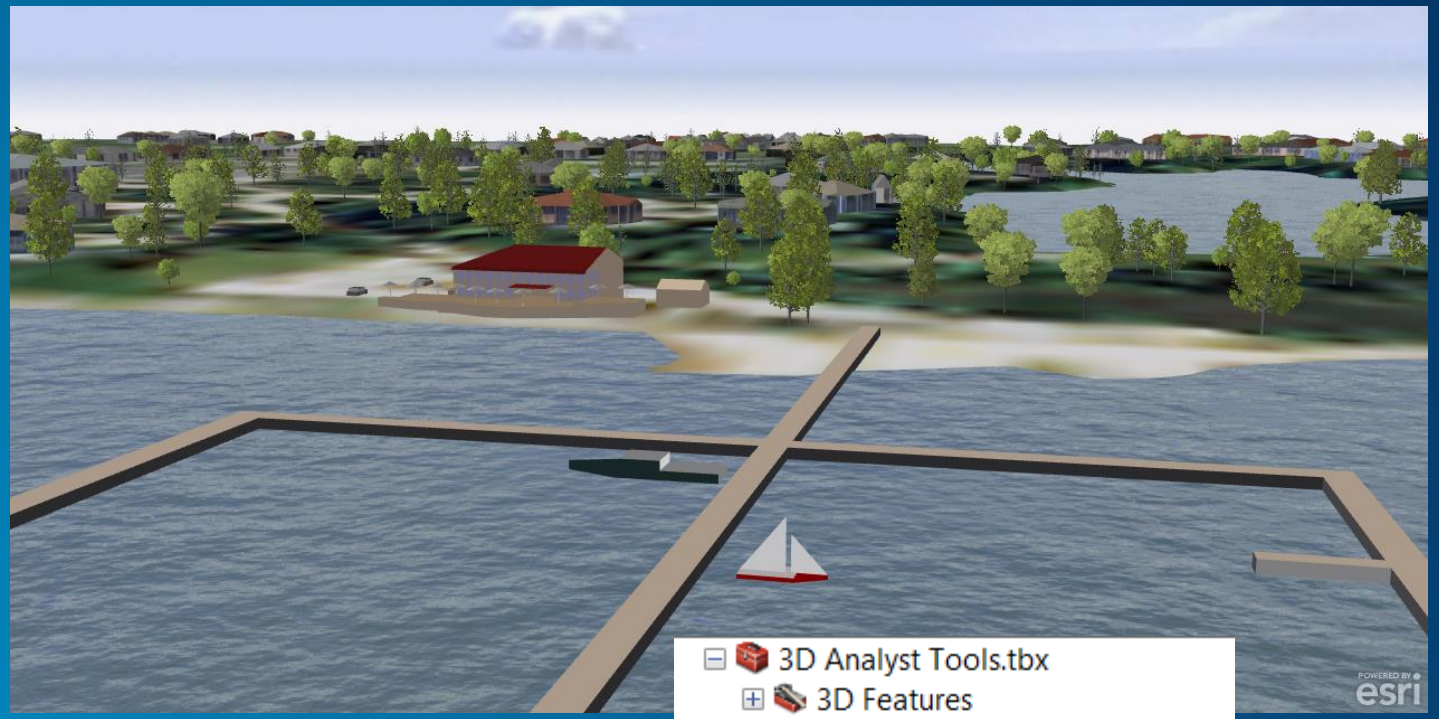


CityEngine
Tower Rule



Water Breaklines Preserved in DEM Creation





Terrain Properties

General | Data Sources | Pyramid Levels | Resolution Bounds | Update

Feature Class	Height Sour...	Group	SFType	Overview
MASSPOINTS2_embed	Shape	1	mass points	Yes
extent2	<None>	2	soft clip	Yes
waterdissolve2Z	SHAPE	3	hard replace	Yes
emptyareaZclip	SHAPE	4	hard replace	Yes

- 3D Analyst Tools.tbx
  - 3D Features
  - CityEngine
  - Conversion
    - From Feature Class
    - From File
    - From LAS Dataset
    - From Raster
    - From Terrain
      - Terrain to Points
      - Terrain to Raster
      - Terrain to TIN
    - From TIN
    - Layer 3D to Feature Class

CityEngine Rule Packages Create Simple Textured Buildings with Roofs

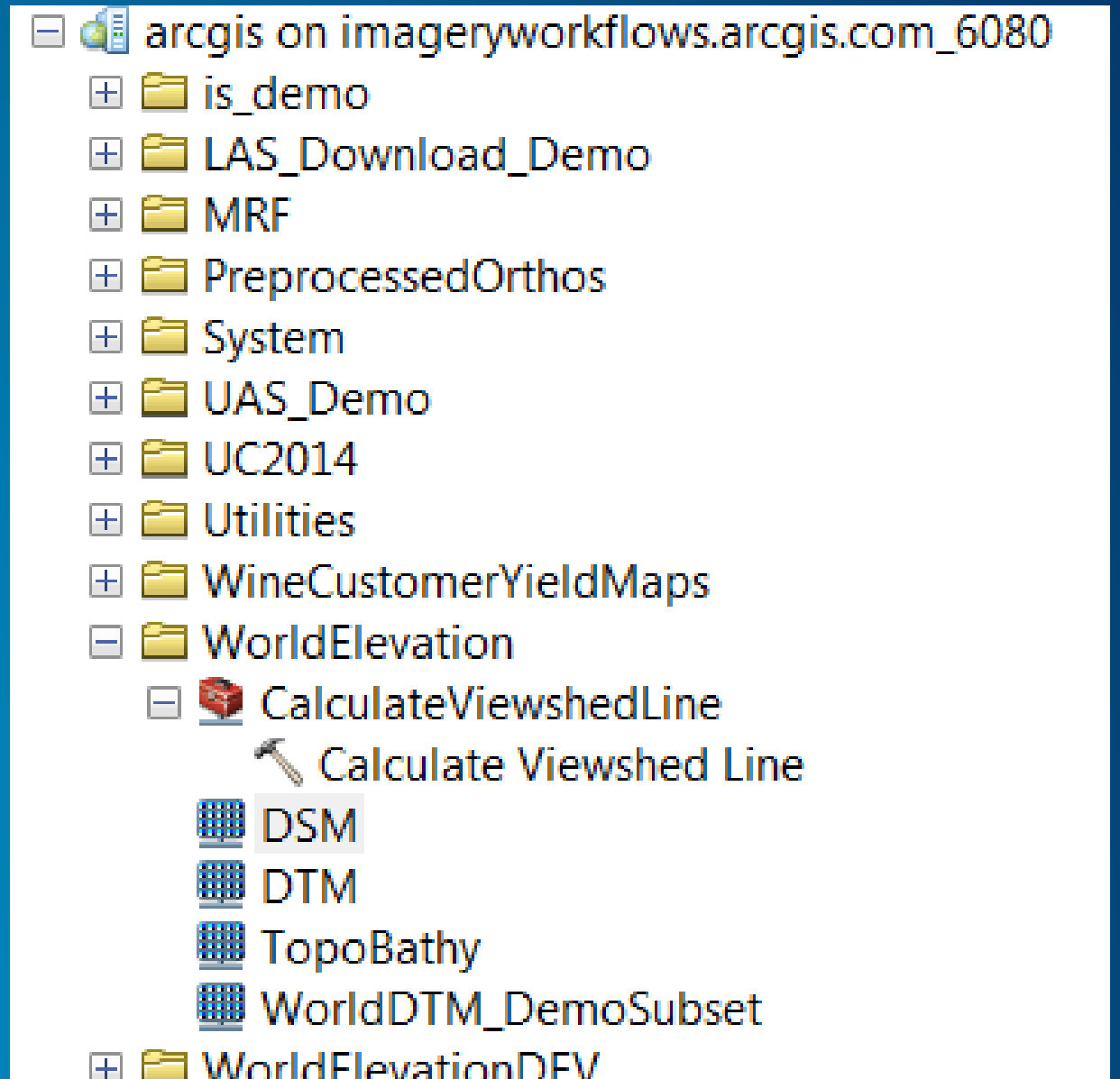
- 3D Analyst Tools.tbx
  - 3D Features
  - CityEngine
    - Export To 3D Web Scene
    - Features From CityEngine Rules

