April 21, 2021

City of Arvada
Public Works Department
Engineering Division
8101 Ralston Rd.
Arvada, CO 80002

RE: Drainage Addendum for Blocks 1-4 – GEOS

This is an addendum to the approved Final Drainage Report for Geos Neighborhood prepared by Travis Nicholson, P.E. # 35814 of MB Consulting, Inc. in 2008. The neighborhood has remained the same as previously approved, but the detention ponds and outlet structures have been updated to meet the current UDFCD requirements and utilizing the new NOAA rainfall data.

One change has been made to original drainage pattern of the project. Basin D1 now drains to the A basin and not the D basin. This change caused the originally proposed 15' Type R inlet to be increased to a 20' Type R inlet. We increased the proposed pipe size to 18" to accommodate the additional flow. You can find all the relevant design information in the Appendix to this addendum.

The last change from the originally approved drainage report is that the E drainage basins are no longer detained in Pond E. We have consolidated Pond E into Pond B. This simplified the design by no longer having Pond E release at a rate higher than allowed rate and therefore needing over detention in Pond B. The updated Pond B now has capacity for WQ, EURV, and 100-yr storage and releases at the required rates set by UDFCD.

In this design addendum we also re-calculated the impervious percentage of all basins to account for the change of no longer using porous materials in the alley and other locations.

An example calculation showing that the increase in imperviousness did not cause an increase in runoff rates from Basin A3 is provided in the Appendix. The original runoff from this basin was calculated to be 4.2 cfs in the approved report, and now it is determined to be 2.62 cfs. This reduction in flow rates in the 100yr storm was due to the new NOAA rainfall data even though the impervious percentage was higher than previously calculated. This holds true for all basins within the project. The HGLs shown in the construction plans were calculated using the previous 100yr flow rates to be conservative.

Given that the rainfall intensity updates in the currently used ATLAS-14 database have caused the design rainfall intensity to decrease it was not necessary to redesign any other storm infrastructure. The changes to UDFCD detention requirements and the rainfall data updates allowed us to consolidate Pond E and Pond B. The current pond and outlet structure design reflect these changes. In the future developments the design

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Denver, CO

of Pond F, G, and H will be updated to meet current UDFCD standards, and the shift of previously needed overdetention from Pond E to Pond F, which is no longer needed, will likely result in a reduced size for Pond F in the future.

Pond F has been analyzed with the interim condition of the F basins to determine an interim condition detention pond design. The pond outlet structure was designed in a way to allow a swap of the water quality plate to accommodate additional development and inflow into the pond in its final condition.

Maintenance of the detention ponds will be performed by the Metro District. Ponds will be checked after major rain events, and also intermittently during drier periods, to ensure that there is no clogging and the facilities are functioning in the manner they were designed.

A copy of the original drainage basin map, updated pond outlet structures and pond volume design for Pond A, B, D, and F, analysis of the 20' Type 'R' inlet, analysis of 18" storm to pond A, impervious calculations, and Basin E to Pond B Storm line analysis is provided in the Appendix.

Thanks,

Nathan Laudick, PE 51224

APPENDIX

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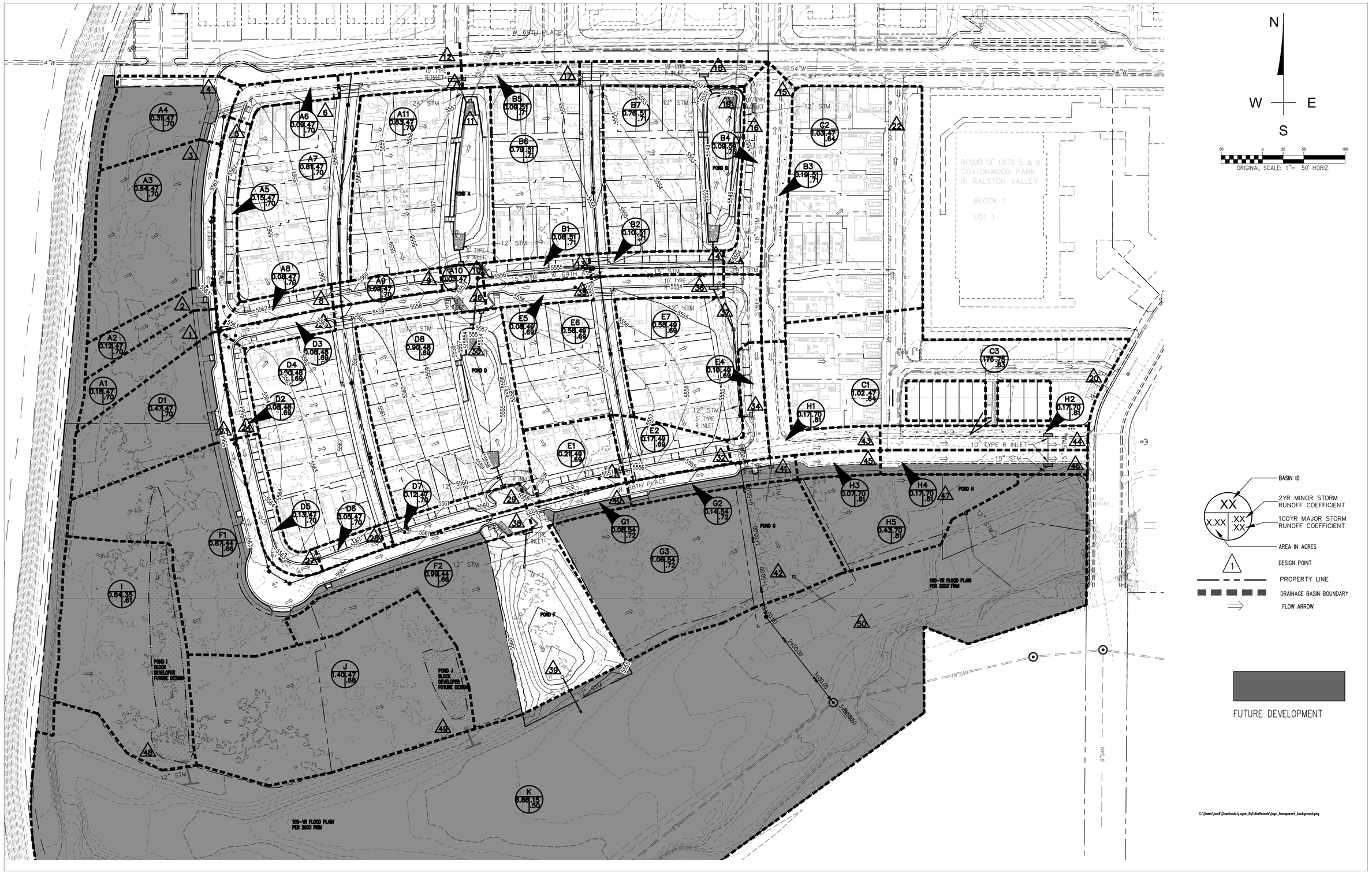


LAUDICK & LAUDICK
Civil Engineering Services

PROJECT: **GEOS Neighborhood Block 1-4**
SUBJECT: Basin Imperviousness

JOB #:
DATE: **8/29/2019**
BY: **NAL**

Basin Name	Square Footage	Acres	Lawns/ Landscaped (sf)	Lawns/ Landscaped (Acres)	Asphalt/ Concrete (sf)	Asphalt/ Concrete (Acres)	Roofs (sf)	Roofs (Acres)	Soil Type "C" Composite Runoff Factors			
									C_5	C_{10}	C_{100}	I %
A	165,423	3.80	69,972	1.61	56,755	1.30	38,696	0.89	0.49	0.55	0.71	56.21
B	86,944	2.00	28,460	0.65	38,698	0.89	19,786	0.45	0.57	0.62	0.75	65.65
D	98,966	2.27	49,465	1.14	29,097	0.67	20,404	0.47	0.43	0.49	0.68	48.96
E	74,224	1.70	33,240	0.76	24,222	0.56	16,762	0.38	0.47	0.53	0.70	53.85
F (INTERIM)	89,656	2.06	79,347	1.82	10,309	0.24	0	0.00	0.14	0.23	0.54	13.27
B&E	161,168	3.70	61,700	1.42	62,920	1.44	36,548	0.84	0.53	0.58	0.73	60.21
Totals (A,B,D,E):	**165,423**	**3.80**	**69,972**	**1.61**	**56,755**	**1.30**	**38,696**	**0.89**	**0.49**	**0.46**	**0.71**	**56.21**

Basin A Note: Added Sub-basin D1 to A Basin

Basin D Note: Subtracted Sub-basin D1 from D basin due to flow going to A basin

Basin E Note: Basin E now detained in in Pond B

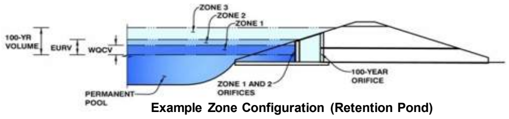
Lans Use	Imp., I %
Lawns/landscaped	2%
Asphalt/Concrete	100%

DETENTION BASIN STAGE-STORAGE TABLE BUILDER

UD-Detention, Version 3.07 (February 2017)

Project: GEOS NEIGHBORHOOD BLOCKS 1-4

Basin ID: BASIN A + D1



Example Zone Configuration (Retention Pond)

Required Volume Calculation

Selected BMP Type =	EDB			
Watershed Area =	3.80	acres		
Watershed Length =	592	ft		
Watershed Slope =	0.015	ft/ft		
Watershed Imperviousness =	56.21%	percent		
Percentage Hydrologic Soil Group A =	0.0%	percent		
Percentage Hydrologic Soil Group B =	0.0%	percent		
Percentage Hydrologic Soil Groups C/D =	100.0%	percent		
Desired WQCV Drain Time =	40.0	hours		
Location for 1-hr Rainfall Depths =	Arvada - City Hall			
Water Quality Capture Volume (WQCV) =	0.071	acre-feet	Optional User Override	
Excess Urban Runoff Volume (EURV) =	0.204	acre-feet	1-hr Precipitation	
2-yr Runoff Volume (P1 = 0.78 in.) =	0.127	acre-feet		inches
5-yr Runoff Volume (P1 = 1.05 in.) =	0.196	acre-feet		inches
10-yr Runoff Volume (P1 = 1.3 in.) =	0.262	acre-feet		inches
25-yr Runoff Volume (P1 = 1.66 in.) =	0.388	acre-feet		inches
50-yr Runoff Volume (P1 = 1.95 in.) =	0.482	acre-feet		inches
100-yr Runoff Volume (P1 = 2.27 in.) =	0.599	acre-feet		inches
500-yr Runoff Volume (P1 = 3.08 in.) =	0.871	acre-feet		inches
Approximate 2-yr Detention Volume =	0.119	acre-feet		
Approximate 5-yr Detention Volume =	0.185	acre-feet		
Approximate 10-yr Detention Volume =	0.223	acre-feet		
Approximate 25-yr Detention Volume =	0.268	acre-feet		
Approximate 50-yr Detention Volume =	0.289	acre-feet		
Approximate 100-yr Detention Volume =	0.336	acre-feet		

