HYDRAULIC ANALYSIS
FOR THE
PEDESTRIAN BRIDGE OVER HOWARD CREEK

Greenbrier County, White Sulphur Springs, WV

Faheem Ahmad, PE, PS, CFM
Venkata Ajay Madala , CPESC

May 16, 2023
1:00 – 1:30 PM

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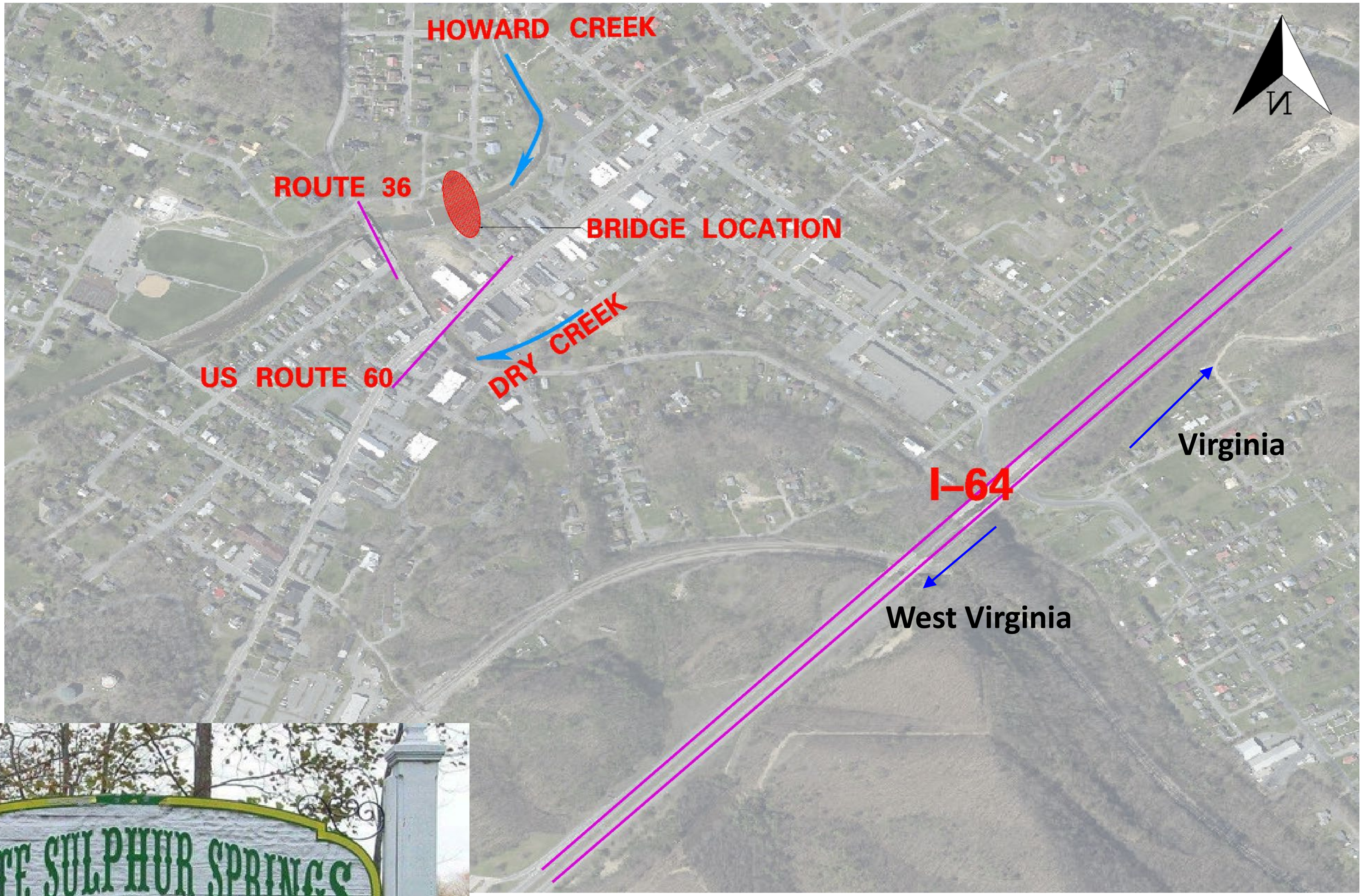
Project Location



