4. Detention Computations

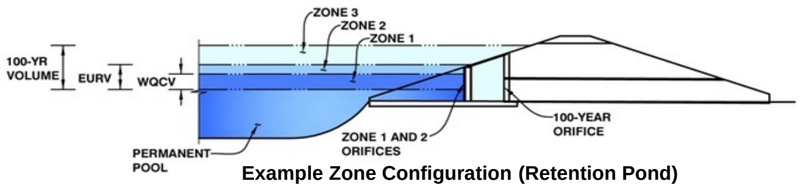
MHFD Spreadsheet

DETENTION BASIN STAGE-STORAGE TABLE BUILDER

MHFD-Detention, Version 4.06 (July 2022)

Project: 7610 Maverick Road

Basin ID: ENTIRE SITE



Example Zone Configuration (Retention Pond)

Watershed Information

Selected BMP Type =	EDB		
Watershed Area =	4.51	acres	
Watershed Length =	350	ft	
Watershed Length to Centroid =	175	ft	
Watershed Slope =	0.020	ft/ft	
Watershed Imperviousness =	55.60%	percent	
Percentage Hydrologic Soil Group A =	100.0%	percent	
Percentage Hydrologic Soil Group B =	0.0%	percent	
Percentage Hydrologic Soil Groups C/D =	0.0%	percent	
Target WQCV Drain Time =	40.0	hours	
Location for 1-hr Rainfall Depths =	User Input		

Note: L / W Ratio < 1

L / W Ratio = 0.62

After providing required inputs above including 1-hour rainfall depths, click 'Run CUHP' to generate runoff hydrographs using the embedded Colorado Urban Hydrograph Procedure.

			Optional User Overrides	
Water Quality Capture Volume (WQCV) =	0.084	acre-feet		acre-feet
Excess Urban Runoff Volume (EURV) =	0.298	acre-feet		acre-feet
2-yr Runoff Volume (P1 = 0.95 in.) =	0.159	acre-feet	0.95	inches
5-yr Runoff Volume (P1 = 1.23 in.) =	0.211	acre-feet	1.23	inches
10-yr Runoff Volume (P1 = 1.48 in.) =	0.264	acre-feet	1.48	inches
25-yr Runoff Volume (P1 = 1.88 in.) =	0.363	acre-feet	1.88	inches
50-yr Runoff Volume (P1 = 2.21 in.) =	0.461	acre-feet	2.21	inches
100-yr Runoff Volume (P1 = 2.57 in.) =	0.582	acre-feet	2.57	inches
500-yr Runoff Volume (P1 = 3.52 in.) =	0.901	acre-feet	3.52	inches
Approximate 2-yr Detention Volume =	0.154	acre-feet		
Approximate 5-yr Detention Volume =	0.207	acre-feet		
Approximate 10-yr Detention Volume =	0.259	acre-feet		
Approximate 25-yr Detention Volume =	0.350	acre-feet		
Approximate 50-yr Detention Volume =	0.406	acre-feet		
Approximate 100-yr Detention Volume =	0.470	acre-feet		