Stage-Storage Calculation

Zone 1 Volume (WQCV) =	0.071	acre-feet
Zone 2 Volume (EURV - Zone 1) =	0.133	acre-feet
Zone 3 Volume (100-year - Zones 1 & 2) =	0.132	acre-feet
Total Detention Basin Volume =	0.336	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 = 0.25 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	--	--	--	156	0.004		
5551.75	--	0.25	--	--	--	162	0.004	38	0.001
	--	0.50	--	--	--	185	0.004	81	0.002
	--	0.75	--	--	--	573	0.013	172	0.004
	--	1.00	--	--	--	1,291	0.030	398	0.009
	--	1.25	--	--	--	2,031	0.047	806	0.019
	--	1.50	--	--	--	2,706	0.062	1,391	0.032
	--	1.75	--	--	--	3,194	0.073	2,124	0.049
	--	2.00	--	--	--	3,643	0.084	2,974	0.068
	--	2.25	--	--	--	4,110	0.094	3,979	0.091
	--	2.50	--	--	--	4,487	0.103	5,054	0.116
	--	2.75	--	--	--	4,799	0.110	6,215	0.143
	--	3.00	--	--	--	5,226	0.120	7,468	0.171
	--	3.25	--	--	--	5,536	0.127	8,813	0.202
	--	3.50	--	--	--	5,783	0.133	10,228	0.235
	--	3.75	--	--	--	6,005	0.138	11,702	0.269
	--	4.00	--	--	--	6,233	0.143	13,231	0.304
	--	4.25	--	--	--	6,468	0.148	14,819	0.340
	--	4.50	--	--	--	6,768	0.155	16,473	0.378
	--	4.75	--	--	--	7,247	0.166	18,225	0.418
	--	5.00	--	--	--	7,300	0.168	20,044	0.460
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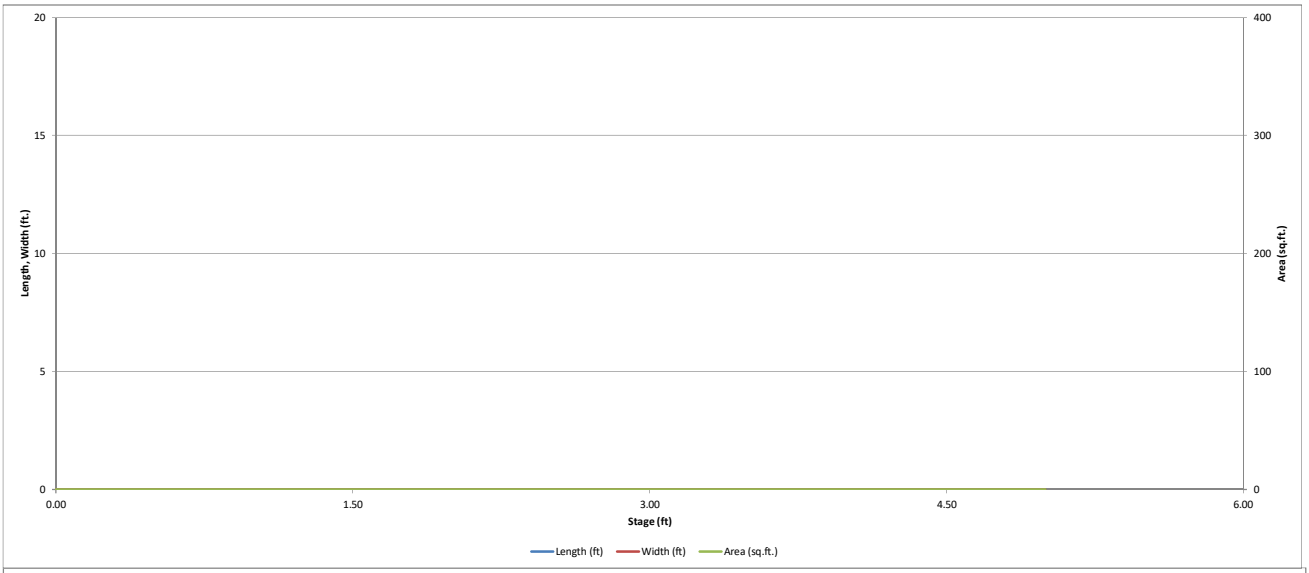
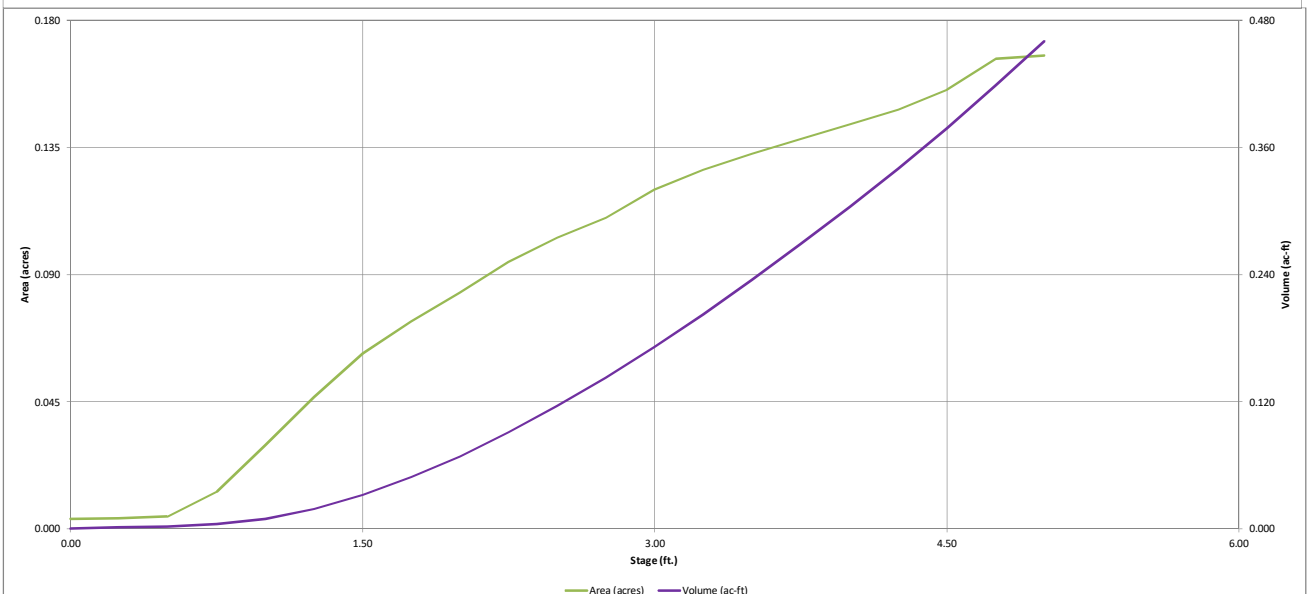
DETENTION BASIN STAGE-STORAGE TABLE BUILDER

UD-Detention, Version 3.07 (February 2017)



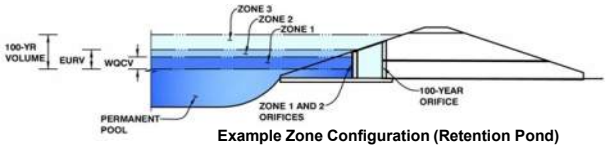


Detention Basin Outlet Structure Design

UD-Detention, Version 3.07 (February 2017)

Project: GEOS NEIGHBORHOOD BLOCKS 1-4

Basin ID: A Basin + D1



Example Zone Configuration (Retention Pond)

	Stage (ft)	Zone Volume (ac-ft)	Outlet Type
Zone 1 (WQCV)	2.03	0.071	Orifice Plate
Zone 2 (EURV)	3.27	0.133	Circular Orifice
Zone 3 (100-year)	4.23	0.132	Weir&Pipe (Restrict)
		0.336	Total

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

Underdrain Orifice Invert Depth =	N/A	ft (distance below the filtration media surface)	Underdrain Orifice Area =	N/A	ft^2
Underdrain Orifice Diameter =	N/A	inches	Underdrain Orifice Centroid =	N/A	feet

Calculated Parameters for Underdrain

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)

Invert of Lowest Orifice =	0.00	ft (relative to basin bottom at Stage = 0 ft)	WQ Orifice Area per Row =	2.083E-03	ft^2
Depth at top of Zone using Orifice Plate =	2.03	ft (relative to basin bottom at Stage = 0 ft)	Elliptical Half-Width =	N/A	feet
Orifice Plate: Orifice Vertical Spacing =	7.80	inches	Elliptical Slot Centroid =	N/A	feet
Orifice Plate: Orifice Area per Row =	0.30	sq. inches (diameter = 5/8 inch)	Elliptical Slot Area =	N/A	ft^2

Calculated Parameters for Plate

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	0.68	1.35					
Orifice Area (sq. inches)	0.30	0.30	0.30					

	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)

	Zone 2 Circular	Not Selected			Zone 2 Circular	Not Selected	
Invert of Vertical Orifice =	2.03	N/A	ft (relative to basin bottom at Stage = 0 ft)	Vertical Orifice Area =	0.02	N/A	ft^2
Depth at top of Zone using Vertical Orifice =	3.27	N/A	ft (relative to basin bottom at Stage = 0 ft)	Vertical Orifice Centroid =	0.08	N/A	feet
Vertical Orifice Diameter =	2.00	N/A	inches				

Calculated Parameters for Vertical Orifice

User Input: Overflow Weir (Dropbox) and Grate (Flat or Sloped)

	Zone 3 Weir	Not Selected			Zone 3 Weir	Not Selected	
Overflow Weir Front Edge Height, Ho =	3.27	N/A	ft (relative to basin bottom at Stage = 0 ft)	Height of Grate Upper Edge, H_t =	3.27	N/A	feet
Overflow Weir Front Edge Length =	3.00	N/A	feet	Over Flow Weir Slope Length =	3.00	N/A	feet
Overflow Weir Slope =	0.00	N/A	H:V (enter zero for flat grate)	Grate Open Area / 100-yr Orifice Area =	15.45	N/A	should be ≥ 4
Horiz. Length of Weir Sides =	3.00	N/A	feet	Overflow Grate Open Area w/o Debris =	6.30	N/A	ft^2
Overflow Grate Open Area % =	70%	N/A	%, grate open area/total area	Overflow Grate Open Area w/ Debris =	3.15	N/A	ft^2
Debris Clogging % =	50%	N/A	%				

Calculated Parameters for Overflow Weir

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

	Zone 3 Restrictor	Not Selected			Zone 3 Restrictor	Not Selected	
Depth to Invert of Outlet Pipe =	0.00	N/A	ft (distance below basin bottom at Stage = 0 ft)	Outlet Orifice Area =	0.41	N/A	ft^2
Outlet Pipe Diameter =	15.00	N/A	inches	Outlet Orifice Centroid =	0.27	N/A	feet
Restrictor Plate Height Above Pipe Invert =	5.50		inches	Half-Central Angle of Restrictor Plate on Pipe =	1.30	N/A	radians

Calculated Parameters for Outlet Pipe w/ Flow Restriction Plate

User Input: Emergency Spillway (Rectangular or Trapezoidal)

Spillway Invert Stage=	4.75	ft (relative to basin bottom at Stage = 0 ft)	Spillway Design Flow Depth=	0.21	feet
Spillway Crest Length =	30.00	feet	Stage at Top of Freeboard =	5.09	feet
Spillway End Slopes =	4.00	H:V	Basin Area at Top of Freeboard =	0.17	acres
Freeboard above Max Water Surface =	0.13	feet			

