

Unit 03: Understanding Simulation Outputs

WEB-BASED FLOOD INUNDATION MODELING WITH DSS-WISE WEB: A
SHORT COURSE ON RECENT UPDATES WITH HANDS-ON TRAINING

For
FEDERAL EMERGENCY
MANAGEMENT AGENCY



FEMA



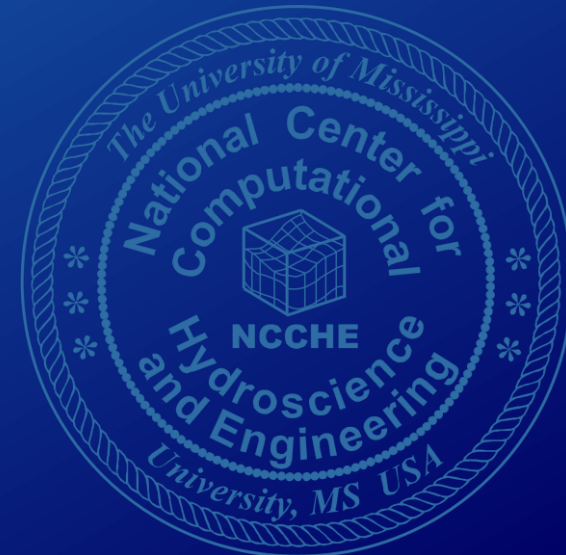
Technical Workshop

May 19, 2024

*Baird Center, 400 W. Wisconsin Ave, Room S 102 C
Milwaukee, WI 53203*

Developed by

NATIONAL CENTER FOR COMPUTATIONAL HYDROSCIENCE AND ENGINEERING
THE UNIVERSITY OF MISSISSIPPI



Status & Results Page

3.1

Status & Results

Home Portal About Help Nuttita Popphet UNITED STATES

#76659 • VA15302 May 12, 2024 7:25:02 pm

Layers Query Tool

Base Layers

Maps

- OpenStreetMap
- Mapbox Streets
- Mapbox Light
- Mapbox Outdoors
- Mapbox Dark
- Blank

Imagery

- ESRI World Imagery
- Bing Satellite
- Mapbox Satellite
- Mapbox Satellite Streets

Elevation

- USGS Elevation

Human Consequences: Finished
May 12, 2024 7:34:20 pm 2 mins

Nighttime PAR: 2,028
Daytime PAR: 818
Inundated Area: 4,765 acres
Virginia counties: 3

Simulation: Finished
May 12, 2024 7:26:13 pm 4 mins

Distance Achieved: 15.5 miles
Time Achieved: 1 day
120,269 compute cells

Breaching Reservoir Vol. 99.9% Released
0.1% Remaining

Data Prep: Finished
May 12, 2024 7:25:19 pm less than a minute

Filled reservoir volume match:
1. Reservoir 1: 100%

Simulation Details

Project name	Scenario Properties
T. Nelson Elliott Dam	Cell size: 45 ft
Scenario name Partial Breach Sunny Day Failure	Breach type: Partial breach
Scenario description 180 ft breach Reservoir at Max Pool	Breach width: 180 ft
This simulation was created from #76657	Breach formation time: 0.3 hr
	Breach invert elevation: 242 ft
	Reservoir 1: Reservoir 1 290 ft / 15,951 ac-ft

Downloads

Request Intermediate Results

Package Name	Size	Download	List
Simulation Results Package	10.21 MB		
Human Consequences Results Package	20.55 MB		

Status & Results Page has three main sections: **Layers**, **Query Tool**, and **Simulation Status, Details, and Downloads**.

Layers

Query Tool

Simulation Status and Details

Downloads

Load this simulation as a new simulation in the Prep Tool

Links to download full or individual simulation results files

Status & Results Page: Layers

3.2

Status & Results Page: Layers

Layers tab has two sections:

- “**Base Layers**” provide Maps, Imagery and USGS Elevation.
- “**Overlay Layers**” include Data, Inputs, Simulation Results, and HCOM Results (if launched)

Overlay Layers

Data

- National Bridge Inventory

Inputs

- Observation Lines
- Bridge Points
- Breach Center
- Reservoir Point(s)
- Breached Width
- Impounding Structures
- Impounding Structure Base Footprints
- Filled Reservoir(s)
- Simulation Domain Extent

The screenshot displays the 'Layers' panel on the left side of the interface. The 'Base Layers' section is highlighted with a red box and includes options for Maps (OpenStreetMap, Mapbox Streets, Mapbox Light, Mapbox Outdoors, Mapbox Dark, Blank), Imagery (ESRI World Imagery, Bing Satellite, Mapbox Satellite, Mapbox Satellite Streets), and Elevation (USGS Elevation). The 'Overlay Layers' section is also highlighted with a red box and includes options for Data (National Bridge Inventory) and Inputs. The main map area shows a 3D topographic view of a reservoir with roads labeled: GLEN ROAD, ROLLINS FORD RD EB, VINT HILL ROAD, Anchor Mill PL, and ROLLINS FORD RD. A scale bar at the bottom indicates 2000 ft.

Simulation Results

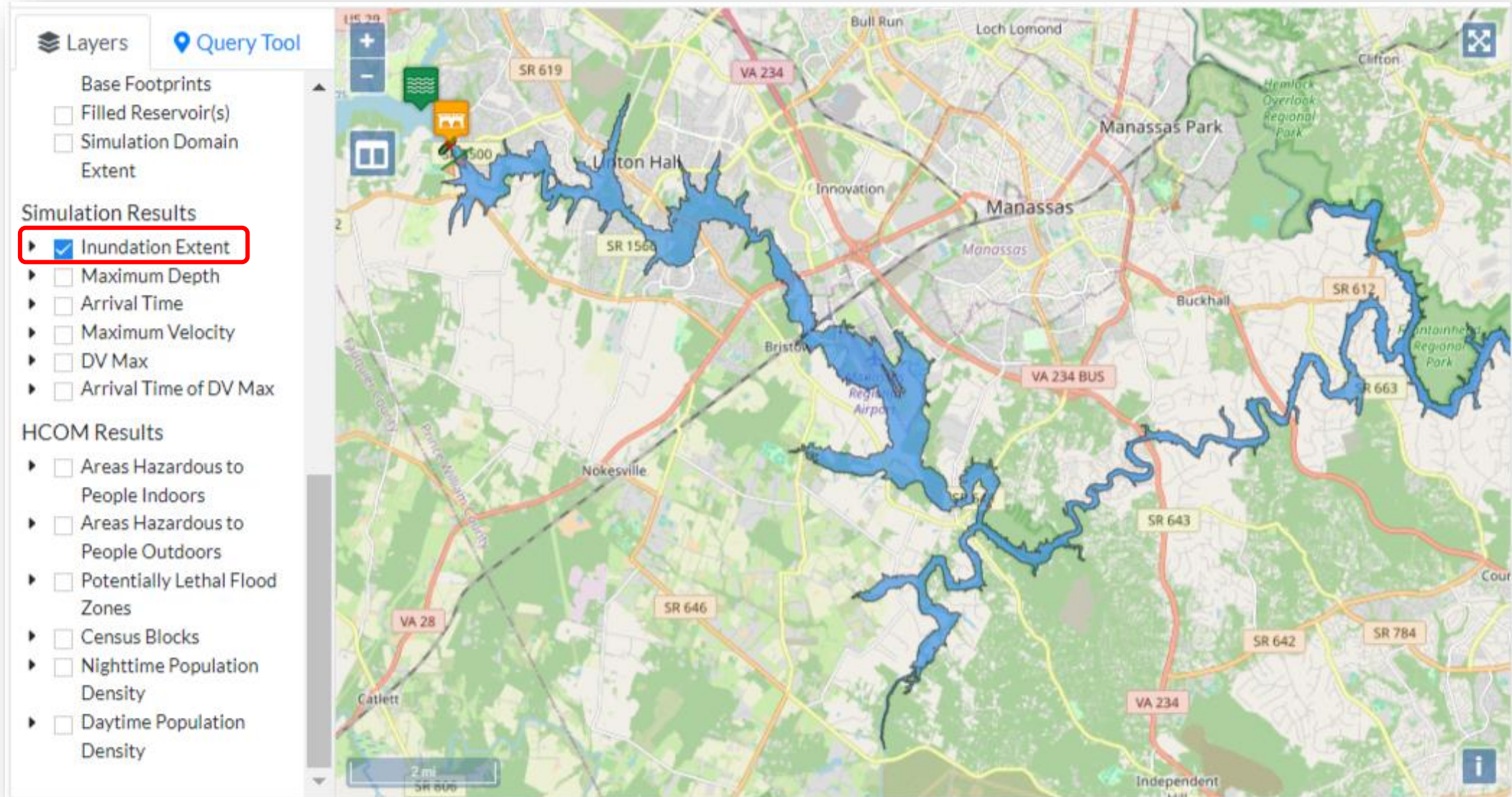
- ▶ Inundation Extent
- ▶ Maximum Depth
- ▶ Arrival Time
- ▶ Maximum Velocity
- ▶ DV Max
- ▶ Arrival Time of DV Max

HCOM Results

- ▶ Areas Hazardous to People Indoors
- ▶ Areas Hazardous to People Outdoors
- ▶ Potentially Lethal Flood Zones
- ▶ Census Blocks
- ▶ Nighttime Population Density
- ▶ Daytime Population Density

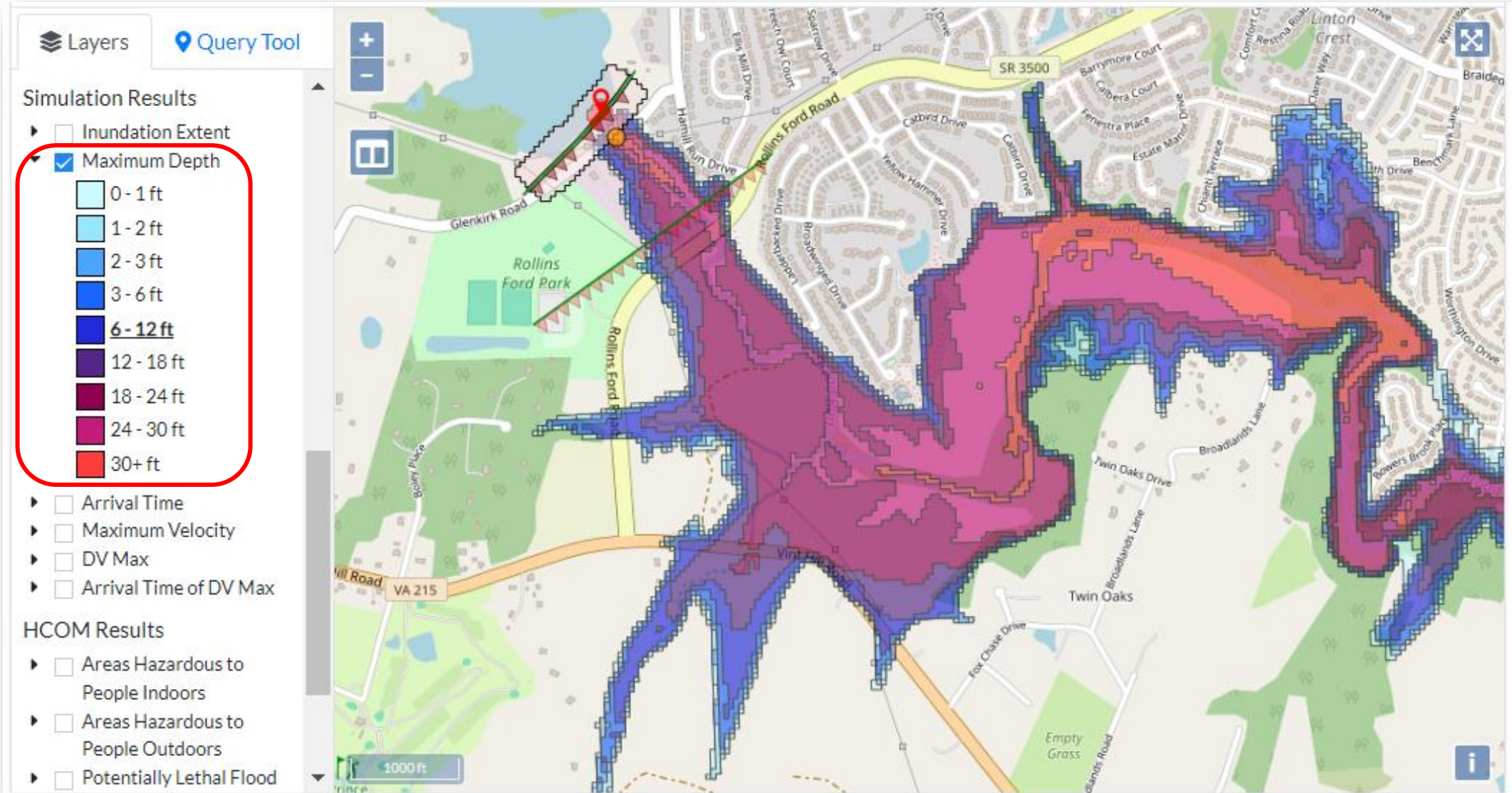
Simulation Results: Inundation Extent

The inundation extent layer has been displayed on the map.



