HIGH MEADOWS FUND

Building Resilience in Vermont's Watersheds

LAMOILLE COUNTY PLANNING COMMISSION

Lamoille River Hydraulic Model

Presented By

Roy Schiff

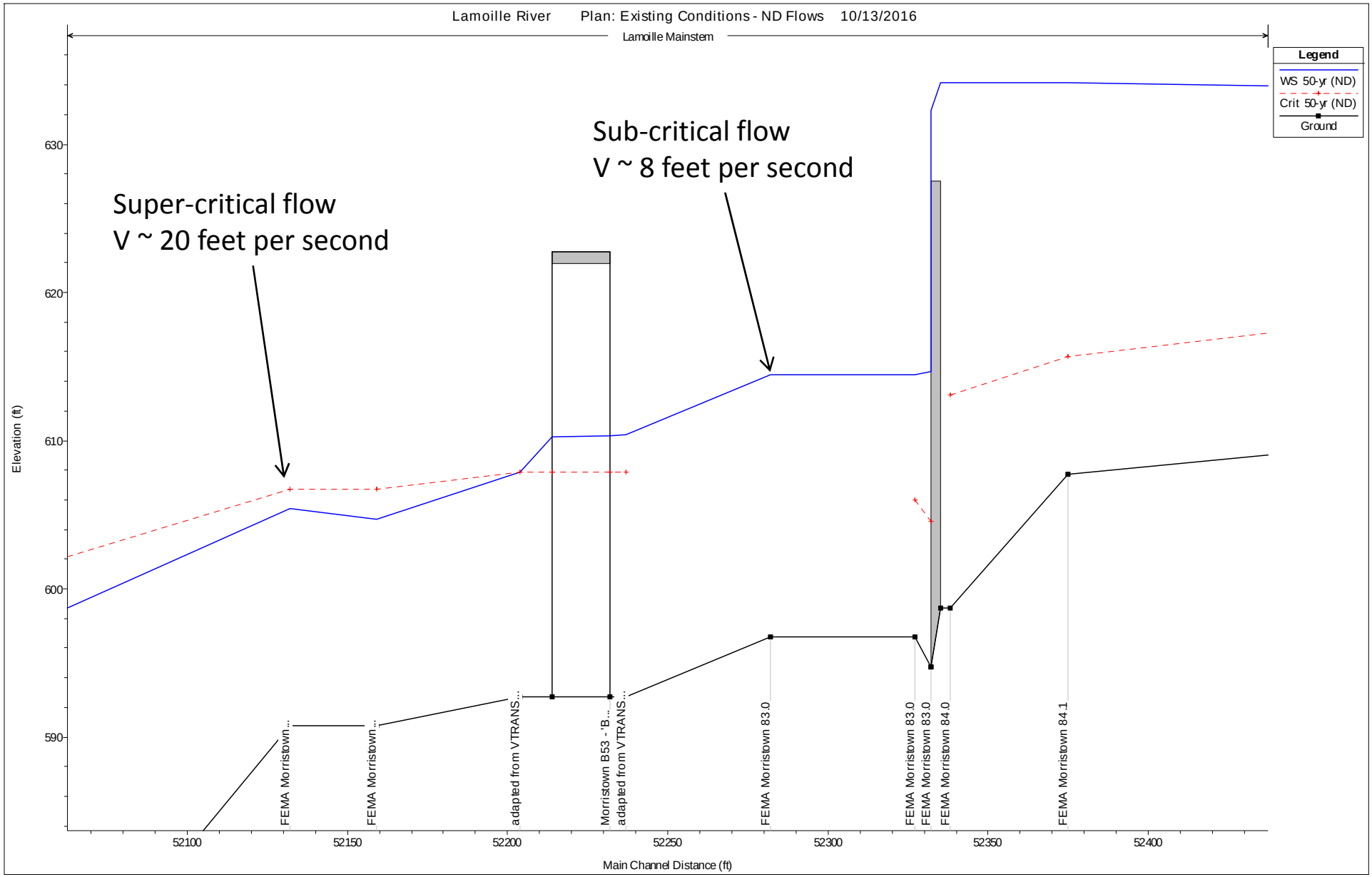
MILONE & MACBROOM

Town of Cambridge | November 7, 2016

HEC-RAS Common Applications

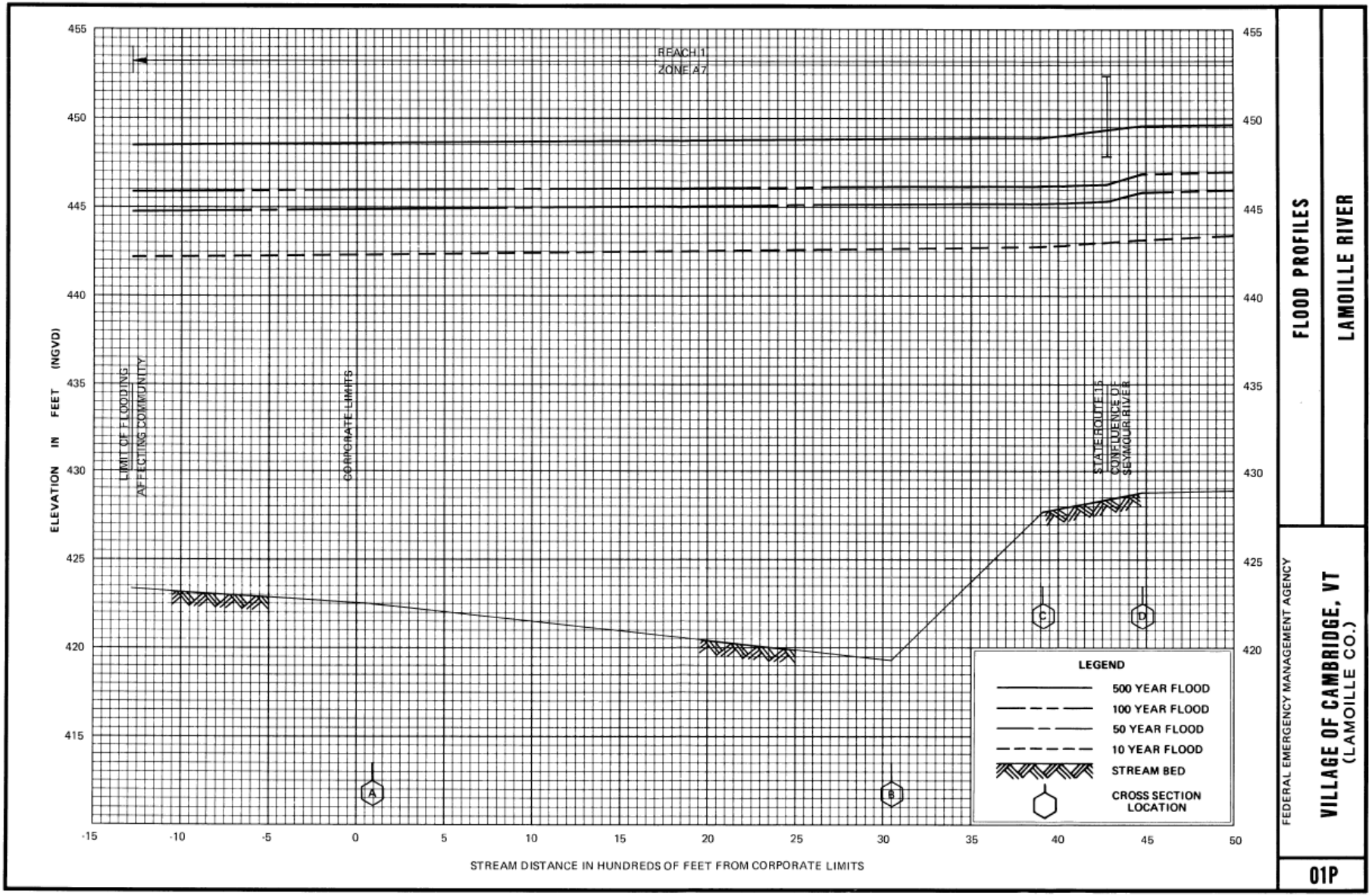
- EXTENT OF FLOODING (FLOODPLAINS)
- FLOOD STUDIES AND MITIGATION
- STRUCTURE EVALUATION AND DESIGN (DAMS, BRIDGES, CULVERTS)
- FLOODWAY DELINEATION
- BRIDGE SCOUR
- HYDRAULIC ALTERNATIVES ANALYSIS
- STABLE CHANNEL DESIGN
- ROBUST, APPEARS TO BE PRECISE ALWAYS, MAY BE ACCURATE, USUALLY RELIABLE