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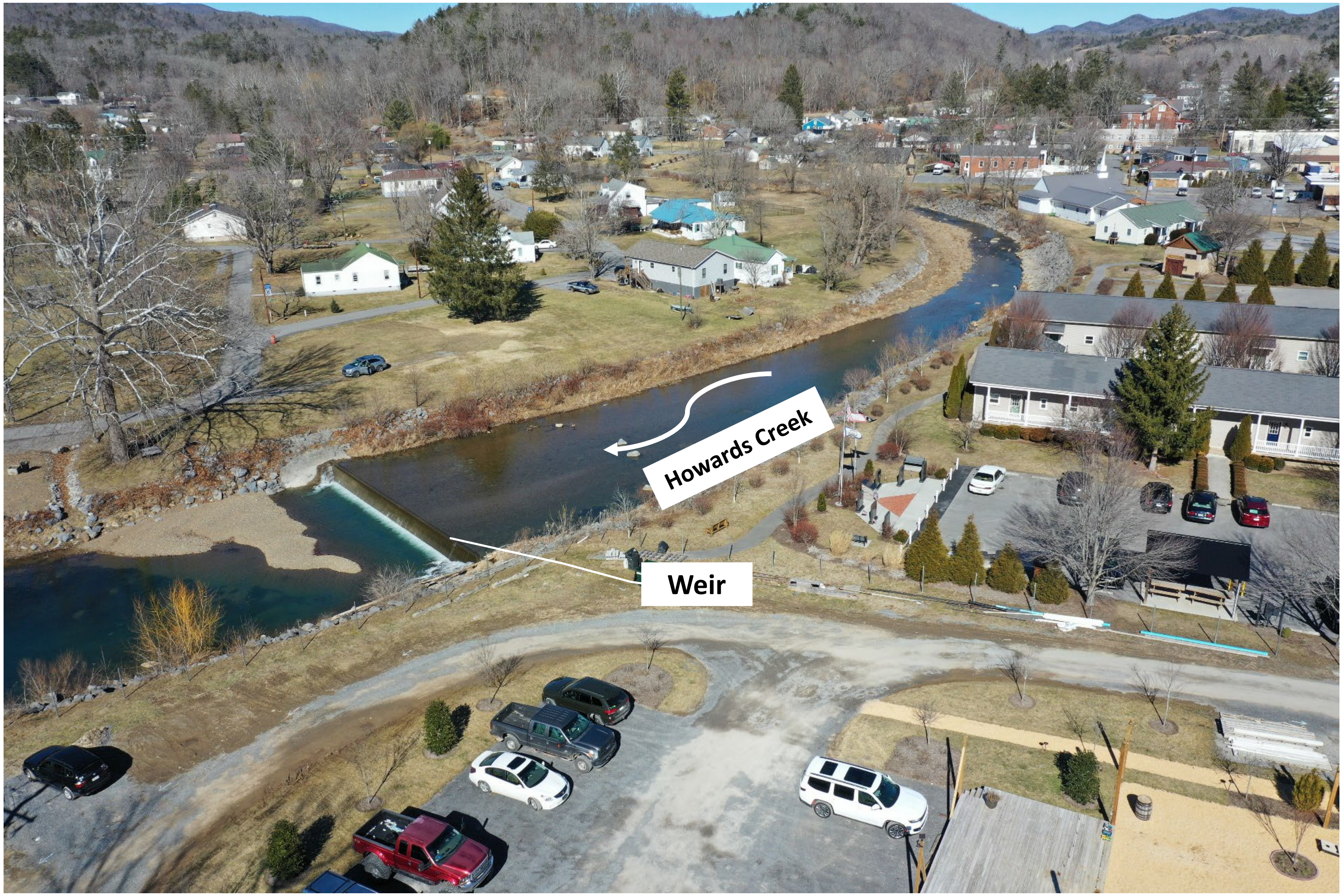
Project Location