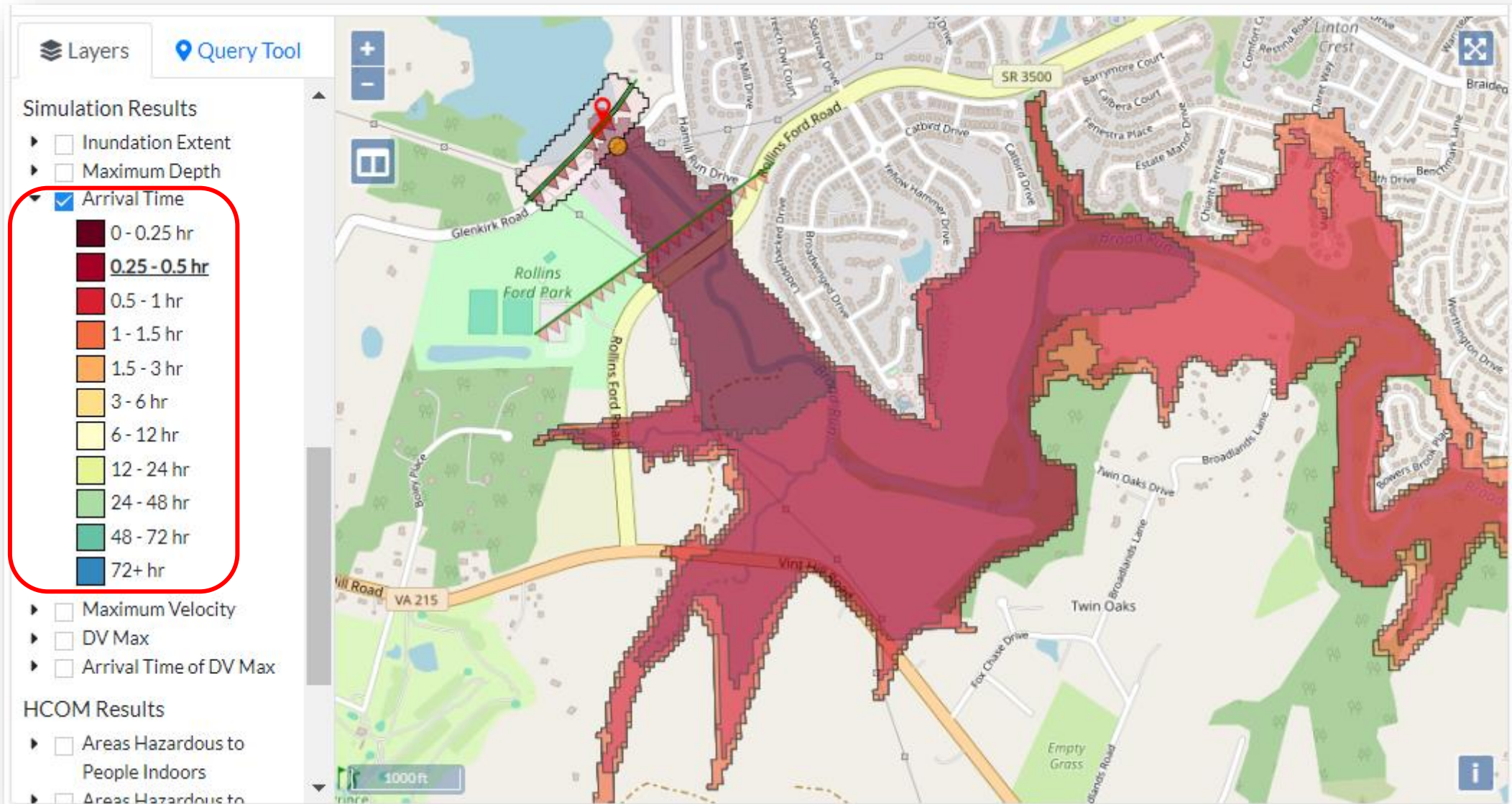
Simulation Results: Maximum Depth

The **maximum depth layer** has been displayed on the map.



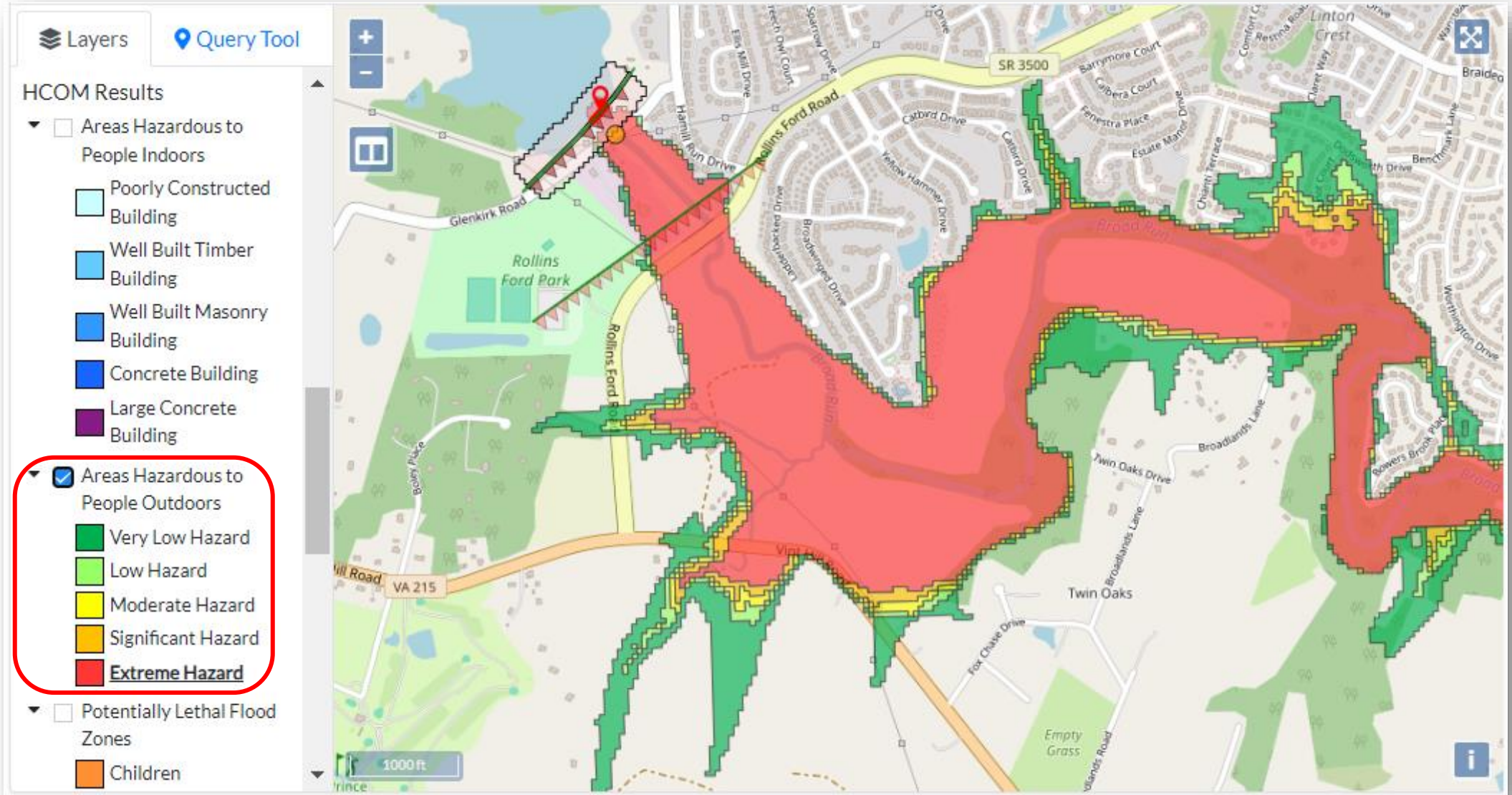
Simulation Results: Arrival Time

The arrival time layer has been displayed on the map.



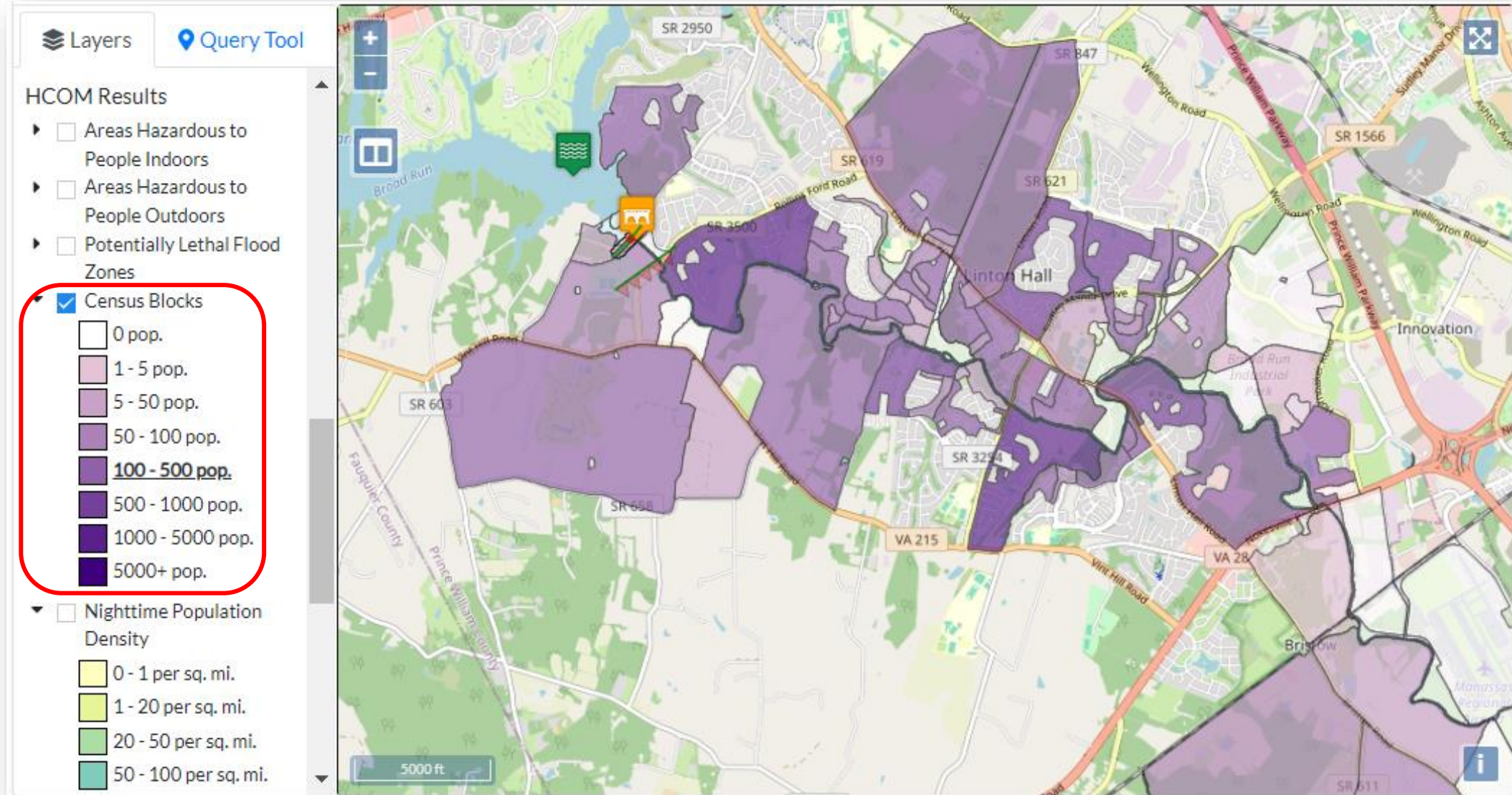
HCOM Results: Areas Hazardous to People Outdoors

The areas hazardous to people outdoors layer has been displayed on the map.



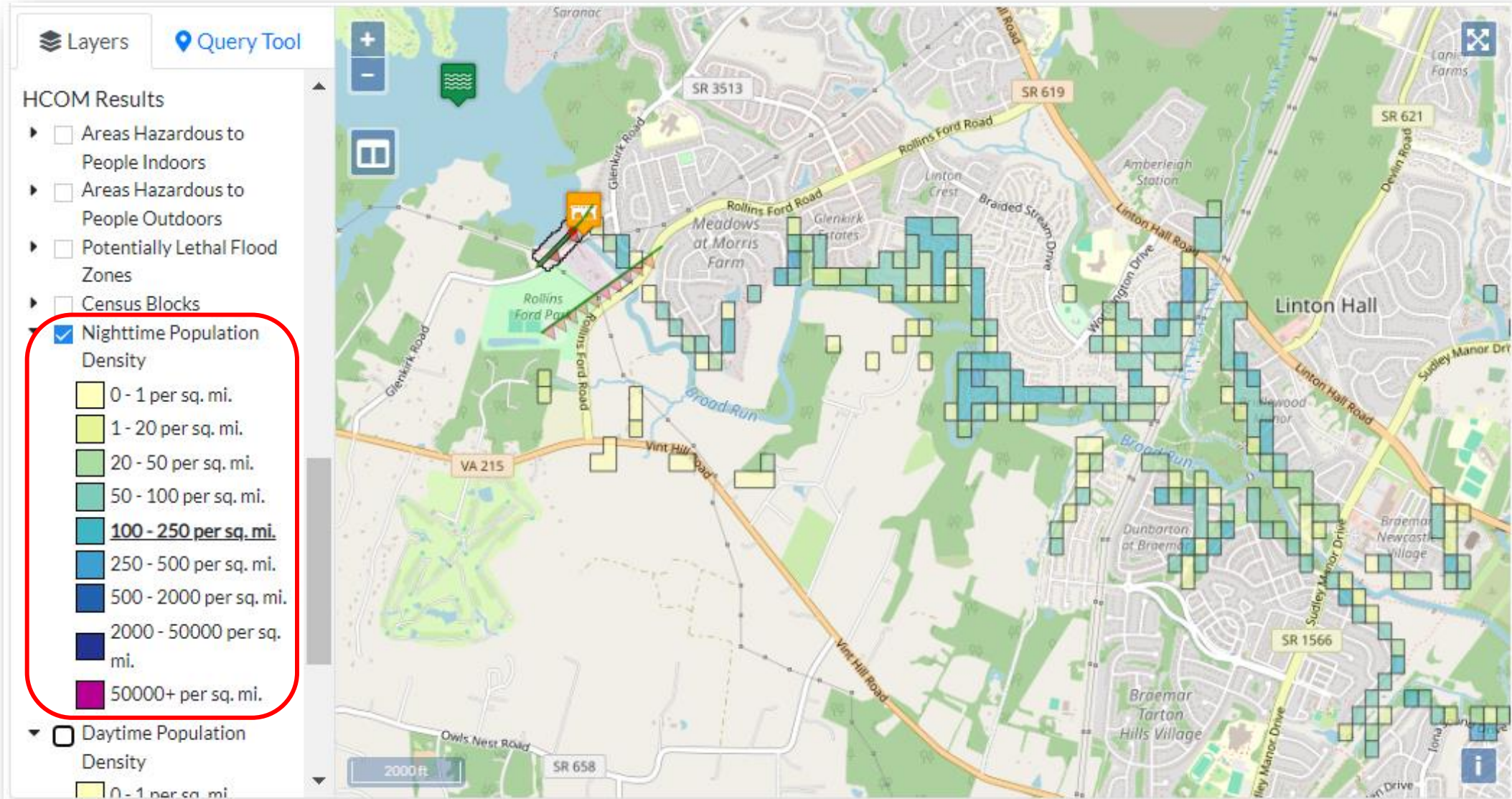
HCOM Results: Census Blocks

The census block layer has been displayed on the map.