25-Year Floodplain Map



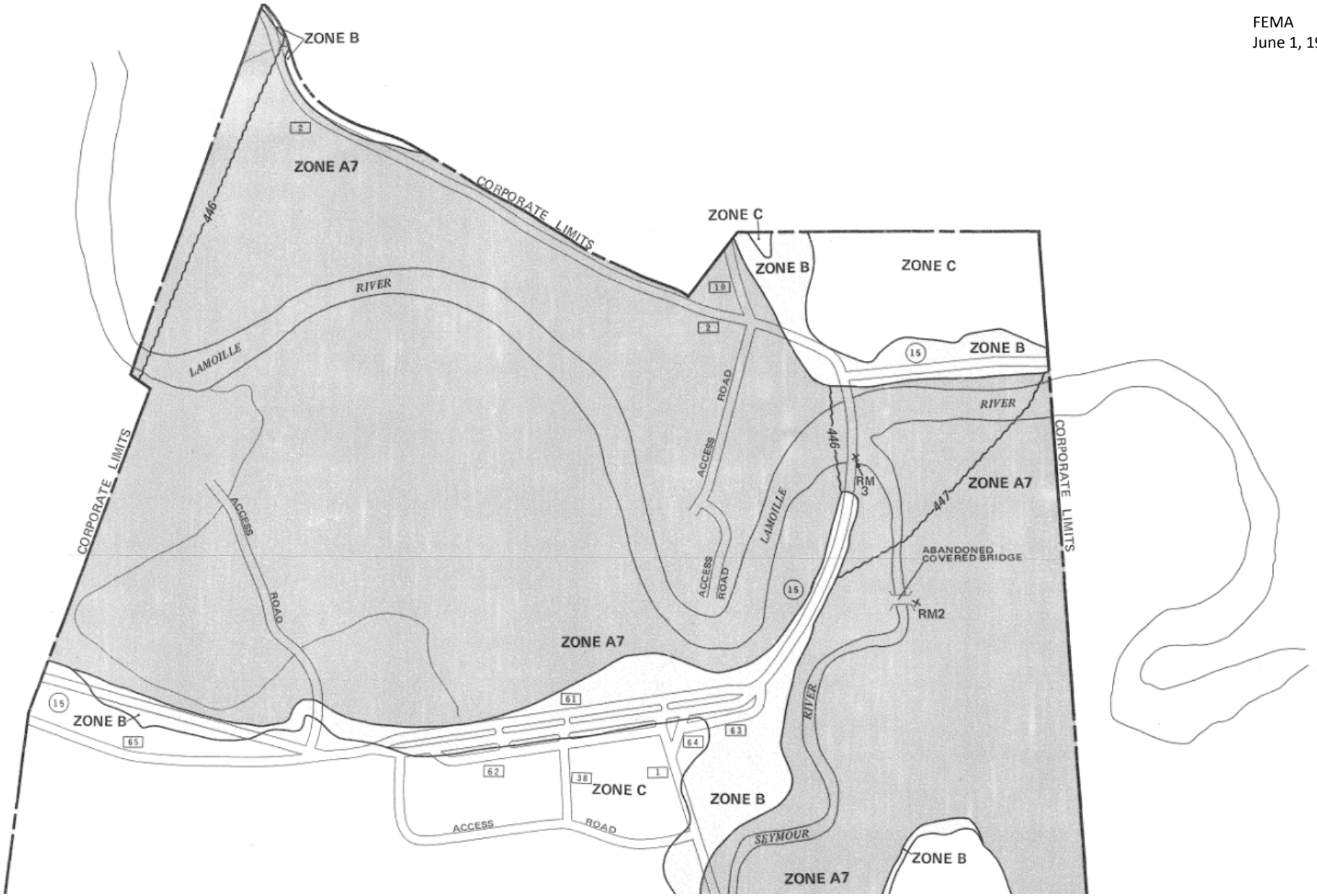
Morristown B53 - 'B' Street Bridge, 100 feet downstream of Morrisville Dam