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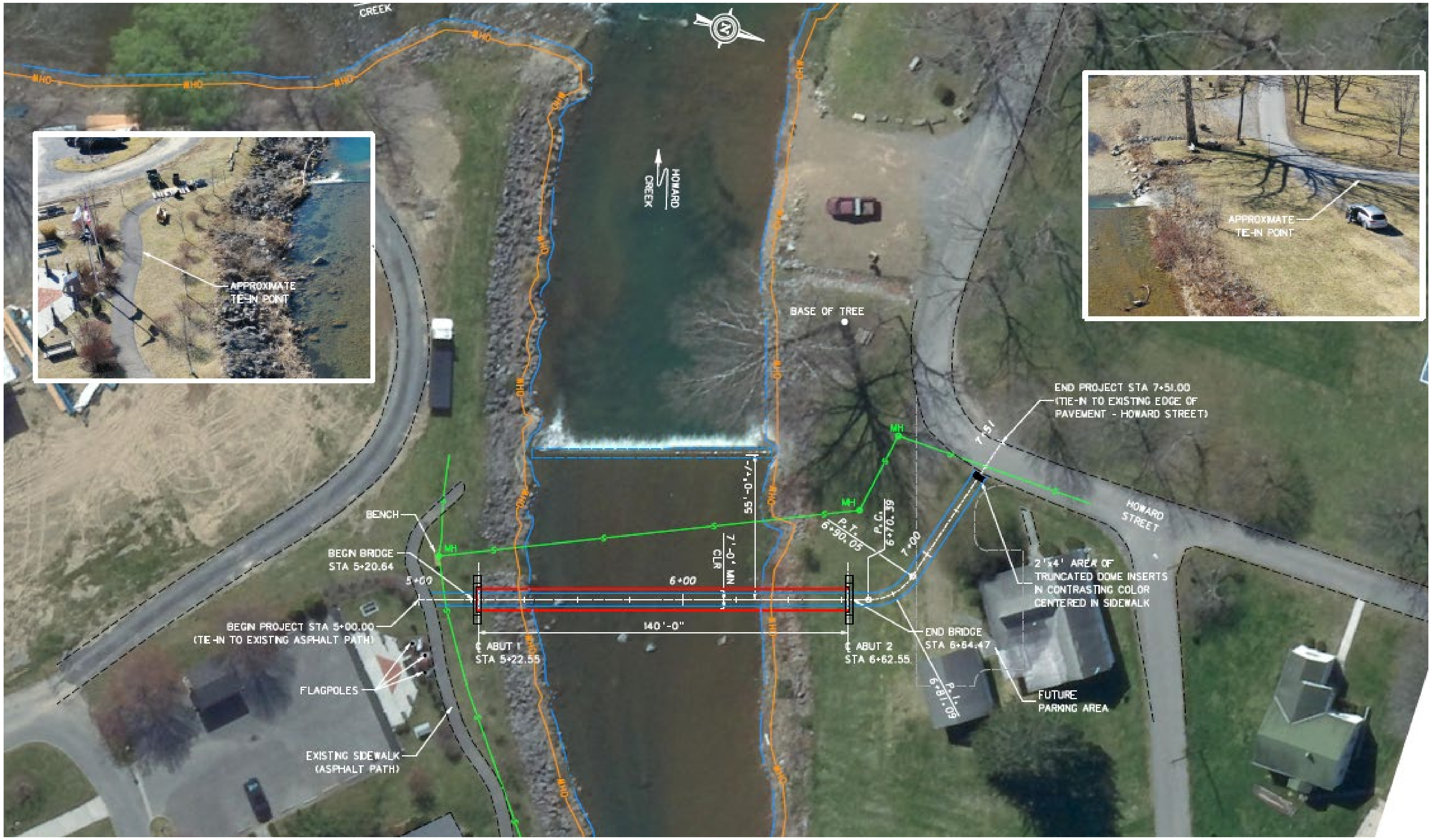
Pedestrian Bridge Over Howard Creek



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Project Location (Rendering)

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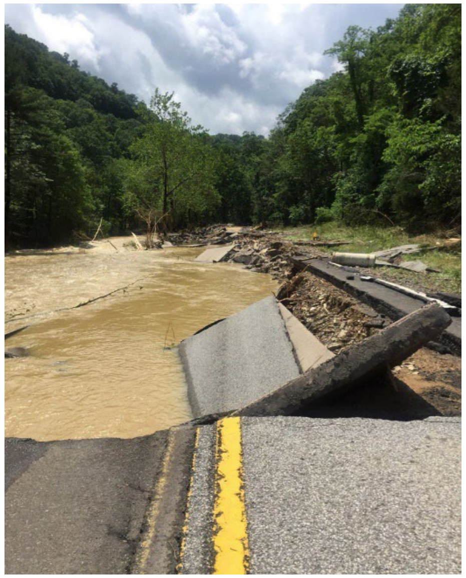
Flooding History (2016 Flooding)

- During the 2016 flood event, the bridge was under water due to the backwater from Howard Creek
- Two-day rainfall accumulations reached 9.17”
- The flood was recorded as 1000-year event

White Sulphur Springs, WV During the Flood



US Route 60 During the Flood

Greenbrier County Golf Course

Flood Damages in White Sulphur Springs, WV During the Flood

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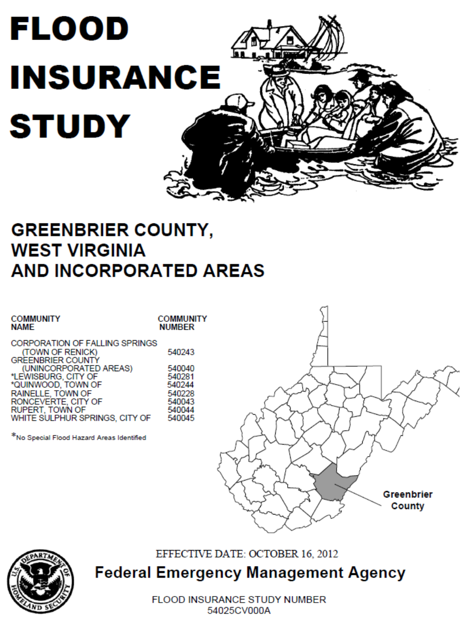
Hydraulics

As per the Flood Insurance Study of Greenbrier County, WV, the **drainage area** of the Howard Creek at Big Draft Road is **59.80 sq. miles**.


