PROJECT CONCEPT
TOWN OF GOSHEN
MILL CREEK AND CALFPASTURE RIVER CONFLUENCE

Location Description
37.98634, -79.49412
Confluence of Mill Creek and Calfpasture River at the eastern end of town. Multiple road and railroad bridges cross the area.

Project Purpose
Alleviate the primary hydraulic choke point at the Mill Creek/Calfpasture River confluence to evaluate and reduce, where feasible, flood depths and duration for the entire Town of Goshen and maintain emergency access routes.

Additional Information Needed
- FEMA flood study data and results
- Rate of channel debris accumulation
- Presence and location of utilities
- Nature and status of noted EPA restriction on channel modification

Background
The Town of Goshen is situated within the floodplain of the confluence of Mill Creek and the Calfpasture River, with portions of the Town in the regulatory floodway (**Figure 1**). There is a natural choke point in the corridor during high flows, with multiple road and railroad bridges crossing the channels, leading to a hydraulic restriction. When flows are high in Mill Creek and the Calfpasture River, significant portions of the town flood. Town staff have noted that the channels often accumulate logs, debris, and vegetation overgrowth that may obstruct flow. Mill Creek is particularly susceptible to debris jams at the low bridge on Maury River Road (**Figure 2**, **Figure 3**). The routine flooding of this low bridge was noted as a particular concern, as the crossing is utilized by emergency vehicles to access the northern portion of the Town when train cars may be blocking the primary route (Main Street/VA Route 39 Alternate).