Define Zones and Basin Geometry

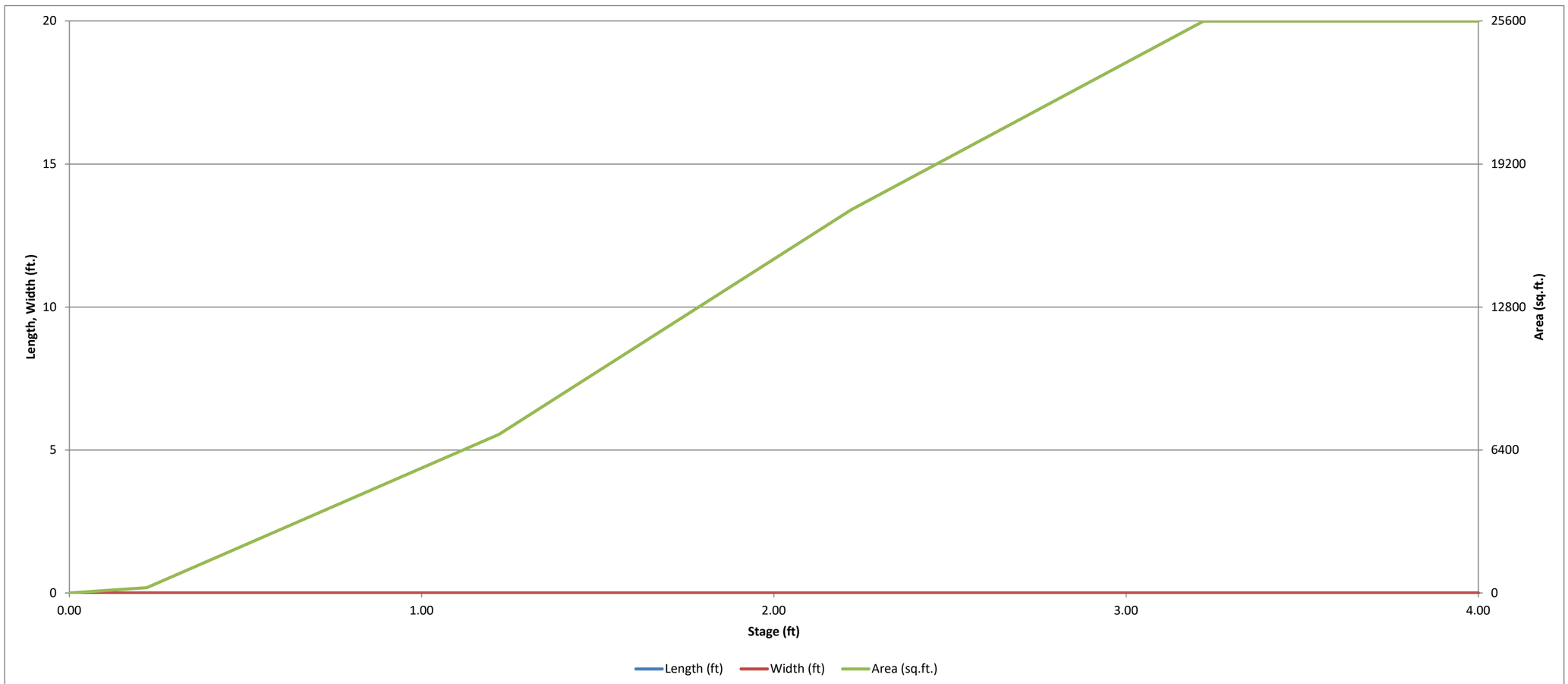
Zone 1 Volume (WQCV) =	0.084	acre-feet
Zone 2 Volume (EURV - Zone 1) =	0.214	acre-feet
Zone 3 Volume (100-year - Zones 1 & 2) =	0.172	acre-feet
Total Detention Basin Volume =	0.470	acre-feet
Initial Surcharge Volume (ISV) =	user	ft^3
Initial Surcharge Depth (ISD) =	user	ft
Total Available Detention Depth (H_{total}) =	user	ft
Depth of Trickle Channel (H_{TC}) =	user	ft
Slope of Trickle Channel (S_{TC}) =	user	ft/ft
Slopes of Main Basin Sides (S_{main}) =	user	H:V
Basin Length-to-Width Ratio ($R_{L/W}$) =	user	
Initial Surcharge Area (A_{ISV}) =	user	ft^2
Surcharge Volume Length (L_{ISV}) =	user	ft
Surcharge Volume Width (W_{ISV}) =	user	ft
Depth of Basin Floor (H_{FLOOR}) =	user	ft
Length of Basin Floor (L_{FLOOR}) =	user	ft
Width of Basin Floor (W_{FLOOR}) =	user	ft
Area of Basin Floor (A_{FLOOR}) =	user	ft^2
Volume of Basin Floor (V_{FLOOR}) =	user	ft^3
Depth of Main Basin (H_{MAIN}) =	user	ft
Length of Main Basin (L_{MAIN}) =	user	ft
Width of Main Basin (W_{MAIN}) =	user	ft
Area of Main Basin (A_{MAIN}) =	user	ft^2
Volume of Main Basin (V_{MAIN}) =	user	ft^3
Calculated Total Basin Volume (V_{total}) =	**user**	acre-feet