FLOOD
INSURANCE
STUDY

GREENBRIER COUNTY,
WEST VIRGINIA
AND INCORPORATED AREAS

COMMUNITY NAME	COMMUNITY NUMBER
CORPORATION OF FALLING SPRINGS (TOWN OF RENICK)	540243
GREENBRIER COUNTY (UNINCORPORATED AREAS)	540040
*LEWISBURG, CITY OF	540281
*QUINWOOD, TOWN OF	540244
RAINELLE, TOWN OF	540228
RONCEVERTE, CITY OF	540043
RUPERT, TOWN OF	540044
WHITE SULPHUR SPRINGS, CITY OF	540045

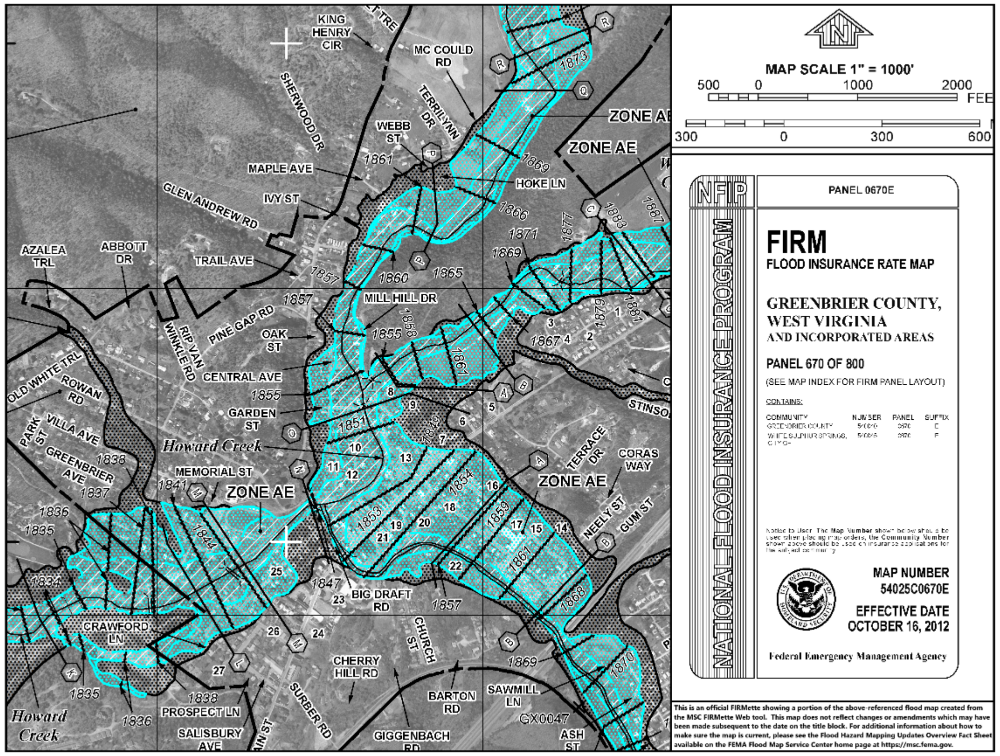
*No Special Flood Hazard Areas Identified

Greenbrier County

EFFECTIVE DATE: OCTOBER 16, 2012

Federal Emergency Management Agency

FLOOD INSURANCE STUDY NUMBER
54025CV000A



Local Floodplain Manager
City of White Sulphur Springs
Reece "BO" Belshee
Ph: 304-536-1454