FEMA Flood Profile



FEMA FIRM

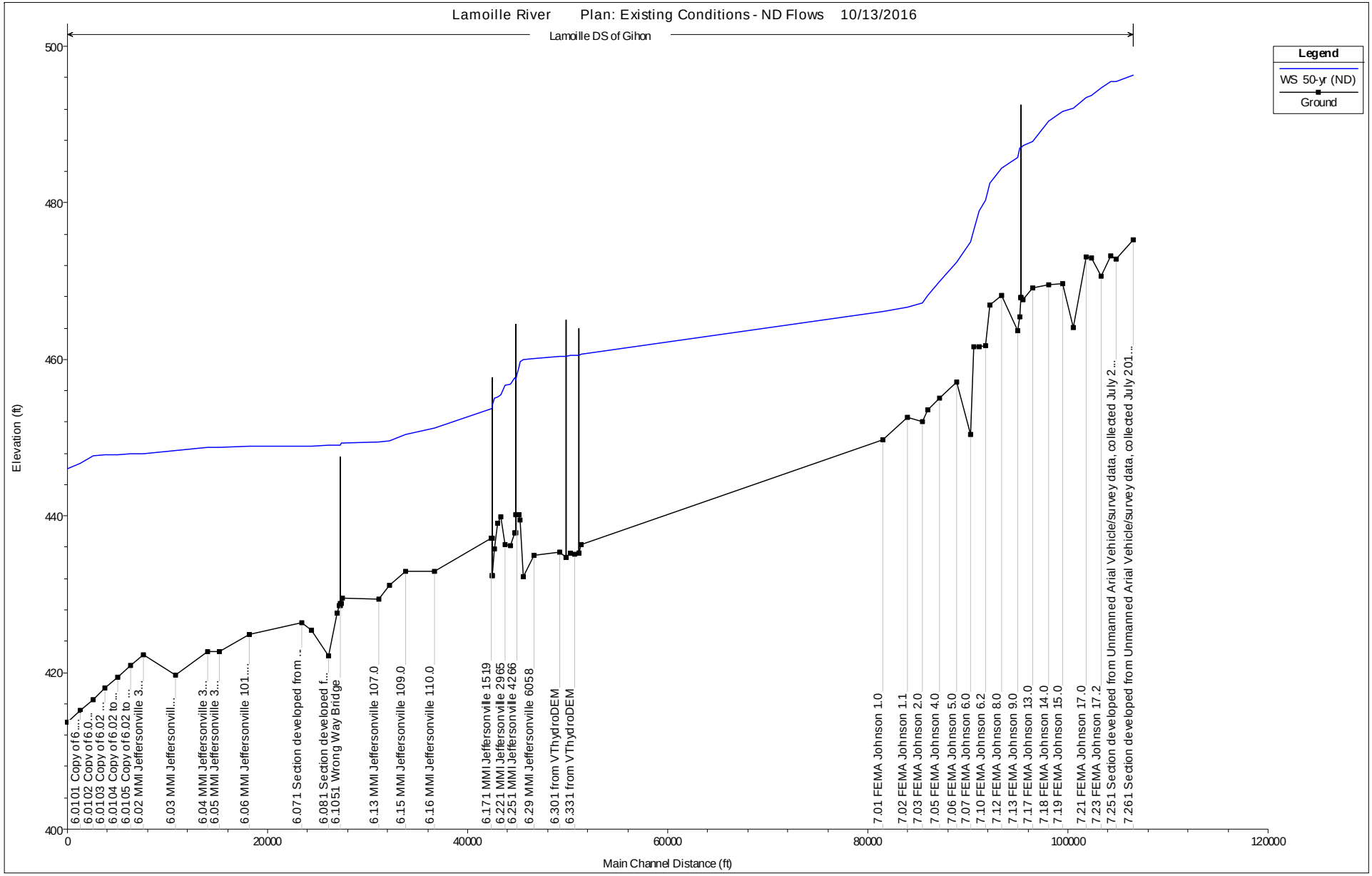
FEMA
June 1, 1983



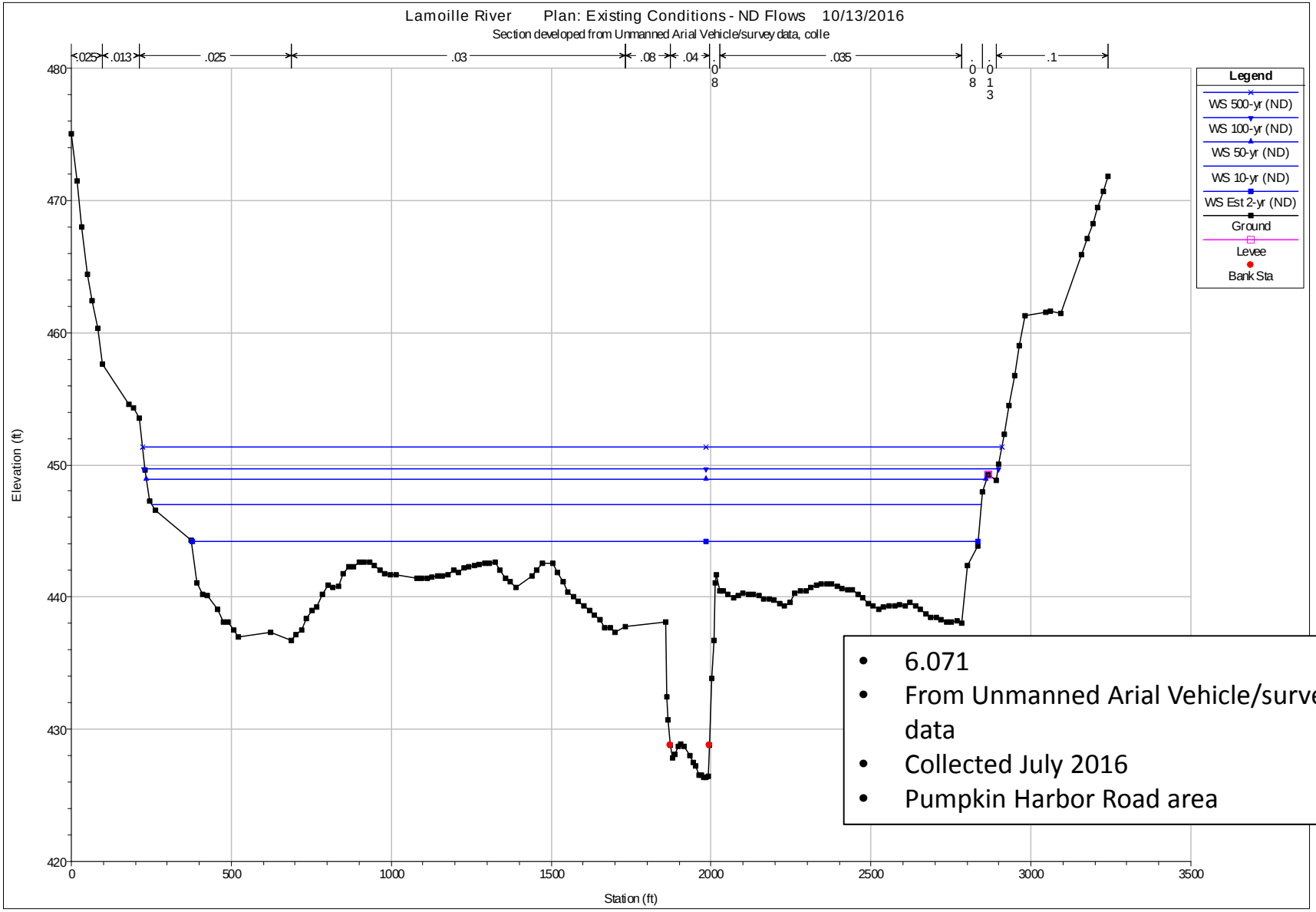
Calibration / Validation

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

Model Profile

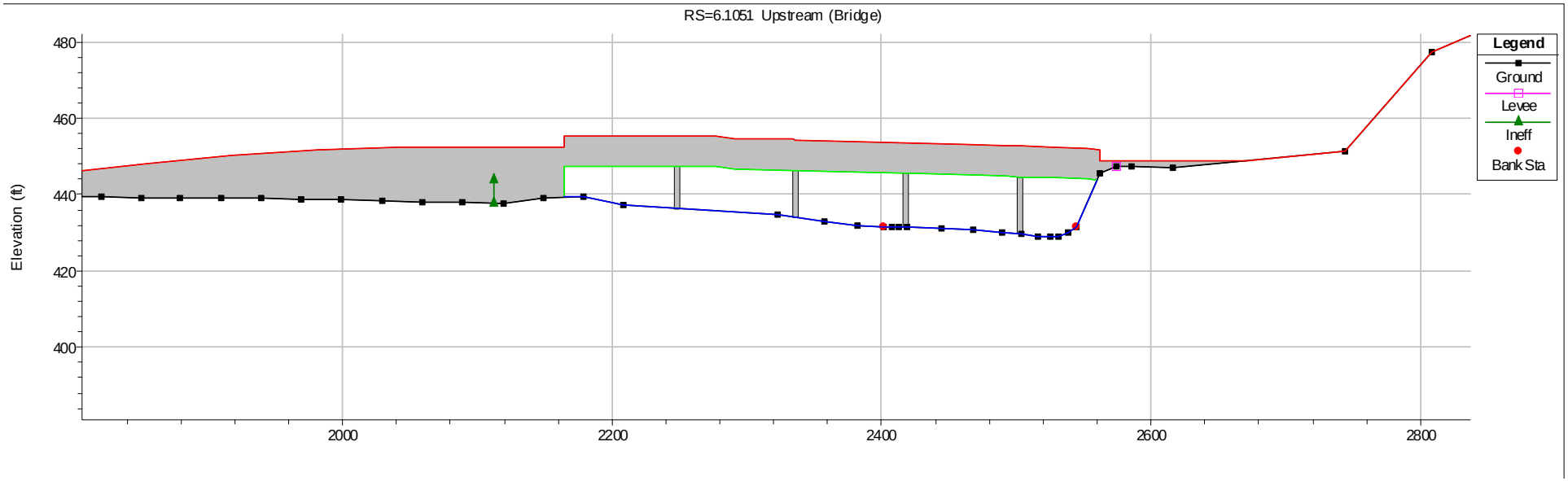


Cross Section

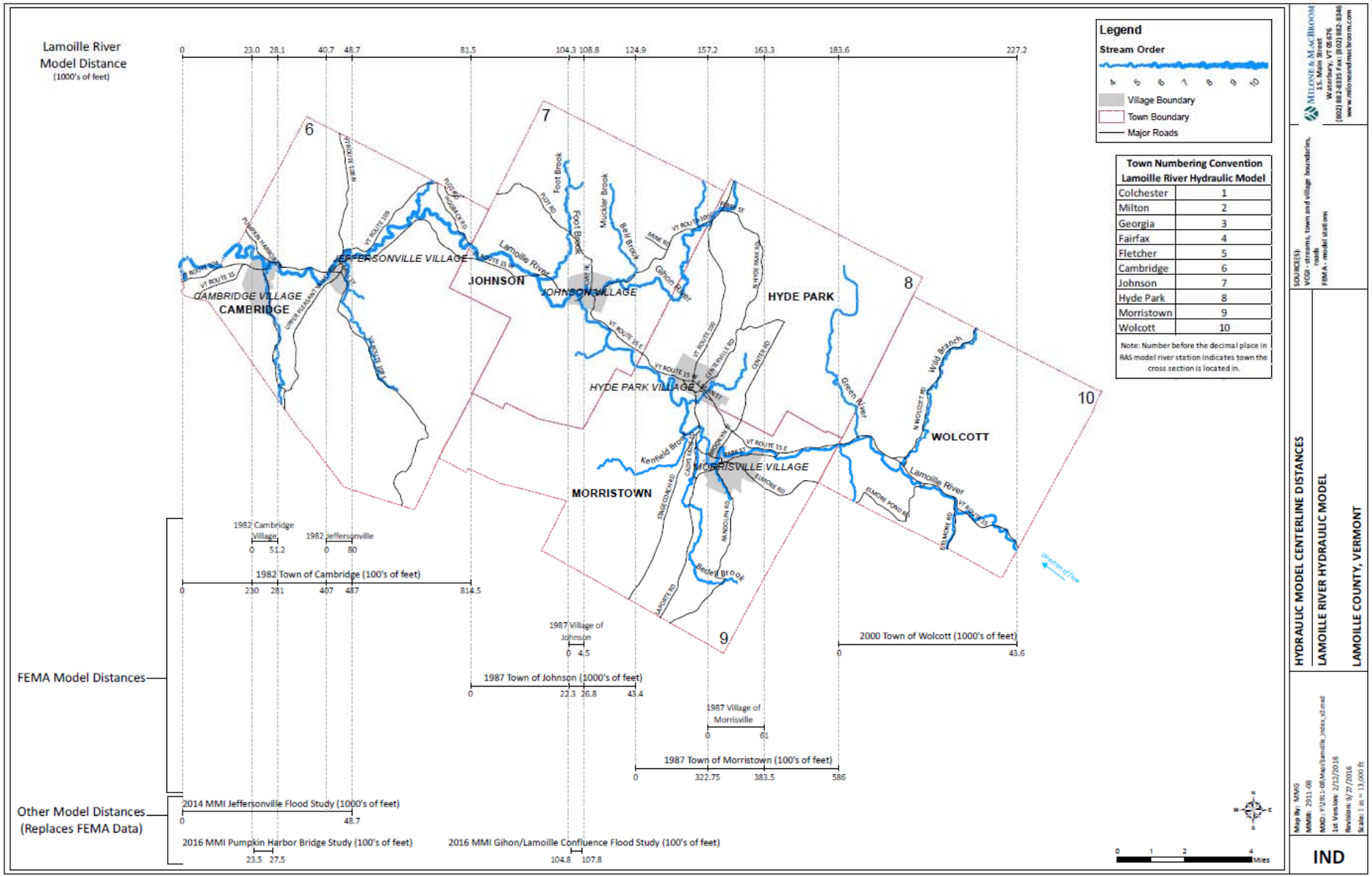


- 6.071
- From Unmanned Arial Vehicle/survey data
- Collected July 2016
- Pumpkin Harbor Road area

Wrong Way Bridge



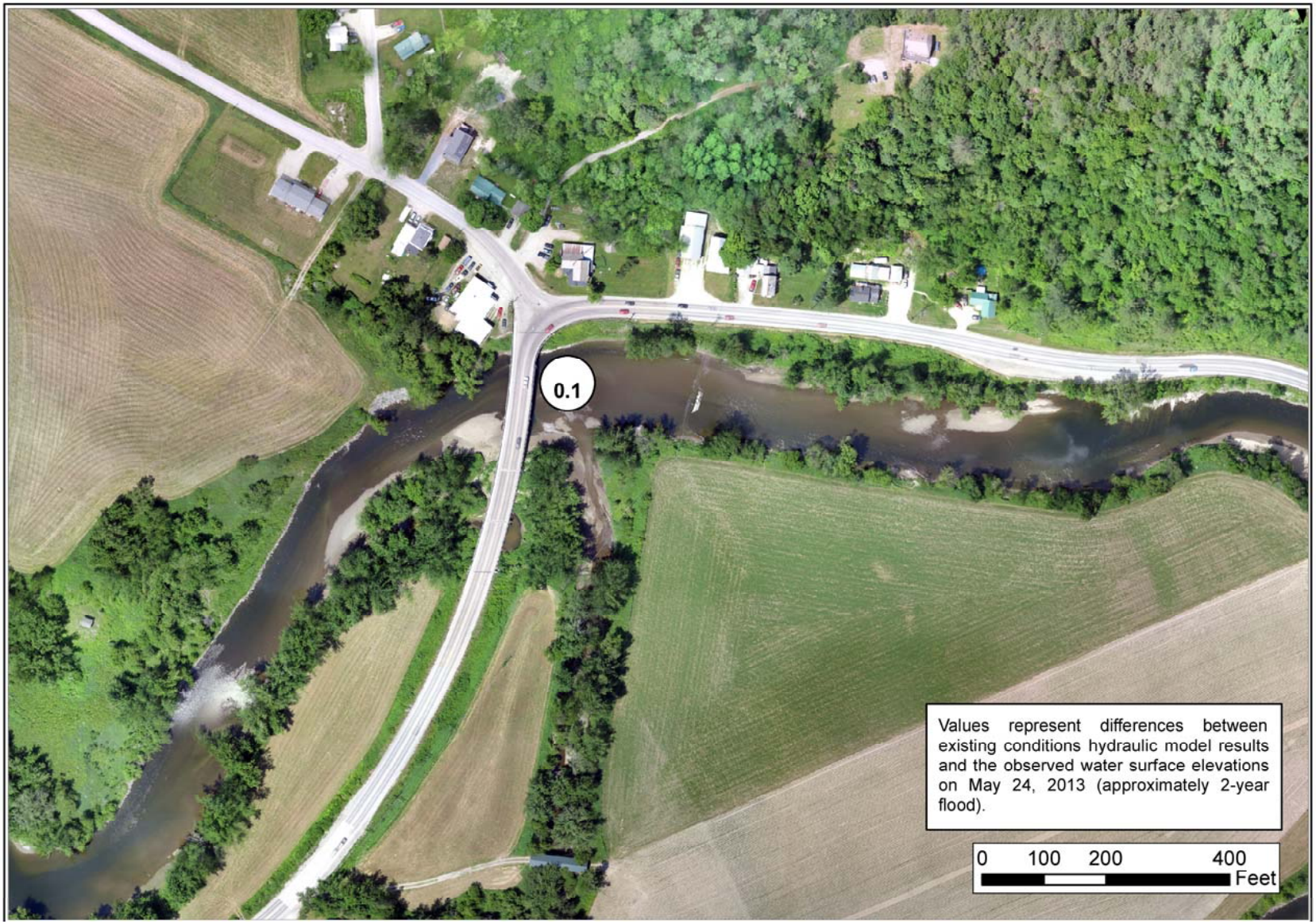
Model Overview Figure (Handout)



