Granite Street Historic District Flood Resiliency Plan

Hardwick, Vermont

June 10, 2026

SLRCONSULTING.COM

SLR

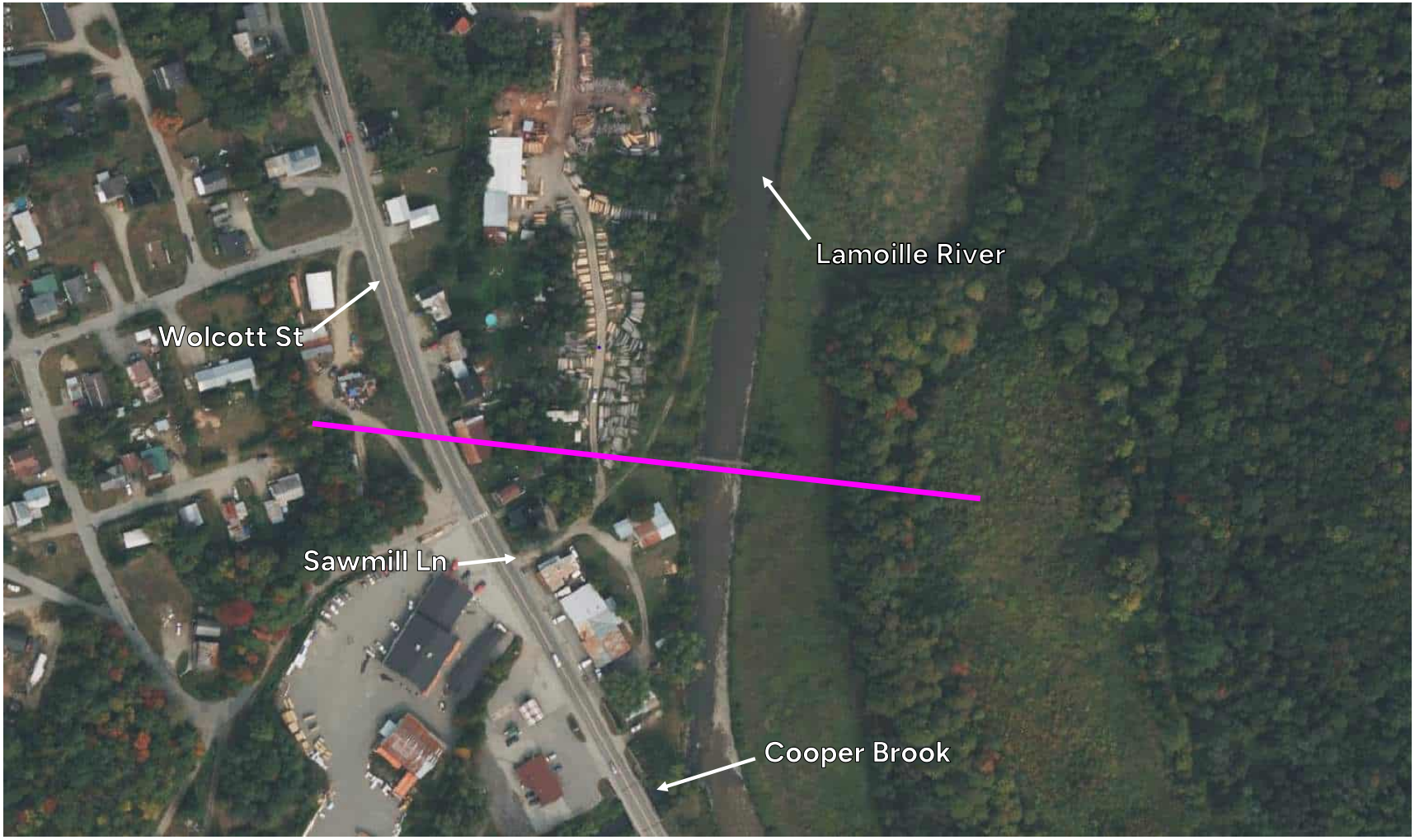
Agenda

- River Model Setup & Results
- Flood Mitigation Strategies
- Lamoille River Alternative Modeling Recap
- Cooper Brook Alternative Modeling
- Post Flood Drainage

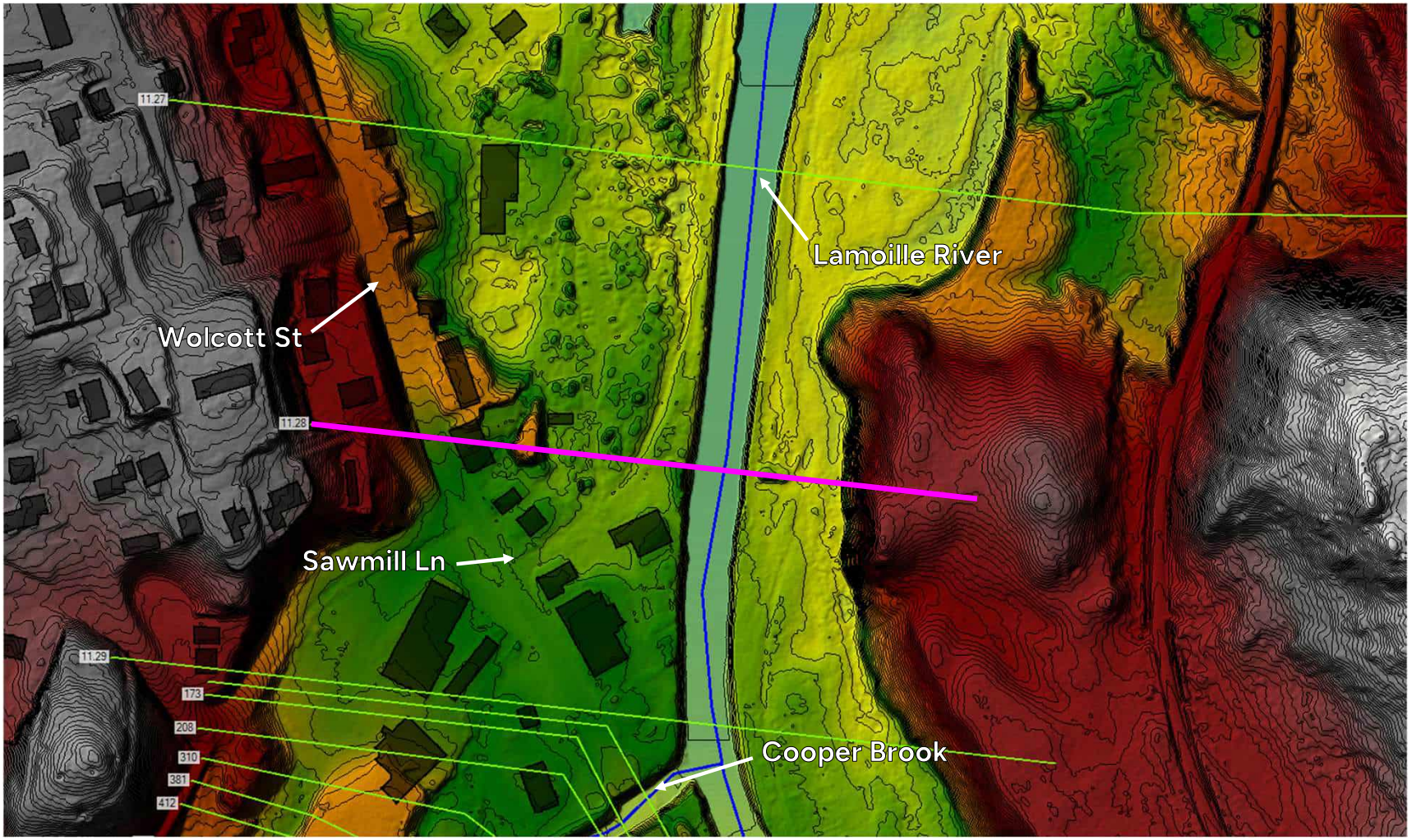
Granite Street Historic District

Photo by: Orleans County NRCD

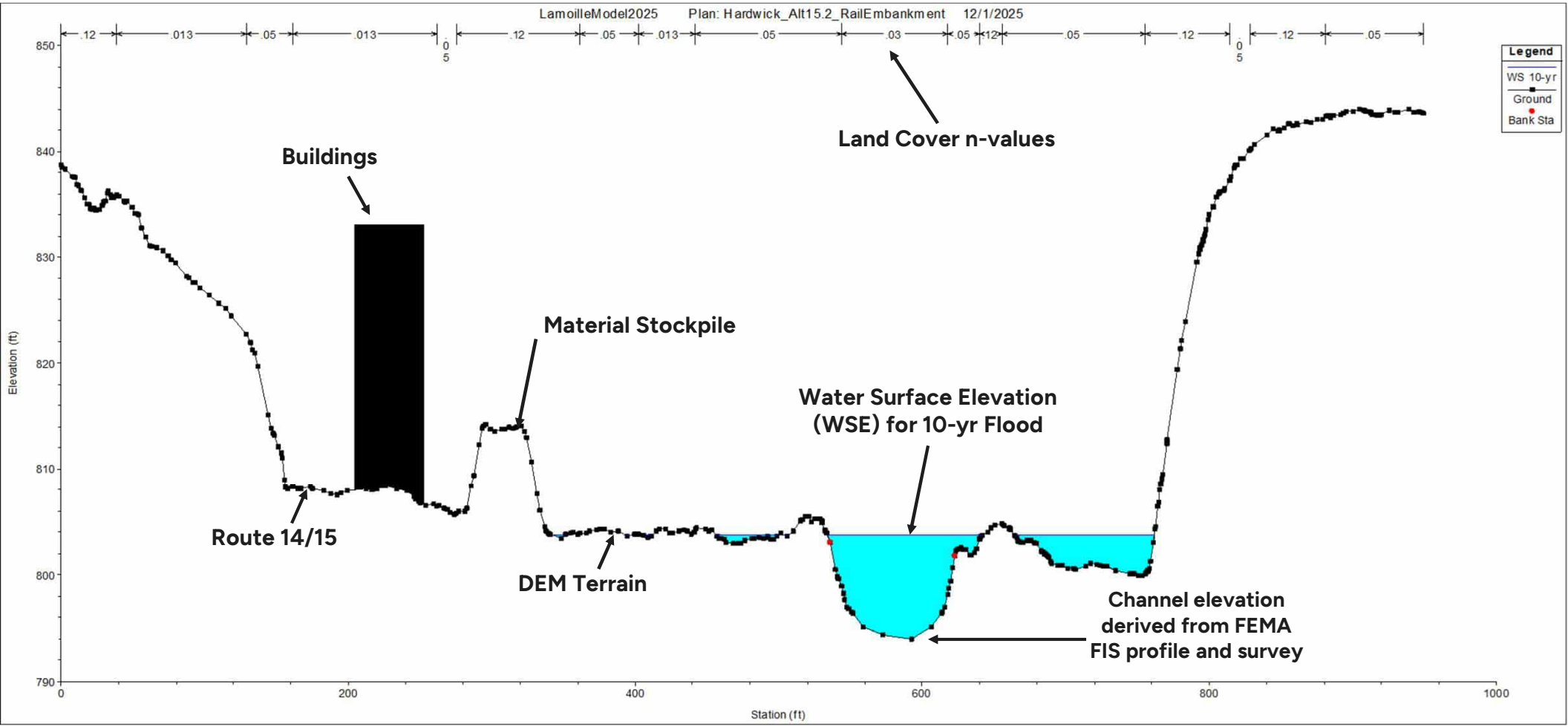
Map View



Model Terrain

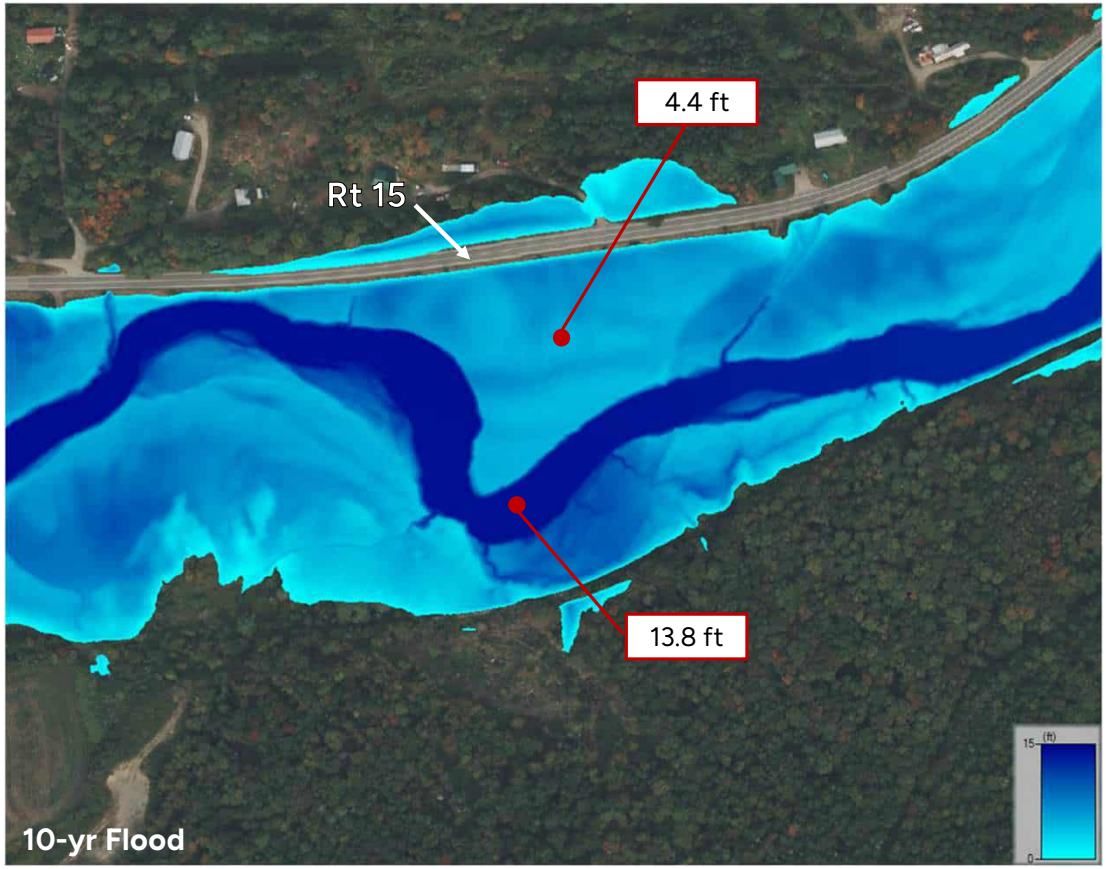


Cross Section View



What can the model tell us?

- Water Surface Elevation
- Floodplain Mapping
- **Flow Characteristics**
  - Velocity
  - **Depth**
- Channel and Water profiles
- Dam, Bridge, and Culvert Impacts
  - Backwatering
  - Overtopping
  - Scour



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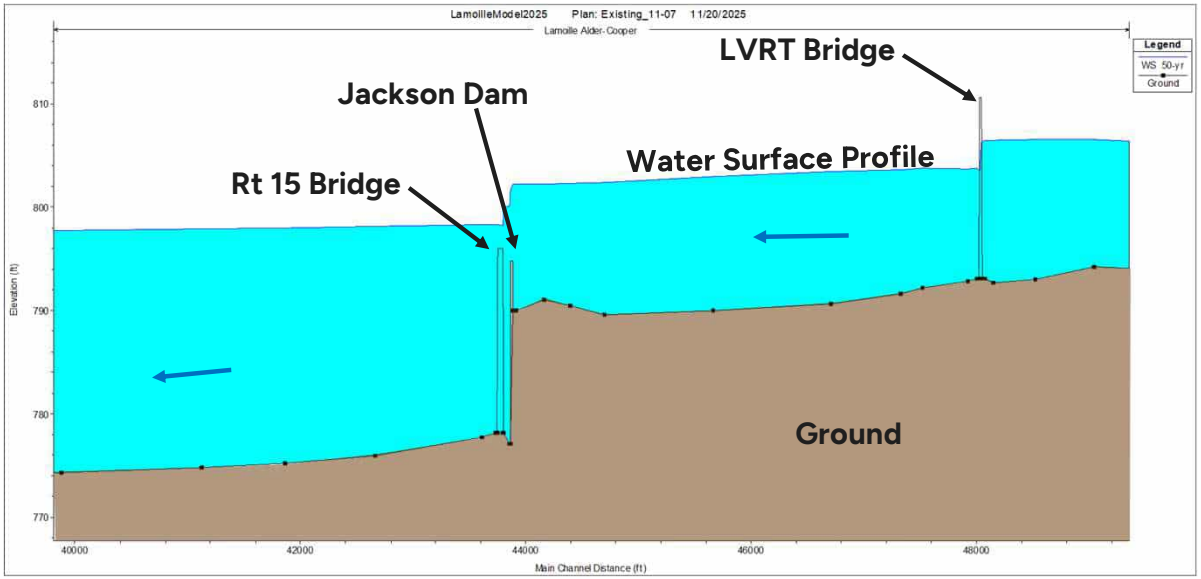
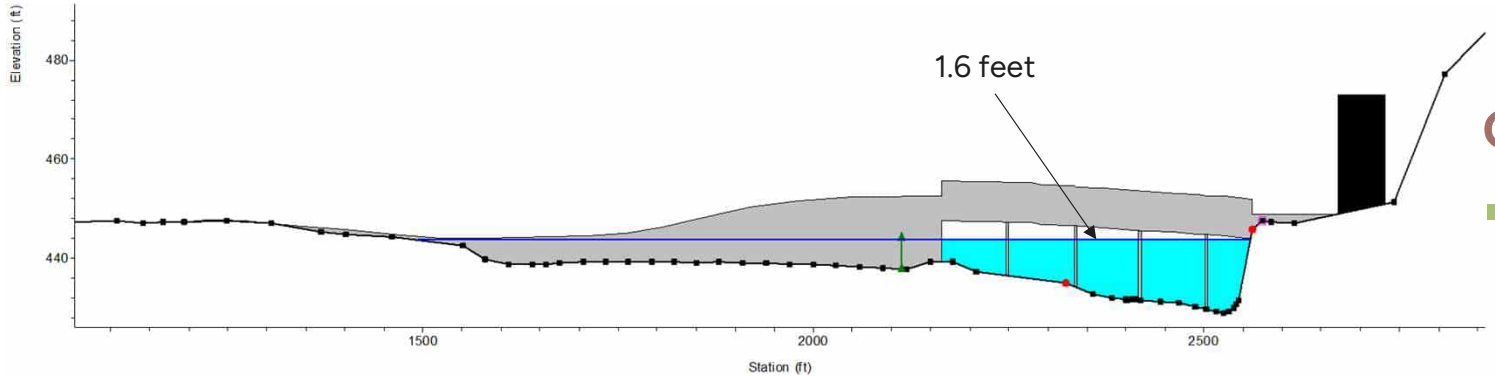


How Accurate is it?

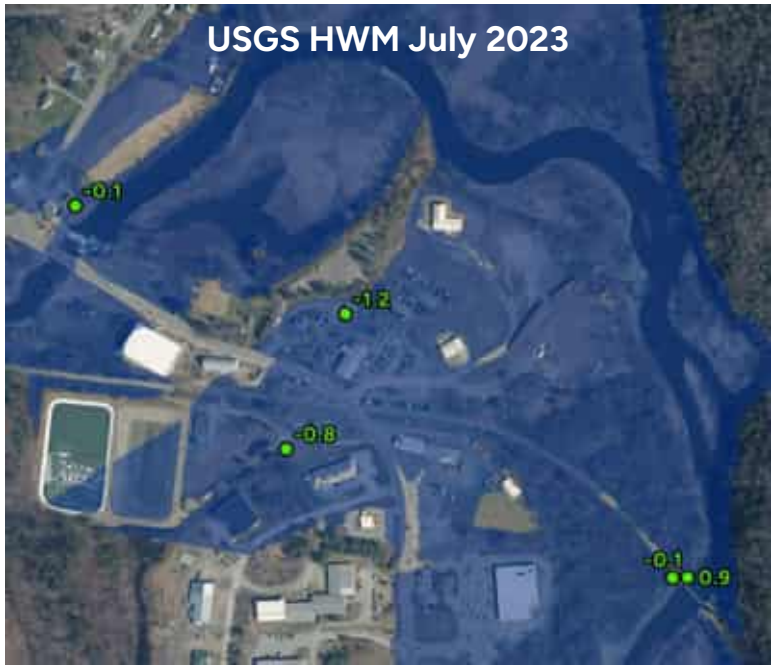


Calibration / Validation:

- Flooding Photos

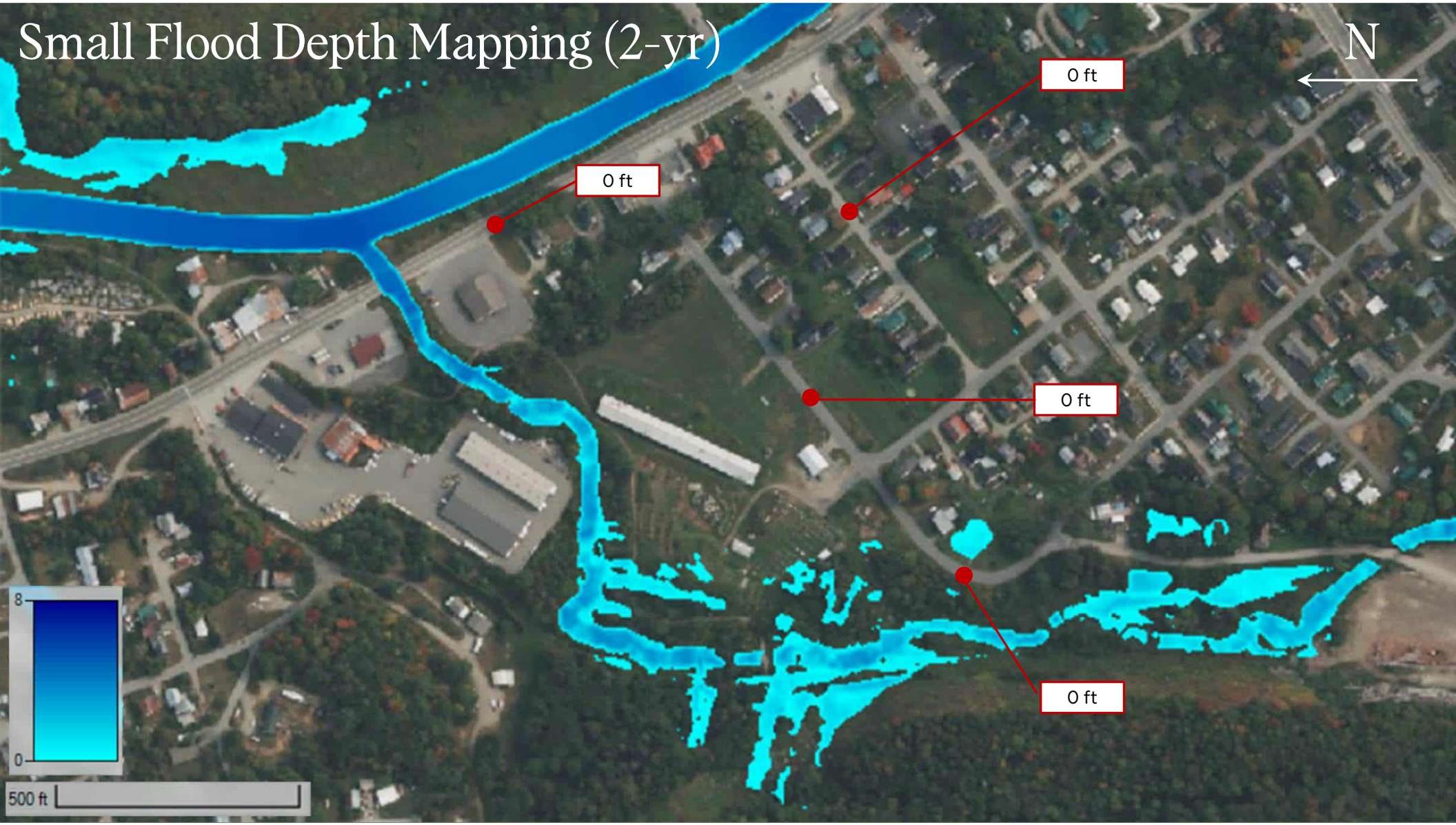
Wrong Way Bridge
Lamoille River at ~2-year flood level
Jessica Louisos, May 24, 2013

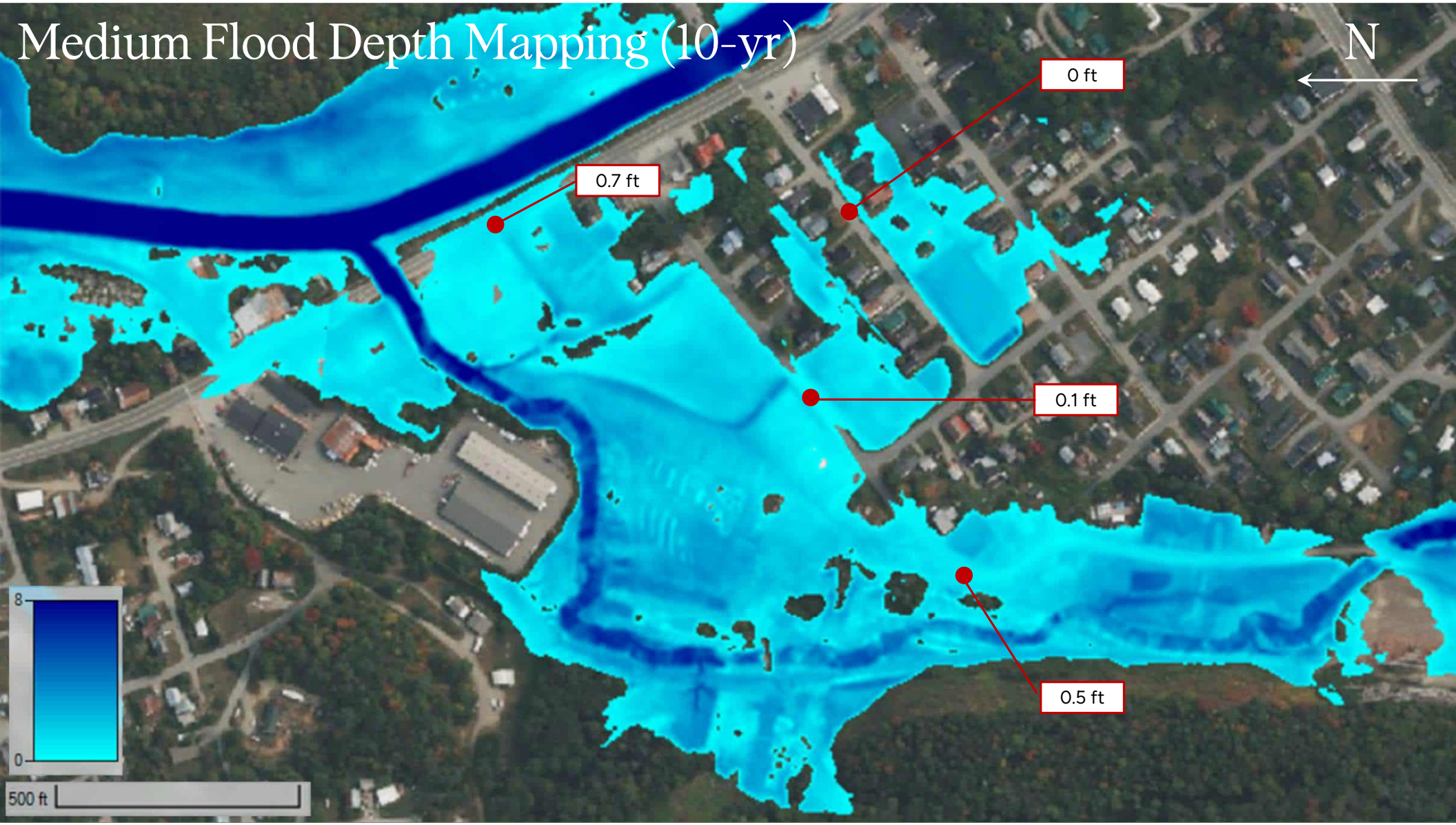
How Accurate is it?