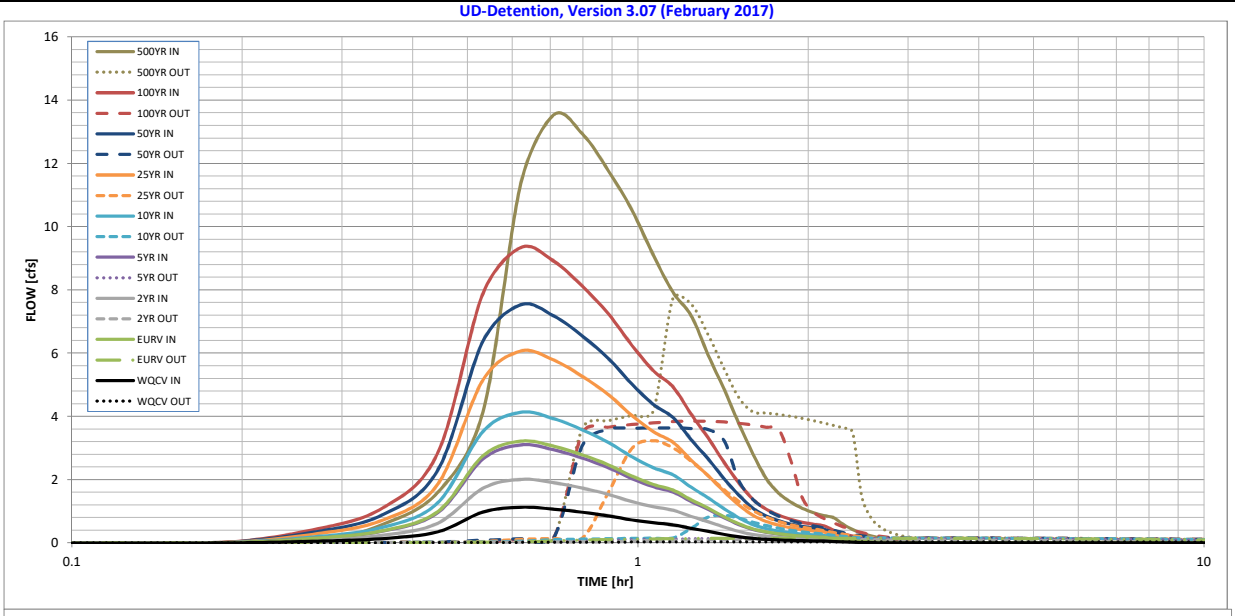
Calculated Parameters for Spillway

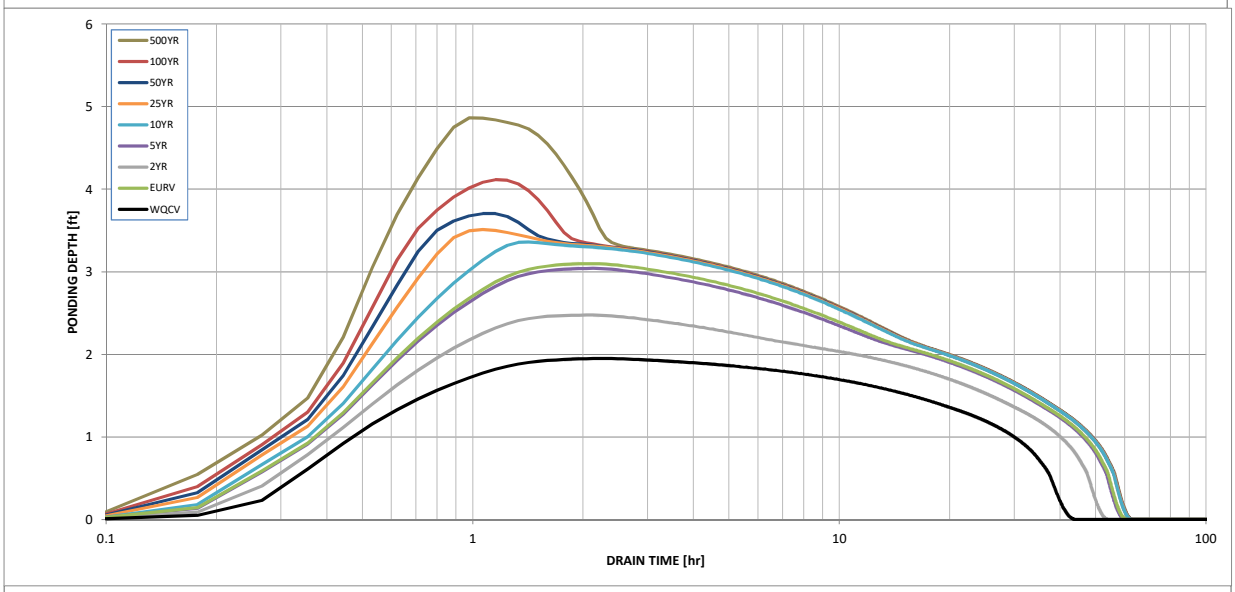
Routed Hydrograph Results

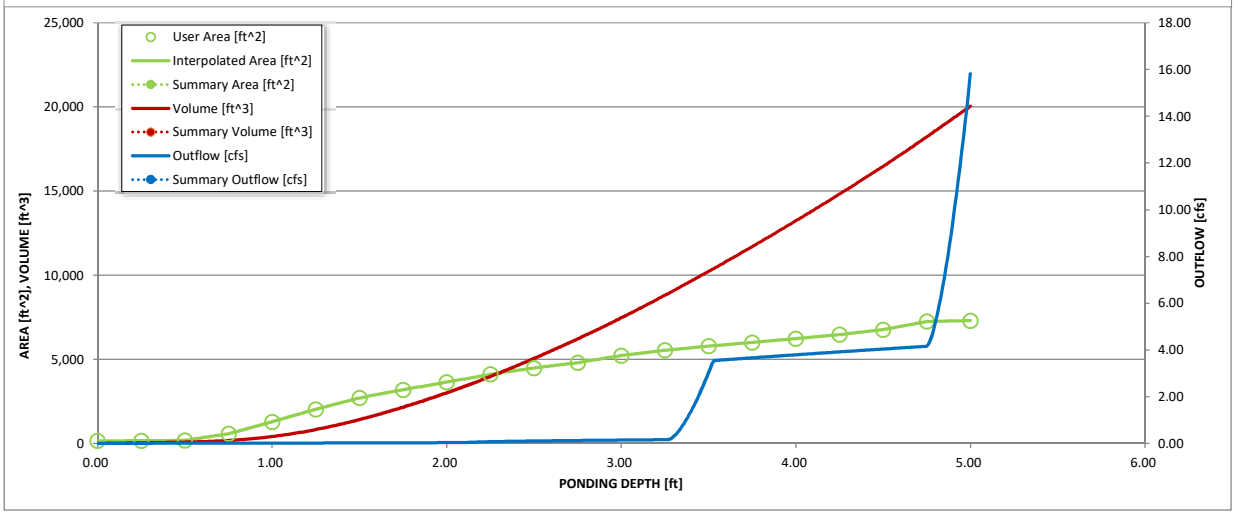
Design Storm Return Period =	WQCV	EURV	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	500 Year
One-Hour Rainfall Depth (in) =	0.53	1.07	0.78	1.05	1.30	1.66	1.95	2.27	3.08
Calculated Runoff Volume (acre-ft) =	0.071	0.204	0.127	0.196	0.262	0.388	0.482	0.599	0.871
OPTIONAL Override Runoff Volume (acre-ft) =									
Inflow Hydrograph Volume (acre-ft) =	0.070	0.203	0.126	0.196	0.262	0.387	0.481	0.598	0.870
Predevelopment Unit Peak Flow, q (cfs/acre) =	0.00	0.00	0.01	0.08	0.23	0.61	0.84	1.14	1.80
Predevelopment Peak Q (cfs) =	0.0	0.0	0.0	0.3	0.9	2.3	3.2	4.3	6.8
Peak Inflow Q (cfs) =	1.1	3.2	2.0	3.1	4.1	6.1	7.5	9.3	13.5
Peak Outflow Q (cfs) =	0.0	0.2	0.1	0.1	0.9	3.2	3.6	3.9	7.7
Ratio Peak Outflow to Predevelopment Q =	N/A	N/A	N/A	0.5	1.0	1.4	1.1	0.9	1.1
Structure Controlling Flow =	Plate	Vertical Orifice 1	Vertical Orifice 1	Vertical Orifice 1	Overflow Grate 1	Overflow Grate 1	Outlet Plate 1	Outlet Plate 1	Spillway
Max Velocity through Grate 1 (fps) =	N/A	N/A	N/A	N/A	0.1	0.5	0.5	0.6	0.6
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) =	38	50	45	49	50	47	45	43	38
Time to Drain 99% of Inflow Volume (hours) =	**40**	54	49	54	55	54	53	52	50
Maximum Ponding Depth (ft) =	1.95	3.10	2.48	3.04	3.36	3.51	3.71	4.12	4.86
Area at Maximum Ponding Depth (acres) =	0.08	0.12	0.10	0.12	0.13	0.13	0.14	0.15	0.17
Maximum Volume Stored (acre-ft) =	0.064	0.182	0.113	0.176	0.216	0.236	0.262	0.320	0.437

Detention Basin Outlet Structure Design

UD-Detention, Version 3.07 (February 2017)





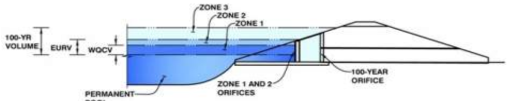


DETENTION BASIN STAGE-STORAGE TABLE BUILDER

UD-Detention, Version 3.07 (February 2017)

Project: GEOS NEIGHBORHOOD BLOCKS 1-4

Basin ID: BASIN B & E



Example Zone Configuration (Retention Pond)

Required Volume Calculation

Selected BMP Type =	**EDB**	
Watershed Area =	3.70	acres
Watershed Length =	550	ft
Watershed Slope =	0.017	ft/ft
Watershed Imperviousness =	60.21%	percent
Percentage Hydrologic Soil Group A =	0.0%	percent
Percentage Hydrologic Soil Group B =	0.0%	percent
Percentage Hydrologic Soil Groups C/D =	100.0%	percent
Desired WQCV Drain Time =	40.0	hours
Location for 1-hr Rainfall Depths =	Arvada - City Hall	
Water Quality Capture Volume (WQCV) =	0.073	acre-feet
Excess Urban Runoff Volume (EURV) =	0.214	acre-feet
2-yr Runoff Volume (P1 = 0.78 in.) =	0.134	acre-feet
5-yr Runoff Volume (P1 = 1.05 in.) =	0.203	acre-feet
10-yr Runoff Volume (P1 = 1.3 in.) =	0.269	acre-feet
25-yr Runoff Volume (P1 = 1.66 in.) =	0.391	acre-feet
50-yr Runoff Volume (P1 = 1.95 in.) =	0.483	acre-feet
100-yr Runoff Volume (P1 = 2.27 in.) =	0.597	acre-feet
500-yr Runoff Volume (P1 = 3.08 in.) =	0.862	acre-feet
Approximate 2-yr Detention Volume =	0.125	acre-feet
Approximate 5-yr Detention Volume =	0.192	acre-feet
Approximate 10-yr Detention Volume =	0.232	acre-feet
Approximate 25-yr Detention Volume =	0.278	acre-feet
Approximate 50-yr Detention Volume =	0.299	acre-feet
Approximate 100-yr Detention Volume =	0.344	acre-feet

Optional User Override 1-hr Precipitation

	inches
	inches
	inches
	inches
	inches
	inches
	inches

Stage-Storage Calculation

Zone 1 Volume (WQCV) =	0.073	acre-feet
Zone 2 Volume (EURV - Zone 1) =	0.141	acre-feet
Zone 3 Volume (100-year - Zones 1 & 2) =	0.130	acre-feet
Total Detention Basin Volume =	0.344	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 = 0.25 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	--	--	--	150	0.003		
	--	0.25	--	--	--	285	0.007	52	0.001
	--	0.50	--	--	--	428	0.010	139	0.003
	--	0.75	--	--	--	654	0.015	272	0.006
	--	1.00	--	--	--	956	0.022	470	0.011
	--	1.25	--	--	--	1,368	0.031	757	0.017
	--	1.50	--	--	--	1,891	0.043	1,159	0.027
	--	1.75	--	--	--	2,344	0.054	1,684	0.039
	--	2.00	--	--	--	2,788	0.064	2,321	0.053
	--	2.25	--	--	--	3,232	0.074	3,101	0.071
	--	2.50	--	--	--	3,676	0.084	3,965	0.091
	--	2.75	--	--	--	4,010	0.092	4,926	0.113
	--	3.00	--	--	--	4,179	0.096	5,949	0.137
	--	3.25	--	--	--	4,357	0.100	7,016	0.161
	--	3.50	--	--	--	4,584	0.105	8,134	0.187
	--	3.75	--	--	--	4,919	0.113	9,322	0.214
	--	4.00	--	--	--	5,191	0.119	10,585	0.243
	--	4.25	--	--	--	5,455	0.125	11,916	0.274
	--	4.50	--	--	--	5,733	0.132	13,315	0.306
	--	4.75	--	--	--	6,096	0.140	14,793	0.340
	--	5.00	--	--	--	6,344	0.146	16,348	0.375
	--	5.25	--	--	--	6,518	0.150	17,956	0.412
	--	5.50	--	--	--	6,684	0.153	19,606	0.450
	--	5.75	--	--	--	6,834	0.157	21,296	0.489
	--	6.00	--	--	--	6,969	0.160	23,021	0.528
	--	6.25	--	--	--	7,023	0.161	24,770	0.569
	--	6.50	--	--	--	7,023	0.161	26,526	0.609
	--	6.75	--	--	--	7,023	0.161	28,282	0.649
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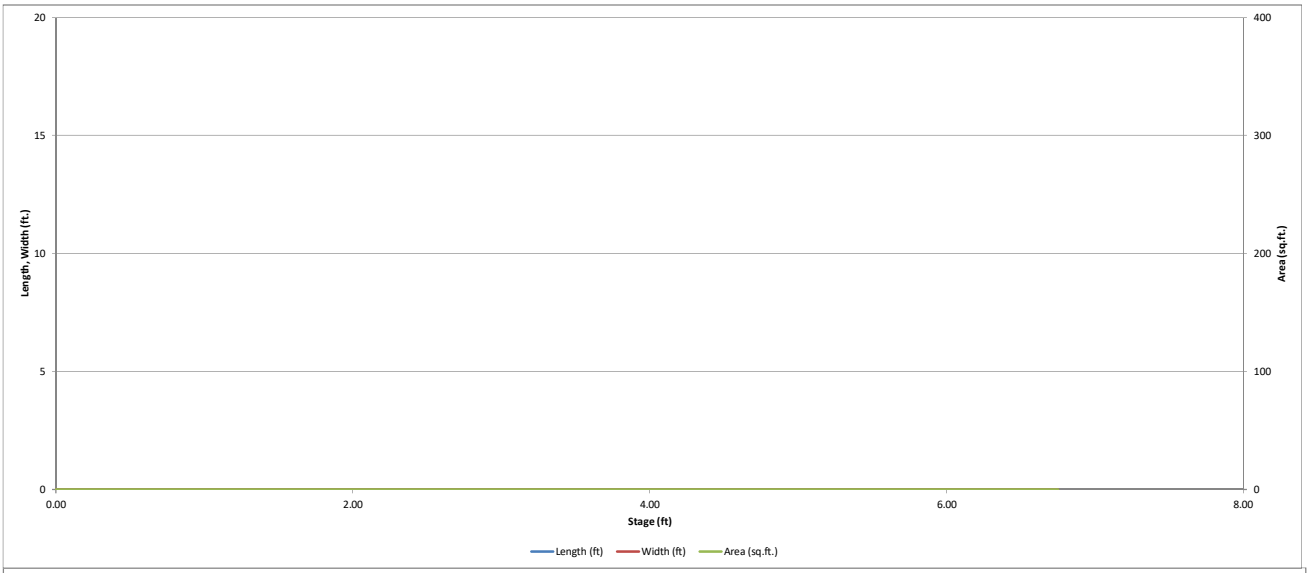
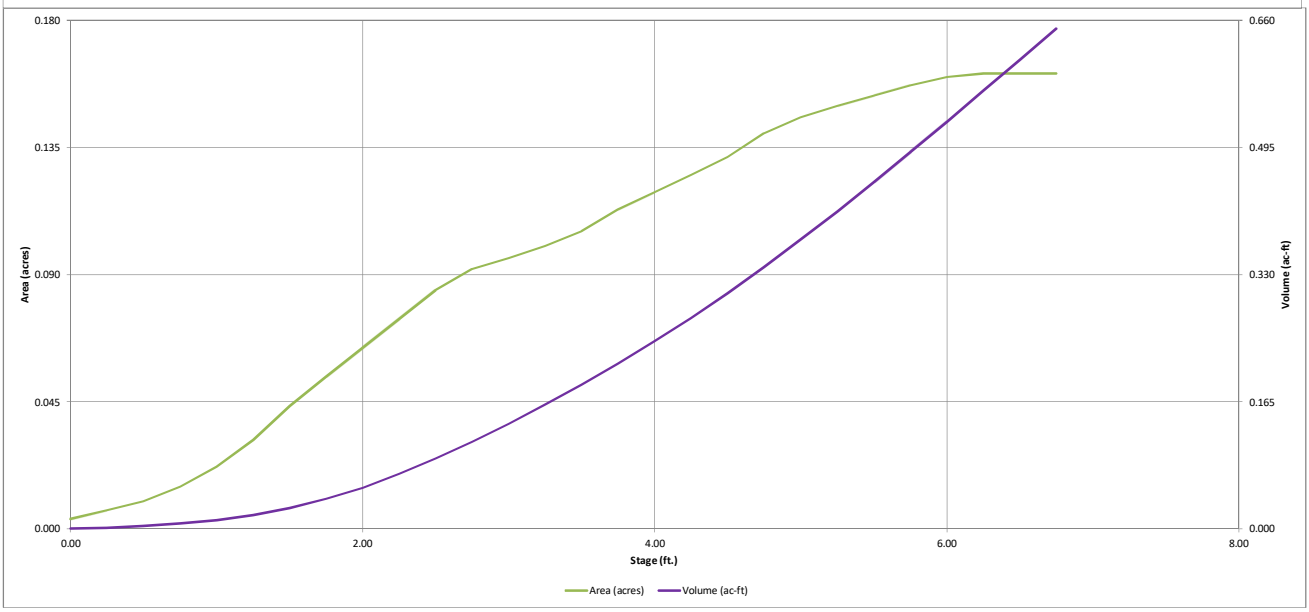
DETENTION BASIN STAGE-STORAGE TABLE BUILDER

UD-Detention, Version 3.07 (February 2017)



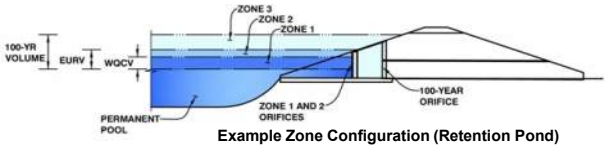


Detention Basin Outlet Structure Design

UD-Detention, Version 3.07 (February 2017)