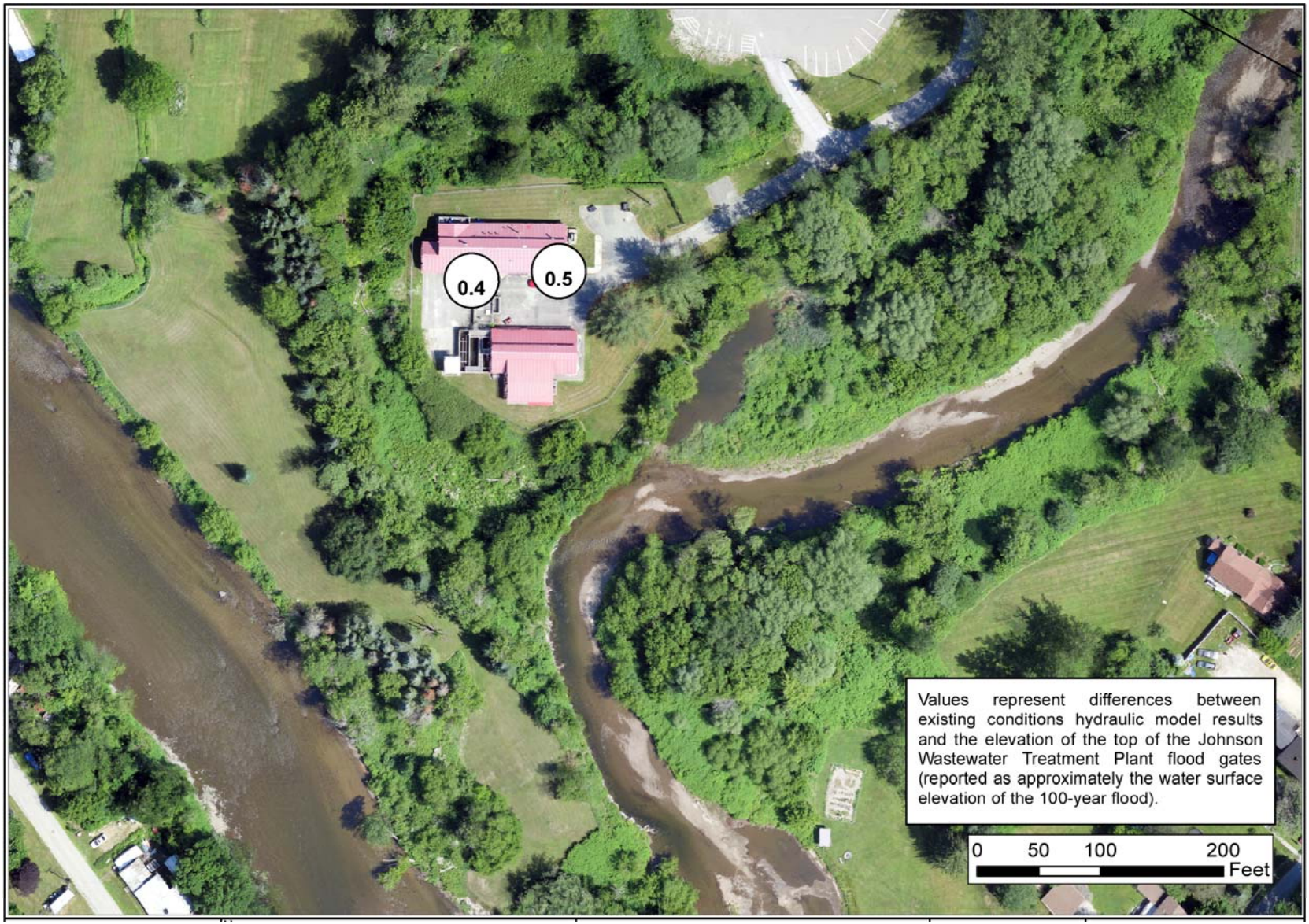
Model Overview Table (Handout)

Town:	Wolcott		Morristown		Johnson		Cambridge	
Channel Length (miles):	8		11		8		15	
Number of Bridges:	10		8		3		5	
Number of Dams:	1		2		0		0	
FEMA Cross Sections:	Town of Wolcott A to AK		Town of Morristown A to AU Village of Morrisville A to P		Town of Johnson A to AO Village of Johnson A to E		Town of Cambridge A to I Village of Jeffersonville A to F	
RAS Cross Sections (#):	10.06 to 10.68 (83)		9.01 to 9.79 (103)		7.01 to 7.56 (59)		6.01 to 6.35 (48)	
	10-year	100-year	10-year	100-year	10-year	100-year	10-year	100-year
Flow In (cfs):	6,550	12,250	8,850	15,500	10,450	18,300	12,950	22,650
Flow Out (cfs):	8,850	15,500	10,450	18,300	12,950	22,650	19,788	30,680
100-year flood difference between RAS model & FEMA data (feet):	-0.7 to 1.6		0.0 to 1.2		0.1 to 3.9		1.3 to 5.9	

Model Calibration – Cambridge (2-year)



Model Calibration – Johnson (100-year)



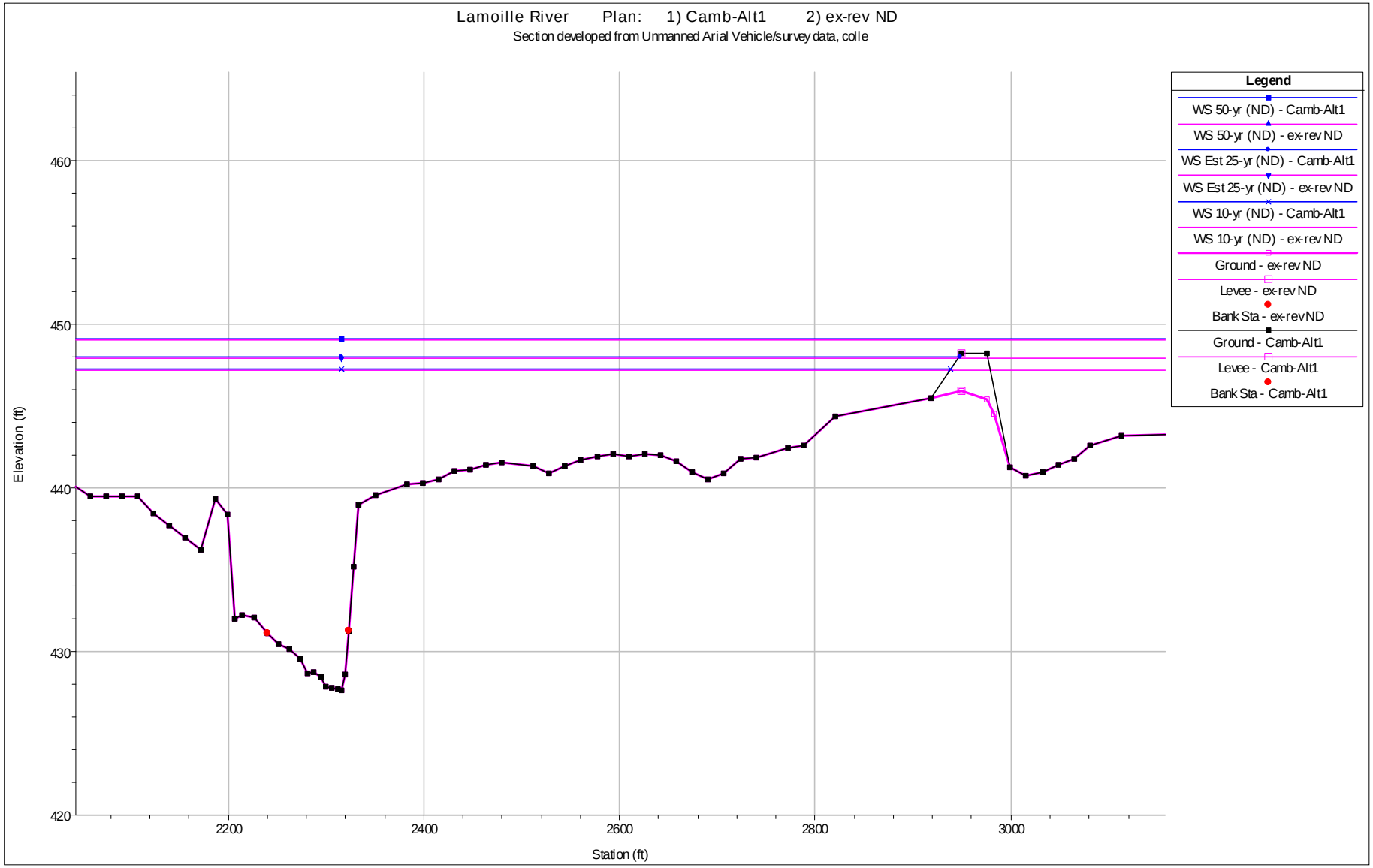
Pumpkin Harbor Road Flooding

Lamoille River Flood
Photo taken by Fly-Right Aerial Photography
Spring 2014

Pumpkin Harbor Road Flooding

Lamoille River Flood
Photo taken by Fly-Right Aerial Photography
Spring 2014

Elevate Pumpkin Harbor Road to Q10+1 (Alt. 1)