HCOM Results: Nighttime Population Density

The nighttime population density has been displayed on the map.



Status & Results Page: Query Tool

3.3

Layers **Query Tool**

Results Query

Simulation DEM Elevation	234.93 ft
Arrival Time	0.17 hr
DV Max	189.96 ft ² /s
Arrival Time of DV Max	0.39 hr
Maximum Depth	24.6 ft
Maximum Velocity	7.95 ft/s

Click on any point to query info

1000 ft

Status & Results Page: Simulation Status, Details and Downloads

3.4

Simulation Status, Details, and Downloads

Human Consequences: Finished

May 07, 2024 0:37:47 pm 2 mins

Nighttime PAR: 2,028
Daytime PAR: 818
Inundated Area: 4,765 acres
Virginia counties: 3

Simulation: Finished

May 06, 2024 4:54:19 pm 4 mins

Distance Achieved
15.5 miles

Breaching Reservoir Vol.
99.9% Released
0.1% Remaining

Time Achieved
1 day

120,269 compute cells

Data Prep: Finished

May 06, 2024 4:53:30 pm less than a minute

Filled reservoir volume match:
1. Reservoir 1: 100%

Simulation Details

Load

Project name

T. Nelson Elliott Dam

Scenario name

Partial Breach Sunny Day Failure

Scenario description

180 ft breach Reservoir at Max Pool

This simulation was created from #26469

Scenario Properties

Cell size: 45 ft
Breach type: Partial breach
Breach width: 180 ft
Breach formation time: 0.3 hr
Breach invert elevation: 242 ft
Reservoir 1: Reservoir 1 290 ft / 15,951 ac-ft

Downloads

Request Intermediate Results



Simulation Results Package 10.21 MB

Zipped results package containing final report, shapefiles, gridded raster files, and other outputs

List



Human Consequences Results Package 20.55 MB

Zipped results package containing final report, shapefiles, gridded raster files, and other outputs











List





DSS-WISE Lite Simulation and HCOM Results Packages


3.5


Simulation Results Package


-  **Simulation Results Package** 10.21 MB
Zipped results package containing final report, shapefiles, gridded raster files, and other outputs
-  **DEM Coverage** 132.19 kB
Shapefile containing polygons of DEM source and resolution
-  **Final Report** 2.45 MB
PDF Document describing simulation
-  **Maximum Specific Discharge Arrival Time Polygons** 74.44 kB
Shapefile containing polygons of maximum specific discharge arrival time intervals
-  **Maximum Specific Discharge Polygons** 209 kB
Shapefile containing polygons of maximum specific discharge intervals
-  **Arrival Time Polygons** 95.45 kB
Shapefile containing polygons of arrival time intervals
-  **Maximum Depth Polygons** 247.65 kB
Shapefile containing polygons of maximum depth intervals
-  **Input Features** 4.77 kB
Shapefiles containing drawn input features
-  **Inundation Extent at 15 miles** 42.5 kB
Shapefile containing inundation extent at 15 miles
-  **Inundation Extent at 3 miles** 6.6 kB
Shapefile containing inundation extent at 3 miles


☰ List 




































-  **Inundation Extent at 3 miles** 6.6 kB
Shapefile containing inundation extent at 3 miles
-  **Inundation Extent at 7 miles** 13.26 kB
Shapefile containing inundation extent at 7 miles
-  **Inundation Extent KMZ File** 41.48 kB
Google Earth KMZ file showing final inundation extent
-  **Final Inundation Extent** 43.1 kB
Shapefile containing inundation extent at the end of the simulation at 15.498 miles
-  **Observation Lines** 8.38 kB
Tabulated CSV files of time vs. discharge and cumulative volume
-  **Raster Files** 6.86 MB
Gridded raster files for DEM, maximum depth, and arrival time
-  **Reservoir Time History** 3.05 kB
Comma-separated values file containing time history of the breaching reservoir's elevation at its given upstream point and approximate remaining volume
-  **Reservoir Volume(s)** 3.95 kB
Comma-separated values file containing elevations and volumes of the filled reservoir(s)
-  **Maximum Velocity Polygons** 136.06 kB
Shapefile containing polygons of maximum velocity intervals













































Links to download full or individual simulation results files

 Human Consequences Results Package 20.55 MB Zipped results package containing final report, shapefiles, gridded raster files, and other outputs	 List 
 HCOM PAR Analysis Results 91.44 kB MS Excel spreadsheet containing tabulated results of population at risk analysis	
 HCOM PAR by Census Blocks 571.3 kB Shapefile containing polygons of census blocks in the inundation extent	
 HCOM Daytime Population Density 19.14 kB Shapefile containing polygons of daytime population density derived from LANDSCAN data	
 HCOM Final Report 20.1 MB PDF Document describing the results of this HCOM calculation	
 HCOM Hazard Level to People Indoors 18.15 kB Shapefile containing polygons of hazard levels to people caught indoors in the flooded extent	
 HCOM Nighttime Population Density 22.5 kB Shapefile containing polygons of nighttime population density derived from LANDSCAN data	
 HCOM Hazard Level to People Outdoors 188.61 kB Shapefile containing polygons of hazard levels to people caught outdoors in the flooded extent	
 HCOM Potentially Lethal Flood Zones 85.89 kB Shapefile containing polygons of flood zones potentially lethal to adults and children	

Links to download full or individual simulation results files

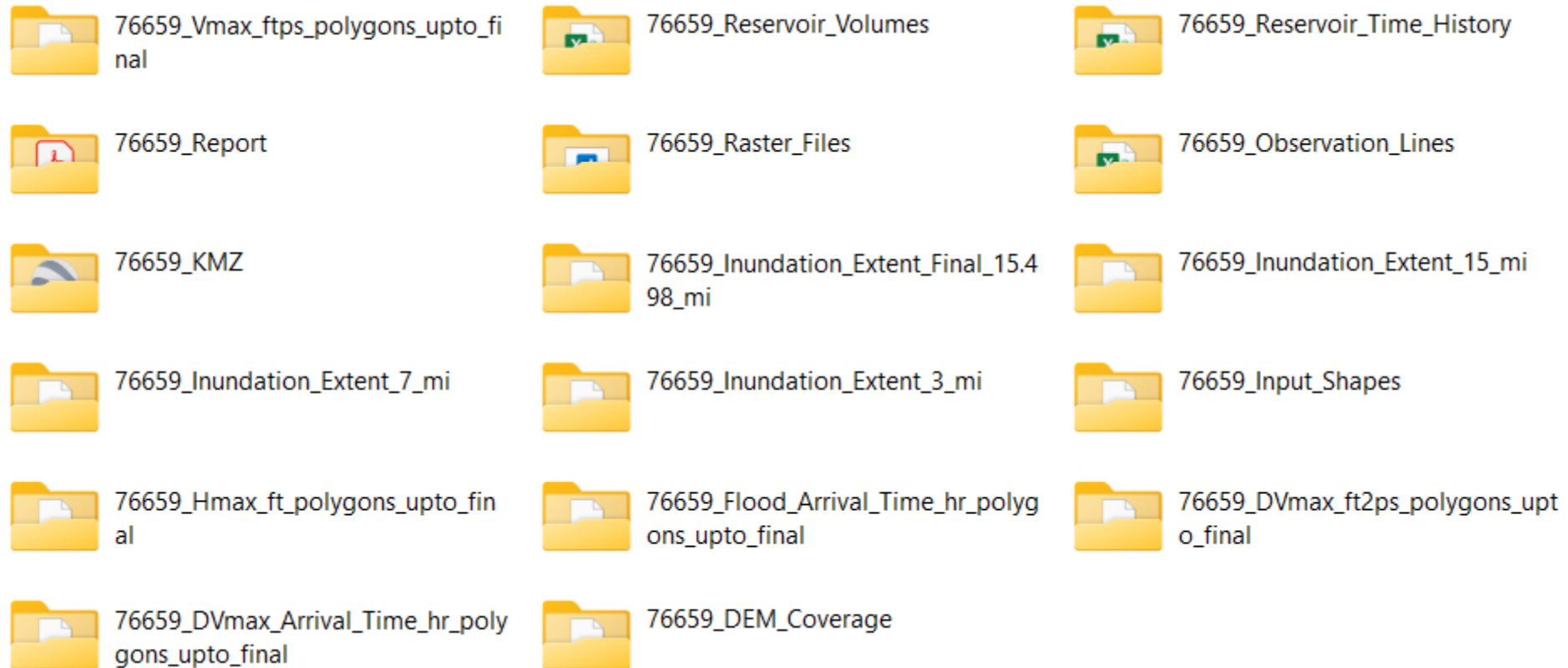
Viewing and Analysis of DSS-WISE Lite Simulation Results

3.6

Contents of the DSS-WISE Lite Results Package

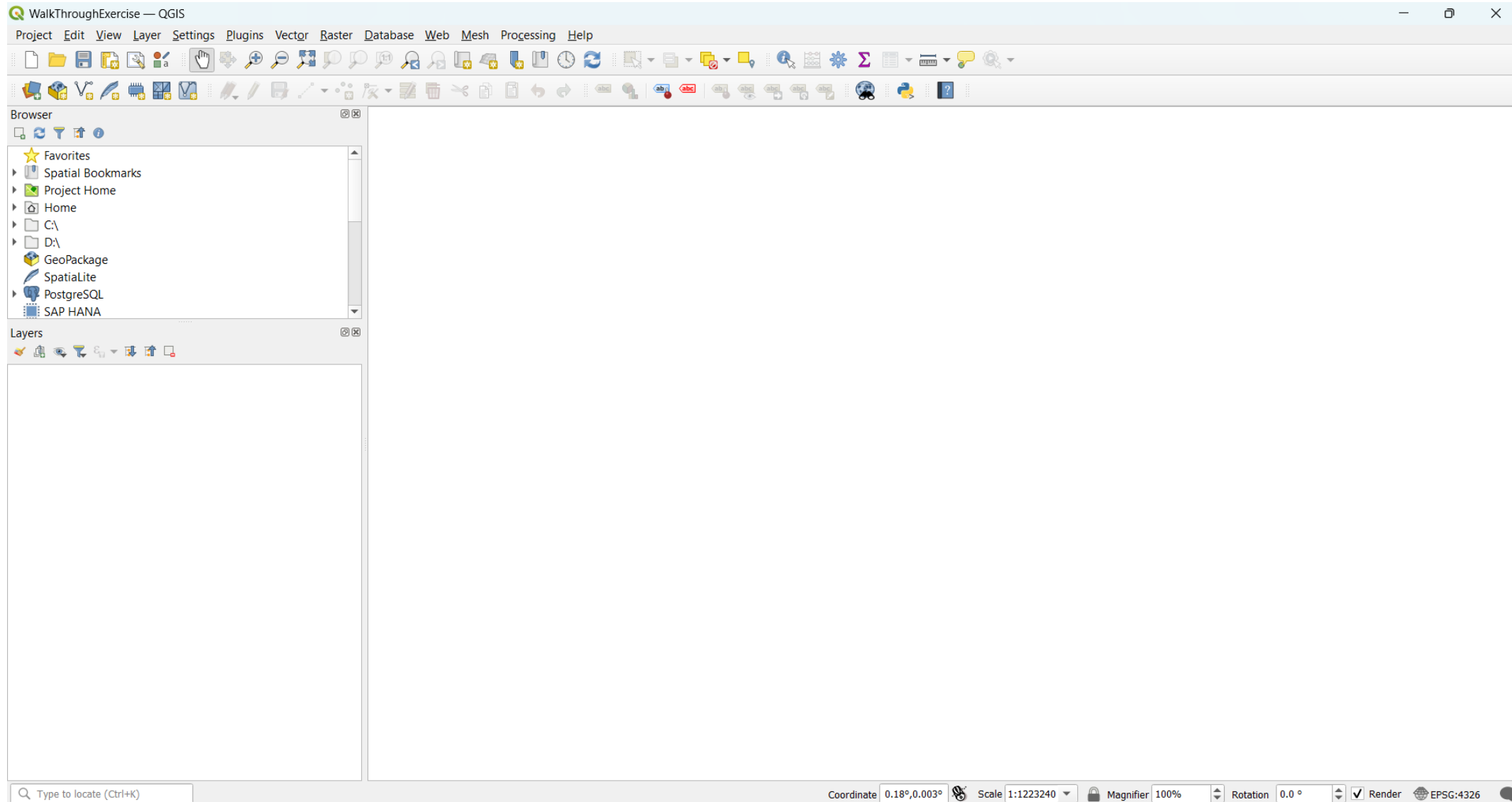
If the package is downloaded as a single compressed file, unzip the file. The contents of the unzipped file is shown below.