Hand Modeled ‘Signature’ Historic Buildings Imported as Collada Models

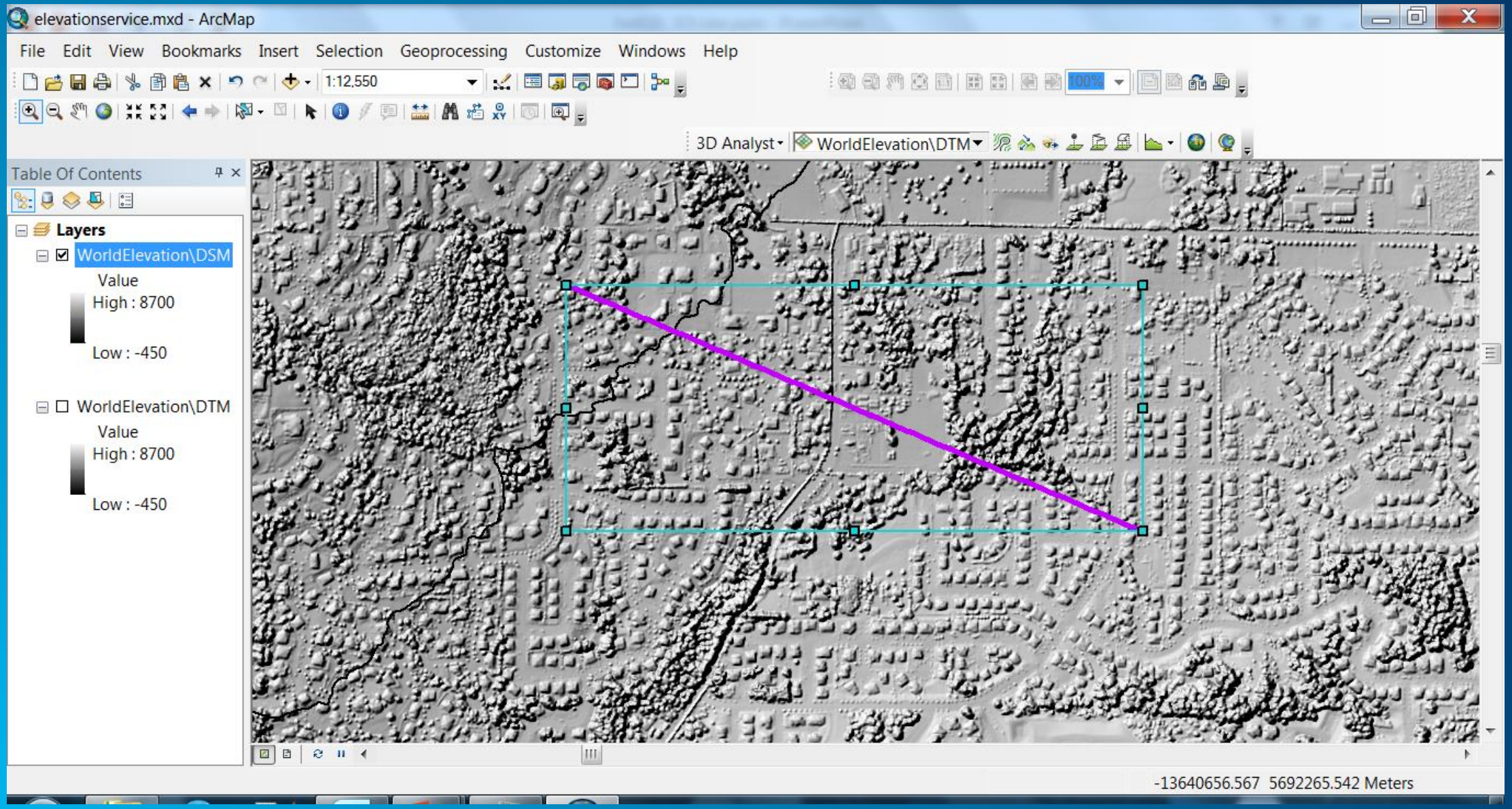
Demo – James River Webscene Video

Published Image Service From Lidar - DSM and DTM

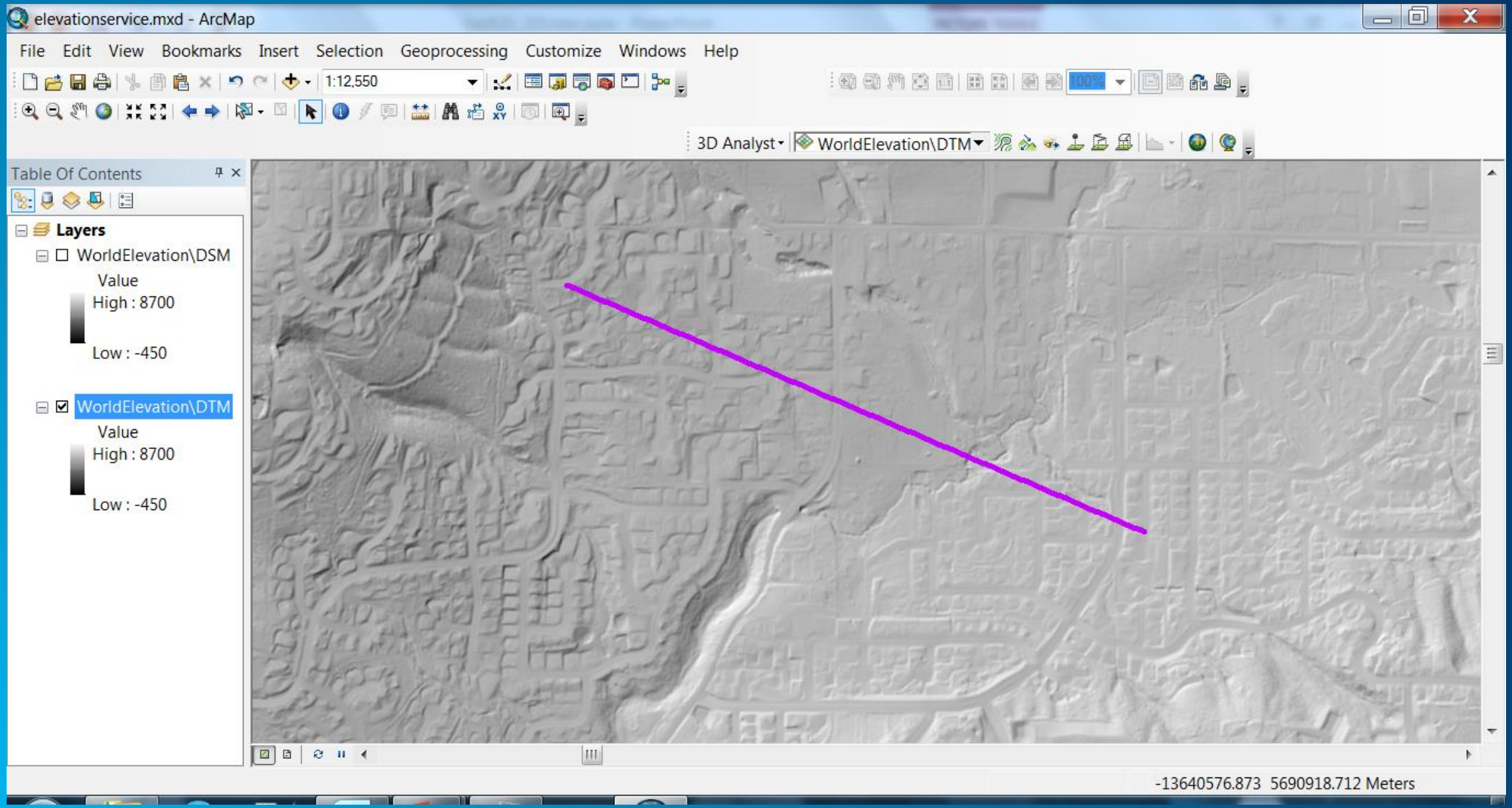
- Rest Endpoints to Service
- Connect from ArcGIS Desktop too