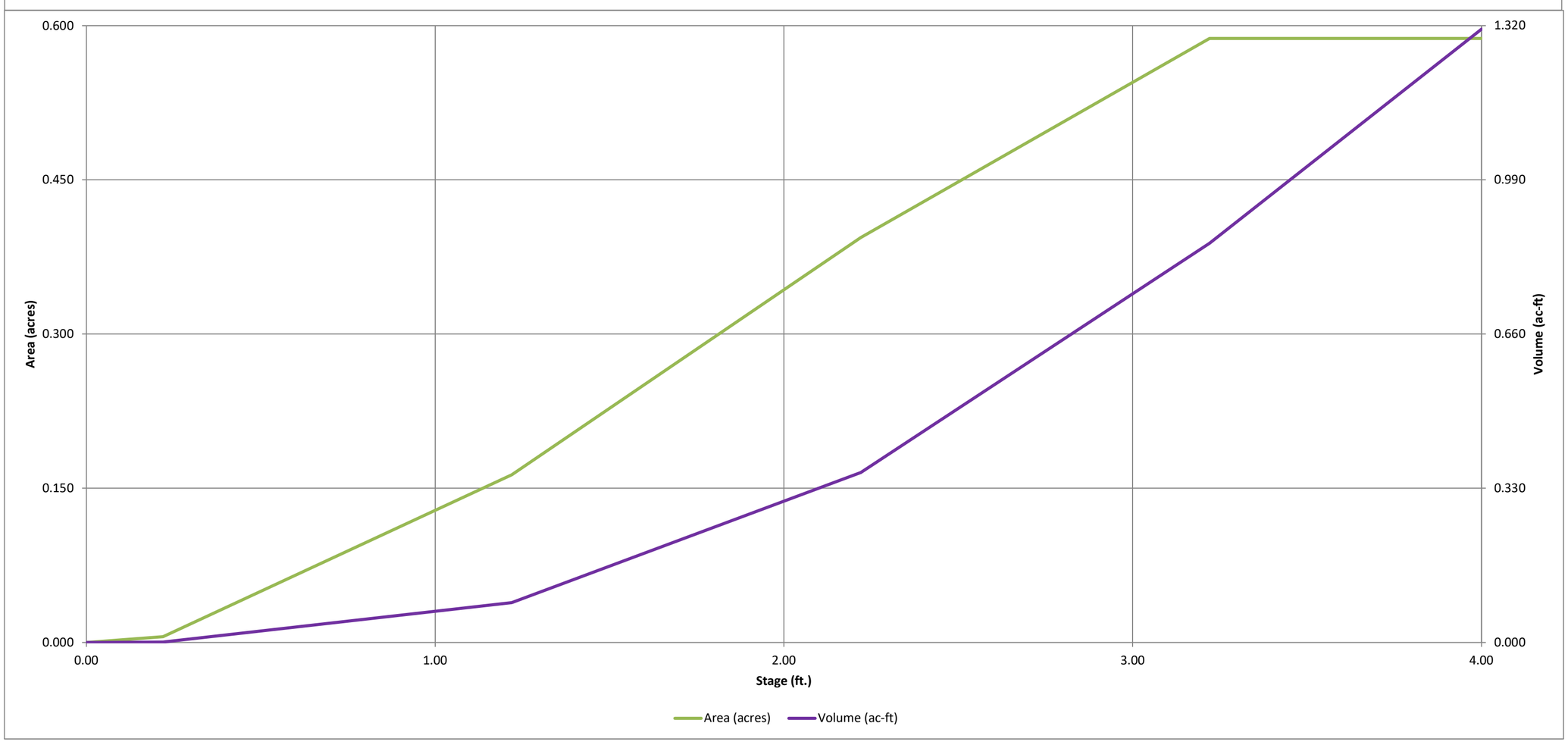
Depth Increment = ft

Stage - Storage Description	Stage (ft)	Optional Override Stage (ft)	Length (ft)	Width (ft)	Area (ft^2)	Optional Override Area (ft^2)	Area (acre)	Volume (ft^3)	Volume (ac-ft)
Top of Micropool	--	0.00	--	--	--	0	0.000		
Plan 24	--	0.22	--	--	--	245	0.006	27	0.001
Plan 25	--	1.22	--	--	--	7,105	0.163	3,702	0.085
Plan 26	--	2.22	--	--	--	17,156	0.394	15,832	0.363
Plan 27	--	3.22	--	--	--	25,593	0.588	37,207	0.854
Plan 27.8	--	4.00	--	--	--	25,593	0.588	57,169	1.312

DETENTION BASIN STAGE-STORAGE TABLE BUILDER

MHFD-Detention, Version 4.06 (July 2022)



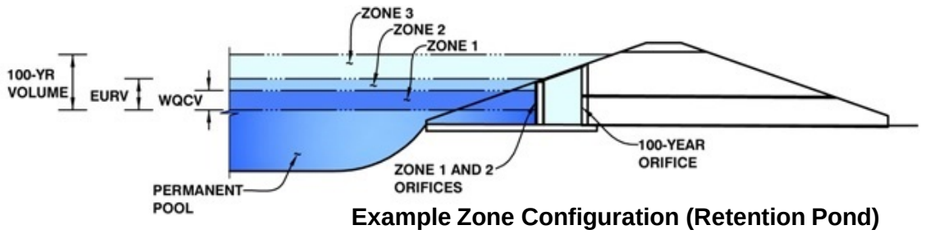


DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.06 (July 2022)

Project: **7610 Maverick Road**

Basin ID: **ENTIRE SITE**



Example Zone Configuration (Retention Pond)

	Estimated Stage (ft)	Estimated Volume (ac-ft)	Outlet Type
Zone 1 (WQCV)	1.22	0.084	Orifice Plate
Zone 2 (EURV)	2.05	0.214	Orifice Plate
Zone 3 (100-year)	2.48	0.172	Weir&Pipe (Circular)
Total (all zones)		0.470	

User Input: Orifice at Underdrain Outlet (typically used to drain WQCV in a Filtration BMP)

Underdrain Orifice Invert Depth =		ft (distance below the filtration media surface)
Underdrain Orifice Diameter =		inches

Calculated Parameters for Underdrain

Underdrain Orifice Area =		ft^2
Underdrain Orifice Centroid =		feet

User Input: Orifice Plate with one or more orifices or Elliptical Slot Weir (typically used to drain WQCV and/or EURV in a sedimentation BMP)

Centroid of Lowest Orifice =	0.00	ft (relative to basin bottom at Stage = 0 ft)
Depth at top of Zone using Orifice Plate =	2.05	ft (relative to basin bottom at Stage = 0 ft)
Orifice Plate: Orifice Vertical Spacing =	N/A	inches
Orifice Plate: Orifice Area per Row =	N/A	sq. inches