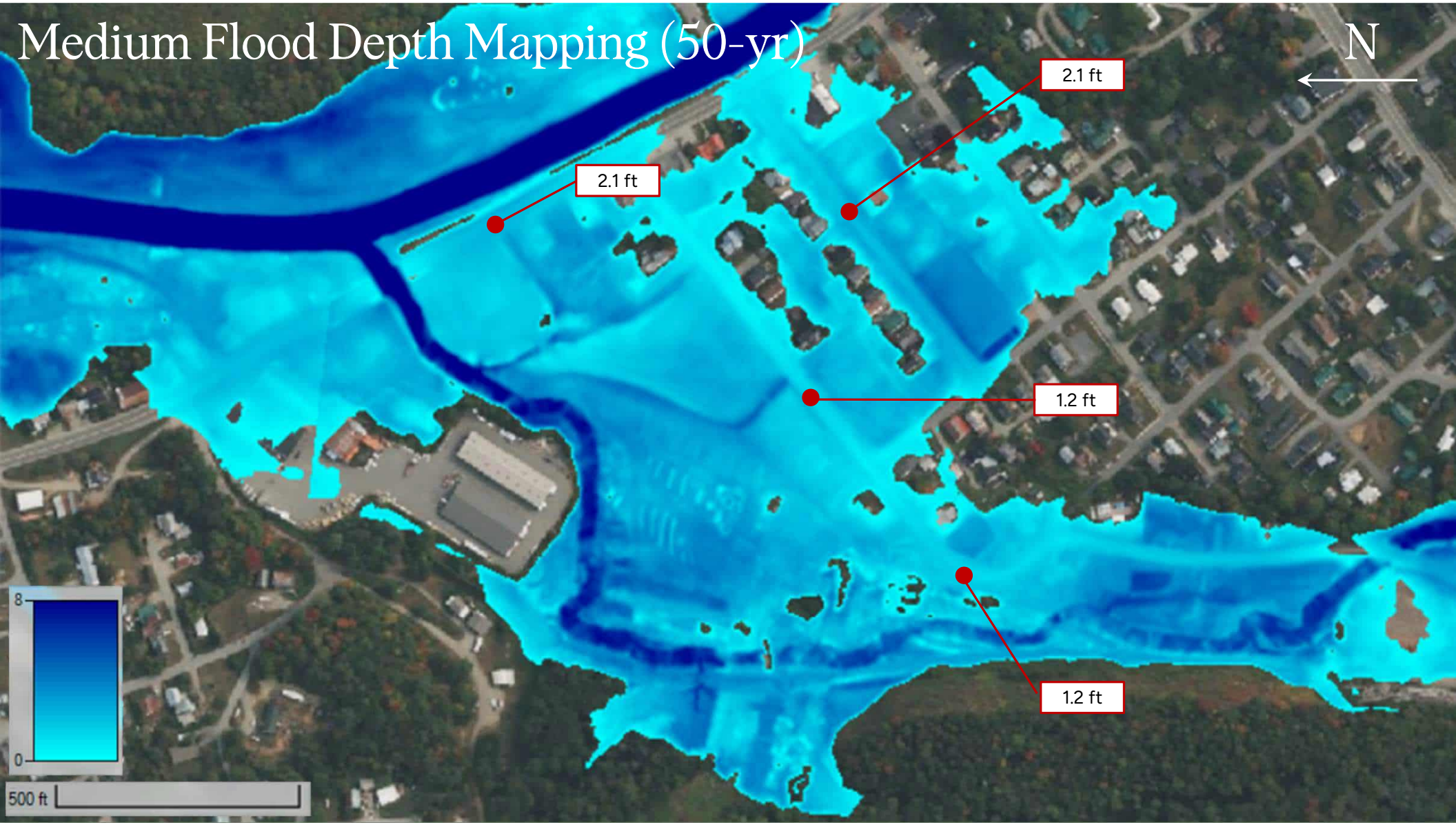


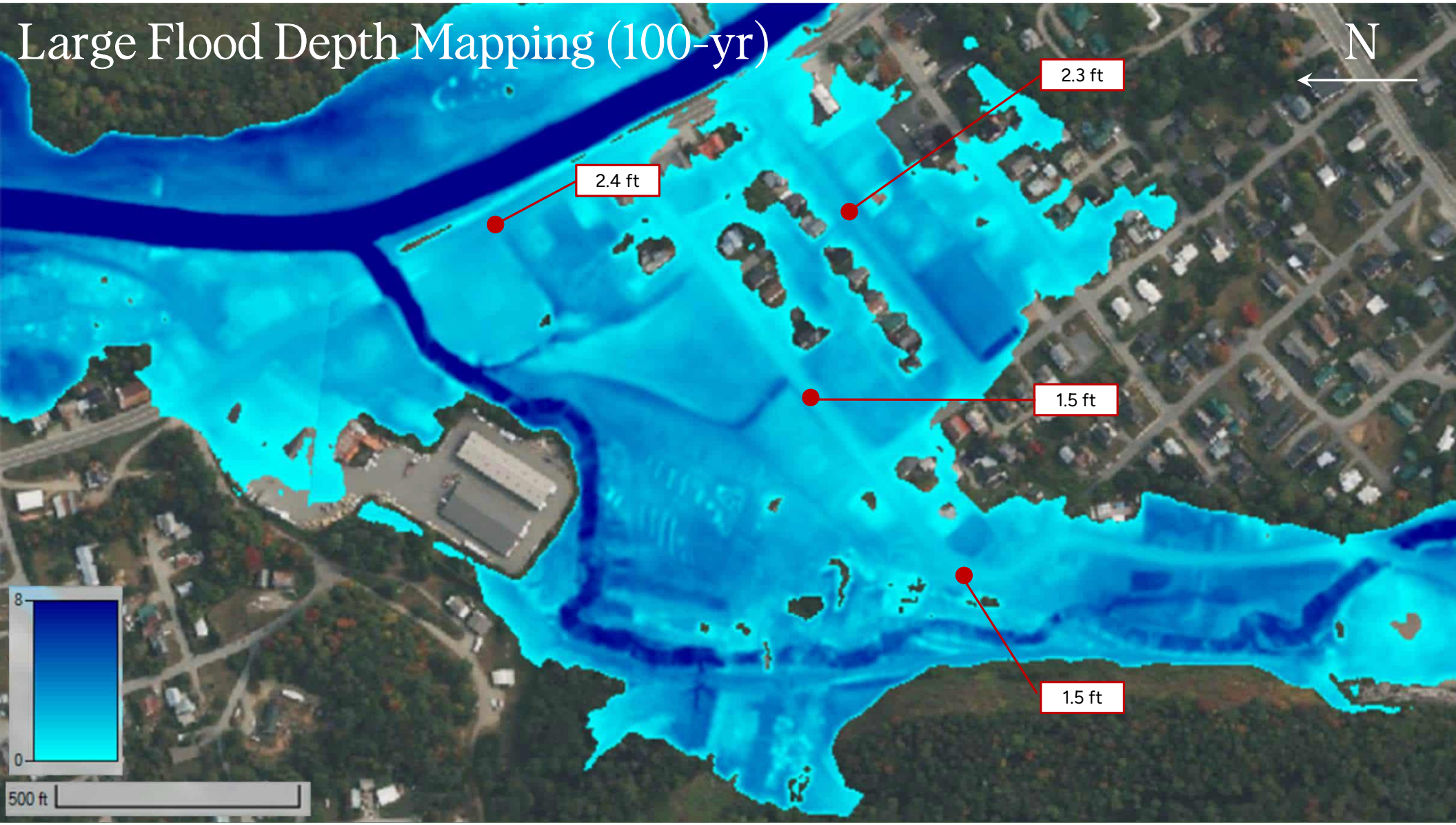
Calibration / Validation:

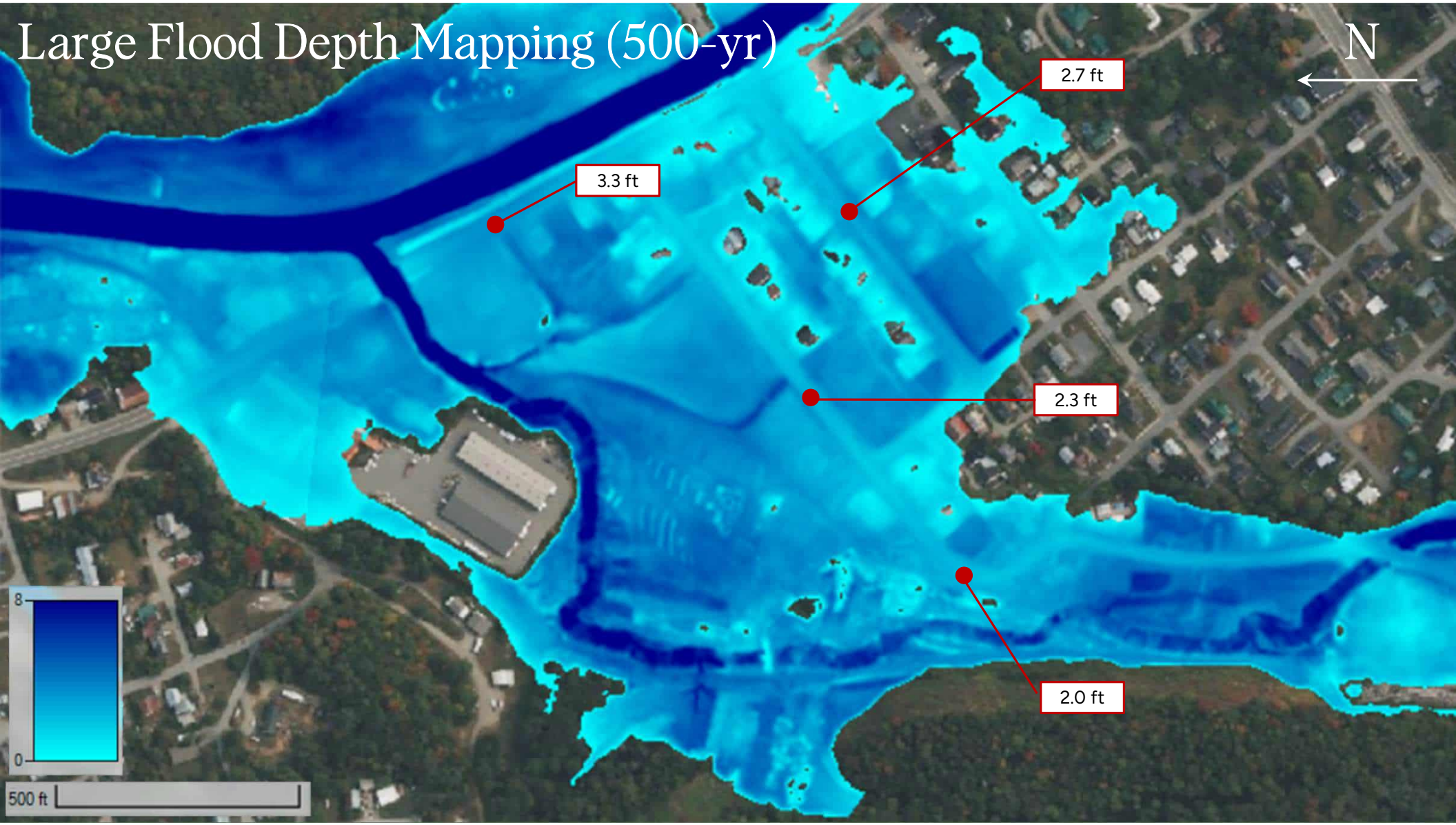
- High Water Marks (HWMs)
- Accuracy is within 1 ft
- Good for comparing alternatives


Small Flood Depth Mapping (2-yr)
N
0 ft
0 ft
0 ft
0 ft
8
0
500 ft

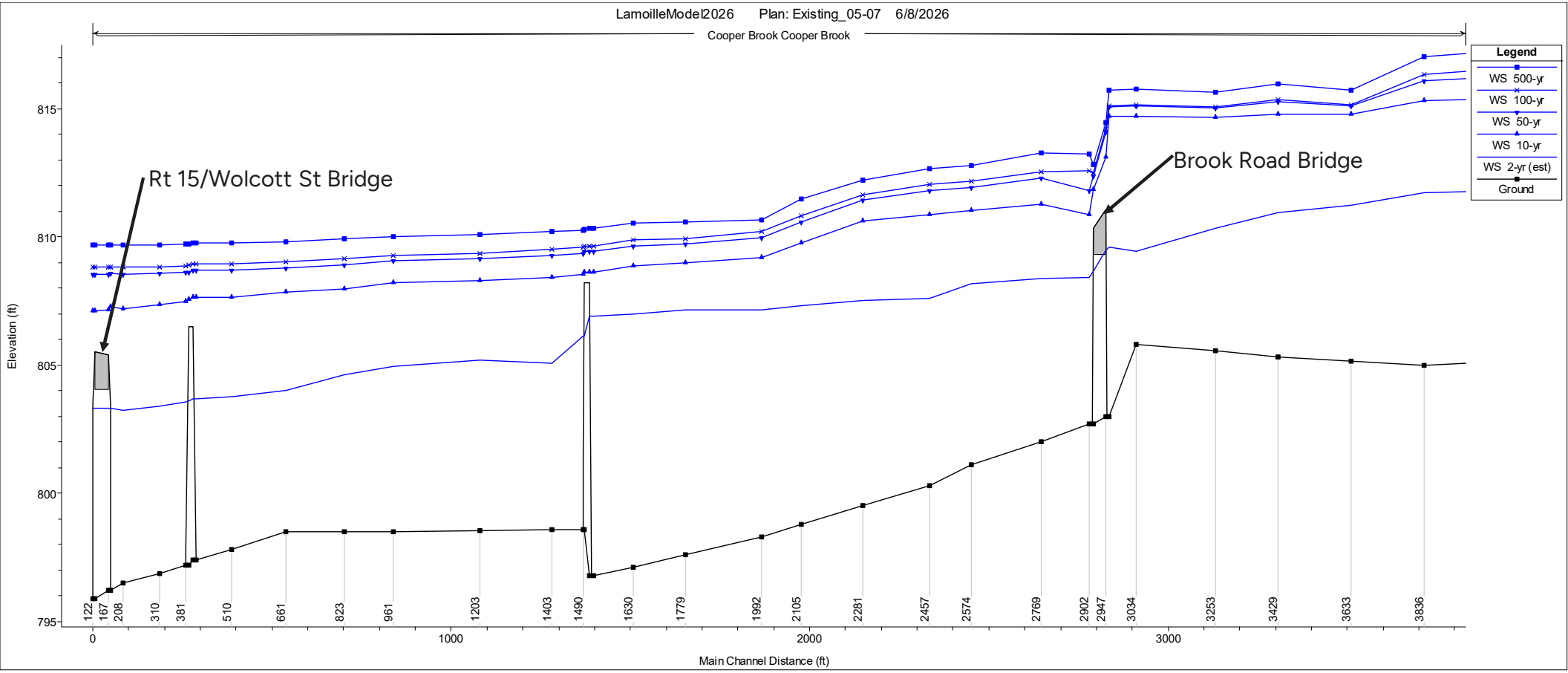

Medium Flood Depth Mapping (10-yr)
N
0 ft
0.7 ft
0.1 ft
0.5 ft
8
0
500 ft


Medium Flood Depth Mapping (50-yr)
N
2.1 ft
2.1 ft
1.2 ft
1.2 ft
8
0
500 ft

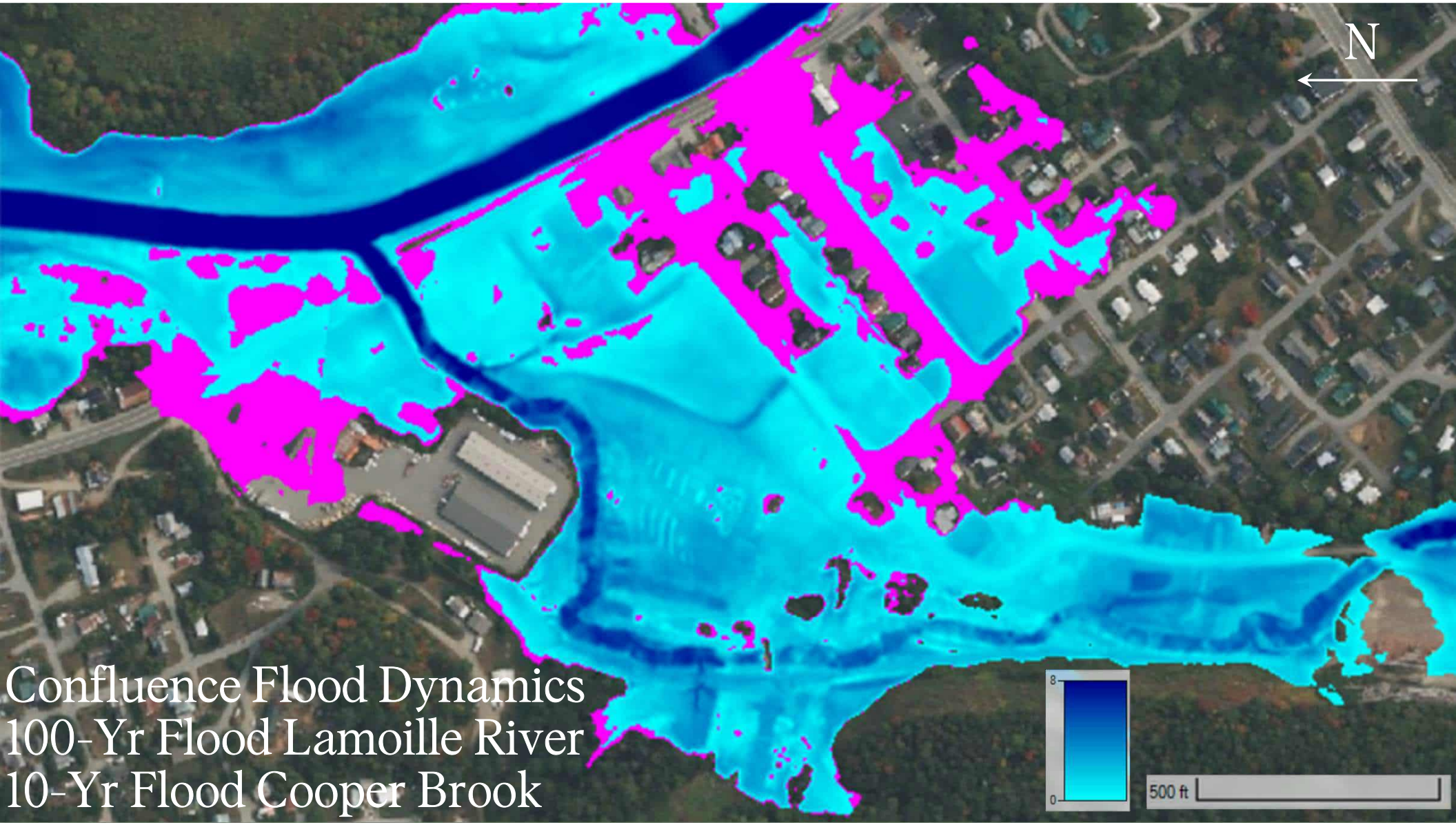

Large Flood Depth Mapping (100-yr)
N
2.3 ft
2.4 ft
1.5 ft
1.5 ft
8
0
500 ft

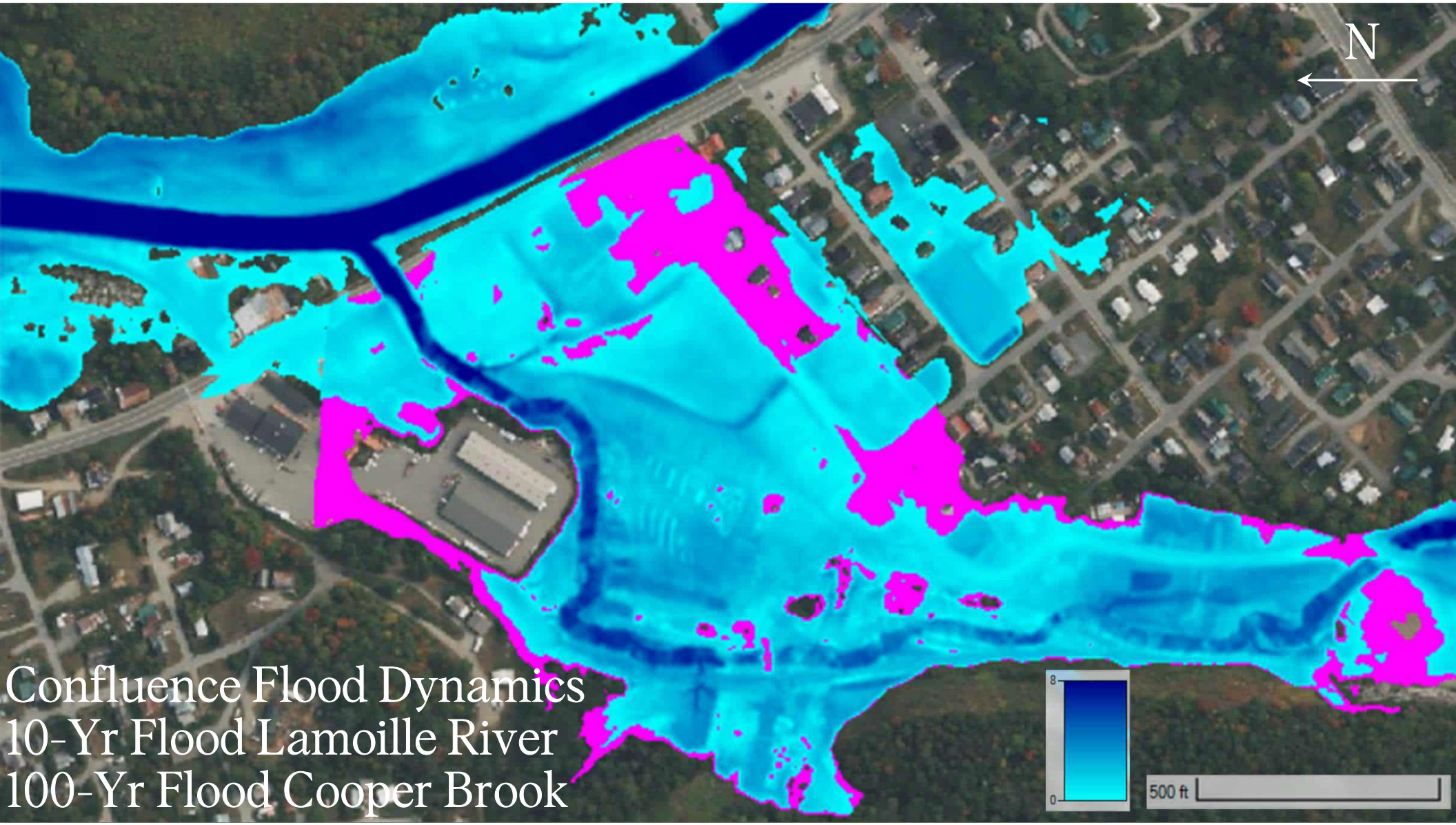

Large Flood Depth Mapping (500-yr)
N
2.7 ft
3.3 ft
2.3 ft
2.0 ft
8
0
500 ft

Existing Conditions – Cooper Brook Profile



3,800 ft (0.7 miles)


N
Confluence Flood Dynamics
100-Yr Flood Lamoille River
10-Yr Flood Cooper Brook
8
0
500 ft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10-Yr Flood Lamoille River
100-Yr Flood Cooper Brook
8
0
500 ft

Types of Flood Mitigation Alternatives

Constriction Reduction

- Widen bridges, culverts, or other structures
- Remove fill or buildings

Floodplain Reconnection

- Lower floodplain
- Remove berm
- Elevate channel
- Buyouts

Infrastructure Protection

- WWTP and utilities
- Roads
- Buildings

Floodplain Restoration in Brattleboro

Removed Buildings, People, and Infrastructure from Most Vulnerable Locations

- Removed 11 buildings
- Relocated road
- Relocated sewer main / utilities

Increased Floodplain Storage Capacity

- Removed 28,000 CY of fill in floodplain and lowered land average of 5 feet
- Planted and restored 4.4 acres of floodplain with native vegetation

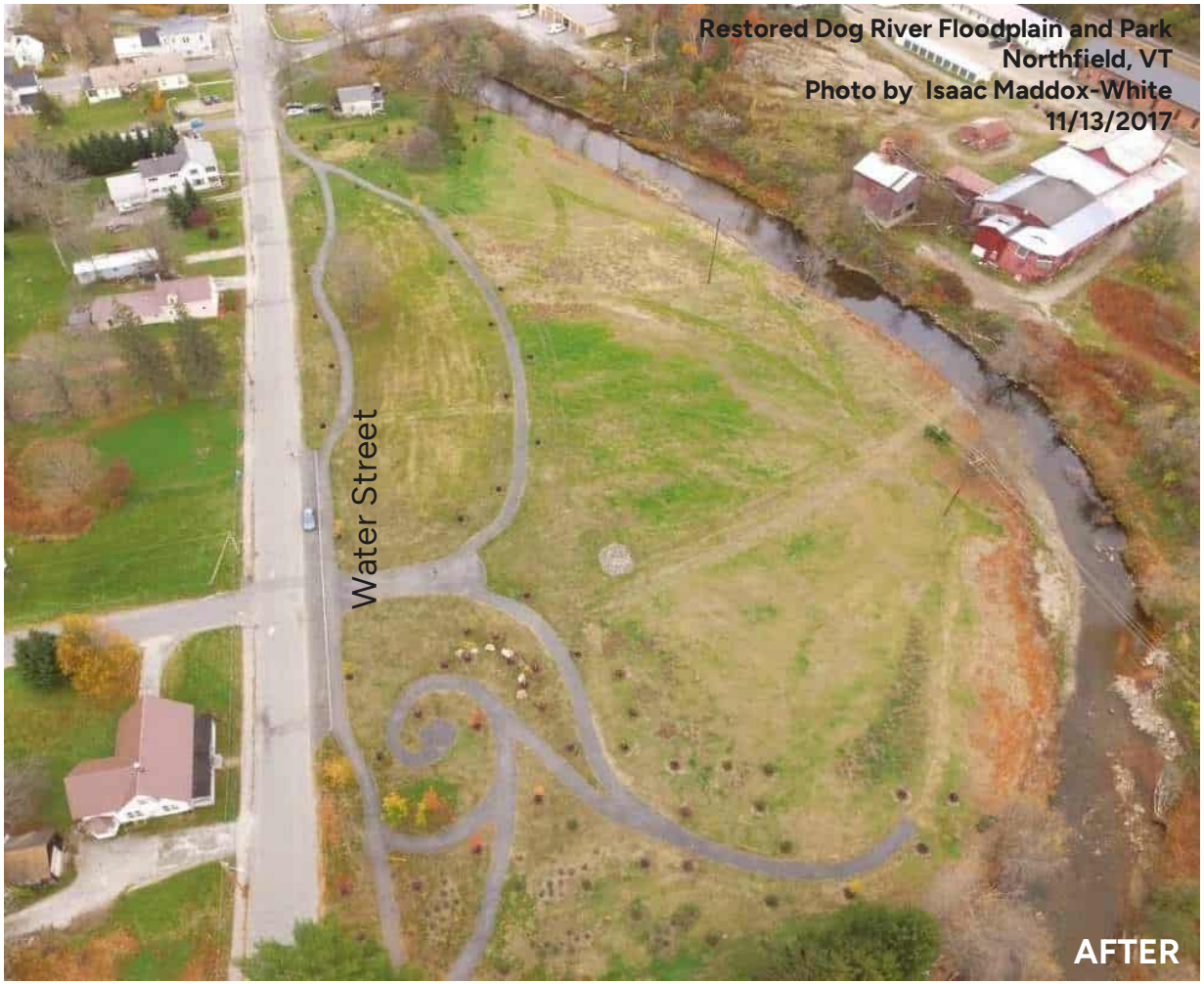
Floodplain Restoration in Brattleboro

Pre-construction

Post-construction

Dog River Park in Northfield

- Remove 7 damaged homes
- Remove 9,000 CY fill in floodplain & lower land average 4 feet over 3 acres
- Remove berm
- Plant restored floodplain with native vegetation



Dog River Park in Northfield

Dog Floodplain
Northfield, VT
Photo by M. Braun
10/30/2017

Dog Floodplain
Northfield, VT
Photo by R. Schiff
9/7/2018

Route 15 Bypass Culverts - Cambridge

Provide additional capacity under highway embankment

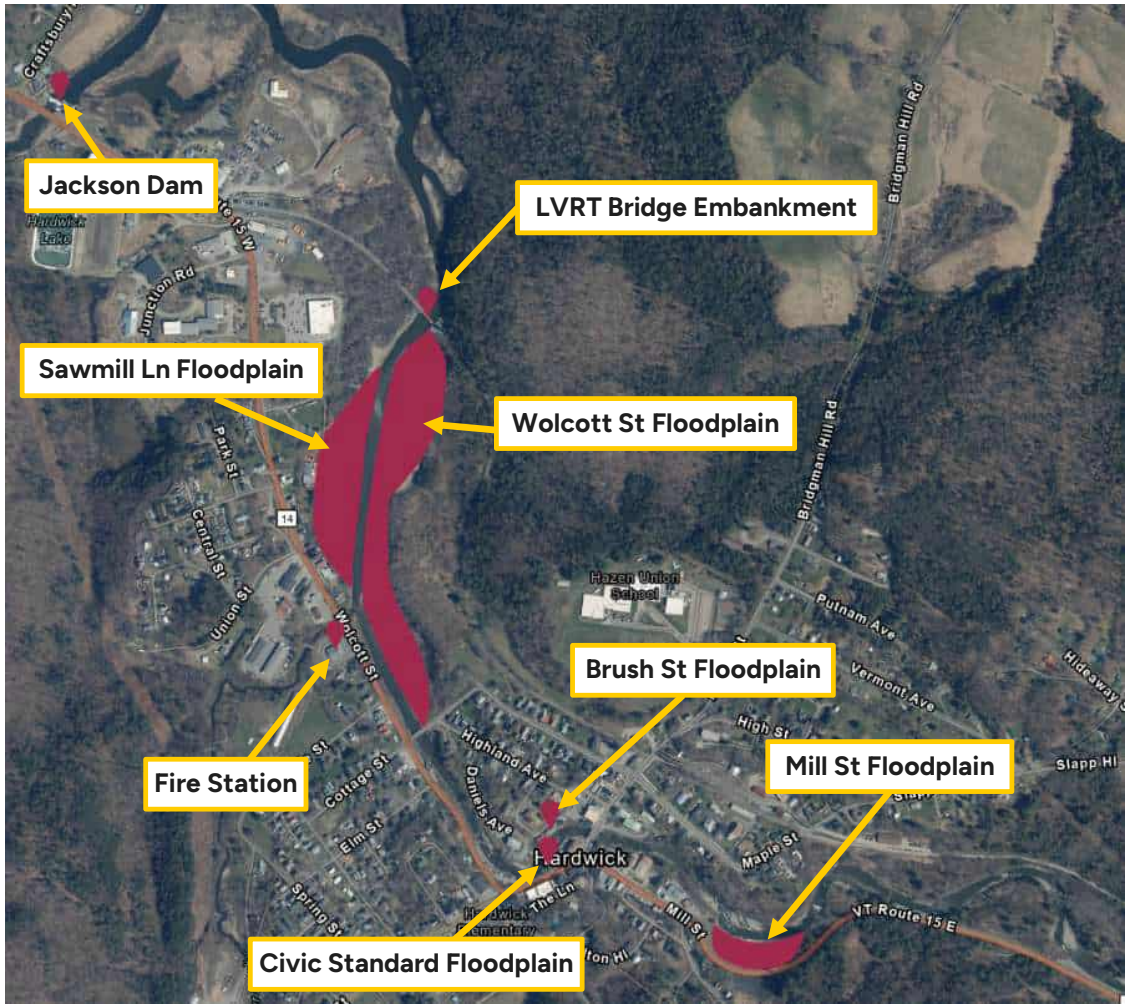
- Large culvert installed under road
- Floodwater trapped behind road embankment can flow out of village
- Road overtops less
- Buildings flooded less