Elevate Pumpkin Harbor Road to Q10+1 (Alt. 1)

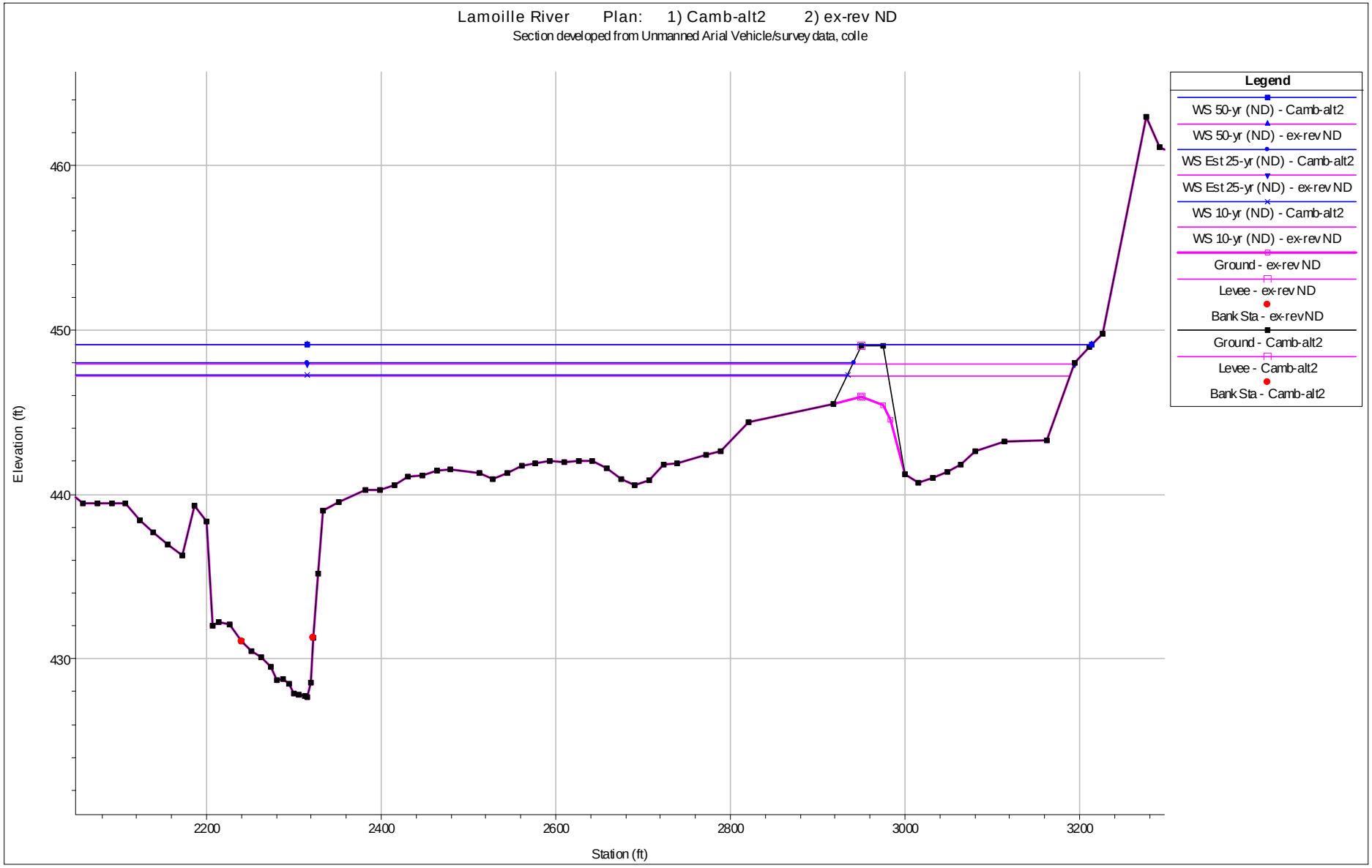
		10-year						Estimated 25-year					
		Flood Elevation		Flood Velocity		Flood Width		Flood Elevation		Flood Velocity		Flood Width	
River Station	Distance from Wrong Way Bridge	Elevation (feet)	Change (feet)	Velocity (ft/s)	Change (ft/s)	Width (feet)	Change (feet)	Elevation (feet)	Change (feet)	Velocity (ft/s)	Change (ft/s)	Width (feet)	Change (feet)
6.15	6,461	448.6	0.1	2.9	0.0	1178.1	1.5	449.4	0.1	2.9	0.0	1199.3	1.6
6.14	4,931	447.9	0.1	4.8	0.0	1228.1	1.2	448.6	0.1	4.9	0.0	1240.3	1.2
6.13	3,851	447.7	0.1	2.2	0.0	1730.7	1.5	448.5	0.1	2.3	0.0	1742.0	1.2
6.121	181	447.6	0.1	1.6	0.0	2512.5	3.6	448.3	0.1	1.6	0.0	2524.9	1.3
6.111	96	447.5	0.1	2.8	0.0	2163.6	22.0	448.3	0.1	2.9	0.0	2297.7	5.7
6.1051	*Bridge*												
6.101	136	447.3	0.1	2.4	0.0	1941.4	21.7	448.0	0.1	2.4	0.0	2240.1	13.7
6.091	300	447.3	0.1	2.9	0.1	2385.5	-167.6	448.0	0.1	2.9	0.1	2620.5	-240.1
6.081	1,179	447.1	0.0	3.7	0.6	1674.5	-417.6	447.9	0.0	3.7	0.7	1889.8	-416.1
6.072	2,952	447.0	0.0	2.2	0.3	2071.6	-425.3	447.8	0.0	2.1	0.3	2086.9	-426.7
6.071	3,825	447.0	0.0	1.6	0.0	2593.2	0.0	447.7	0.0	1.6	0.0	2606.9	0.0
6.06	9,059	446.9	0.0	0.7	0.0	2167.2	0.0	447.7	0.0	0.8	0.0	2175.2	0.0

Red = Increase in flood level, increase in velocity, and increase in top width.

		50-year						100-year					
		Flood Elevation		Flood Velocity		Flood Width		Flood Elevation		Flood Velocity		Flood Width	
River Station	Distance from Wrong Way Bridge	Elevation (feet)	Change (feet)	Velocity (ft/s)	Change (ft/s)	Width (feet)	Change (feet)	Elevation (feet)	Change (feet)	Velocity (ft/s)	Change (ft/s)	Width (feet)	Change (feet)
6.15	6,461	450.4	0.0	3.1	0.0	1229.3	0.2	451.1	0.0	3.2	0.0	1250.8	0.3
6.14	4,931	449.7	0.0	5.2	0.0	1257.0	0.2	450.4	0.0	5.3	0.0	1269.1	0.2
6.13	3,851	449.5	0.0	2.4	0.0	1757.4	0.2	450.3	0.0	2.5	0.0	1768.6	0.2
6.121	181	449.4	0.0	1.7	0.0	2540.3	0.2	450.1	0.0	1.7	0.0	2551.0	0.2
6.111	96	449.3	0.0	3.0	0.0	2437.6	0.6	450.1	0.0	3.1	0.0	2479.6	0.9
6.1051	*Bridge*												
6.101	136	449.1	0.0	2.5	0.0	2499.8	0.2	449.9	0.0	2.5	0.0	2534.6	0.3
6.091	300	449.1	0.0	2.7	0.0	2963.9	0.3	449.9	0.0	2.6	0.0	2995.7	0.2
6.081	1,179	449.0	0.0	3.1	0.1	2769.8	0.7	449.8	0.0	3.1	0.1	2826.7	0.1
6.072	2,952	448.9	0.0	1.8	0.0	2570.2	0.0	449.7	0.0	1.8	0.0	2619.0	0.0
6.071	3,825	448.9	0.0	1.6	0.0	2627.0	-6.0	449.7	0.0	1.6	0.0	2668.5	0.0
6.06	9,059	448.9	0.0	0.9	0.0	2264.8	0.0	449.7	0.0	0.9	0.0	2325.4	0.0

Red = Increase in flood level, increase in velocity, and increase in top width.

Elevate Pumpkin Harbor Road to Q25+1 (Alt. 2)



Elevate Pumpkin Harbor Road to Q25+1 (Alt. 2)