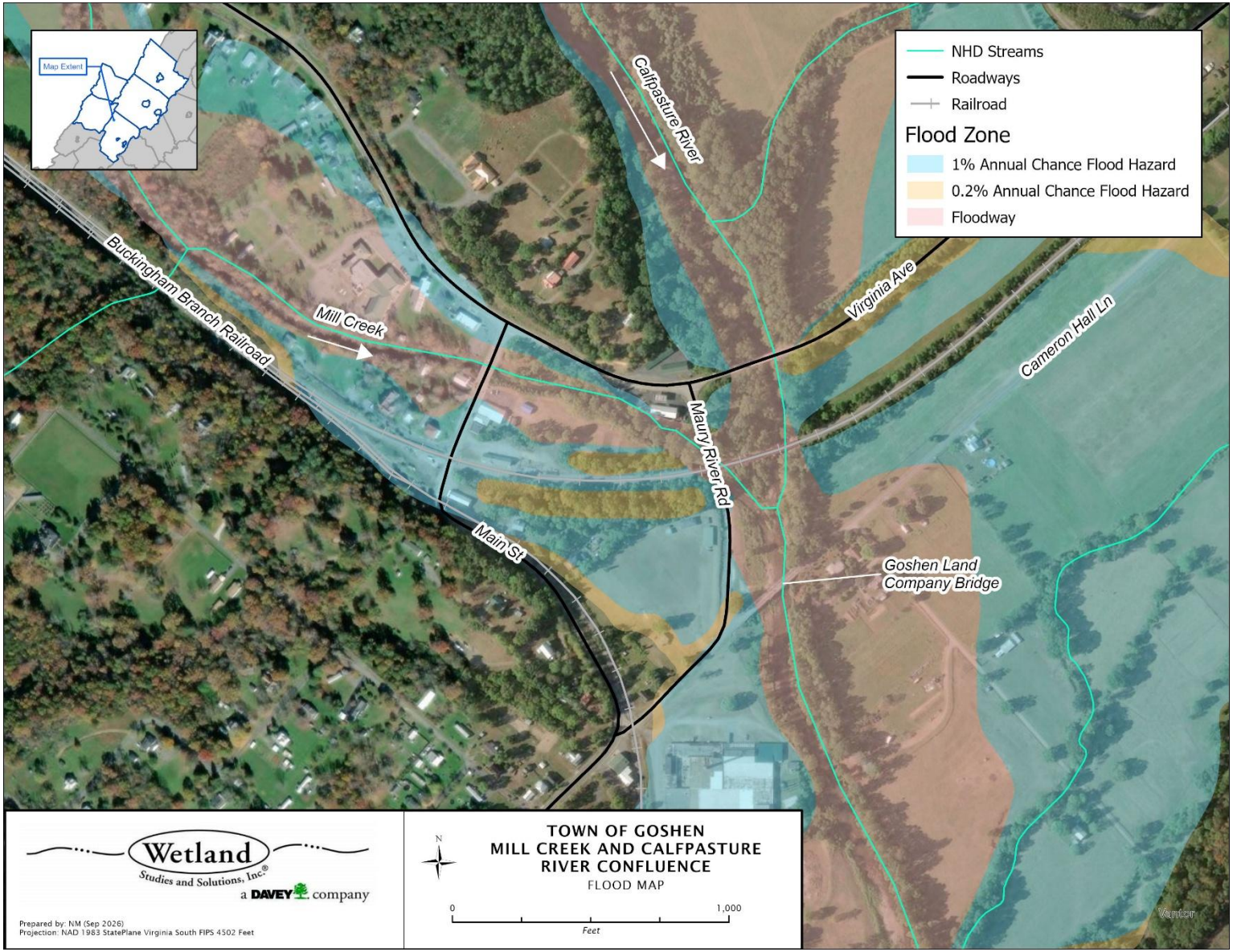


Figure 1. Map displaying the confluence of the Calfpasture River and Mill Creek in the Town of Goshen. Flood zones are displayed, showing areas of severity.



Figure 2. Maury River Road (lower) and Buckingham Branch railroad bridge (upper) spanning Mill Creek. Photograph taken facing upstream (approximately northwest).



Figure 3. Upstream side of low bridge on Maury River Road across Mill Creek. Photograph taken facing southeast.

Based on limited historic satellite imagery, it appears that the configuration of the confluence changed sometime between 2011 and 2013, from Mill Creek joining Calfpasture at a single junction to Mill Creek splitting into 3+ flow paths among islands of deposited cobble prior to joining the Calfpasture River (**Figure 4**, **Figure 5**). This phenomenon could have been due to natural channel processes or previous channel modifications (Town staff noted that some clearing of vegetation has been completed in the past, which could lead to re-working of deposits previously anchored by root systems). The Town has previously contacted the EPA regarding this area. The agency has authorized clearing debris and vegetation from the confluence but has prohibited deepening or widening of the channel. Any work done throughout the area would likely require cooperation and coordination with VDOT and railroad authorities.



Figure 4. Photograph of the confluence of the two streams – Calfpasture River flowing along right, Mill Creek entering from left. The existing depositional bar can be seen between them. Photograph was taken from the Goshen Land Company bridge, facing upstream (approximately north).



Figure 5. Evolution of flow paths at confluence of Mill Creek and Calfpasture River. Top row: 2007 (left) and 2011 (right) showing Mill Creek as a single channel entering Calfpasture River from the left; bottom row: 2013 (left) and 2025 (right) showing Mill Creek flow split into multiple paths around dissected point bar. All images sourced from Google Earth.

Conceptual Design and Planning-Level Cost Estimate

The existing FEMA flood study and any other flood analysis already completed relating to the confluence should be evaluated and updated. The effective FEMA FIRM appears to be dated 2000, and as such would not have benefited from the recent advances in 2D hydraulic modeling to better simulate complicated systems such as confluences. **Phase 1** of the project would involve developing a detailed 2D hydraulic model of the confluence area. This model could be used to create a targeted debris management strategy that may beneficially re-use some of the debris, anchoring/positioning it to increase flow efficiency and sediment transport, thus potentially reducing the maintenance burden.

While some amount of woody debris is expected and ecologically beneficial in a natural channel, that must be balanced in an urban environment with an appropriate amount of maintenance to ensure consistent conveyance and protection of infrastructure. To address flooding and evacuation concerns in the Town of Goshen, the Town has periodically removed debris from the channel. Debris removal can increase the velocity and flow in the channel, creating a slightly more efficient channel and decrease the chances of objects blocking flow between bridge piers and creating backwater during floods. However, over-widening of a channel during debris removal efforts can lead to additional deposition of sediments and future debris accumulation. A maintenance schedule should be created for Town officials or others to regularly identify and remove debris that appears likely to cause blockages, particularly on the upstream side of bridges, if not already developed. Additionally, renewed collaboration with the railroad entity(ies) should be pursued to minimize the amount of time Main Street is blocked by train cars, given the safety concerns.

The channels throughout the corridor are restricted by bedrock, preventing certain designs that would adjust the depth or planform of the channel. Instead, subject to results of 2D modeling, it is proposed that the Town of Goshen constructs a modified cross-vane structure in Mill Creek in **Phase 2** of the project to re-establish and maintain a more efficient confluence with the Calfpasture River (**Figure 6**). Sediment accumulation has been noted throughout the confluence, altering the flow path of Mill Creek at the confluence over time. A cross-vane could re-establish the historic single flow path of Mill Creek at the confluence. The arms of cross vanes extend along the banks, slowing and redirecting flow from the edges of the channel back to the center, protecting the banks against erosion and maintaining a central flow path. Wide and shallow channels encourage deposition of sediments and other material, while establishing a defined channel along this reach would reduce the probability that the channel is filled with sediment and other debris.