Greenway Trail Bridge Replacement– Jeffersonville

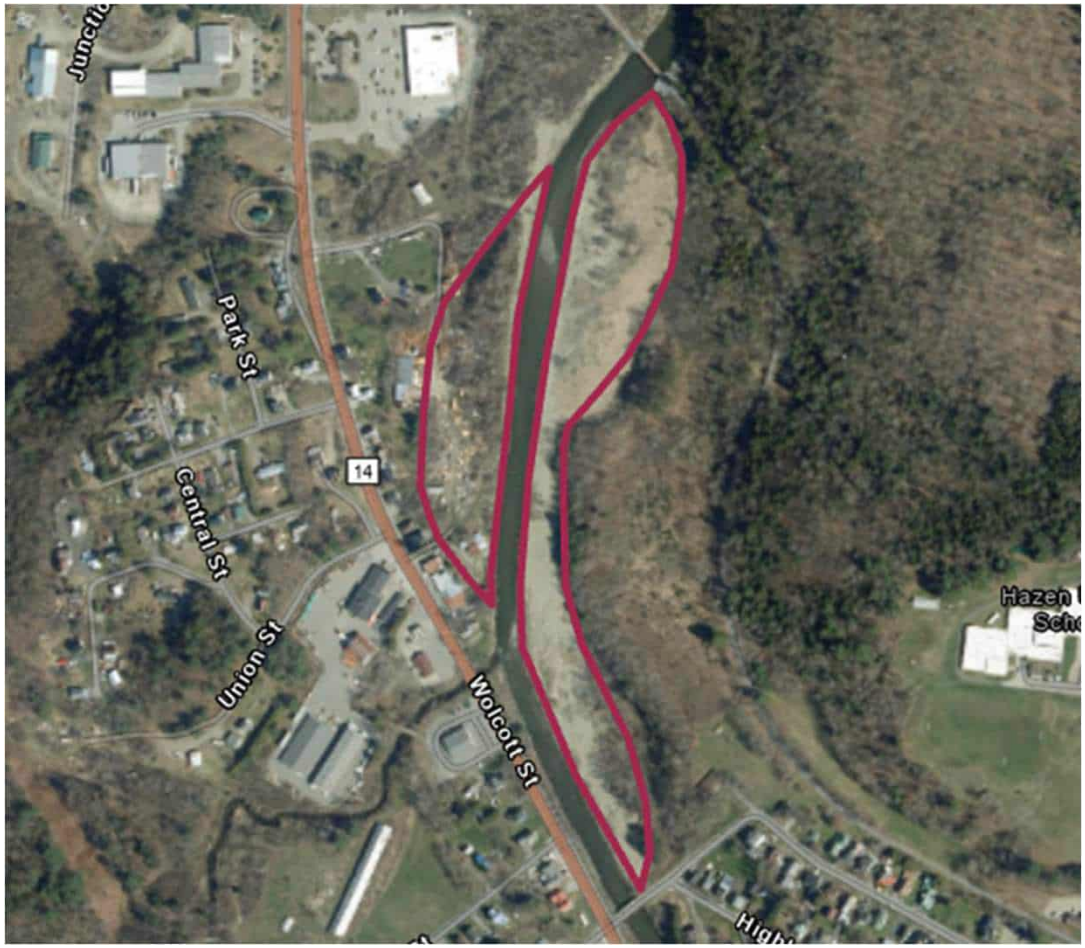
Removed constriction

- An undersized bridge and unused abutments were removed
- Larger bridge installed
- Opened up floodplain under bridge

Potential Flood Mitigation Alternatives in Hardwick



Wolcott Street and Sawmill Lane Floodplains



Problems

- Sediment deposition
- Inundation flooding
- Possible buyouts

Possible Solutions

- Floodplain restoration opportunity

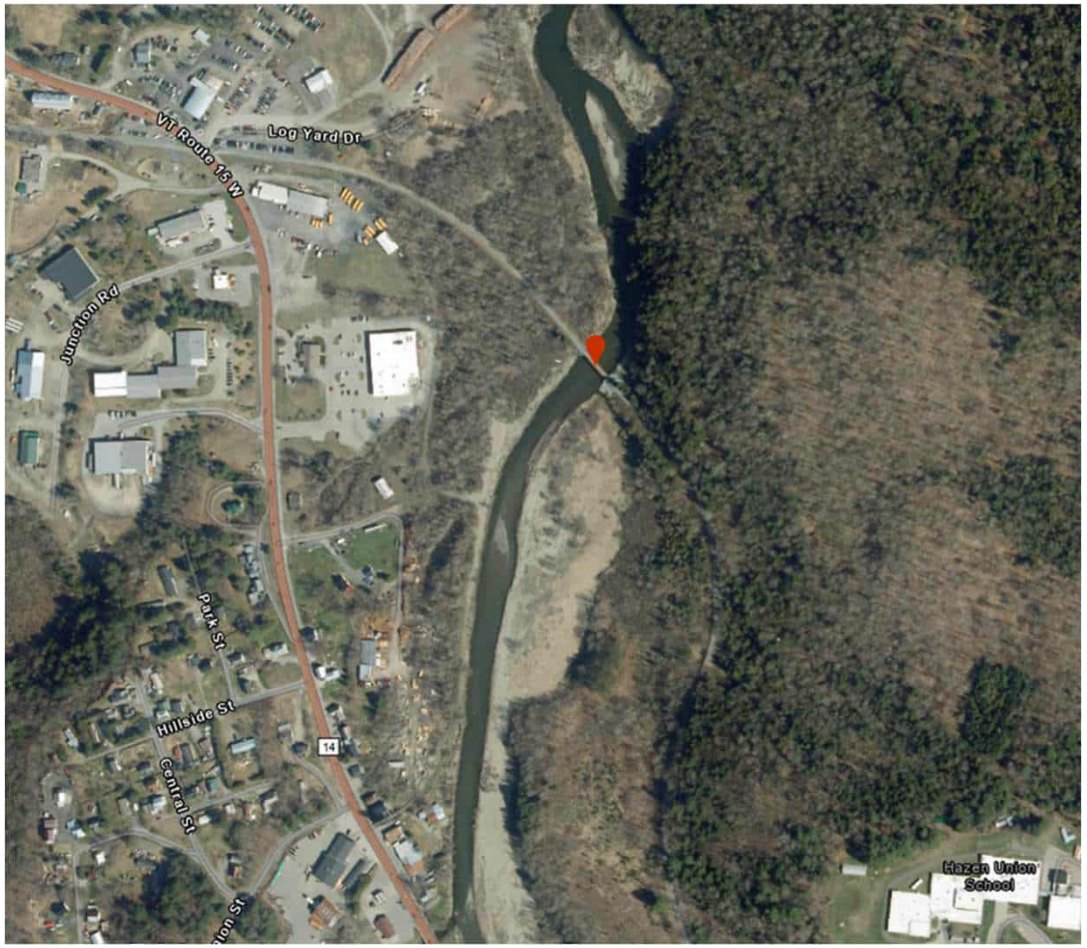
LVRT Embankment

Problems

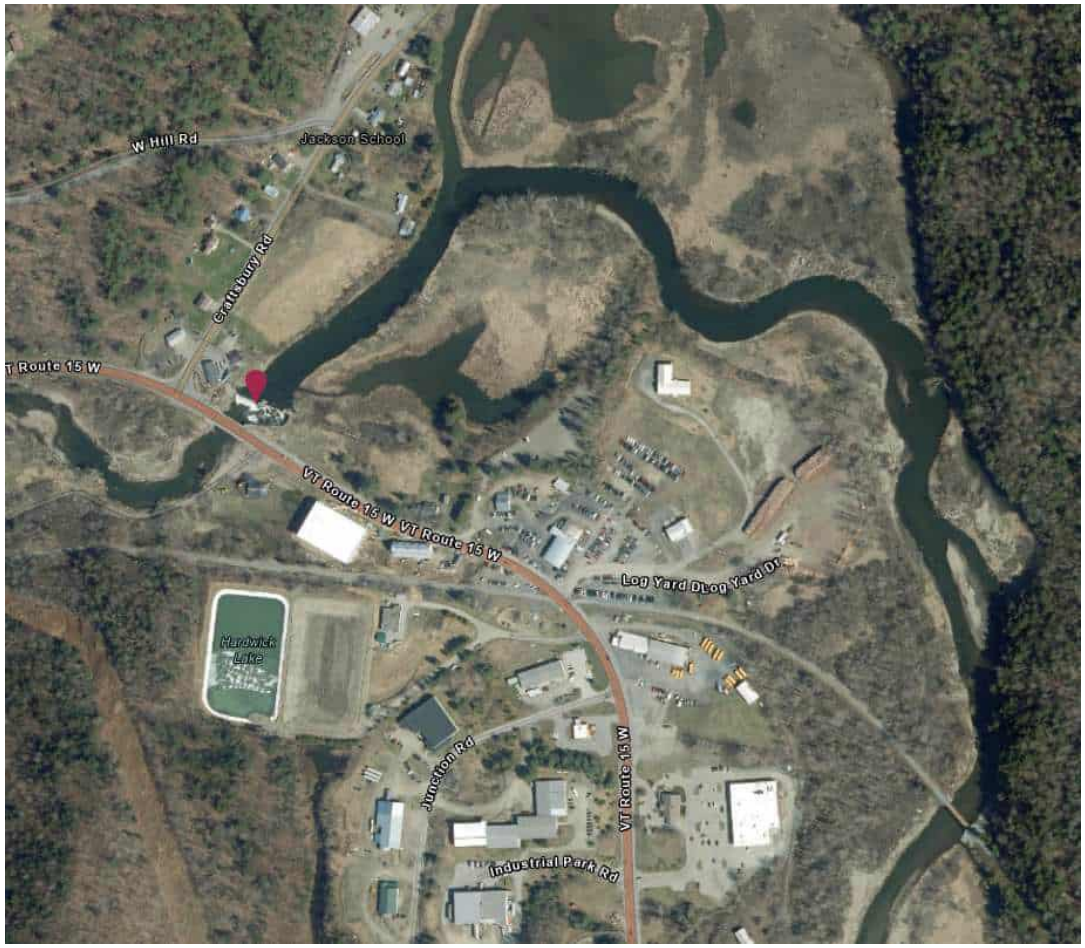
- LVRT Bridge is a constriction and backs up flow
- Embankment fully blocks floodplain

Possible Solutions

- Lower Embankment / Planned Overflow
- Widen Bridge



Jackson Dam



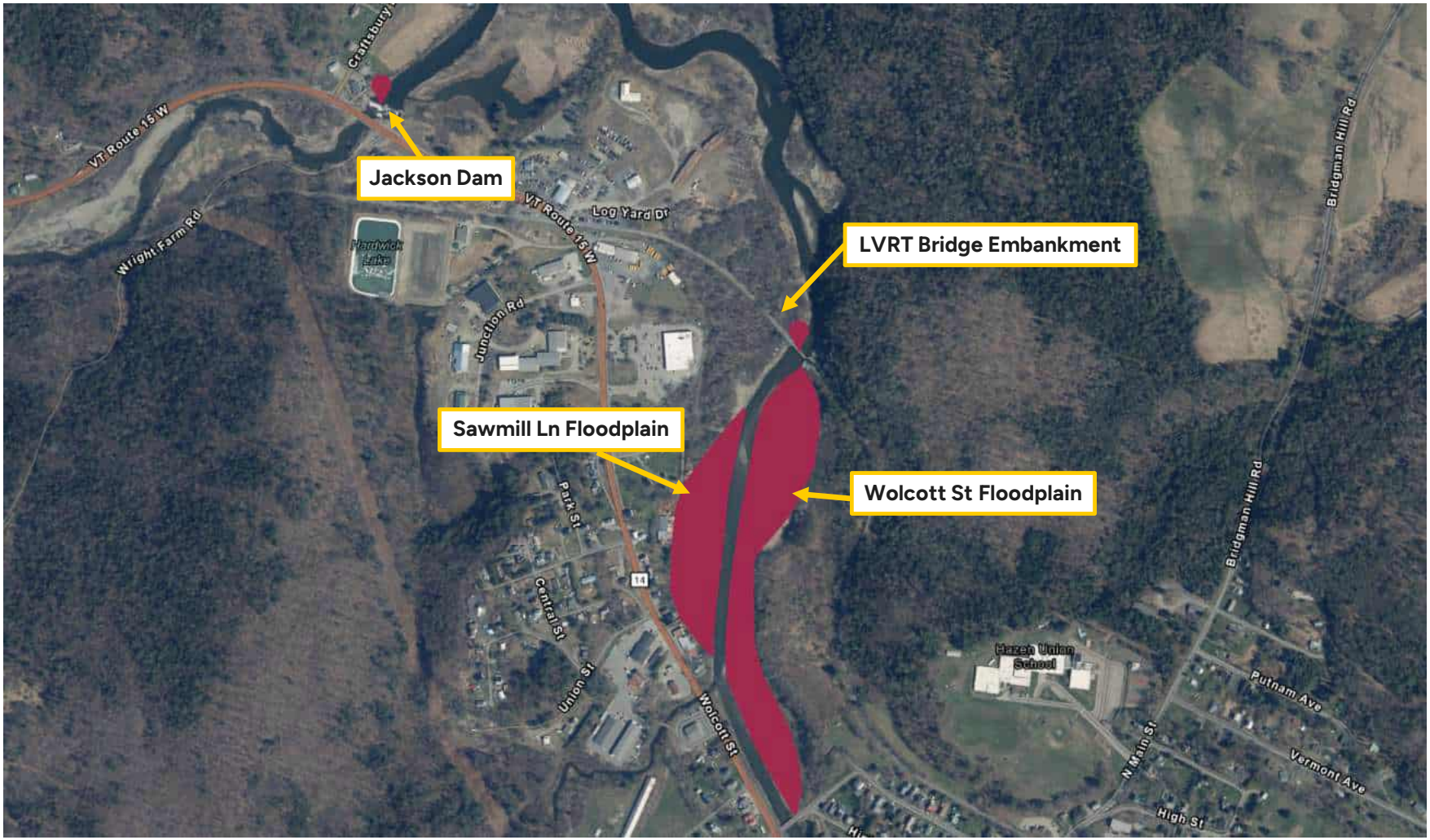
Problems

- Barrier in River

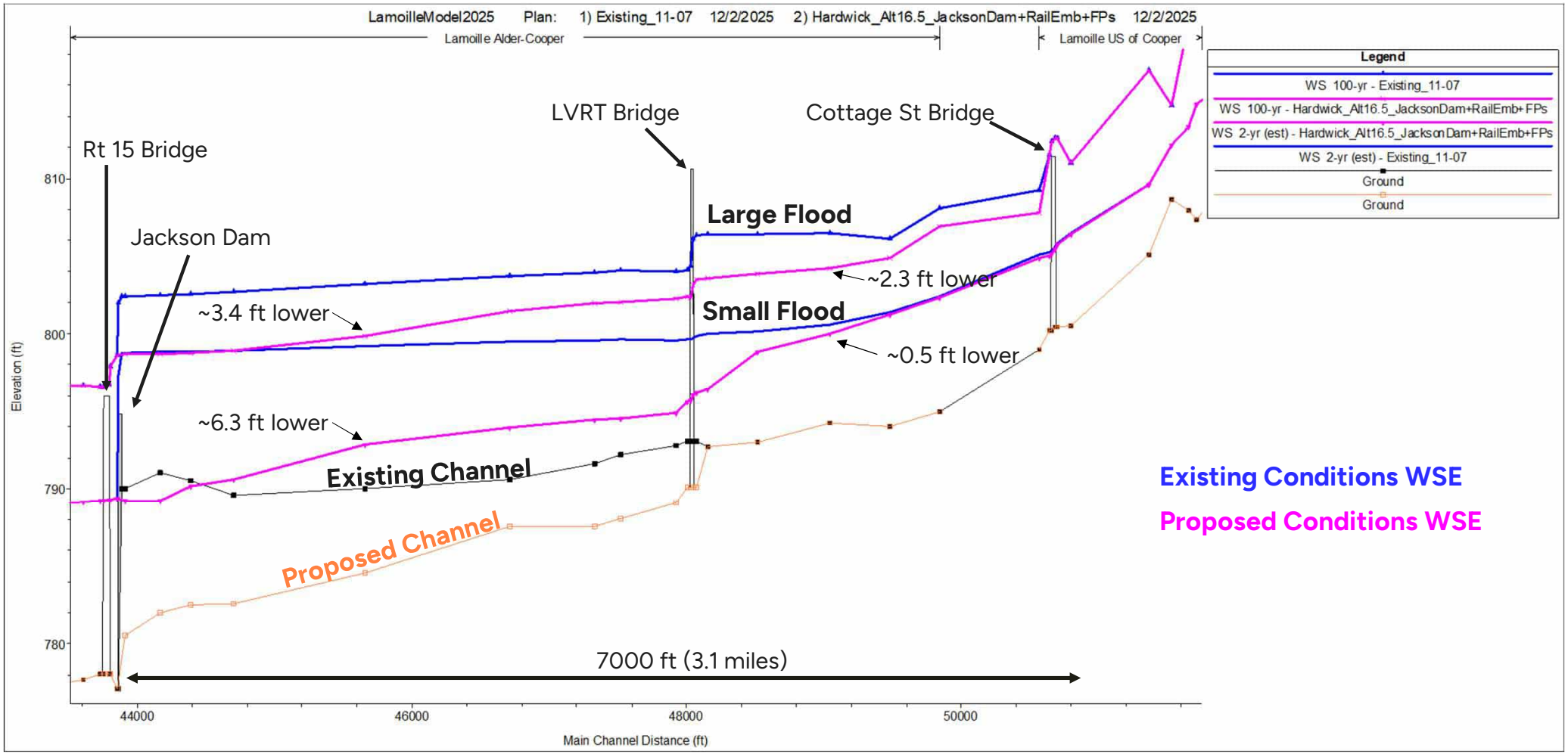
Possible Solutions

- Dam removal
- Permanent drawdown

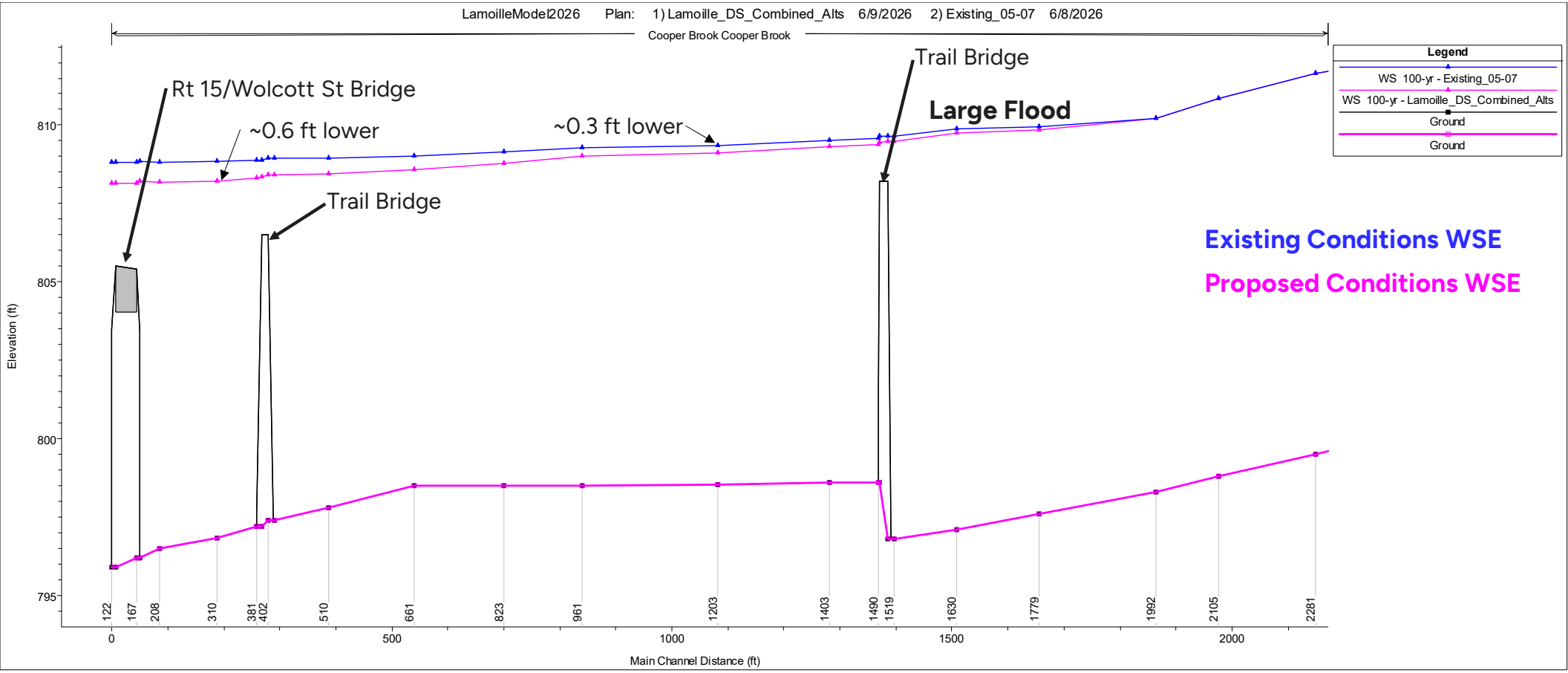
Combined Flood Mitigation Alternatives



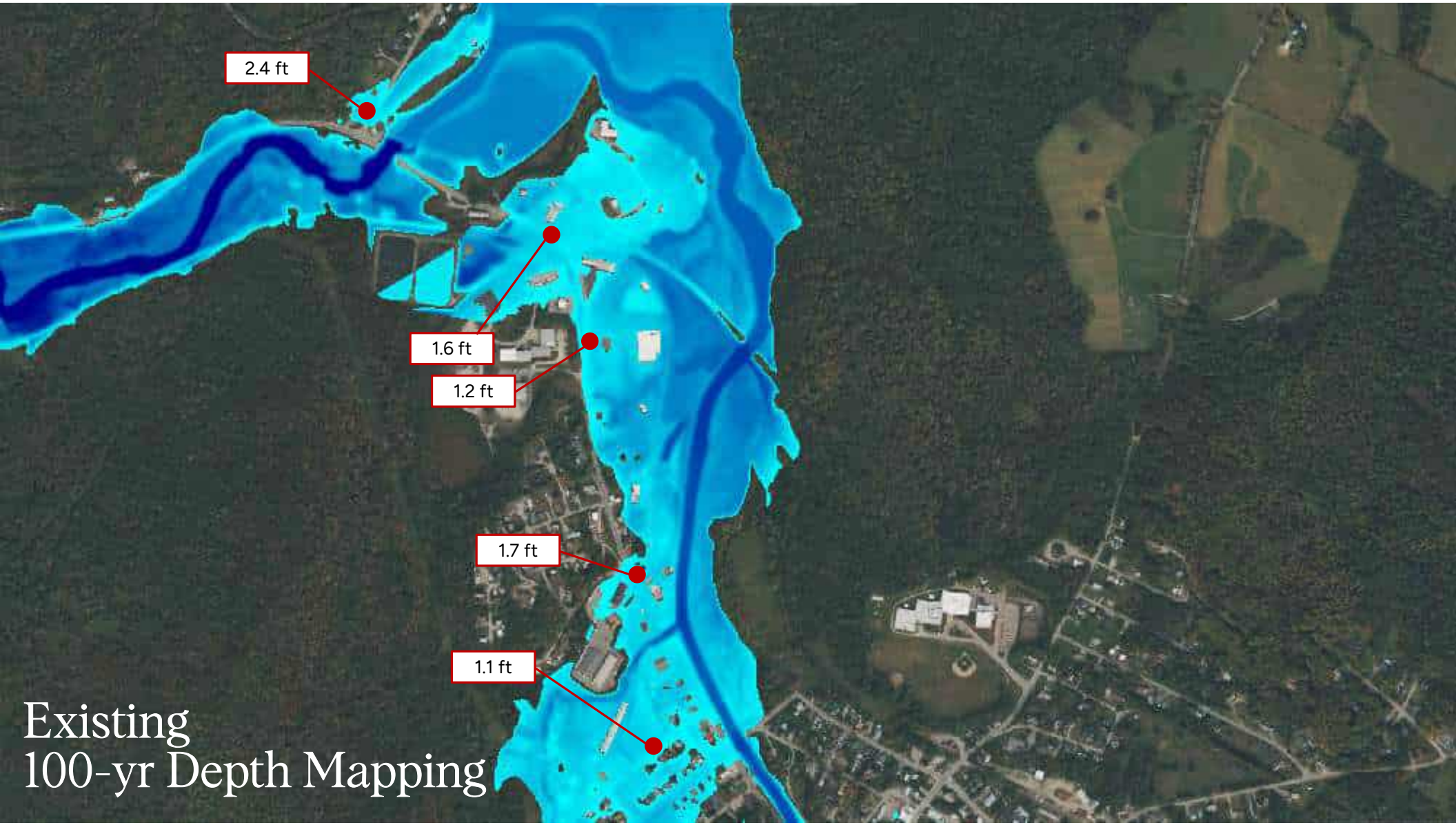
Results – Lamoille River Profile



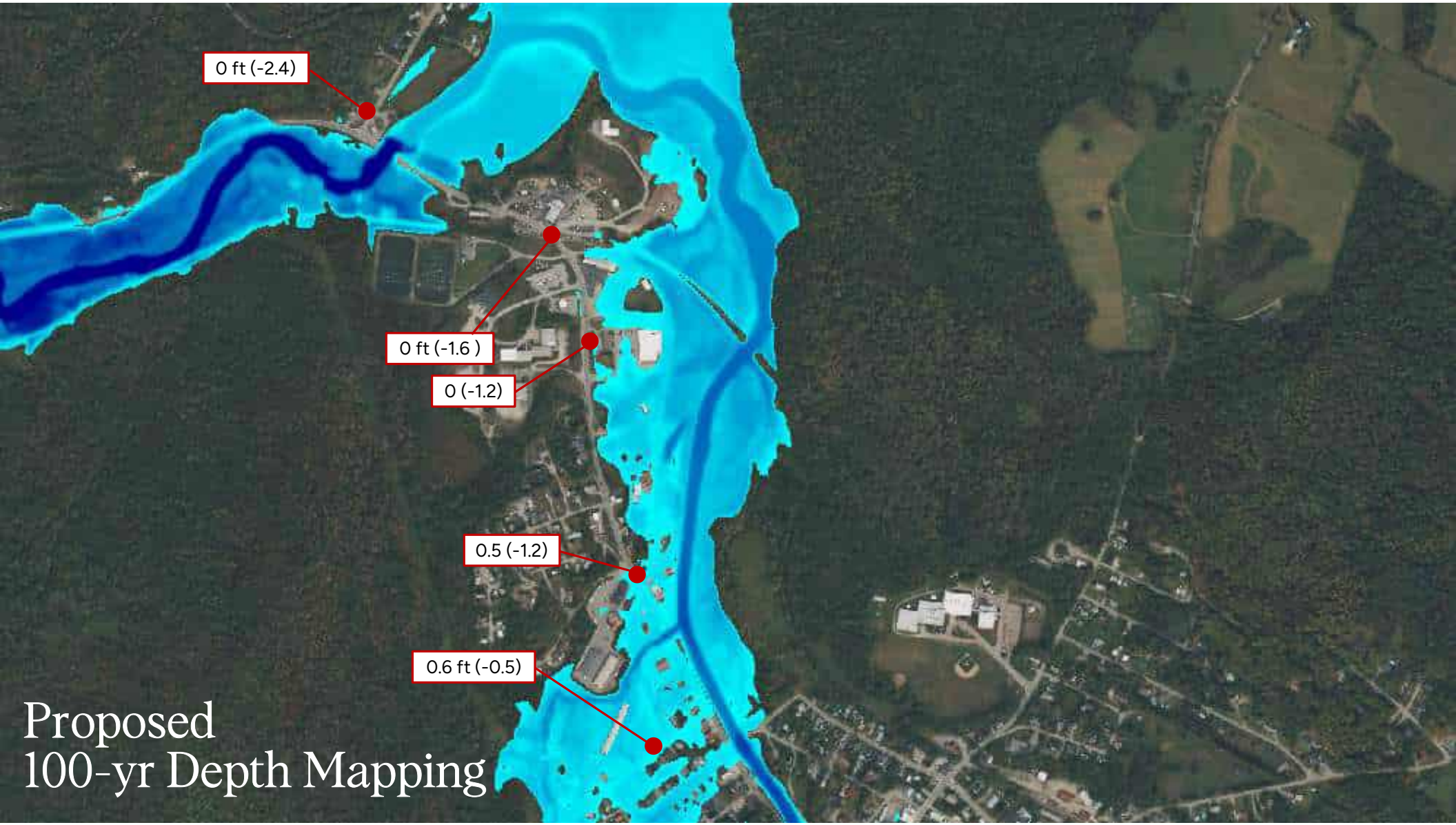
Results – Cooper Brook Profile



1,870 ft (0.4 miles)