Calculated Parameters for Plate

WQ Orifice Area per Row =	N/A	ft^2
Elliptical Half-Width =	N/A	feet
Elliptical Slot Centroid =	N/A	feet
Elliptical Slot Area =	N/A	ft^2

User Input: Stage and Total Area of Each Orifice Row (numbered from lowest to highest)

	Row 1 (required)	Row 2 (optional)	Row 3 (optional)	Row 4 (optional)	Row 5 (optional)	Row 6 (optional)	Row 7 (optional)	Row 8 (optional)
Stage of Orifice Centroid (ft)	0.00	0.67	1.34					
Orifice Area (sq. inches)	0.60	0.60	1.77					

	Row 9 (optional)	Row 10 (optional)	Row 11 (optional)	Row 12 (optional)	Row 13 (optional)	Row 14 (optional)	Row 15 (optional)	Row 16 (optional)
Stage of Orifice Centroid (ft)								
Orifice Area (sq. inches)								

User Input: Vertical Orifice (Circular or Rectangular)

	Not Selected	Not Selected	
Invert of Vertical Orifice =	N/A	N/A	ft (relative to basin bottom at Stage = 0 ft)
Depth at top of Zone using Vertical Orifice =	N/A	N/A	ft (relative to basin bottom at Stage = 0 ft)
Vertical Orifice Diameter =	N/A	N/A	inches

Calculated Parameters for Vertical Orifice

	Not Selected	Not Selected	
Vertical Orifice Area =	N/A	N/A	ft^2
Vertical Orifice Centroid =	N/A	N/A	feet

User Input: Overflow Weir (Dropbox with Flat or Sloped Grate and Outlet Pipe OR Rectangular/Trapezoidal Weir and No Outlet Pipe)

	Zone 3 Weir	Not Selected	
Overflow Weir Front Edge Height, Ho =	2.05	N/A	ft (relative to basin bottom at Stage = 0 ft)
Overflow Weir Front Edge Length =	5.67	N/A	feet
Overflow Weir Grate Slope =	0.00	N/A	H:V
Horiz. Length of Weir Sides =	2.92	N/A	feet
Overflow Grate Type =	Type C Grate	N/A	
Debris Clogging % =	50%	N/A	%

Calculated Parameters for Overflow Weir

	Zone 3 Weir	Not Selected	
Height of Grate Upper Edge, H_t =	2.05	N/A	feet
Overflow Weir Slope Length =	2.92	N/A	feet
Grate Open Area / 100-yr Orifice Area =	21.13	N/A	
Overflow Grate Open Area w/o Debris =	11.52	N/A	ft^2
Overflow Grate Open Area w/ Debris =	5.76	N/A	ft^2

User Input: Outlet Pipe w/ Flow Restriction Plate (Circular Orifice, Restrictor Plate, or Rectangular Orifice)

	Zone 3 Circular	Not Selected	
Depth to Invert of Outlet Pipe =	0.00	N/A	ft (distance below basin bottom at Stage = 0 ft)
Circular Orifice Diameter =	10.00	N/A	inches

Calculated Parameters for Outlet Pipe w/ Flow Restriction Plate

	Zone 3 Circular	Not Selected	
Outlet Orifice Area =	0.55	N/A	ft^2
Outlet Orifice Centroid =	0.42	N/A	feet
Half-Central Angle of Restrictor Plate on Pipe =	N/A	N/A	radians

User Input: Emergency Spillway (Rectangular or Trapezoidal)

Spillway Invert Stage=	2.48	ft (relative to basin bottom at Stage = 0 ft)
Spillway Crest Length =	40.00	feet
Spillway End Slopes =	3.00	H:V
Freeboard above Max Water Surface =	1.00	feet

Calculated Parameters for Spillway

Spillway Design Flow Depth=	0.23	feet
Stage at Top of Freeboard =	3.71	feet
Basin Area at Top of Freeboard =	0.59	acres
Basin Volume at Top of Freeboard =	1.14	acre-ft