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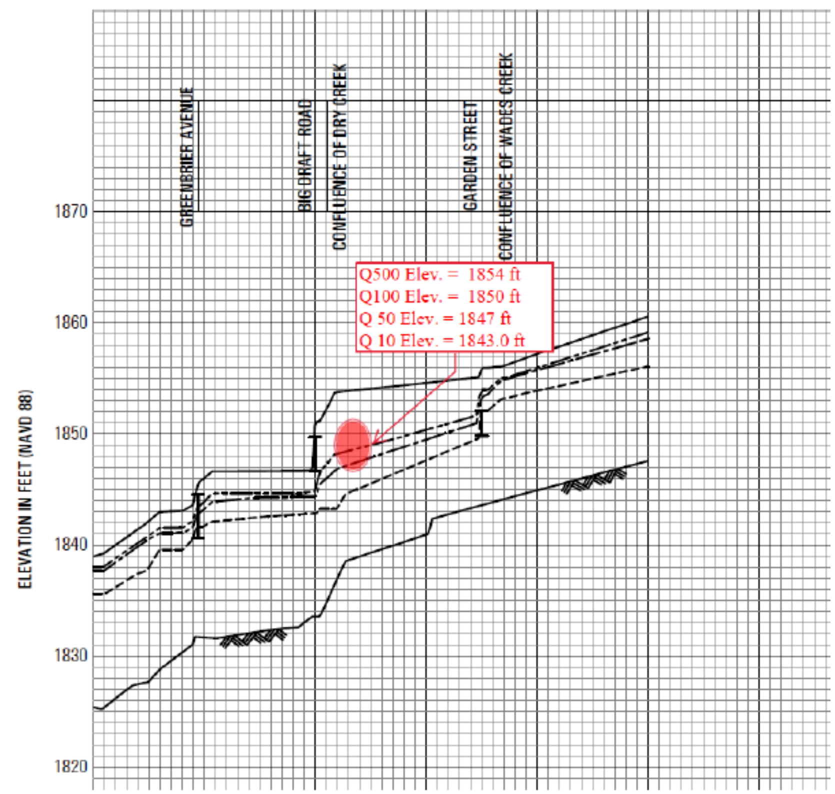
Hydraulics

- As per Flood Insurance Rate map (54025CV000A), the proposed bridge is in **Zone AE**, which was identified on October 16, 2012. It has base floods and floodway determined.

- The floodway width within the limits of the project ranges from a min of **111 ft to a max of 492 ft.**



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Hydraulics

Profile Name	Peak Discharges (CFS) at various locations		
	At US Route 60 RS 41574	**At Big Draft Road RS 40176**	**At Garden Street * RS 38486**
10-Yr	7,732	6,807	4,938
50-Yr	13,109	11,750	9,100
100-Yr	15,860	14,264	11,201
500-Yr	26,500	24,900	15,600

* Approximately 2,670 ft upstream of Garden Street

Hydraulic Modeling

- One-dimensional models represent a waterway with cross sections and associated attributes specified along and between each section.
- Input data and computed model results are associated with user-defined cross sections.
- 1D models are useful when the hydraulics do not violate the internal assumptions of 1D models and when modelers can confidently make the assumptions required for input.
- For example, flow in a channel is relatively simple and can be analyzed successfully with a 1D model.
- The equations that are used for 1D Modeling do not account for flow direction or path, velocity distribution, momentum, and or turbulence.

US Army Corps of Engineers®

HEC-RAS

Reference: FHWWA-HIF-19-061
Two-Dimensional Hydraulic Modeling for Highways in the River Encroachment, Reference Document

2D Hydraulics

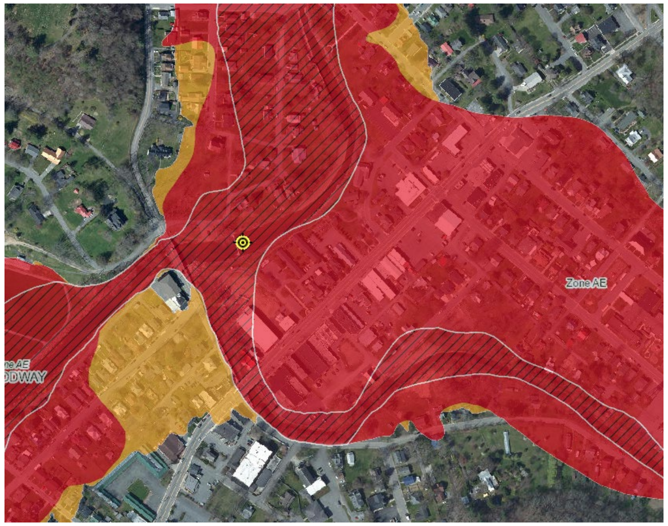
According to, FEMA's Guidance for Flood Risk Analysis and Mapping, 2020, "there are some situations where 1D modeling alone is not capable of accurately representing flood conditions.

These include flat terrain with very wide, shallow floodplains; **flow through highly urbanized areas**; and breakout flow that is hydraulically independent from a main channel/watercourse. In these situations, it may be necessary to employ two-dimensional (2D) modeling, or 2Dinformed 1D modeling".

The Federal Highway Administration (FHWA) is encouraging to change from 1-D to 2-D modeling through the CHANGE: Collaborative Hydraulics: Advancing to the Next Generation of Engineering. 2-D models avoid many of the limiting assumptions required by 1-D models, and the results can significantly improve the ability to design safer, more cost-effective, and resilient structures on waterways.