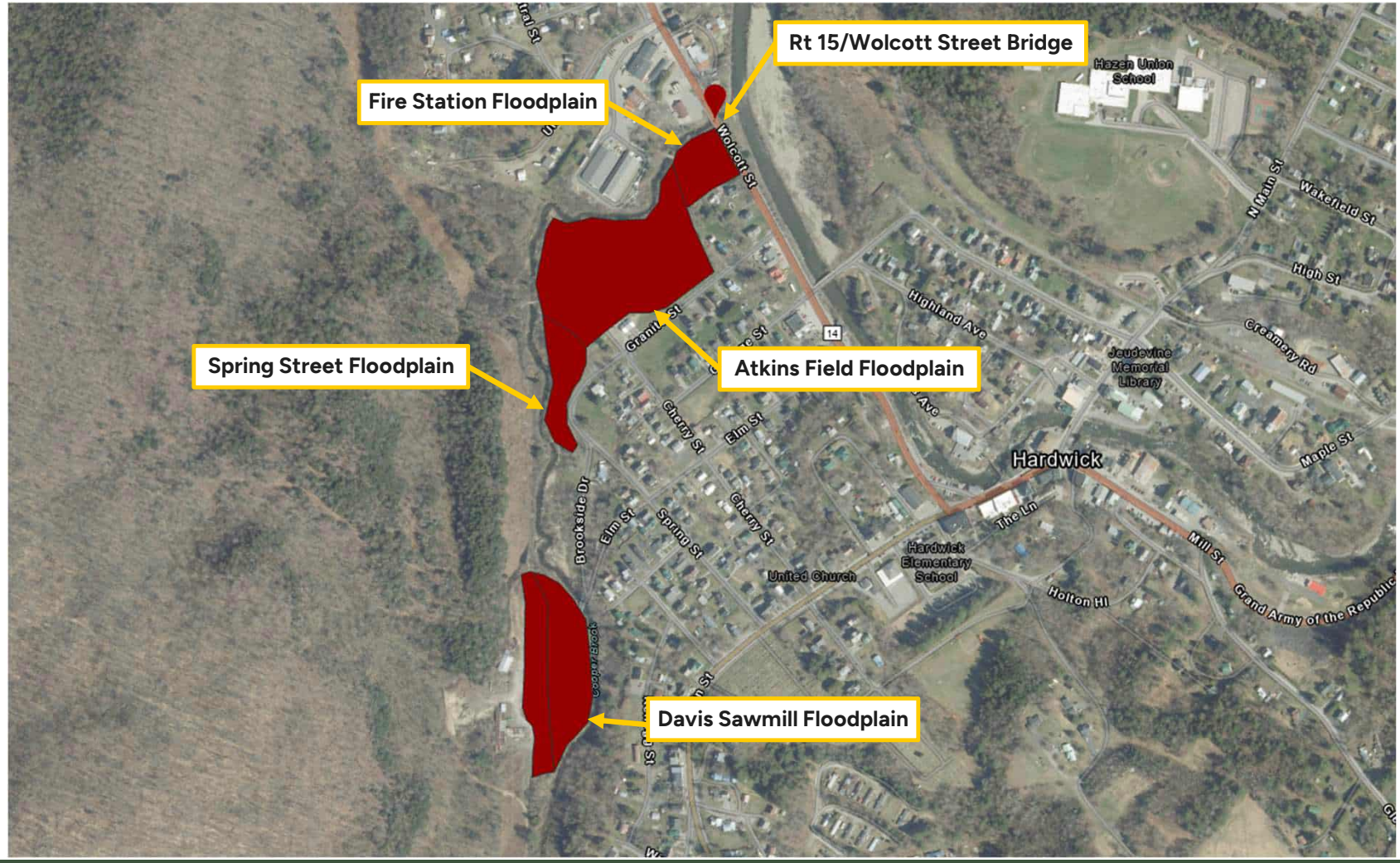


Existing
100-yr Depth Mapping



Proposed 100-yr Depth Mapping

Cooper Brook Flood Mitigation Alternatives



Davis Sawmill Floodplain

- Upstream of Granite Street neighborhood
- Potential area for flood benches or floodplain restoration
  - 2.5 – 4.5 acres
- The Brook Road bridge to access the sawmill is a constriction
- Existing modeling shows the area floods regularly (2 to 10-year flood)

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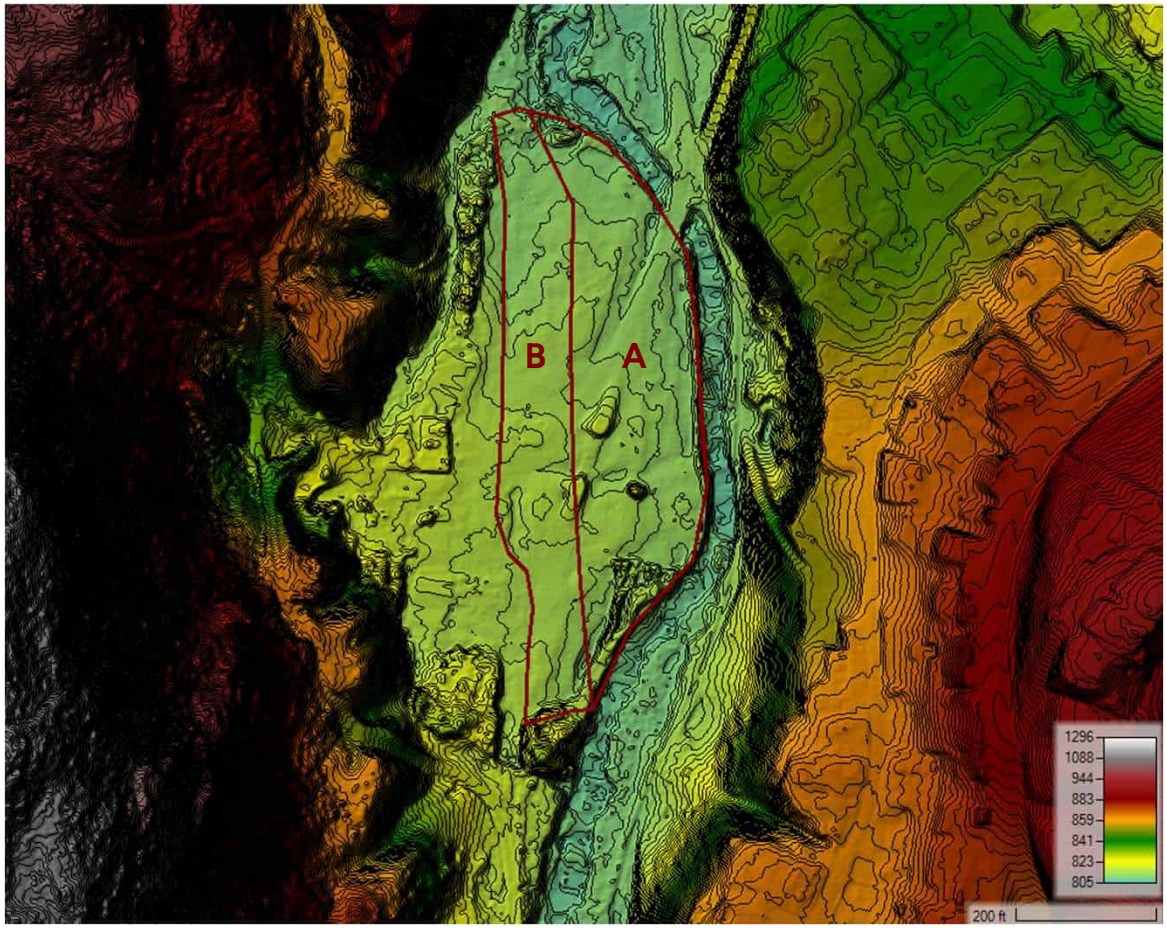
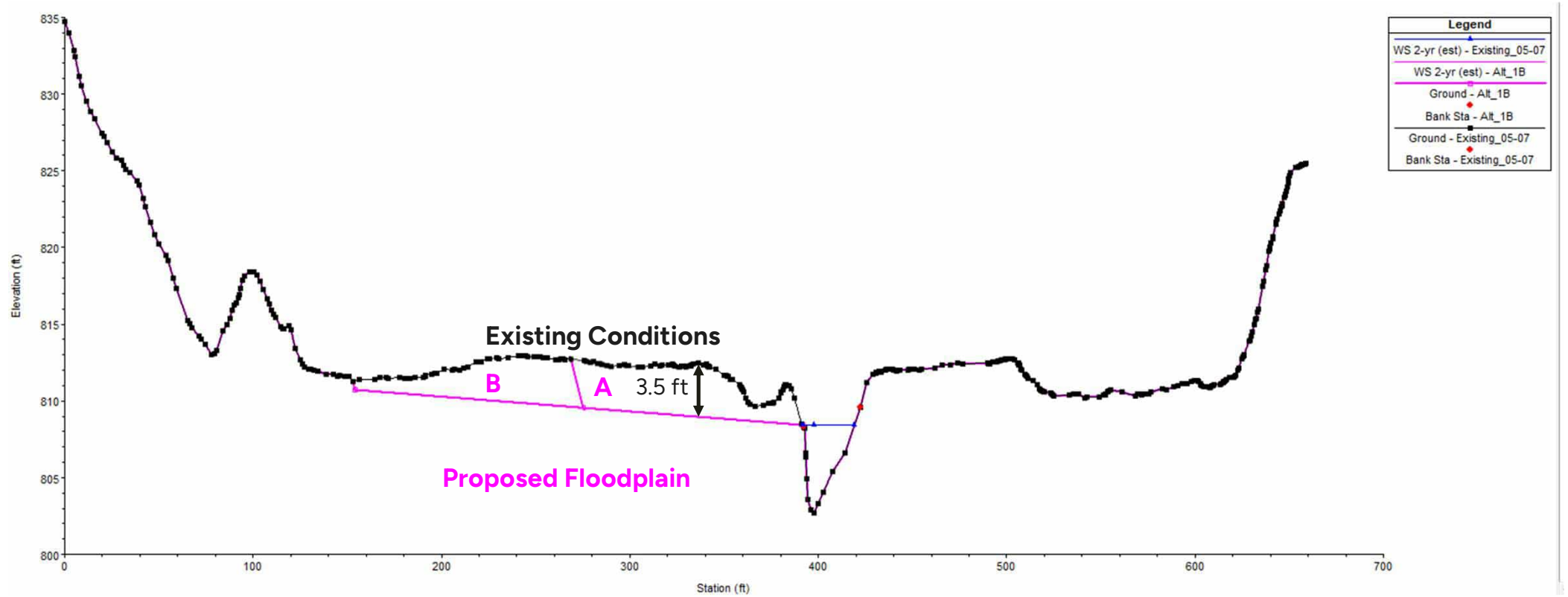


Cross Section View – Existing and Proposed



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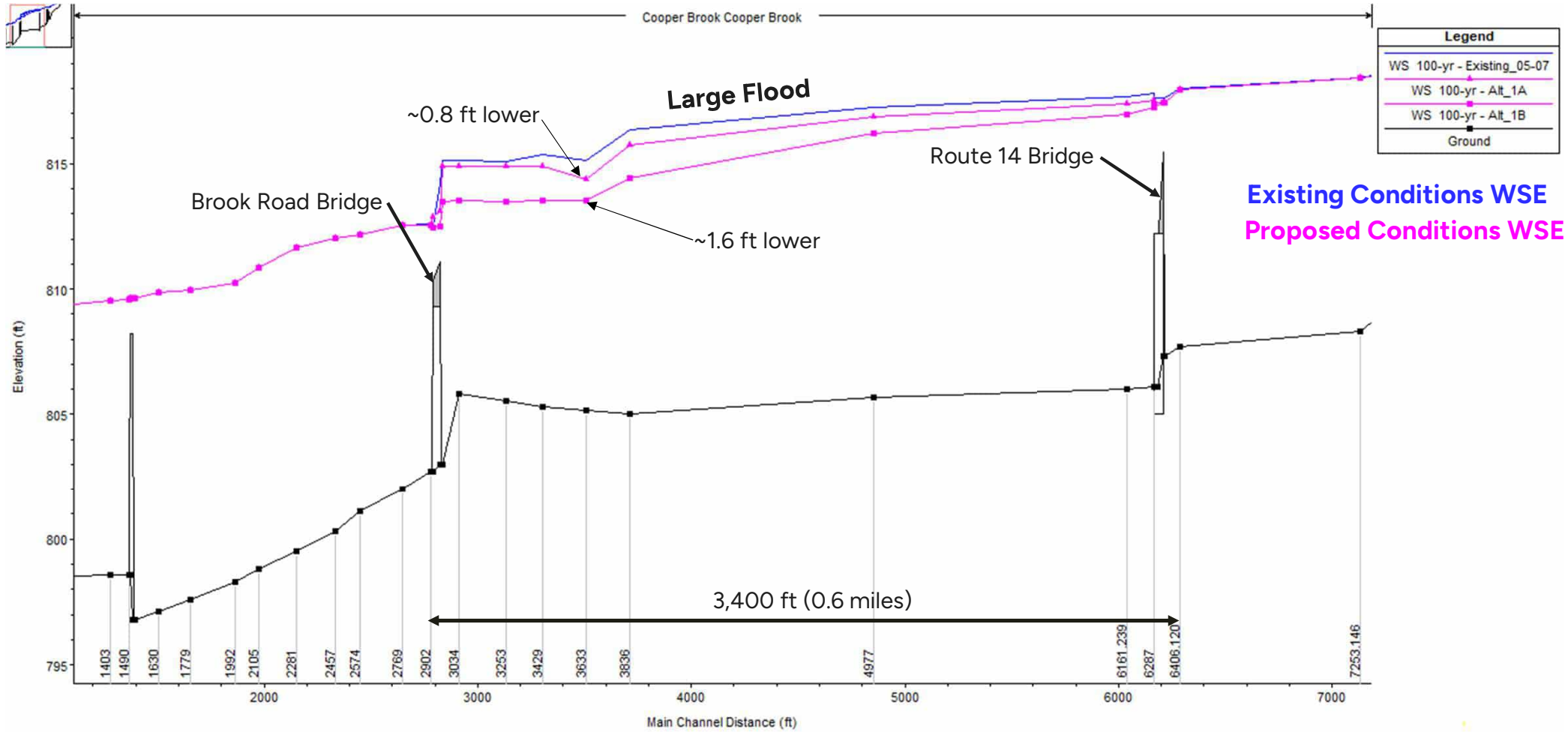

Spring Street Floodplain

- Narrow point in valley upstream of Atkins Field
- Potential area for floodplain restoration
  - 4.1 acres
  - Up to ~4 feet of cut
- Flood waters begin to enter the neighborhood
- Existing modeling shows the area floods regularly (2 to 10-year flood)

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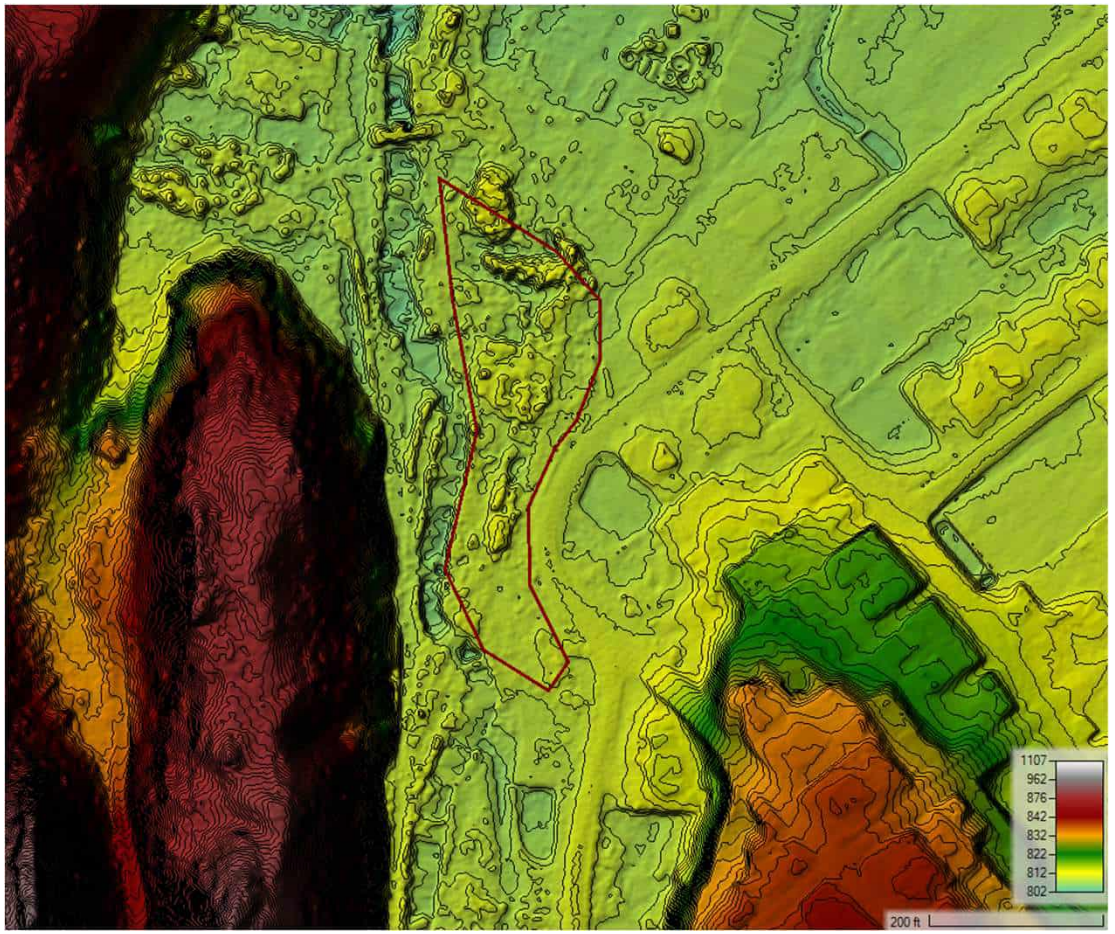

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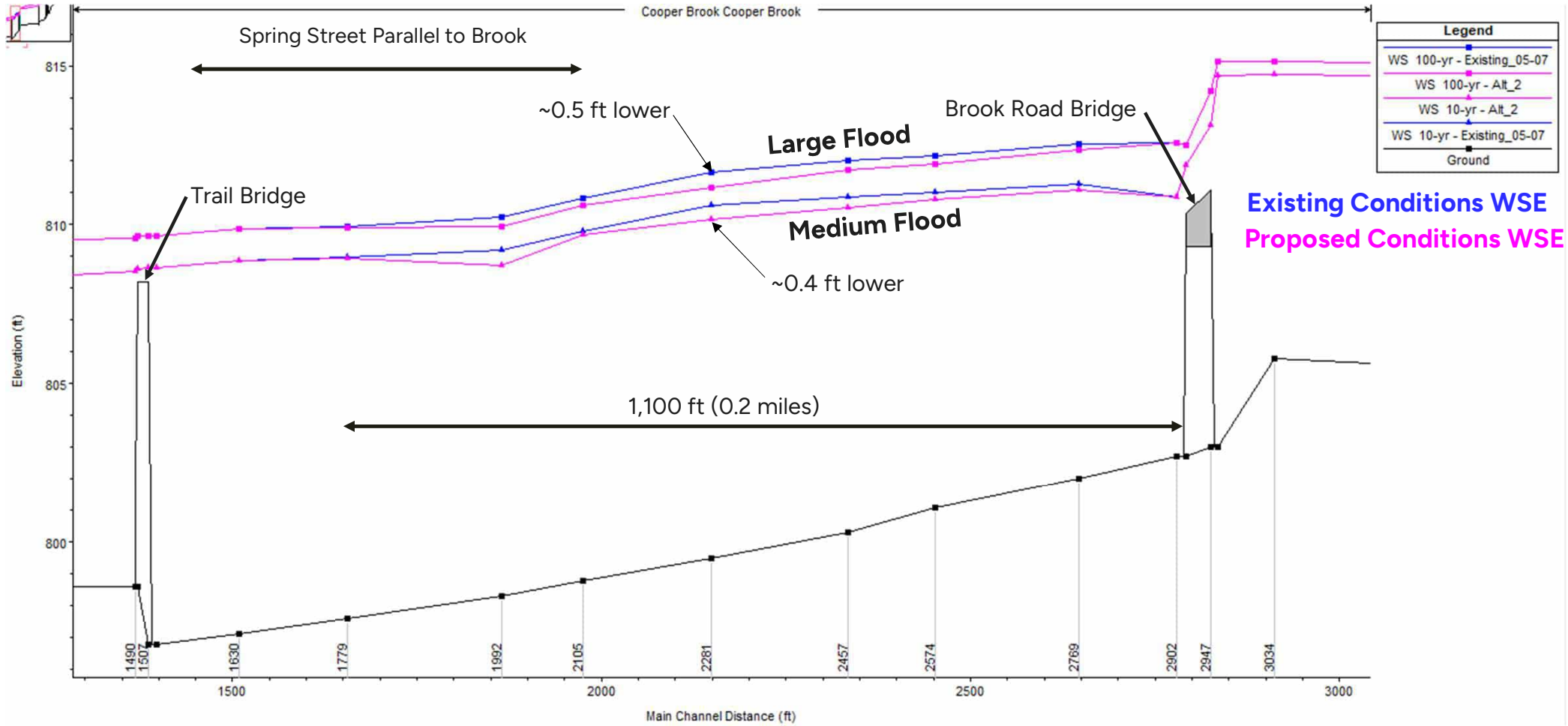
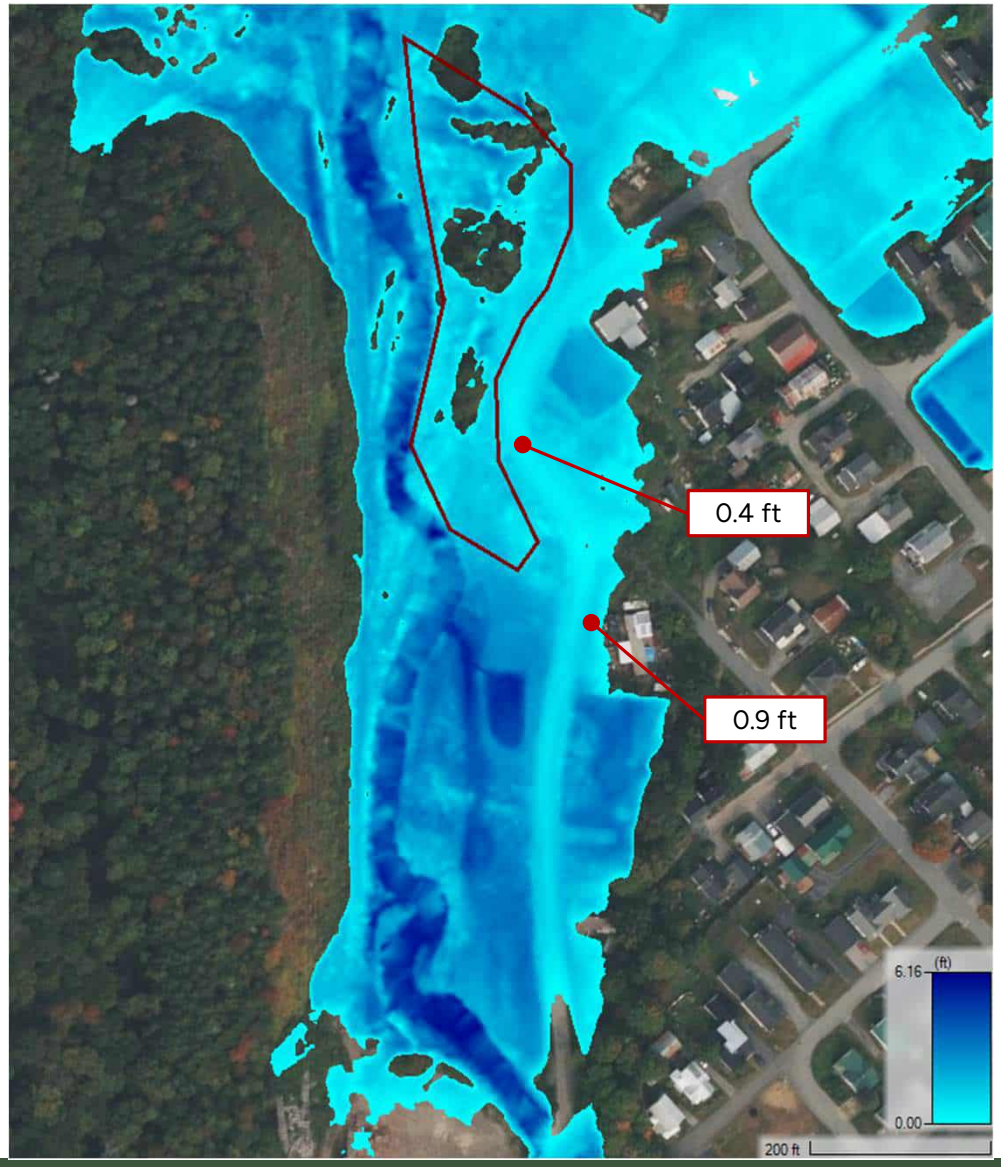
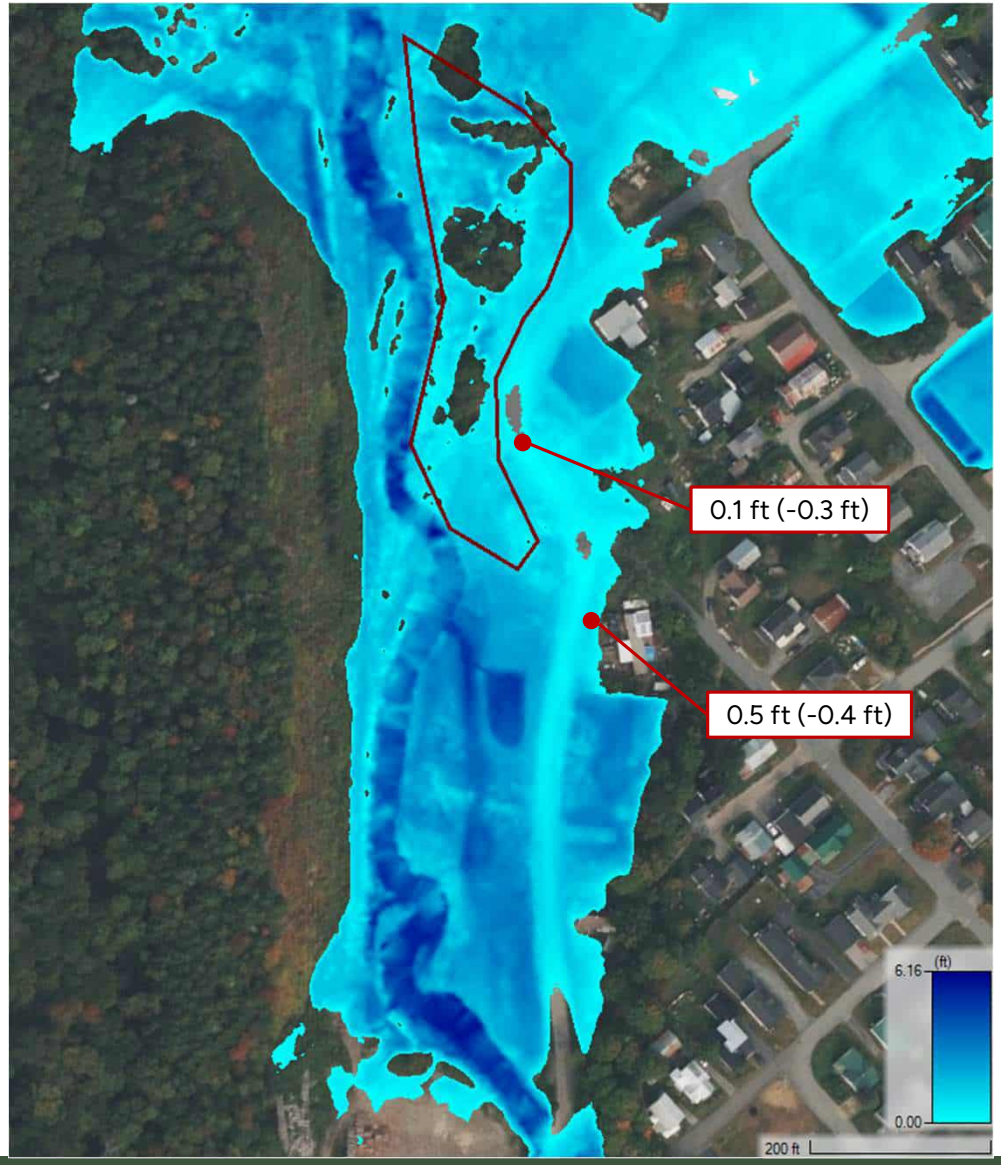