DSM Service with Hillshade Applied on the Fly

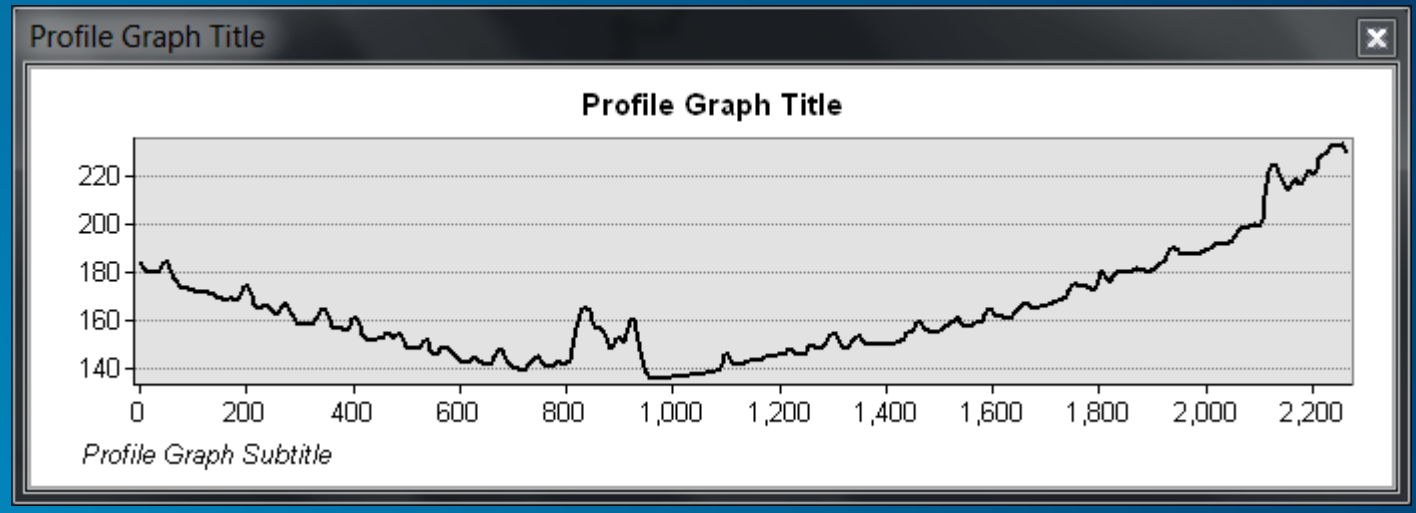


DTM Service with Hillshade Applied on the Fly

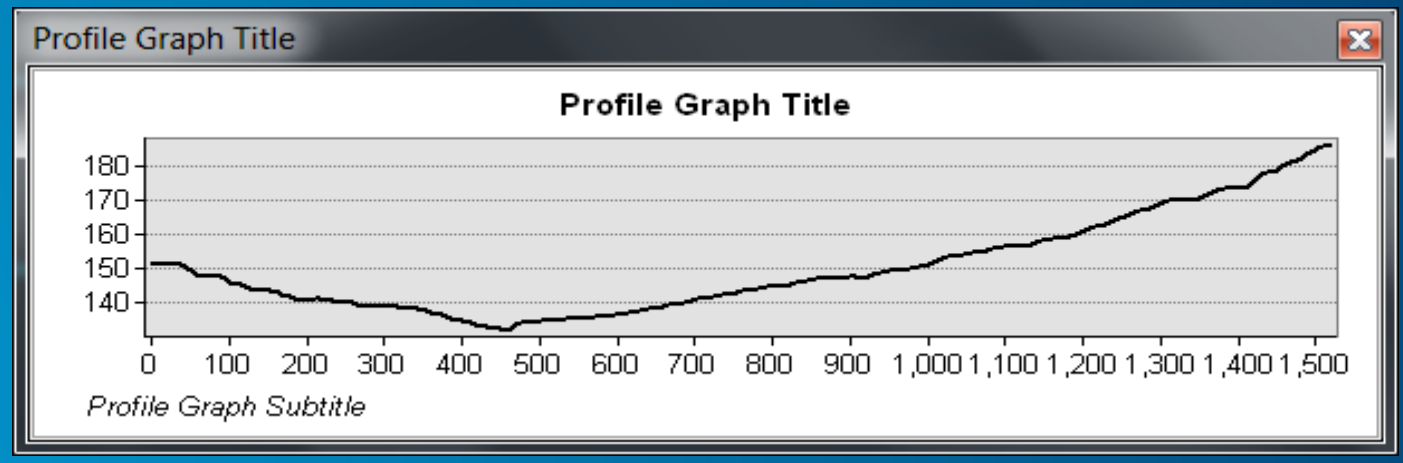


Comparison of Elevation Profiles Using 3D Analyst Profile Tool

DSM Profile



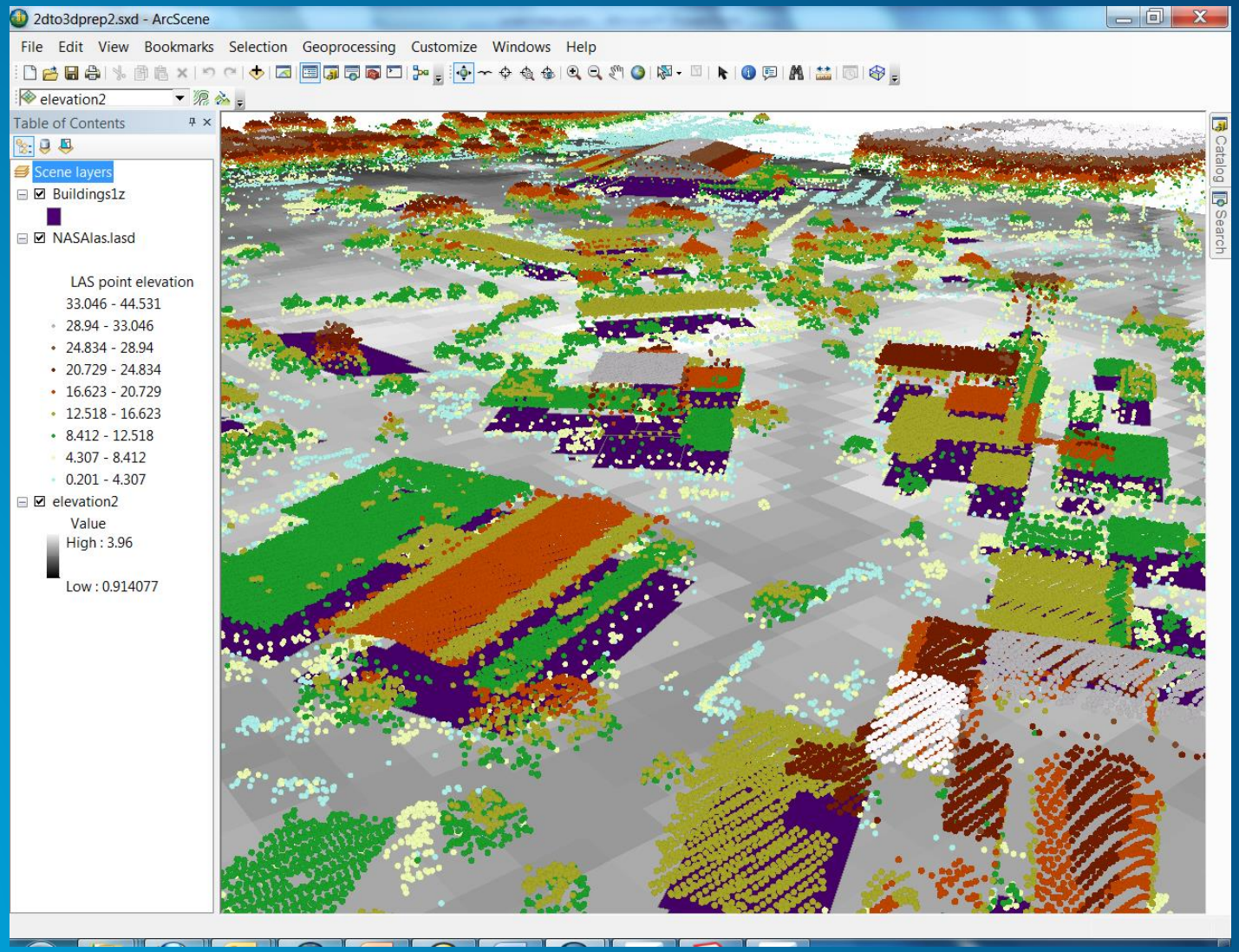
DTM Profile



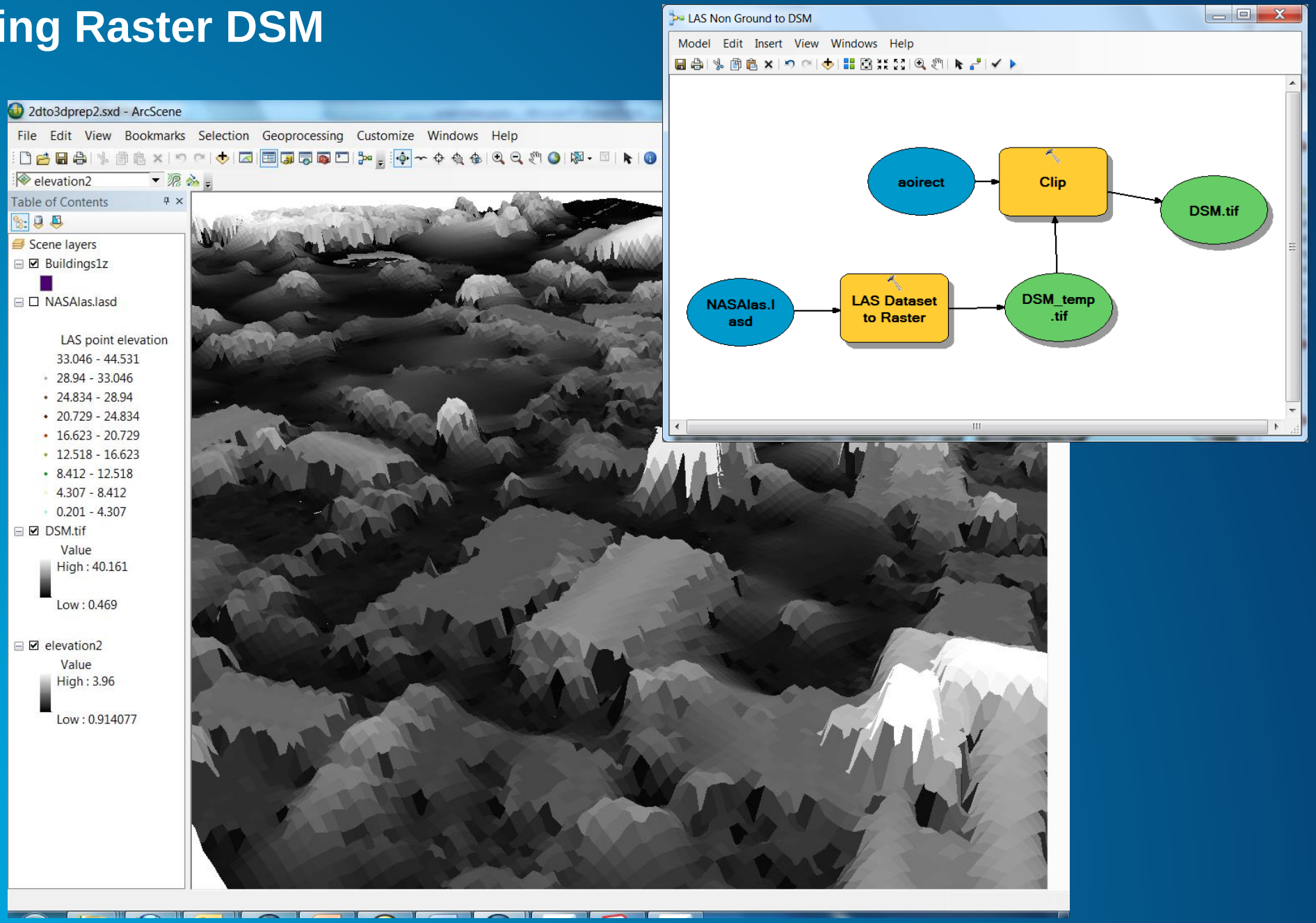
Using Lidar to Calculate Building Heights