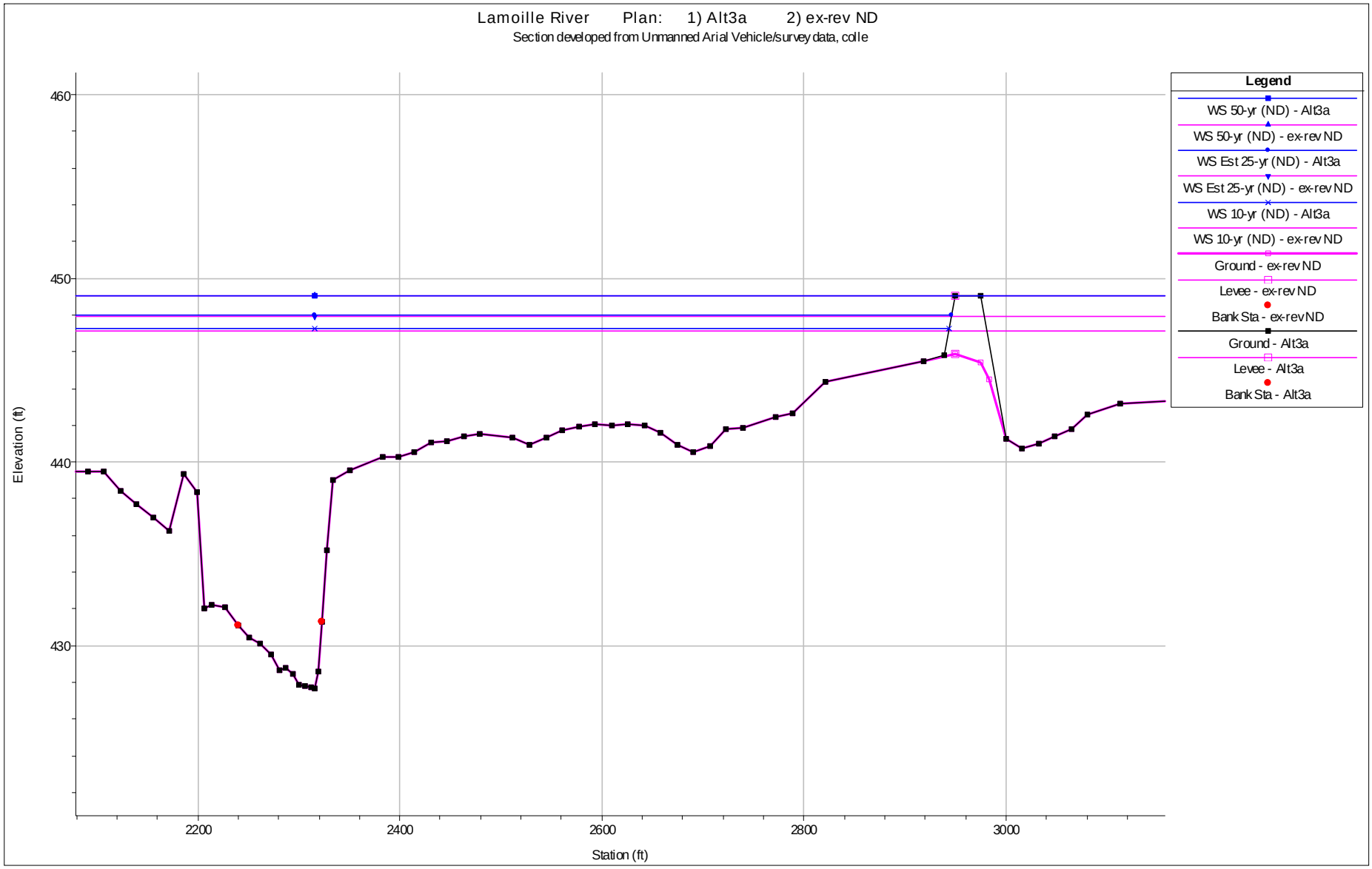
		10-year						Estimated 25-year					
		Flood Elevation		Flood Velocity		Flood Width		Flood Elevation		Flood Velocity		Flood Width	
River Station	Distance from Wrong Way Bridge	Elevation (feet)	Change (feet)	Velocity (ft/s)	Change (ft/s)	Width (feet)	Change (feet)	Elevation (feet)	Change (feet)	Velocity (ft/s)	Change (ft/s)	Width (feet)	Change (feet)
6.15	6,461	448.6	0.1	2.9	0.0	1178.1	1.5	449.4	0.1	2.9	0.0	1199.3	1.6
6.14	4,931	447.9	0.1	4.8	0.0	1228.1	1.2	448.6	0.1	4.9	0.0	1240.3	1.2
6.13	3,851	447.7	0.1	2.2	0.0	1730.7	1.5	448.5	0.1	2.3	0.0	1742.0	1.2
6.121	181	447.6	0.1	1.6	0.0	2512.5	3.6	448.3	0.1	1.6	0.0	2524.9	1.3
6.111	96	447.5	0.1	2.8	0.0	2163.6	22.0	448.3	0.1	2.9	0.0	2297.7	5.7
6.1051	*Bridge*												
6.101	136	447.3	0.1	2.4	0.0	1941.4	21.7	448.0	0.1	2.4	0.0	2240.1	13.7
6.091	300	447.3	0.1	2.9	0.1	2385.5	-167.6	448.0	0.1	2.9	0.1	2620.5	-240.1
6.081	1,179	447.1	0.0	3.7	0.6	1674.5	-417.6	447.9	0.0	3.7	0.7	1889.8	-416.1
6.072	2,952	447.0	0.0	2.2	0.3	2071.6	-425.3	447.8	0.0	2.1	0.3	2086.9	-426.7
6.071	3,825	447.0	0.0	1.6	0.0	2593.2	0.0	447.7	0.0	1.6	0.0	2606.9	0.0
6.06	9,059	446.9	0.0	0.7	0.0	2167.2	0.0	447.7	0.0	0.8	0.0	2175.2	0.0

Red = Increase in flood level, increase in velocity, and increase in top width.

		50-year						100-year					
		Flood Elevation		Flood Velocity		Flood Width		Flood Elevation		Flood Velocity		Flood Width	
River Station	Distance from Wrong Way Bridge	Elevation (feet)	Change (feet)	Velocity (ft/s)	Change (ft/s)	Width (feet)	Change (feet)	Elevation (feet)	Change (feet)	Velocity (ft/s)	Change (ft/s)	Width (feet)	Change (feet)
6.15	6,461	450.4	0.0	3.1	0.0	1229.4	0.3	451.1	0.0	3.2	0.0	1250.8	0.4
6.14	4,931	449.7	0.0	5.2	0.0	1257.1	0.2	450.4	0.0	5.3	0.0	1269.1	0.3
6.13	3,851	449.5	0.0	2.4	0.0	1757.4	0.2	450.3	0.0	2.5	0.0	1768.6	0.3
6.121	181	449.4	0.0	1.7	0.0	2540.3	0.2	450.1	0.0	1.7	0.0	2551.1	0.3
6.111	96	449.3	0.0	3.0	0.0	2437.8	0.8	450.1	0.0	3.1	0.0	2479.8	1.1
6.1051	*Bridge*												
6.101	136	449.1	0.0	2.5	0.0	2499.9	0.4	449.9	0.0	2.5	0.0	2534.7	0.3
6.091	300	449.1	0.0	2.7	0.0	2963.9	0.4	449.9	0.0	2.7	0.0	2995.7	0.2
6.081	1,179	449.0	0.0	3.1	0.1	2769.8	0.7	449.8	0.0	3.1	0.1	2826.7	0.1
6.072	2,952	448.9	0.0	1.8	0.0	2570.2	0.0	449.7	0.0	1.8	0.0	2619.0	0.0
6.071	3,825	448.9	0.0	1.6	0.0	2627.0	-6.0	449.7	0.0	1.6	0.0	2668.5	0.0
6.06	9,059	448.9	0.0	0.9	0.0	2264.8	0.0	449.7	0.0	0.9	0.0	2325.4	0.0

Red = Increase in flood level, increase in velocity, and increase in top width.

Elevate Pumpkin Harbor Road to Q50 (Alt. 3a)



Elevate Pumpkin Harbor Road to Q50 (Alt. 3a)

		10-year						Estimated 25-year					
		Flood Elevation		Flood Velocity		Flood Width		Flood Elevation		Flood Velocity		Flood Width	
River Station	Distance from Wrong Way Bridge	Elevation (feet)	Change (feet)	Velocity (ft/s)	Change (ft/s)	Width (feet)	Change (feet)	Elevation (feet)	Change (feet)	Velocity (ft/s)	Change (ft/s)	Width (feet)	Change (feet)
6.15	6,461	448.6	0.1	2.9	0.0	1178.1	1.5	449.4	0.1	2.9	0.0	1199.3	1.6
6.14	4,931	447.9	0.1	4.8	0.0	1228.1	1.2	448.6	0.1	4.9	0.0	1240.3	1.2
6.13	3,851	447.7	0.1	2.2	0.0	1730.7	1.5	448.5	0.1	2.3	0.0	1742.0	1.2
6.121	181	447.6	0.1	1.6	0.0	2512.5	3.6	448.3	0.1	1.6	0.0	2524.9	1.3
6.111	96	447.5	0.1	2.8	0.0	2163.6	22.0	448.3	0.1	2.9	0.0	2297.7	5.8
6.1051	*Bridge*												
6.101	136	447.3	0.1	2.4	0.0	1941.5	21.8	448.0	0.1	2.4	0.0	2235.2	8.8
6.091	300	447.3	0.1	2.9	0.1	2390.9	-162.2	448.0	0.1	2.9	0.1	2619.2	-241.4
6.081	1,179	447.1	0.0	3.7	0.6	1672.0	-420.2	447.9	0.0	3.7	0.7	1887.1	-418.8
6.072	2,952	447.0	0.0	2.2	0.3	2069.2	-427.7	447.8	0.0	2.1	0.3	2084.4	-429.2
6.071	3,825	447.0	0.0	1.6	0.0	2593.2	0.0	447.7	0.0	1.6	0.0	2606.9	0.0
6.06	9,059	446.9	0.0	0.7	0.0	2167.2	0.0	447.7	0.0	0.8	0.0	2175.2	0.0

Red = Increase in flood level, increase in velocity, and increase in top width.