Existing
10-yr Depth Mapping

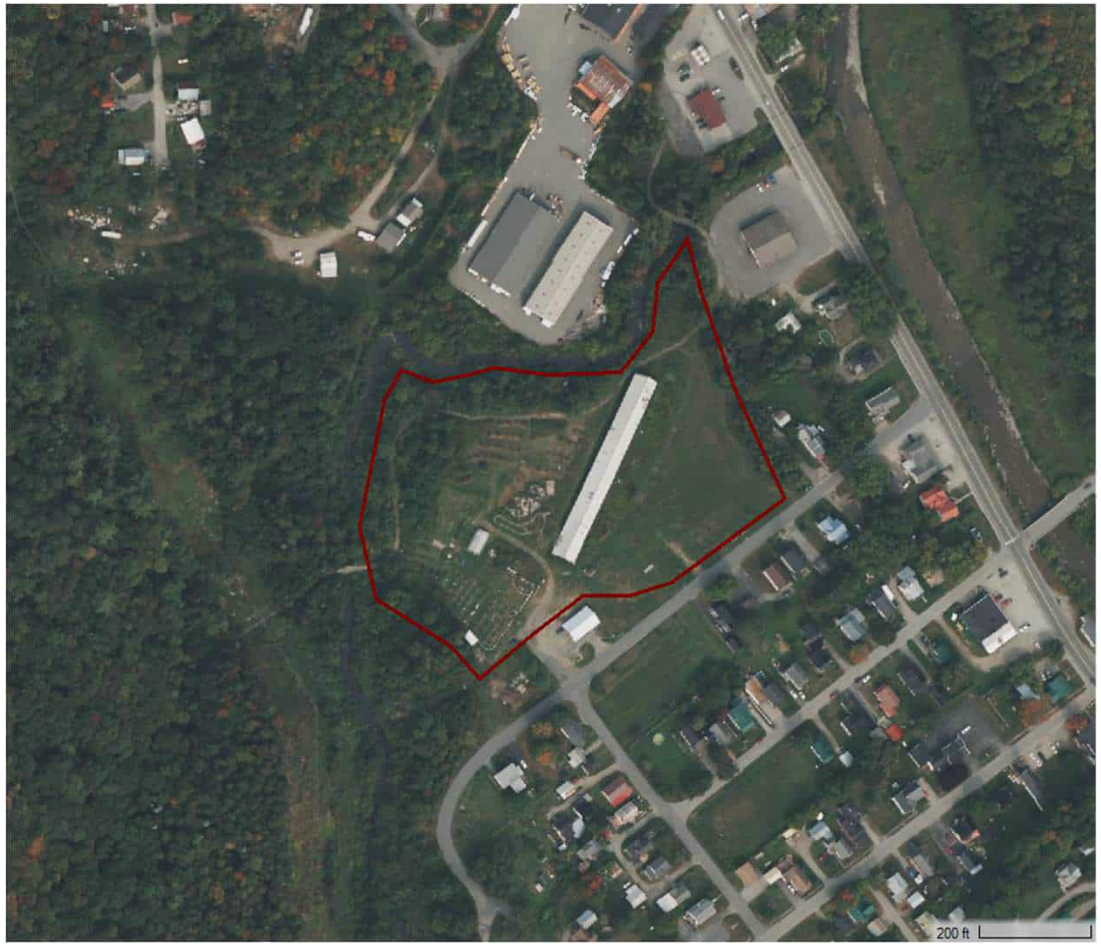


Proposed
10-yr Depth Mapping



Atkins Field Floodplain

- Potential area for floodplain restoration
  - 3.4 acres
  - Up to ~4.5 feet of cut
- Berm along river channel on upstream portion
- Existing modeling shows the area floods regularly (2 to 10-year flood)



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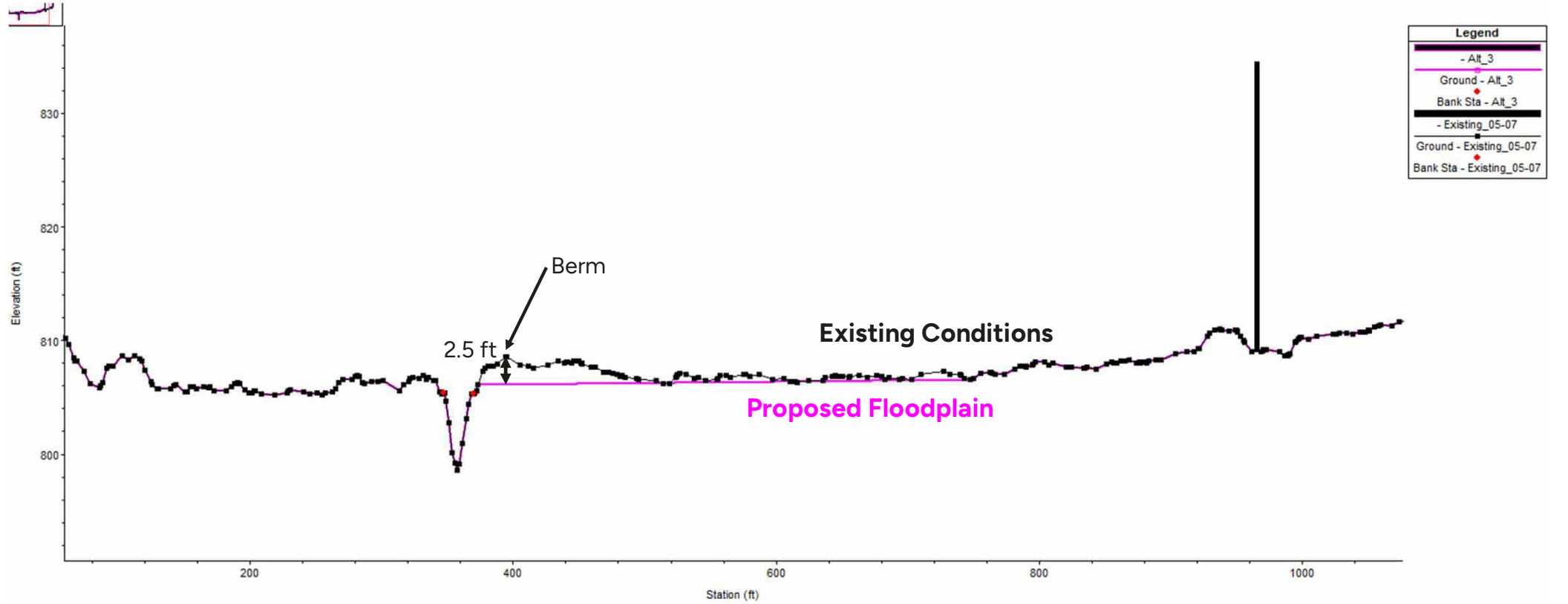

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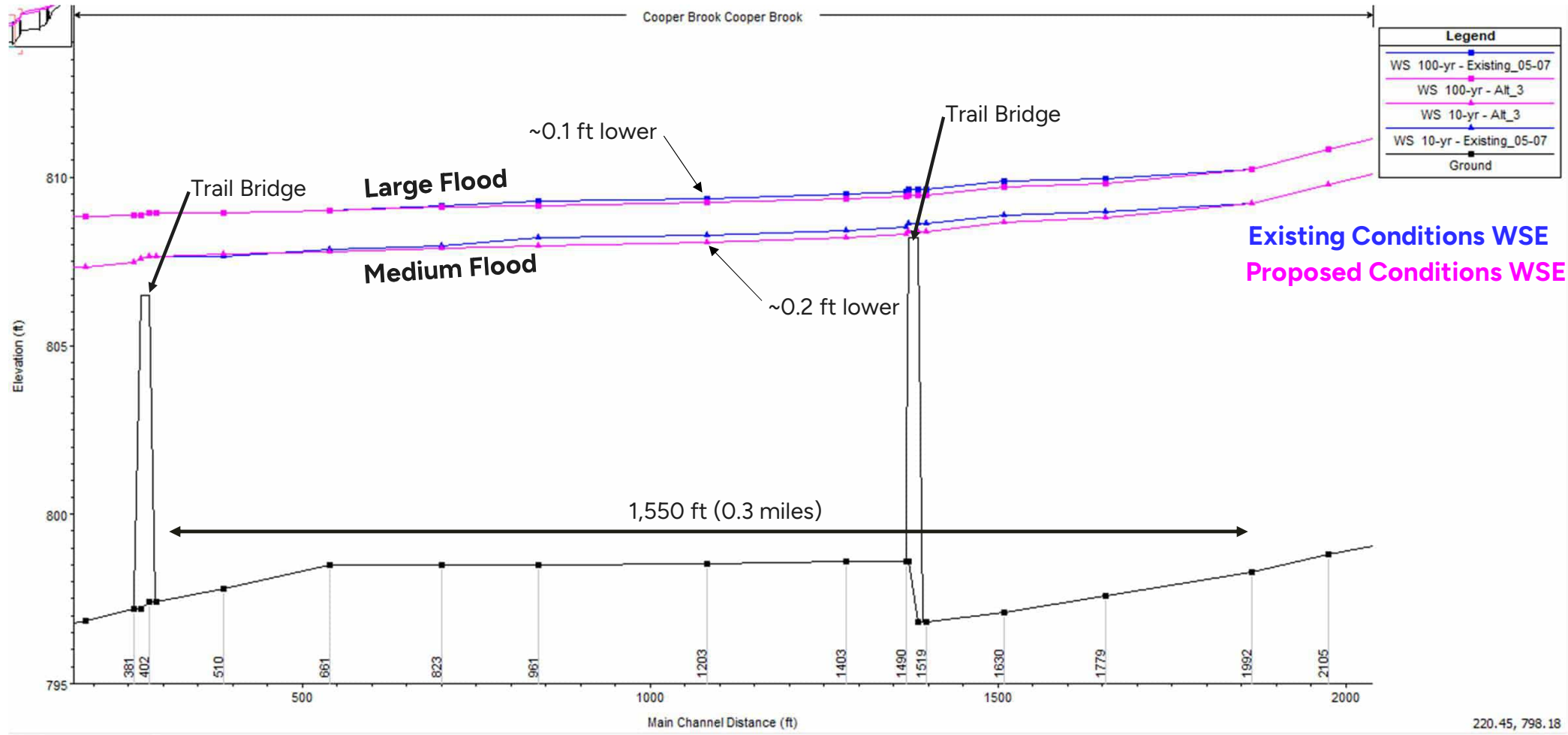

Hardwick Fire Station

- Potential area for floodplain restoration if Fire Station is relocated
  - 1.2 acres
  - Up to ~4 feet of cut

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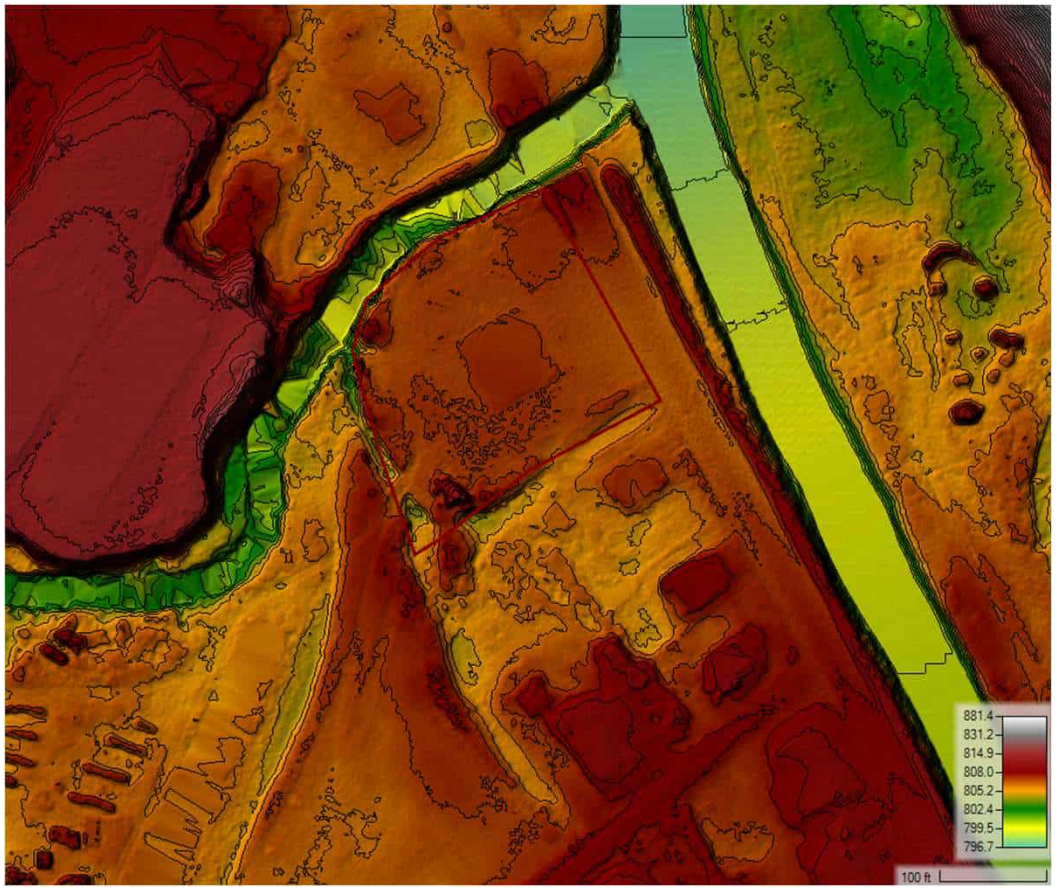

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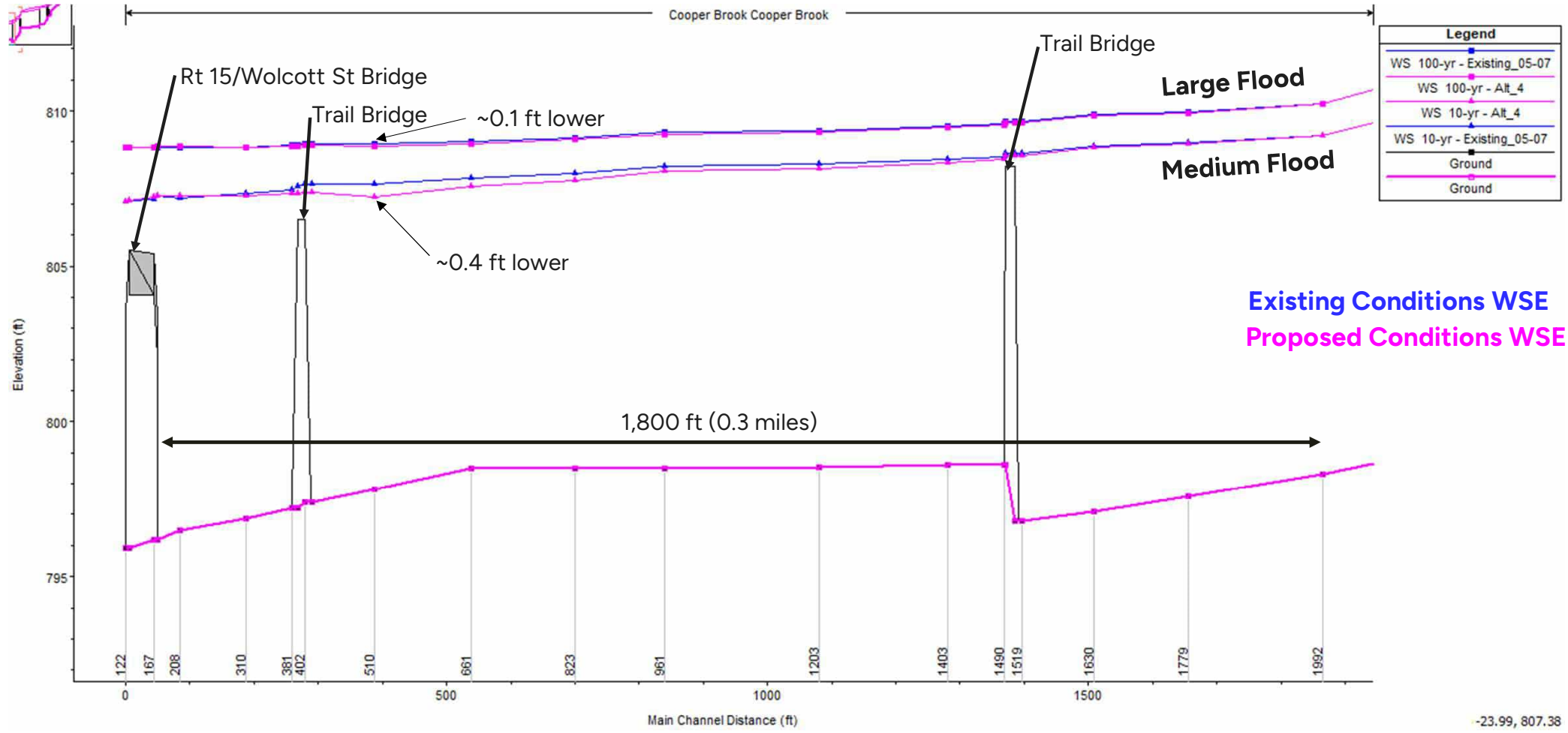
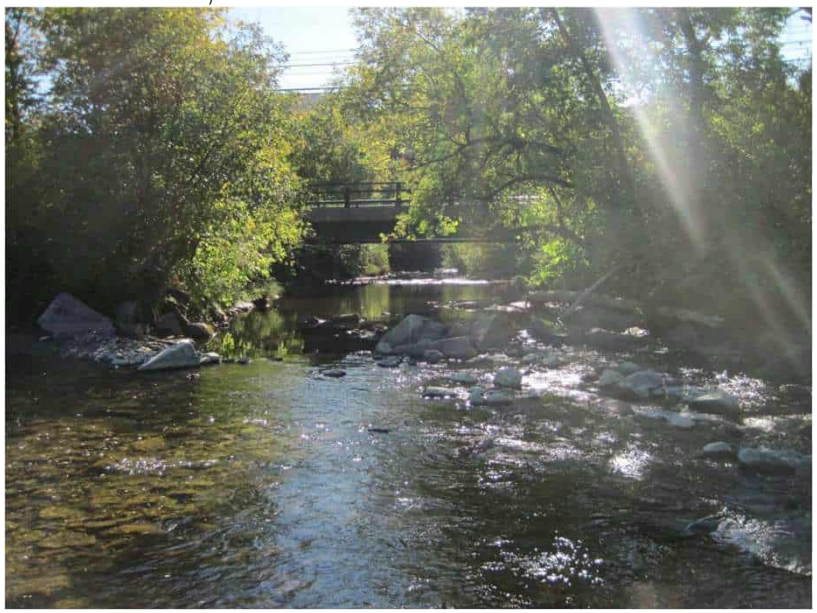


Rt 15/Wolcott Street Bridge



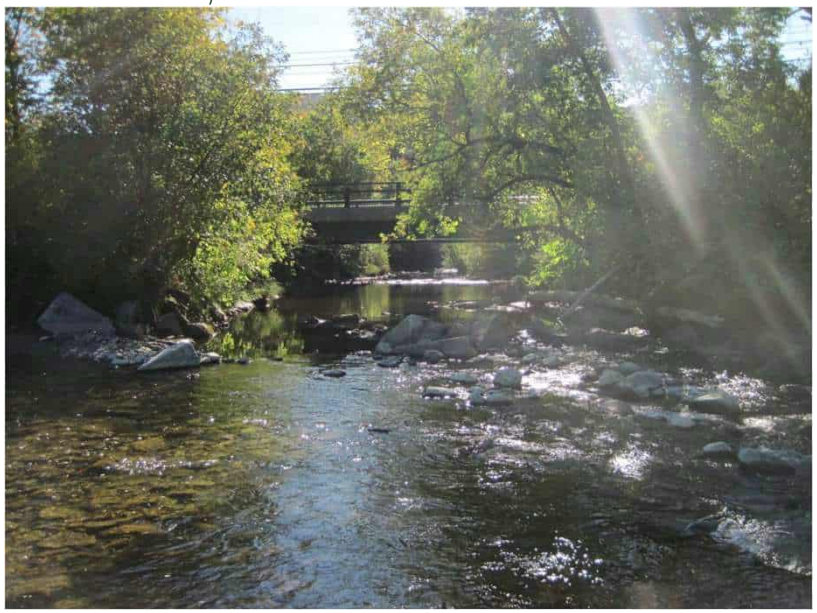
Problems

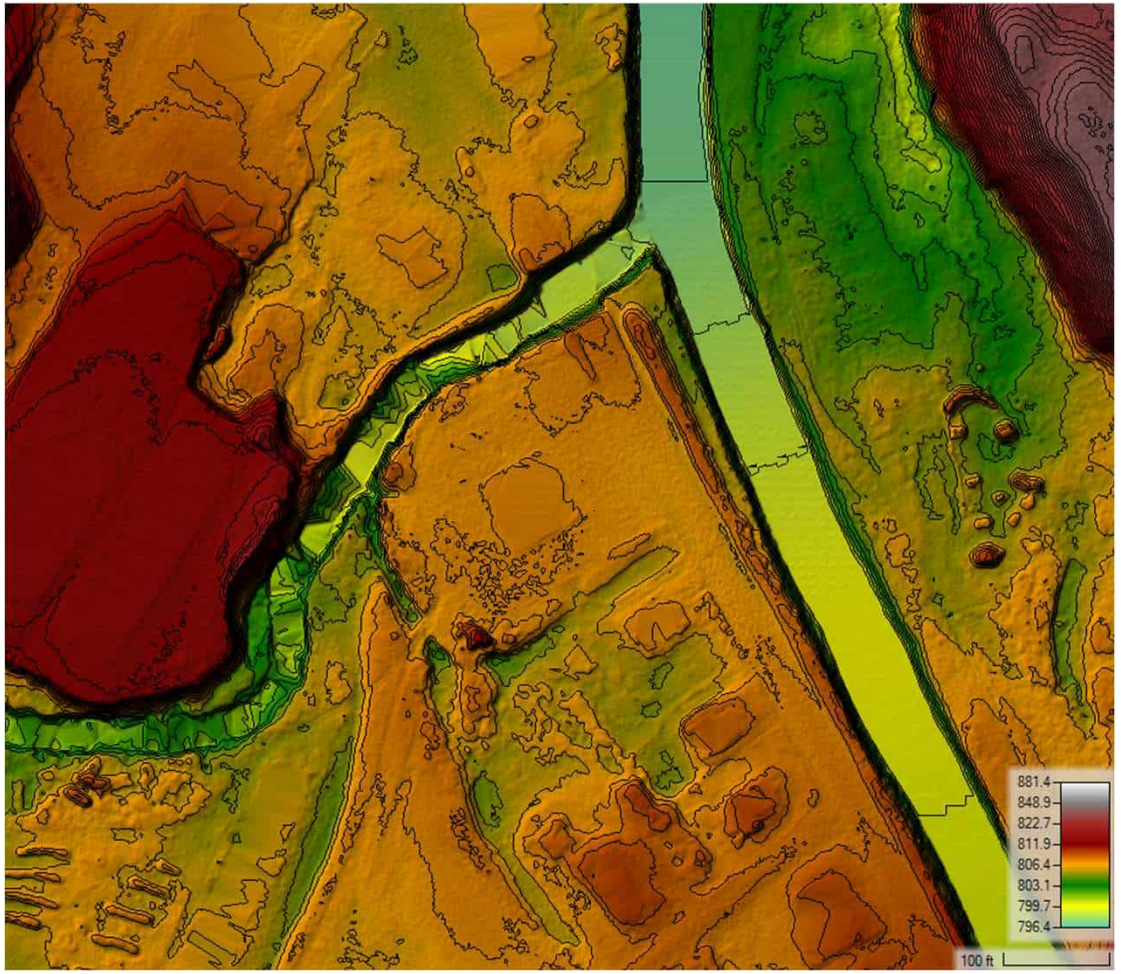
- Small floods cannot fit into bridge opening

Recommended Solutions

- Elevate bridge low chord
- Expand bridge opening width

Rt 15/Wolcott Street Bridge





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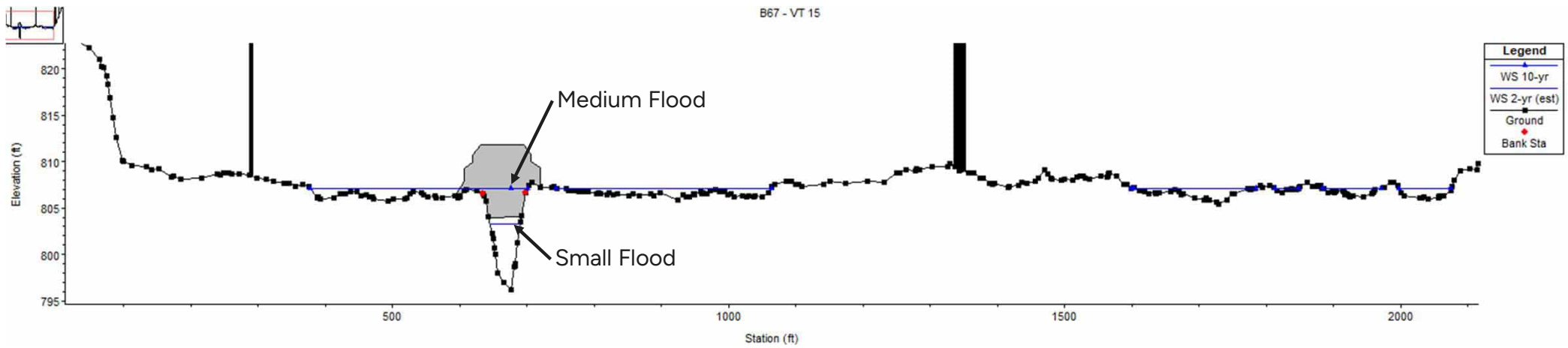
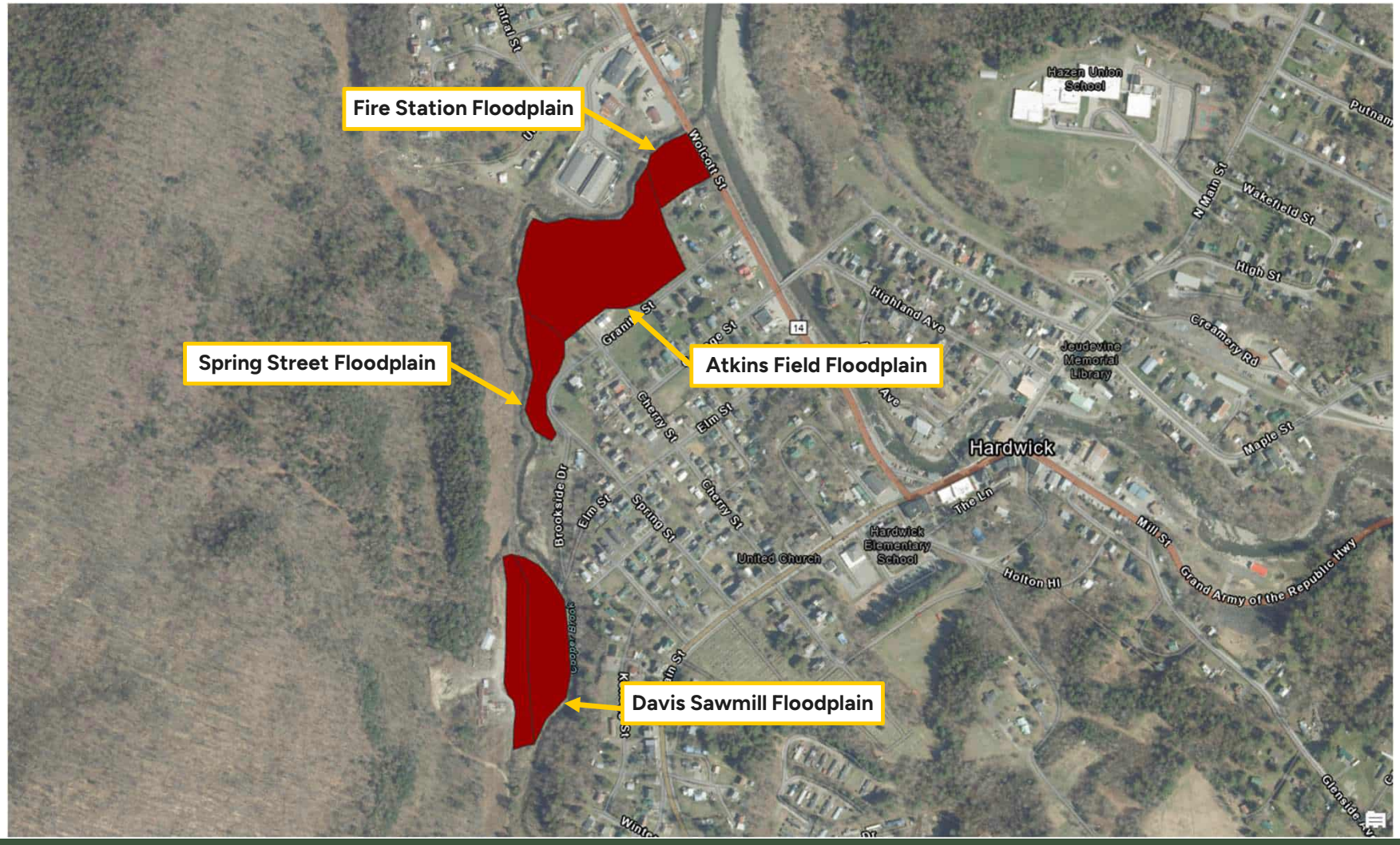