Project: GEOS NEIGHBORHOOD BLOCKS 1-4

Basin ID: BASIN B & E



Example Zone Configuration (Retention Pond)

	Stage (ft)	Zone Volume (ac-ft)	Outlet Type
Zone 1 (WQCV)	2.28	0.073	Orifice Plate
Zone 2 (EURV)	3.75	0.141	Circular Orifice
Zone 3 (100-year)	4.78	0.130	Weir&Pipe (Restrict)
		0.344	Total

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

Underdrain Orifice Invert Depth =	N/A	ft (distance below the filtration media surface)	Underdrain Orifice Area =	N/A	ft^2
Underdrain Orifice Diameter =	N/A	inches	Underdrain Orifice Centroid =	N/A	feet

Calculated Parameters for Underdrain

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)

Invert of Lowest Orifice =	0.00	ft (relative to basin bottom at Stage = 0 ft)	WQ Orifice Area per Row =	2.222E-03	ft^2
Depth at top of Zone using Orifice Plate =	2.44	ft (relative to basin bottom at Stage = 0 ft)	Elliptical Half-Width =	N/A	feet
Orifice Plate: Orifice Vertical Spacing =	9.80	inches	Elliptical Slot Centroid =	N/A	feet
Orifice Plate: Orifice Area per Row =	0.32	sq. inches (diameter = 5/8 inch)	Elliptical Slot Area =	N/A	ft^2

Calculated Parameters for Plate

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	0.81	1.63					
Orifice Area (sq. inches)	0.32	0.32	0.32					

	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)

	Zone 2 Circular	Not Selected			Zone 2 Circular	Not Selected	
Invert of Vertical Orifice =	2.28	N/A	ft (relative to basin bottom at Stage = 0 ft)	Vertical Orifice Area =	0.02	N/A	ft^2
Depth at top of Zone using Vertical Orifice =	3.75	N/A	ft (relative to basin bottom at Stage = 0 ft)	Vertical Orifice Centroid =	0.08	N/A	feet
Vertical Orifice Diameter =	1.99	N/A	inches				

Calculated Parameters for Vertical Orifice

User Input: Overflow Weir (Dropbox) and Grate (Flat or Sloped)

	Zone 3 Weir	Not Selected			Zone 3 Weir	Not Selected	
Overflow Weir Front Edge Height, Ho =	3.82	N/A	ft (relative to basin bottom at Stage = 0 ft)	Height of Grate Upper Edge, H_t =	3.82	N/A	feet
Overflow Weir Front Edge Length =	3.00	N/A	feet	Over Flow Weir Slope Length =	3.00	N/A	feet
Overflow Weir Slope =	0.00	N/A	H:V (enter zero for flat grate)	Grate Open Area / 100-yr Orifice Area =	15.45	N/A	should be ≥ 4
Horiz. Length of Weir Sides =	3.00	N/A	feet	Overflow Grate Open Area w/o Debris =	6.30	N/A	ft^2
Overflow Grate Open Area % =	70%	N/A	%, grate open area/total area	Overflow Grate Open Area w/ Debris =	3.15	N/A	ft^2
Debris Clogging % =	50%	N/A	%				

Calculated Parameters for Overflow Weir

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

	Zone 3 Restrictor	Not Selected			Zone 3 Restrictor	Not Selected	
Depth to Invert of Outlet Pipe =	0.00	N/A	ft (distance below basin bottom at Stage = 0 ft)	Outlet Orifice Area =	0.41	N/A	ft^2
Outlet Pipe Diameter =	15.00	N/A	inches	Outlet Orifice Centroid =	0.27	N/A	feet
Restrictor Plate Height Above Pipe Invert =	5.50		inches	Half-Central Angle of Restrictor Plate on Pipe =	1.30	N/A	radians

Calculated Parameters for Outlet Pipe w/ Flow Restriction Plate

User Input: Emergency Spillway (Rectangular or Trapezoidal)

Spillway Invert Stage=	6.25	ft (relative to basin bottom at Stage = 0 ft)	Spillway Design Flow Depth=	0.29	feet
Spillway Crest Length =	18.00	feet	Stage at Top of Freeboard =	7.04	feet
Spillway End Slopes =	10.00	H:V	Basin Area at Top of Freeboard =	0.16	acres
Freeboard above Max Water Surface =	0.50	feet			

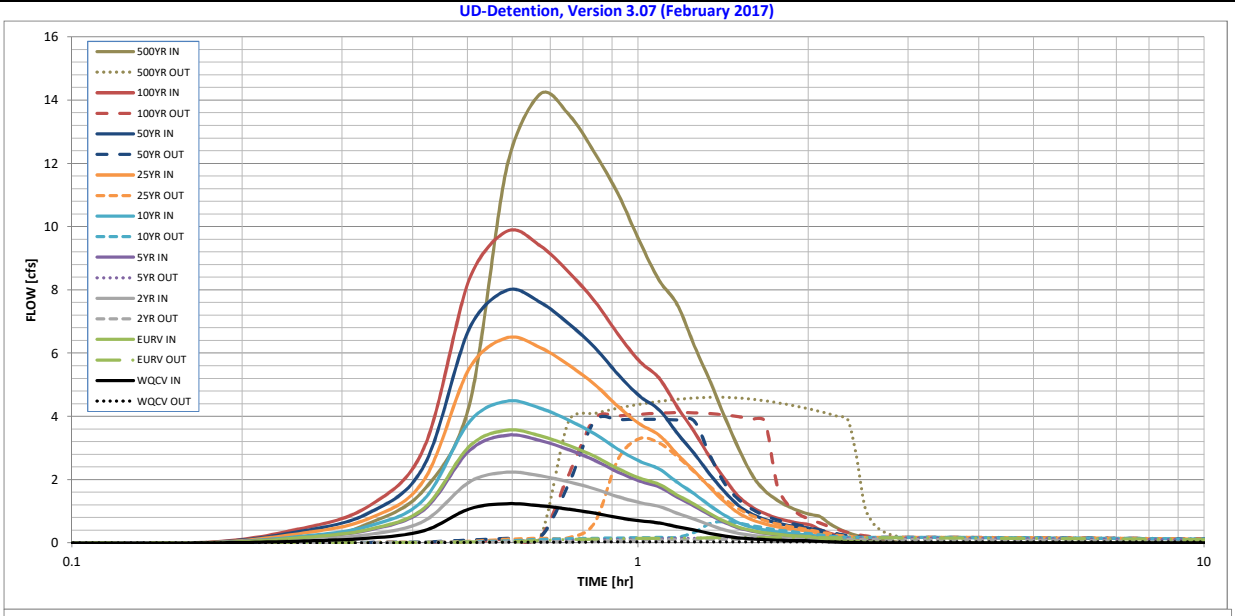
Calculated Parameters for Spillway

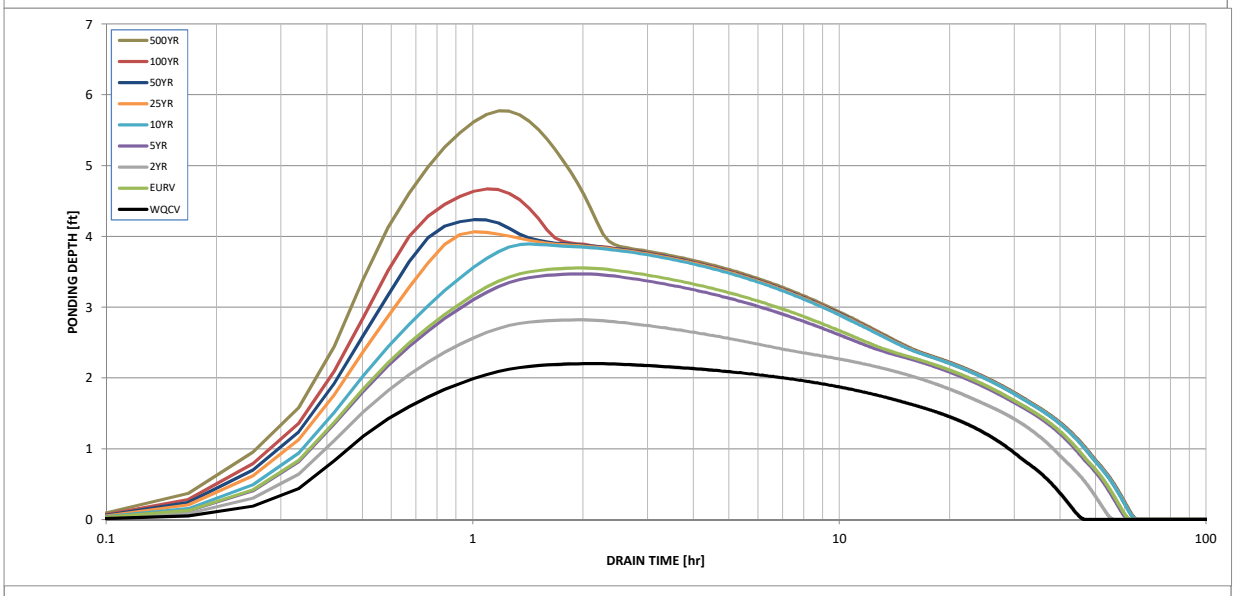
Routed Hydrograph Results

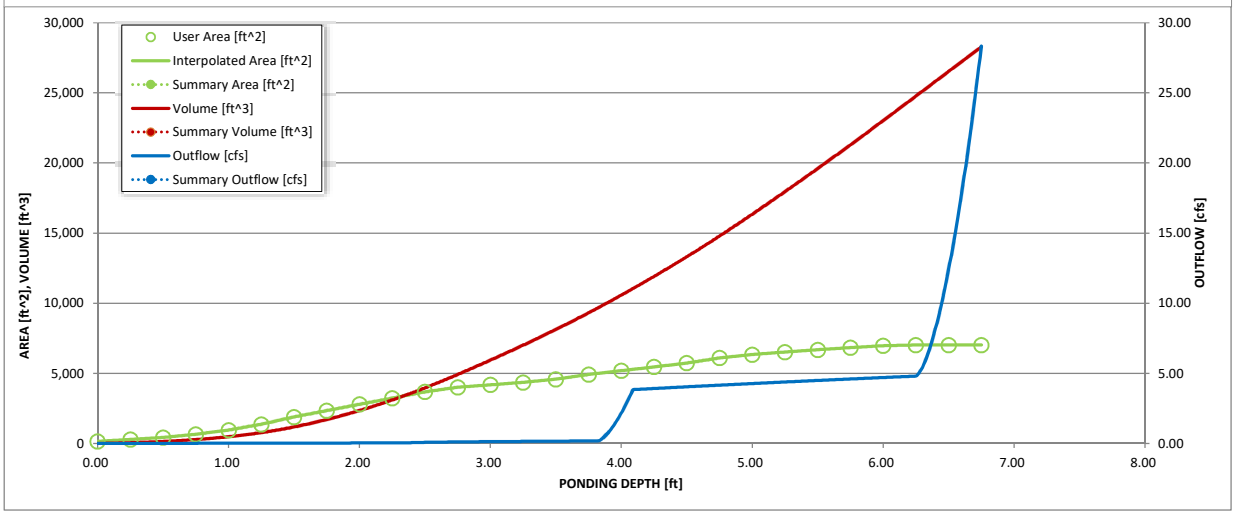
Design Storm Return Period =	WQCV	EURV	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	500 Year
One-Hour Rainfall Depth (in) =	0.53	1.07	0.78	1.05	1.30	1.66	1.95	2.27	3.08
Calculated Runoff Volume (acre-ft) =	0.073	0.214	0.134	0.203	0.269	0.391	0.483	0.597	0.862
OPTIONAL Override Runoff Volume (acre-ft) =									
Inflow Hydrograph Volume (acre-ft) =	0.073	0.213	0.133	0.203	0.269	0.391	0.483	0.597	0.862
Predevelopment Unit Peak Flow, q (cfs/acre) =	0.00	0.00	0.01	0.09	0.25	0.65	0.90	1.21	1.91
Predevelopment Peak Q (cfs) =	0.0	0.0	0.0	0.3	0.9	2.4	3.3	4.5	7.1
Peak Inflow Q (cfs) =	1.2	3.6	2.2	3.4	4.5	6.5	8.0	9.9	14.2
Peak Outflow Q (cfs) =	0.0	0.2	0.1	0.2	0.7	3.3	3.9	4.1	4.6
Ratio Peak Outflow to Predevelopment Q =	N/A	N/A	N/A	0.5	0.7	1.4	1.2	0.9	0.7
Structure Controlling Flow =	Plate	Vertical Orifice 1	Vertical Orifice 1	Vertical Orifice 1	Overflow Grate 1	Overflow Grate 1	Outlet Plate 1	Outlet Plate 1	Outlet Plate 1
Max Velocity through Grate 1 (fps) =	N/A	N/A	N/A	N/A	0.1	0.5	0.6	0.6	0.7
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) =	40	49	46	49	49	46	44	42	38
Time to Drain 99% of Inflow Volume (hours) =	**43**	56	51	55	57	55	54	52	49
Maximum Ponding Depth (ft) =	2.20	3.55	2.82	3.47	3.89	4.06	4.24	4.67	5.77
Area at Maximum Ponding Depth (acres) =	0.07	0.11	0.09	0.10	0.12	0.12	0.12	0.14	0.16
Maximum Volume Stored (acre-ft) =	0.068	0.192	0.120	0.183	0.230	0.250	0.271	0.329	0.492

Detention Basin Outlet Structure Design

UD-Detention, Version 3.07 (February 2017)





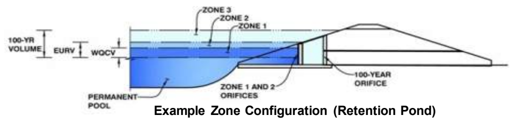


DETENTION BASIN STAGE-STORAGE TABLE BUILDER

UD-Detention, Version 3.07 (February 2017)