- Create a ground surface from ground returns – DTM
- Use first return to create a DSM surface
- DSM – DTM = nDSM
- Use Zonal Statisitics to find height over building footprints.

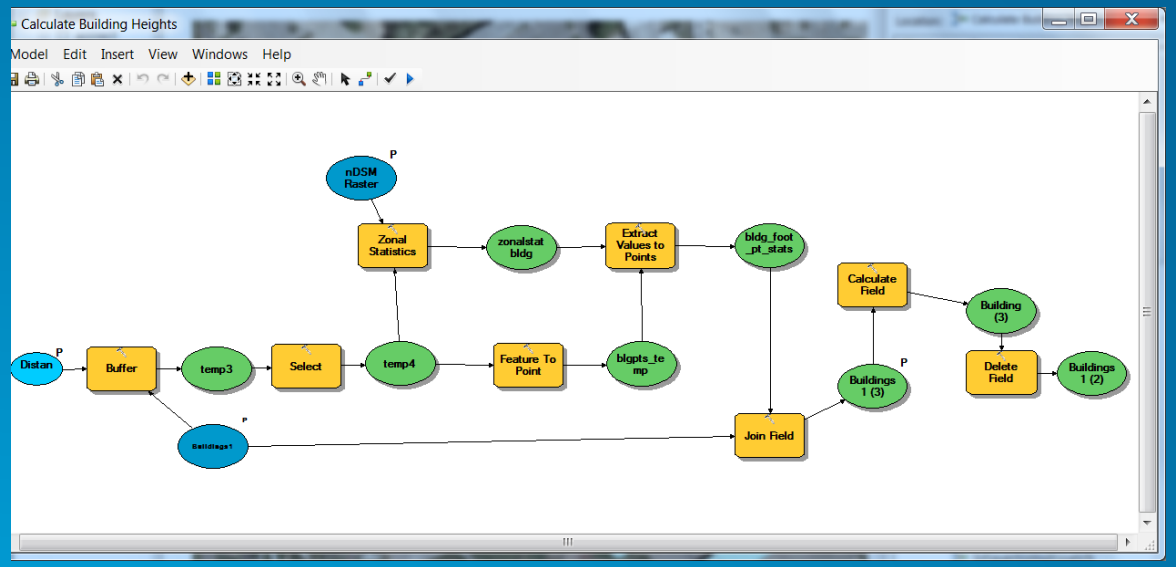
Obtain Digital Surface Terrain Model Raster (DSM) from Lidar – Here is the LIDAR data first return points LAS Dataset in ArcScene

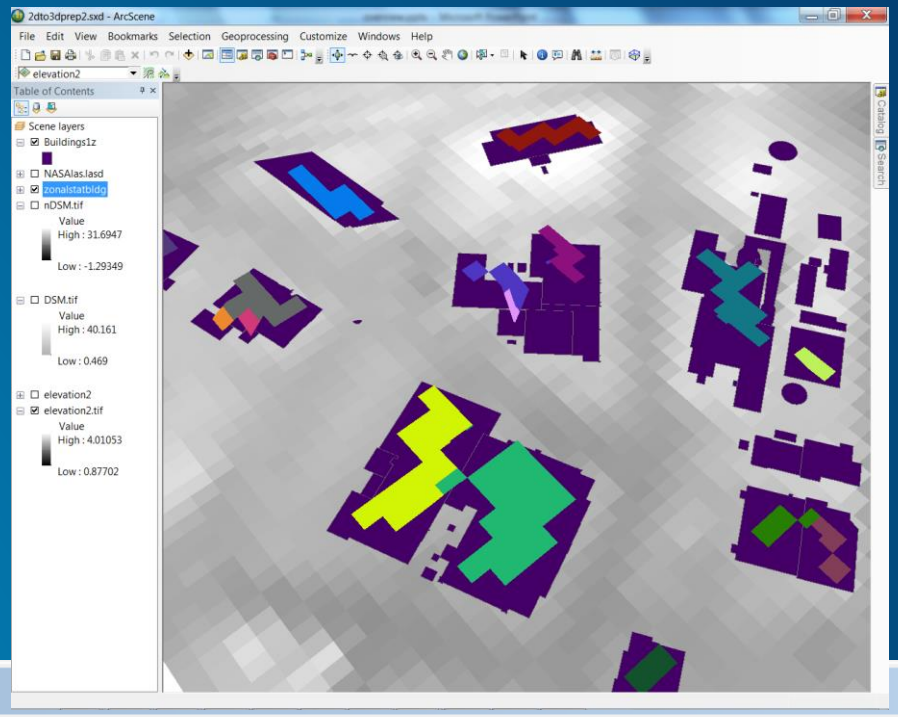


The Resulting Raster DSM



Calculate Building Heights and Levels Above Ground from nDSM





Table

Buildings1z

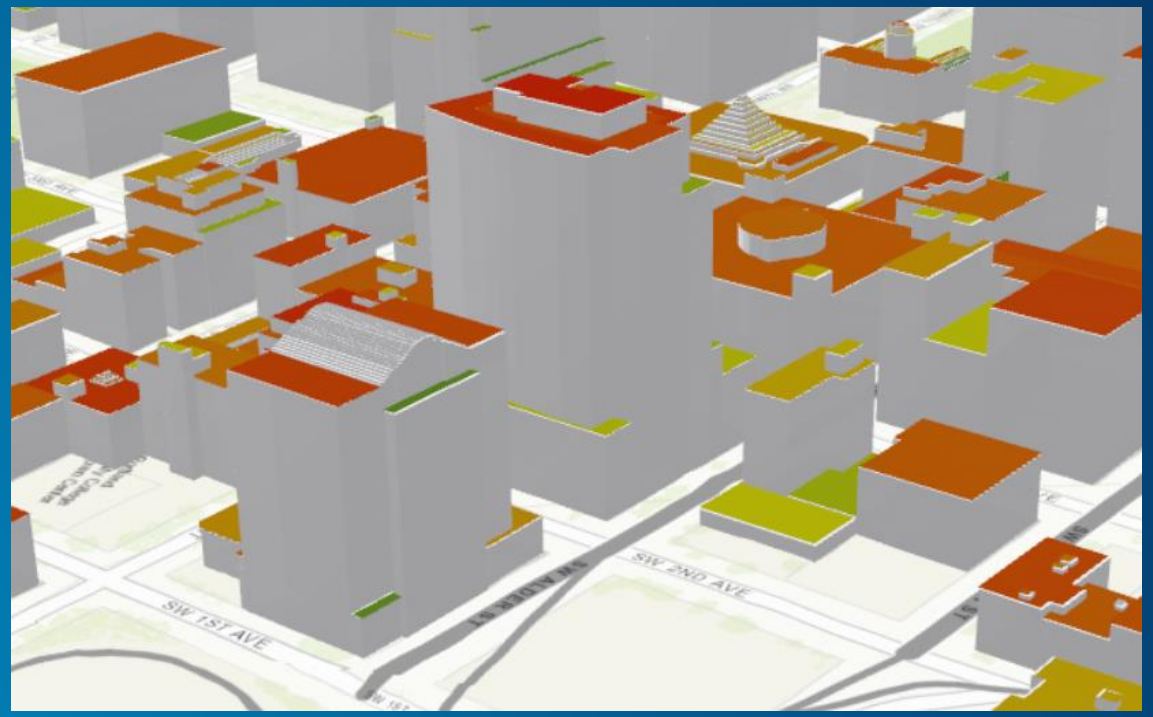
Attribution/Source	Subtype	Usage	Total height	Eave height	Roof form	Levels above ground	Levels
<Null>	<Null>	<Null>	3.6587	<Null>	<Null>	1	<Null>
<Null>	<Null>	<Null>	21.9221	<Null>	<Null>	7	<Null>
<Null>	<Null>	<Null>	5.3553	<Null>	<Null>	2	<Null>
<Null>	<Null>	<Null>	29.648901	<Null>	<Null>	10	<Null>
<Null>	<Null>	<Null>	3.9033	<Null>	<Null>	1	<Null>
<Null>	<Null>	<Null>	3	<Null>	<Null>	1	<Null>