- The folder “**76659_Report**” contains DSS-WISE Lite Final Report in PDF format. The pdf report must be read using Adobe Acrobat Reader
- The folder “**76659_KMZ**” contains the flood extent polygon in KMZ format. The KMZ file can be viewed in Google Earth (you can also view KMZ files on some GIS software, such as QGIS)
- The folders “**76659_Observation_Lines**”, “**76659_Reservoir_volumes**”, and “**76659_Reservoir_Time_History**” contains “csv” (comma separated value) files for the observation files, the reservoir volume files and the reservoir time history file. Generally, these csv files would be viewed and analyzed using a spreadsheet program
- All other folders contain **geospatial files** that must be viewed using a GIS software. These course notes will use QGIS software.



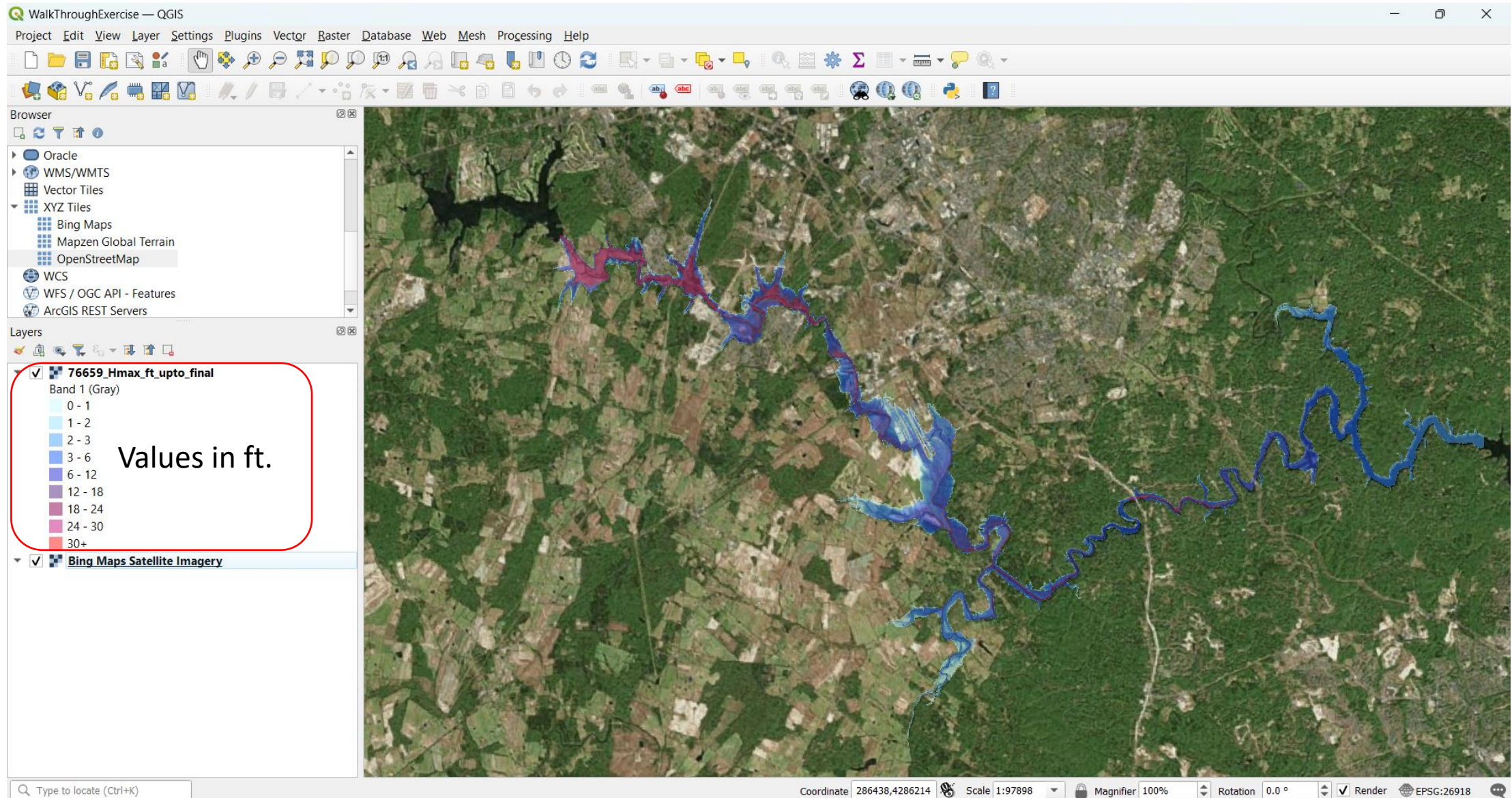
Mapping Results Using QGIS Software

Launch QGIS software and create a new project. In this case, the project is named "WalkThroughExercise". The empty document is shown below.



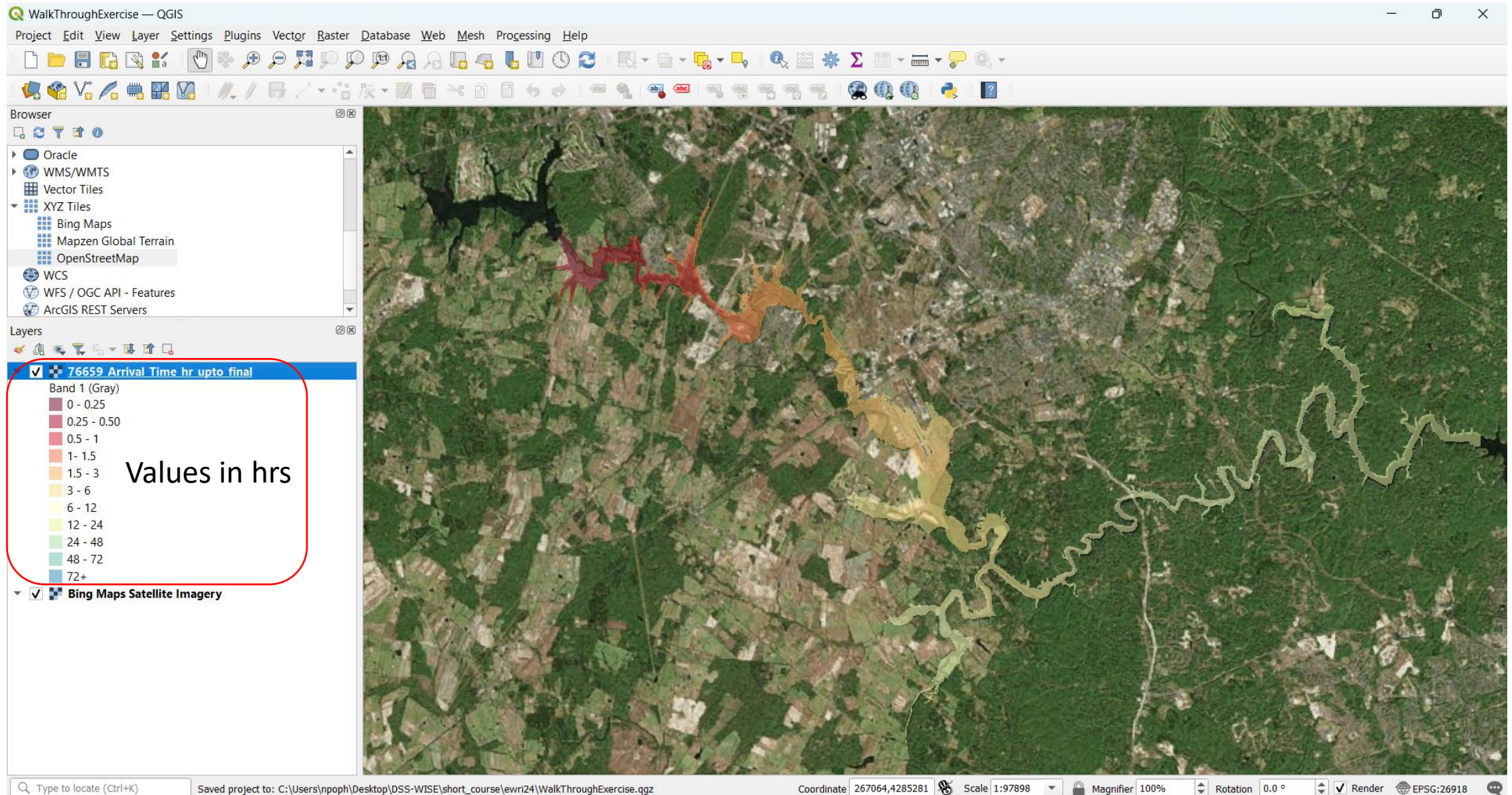
Maximum Flood Depth Map

Maximum Flood Depth raster is displayed using proposed color ramp (76659_Hmax_ft_upto_final.tif).



Flood Arrival Time Map

Flood Arrival Time raster is displayed using proposed color ramp (76659_Arrival_Time_hr_upto_final.tif).



Maximum Flood Depth Map

Maximum Flood Depth polygon shapefile is displayed using proposed color ramp (76659_Hmax_ft_polygons_upto_final.shp).

WalkThroughExercise — QGIS

Project Edit View Layer Settings Plugins Vector Raster Database Web Mesh Processing Help

Browser

- Oracle
- WMS/WMTS
 - Vector Tiles
 - XYZ Tiles
 - Bing Maps
 - Mapzen Global Terrain
 - OpenStreetMap
- WCS
- WFS / OGC API - Features
- ArcGIS REST Servers

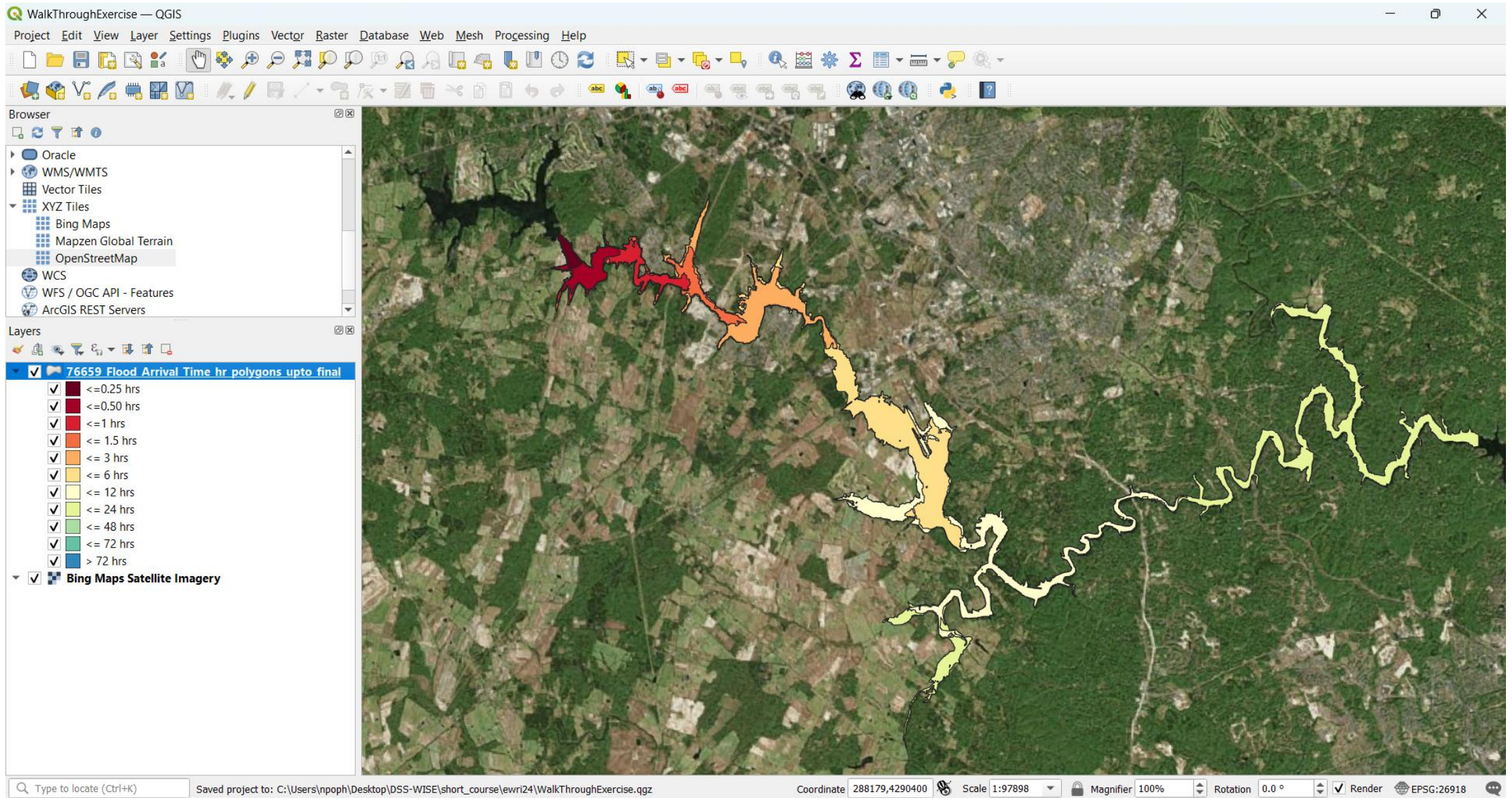
Layers

- 76659_Hmax_ft_polygons_upto_final
 - <= 1 ft
 - <= 2 ft
 - <= 3 ft
 - <= 6 ft
 - <= 12 ft
 - <= 18 ft
 - <= 24 ft
 - <= 30 ft
 - > 30 ft
- Bing Maps Satellite Imagery