		50-year						100-year					
		Flood Elevation		Flood Velocity		Flood Width		Flood Elevation		Flood Velocity		Flood Width	
River Station	Distance from Wrong Way Bridge	Elevation (feet)	Change (feet)	Velocity (ft/s)	Change (ft/s)	Width (feet)	Change (feet)	Elevation (feet)	Change (feet)	Velocity (ft/s)	Change (ft/s)	Width (feet)	Change (feet)
6.15	6,461	450.4	0.0	3.1	0.0	1229.4	0.3	451.1	0.0	3.2	0.0	1250.9	0.4
6.14	4,931	449.7	0.0	5.2	0.0	1257.1	0.2	450.4	0.0	5.3	0.0	1269.2	0.3
6.13	3,851	449.5	0.0	2.4	0.0	1757.5	0.2	450.3	0.0	2.5	0.0	1768.7	0.3
6.121	181	449.4	0.0	1.7	0.0	2540.3	0.2	450.1	0.0	1.7	0.0	2551.1	0.3
6.111	96	449.3	0.0	3.0	0.0	2437.9	0.9	450.1	0.0	3.1	0.0	2479.9	1.2
6.1051	*Bridge*												
6.101	136	449.1	0.0	2.5	0.0	2500.3	0.8	449.9	0.0	2.5	0.0	2534.7	0.3
6.091	300	449.1	0.0	2.7	0.0	2964.0	0.5	449.9	0.0	2.7	0.0	2995.8	0.2
6.081	1,179	449.0	0.0	3.1	0.1	2769.9	0.8	449.8	0.0	3.1	0.1	2826.7	0.1
6.072	2,952	448.9	0.0	1.9	0.0	2570.2	0.0	449.7	0.0	1.9	0.0	2619.0	0.0
6.071	3,825	448.9	0.0	1.6	0.0	2627.0	-6.0	449.7	0.0	1.6	0.0	2668.4	-0.1
6.06	9,059	448.9	0.0	0.9	0.0	2264.8	0.0	449.7	0.0	0.9	0.0	2325.4	0.0

Red = Increase in flood level, increase in velocity, and increase in top width.

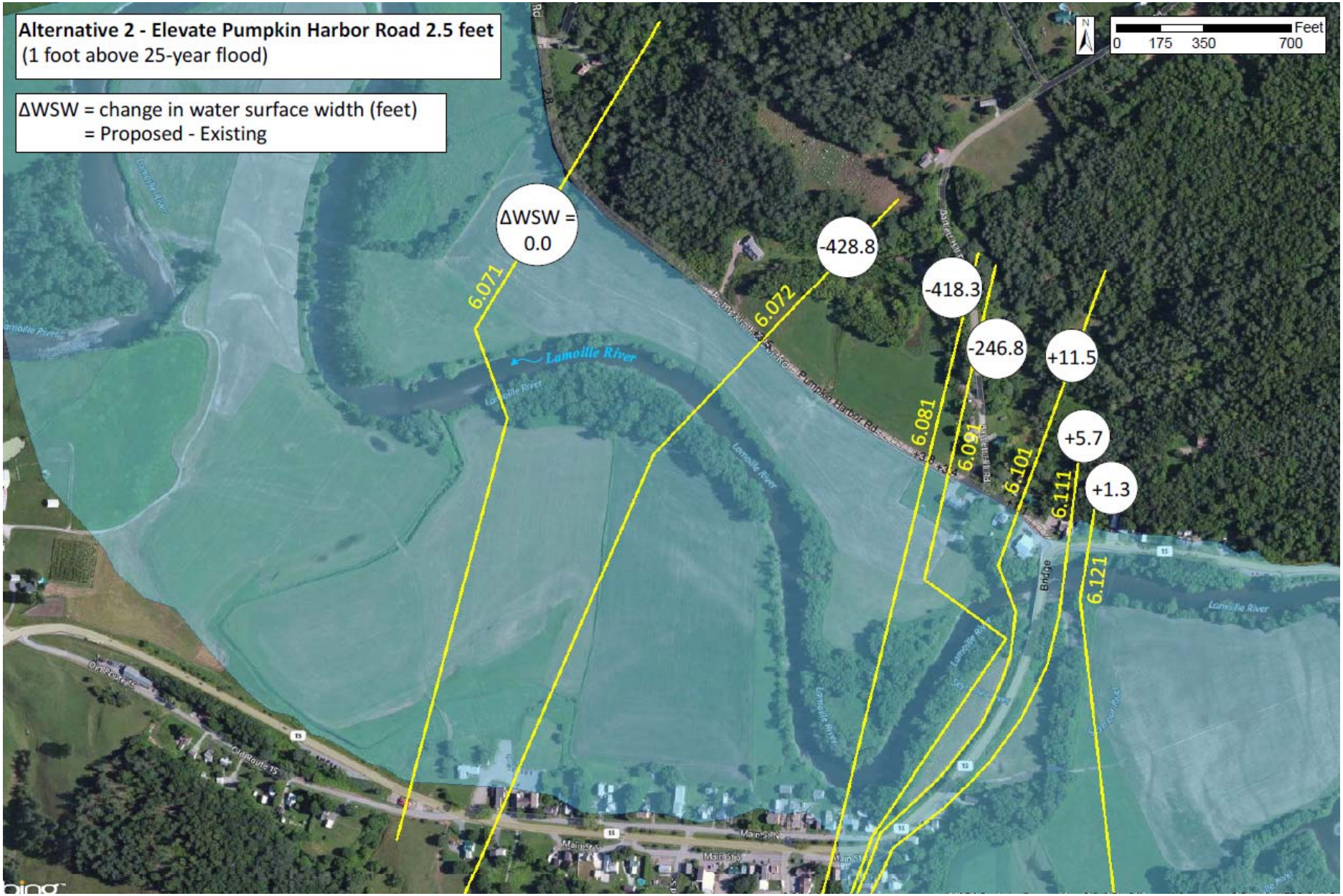
Alternatives Analysis Summary

Alternative	Level to Elevate Pumpkin Harbor Road	Average Fill Depth (feet)	Fill Volume (Cubic Yards)	Reduce Flood and Erosion Risk to Road	No Adverse Impacts	Comparative Implementation Cost	Comparative Maintenance Cost	Preferred
1	1 foot above 10-year flood level	1.7	10,738	+	+	Low	High	
2	1 foot above 25-year flood level	2.4	17,125	+	+	Moderate	Moderate	YES
3a	50-year flood level	2.8	20,679	+	o	Moderate	Moderate	
3	1 foot above 50-year flood level	3.4	25,561	o	-	Moderate	Moderate	
4	100-year flood level	4.4	30,925	o	-	High	Low	

KEY: ++ = best; + = good; o = moderate; - = poor

Pumpkin Harbor Road Guide Map (25-year Flood)

Elevate Pumpkin Harbor Road to Q25+1 (Alt. 2)



Elevate Pumpkin Harbor Road to Q25+1 (Alt. 2)

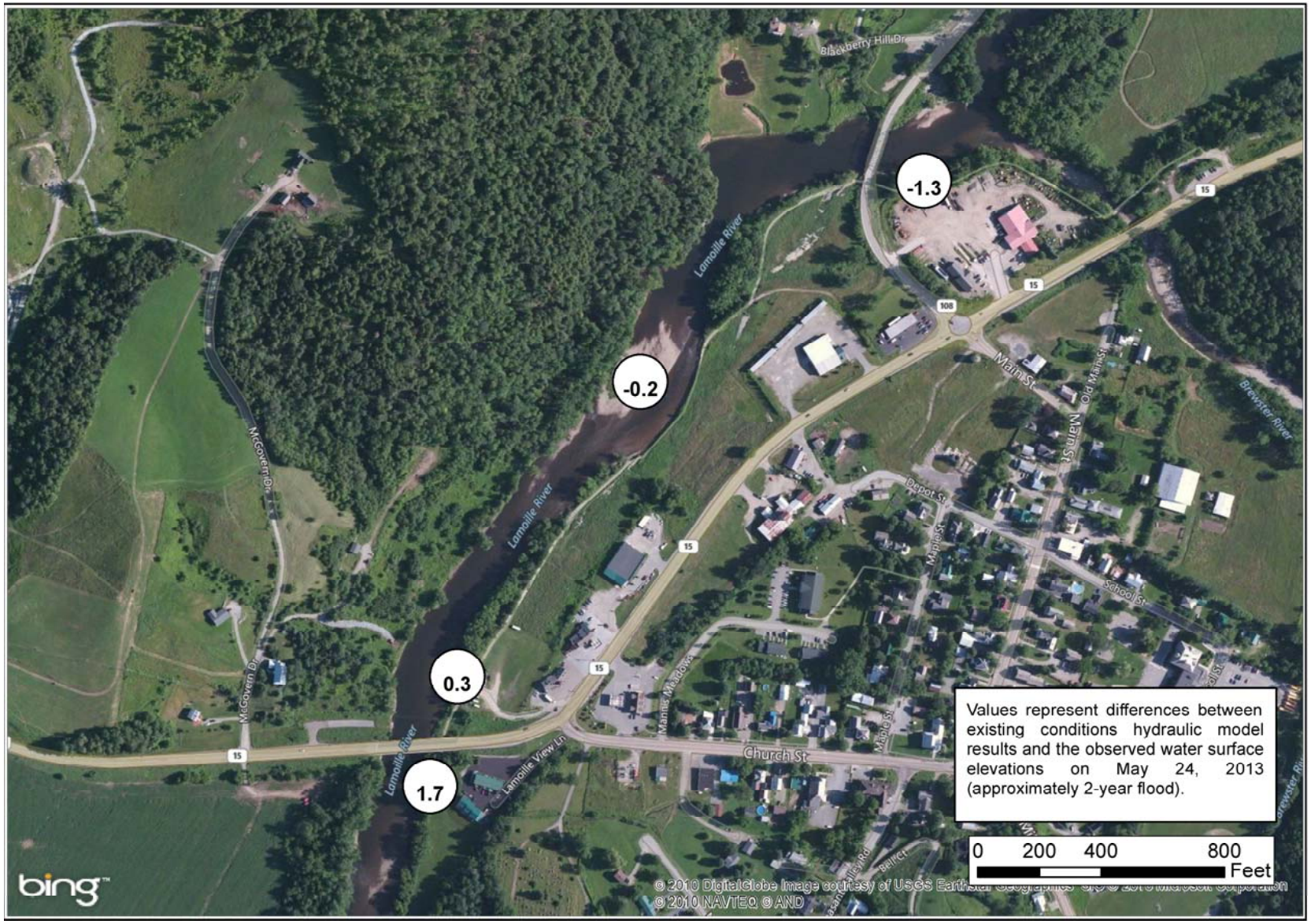
Elevate Pumpkin Harbor Road to Q25+1 (Alt. 2)