1 (0 out of 105 Selected)

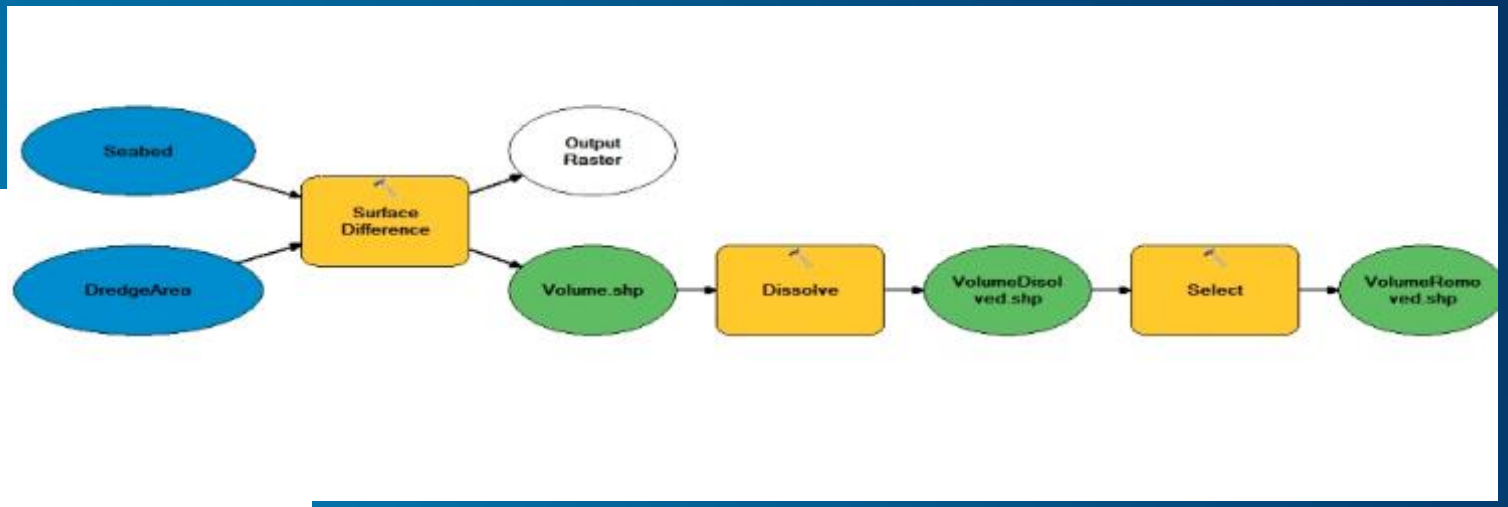
Buildings1z

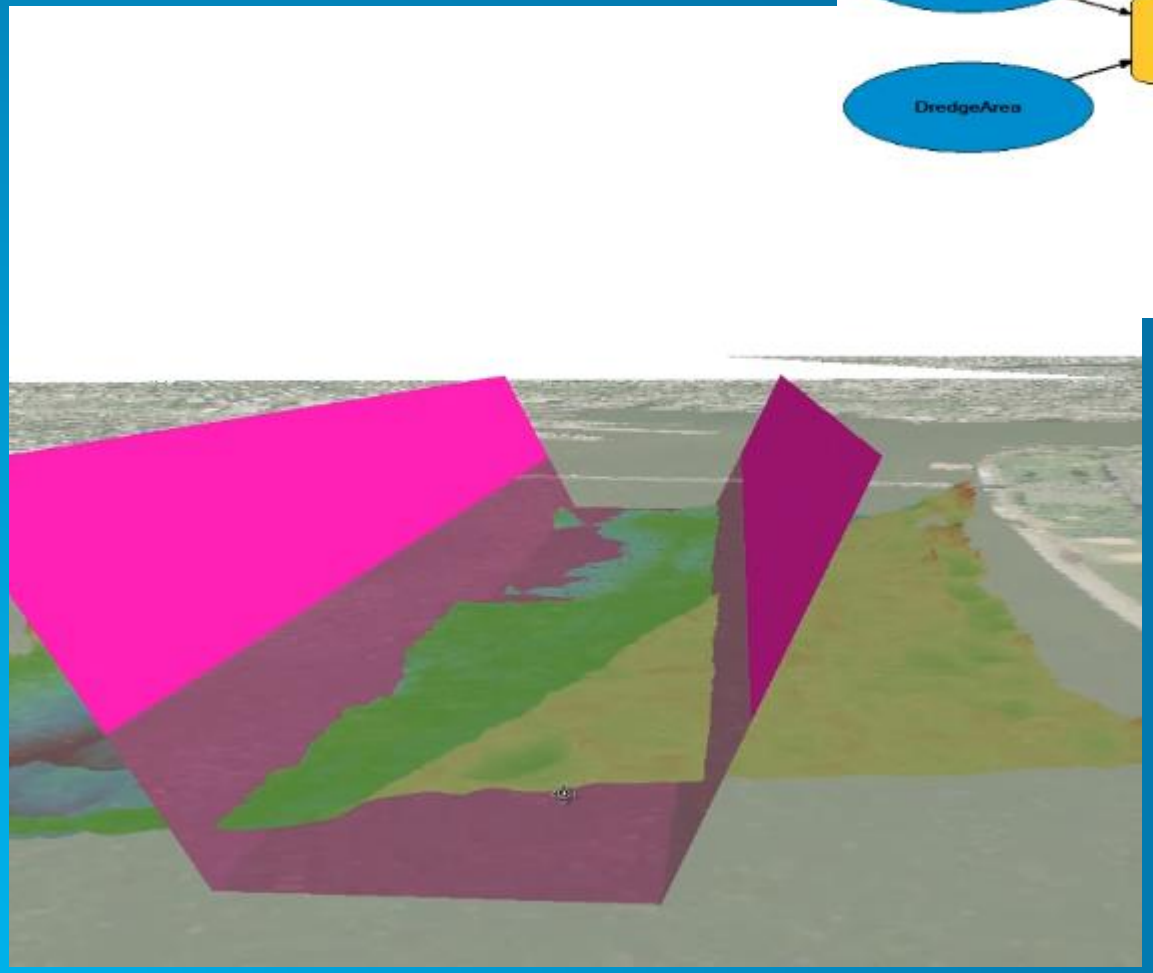
Demo – Presenting Analysis In WebScenes

- Solar Potential
- Buildable Volume
- Shadow Patterns



Volumetric Analysis – Dredging Example

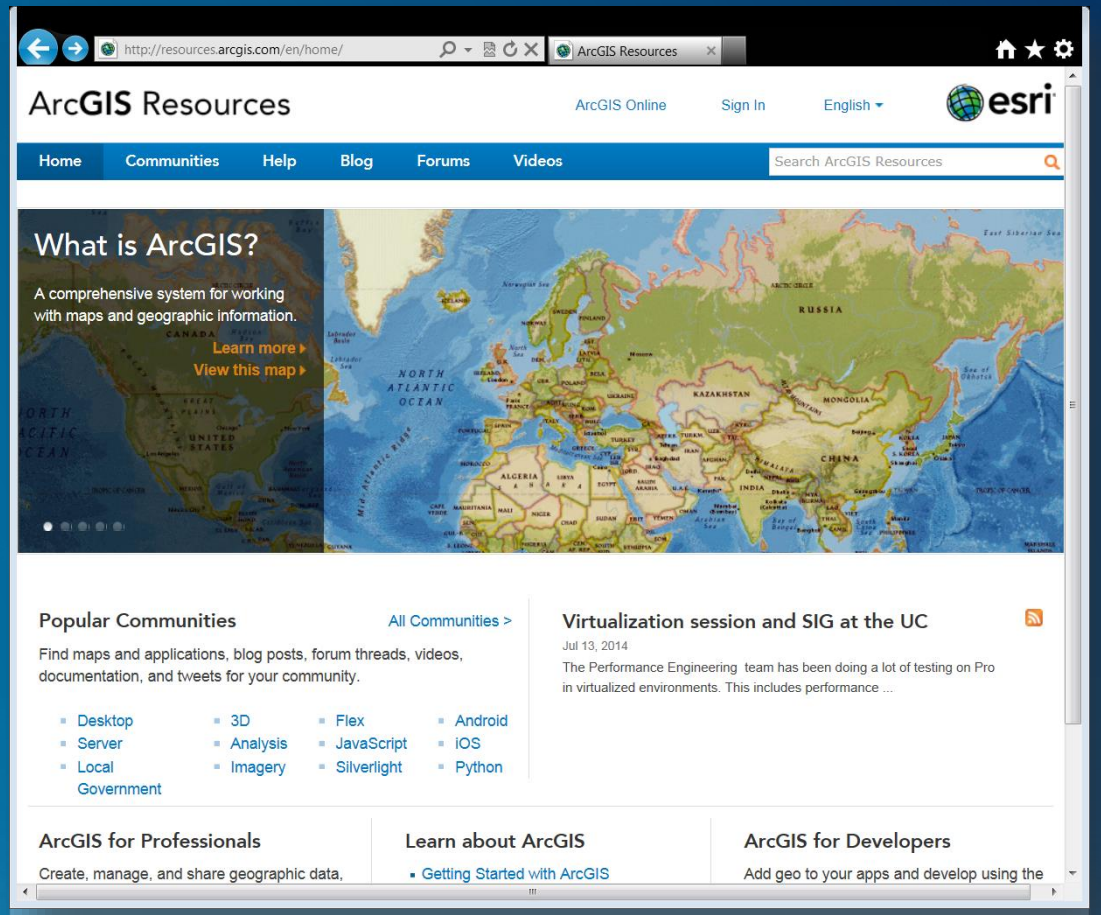




3D Community on ArcGIS Resource Center

http://resources.arcgis.com

- Helpful Utilities: LAS Optimizer, Custom Tools
- Solution Templates: Guides and sample data to illustrate best practice applications for tasks in 3D
- News: Learn about what's new in 3D GIS.



