Downstream Analysis

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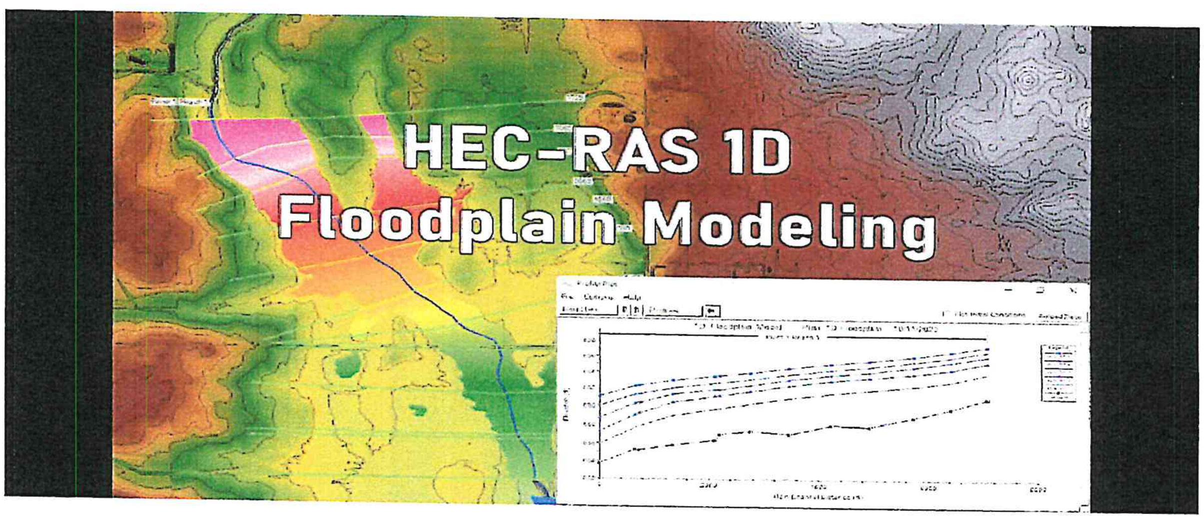
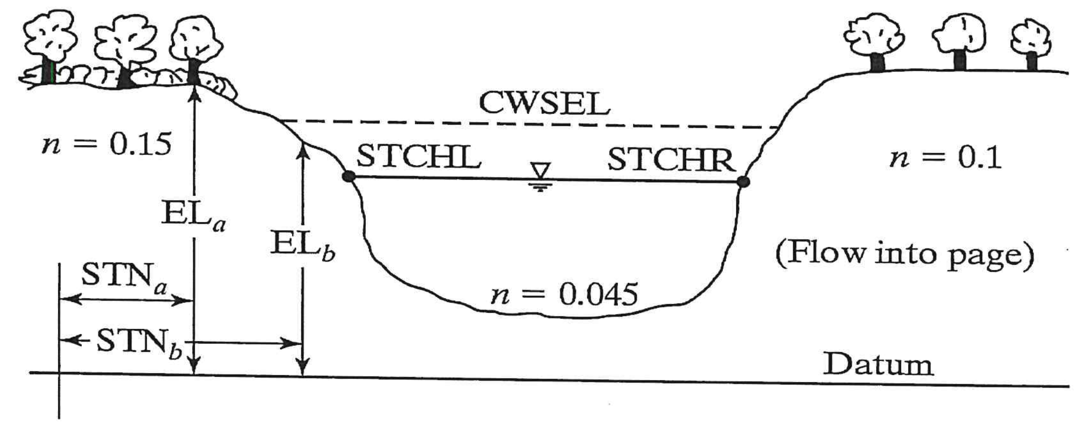
Downstream Analysis – HEC RAS