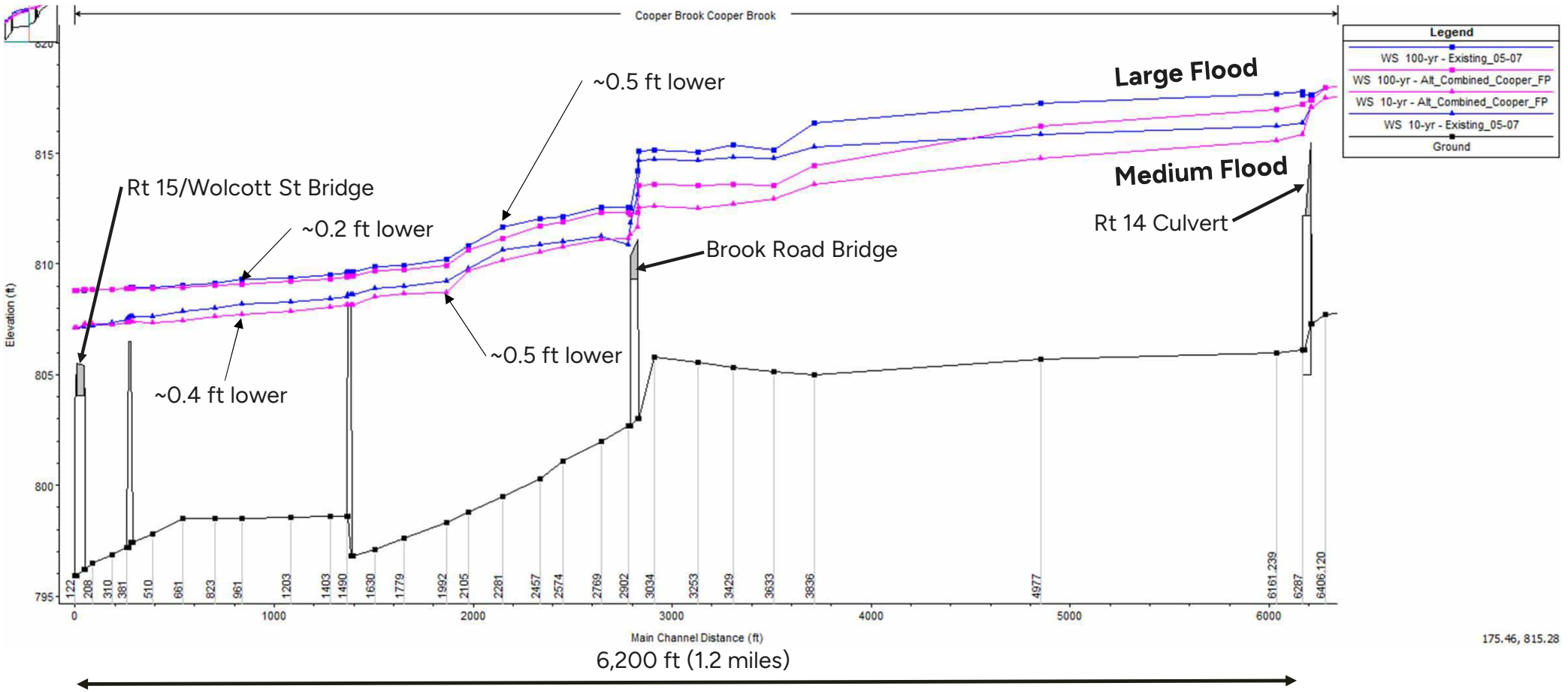
Combined Alternative



Results – Cooper Brook Profile

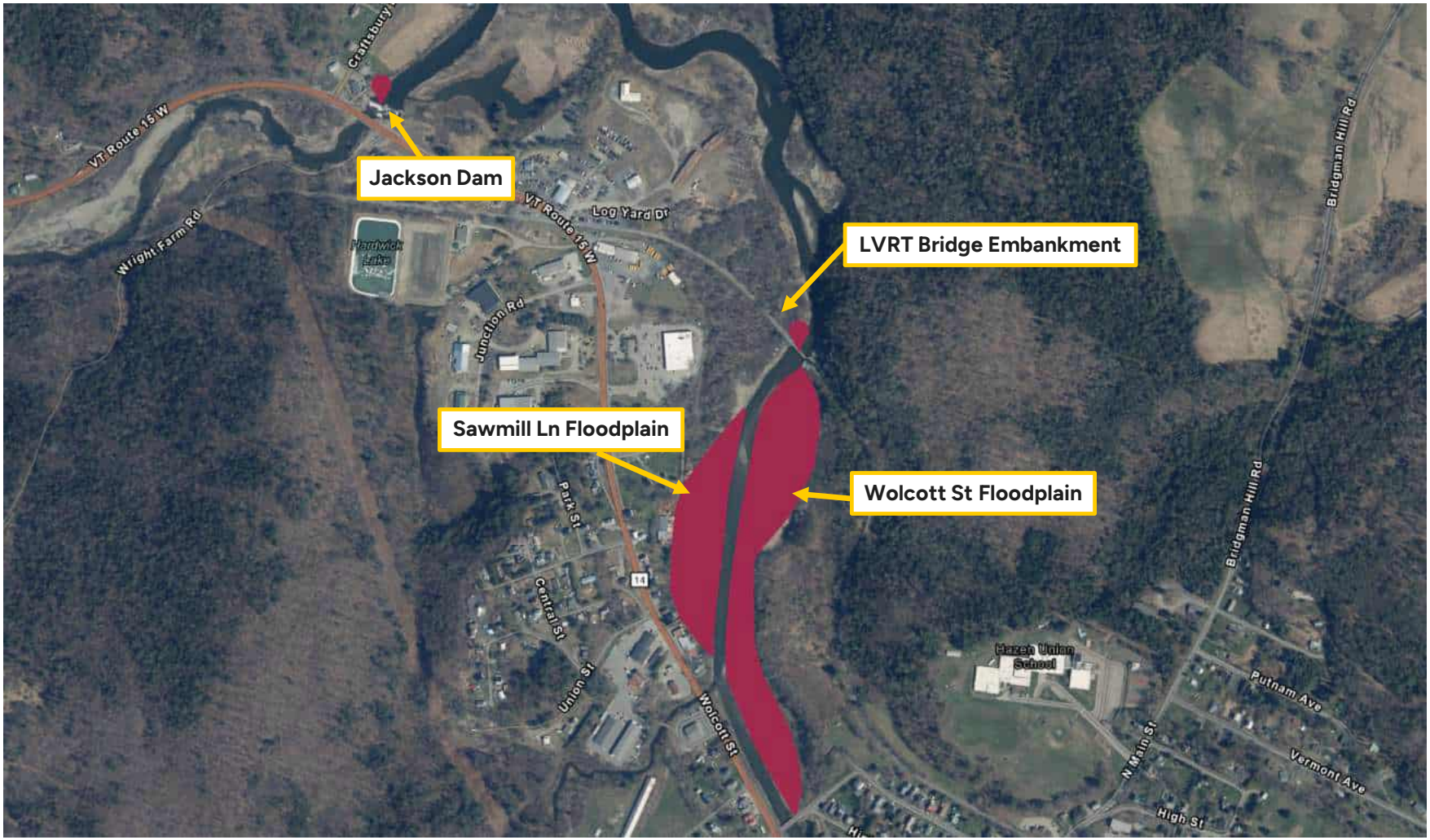
Existing Conditions WSE

Proposed Conditions WSE



6,200 ft (1.2 miles)

Combined Flood Mitigation Alternatives



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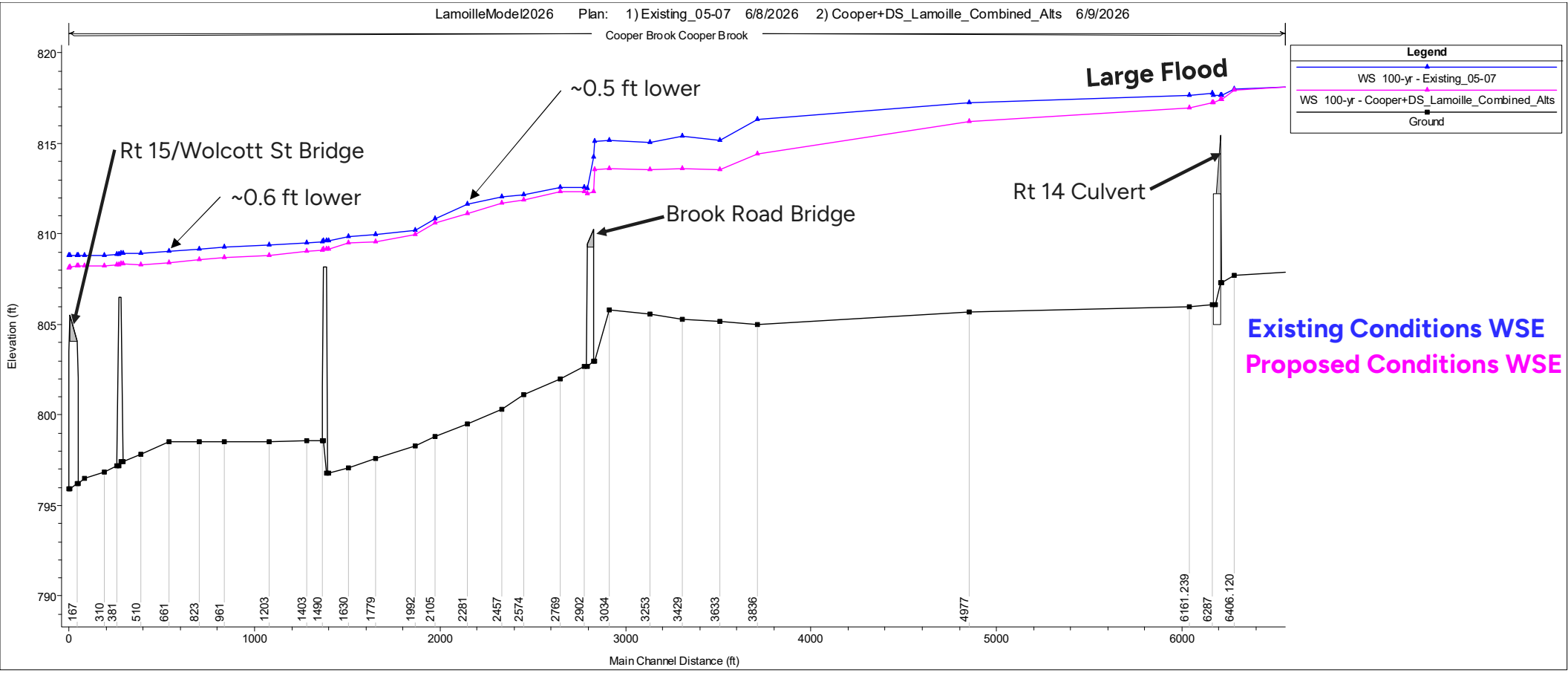
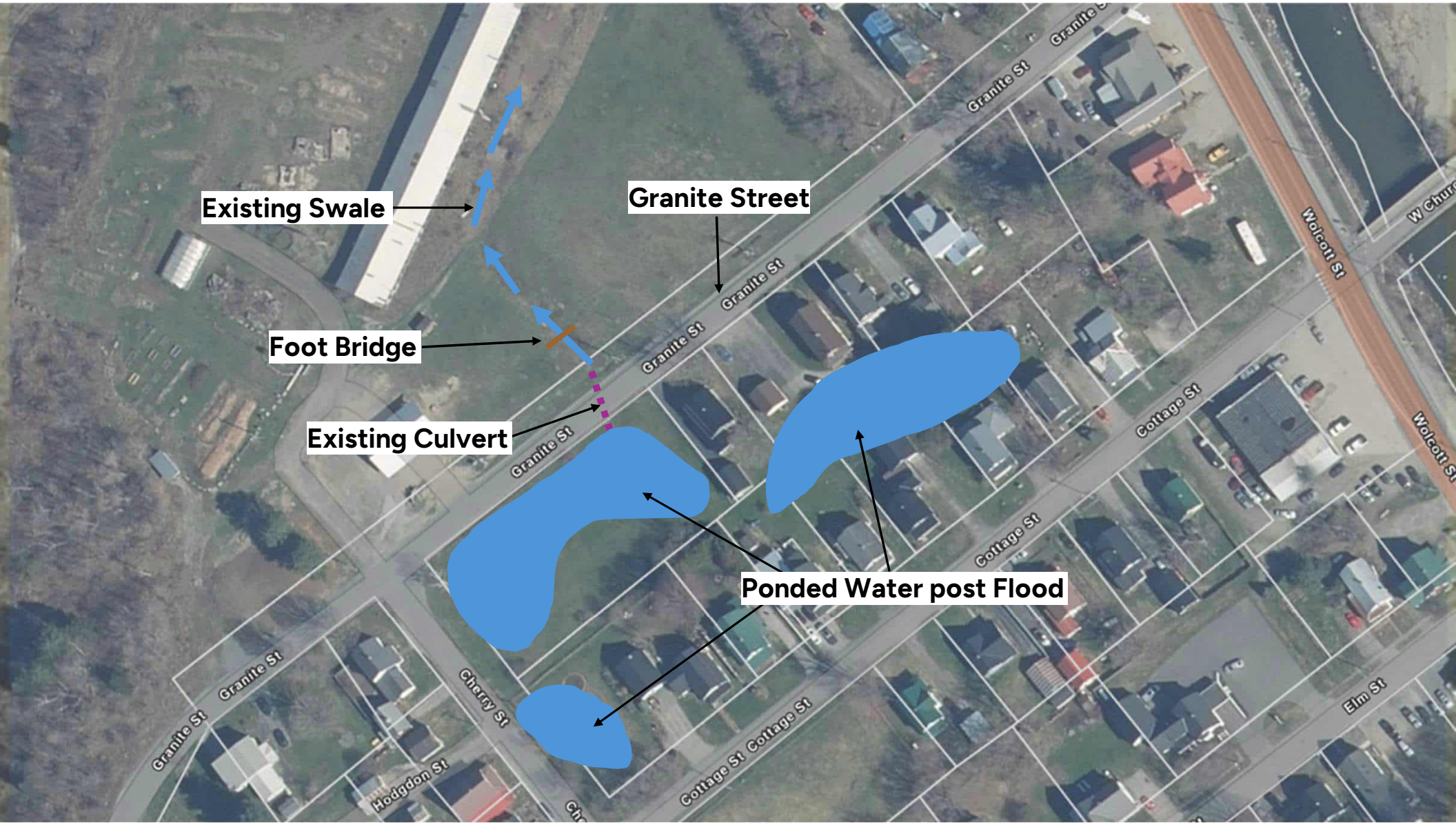
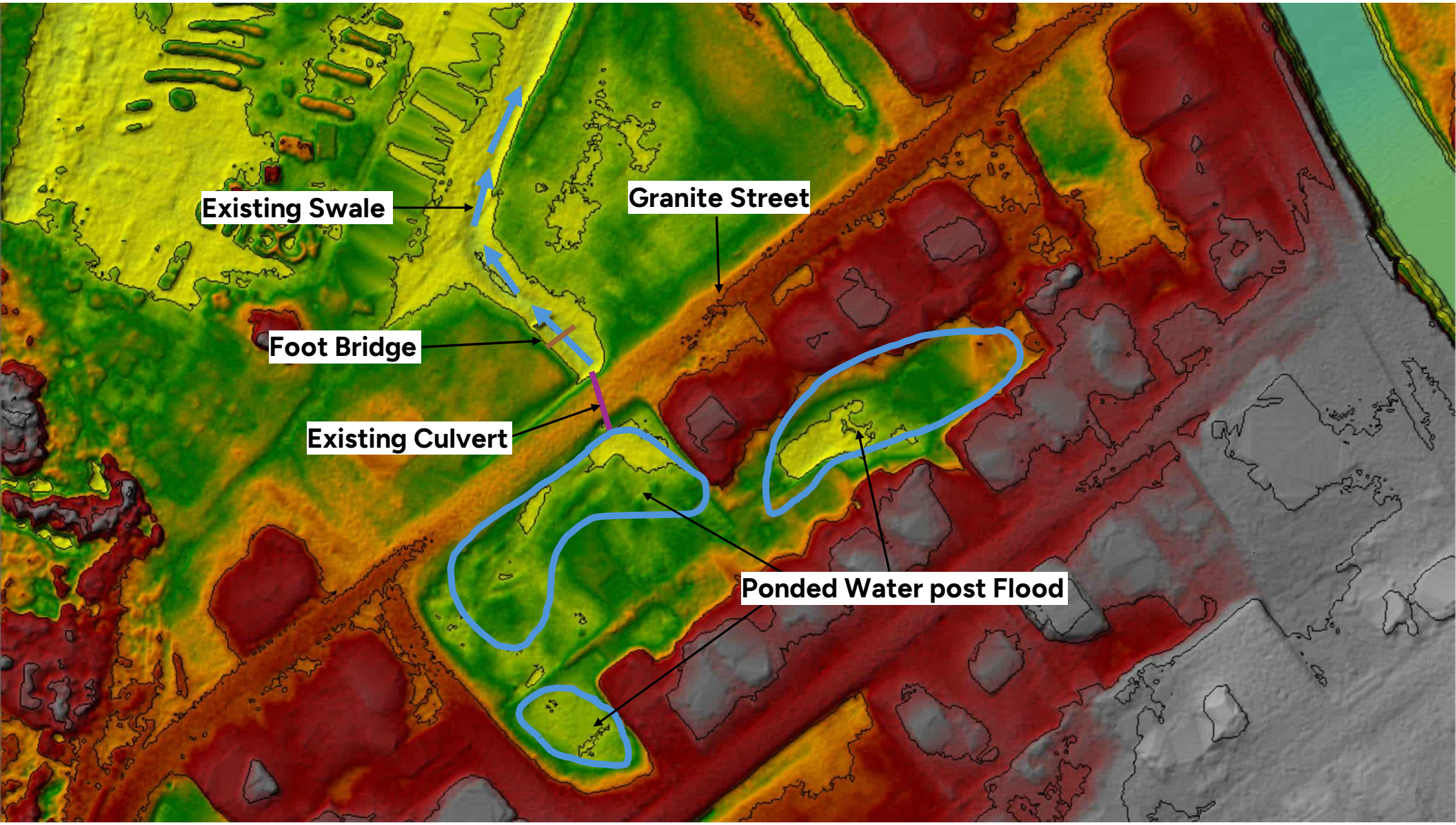


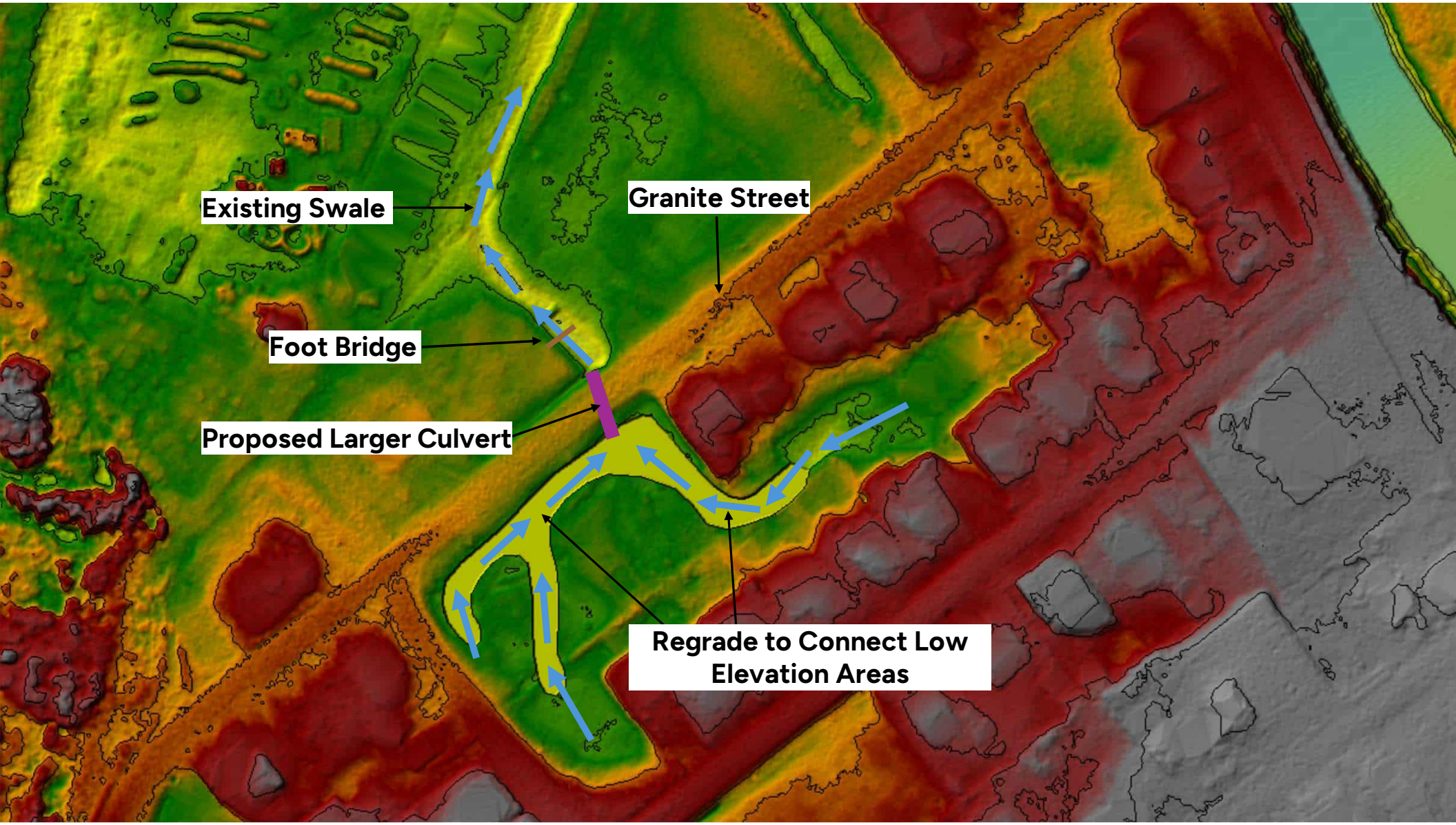
6,200 ft (1.2 miles)

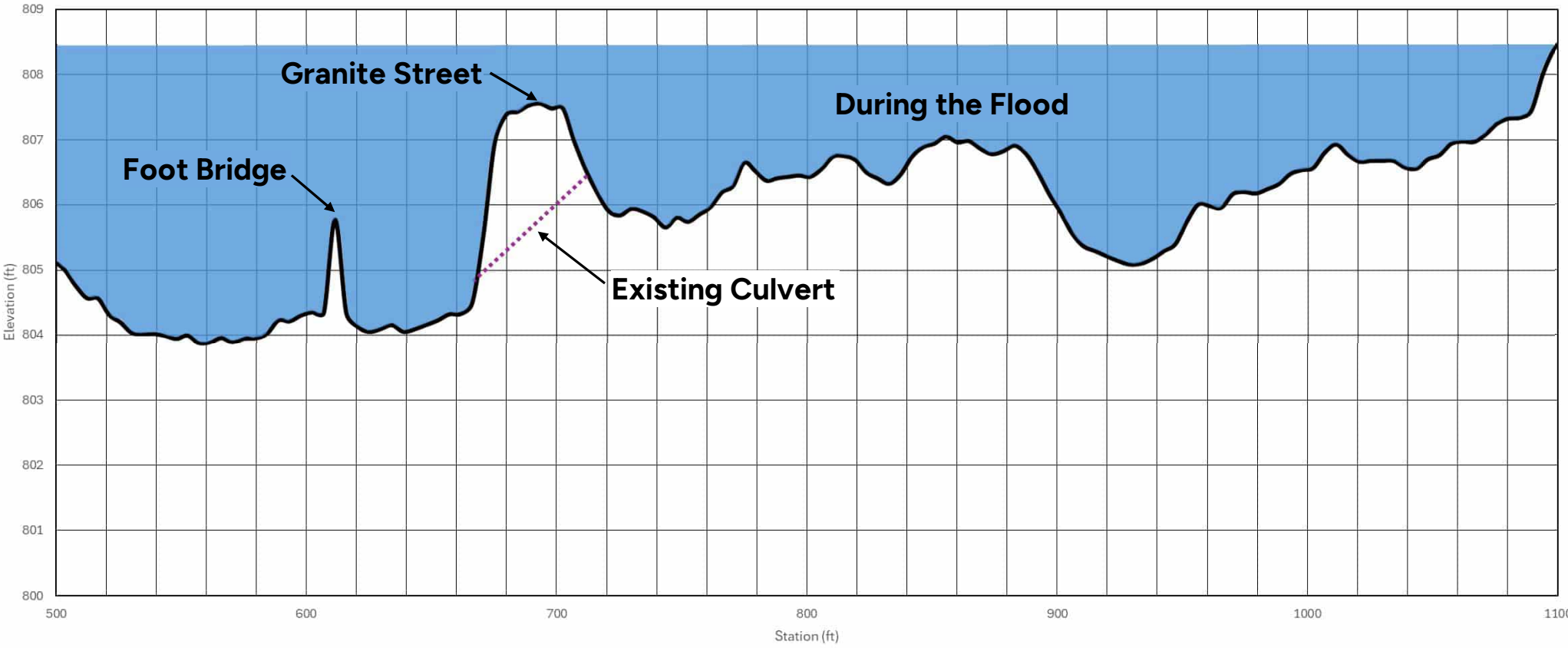
Post Flood Drainage

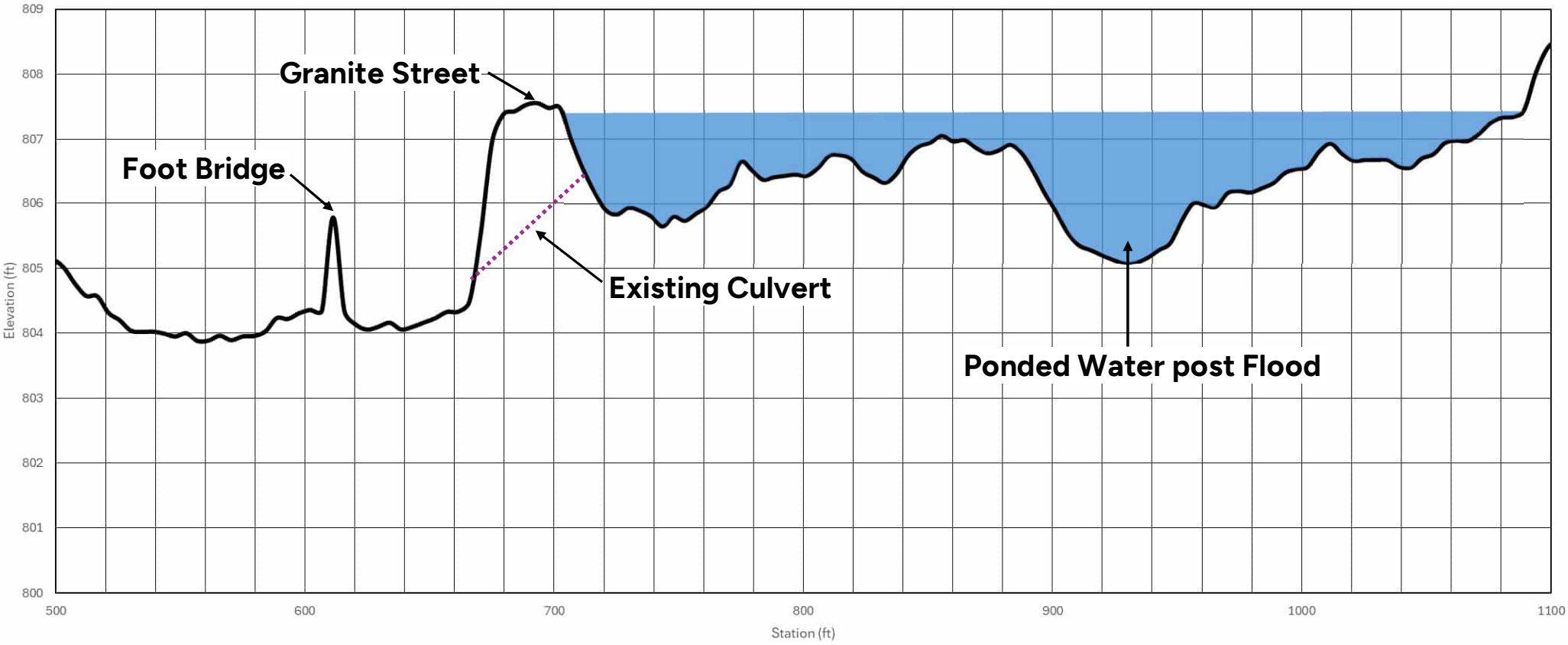
Post Flood Drainage

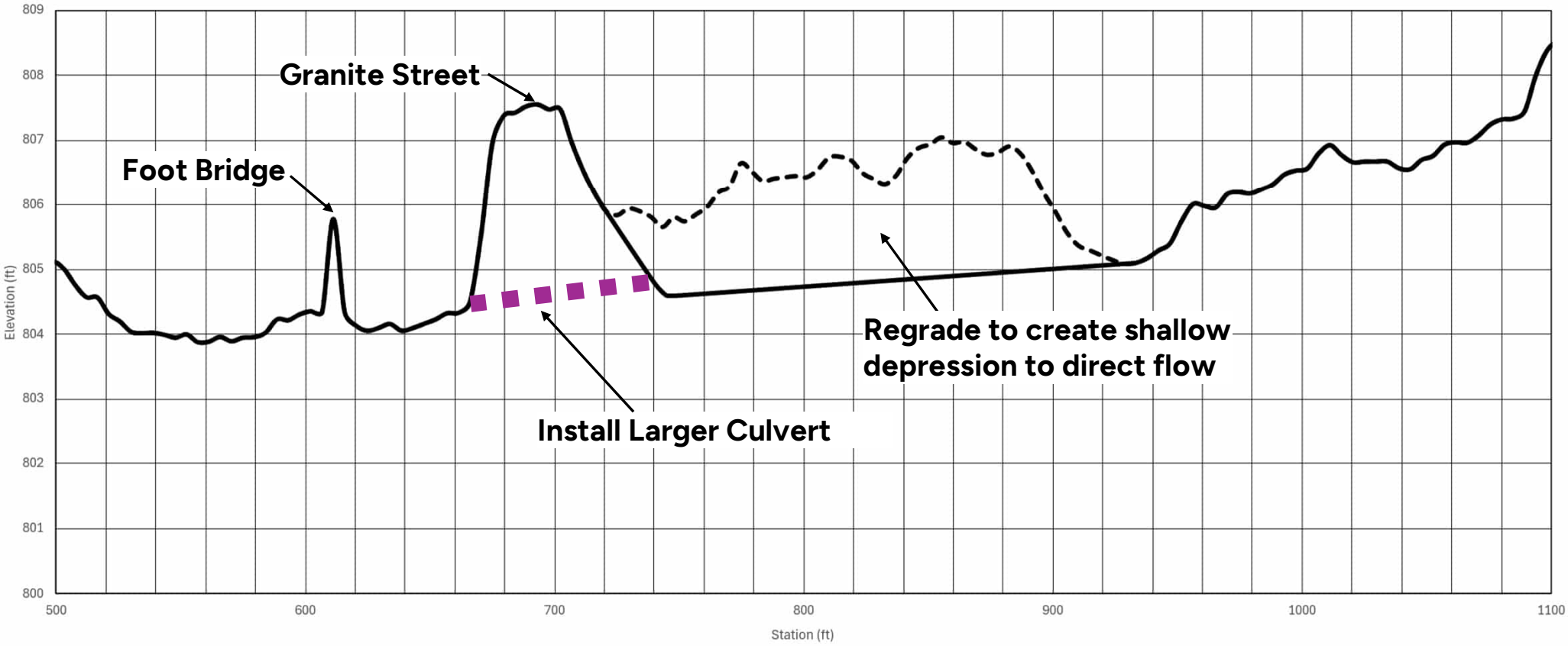

Existing Swale
Granite Street
Foot Bridge
Existing Culvert
Ponded Water post Flood
Granite St
Wolcott St
Cottage St
Cherry St
Hodgdon St
Elm St