Extra Slides

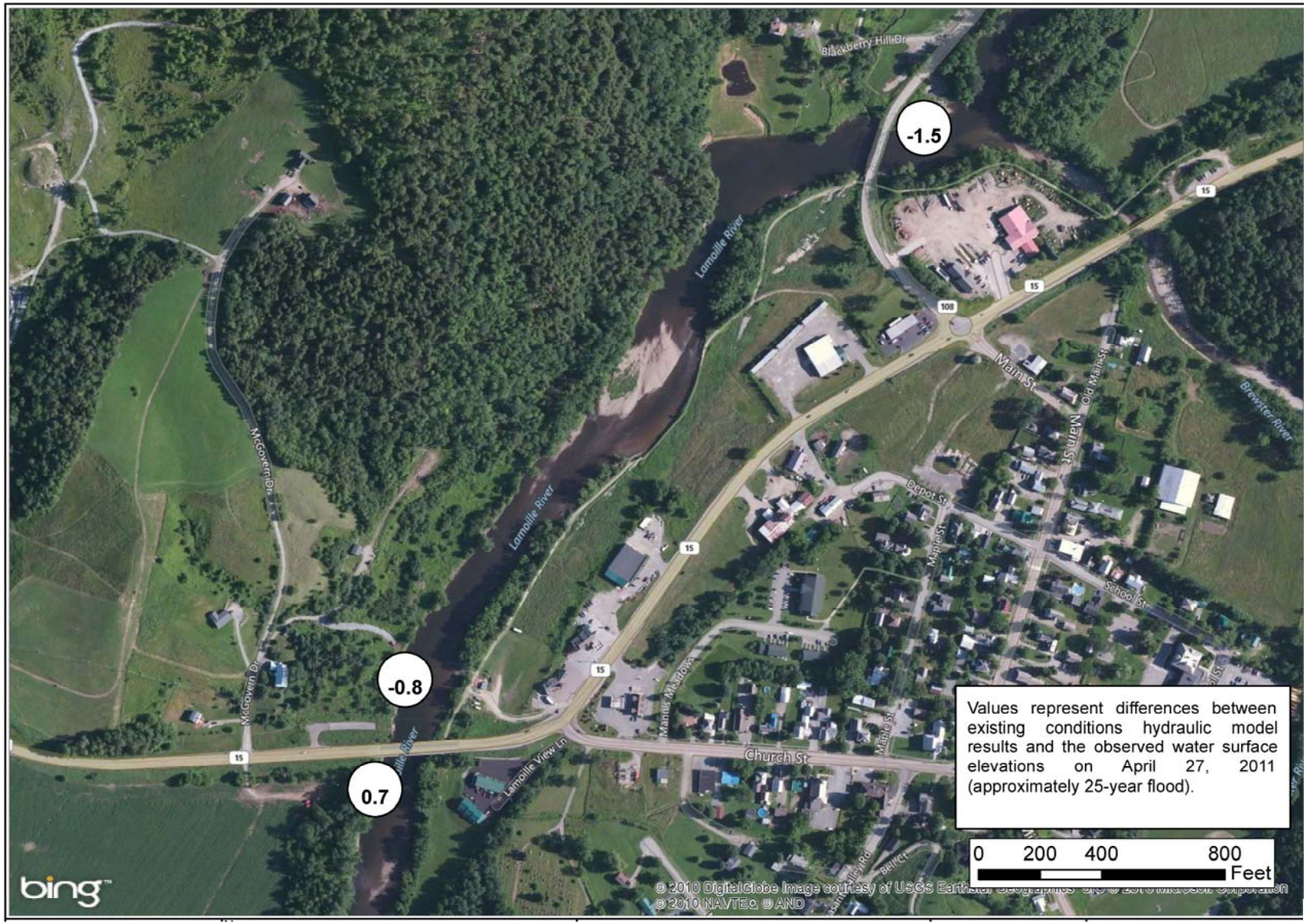
Model Calibration

Location Description	Model Section	Observed WSE 4/27/2011	Model WSE 25-year	**Difference**	Observed WSE 5/24/2013	Model WSE 2-year	**Difference**
Lamoille River:							
Wrong Way Bridge	Lamoille 6.1051	N/A	N/A	N/A	444.5	444.6	**0.1**
DS of Route 15	Lamoille 6.171	452	452.7	**0.7**	448	449.67	**1.7**
USGS Gage at Route 15	Lamoille 6.181	453.89	453.1	**-0.8**	449.55	449.9	**0.3**
Left bank erosion	Lamoille 6.221	N/A	N/A	N/A	451.5	451.26	**-0.2**
US of Route 108	Lamoille 6.261	459	457.48	**-1.5**	454	452.73	**-1.3**
Location Description	Model Section	Observed WSE 4/27/2011	Model WSE 25-year	**Difference**	Height of WWTP flood gates (approx 100-yr flood)	Model WSE 100-year	**Difference**
Gihon River:							
At Johnson Wastewater Treatment Plant	Gihon 100.1	496.0	494.6	**-1.4**	497.4	497.9	**0.5**
At Johnson Wastewater Treatment Plant	Gihon 100.0	496.0	494.5	**-1.5**	497.4	497.9	**0.4**

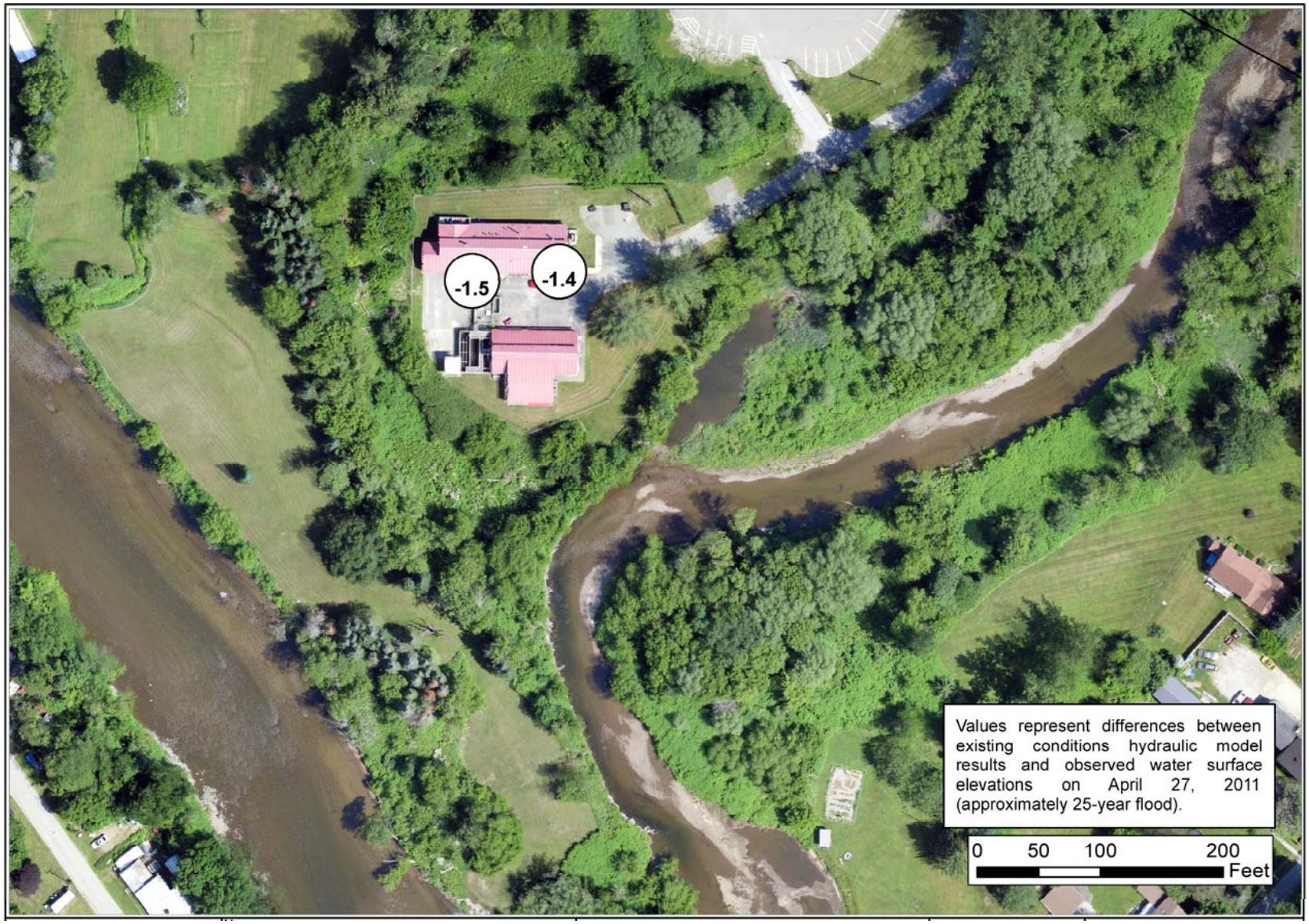
Model Calibration – Jeffersonville (2-year)



Model Calibration – Jeffersonville (25-year)



Model Calibration – Johnson (25-year)



HEC-RAS Predicts…

- FLOW WIDTH, DEPTH AND AREA
- WATER PROFILES
- CRITICAL FLOW
- VELOCITY
- ENERGYGRADE ELEVATIONS
- FLOODPLAIN SIZE
- SHEAR STRESS

HEC-RAS Limitations

- HYDRAULICS AT CONFLUENCE AREAS
- DEFORMABLE BOUNDARIES
- FLOOD AND SEDIMENT PULSES (RAPIDLY VARYING FLOW)
- FLOW AND SEDIMENT YIELD ESTIMATED INDEPENDENTLY
- MEANDER GEOMETRY INVISIBLE TO MODEL
- NO LATERAL CHANNEL MIGRATION (AVULSION)
- PRECISE FLOOD LEVELS (UNLESS VALIDATED)
- COMPLEX (2D) FLOW PATTERNS

MILONE & MACBROOM