RAISE THE RED FLAG

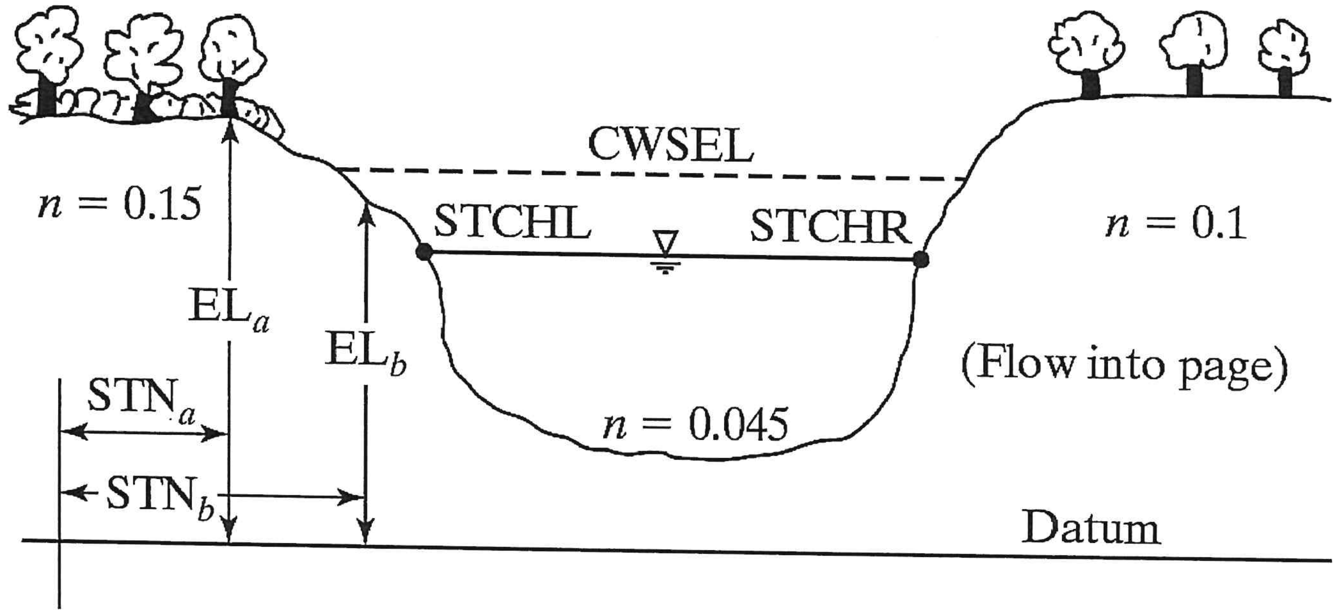
Stormwater designers must be able to demonstrate that runoff will not cause downstream flooding within the stream reach. A typical downstream will require a hydrologic investigation of the disturbed area …and the contributory watershed… for the 10 and 100–year, 24–hour, Type III storms. Depending on the magnitude of the impact and the specific conditions of the analysis, additional information may be necessary such as collecting field run topography, establishing building elevations and culvert sizes or investigating specific drainage.



HEC RAS (River Analysis System, 1995)



HEC RAS or (HEC-2)is a computer model designed for natural cross sections in natural rivers. It solves the governing equations for the standard step method, generally in a downstream to upstream direction. It can Also handle the presence of bridges, culverts, and variable roughness, flow rate, depth, and velocity.



EL_a, EL_b = Ground elevation above datum for points a and b, respectively

STN_a, STN_b = Distance from reference point for points a and b, respectively

STCHL = Left channel bank station (when looking downstream)

STCHR = Right channel bank station (when looking downstream)

Note: Up to 100 points (EL, STN) may be defined for each section.

Figure 7.11

Typical cross section.