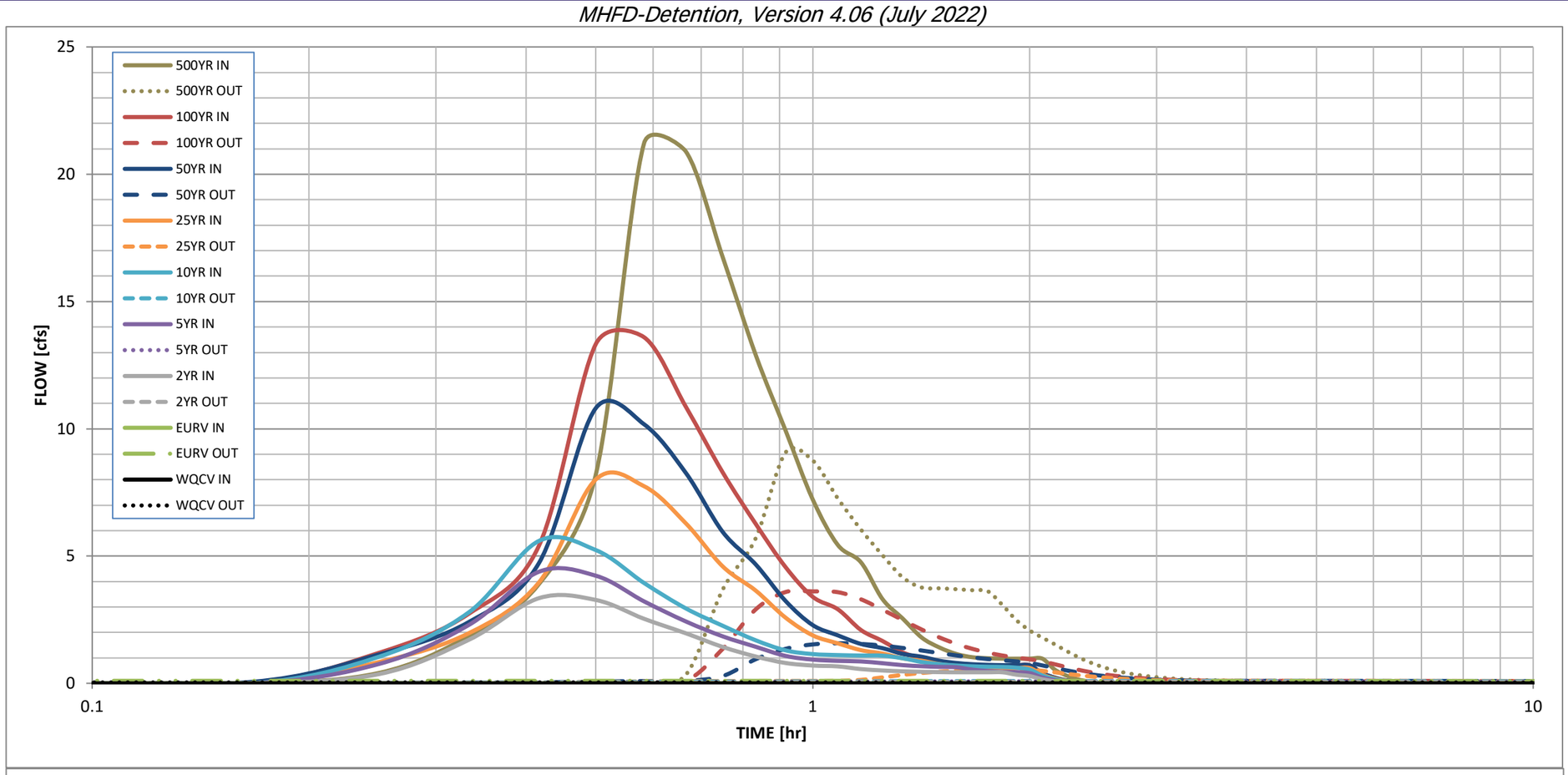
Routed Hydrograph Results

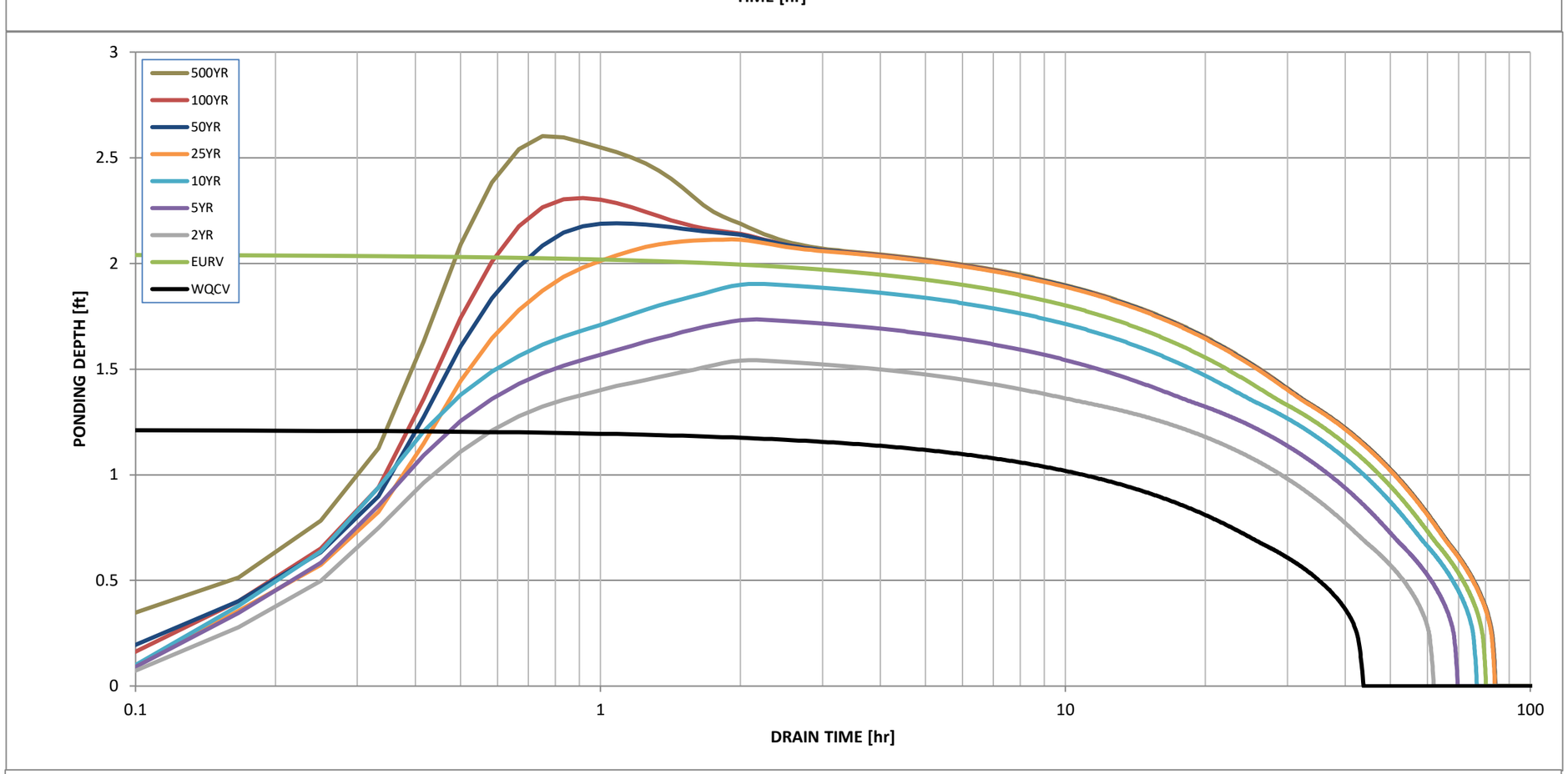
The user can override the default CUHP hydrographs and runoff volumes by entering new values in the Inflow Hydrographs table (Columns W through AF).