Project: GEOS NEIGHBORHOOD BLOCKS 1-4

Basin ID: BASIN D



Example Zone Configuration (Retention Pond)

Required Volume Calculation

Selected BMP Type =	EDB	
Watershed Area =	2.27	acres
Watershed Length =	566	ft
Watershed Slope =	0.010	ft/ft
Watershed Imperviousness =	49.00%	percent
Percentage Hydrologic Soil Group A =	0.0%	percent
Percentage Hydrologic Soil Group B =	0.0%	percent
Percentage Hydrologic Soil Groups C/D =	100.0%	percent
Desired WQCV Drain Time =	40.0	hours
Location for 1-hr Rainfall Depths =	Arvada - City Hall	

			Optional User Override 1-hr Precipitation	
Water Quality Capture Volume (WQCV) =	0.039	acre-feet		
Excess Urban Runoff Volume (EURV) =	0.105	acre-feet		
2-yr Runoff Volume (P1 = 0.78 in.) =	0.065	acre-feet		inches
5-yr Runoff Volume (P1 = 1.05 in.) =	0.103	acre-feet		inches
10-yr Runoff Volume (P1 = 1.3 in.) =	0.141	acre-feet		inches
25-yr Runoff Volume (P1 = 1.66 in.) =	0.216	acre-feet		inches
50-yr Runoff Volume (P1 = 1.95 in.) =	0.272	acre-feet		inches
100-yr Runoff Volume (P1 = 2.27 in.) =	0.343	acre-feet		inches
500-yr Runoff Volume (P1 = 3.08 in.) =	0.505	acre-feet		inches
Approximate 2-yr Detention Volume =	0.061	acre-feet		
Approximate 5-yr Detention Volume =	0.097	acre-feet		
Approximate 10-yr Detention Volume =	0.117	acre-feet		
Approximate 25-yr Detention Volume =	0.142	acre-feet		
Approximate 50-yr Detention Volume =	0.154	acre-feet		
Approximate 100-yr Detention Volume =	0.182	acre-feet		

Stage-Storage Calculation

Zone 1 Volume (WQCV) =	0.039	acre-feet
Zone 2 Volume (EURV - Zone 1) =	0.067	acre-feet
Zone 3 Volume (100-year - Zones 1 & 2) =	0.077	acre-feet
Total Detention Basin Volume =	0.182	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 = 0.25 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	--	--	--	135	0.003		
	--	0.25	--	--	--	266	0.006	48	0.001
	--	0.50	--	--	--	402	0.009	130	0.003
	--	0.75	--	--	--	616	0.014	255	0.006
	--	1.00	--	--	--	907	0.021	442	0.010
	--	1.25	--	--	--	1,276	0.029	711	0.016
	--	1.50	--	--	--	1,698	0.039	1,079	0.025
	--	1.75	--	--	--	2,173	0.050	1,558	0.036
	--	2.00	--	--	--	2,664	0.061	2,158	0.050
	--	2.25	--	--	--	3,204	0.074	2,918	0.067
	--	2.50	--	--	--	3,764	0.086	3,789	0.087
	--	2.75	--	--	--	4,319	0.099	4,799	0.110
	--	3.00	--	--	--	5,217	0.120	5,991	0.138
	--	3.25	--	--	--	5,842	0.134	7,374	0.169
	--	3.50	--	--	--	6,143	0.141	8,872	0.204
	--	3.75	--	--	--	6,428	0.148	10,443	0.240
	--	4.00	--	--	--	6,698	0.154	12,084	0.277
	--	4.25	--	--	--	6,976	0.160	13,793	0.317
	--	4.50	--	--	--	7,256	0.167	15,572	0.357
	--	4.75	--	--	--	7,547	0.173	17,423	0.400
	--	5.00	--	--	--	7,839	0.180	19,346	0.444
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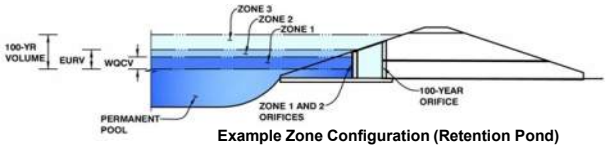
Detention Basin Outlet Structure Design

UD-Detention, Version 3.07 (February 2017)

Project: GOES NEIGHBORHOOD BLOCKS 1-4

Basin ID: BASIN D -D1



Example Zone Configuration (Retention Pond)

	Stage (ft)	Zone Volume (ac-ft)	Outlet Type
Zone 1 (WQCV)	1.80	0.039	Orifice Plate
Zone 2 (EURV)	2.70	0.067	Circular Orifice
Zone 3 (100-year)	3.35	0.077	Weir&Pipe (Restrict)
		0.182	Total

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

Underdrain Orifice Invert Depth =	N/A	ft (distance below the filtration media surface)	Underdrain Orifice Area =	N/A	ft^2
Underdrain Orifice Diameter =	N/A	inches	Underdrain Orifice Centroid =	N/A	feet

Calculated Parameters for Underdrain

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)

Invert of Lowest Orifice =	0.00	ft (relative to basin bottom at Stage = 0 ft)	WQ Orifice Area per Row =	1.458E-03	ft^2
Depth at top of Zone using Orifice Plate =	1.80	ft (relative to basin bottom at Stage = 0 ft)	Elliptical Half-Width =	N/A	feet
Orifice Plate: Orifice Vertical Spacing =	7.20	inches	Elliptical Slot Centroid =	N/A	feet
Orifice Plate: Orifice Area per Row =	0.21	sq. inches (diameter = 1/2 inch)	Elliptical Slot Area =	N/A	ft^2

Calculated Parameters for Plate

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	0.60	1.20					
Orifice Area (sq. inches)	0.21	0.21	0.21					

	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)

	Zone 2 Circular	Not Selected		Zone 2 Circular	Not Selected	
Invert of Vertical Orifice =	1.80	N/A	ft (relative to basin bottom at Stage = 0 ft)	Vertical Orifice Area =	0.01	N/A	ft^2
Depth at top of Zone using Vertical Orifice =	2.70	N/A	ft (relative to basin bottom at Stage = 0 ft)	Vertical Orifice Centroid =	0.05	N/A	feet
Vertical Orifice Diameter =	1.25	N/A	inches				

Calculated Parameters for Vertical Orifice

User Input: Overflow Weir (Dropbox) and Grate (Flat or Sloped)

	Zone 3 Weir	Not Selected		Zone 3 Weir	Not Selected	
Overflow Weir Front Edge Height, Ho =	2.70	N/A	ft (relative to basin bottom at Stage = 0 ft)	Height of Grate Upper Edge, H_t =	2.70	N/A	feet
Overflow Weir Front Edge Length =	3.00	N/A	feet	Over Flow Weir Slope Length =	3.00	N/A	feet
Overflow Weir Slope =	0.00	N/A	H:V (enter zero for flat grate)	Grate Open Area / 100-yr Orifice Area =	30.16	N/A	should be ≥ 4
Horiz. Length of Weir Sides =	3.00	N/A	feet	Overflow Grate Open Area w/o Debris =	6.30	N/A	ft^2
Overflow Grate Open Area % =	70%	N/A	%, grate open area/total area	Overflow Grate Open Area w/ Debris =	3.15	N/A	ft^2
Debris Clogging % =	50%	N/A	%				

Calculated Parameters for Overflow Weir

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

	Zone 3 Restrictor	Not Selected		Zone 3 Restrictor	Not Selected	
Depth to Invert of Outlet Pipe =	0.50	N/A	ft (distance below basin bottom at Stage = 0 ft)	Outlet Orifice Area =	0.21	N/A	ft^2
Outlet Pipe Diameter =	15.00	N/A	inches	Outlet Orifice Centroid =	0.17	N/A	feet
Restrictor Plate Height Above Pipe Invert =	3.40		inches	Half-Central Angle of Restrictor Plate on Pipe =	0.99	N/A	radians

Calculated Parameters for Outlet Pipe w/ Flow Restriction Plate

User Input: Emergency Spillway (Rectangular or Trapezoidal)

Spillway Invert Stage=	4.75	ft (relative to basin bottom at Stage = 0 ft)	Spillway Design Flow Depth=	0.08	feet
Spillway Crest Length =	55.00	feet	Stage at Top of Freeboard =	5.00	feet
Spillway End Slopes =	6.00	H:V	Basin Area at Top of Freeboard =	0.18	acres
Freeboard above Max Water Surface =	0.17	feet			