2-D Hydraulic Modeling Recommendations

- Wide Floodplains
- Highly variable floodplain roughness
- Highly sinuous channels
- Multiple embankment openings
- Moderate to high roadway skew
- Multiple channels
- Large tidal waterways
- Upstream hydraulic controls
- Roadway overtopping



Reference: FHWWA-HIF-19-061
Two-Dimensional Hydraulic Modeling for Highways in the River Encroachment, Reference Document

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Advantages of 2D Hydraulics

- Fewer Modeling Assumptions
- Accurate Representations of Flow distribution, Velocity and Elevation
- Two-dimensional models calculate hydraulic results at locations within a mesh that covers the entire geographic extents of a river and floodplain.
- 2D models provide a more intuitive graphical representation of results as opposed to cross sections and tables from a 1D mode

Reference: FHWWA-HIF-19-061
Two-Dimensional Hydraulic Modeling for Highways in the River Encroachment, Reference Document

1D vs 2D

Hydraulic Variables	1D Modeling	2D Modeling
Flow direction	**Assumed** by user	**Computed**
Flow paths	**Assumed** by user	**Computed**
Channel roughness	**Assumed** constant between cross sections	Roughness values at individual elements used in computations.
Ineffective flow areas	**Assumed** by user	**Computed**
Flow contraction and expansion through bridges	**Assumed** by user	**Computed**
Flow velocity	**Averaged** at each cross section	**Computed** at each element
Flow distribution	**Approximated** based on conveyance	**Computed** based on continuity and momentum
Water Surface Elevation	**Assumed** constant across entire cross section	**Computed** at each element

Reference: FHWWA-HIF-19-061
Two-Dimensional Hydraulic Modeling for Highways in the River Encroachment, Reference Document

2-D Hydraulic Model Development
Of
Pedestrian Bridge over Howard Creek

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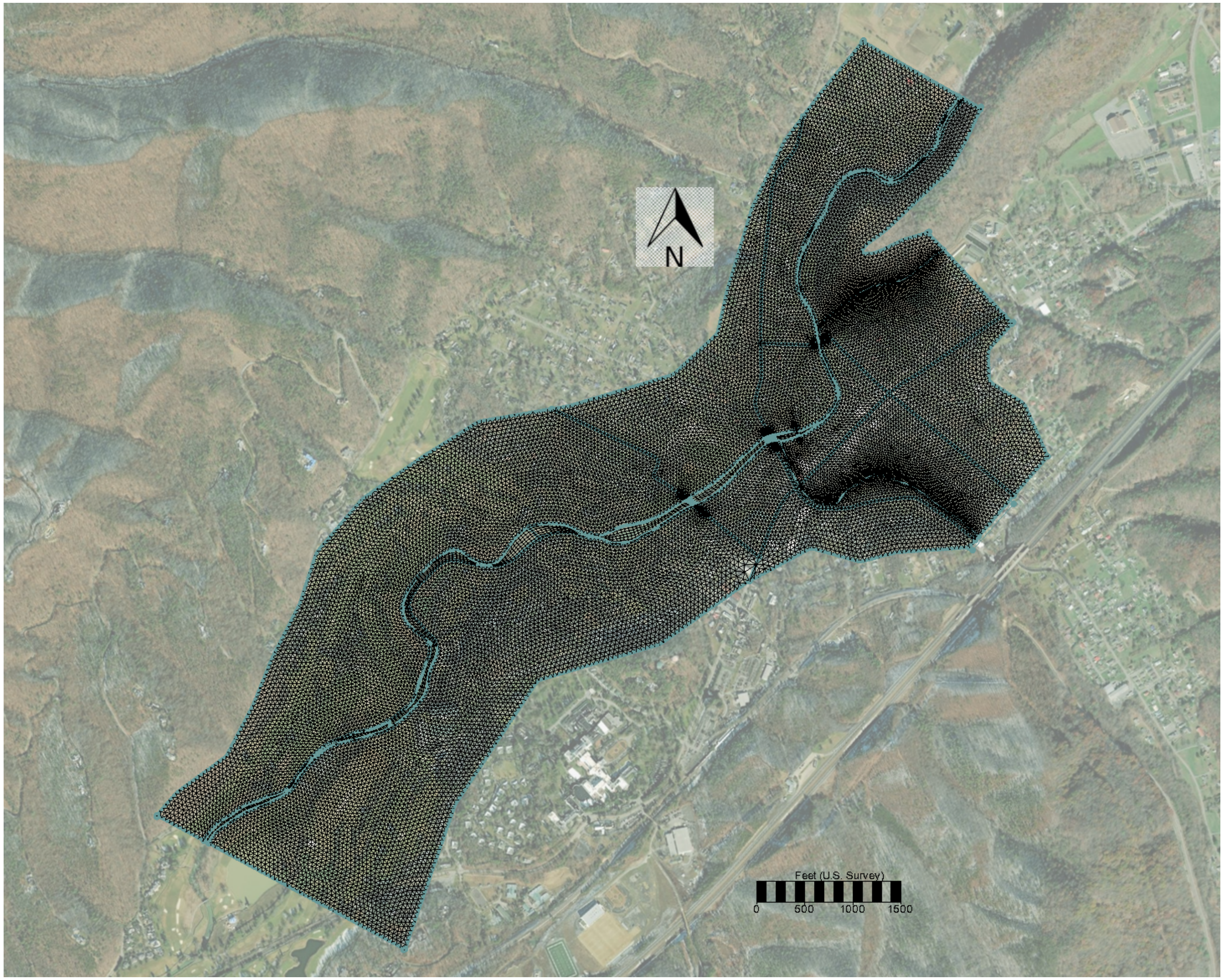
2D Hydraulic Model – Mesh Generation