The cross vane should be constructed using imbricated stones, with a minimum intermediate dimension of approximately 4 feet. The structure rock sizing should be updated based on the chosen design flow and the results from updated models developed in **Phase 1**. The exact geometry of the structure should be verified in later stages as more detailed 2D modeling information is available. Typical construction details for a modified cross vane can be found in **Figure 7**. To

ensure the structure is operating successfully, monitoring is required after construction. This should be done to ensure structure rocks are not displaced and sediment transport dynamics are improved. Native vegetation should also be planted along the Calfpasture River and Mill Creek banks. This would stabilize the banks, preventing erosion and sedimentation in the channel.

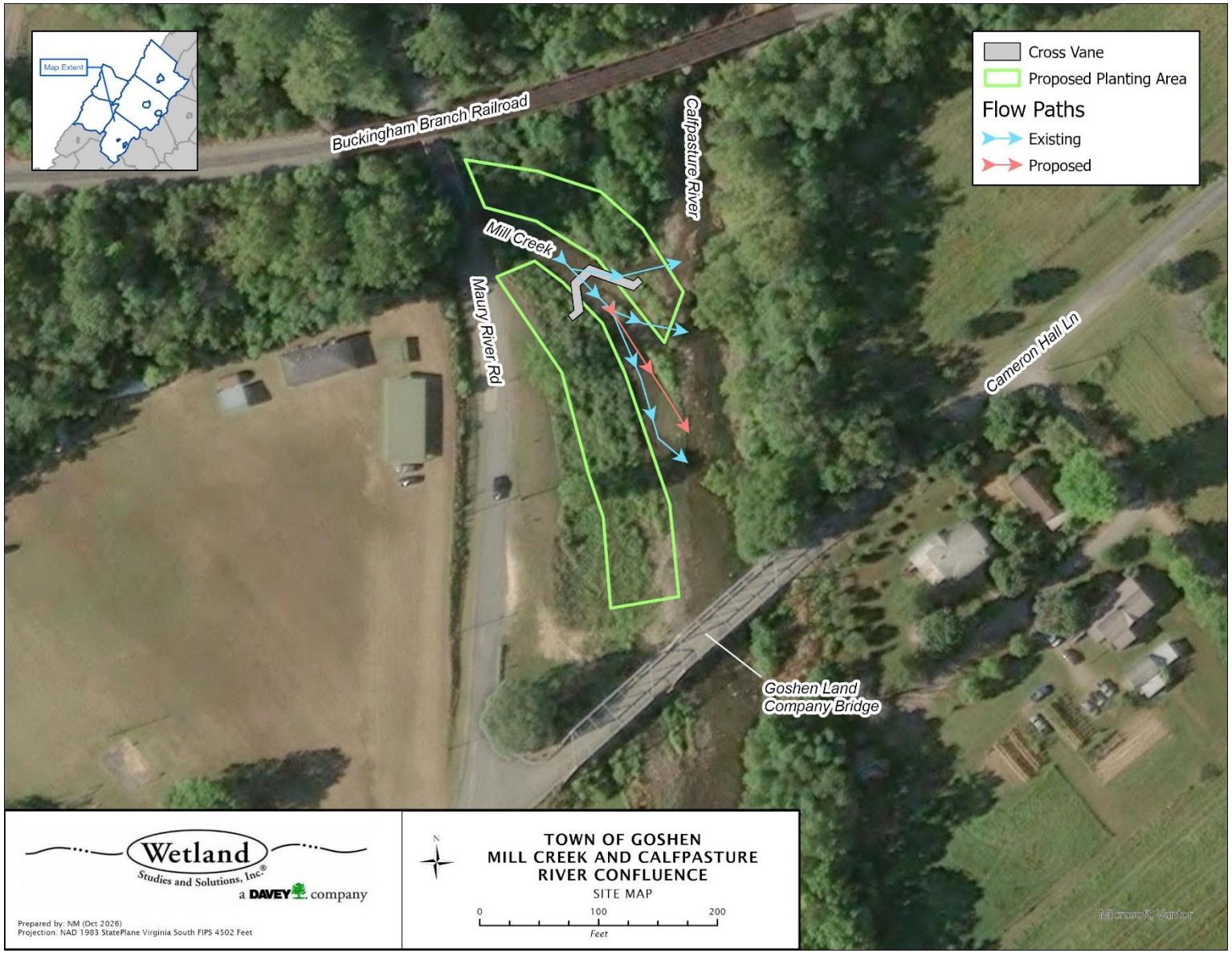
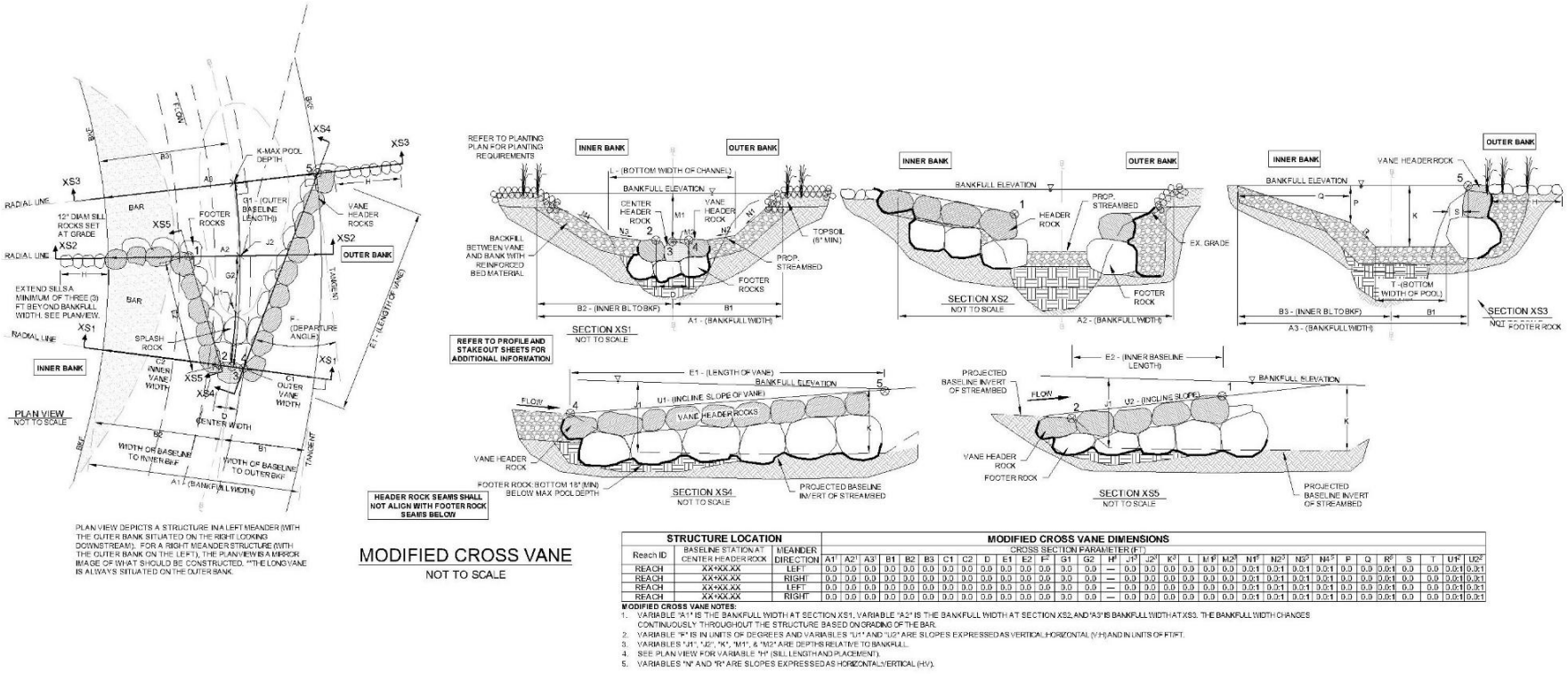


Figure 6. Map of the confluence of Mill Creek and the Calfpasture River, showing the proposed design.