Philip B. Bedient
Hydrology and Floodplain Analysis

Proposed Gooding Avenue Hotel

Downstream Analysis

Natural Streams Characteristics

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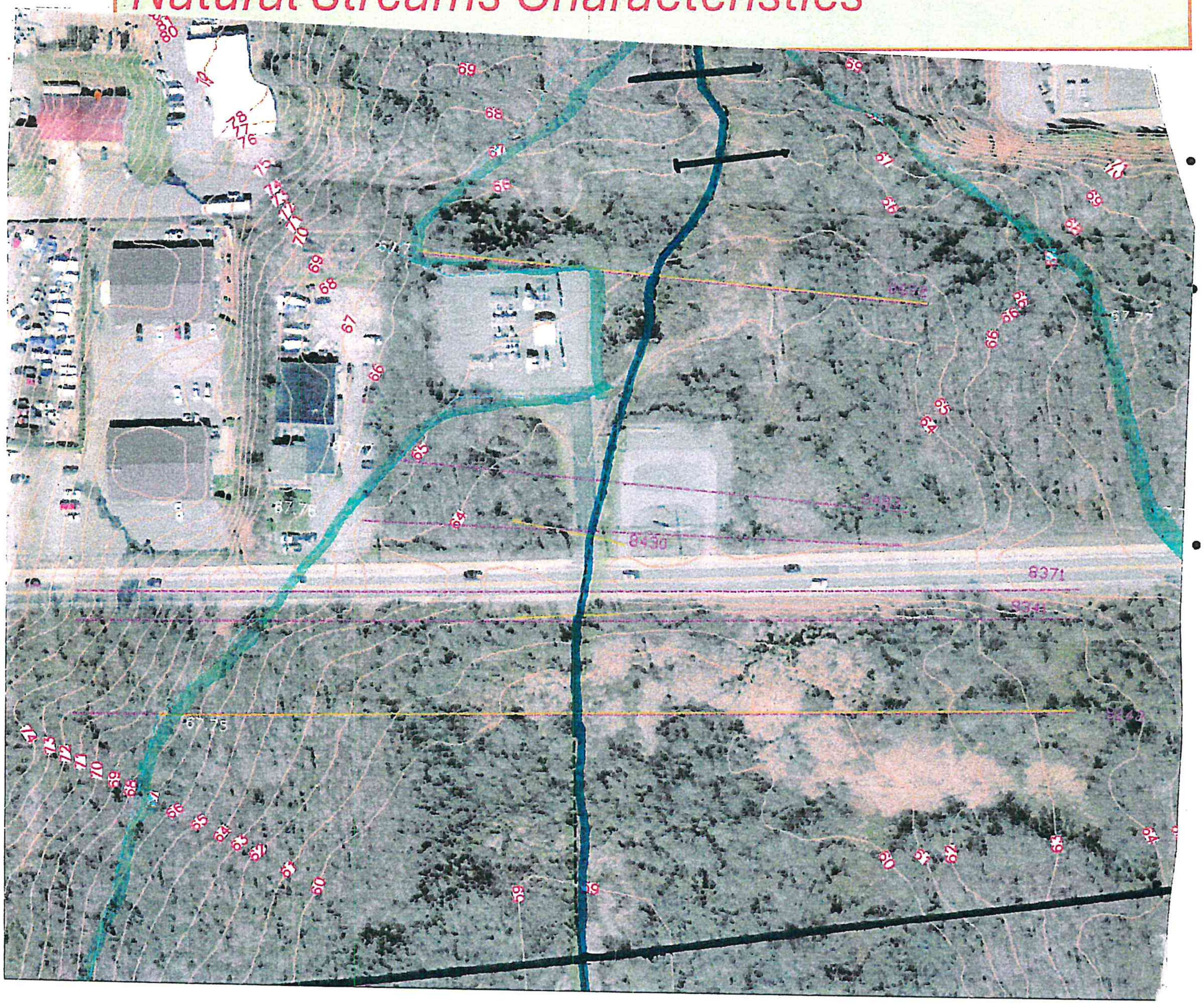

- Natural streams are **NOT Uniform**
- They have varying shapes, depths, slopes, velocities, and surface conditions.
- ~~Areal~~ AERIAL photograph shows two different Silver Creek cross-sections: 250 feet north and 250 feet south of Gooding Ave.