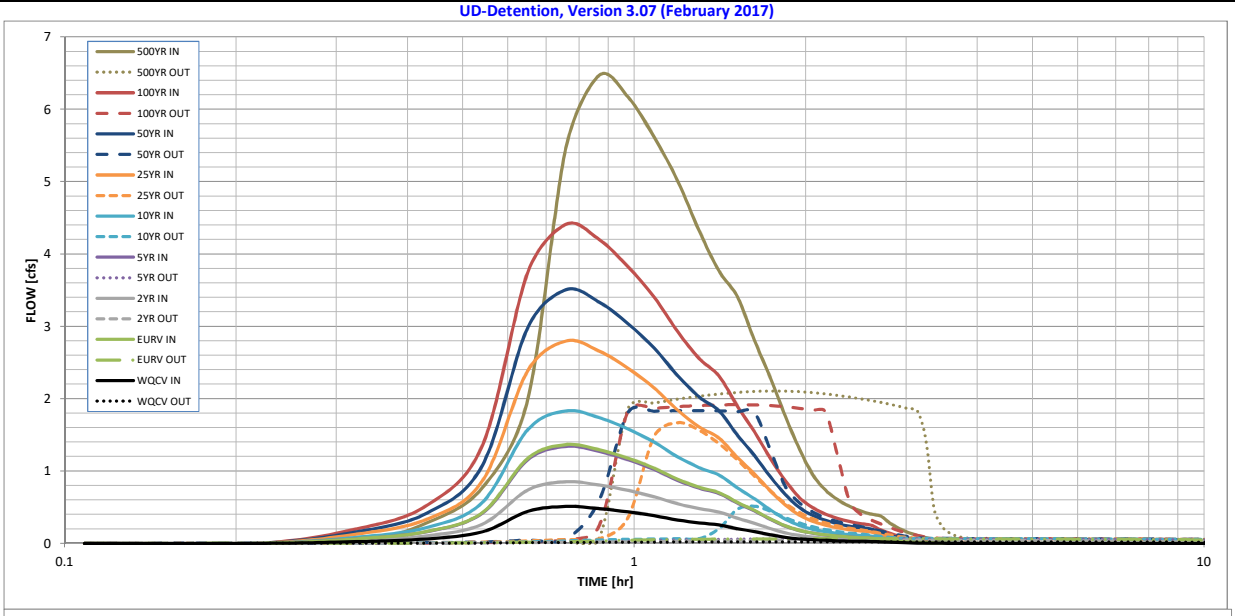
Calculated Parameters for Spillway

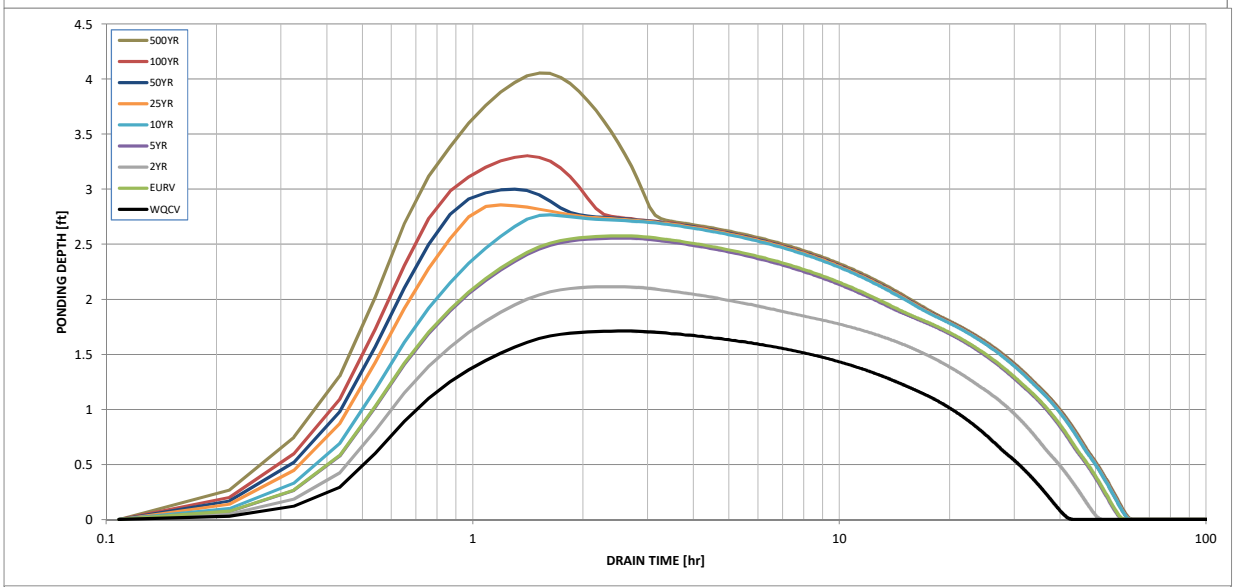
Routed Hydrograph Results

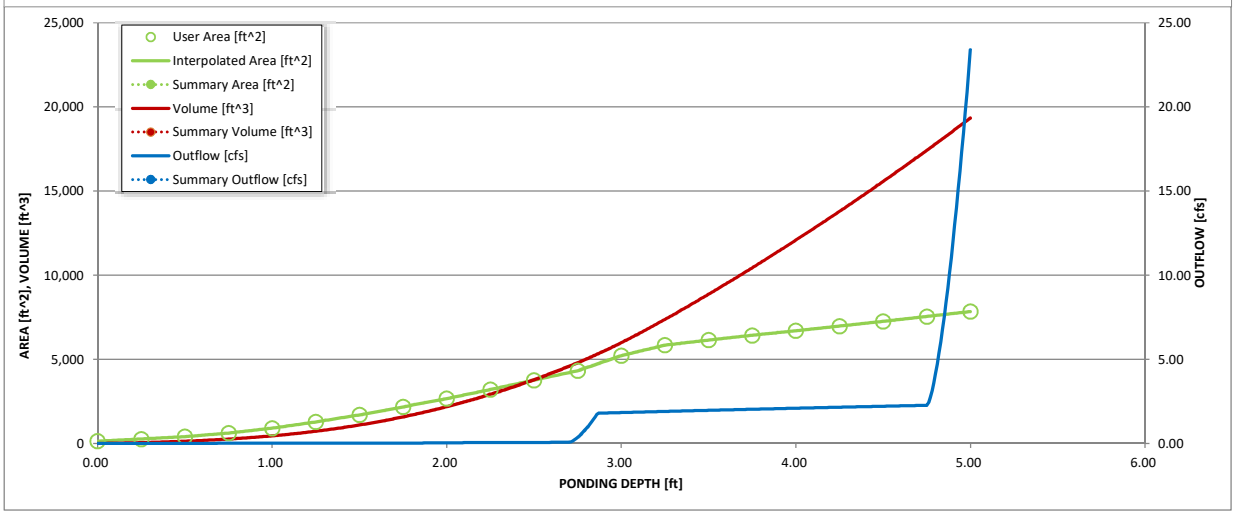
Design Storm Return Period =	WQCV	EURV	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	500 Year
One-Hour Rainfall Depth (in) =	0.53	1.07	0.78	1.05	1.30	1.66	1.95	2.27	3.08
Calculated Runoff Volume (acre-ft) =	0.039	0.105	0.065	0.103	0.141	0.216	0.272	0.343	0.505
OPTIONAL Override Runoff Volume (acre-ft) =									
Inflow Hydrograph Volume (acre-ft) =	0.038	0.104	0.065	0.102	0.140	0.216	0.272	0.343	0.505
Predevelopment Unit Peak Flow, q (cfs/acre) =	0.00	0.00	0.01	0.06	0.18	0.49	0.67	0.92	1.46
Predevelopment Peak Q (cfs) =	0.0	0.0	0.0	0.1	0.4	1.1	1.5	2.1	3.3
Peak Inflow Q (cfs) =	0.5	1.4	0.9	1.3	1.8	2.8	3.5	4.4	6.5
Peak Outflow Q (cfs) =	0.0	0.1	0.0	0.1	0.5	1.7	1.8	1.9	2.1
Ratio Peak Outflow to Predevelopment Q =	N/A	N/A	N/A	0.5	1.3	1.5	1.2	0.9	0.6
Structure Controlling Flow =	Plate	Vertical Orifice 1	Vertical Orifice 1	Vertical Orifice 1	Overflow Grate 1	Outlet Plate 1	Outlet Plate 1	Outlet Plate 1	Outlet Plate 1
Max Velocity through Grate 1 (fps) =	N/A	N/A	N/A	N/A	0.1	0.3	0.3	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) =	36	48	43	47	47	44	42	40	35
Time to Drain 99% of Inflow Volume (hours) =	**40**	54	47	53	55	52	51	49	47
Maximum Ponding Depth (ft) =	1.71	2.58	2.11	2.56	2.77	2.86	3.00	3.30	4.06
Area at Maximum Ponding Depth (acres) =	0.05	0.09	0.07	0.09	0.10	0.11	0.12	0.14	0.16
Maximum Volume Stored (acre-ft) =	0.034	0.093	0.057	0.091	0.111	0.121	0.136	0.176	0.285

Detention Basin Outlet Structure Design

UD-Detention, Version 3.07 (February 2017)





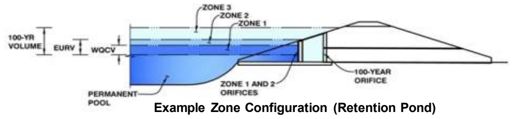


DETENTION BASIN STAGE-STORAGE TABLE BUILDER

UD-Detention, Version 3.07 (February 2017)

Project: GEOS NEIGHBORHOOD BLOCKS 1-4

Basin ID: BASIN F - Interim Condition



Example Zone Configuration (Retention Pond)

Required Volume Calculation

Selected BMP Type =	EDB				
Watershed Area =	2.05	acres			
Watershed Length =	500	ft			
Watershed Slope =	0.020	ft/ft			
Watershed Imperviousness =	13.20%	percent			
Percentage Hydrologic Soil Group A =	0.0%	percent			
Percentage Hydrologic Soil Group B =	0.0%	percent			
Percentage Hydrologic Soil Groups C/D =	100.0%	percent			
Desired WQCV Drain Time =	40.0	hours			
Location for 1-hr Rainfall Depths =	Arvada - City Hall				
Water Quality Capture Volume (WQCV) =	0.014	acre-feet	Optional User Override		
Excess Urban Runoff Volume (EURV) =	0.023	acre-feet	1-hr Precipitation		
2-yr Runoff Volume (P1 = 0.78 in.) =	0.013	acre-feet		inches	
5-yr Runoff Volume (P1 = 1.05 in.) =	0.030	acre-feet		inches	
10-yr Runoff Volume (P1 = 1.3 in.) =	0.058	acre-feet		inches	
25-yr Runoff Volume (P1 = 1.66 in.) =	0.127	acre-feet		inches	
50-yr Runoff Volume (P1 = 1.95 in.) =	0.177	acre-feet		inches	
100-yr Runoff Volume (P1 = 2.27 in.) =	0.243	acre-feet		inches	
500-yr Runoff Volume (P1 = 3.08 in.) =	0.386	acre-feet		inches	
Approximate 2-yr Detention Volume =	0.012	acre-feet			
Approximate 5-yr Detention Volume =	0.028	acre-feet			
Approximate 10-yr Detention Volume =	0.038	acre-feet			
Approximate 25-yr Detention Volume =	0.051	acre-feet			
Approximate 50-yr Detention Volume =	0.055	acre-feet			
Approximate 100-yr Detention Volume =	0.078	acre-feet			

Stage-Storage Calculation

Zone 1 Volume (WQCV) =	0.014	acre-feet
Zone 2 Volume (EURV - Zone 1) =	0.009	acre-feet
Zone 3 Volume (100-year - Zones 1 & 2) =	0.055	acre-feet
Total Detention Basin Volume =	0.078	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 = 0.25 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		
	--	0.25	--	--	--	117	0.003	13	0.000
	--	0.50	--	--	--	488	0.011	85	0.002
	--	0.75	--	--	--	1,032	0.024	270	0.006
	--	1.00	--	--	--	1,658	0.038	600	0.014
	--	1.25	--	--	--	2,354	0.054	1,095	0.025
	--	1.50	--	--	--	3,116	0.072	1,771	0.041
	--	1.75	--	--	--	3,945	0.091	2,645	0.061
	--	2.00	--	--	--	4,841	0.111	3,734	0.086
	--	2.25	--	--	--	5,783	0.133	5,111	0.117
	--	2.50	--	--	--	6,733	0.155	6,675	0.153
	--	2.75	--	--	--	7,659	0.176	8,474	0.195
	--	3.00	--	--	--	8,487	0.195	10,492	0.241
	--	3.25	--	--	--	9,226	0.212	12,706	0.292
	--	3.50	--	--	--	9,958	0.229	15,104	0.347
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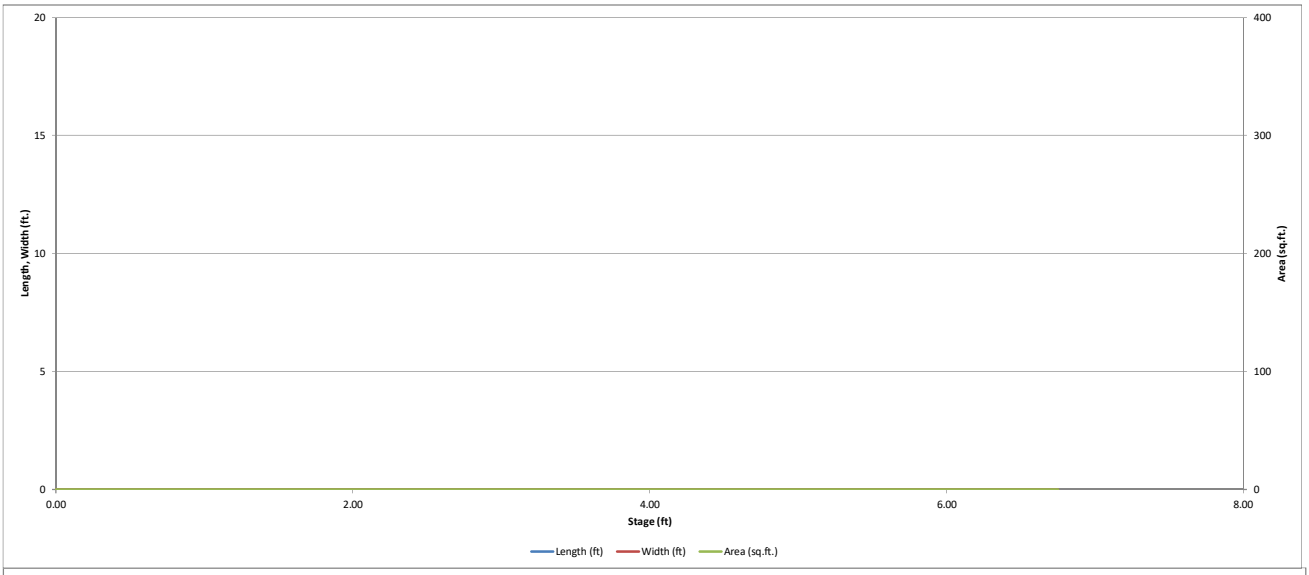
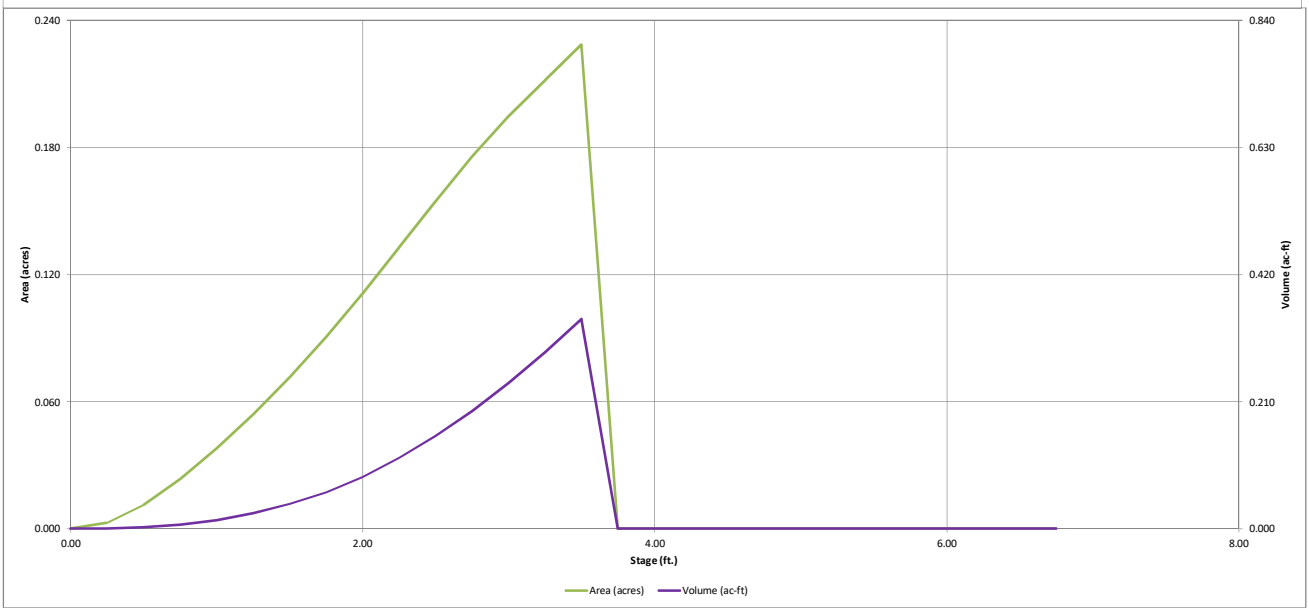
DETENTION BASIN STAGE-STORAGE TABLE BUILDER

UD-Detention, Version 3.07 (February 2017)



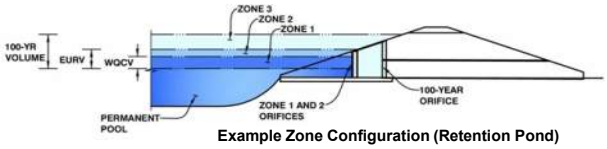


Detention Basin Outlet Structure Design

UD-Detention, Version 3.07 (February 2017)

Project: GEOS NEIGHBORHOOD BLOCKS 1-4

Basin ID: BASIN F



Example Zone Configuration (Retention Pond)

	Stage (ft)	Zone Volume (ac-ft)	Outlet Type
Zone 1 (WQCV)	1.01	0.014	Orifice Plate
Zone 2 (EURV)	1.20	0.009	Circular Orifice
Zone 3 (100-year)	1.92	0.055	Rectangular Orifice
		0.078	Total

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

Underdrain Orifice Invert Depth =	N/A	ft (distance below the filtration media surface)	Underdrain Orifice Area =	N/A	ft^2
Underdrain Orifice Diameter =	N/A	inches	Underdrain Orifice Centroid =	N/A	feet

Calculated Parameters for Underdrain

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)

Invert of Lowest Orifice =	0.00	ft (relative to basin bottom at Stage = 0 ft)	WQ Orifice Area per Row =	8.333E-04	ft^2
Depth at top of Zone using Orifice Plate =	1.01	ft (relative to basin bottom at Stage = 0 ft)	Elliptical Half-Width =	N/A	feet
Orifice Plate: Orifice Vertical Spacing =	N/A	inches	Elliptical Slot Centroid =	N/A	feet
Orifice Plate: Orifice Area per Row =	0.12	sq. inches (diameter = 3/8 inch)	Elliptical Slot Area =	N/A	ft^2