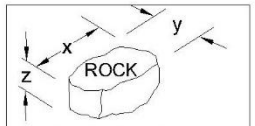


STRUCTURE LOCATION			MODIFIED CROSS VANE DIMENSIONS																																				
Reach ID	BASELINE STATION AT CENTER HEADER ROCK	MEANDER DIRECTION	CROSS SECTION PARAMETER (FT)																																				
			A1[1]	A2[1]	A3[1]	B1	B2	B3	C1	C2	D	E1	E2	F[2]	G1	G2	H[3]	J1[3]	J2[3]	K[3]	L	M1[3]	M2[3]	N1[3]	N2[3]	N3[3]	N4[3]	P	Q	R[3]	S	T	U1[4]	U2[4]
REACH	XX+XX.XX	LEFT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	—	0.0	0.0	0.0	0.0	0.0	0.0	0.0:1	0.0:1	0.0:1	0.0:1	0.0	0.0	0.0:1	0.0	0.0	0.0:1	0.0:1
REACH	XX+XX.XX	RIGHT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	—	0.0	0.0	0.0	0.0	0.0	0.0	0.0:1	0.0:1	0.0:1	0.0:1	0.0	0.0	0.0:1	0.0	0.0	0.0:1	0.0:1
REACH	XX+XX.XX	LEFT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	—	0.0	0.0	0.0	0.0	0.0	0.0	0.0:1	0.0:1	0.0:1	0.0:1	0.0	0.0	0.0:1	0.0	0.0	0.0:1	0.0:1
REACH	XX+XX.XX	RIGHT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	—	0.0	0.0	0.0	0.0	0.0	0.0	0.0:1	0.0:1	0.0:1	0.0:1	0.0	0.0	0.0:1	0.0	0.0	0.0:1	0.0:1

MODIFIED CROSS VANE NOTES:
1. VARIABLE "A1" IS THE BANKFULL WIDTH AT SECTION XS1, VARIABLE "A2" IS THE BANKFULL WIDTH AT SECTION XS2, AND "A3" IS BANKFULL WIDTH AT XS3. THE BANKFULL WIDTH CHANGES CONTINUOUSLY THROUGHOUT THE STRUCTURE BASED ON GRADING OF THE BAR.
2. VARIABLE "F" IS IN UNITS OF DEGREES AND VARIABLES "U1" AND "U2" ARE SLOPES EXPRESSED AS VERTICAL:HORIZONTAL (V:H) AND IN UNITS OF FT:FT.
3. VARIABLES "J1", "J2", "K", "M1", & "M2" ARE DEPTHS RELATIVE TO BANKFULL.
4. SEE PLAN VIEW FOR VARIABLE "H" (SILL LENGTH AND PLACEMENT).
5. VARIABLES "N" AND "R" ARE SLOPES EXPRESSED AS HORIZONTAL:VERTICAL (H:V).

STRUCTURE ROCK NOTES

1. ALL HEADER AND FOOTER ROCKS USED IN THE MAIN CHANNEL SHALL HAVE AN INTERMEDIATE DIMENSION OF AT LEAST **48 INCHES**.
2. SILL ROCKS SHALL HAVE AN INTERMEDIATE DIMENSION OF AT LEAST 12 INCHES.
3. THE BOTTOM OF ALL FOOTER ROCKS SHALL BE A MINIMUM OF 18 INCHES BELOW MAX POOL ELEVATION.
4. FOR NARROW STREAMS, THE VANE HEADER ROCKS MAY BE CONFIGURED TO TAKE THE PLACE OF THE CENTER HEADER ROCK AS LONG AS ALL DIMENSIONS OF THE STRUCTURE ARE MAINTAINED.
5. MORE THAN 2 ROWS OF ROCKS MAY BE NECESSARY TO ACHIEVE PROPER DIMENSIONS.
6. STRUCTURE ROCKS SHOULD BE PLACED SO AS TO MINIMIZE GAPS BETWEEN ROCKS. (THIS MAY REQUIRE MISSHAPEN ROCKS BE SET ASIDE FOR USE ELSEWHERE.) PRIORITY SHOULD BE GIVEN TO FORMING TIGHT JOINTS AT THE TOP OF ROCKS. ANY GAPS LARGER THAN FIST-SIZED MUST BE CHINKED ON THE UPSTREAM (BACK SIDE) OF THE STRUCTURE PRIOR TO PLACING FILTER FABRIC AND BACKFILLING.