Federal GIS Conference
February 9–10, 2015 | Washington, DC

3D views of power are powerful
How it helped Washington DC

Gore Bolton, PE, PLS

Former Associate, Office Lead for AMT, LLC, Washington DC

Currently Founder and CEO of www.landfaxusa.com

The analysis in Washington DC

- http://www.ncpc.gov/heightstudy/
- http://www.ncpc.gov/heightstudy/docs/02_Final%20Federal%20Interest%20Report%20and%20Findings.pdf
- http://www.ncpc.gov/heightstudy/docs/District's%20Height%20Master%20Plan%20FINAL%20Recommendations%20Report_Nov%2020%202013.pdf
- **What it was**
  - **Simple analysis of several heights**
- **What it was not**
  - **A skyline development plan**

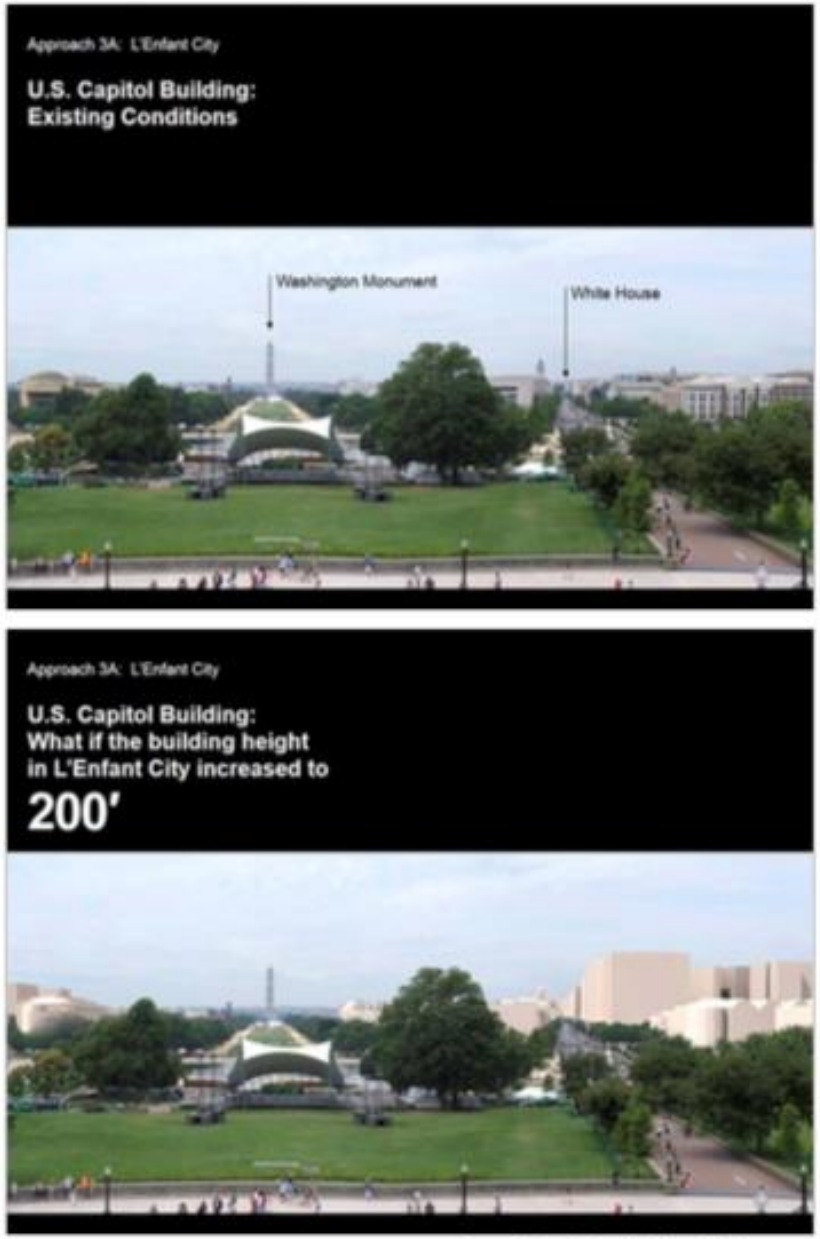
The analysis of Washington DC

- Scope of work as requested by DCOP and Congress
  - Three fixed heights
  - View corridors of significance
  - Historical views
- The real challenge of two dimensional streetscapes
  - Photos photos photos
  - Not much latitude to “play” with scenarios
  - Having to overlay ages and possibility/probability of redevelopment
- How City Engine made the extrusions
  - Stepwise
  - Could have been leveraged even more (i.e. block by block, and reverse lines of site)
  - Construct of “height zones” based on places of significance (i.e. we don’t want the views on the mall to change)

Historic L'Enfant City Boundary

Image: District of Columbia Office of Planning

View from the steps of the U.S. Capitol showing the setting provided by the U.S. Capitol Grounds and the National Mall



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View South on North Capitol Street to the U.S. Capitol

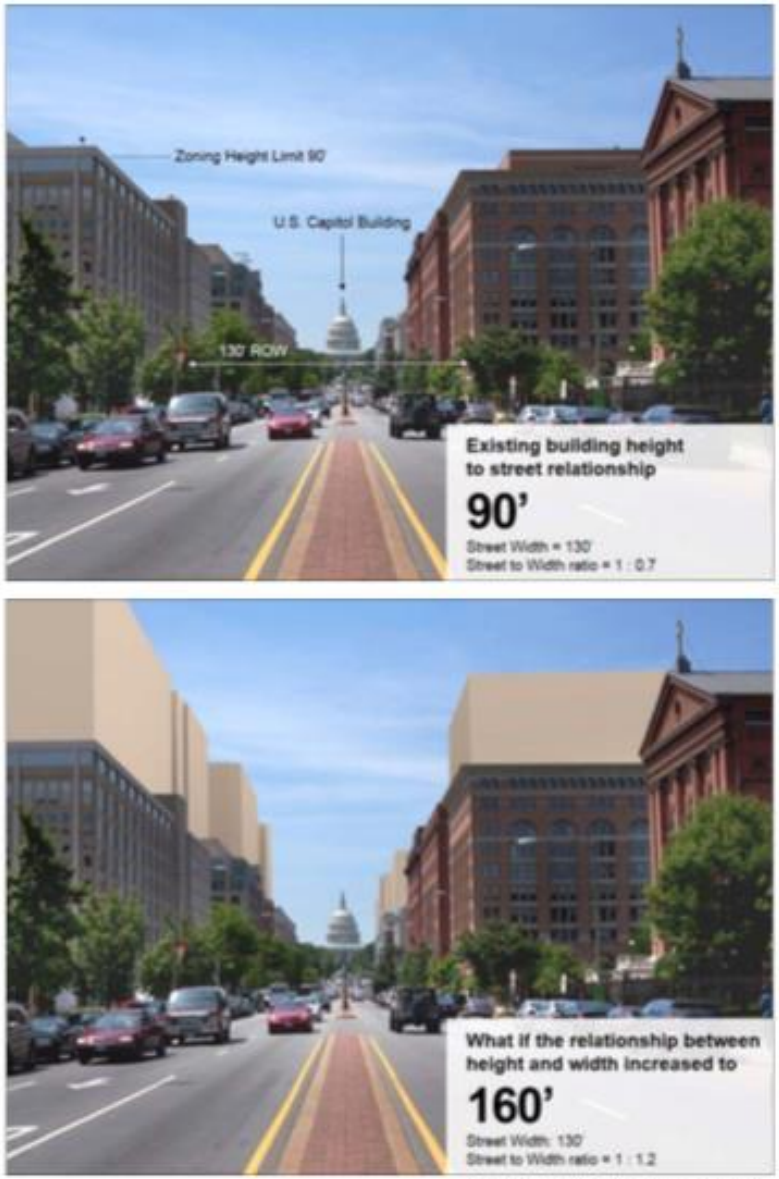

Image: District of Columbia Office of Planning

The District's visual modeling study shows that even increasing building heights to 160' under the ratio proposal begins to diminish the presence of the U.S. Capitol dome.