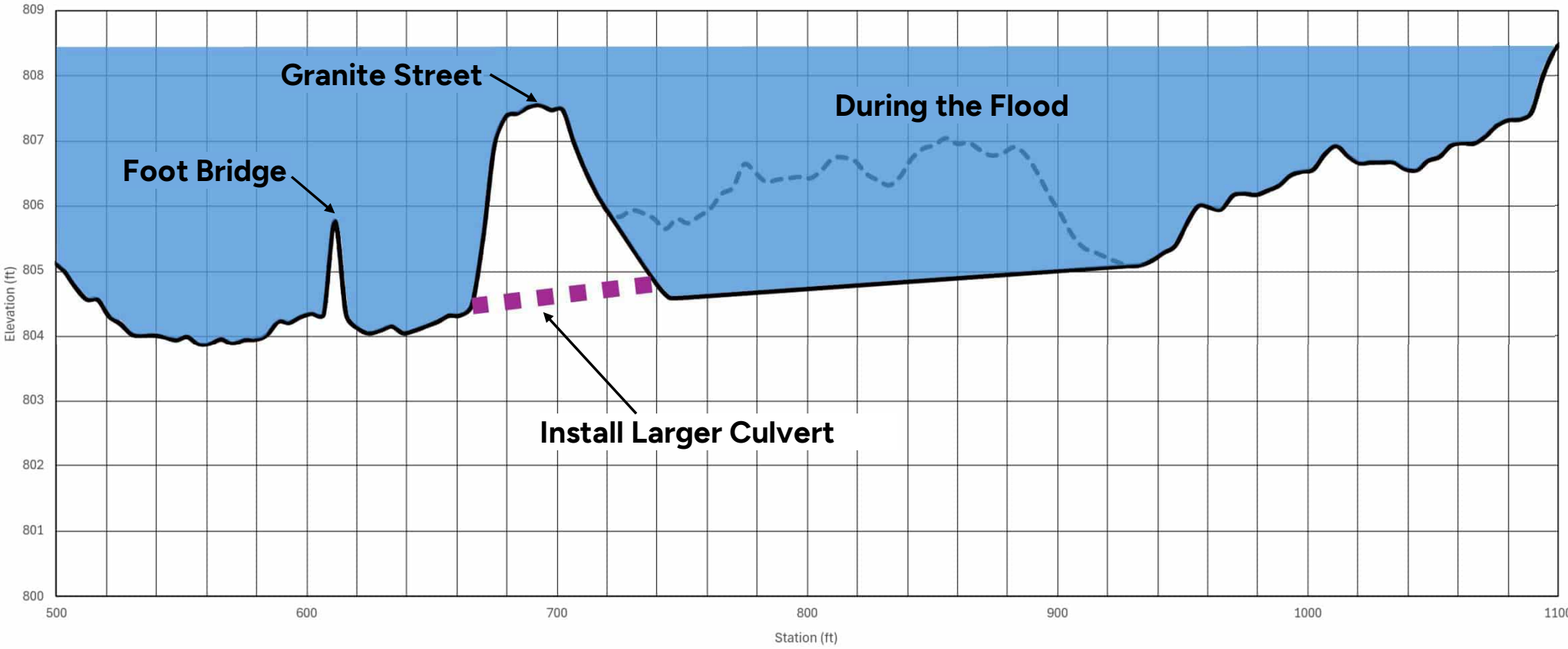

Existing Swale
Granite Street
Foot Bridge
Existing Culvert
Ponded Water post Flood

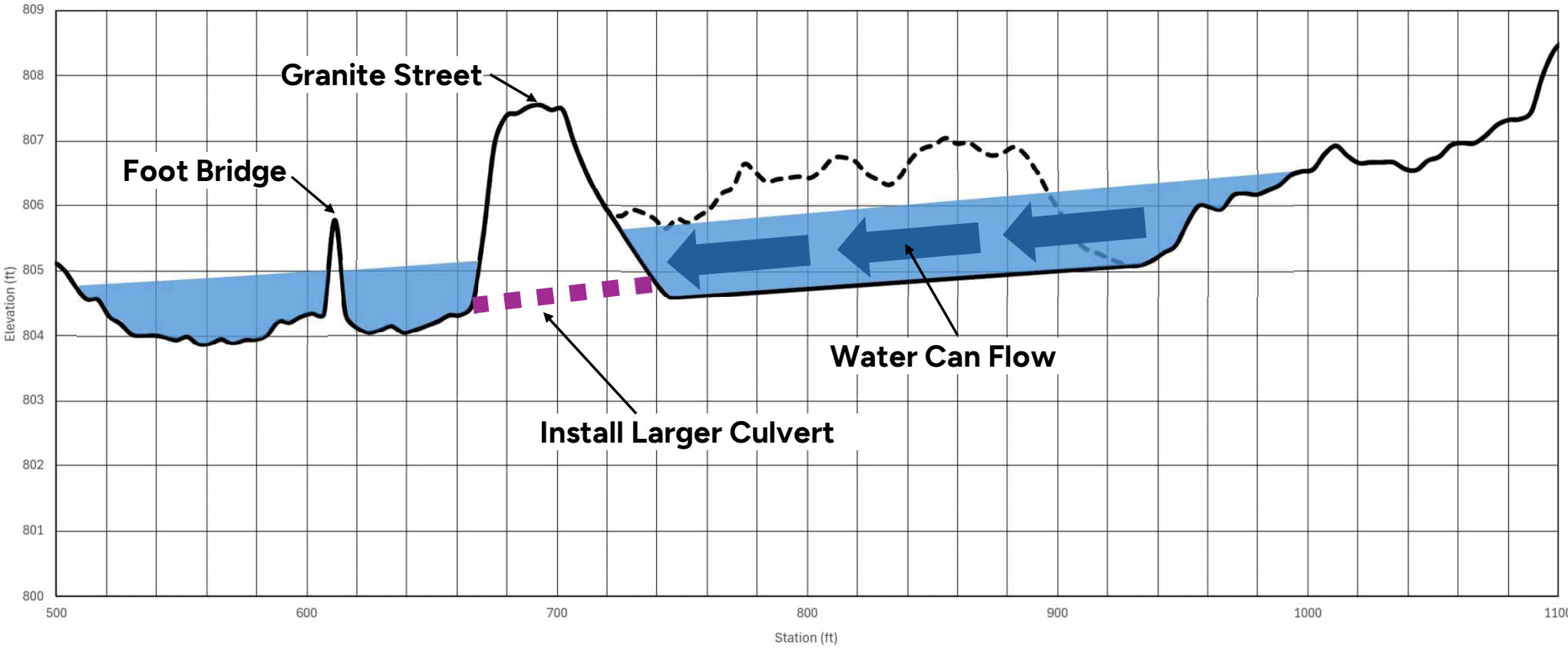

Existing Swale
Granite Street
Foot Bridge
Proposed Larger Culvert
Regrade to Connect Low Elevation Areas


Granite Street
During the Flood
Foot Bridge
Existing Culvert
Elevation (ft)
809
808
807
806
805
804
803
802
801
800
500
600
700
800
900
1000
1100
Station (ft)


Granite Street
Foot Bridge
Existing Culvert
Ponded Water post Flood
Elevation (ft)
Station (ft)
809
808
807
806
805
804
803
802
801
800
500
600
700
800
900
1000
1100


Granite Street
Foot Bridge
Regrade to create shallow depression to direct flow
Install Larger Culvert
Elevation (ft)
Station (ft)
809
808
807
806
805
804
803
802
801
800
500
600
700
800
900
1000
1100


Granite Street
During the Flood
Foot Bridge
Install Larger Culvert
Elevation (ft)
Station (ft)
809
808
807
806
805
804
803
802
801
800
500
600
700
800
900
1000
1100


Granite Street
Foot Bridge
Water Can Flow
Install Larger Culvert
Elevation (ft)
Station (ft)
809
808
807
806
805
804
803
802
801
800
500
600
700
800
900
1000
1100

Questions?

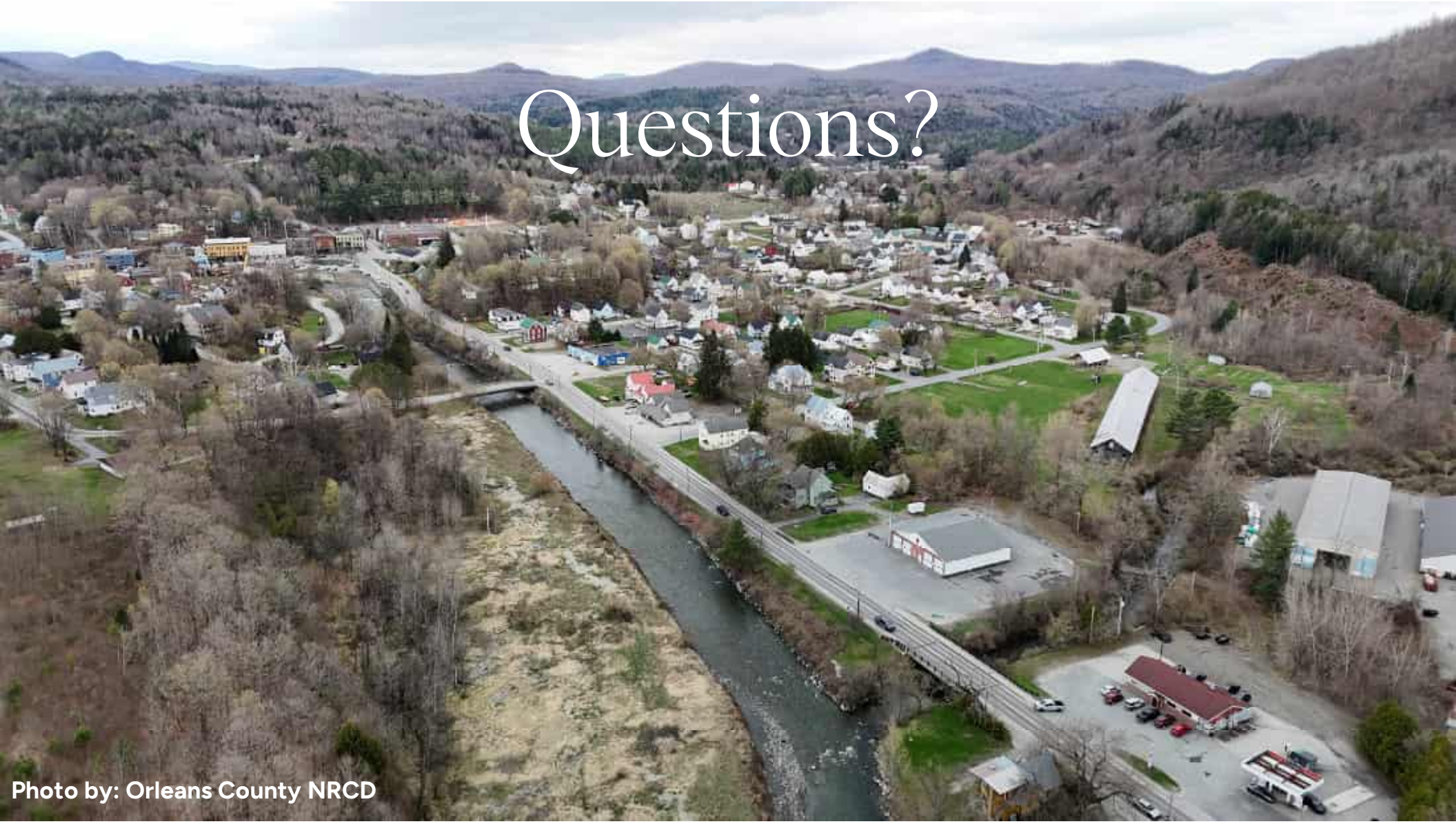
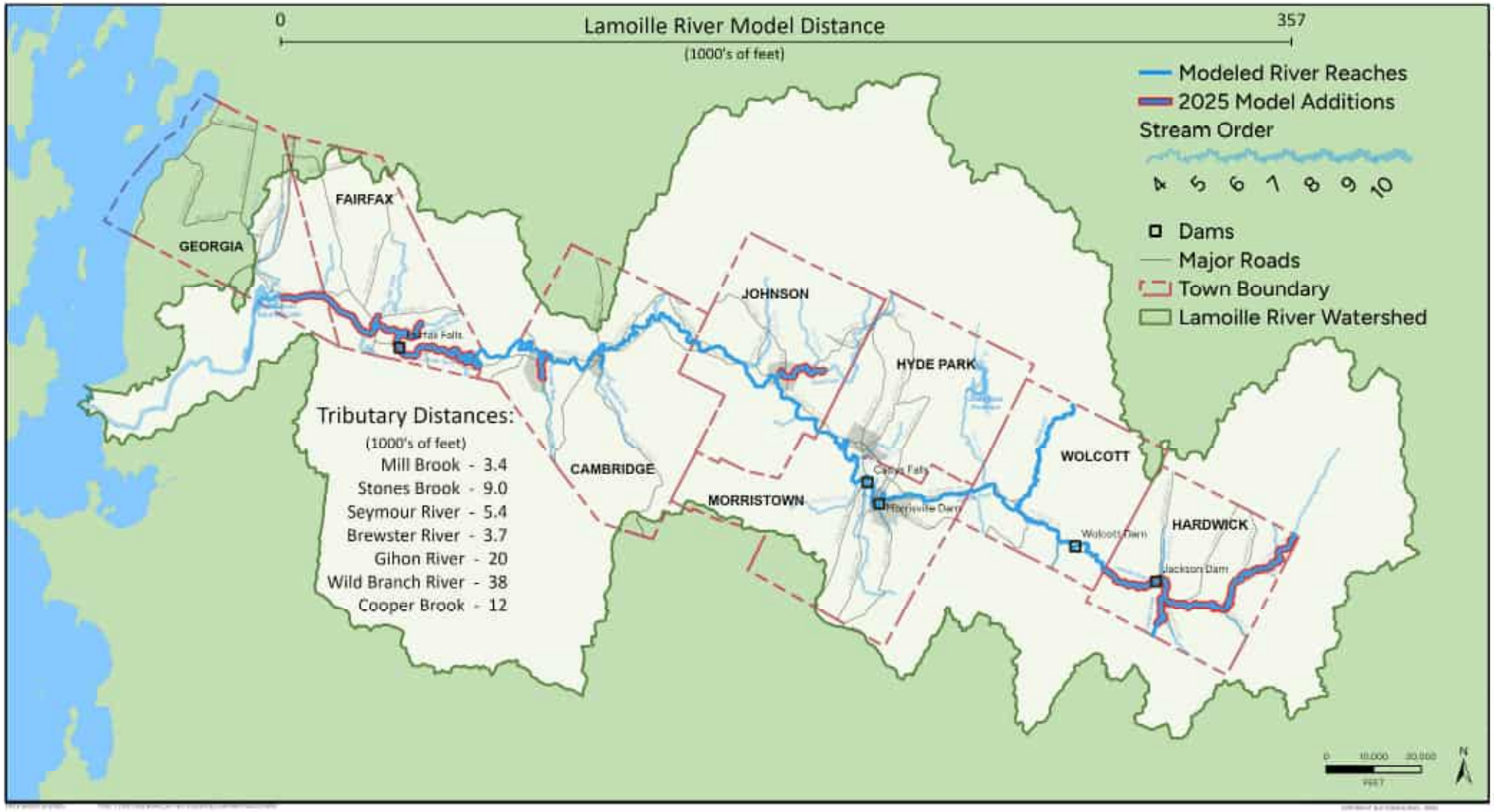
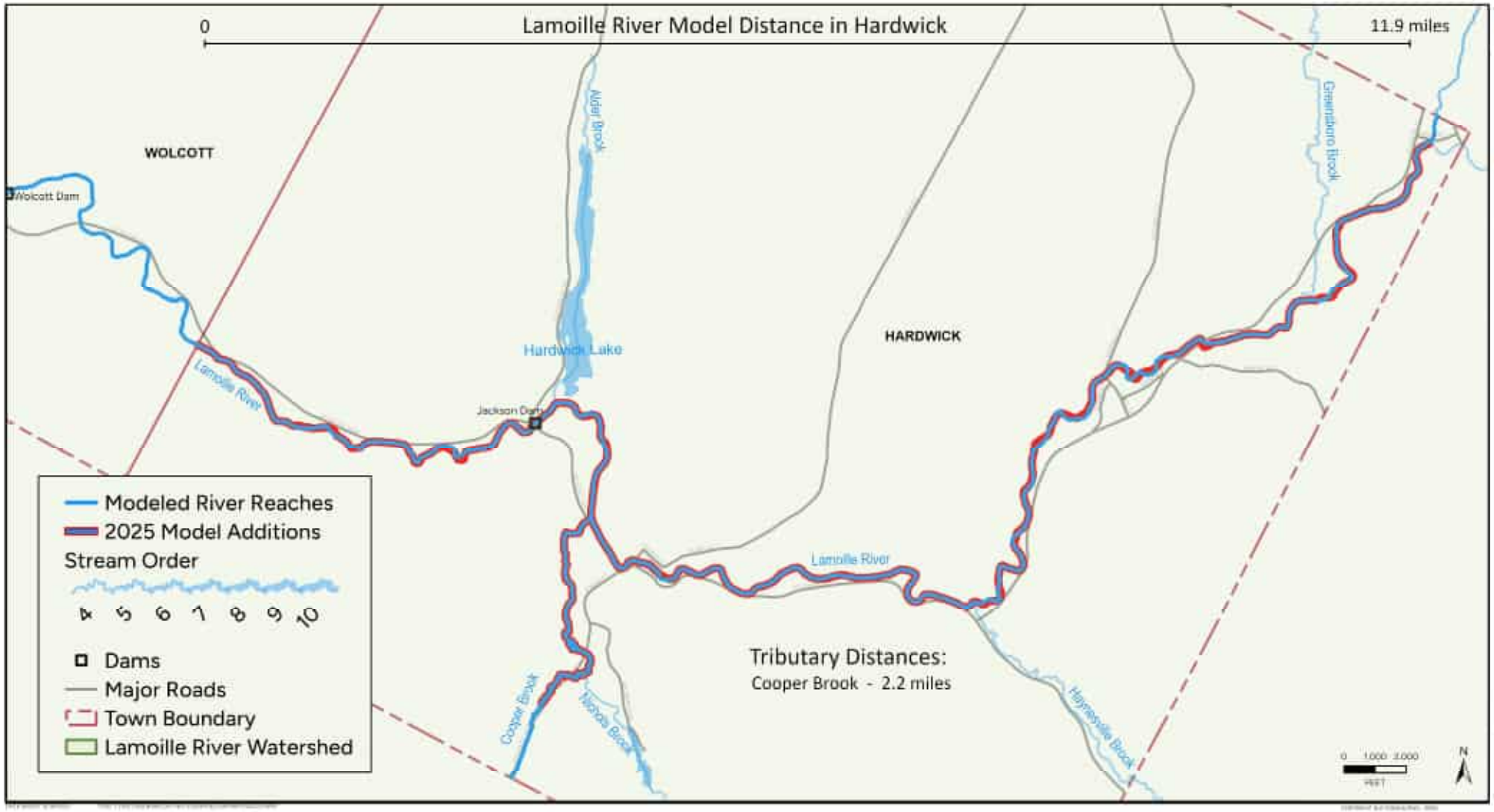


Photo by: Orleans County NRCD

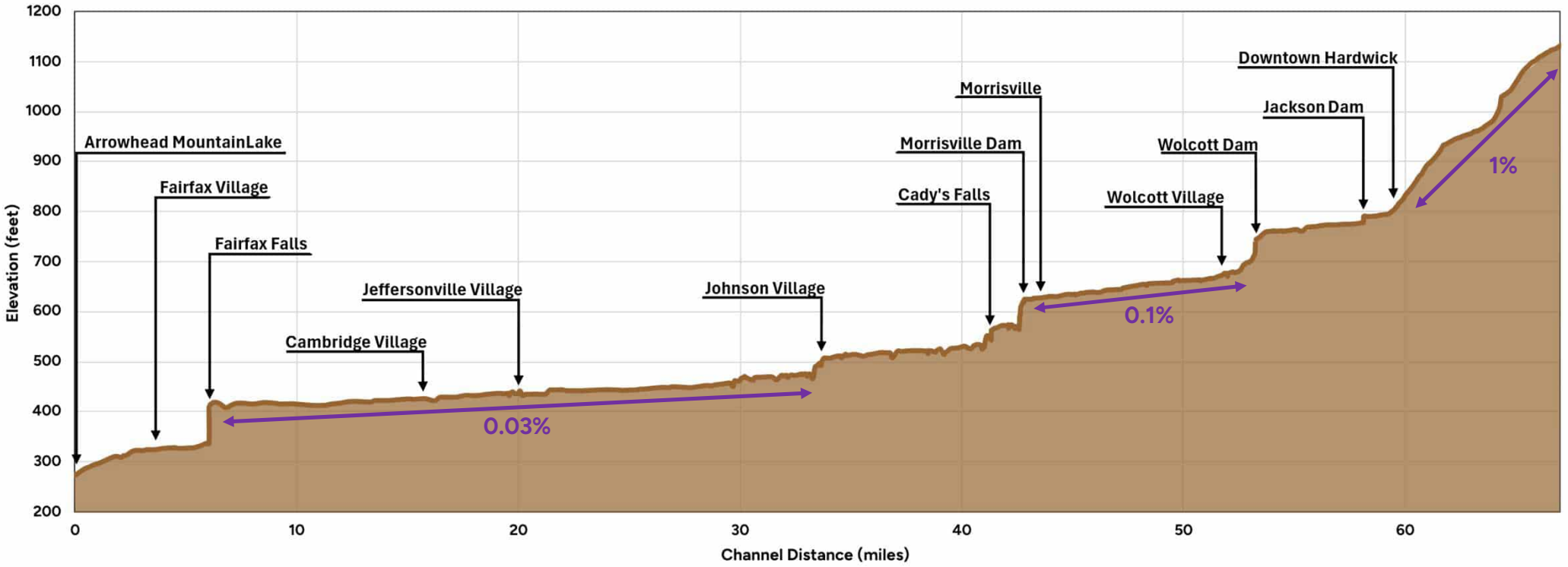
Extra Slides

(Civil Air Patrol, 7/12/2023)


0
Lamoille River Model Distance
357
(1000's of feet)
Modeled River Reaches
2025 Model Additions
Stream Order
4 5 6 7 8 9 10
Dams
Major Roads
Town Boundary
Lamoille River Watershed
GEORGIA
FAIRFAX
CAMBRIDGE
JOHNSON
MORRISTOWN
HYDE PARK
WOLCOTT
HARDWICK
Tributary Distances:
(1000's of feet)
Mill Brook - 3.4
Stones Brook - 9.0
Seymour River - 5.4
Brewster River - 3.7
Gihon River - 20
Wild Branch River - 38
Cooper Brook - 12
Cadys Falls
Morrisville Dam
Wolcott Dam
Jackson Dam
N


Lamoille River Model Distance in Hardwick
0
11.9 miles
WOLCOTT
HARDWICK
Wolcott Dam
Jackson Dam
Hardwick Lake
Alder Brook
Greensboro Brook
Lamoille River
Lamoille River
Cooper Brook
Nichols Brook
Haynesville Brook
Modeled River Reaches
2025 Model Additions
Stream Order
4 5 6 7 8 9 10
Dams
Major Roads
Town Boundary
Lamoille River Watershed
Tributary Distances:
Cooper Brook - 2.2 miles
0 1,000 2,000
FEET
N

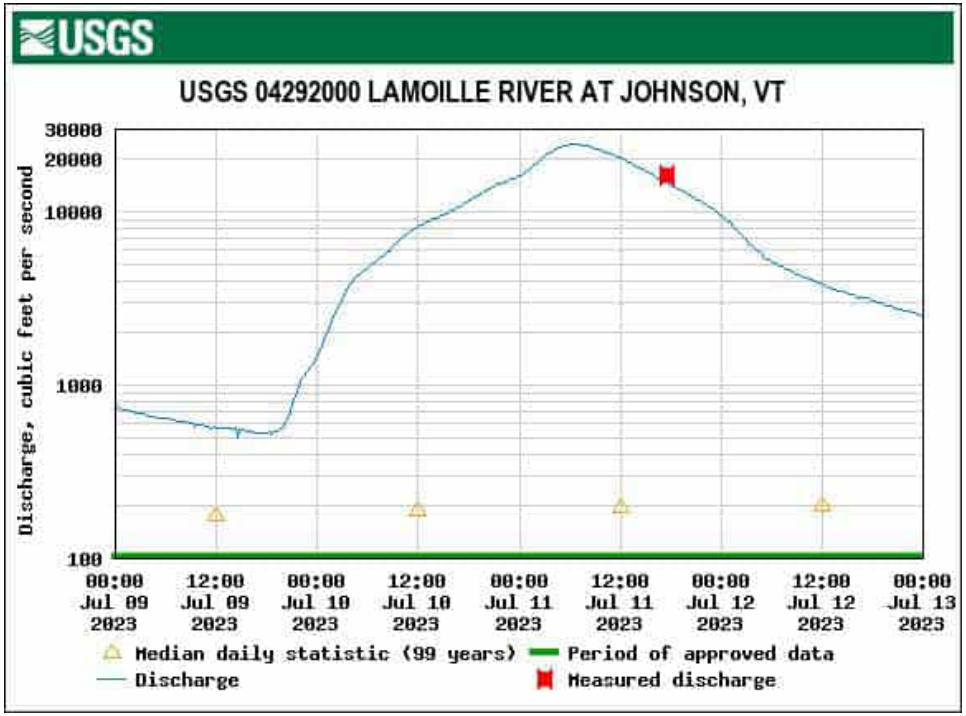
Lamoille River Long Profile



Hydrology

- **How much water is in the river?**
  - Rainfall Amount, Duration, and Intensity
  - Topography
  - Land Cover
  - Soil Moisture
  - Etc.

- **Calculating Flood Flows**
  - Gauge Analysis
  - Rainfall-Runoff Modeling
  - Regional Regression



What is the 100-Year Flood?