HEC RAS Silver Creek Cross Sections

North of Gooding Ave

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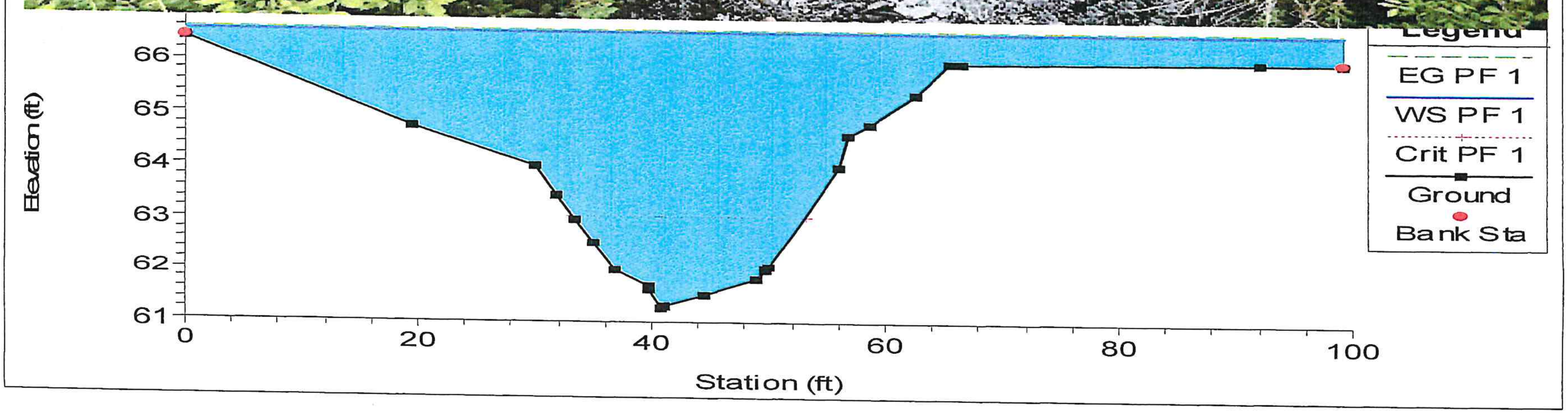
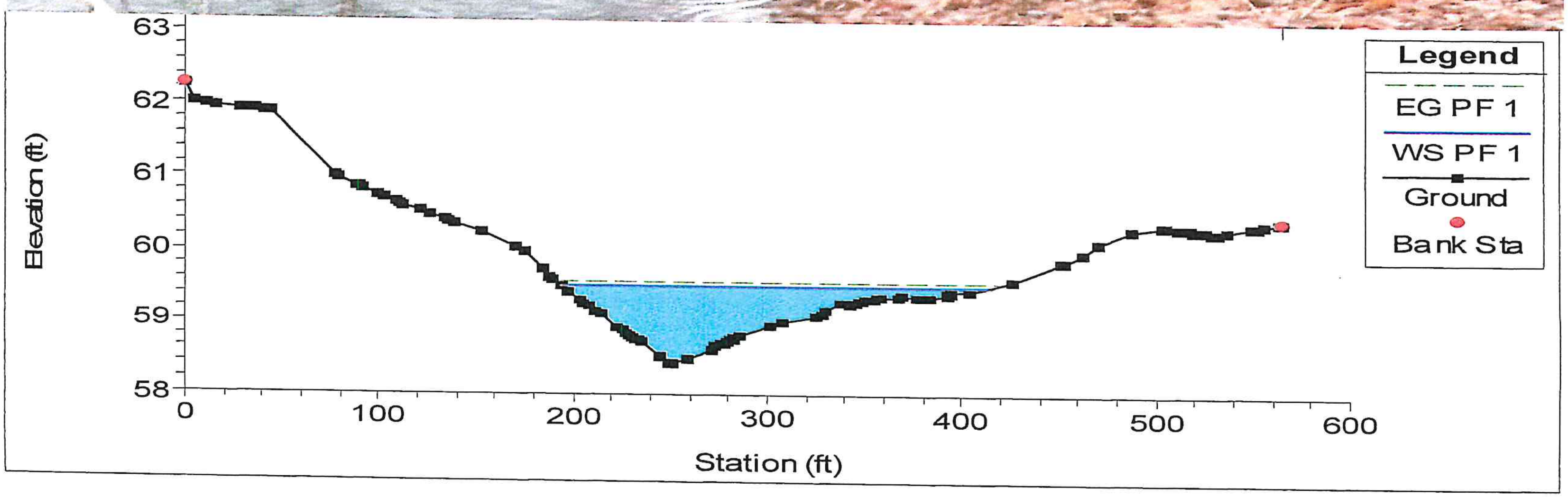


HEC RAS Silver Creek Cross-Section

South of Gooding Ave.

RED FLAG WARNING



The Standard Step Procedure in HEC-RAS

The HEC-RAS algorithm uses the following steps to compute water surface elevations using the standard step method:

1. Establish the downstream boundary condition for subcritical flow or the upstream boundary condition for supercritical flow. The boundary conditions include the starting water surface elevation or depth, the discharge, and the initial cross-section geometry. The starting water surface elevation could be obtained from a measured value at a gage, by assuming critical depth, by assuming normal depth, or by estimating. The conveyance and discharge in the left and right overbanks and in the channel are computed for the specified starting water surface elevation. The discharge-weighted velocity head and the friction slope at the boundary are calculated. In addition, the cross-section geometry for all locations at which computations are required must be known, along with Manning's *n* values, reach lengths, obstruction data, and discharges throughout the river system.
2. The water surface elevation is estimated, with the assumption of subcritical flow, at the next cross section (Section 2) upstream from the boundary (Section 1). HEC-RAS projects the depth from Section 1 onto Section 2 for an initial estimate of the water surface elevation.
3. For the assumed water surface elevation at Section 2, the incremental conveyance is computed for the left and right overbanks and for the channel at Section 2, using Equation 2.47. The conveyance is summed to obtain the total conveyance at Section 2.
4. The total discharge at Section 2 is distributed to the left and right overbank areas and to the channel in proportion to the incremental conveyance. An average discharge is computed for each of the three flow paths (channel and left and right overbank distance) between the two sections.
5. The friction slope at Section 2 is computed with Equation 2.51 from the total discharge and total conveyance at Section 2.
6. The average velocities in the left and right overbank, the channel, and the entire cross section are computed. The mean velocity head is computed with a modification of Equation 2.48 for the velocity and discharge terms for each channel subsegment (left and right overbank areas and the channel) and the total section discharge and average velocity. Although HEC-RAS does not use α for the computations, it is computed and displayed for inspection by the user. The program sets the discharge-weighted velocity head (including α) equal to the right-hand side of the following equation:

$$\alpha\frac{V_{ave}^2}{2g} = \frac{1}{2g}\left(\frac{V_{lob}^2 Q_{lob} + V_{ch}^2 Q_{ch} + V_{rob}^2 Q_{rob}}{Q_{TOT}}\right)$$

7. The initial estimate of the energy grade line elevation is obtained by adding the mean velocity head found from step 6 to the estimated water surface elevation of step 2.
8. A discharge-weighted reach length (L_Q) is found from the discharge and the reach length for each of the three flow paths between the two sections. Equation 2.53 is used for this computation in HEC-RAS.
9. The average friction slope is found between the two sections. Four different equations for average friction slope are available in HEC-RAS. The friction loss between the two sections is computed with Equation 2.44.
10. The mean velocity head at section 2 is subtracted from the mean velocity head at section 1. If the difference is negative, the flow area is contracting and the coefficient of contraction is used in Equation 2.45 to compute the contraction loss. If the difference is positive, the flow area is expanding and the coefficient of expansion is used in Equation 2.45 to compute an expansion loss.
11. Equation 2.46 is used to compute the water surface elevation at Section 2 and the value is compared to the assumed value from step 2. If the difference is within a predefined tolerance, the elevation is accepted as correct and computations move on to the next section upstream (Section 3), with steps 2–11 repeated for computations between Sections 2 and 3. If the difference is outside the required tolerance, a revised $WSEL_2$ is estimated and steps 3–11 are repeated until the tolerance is met.

HEC RAS Abbreviations

Profile Number	Profile Number	
Q Total	Total Flow in Cross-Section	cfs
Min CL El	Minimum Main Channel Elevation	feet
W.S. El	Calculated water surface from Energy equation	feet
Crit W S.	Critical Water Surface elevation. Water surface Corresponding to the minimum energy on the energy versus depth curve	feet
E G Elev	Energy grade line for calculated WS elevation	feet
E G Slope	Slope of Energy Grade line	ft/ft
Vel Chan	Average velocity of flow in main channel	ft/s
Flow Area	Total area of cross section total flow	sqft
Top Width	Total width of wetted cross section	ft
Froude # Chi number	Froude number for main channel	

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HEC RAS Model Silver Creek (East) and Elbow Tributary - Results

Showing the hydraulic parameters for each cross-section used to determine flood elevations