Type to locate (Ctrl+K) Saved project to: C:\Users\npoph\Desktop\DSS-WISE\short_course\ewri24\WalkThroughExercise.gqz Coordinate 266981,4283002 Scale 1:97898 Magnifier 100% Rotation 0.0° Render EPSG:26918

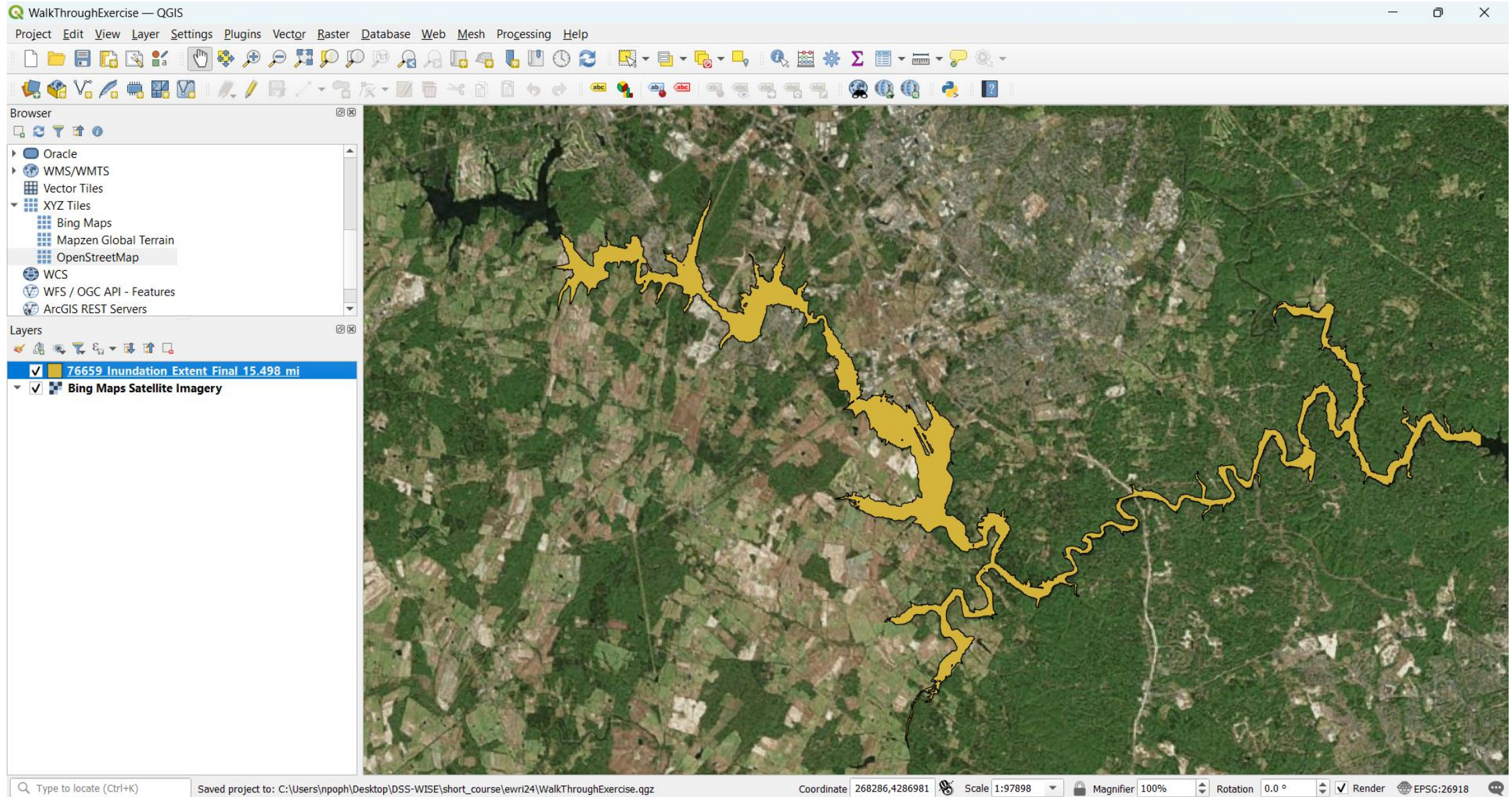
Flood Arrival Time Map

Flood Arrival Time polygon shapefile is displayed using proposed color ramp (76659_Flood_Arrival_Time_hr_polygons_upto_final.shp).



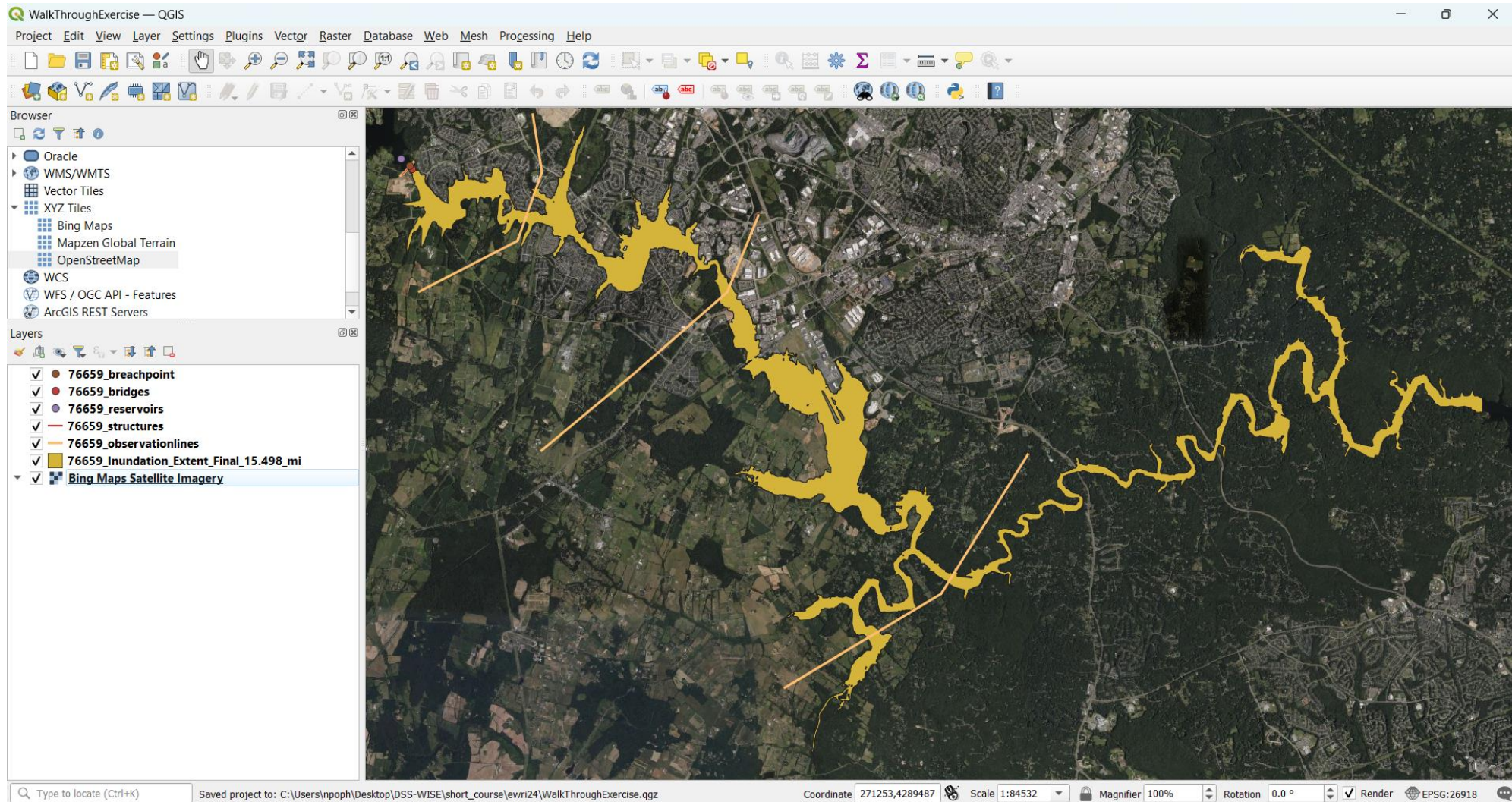
Maximum Inundation Extent

The polygon shapefile of maximum inundation extent is displayed (**76659_Inundation_Extent_Final_15.498_mi.shp**).



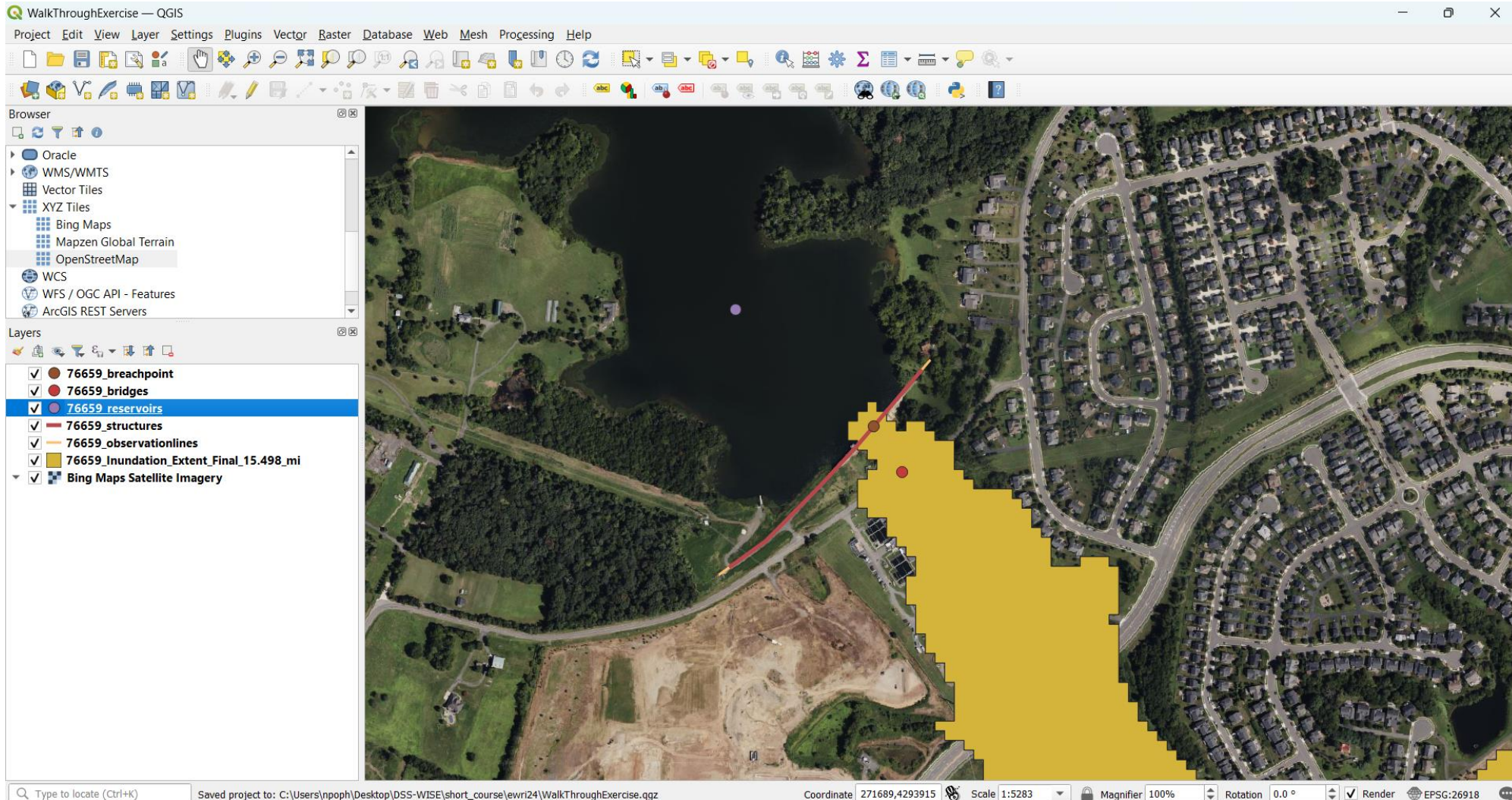
Displaying Shapefiles of Input Data

The folder “76659_Input_Shapes” contain several point and polygon shapefiles. In the present case, the following shapefiles have been uploaded: “76659_structures.shp” (polyline shapefile), “76659_observationlines.shp” (polyline shapefile), “76659_reservoirs.shp” (Point shapefile), “76659_breachpoint.shp” (point shapefile), “76659_bridges.shp” (point shapefile)