Calculated Parameters for Plate

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						
Orifice Area (sq. inches)	0.12	0.12						

	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)

	Zone 2 Circular	Zone 3 Rectangular	
Invert of Vertical Orifice =	1.01	1.20	ft (relative to basin bottom at Stage = 0 ft)
Depth at top of Zone using Vertical Orifice =	1.20	1.92	ft (relative to basin bottom at Stage = 0 ft)
Vertical Orifice Diameter or Height =	0.38	12.00	inches
Vertical Orifice Width =		6.00	inches

Calculated Parameters for Vertical Orifice

	Zone 2 Circular	Zone 3 Rectangular	
Vertical Orifice Area =	0.00	0.50	ft^2
Vertical Orifice Centroid =	0.02	0.50	feet

User Input: Overflow Weir (Dropbox) and Grate (Flat or Sloped)

	Not Selected	Not Selected	
Overflow Weir Front Edge Height, Ho =	N/A	N/A	ft (relative to basin bottom at Stage = 0 ft)
Overflow Weir Front Edge Length =	N/A	N/A	feet
Overflow Weir Slope =	N/A	N/A	H:V (enter zero for flat grate)
Horiz. Length of Weir Sides =	N/A	N/A	feet
Overflow Grate Open Area % =	N/A	N/A	%, grate open area/total area
Debris Clogging % =	N/A	N/A	%

Calculated Parameters for Overflow Weir

	Not Selected	Not Selected	
Height of Grate Upper Edge, H_t =	N/A	N/A	feet
Over Flow Weir Slope Length =	N/A	N/A	feet
Grate Open Area / 100-yr Orifice Area =	N/A	N/A	should be ≥ 4
Overflow Grate Open Area w/o Debris =	N/A	N/A	ft^2
Overflow Grate Open Area w/ Debris =	N/A	N/A	ft^2

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

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

Calculated Parameters for Outlet Pipe w/ Flow Restriction Plate

	Not Selected	Not Selected	
Outlet Orifice Area =	N/A	N/A	ft^2
Outlet Orifice Centroid =	N/A	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=	3.61	ft (relative to basin bottom at Stage = 0 ft)
Spillway Crest Length =	80.00	feet
Spillway End Slopes =	10.00	H:V
Freeboard above Max Water Surface =	1.00	feet

Calculated Parameters for Spillway

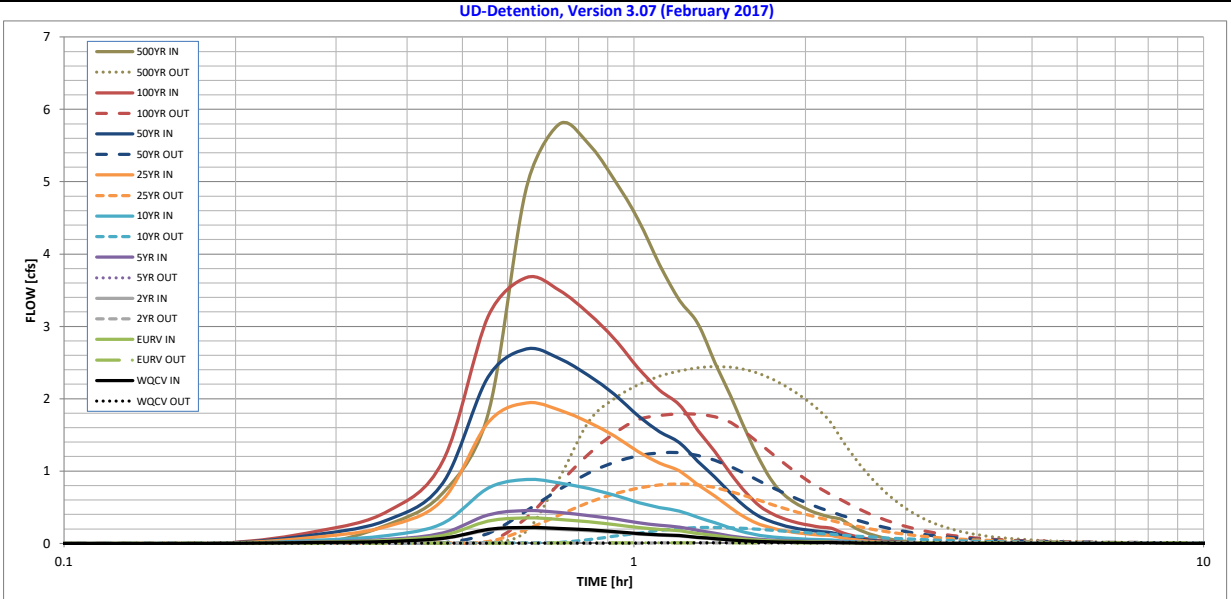
Spillway Design Flow Depth=	0.06	feet
Stage at Top of Freeboard =	4.67	feet
Basin Area at Top of Freeboard =	0.23	acres

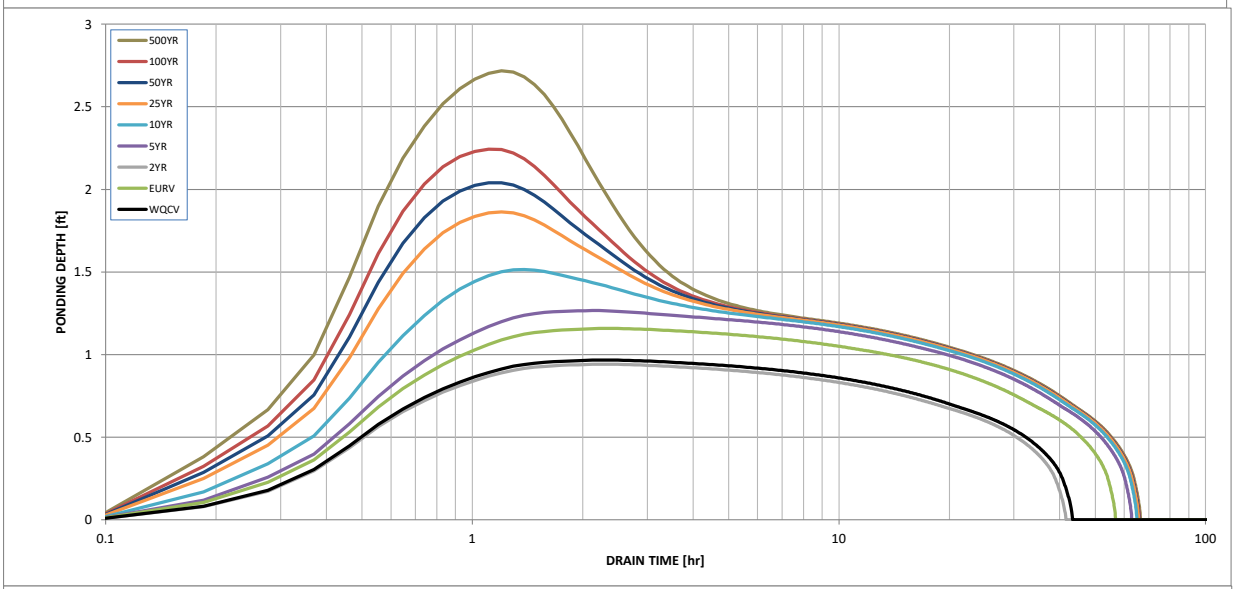
Routed Hydrograph Results

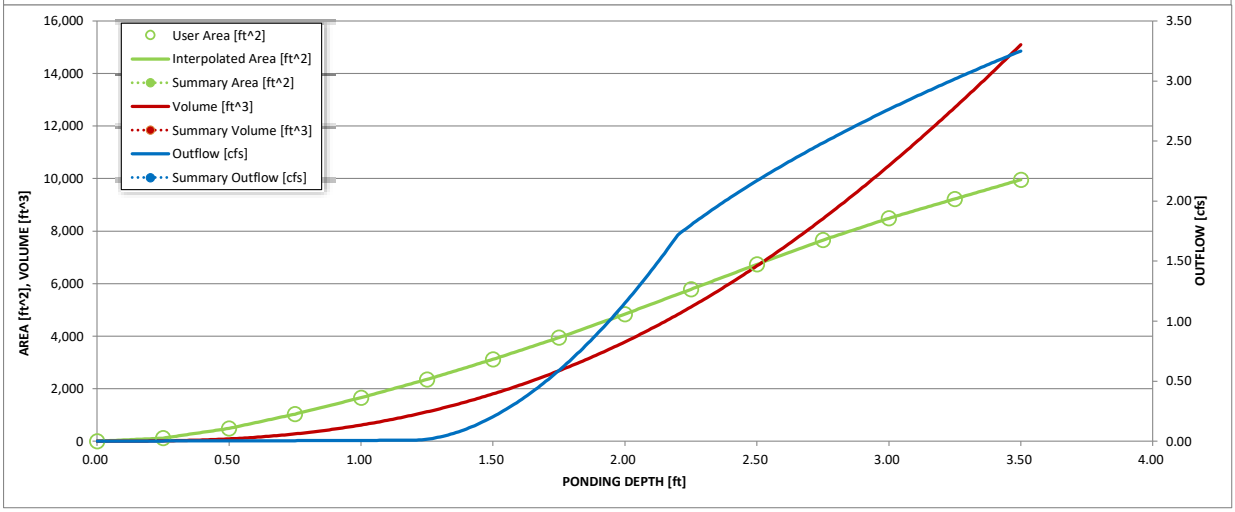
Design Storm Return Period =	WQCV	EURV	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	500 Year
One-Hour Rainfall Depth (in) =	0.53	1.07	0.78	1.05	1.30	1.66	1.95	2.27	3.08
Calculated Runoff Volume (acre-ft) =	0.014	0.023	0.013	0.030	0.058	0.127	0.177	0.243	0.386
OPTIONAL Override Runoff Volume (acre-ft) =									
Inflow Hydrograph Volume (acre-ft) =	0.014	0.022	0.013	0.029	0.057	0.127	0.177	0.243	0.385
Predevelopment Unit Peak Flow, q (cfs/acre) =	0.00	0.00	0.01	0.07	0.22	0.58	0.80	1.08	1.71
Predevelopment Peak Q (cfs) =	0.0	0.0	0.0	0.2	0.4	1.2	1.6	2.2	3.5
Peak Inflow Q (cfs) =	0.2	0.4	0.2	0.5	0.9	1.9	2.7	3.7	5.8
Peak Outflow Q (cfs) =	0.0	0.0	0.0	0.0	0.2	0.8	1.3	1.8	2.4
Ratio Peak Outflow to Predevelopment Q =	N/A	N/A	N/A	0.1	0.5	0.7	0.8	0.8	0.7
Structure Controlling Flow =	Plate	Vertical Orifice 1	Plate	Vertical Orifice 2	Vertical Orifice 2	Vertical Orifice 2	Vertical Orifice 2	Vertical Orifice 2	Vertical Orifice 2
Max Velocity through Grate 1 (fps) =	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
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) =	40	52	39	57	56	48	43	38	28
Time to Drain 99% of Inflow Volume (hours) =	**42**	55	40	61	61	58	56	54	48
Maximum Ponding Depth (ft) =	0.97	1.16	0.94	1.27	1.52	1.86	2.04	2.24	2.72
Area at Maximum Ponding Depth (acres) =	0.04	0.05	0.03	0.05	0.07	0.10	0.11	0.13	0.17
Maximum Volume Stored (acre-ft) =	0.013	0.021	0.012	0.026	0.042	0.072	0.090	0.116	0.188

Detention Basin Outlet Structure Design

UD-Detention, Version 3.07 (February 2017)







Channel Report

Storm to Pond A

Circular

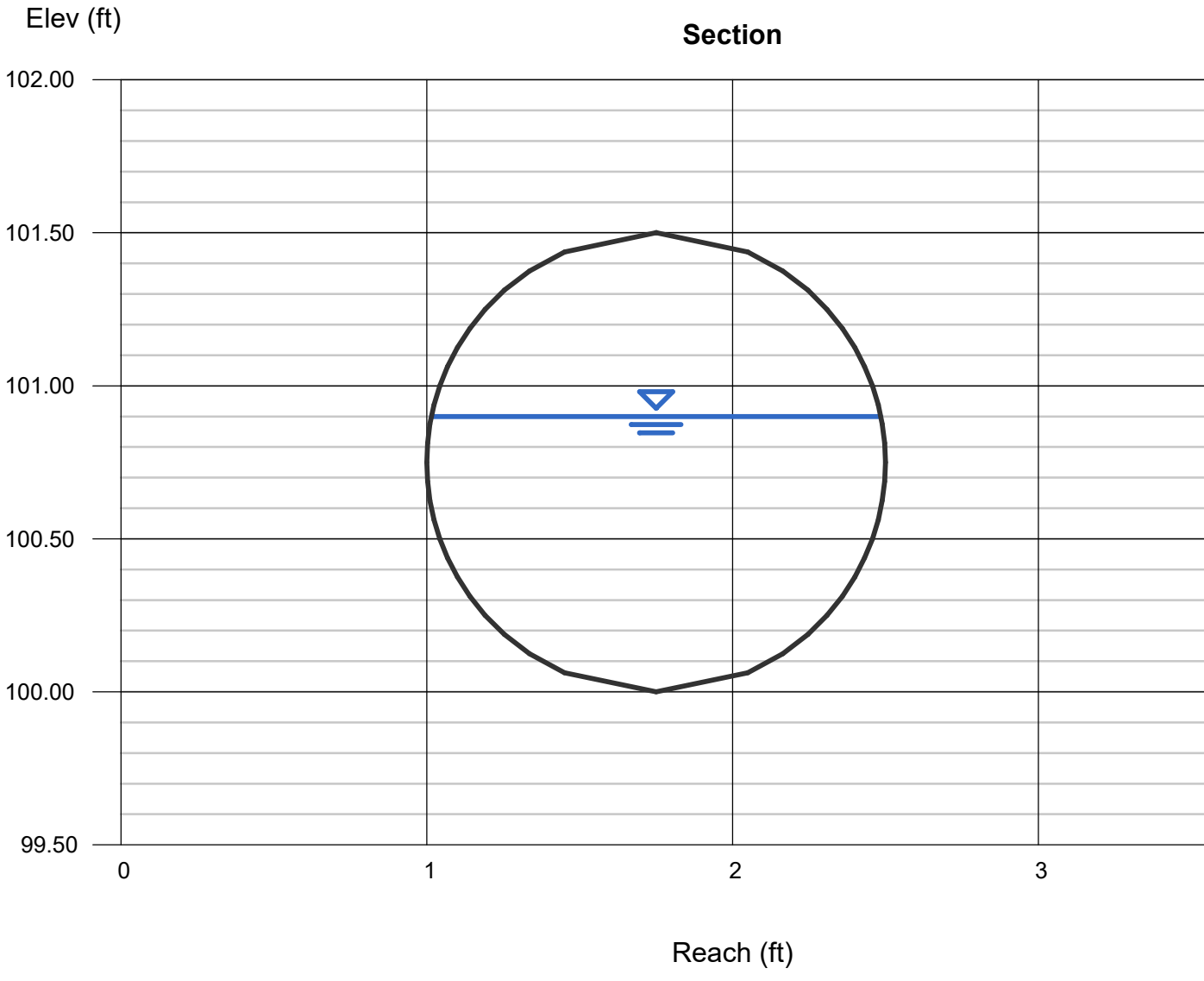
Diameter (ft)	= 1.50
Invert Elev (ft)	= 100.00
Slope (%)	= 2.48
N-Value	= 0.013