HEC-RAS Plan: Plan 08 River: Silver Creek Reach: Silver Creek Upp Profile: PF 1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Silver Creek Upp	9611	PF 1	88.64	78.00	79.21	78.74	79.28	0.013668	2.12	41.85	52.63	0.42
Silver Creek Upp	9386	PF 1	88.64	72.00	72.62	72.62	72.85	0.092268	3.88	22.87	49.01	1.00
Silver Creek Upp	9098	PF 1	88.64	68.00	69.44	68.71	69.46	0.003189	1.00	89.04	117.43	0.20
Silver Creek Upp	8754	PF 1	149.10	64.00	64.53	64.53	64.68	0.109725	3.11	47.98	163.30	1.01
Silver Creek Upp	8483	PF 1	337.53	58.00	63.74	59.51	63.74	0.000098	0.53	689.95	198.47	0.05
Silver Creek Upp	8443		Culvert									
Silver Creek Upp	8410	PF 1	337.53	58.00	63.73		63.74	0.000099	0.53	688.45	198.40	0.05
Silver Creek Upp	8402	PF 1	337.53	58.00	63.73		63.73	0.000035	0.28	1035.96	250.00	0.03
Silver Creek Upp	8304	PF 1	361.40	57.00	63.73		63.73	0.000007	0.13	2747.49	788.61	0.01
Silver Creek Upp	8055	PF 1	373.98	57.00	63.73		63.73	0.000005	0.11	3460.45	952.02	0.01
Silver Creek Upp	7475	PF 1	373.98	57.00	63.73		63.73	0.000001	0.07	5241.41	982.78	0.01
Silver Creek Upp	6822	PF 1	382.86	56.00	63.73		63.73	0.000002	0.08	4710.17	1103.27	0.01
Silver Creek Upp	6602	PF 1	382.86	56.00	63.73		63.73	0.000004	0.12	3186.43	677.10	0.01
Silver Creek Upp	6406	PF 1	382.86	56.00	63.71		63.72	0.000140	0.84	456.42	60.56	0.05

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HEC RAS Model Silver Creek (East) and Elbow Tributary

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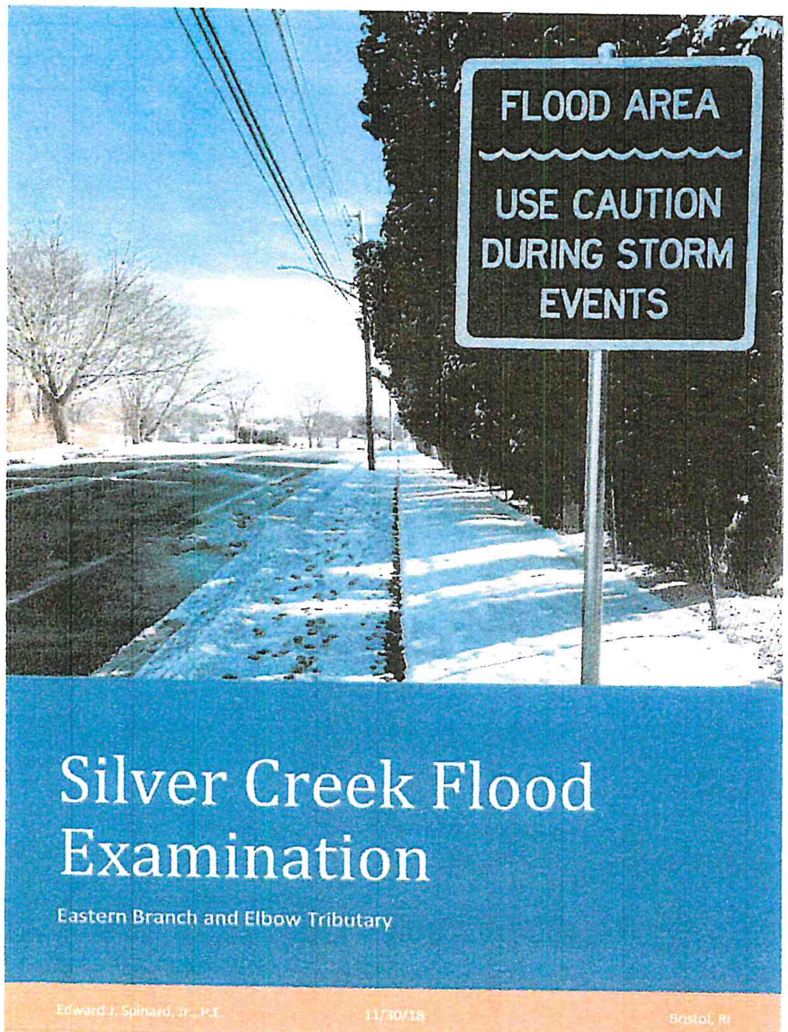

- Prepared to understand the dynamics of natural river flow better.
- Prepared to identify Silver Creek's unique characteristics and how they affect flood flow and flood elevations.
- Prepared to show the feasibility of creating a HEC RAS model of Silver Creek
- Note: This Report does not include recent changes to the High School stormwater management system