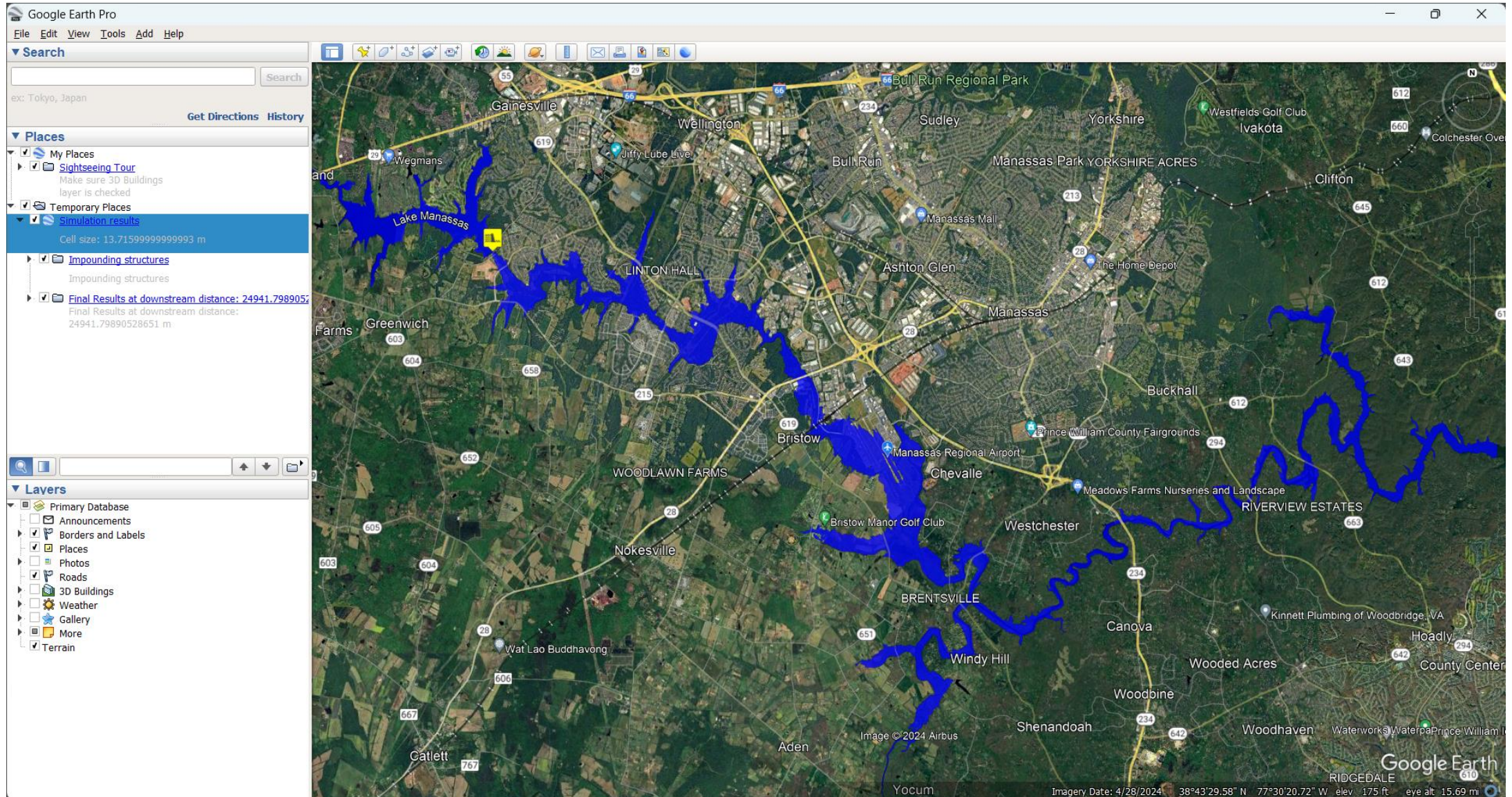
Displaying Shapefiles of Input Data (enlarged view near the dam)

The folder “76659_Input_Shapes” contain several point and polygon shapefiles. In the present case, the following shapefiles have been uploaded: “76659_structures.shp” (polyline shapefile), “76659_observationlines.shp” (polyline shapefile), “76659_reservoirs.shp” (Point shapefile), “76659_breachpoint.shp” (point shapefile), “76659_bridges.shp” (point shapefile)



Displaying KMZ file on Google Earth

Start Google Earth. Drag and drop the KMZ file (**76659_Inundation_Extent_Final_15.498_mi.kmz**) onto the Google Earth satellite imagery. Google Earth will automatically zoom to the full extent of the area represented in the KMZ file.



Plotting Hydrographs Extracted at Observation Lines and Stored in Individual “csv” Files

The folder “76659_Observation_Lines” contain 4 “csv” files, which were written by DSS-WISE Lite at the end of the simulation.

Name	Date modified	Type	Size
OLIN_0000001.csv	5/12/2019 8:14 PM	Microsoft Excel C...	20 KB
OLIN_0000002.csv	5/12/2019 8:14 PM	Microsoft Excel C...	17 KB
OLIN_0000003.csv	5/12/2019 8:14 PM	Microsoft Excel C...	19 KB
OLIN_0000004.csv	5/12/2019 8:14 PM	Microsoft Excel C...	27 KB

As an example, contents of “OLIN_0000001.csv” are shown

Time (hr): time in hours since beginning of simulation

Q+ (ft³/s): Discharge crossing the observation line in positive flow direction

Q- (ft³/s): Discharge crossing the observation line in negative flow direction

V+ (ft³): Cumulative volume that crossed the observation line in positive direction

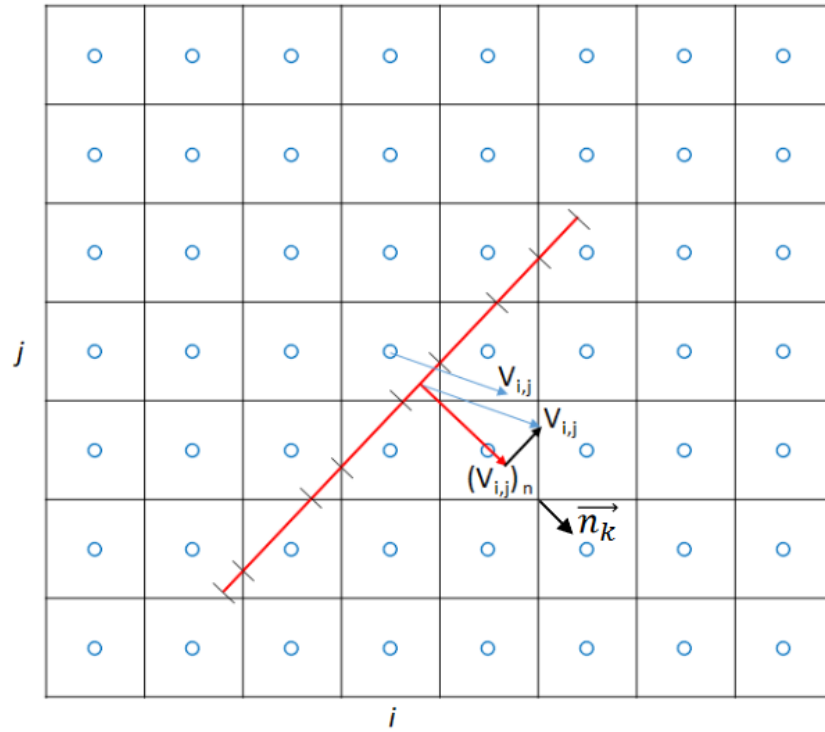
V- (ft³): Cumulative volume that crossed the observation line in negative direction

Contents of “OLIN_0000001.csv” as viewed in Microsoft Excel spreadsheet software

	A	B	C	D	E
1	Observation Line 1				
2	Time (hr)	Q+ (ft ³ /s)	Q- (ft ³ /s)	V+ (ft ³)	V- (ft ³)
3	4.74E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
4	0.166667	0.00E+00	0.00E+00	0.00E+00	0.00E+00
5	0.333333	0.00E+00	0.00E+00	0.00E+00	0.00E+00
6	0.5	0.00E+00	0.00E+00	0.00E+00	0.00E+00
202	27	3.25E+00	8.51E-04	1.22E+09	1.46E+06
203	27.16667	3.15E+00	8.38E-04	1.22E+09	1.46E+06
204	27.333333	3.08E+00	8.26E-04	1.22E+09	1.46E+06
205	27.5	3.01E+00	8.13E-04	1.22E+09	1.46E+06
206	27.66667	2.94E+00	8.01E-04	1.22E+09	1.46E+06
207	27.833333	2.87E+00	7.90E-04	1.22E+09	1.46E+06
208	28	2.80E+00	7.78E-04	1.22E+09	1.46E+06
209	28.16667	2.73E+00	7.67E-04	1.22E+09	1.46E+06

Calculating discharge along an observation line.

Discharge along each small reach is calculated by considering velocity normal to the line.



Positive discharges and negative discharges along small reaches are summed up to give the total positive and negative discharges crossing the line.

\vec{n}_k Unit vector normal (vertical) to the small reach k in the cell (i, j)

$\vec{V}_{i,j}$ Velocity vector normal at the center of the cell (i, j)

d_k Length of the small reach k

Discharge crossing the small reach k is computed from

$$\Delta q_k = (\vec{V}_{i,j} \cdot \vec{n}) d_k = \left| (\vec{V}_{i,j})_n \right| d_k$$

Note that the dot product of the velocity vector at the center of the cell (i, j) with the unit vector normal (vertical) to the small reach k gives the component of velocity vector normal to the reach k .

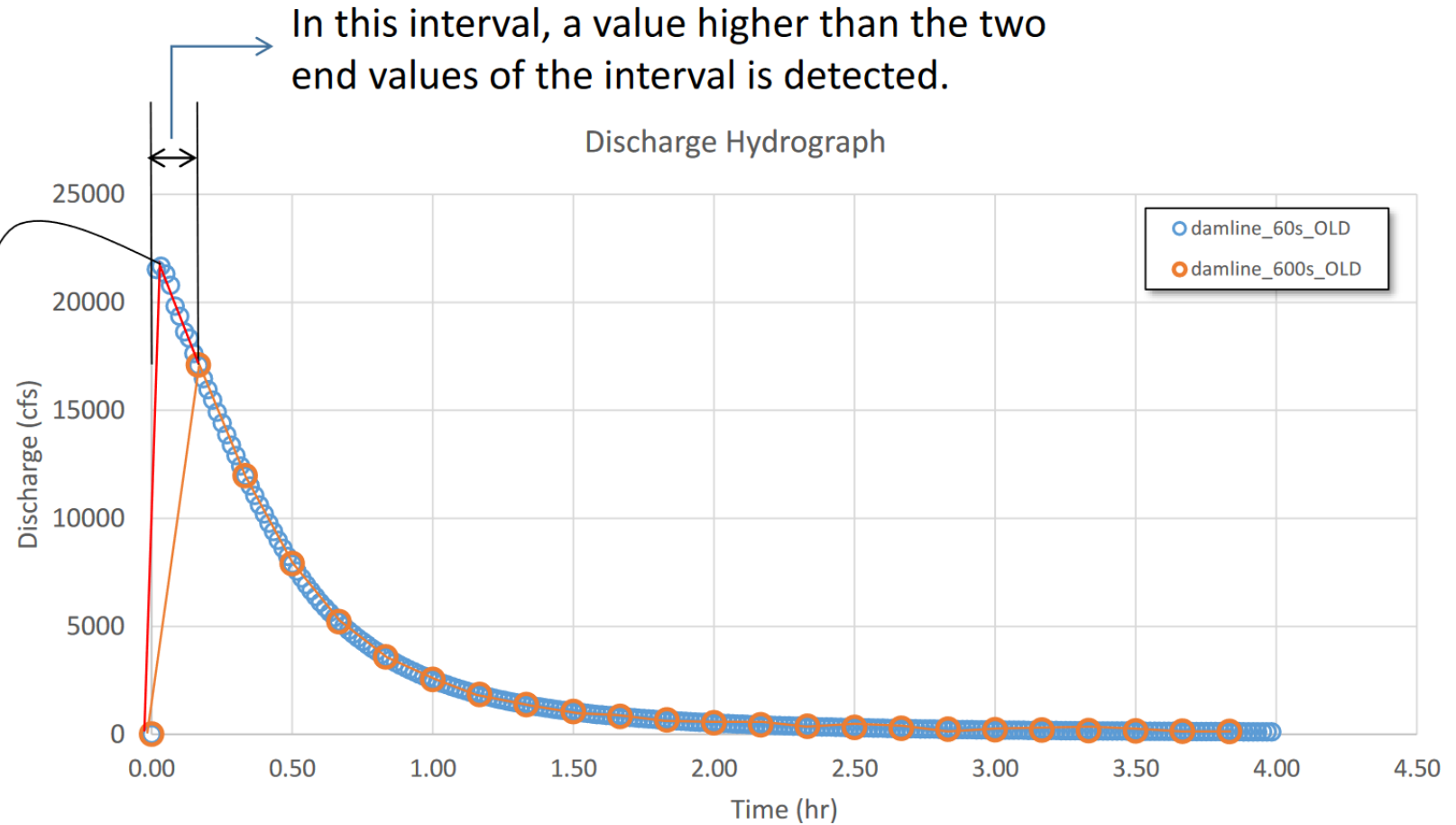
Total volume crossing the small reach k during the time interval reach Δt_m is computed from

$$(\Delta V_k)_m = \Delta q_k \Delta t_m$$

Writing the calculated discharge values into the csv file

The highest value in the interval is added to the list of data written into the csv file.