3 PRIMARY DIMENSIONS OF ROCK:
x = LONGEST DIMENSION
y = INTERMEDIATE DIMENSION
z = SHORTEST DIMENSION

GENERAL STRUCTURE NOTES

1. SEE LONGITUDINAL PROFILE AND STAKEOUT SHEETS FOR ADDITIONAL INFORMATION INCLUDING ELEVATIONS AND SPECIFICS REGARDING POOL ARMORING AND BED MATERIAL THICKNESS. (ANY PORTIONS OF THE CHANNEL WITH SLOPES GREATER THAN 2.0% SHALL HAVE A MINIMUM REINFORCED BED MATERIAL THICKNESS OF 1.5x THE BED MATERIAL ROCK FRACTION D50, UNLESS OTHERWISE SPECIFIED IN THE PROFILE.)
2. REFER TO THE TYPICAL RIFFLE CROSS-SECTION FOR PLACEMENT OF COIR FABRIC ALONG THE STREAM.
3. STRUCTURES SHALL BE UNDERLAIN WITH WOVEN OR NON-WOVEN POLYPROPYLENE GEOTEXTILE AS NOTED IN TECHNICAL SPECIFICATIONS.
4. BACKFILL BETWEEN VANES AND BANKS WITH REINFORCED BED USED IN CHANNEL.
5. ALL STRUCTURES SHALL BE KEYED INTO THE BANK, VIA SILL OR STRUCTURE ROCK PLACEMENT, A MINIMUM OF 3 FT BEYOND BANKFULL AND COMPLETELY ACROSS ANY PLACED FILL (SEE PLAN VIEW FOR DETAILS).
6. THE PLAN VIEWS OF ALL STRUCTURES LOCATED IN MEANDER BENDS ARE SHOWN AS LEFT MEANDERS (THE OUTER BANK SITUATED ON THE RIGHT LOOKING DOWNSTREAM). FOR A RIGHT MEANDER STRUCTURE (THE OUTER BANK SITUATED ON THE LEFT), THE PLAN VIEW SHOWN IS A MIRROR IMAGE OF WHAT SHOULD BE CONSTRUCTED. SEE STRUCTURE STAKEOUT SHEETS FOR STAKEOUT POINT INFORMATION.

Figure 7. Typical construction details for a modified cross vane.

ITEM/DESCRIPTION	QTY	UNIT	UNIT COST	ITEM SUB-TOTAL	EXTENDED SUB-TOTAL
Phase 1: Flood Modeling					**$110,500**
2D Floodplain Model Development					**$85,000**
Existing Conditions Survey	1	LS	$20,000	$20,000	
H&H Study	1	LS	$65,000	$65,000	
Phase 1 Contingency (30%)					**$25,500**
Phase 2: Natural Channel Design and Construction					**$403,104**
Natural Channel Design and Permitting					**$54,000**
Natural Channel Design	1	LS	$40,000	$40,000	
Permitting	1	LS	$14,000	$14,000	
Construction Administration and Oversight					**$15,000**
Construction Oversight	1	LS	$15,000	$15,000	
Access and Erosion/Sediment Control					**$23,100**
Temporary Construction Entrance	1	EA	$4,500	$4,500	
Super Silt Fence	400	LF	$9	$3,600	
Deck Mats	150	LF	$100	$15,000	
Confluence Realignment Construction					**$183,300**
Stakeout	1	LS	$15,000	$15,000	
As-Built Survey	1	LS	$15,000	$15,000	
Mobilization	1	LS	$11,500	$11,500	
Clearing	0.35	AC	$30,000	$10,500	
Excavation and Hauling	500	CY	$100	$50,000	
Grading	0.7	AC	$9,000	$6,300	
Cross Vane	1	EA	$75,000	$75,000	
Planting					**$34,680**
Native Seed and Natural Fiber Matting	1,200	SY	$12	$14,400	
Live Stakes	500	EA	$10	$5,000	
Stream Edge Planting (tubelings)	500	EA	$8	$4,000	
Stream Bank Planting (tubelings)	670	EA	$8	$5,360	
Riparian Planting (tubelings)	740	EA	$8	$5,920	
Phase 2 Contingency (30%)					**$93,024**
TOTAL ESTIMATED BUDGET					**$513,604**

Assumptions

- Watershed (via StreamStats 9/3/2026) is 186 square miles from the confluence of the Calfpasture River and Mill Creek.
    - 45.4 square mile watershed for Mill Creek and 141 square mile watershed for the Calfpasture River
- Construction estimated budget assumes adequate on-site material for re-working stream channel bed and only importing material for the single stone structure. Native plantings to stabilize the channel were estimated for 300 linear feet along the south bank of Mill Creek as well as 200 linear feet of the north bank.

Recommended Next Steps

Reach out to railroad to discuss options for keeping the Main Street intersection open for EMS traffic in the interim before H&H study can be prepared and options evaluated.

References

USGS. StreamStats v4.33.0. Accessed online 3 September 2026.