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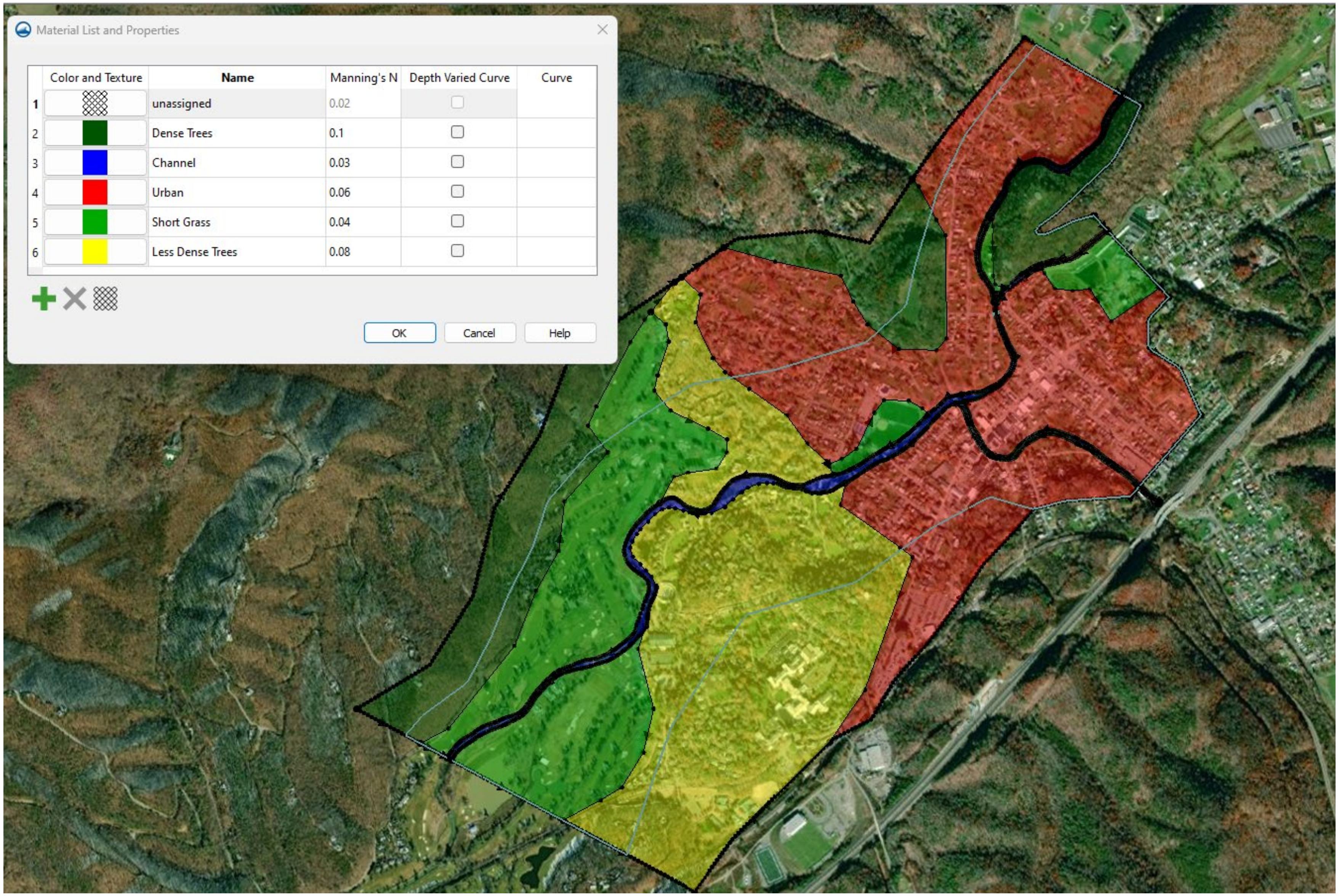
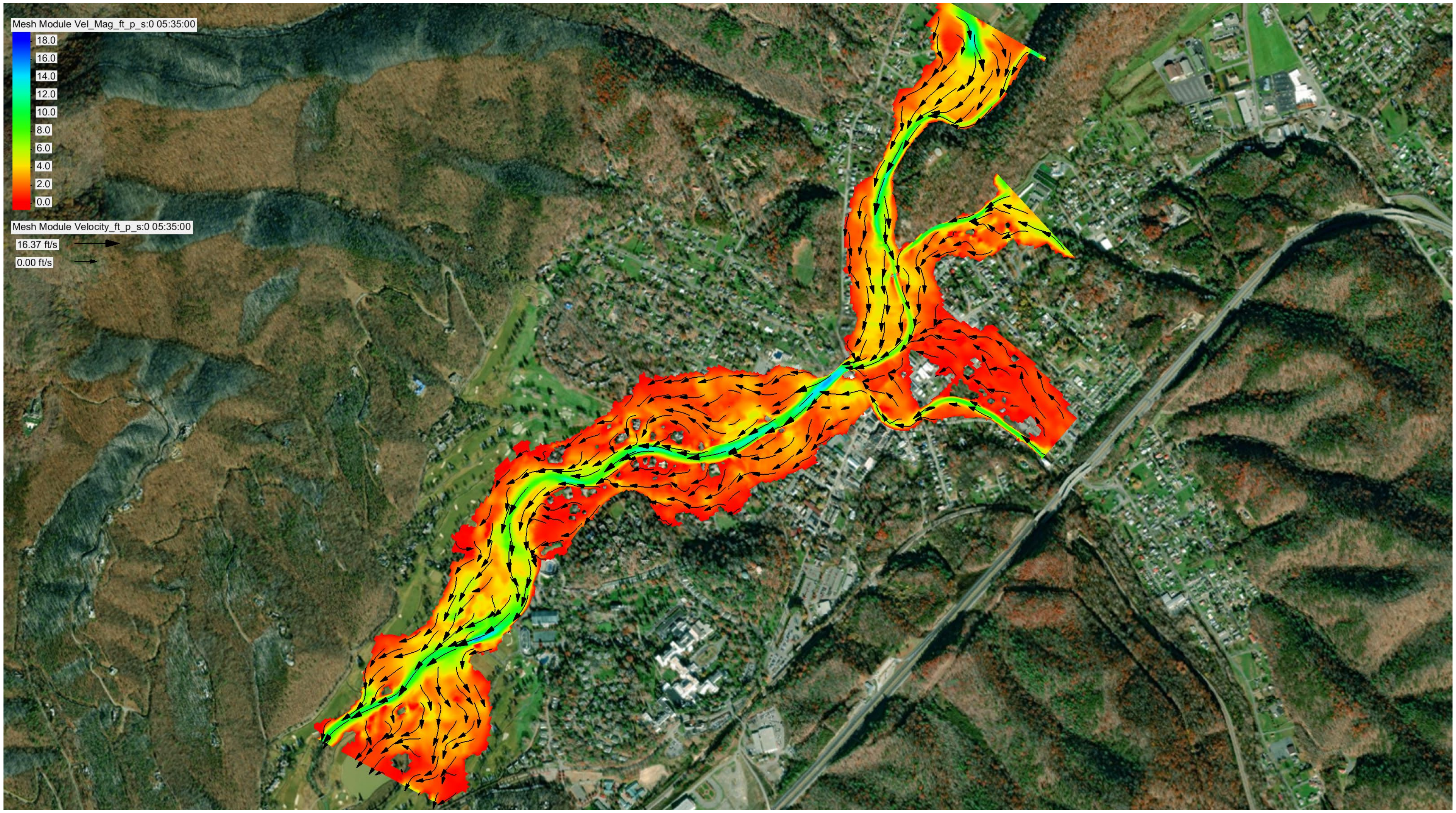
2D Hydraulic Model – Channel Roughness



2D Hydraulic Model – Flow Path & Velocity



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- ✓ **Continuously invest in education and training of our employees.**
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Planning & Environmental Services
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ENR TOP 500

2012, 2019, 2020, 2021, 2022, 2023

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Locations, 185 Employees

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Chapmanville, WV 25508

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Beckley, WV 25801

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3362 Six Forks Roads
Raleigh, NC 27609

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Ashland, KY 41101

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9520 Berger Road,
Berger Road, 21046

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Suite 310
Columbus, OH 43215

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