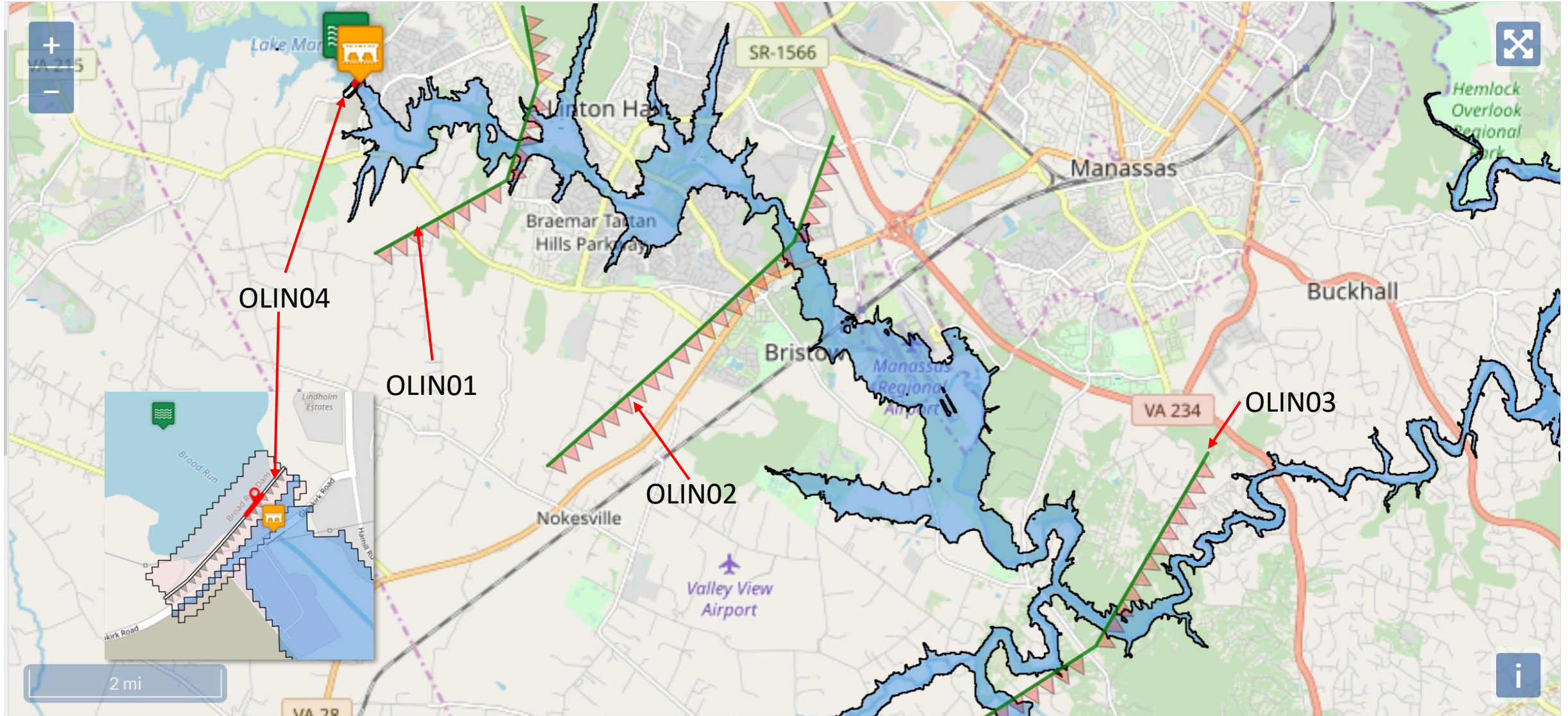
This procedure allows capturing the shape of the hydrograph with better accuracy.



At the end of a write interval, all the values in that interval are checked. If there are values larger than the discharge values at the two ends of the interval, the largest of them is inserted into the interval as a new data pair with its corresponding time. Thus the values in the csv file do not necessarily have a constant time interval.

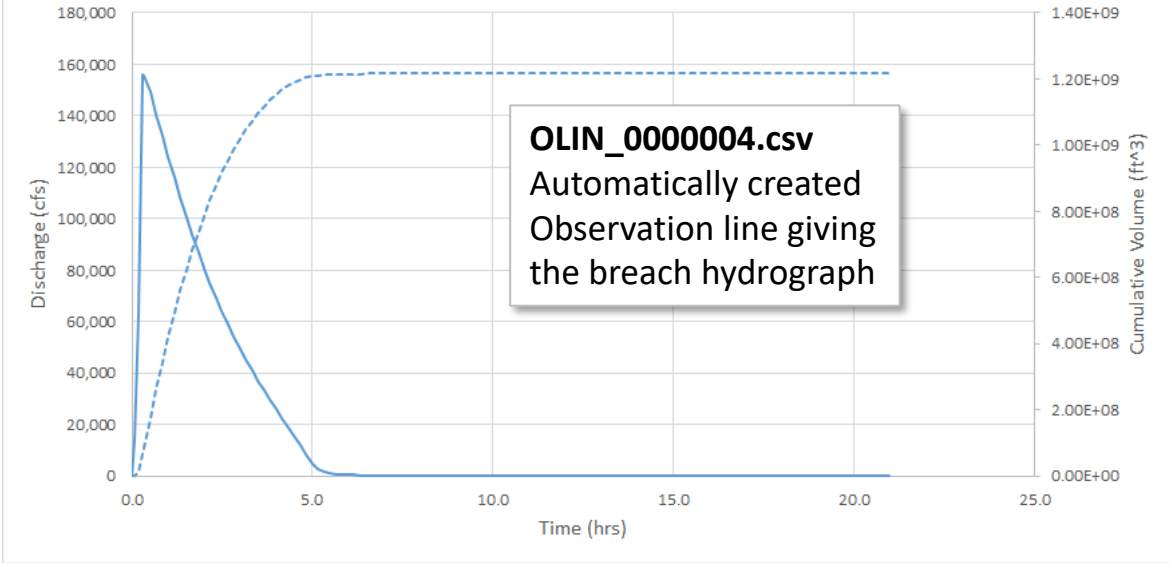
Locations of Observation Lines and Maximum Flood Extent

The hydrographs from observation lines must be interpreted by taking into account the specific location of the observation line and the maximum inundation map.