Modeled view of the White House from the Jefferson Memorial with a uniform building height increase up to 200'

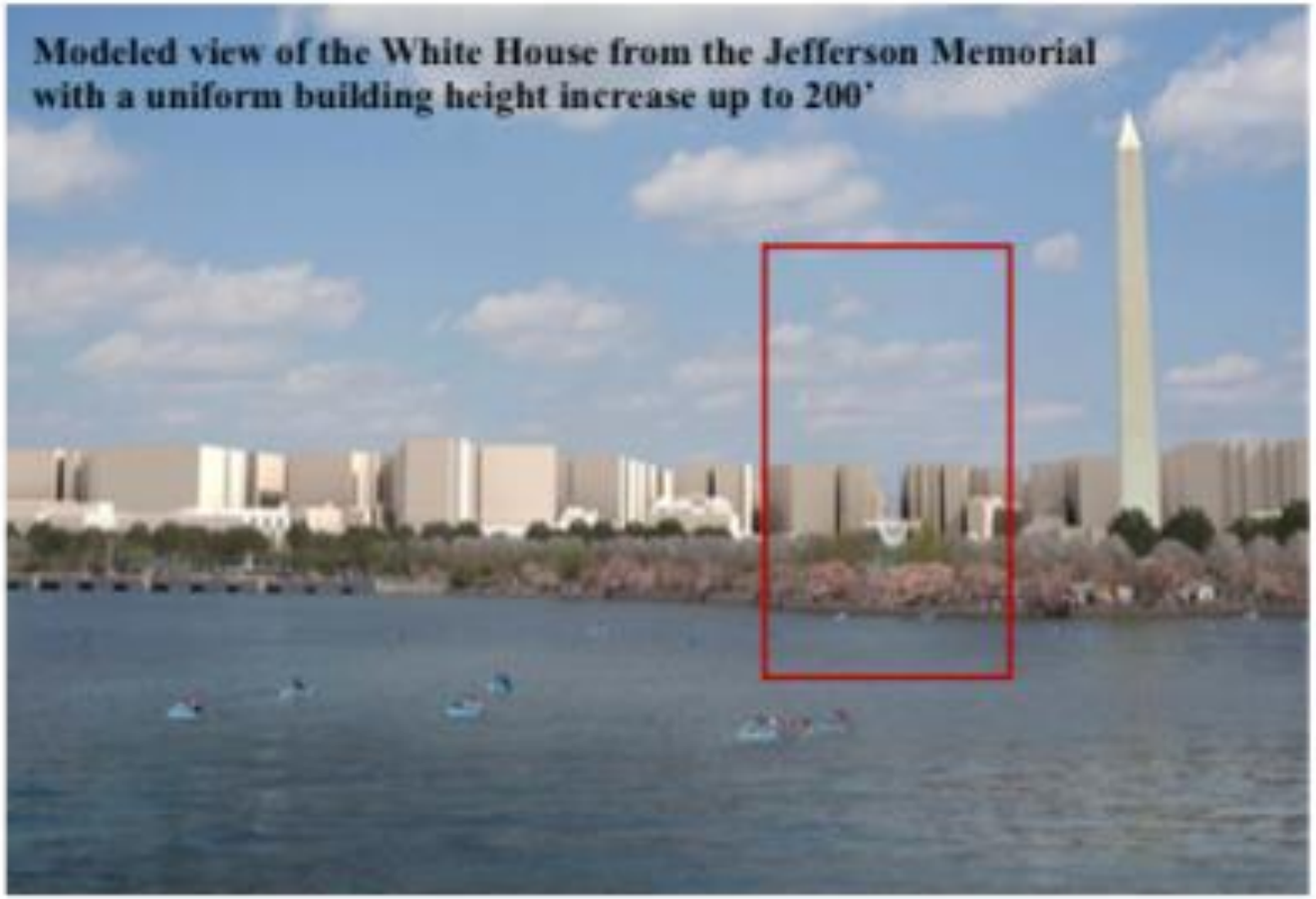

Image: District of Columbia Office of Planning

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Image of Historic Resources Map[29]

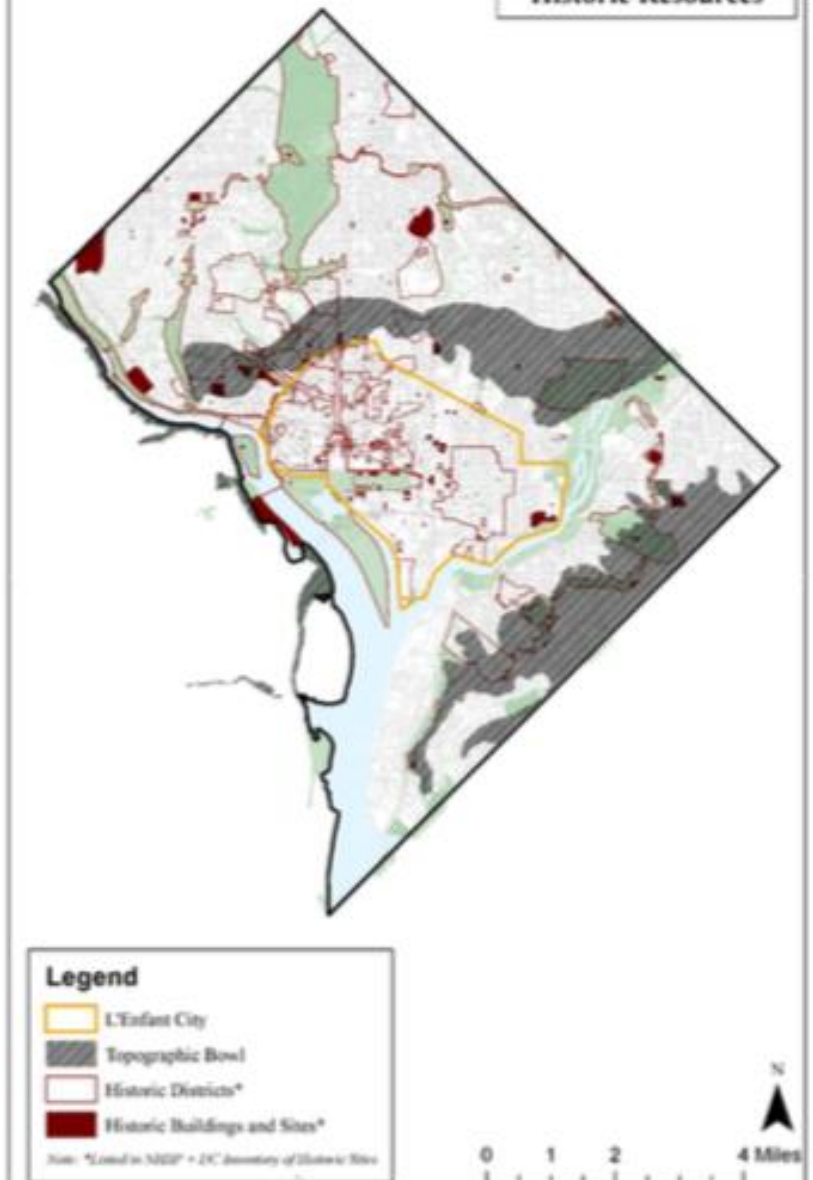

Image: National Capital Planning Commission

Image: nps.gov

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Figure: Examples of location specific interests.
Zoning Map of the District of Columbia, Capitol Interest Overlay District [30]

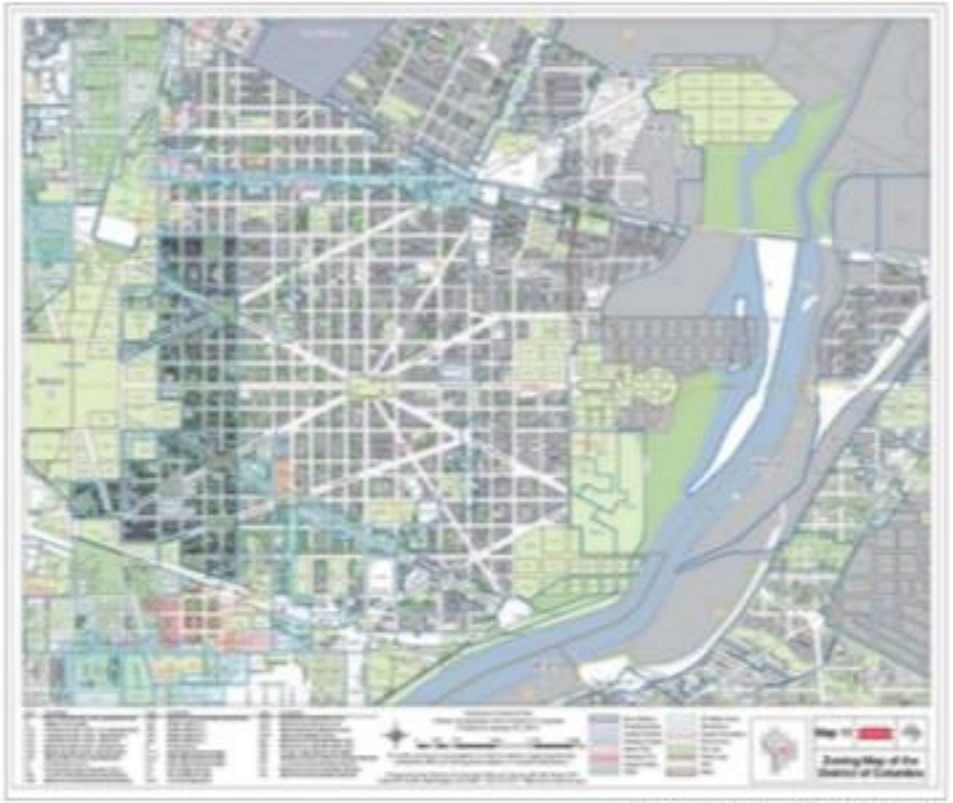

Image: District of Columbia Office of Zoning

Regan National Airport Flight Paths [31]