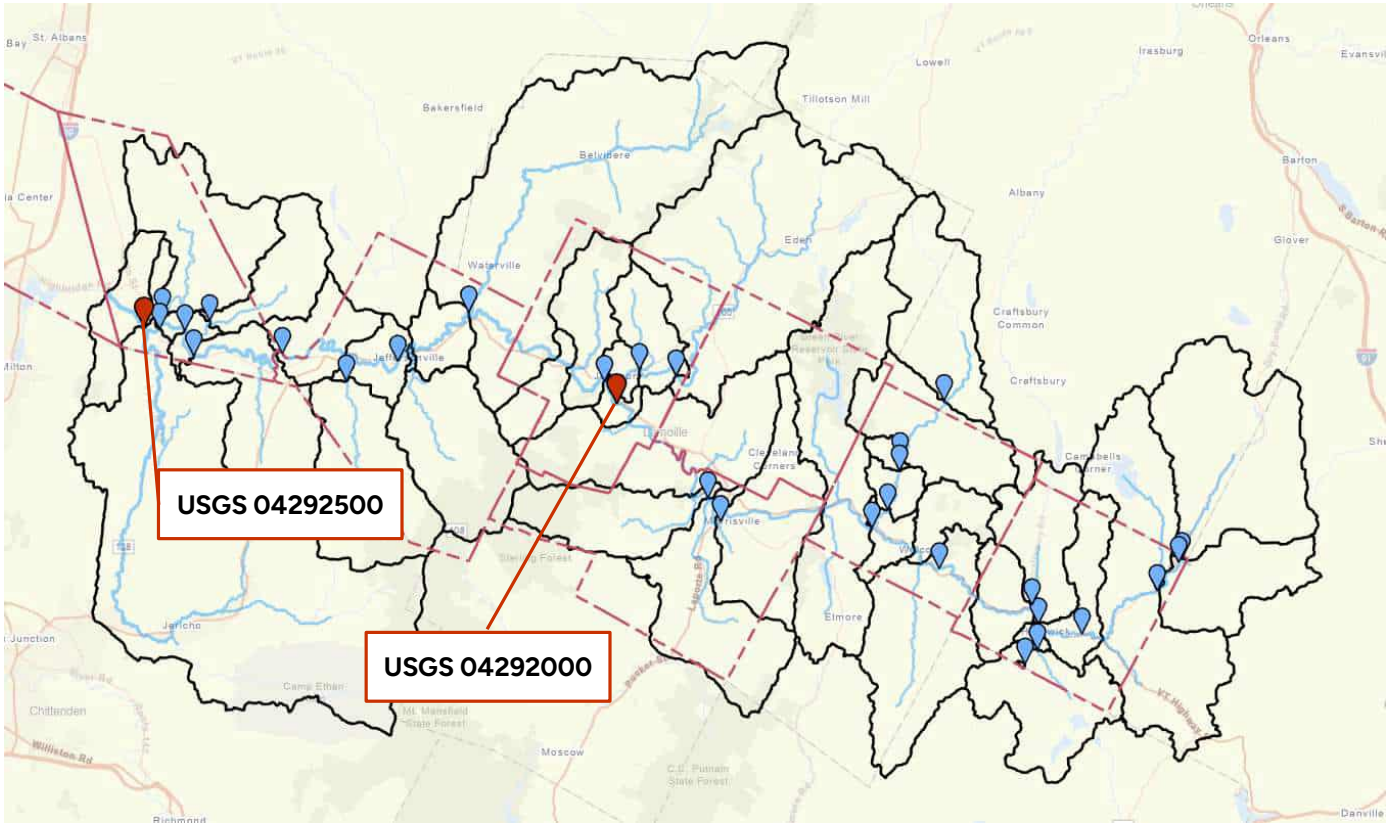
- The 100-year flood has a 1% chance of being equaled or exceeded in any 1-year.
- The 100-year flood has an average recurrence interval of 100 years.
- Chosen in the 1960's as the basis for the National Flood Insurance Program.
- The 1-percent annual exceedance probability (AEP) was "thought to be a fair balance between protecting the public and overly stringent regulation."

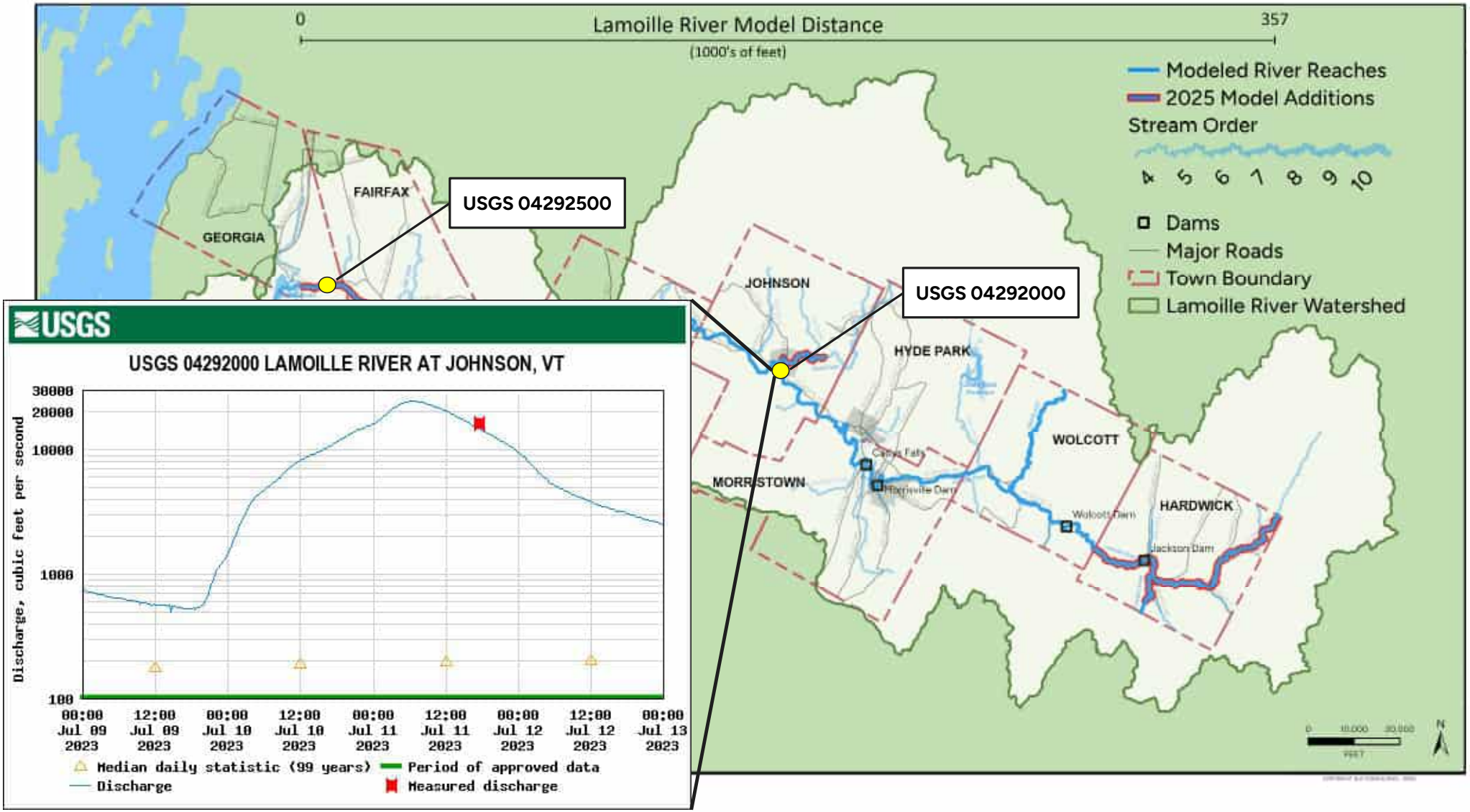
Recurrence Interval (years)	Annual Exceedance Probability
2	50%
10	10%
25	4%
50	2%
100	1%
500	0.2%

Source: Floods and Recurrence Intervals – USGS.gov

Flood Flows

- Used draft updated FEMA flood flows (July 2025).
- Flows were estimated in areas without FEMA flows
  - FEMA flow trend lines
  - Scaled flows by drainage area




0
Lamoille River Model Distance
357
(1000's of feet)
Modeled River Reaches
2025 Model Additions
Stream Order
4 5 6 7 8 9 10
Dams
Major Roads
Town Boundary
Lamoille River Watershed
USGS 04292500
USGS 04292000
FAIRFAX
GEORGIA
JOHNSON
HYDE PARK
WOLCOTT
MORRISTOWN
HARDWICK
Cadys Falls
Morrisville Dam
Wolcott Dam
Jackson Dam
USGS
USGS 04292000 LAMOILLE RIVER AT JOHNSON, VT
Discharge, cubic feet per second
30000
20000
10000
1000
100
00:00 Jul 09 2023
12:00 Jul 09 2023
00:00 Jul 10 2023
12:00 Jul 10 2023
00:00 Jul 11 2023
12:00 Jul 11 2023
00:00 Jul 12 2023
12:00 Jul 12 2023
00:00 Jul 13 2023
Median daily statistic (99 years)
Period of approved data
Discharge
Measured discharge

What is the 100-Year Flood?

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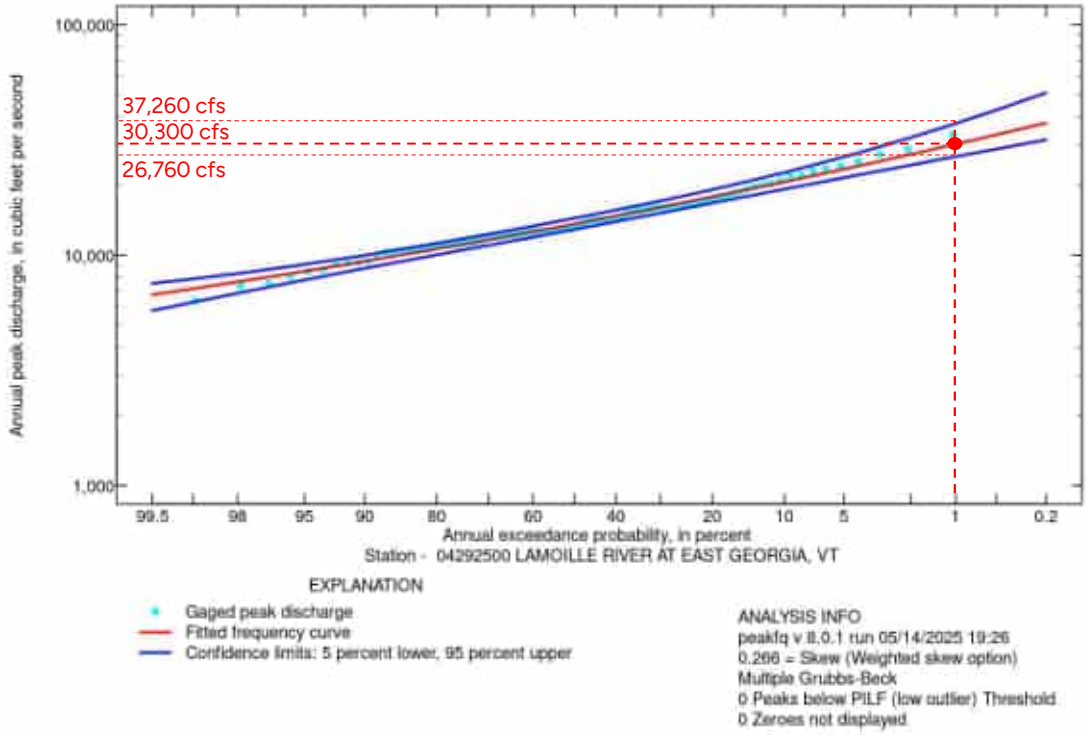
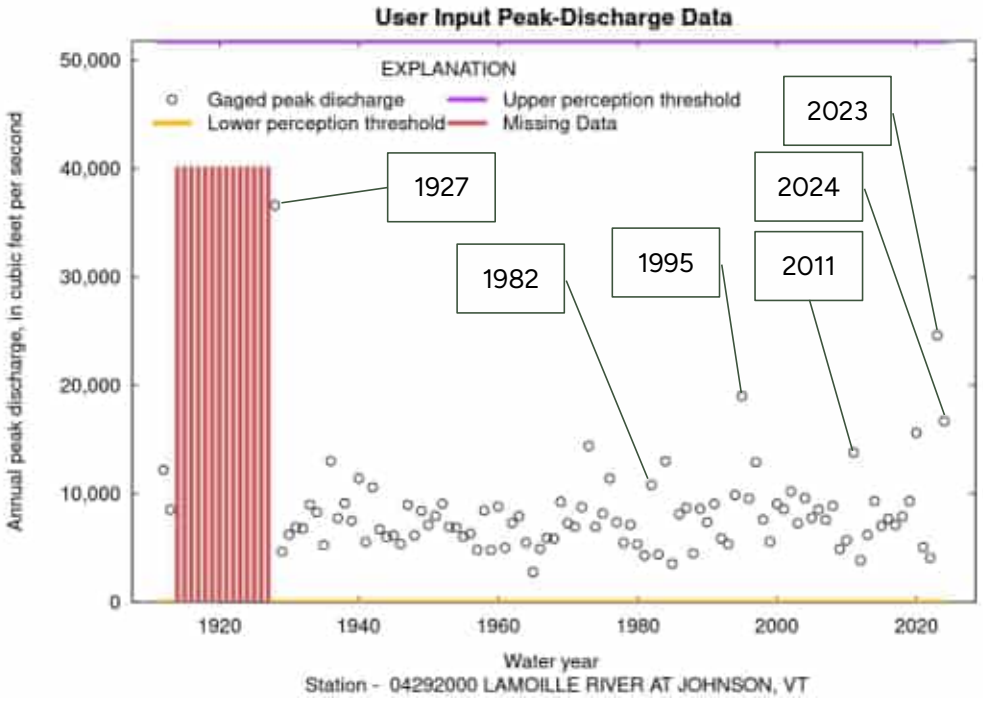
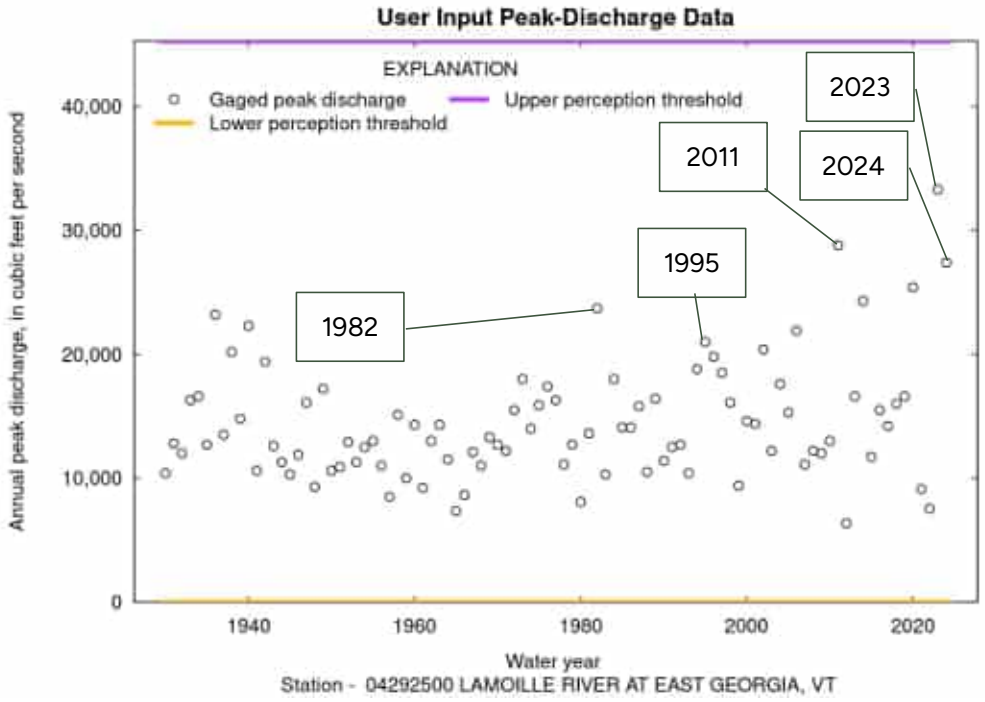


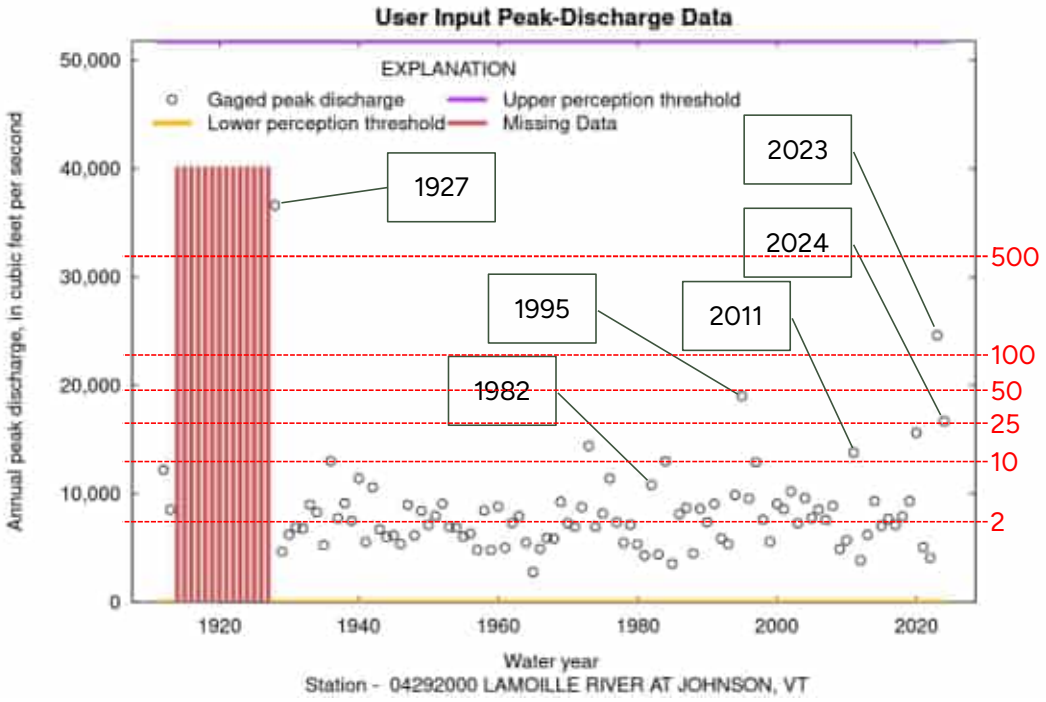
Source: Floods and Recurrence Intervals – USGS.gov

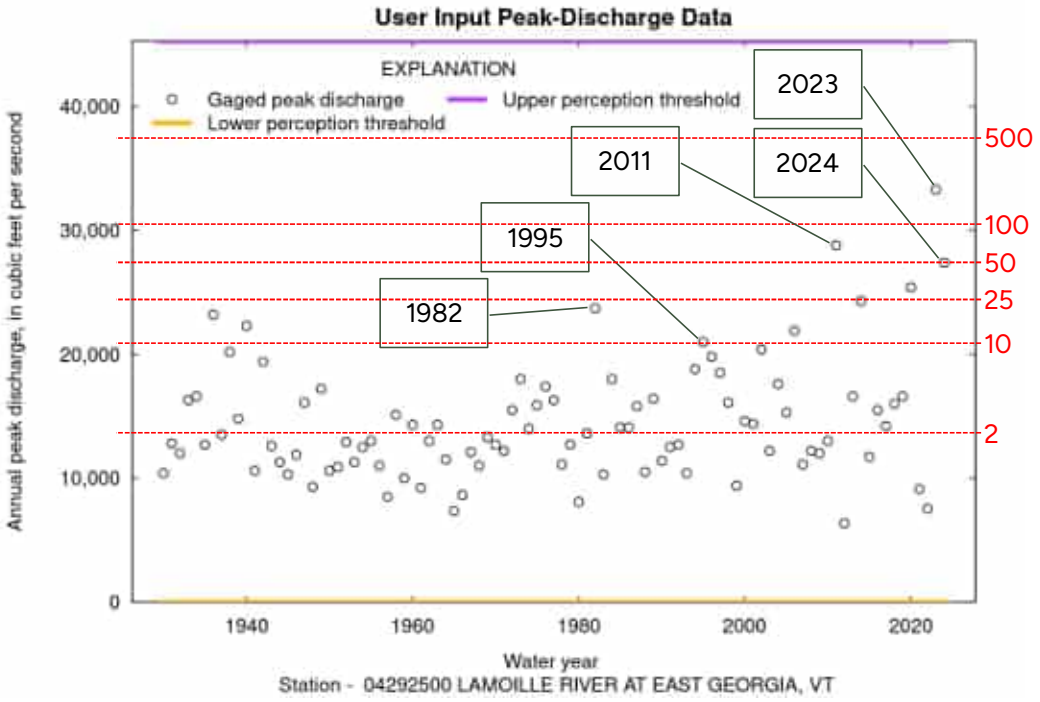
Hydrology


User Input Peak-Discharge Data
EXPLANATION
Gaged peak discharge
Upper perception threshold
Lower perception threshold
Missing Data
1927
1982
1995
2011
2023
2024
Annual peak discharge, in cubic feet per second
50,000
40,000
30,000
20,000
10,000
0
1920
1940
1960
1980
2000
2020
Water year
Station - 04292000 LAMOILLE RIVER AT JOHNSON, VT

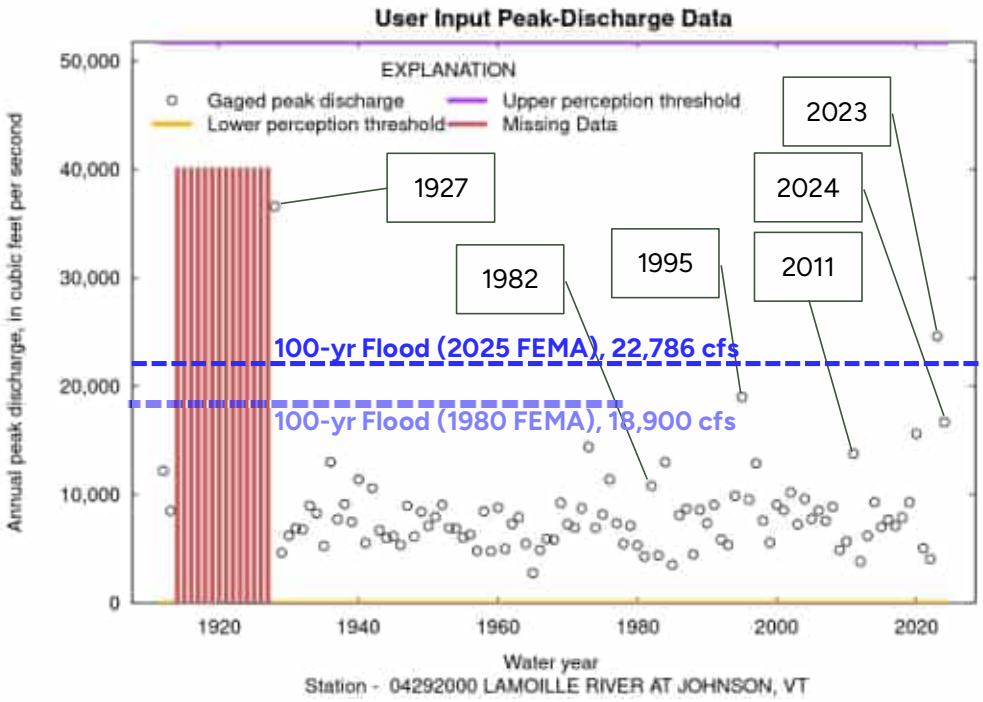

User Input Peak-Discharge Data
EXPLANATION
Gaged peak discharge
Upper perception threshold
Lower perception threshold
1982
1995
2011
2023
2024
Annual peak discharge, in cubic feet per second
40,000
30,000
20,000
10,000
0
1940
1960
1980
2000
2020
Water year
Station - 04292500 LAMOILLE RIVER AT EAST GEORGIA, VT

Hydrology


User Input Peak-Discharge Data
EXPLANATION
Gaged peak discharge
Lower perception threshold
Upper perception threshold
Missing Data
1927
1982
1995
2011
2023
2024
500
100
50
25
10
2
Annual peak discharge, in cubic feet per second
50,000
40,000
30,000
20,000
10,000
0
1920
1940
1960
1980
2000
2020
Water year
Station - 04292000 LAMOILLE RIVER AT JOHNSON, VT


User Input Peak-Discharge Data
EXPLANATION
Gaged peak discharge
Lower perception threshold
Upper perception threshold
1982
1995
2011
2023
2024
500
100
50
25
10
2
Annual peak discharge, in cubic feet per second
40,000
30,000
20,000
10,000
0
1940
1960
1980
2000
2020
Water year
Station - 04292500 LAMOILLE RIVER AT EAST GEORGIA, VT

Hydrology


User Input Peak-Discharge Data
EXPLANATION
Gaged peak discharge
Upper perception threshold
Lower perception threshold
Missing Data
1927
1982
1995
2011
2023
2024
100-yr Flood (2025 FEMA), 22,786 cfs
100-yr Flood (1980 FEMA), 18,900 cfs
Annual peak discharge, in cubic feet per second
50,000
40,000
30,000
20,000
10,000
0
1920
1940
1960
1980
2000
2020
Water year
Station - 04292000 LAMOILLE RIVER AT JOHNSON, VT

Flood Flows

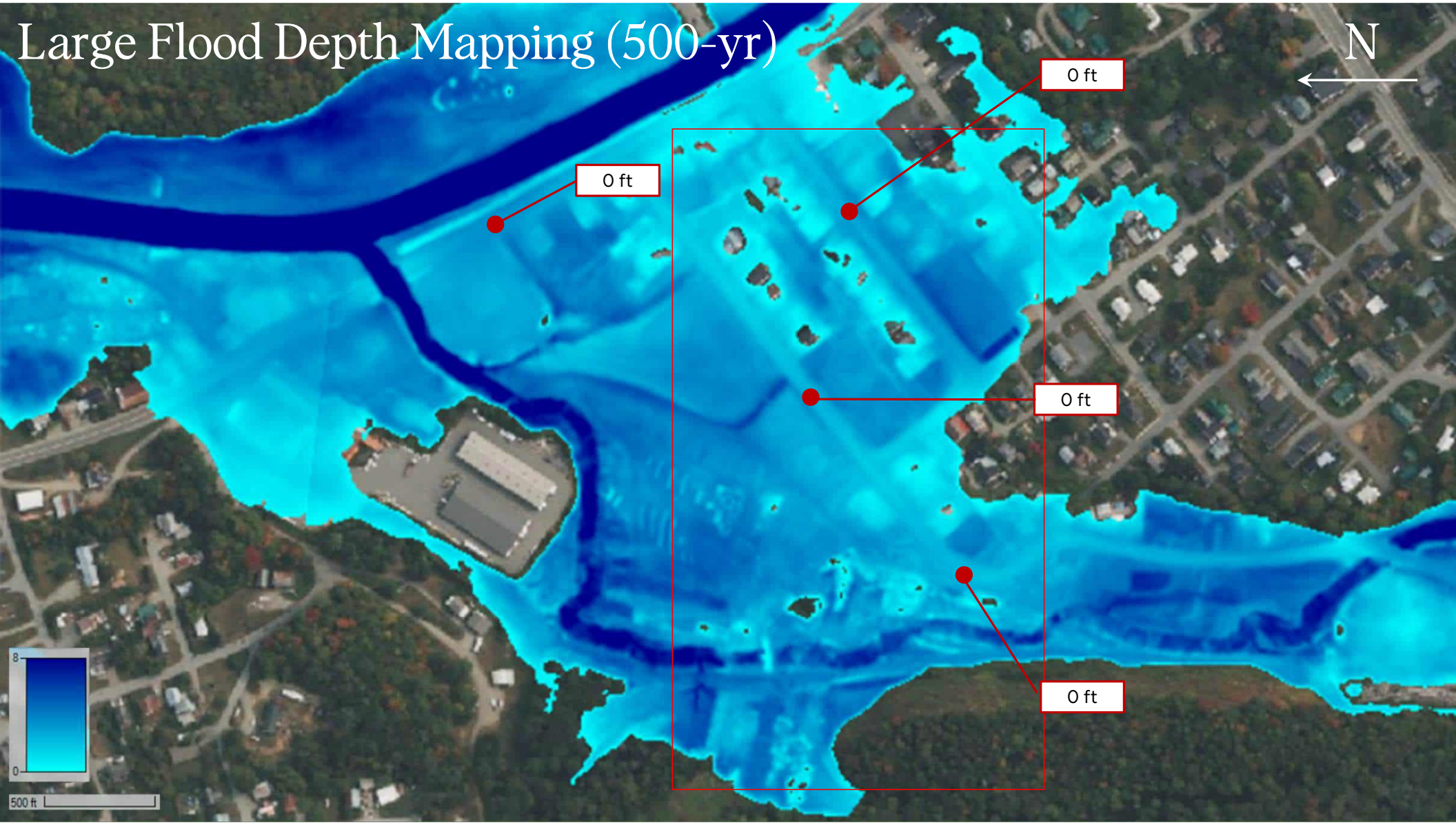
- Used draft updated FEMA flood flows (July 2025).
- Flows were estimated in areas without FEMA flows
  - FEMA flow trend lines
  - Scaled flows by drainage area

Table 1: Flood Flows at USGS Gage 04292000 in Johnson

Recurrence Interval (years)	Updated 2025 FEMA Flows (cfs)	1980 FEMA FIS Flows (cfs)
10	10,890	10,800
25	15,430	n/a
50	19,546	16,050
100	22,786	18,900
500	30,717	27,200

Table 2: Flood Flows at USGS Gage 04292500 in East Georgia

Recurrence Interval (years)	Updated 2025 FEMA Flows (cfs)	1980 FEMA FIS Flows (cfs)
10	14,956	19,100
25	20,553	n/a
50	26,168	28,300
100	31,286	33,310
500	41,448	48,330


Large Flood Depth Mapping (500-yr)
N
0 ft
0 ft
0 ft
0 ft
8
0
500 ft