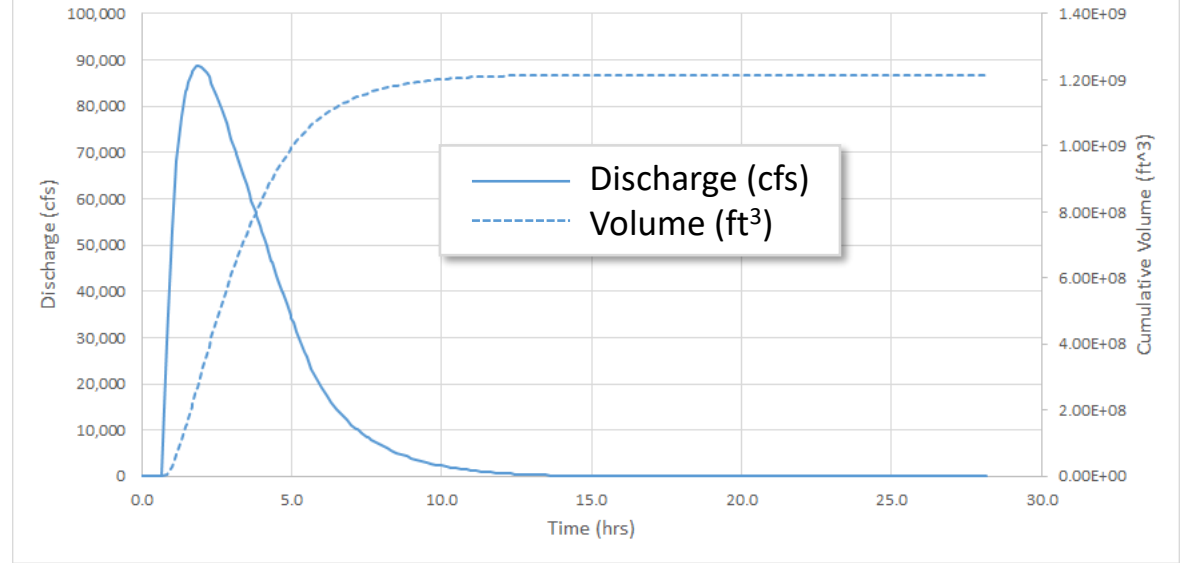


Discharge Hydrographs and Cumulative Volume Plots for Observation Lines

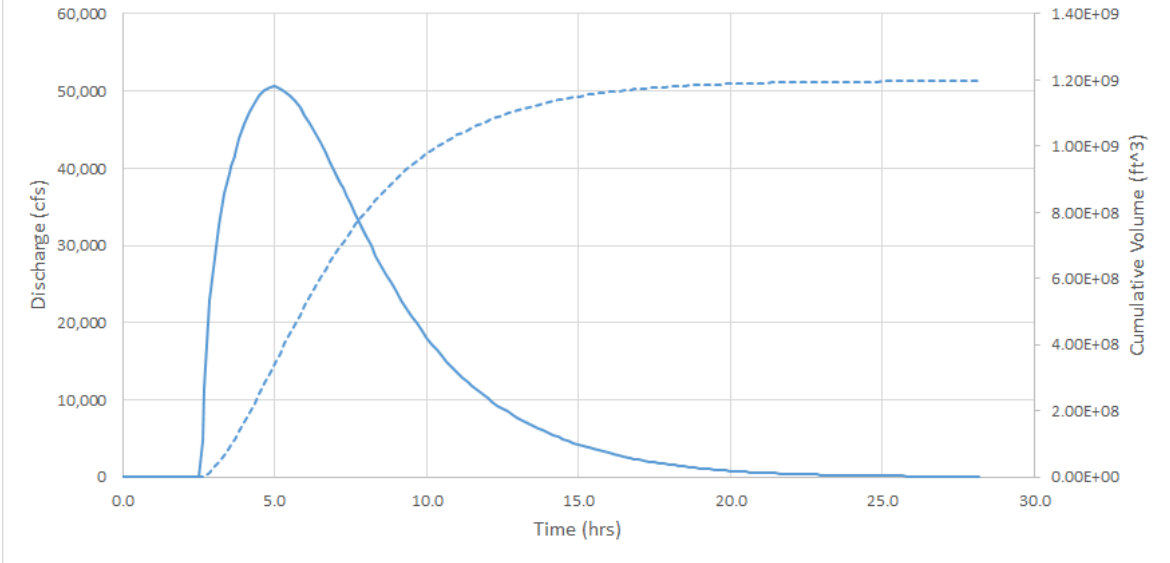
Main Dam: T. Nelson Elliott Dam



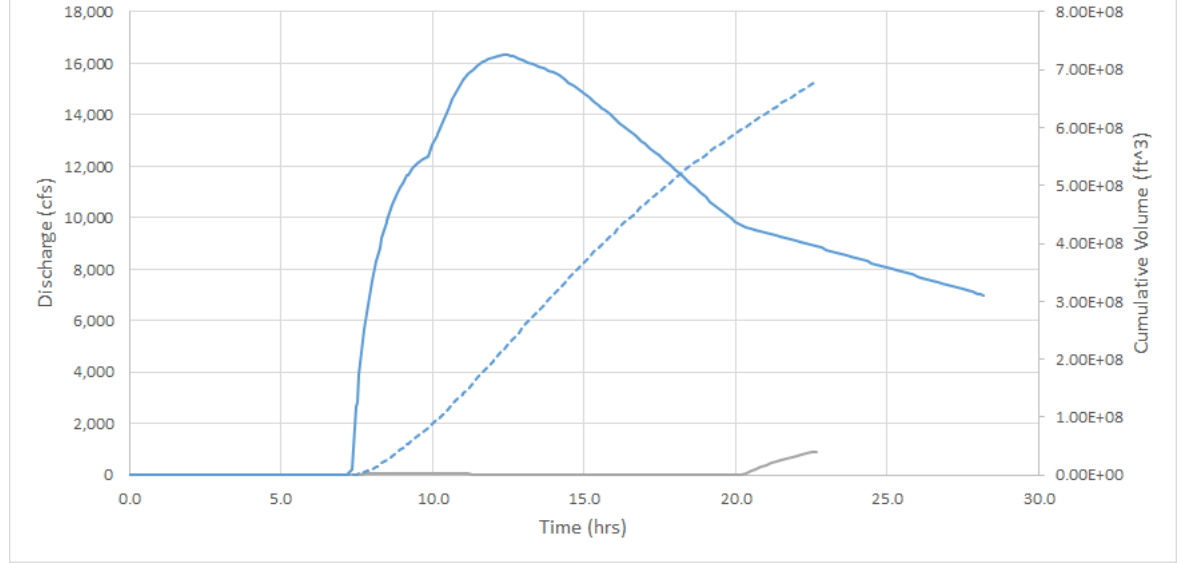
Observation Line 1



Observation Line 2

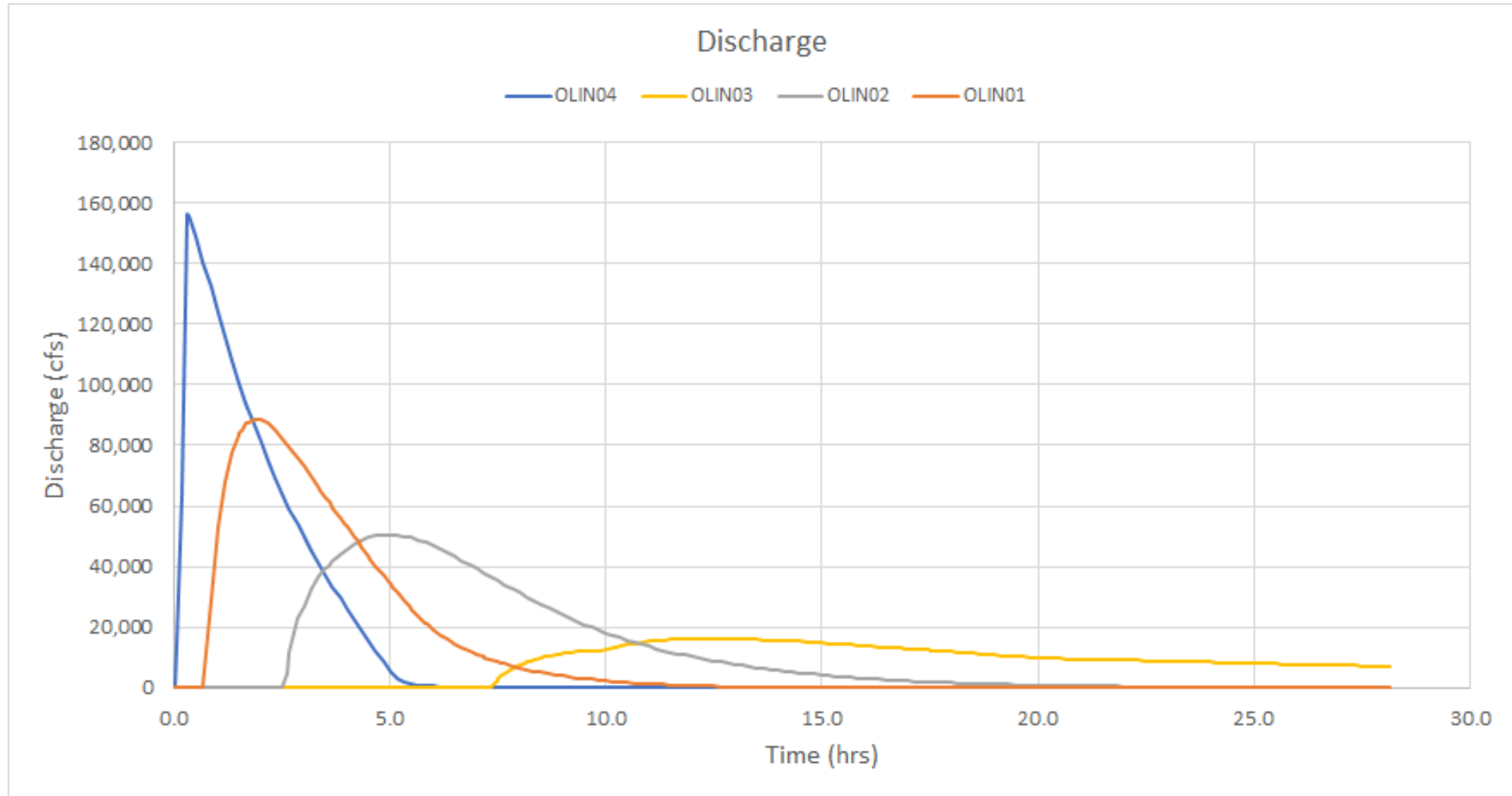


Observation Line 3



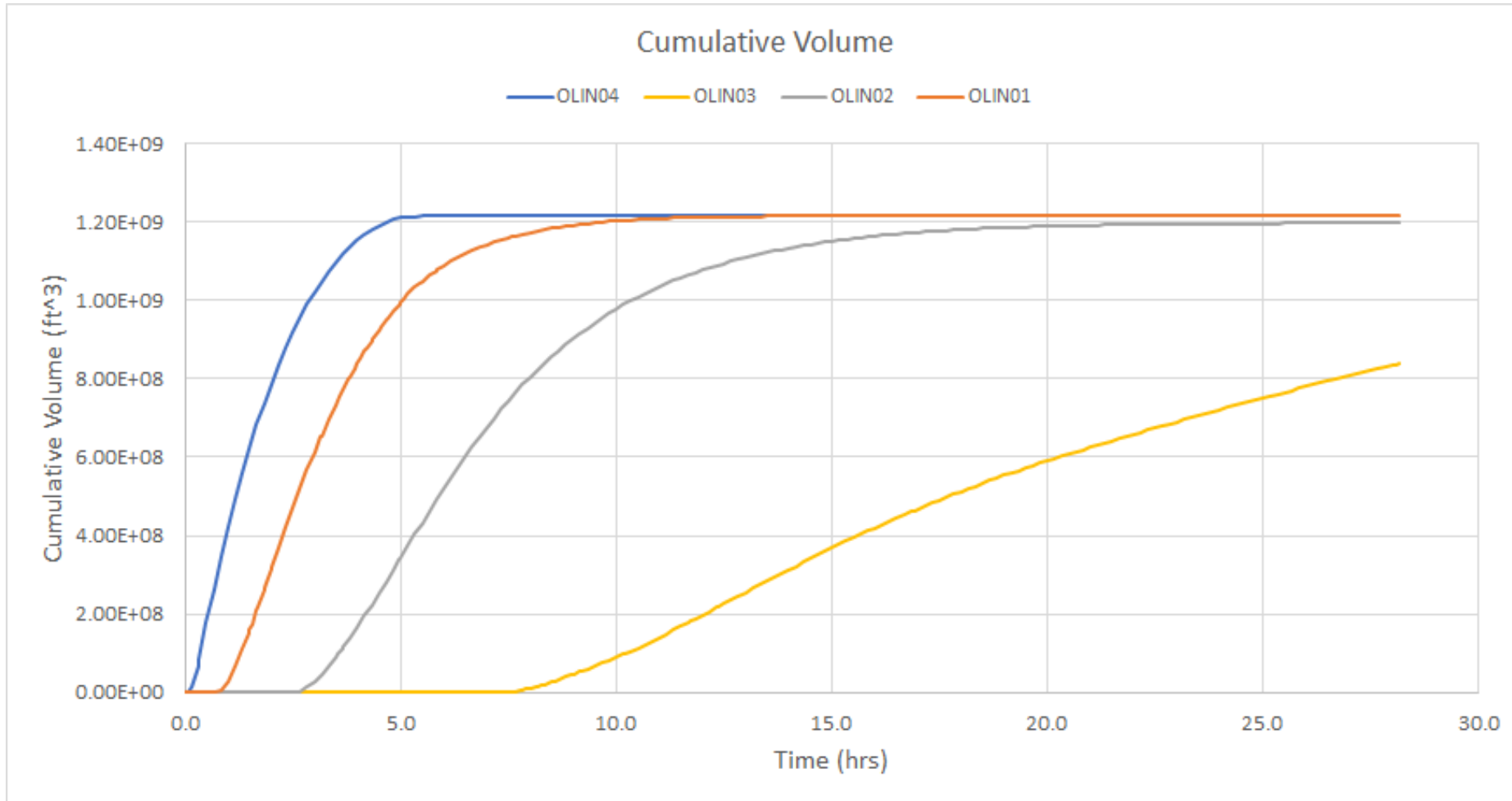
Discharge Hydrographs for All Observation Lines

Note the decrease of the peak discharge with distance from the breach. This is due to friction and spread of the flood.



Cumulative Volume Plots for All Observation Lines

- Note that **OLIN04**, **OLIN01**, **OLIN02** converge to the same constant value of cumulative volume (incidentally, this shows that DSS-WISE Lite has excellent mass conservation properties).
- The flood has not yet fully passed through OLIN03. The simulation duration should be increased to see the discharge hydrograph go through **OLIN03**.



Viewing and Analysis of DSS-WISE Lite HCOM Results

3.7

Contents of the DSS-WISE HCOM Results Package

If the package is downloaded as a single compressed file, unzip the file. The contents of the unzipped file is shown below.

- The folder “**76659_HCOM_Report**” contains DSS-WISE HCOM Final Report in PDF format. The pdf report must be read using Adobe Acrobat Reader
- The folder “**76659_HCOM_Analysis**” contains a Microsoft Excel spreadsheet file with the results of DSS-WISE Lite HCOM Par analysis using both the 2010 Census Block data and the LandScan USA gridded nighttime and daytime population data
- All other folders contain geospatial files that must be viewed using a GIS software. These course notes will use QGIS software.
 - **76659_HCOM_Census_Block_polygons**
 - **76659_HCOM_Indoor_Hazard_Categories_polygons**
 - **76659_HCOM_Outdoor_Hazard_Categories_polygons**
 - **76659_HCOM_PLFZ_polygons**
 - **76659_HCOM_NT_PopDensity_persqmi_polygons**
 - **76659_HCOM_DT_PopDensity_persqmi_polygons**



76659_HCOM_Analysis



76659_HCOM_Census_Block_polyg
ons



76659_HCOM_DT_PopDensity_pers
qmi_polygons



76659_HCOM_Indoor_Hazard_Cate
gories_polygons



76659_HCOM_NT_PopDensity_pers
qmi_polygons



76659_HCOM_Outdoor_Hazard_Cat
egories_polygons



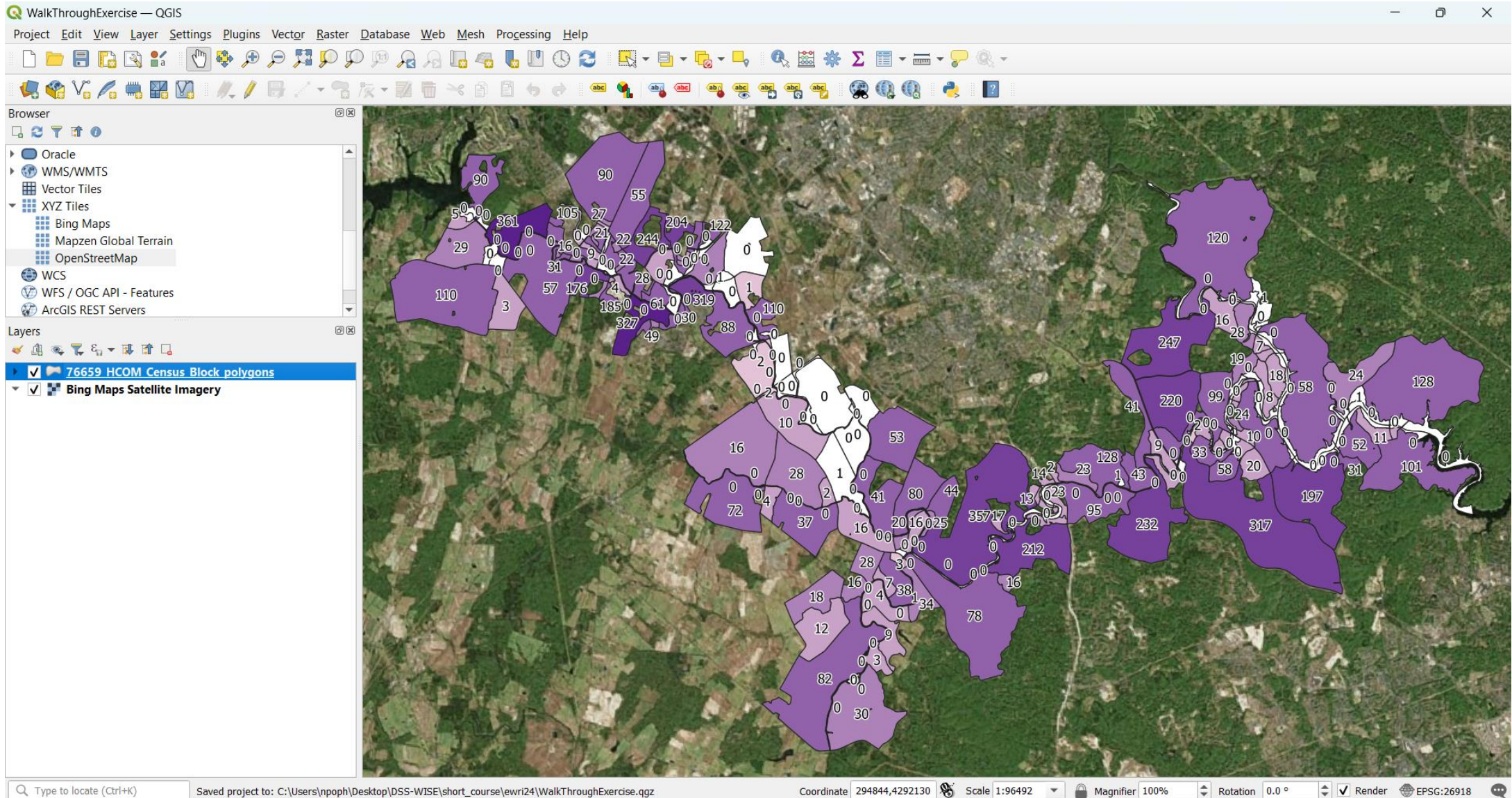
76659_HCOM_PLFZ_polygons



76659_HCOM_Report

2010 Census Block Polygons

2010 Census Block polygons (**76659_HCOM_Census_Block_polygons.shp**) are colored based on the population numbers (attribute **"POP10"**). The numbers indicate number of housings (attribute **"HOUSING10"**).



Flood Hazard Category Polygons for People Caught Outdoors

Flood hazard polygons for people caught outdoors (**76659_HCOM_Outdoor_Hazard_Categories_polygons.shp**) are displayed using proposed color ramp.