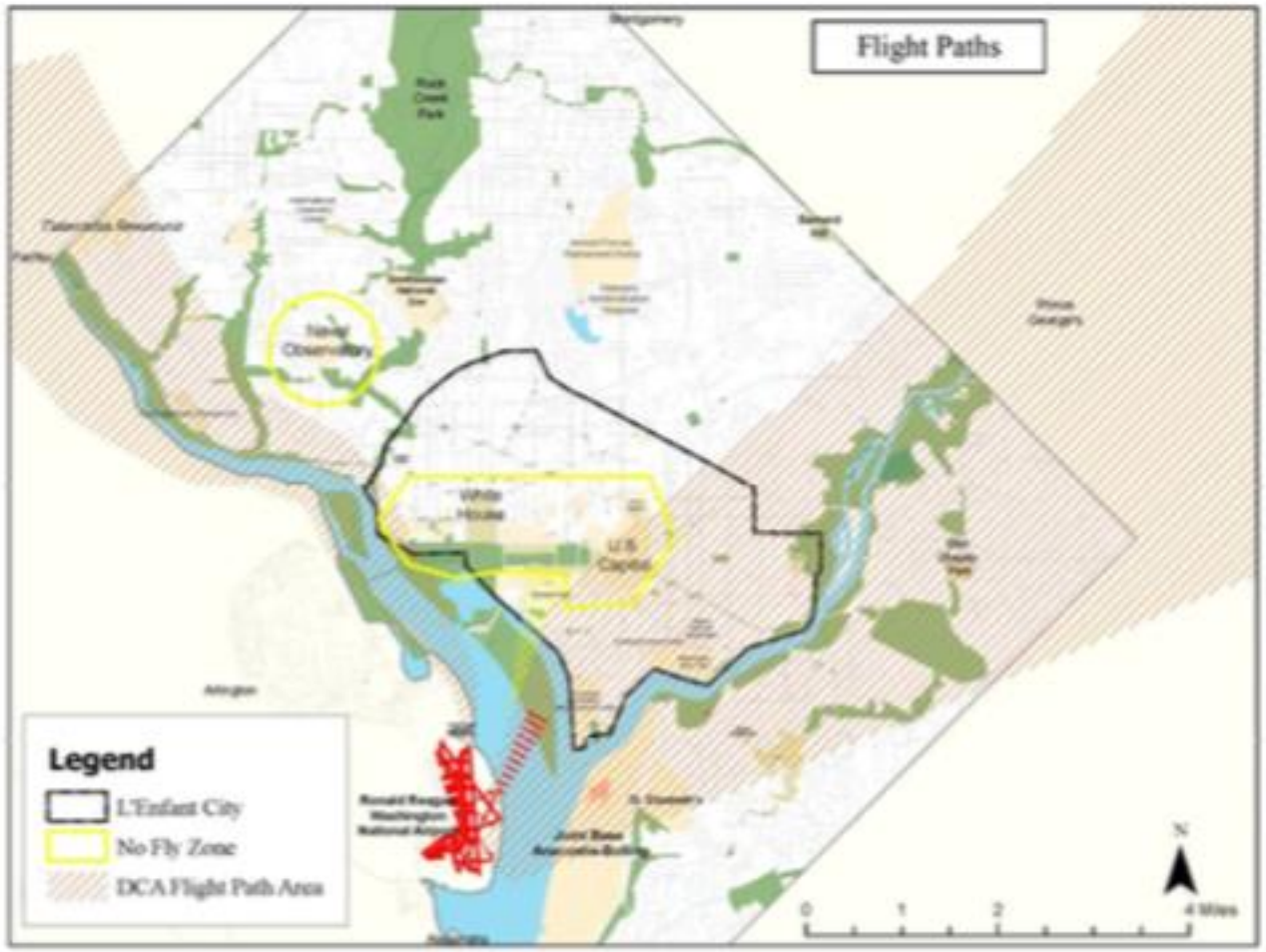

Image: National Capital Planning Commission
Data: Metropolitan Washington Airports Authority

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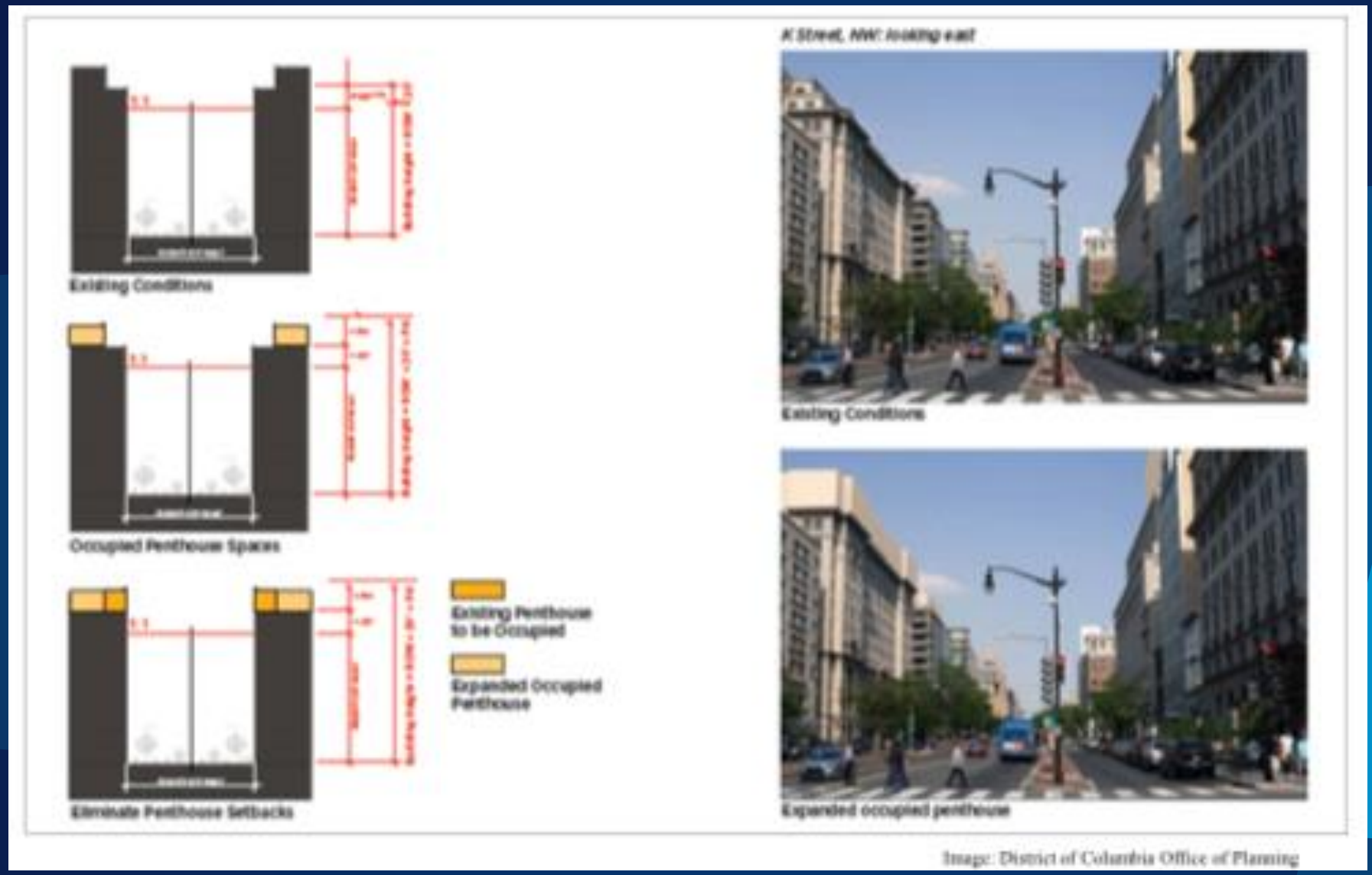

- **Gore Bolton – 3d City Planning**