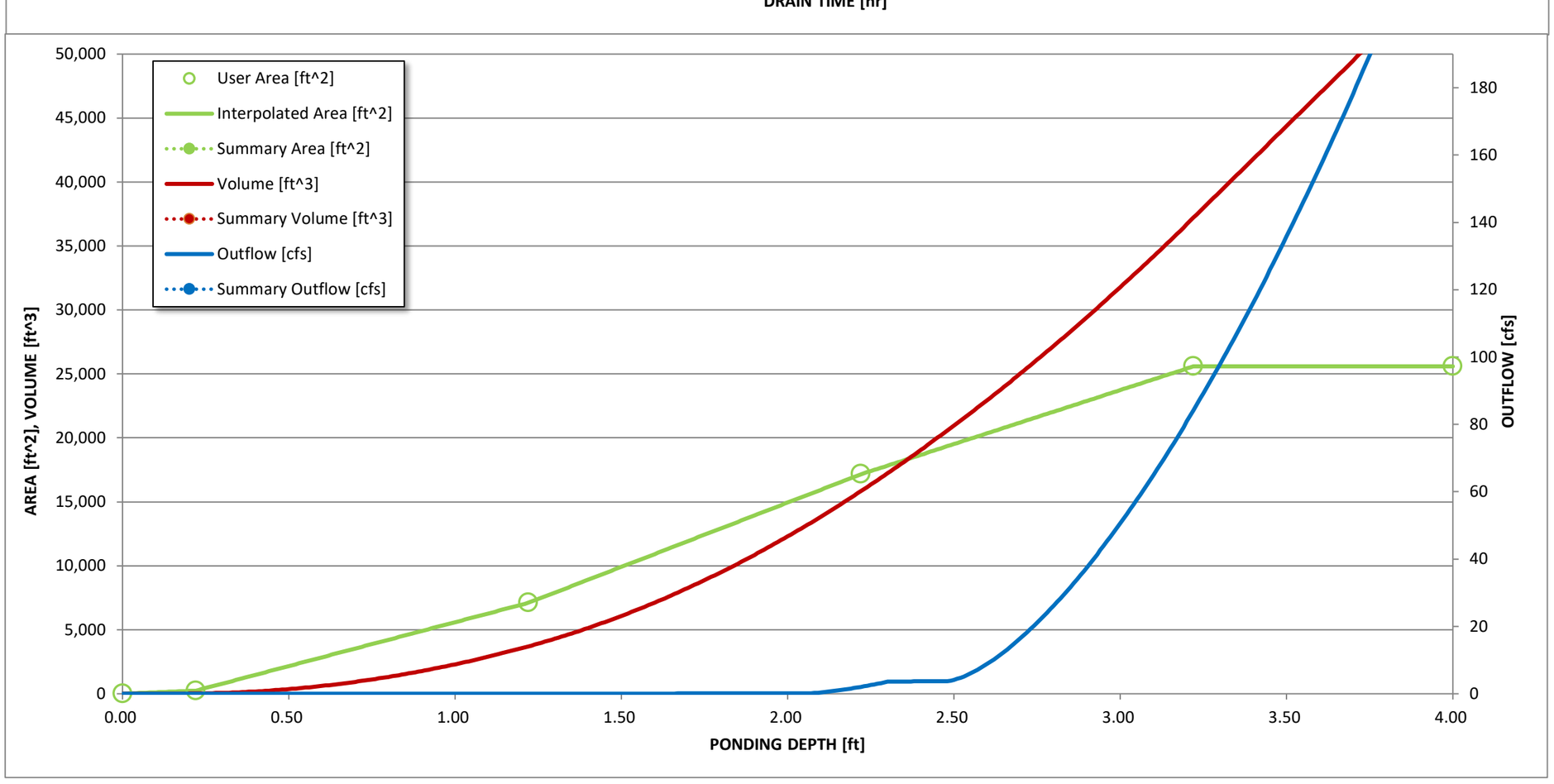
Design Storm Return Period =	WQCV	EURV	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	500 Year
One-Hour Rainfall Depth (in) =	N/A	N/A	0.95	1.23	1.48	1.88	2.21	2.57	3.52
CUHP Runoff Volume (acre-ft) =	0.084	0.298	0.159	0.211	0.264	0.363	0.461	0.582	0.901
Inflow Hydrograph Volume (acre-ft) =	N/A	N/A	0.159	0.211	0.264	0.363	0.461	0.582	0.901
CUHP Predevelopment Peak Q (cfs) =	N/A	N/A	0.0	0.1	0.1	0.8	2.4	4.5	9.8
OPTIONAL Override Predevelopment Peak Q (cfs) =	N/A	N/A							
Predevelopment Unit Peak Flow, q (cfs/acre) =	N/A	N/A	0.00	0.01	0.02	0.17	0.54	1.01	2.17
Peak Inflow Q (cfs) =	N/A	N/A	3.3	4.4	5.6	8.0	10.8	13.6	21.2
Peak Outflow Q (cfs) =	0.0	0.1	0.1	0.1	0.1	0.6	1.6	3.6	9.1
Ratio Peak Outflow to Predevelopment Q =	N/A	N/A	N/A	1.5	1.0	0.7	0.6	0.8	0.9
Structure Controlling Flow =	Plate	Overflow Weir 1	Plate	Plate	Plate	Overflow Weir 1	Overflow Weir 1	Outlet Plate 1	Spillway
Max Velocity through Grate 1 (fps) =	N/A	N/A	N/A	N/A	N/A	0.0	0.1	0.3	0.3
Max Velocity through Grate 2 (fps) =	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Time to Drain 97% of Inflow Volume (hours) =	41	71	57	63	69	73	71	68	63
Time to Drain 99% of Inflow Volume (hours) =	**42**	77	60	67	73	80	79	78	75
Maximum Ponding Depth (ft) =	1.22	2.05	1.54	1.73	1.90	2.11	2.19	2.31	2.60
Area at Maximum Ponding Depth (acres) =	0.16	0.35	0.24	0.28	0.32	0.37	0.39	0.41	0.47
Maximum Volume Stored (acre-ft) =	0.085	0.300	0.149	0.198	0.249	0.322	0.352	0.400	0.527

DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.06 (July 2022)







S-A-V-D Chart Axis Override	X-axis	Left Y-Axis	Right Y-Axis
minimum bound			
maximum bound			

DETENTION BASIN OUTLET STRUCTURE DESIGN

Outflow Hydrograph Workbook Filename:

Inflow Hydrographs

The user can override the calculated inflow hydrographs from this workbook with inflow hydrographs developed in a separate program.

	SOURCE	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP
Time Interval	TIME	WQCV [cfs]	EURV [cfs]	2 Year [cfs]	5 Year [cfs]	10 Year [cfs]	25 Year [cfs]	50 Year [cfs]	100 Year [cfs]	500 Year [cfs]
5.00 min	0:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0:05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.03	0.41
	0:15:00	0.00	0.00	0.37	0.76	1.05	0.84	1.14	1.20	1.86
	0:20:00	0.00	0.00	1.72	2.30	2.80	1.97	2.41	2.74	3.89
	0:25:00	0.00	0.00	3.35	4.38	5.59	3.96	4.72	5.39	8.20
	0:30:00	0.00	0.00	3.28	4.23	5.24	8.01	10.81	13.33	21.22
	0:35:00	0.00	0.00	2.54	3.22	3.94	7.75	10.18	13.60	20.90
	0:40:00	0.00	0.00	1.97	2.43	2.95	6.29	8.27	10.87	16.75
	0:45:00	0.00	0.00	1.43	1.85	2.26	4.60	5.95	8.29	12.91
	0:50:00	0.00	0.00	1.06	1.44	1.69	3.65	4.68	6.27	9.95
	0:55:00	0.00	0.00	0.80	1.08	1.30	2.59	3.24	4.57	7.23
	1:00:00	0.00	0.00	0.70	0.93	1.15	1.89	2.29	3.40	5.44
	1:05:00	0.00	0.00	0.67	0.88	1.11	1.57	1.89	2.91	4.76
	1:10:00	0.00	0.00	0.56	0.86	1.10	1.31	1.55	2.10	3.31
	1:15:00	0.00	0.00	0.51	0.79	1.09	1.17	1.38	1.67	2.55
	1:20:00	0.00	0.00	0.47	0.72	0.99	0.98	1.16	1.22	1.80
	1:25:00	0.00	0.00	0.46	0.67	0.84	0.89	1.05	0.98	1.41
	1:30:00	0.00	0.00	0.44	0.65	0.75	0.76	0.89	0.83	1.15
	1:35:00	0.00	0.00	0.44	0.63	0.70	0.68	0.80	0.75	1.03
	1:40:00	0.00	0.00	0.44	0.54	0.67	0.64	0.75	0.72	0.99
	1:45:00	0.00	0.00	0.44	0.49	0.65	0.62	0.73	0.71	0.97
	1:50:00	0.00	0.00	0.44	0.46	0.65	0.61	0.72	0.71	0.97
	1:55:00	0.00	0.00	0.34	0.44	0.62	0.61	0.71	0.71	0.97
	2:00:00	0.00	0.00	0.29	0.41	0.54	0.61	0.71	0.71	0.97
	2:05:00	0.00	0.00	0.16	0.23	0.31	0.34	0.40	0.40	0.55
	2:10:00	0.00	0.00	0.09	0.13	0.17	0.19	0.23	0.23	0.31
	2:15:00	0.00	0.00	0.04	0.07	0.09	0.10	0.12	0.12	0.16
	2:20:00	0.00	0.00	0.02	0.03	0.04	0.05	0.06	0.06	0.08
	2:25:00	0.00	0.00	0.01	0.01	0.01	0.02	0.02	0.02	0.02
	2:30:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2:35:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2:40:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2:45:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2:50:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2:55:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:15:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:20:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:25:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:30:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:35:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:40:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:45:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:50:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:55:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:15:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:20:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:25:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:30:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:35:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:40:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:45:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:50:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:55:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:15:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:20:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:25:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:30:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:35:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:40:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:45:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:50:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:55:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	6:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.06 (July 2022)

Summary Stage-Area-Volume-Discharge Relationships

The user can create a summary S-A-V-D by entering the desired stage increments and the remainder of the table will populate automatically.

The user should graphically compare the summary S-A-V-D table to the full S-A-V-D table in the chart to confirm it captures all key transition points.

Stage - Storage Description	Stage [ft]	Area [ft ^{2}]	Area [acres]	Volume [ft ^{3}]	Volume [ac-ft]	Total Outflow [cfs]

Perception Design Group, Inc.
6901 South Pierce Street, Suite 220
Littleton, Colorado 80128
(303) 232-8088

Designed by: JWD
Date: 19-Jan-26
Job Number: 2024-020

Project: Maverick Road

Forebay Design Parameters

Inflow at DP 14 + DP 15	8.83	cfs
Inflow at DP 16	16.39	cfs
Total Inflow	25.22	cfs

Percentage of flow DP14+DP15	35%
Percentage of flow DP16	65%

Required Forebay Volume = 1% of WQCV

Total WQCV	0.084	ac-ft

Required volume DP14+DP15	0.029	Ac-Ft
Required volume DP16	0.055	Ac-Ft

Forebay DP14 + DP15 Design

Required Forebay Volume = 1% of WQCV

Total WQCV	0.029	ac-ft	
Forebay Inflow	8.83	cfs	DP14+DP15+DP16

Required Forebay Volume =	13	cubic feet	
Provided Area=	50.0	square feet	A(fb)
Provided Depth =	0.33	feet	h(max)
Provided Volume =	16.50	cubic feet	
t=	277.00	Seconds	t

Required Release = 4-5 min drain time per MHFD Eq. 4-1

$$w = 9.23\ (A_{FB} / t)\ (1 / \sqrt{h_{max}})$$ **Equation 4-1**

Where:

w = width of the rectangular vertical notch (inches)

A_{FB} = surface area of the forebay (square feet)

t = emptying time of the brim-full forebay (seconds)

h_{max} = maximum depth of the forebay (feet)

w = 2.90 inches

Forebay DP16 Design

Required Forebay Volume = 1% of WQCV

Total WQCV	0.055	ac-ft	
Forebay Inflow	16.39	cfs	DP14+DP15+DP16

Required Forebay Volume =	24	cubic feet	
Provided Area=	50.0	square feet	A(fb)
Provided Depth =	0.50	feet	h(max)
Provided Volume =	25.00	cubic feet	
t=	300.00	Seconds	t

Required Release = 4-5 min drain time per MHFD Eq. 4-1

$$w = 9.23\ (A_{FB} / t)\ (1 / \sqrt{h_{max}})$$ **Equation 4-1**

Where:

w = width of the rectangular vertical notch (inches)

A_{FB} = surface area of the forebay (square feet)

t = emptying time of the brim-full forebay (seconds)

h_{max} = maximum depth of the forebay (feet)

w = 2.18 inches