Calculations

Compute by:	Q vs Depth
No. Increments	= 10

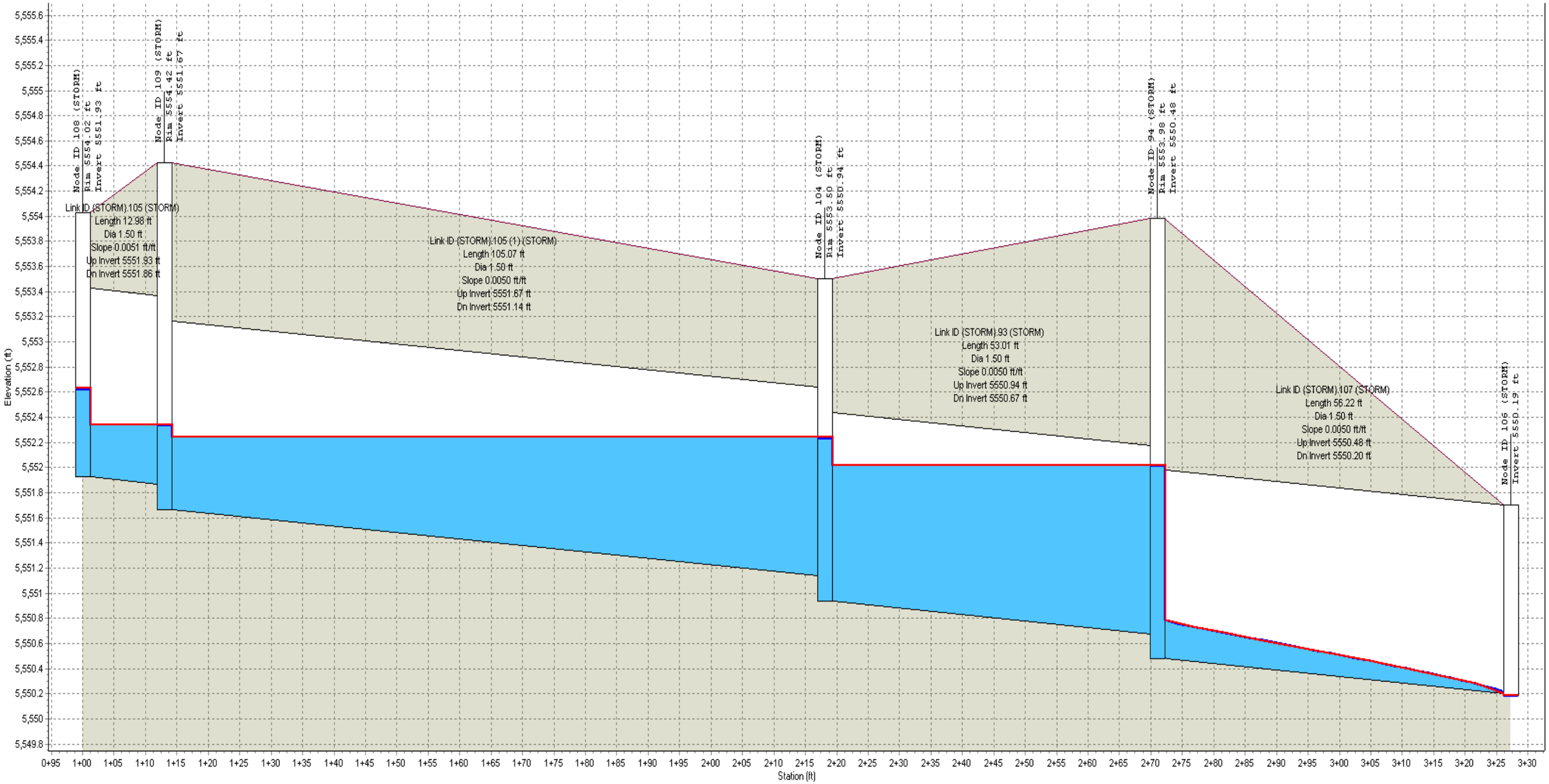
Highlighted

Depth (ft)	= 0.90
Q (cfs)	= 11.15
Area (sqft)	= 1.11
Velocity (ft/s)	= 10.04
Wetted Perim (ft)	= 2.66
Crit Depth, Yc (ft)	= 1.28
Top Width (ft)	= 1.47
EGL (ft)	= 2.47



Profile Plot

Main Street Storm Sewer

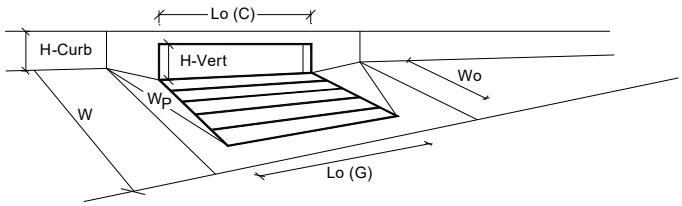


Node ID:	108 (STORM)	109 (STORM)	104 (STORM)	94 (STORM)	106 (STORM)
Rim (ft):	5554.02	5554.42	5553.50	5553.98	
Invert (ft):	5551.93	5551.67	5550.94	5550.48	5550.19
Min Pipe Cover (ft):	0.59	1.06	0.86	1.81	
Max HGL (ft):	5552.64	5552.34	5552.24	5552.02	5550.19

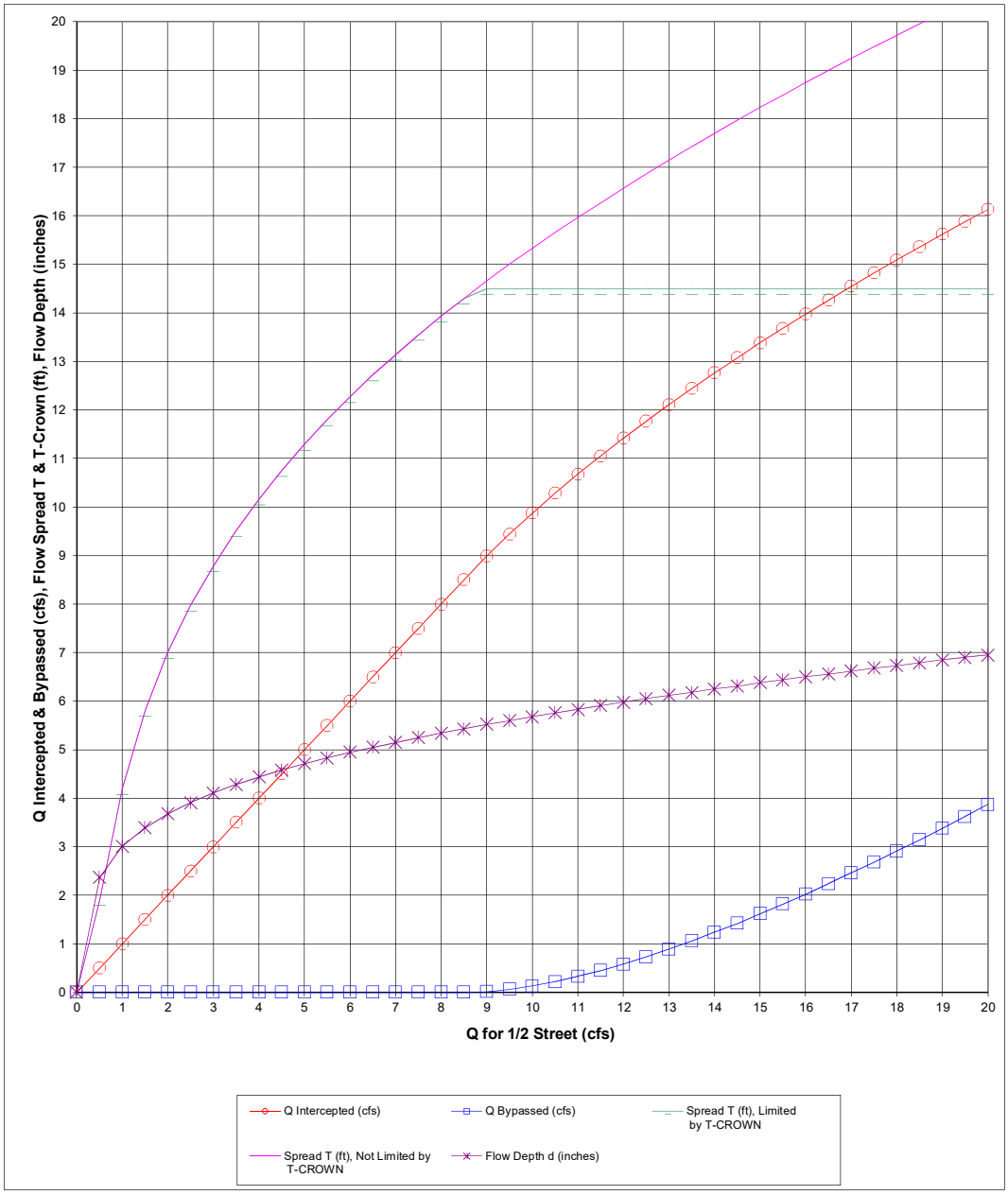
Link ID:	(STORM).105 (STORM)	(STORM).105 (1) (STORM)	(STORM).93 (STORM)	(STORM).107 (STORM)
Length (ft):	12.98	105.07	53.01	56.22
Dia (ft):	1.50	1.50	1.50	1.50
Slope (ft/ft):	0.0051	0.0050	0.0050	0.0050
Up Invert (ft):	5551.93	5551.67	5550.94	5550.48
Dn Invert (ft):	5551.86	5551.14	5550.67	5550.20
Max Q (cfs):	2.33	2.48	5.00	7.80
Max Vel (ft/s):	3.32	2.92	3.29	4.82
Max Depth (ft):	0.62	0.89	1.32	1.29

INLET ON A CONTINUOUS GRADE

Project: Geos Neighborhood
Inlet ID: Design Point 7



Design Information (Input)		MINOR	MAJOR	
Type of Inlet	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a' from 'Q-Allow')	a_{LOCAL} =	3.0	3.0	inches
Total Number of Units in the Inlet (Grate or Curb Opening)	No =	1	1	
Length of a Single Unit Inlet (Grate or Curb Opening)	L_o =	20.00	20.00	ft
Width of a Unit Grate (cannot be greater than W from Q-Allow)	W_o =	N/A	N/A	ft
Clogging Factor for a Single Unit Grate (typical min. value = 0.5)	C_f-G =	N/A	N/A	
Clogging Factor for a Single Unit Curb Opening (typical min. value = 0.1)	C_f-C =	0.10	0.10	
Street Hydraulics: OK - Q < maximum allowable from sheet 'Q-Allow'		MINOR	MAJOR	
Design Discharge for Half of Street (from Sheet *Q-Peak*)	**Q_o =**	**3.90**	**10.99**	**cfs**
Water Spread Width	T =	10.0	14.5	ft
Water Depth at Flowline (outside of local depression)	d =	4.4	5.8	inches
Water Depth at Street Crown (or at T_{MAX})	d_{CROWN} =	0.0	0.4	inches
Ratio of Gutter Flow to Design Flow	E_o =	0.610	0.396	
Discharge outside the Gutter Section W, carried in Section T_x	Q_x =	1.52	6.64	cfs
Discharge within the Gutter Section W	Q_w =	2.38	4.36	cfs
Discharge Behind the Curb Face	Q_{BACK} =	0.00	0.00	cfs
Street Flow Area	A_s =	1.17	2.69	sq ft
Street Flow Velocity	V_s =	3.33	4.08	fps
Water Depth for Design Condition	d_{LOCAL} =	7.4	8.8	inches
Grate Analysis (Calculated)		MINOR	MAJOR	
Total Length of Inlet Grate Opening	L =			ft
Ratio of Grate Flow to Design Flow	$E_{o\text{-}GRATE}$ =			
Under No-Clogging Condition		MINOR	MAJOR	
Minimum Velocity Where Grate Spash-Over Begins	V_o =			fps
Interception Rate of Frontal Flow	R_f =			
Interception Rate of Side Flow	R_x =			
Interception Capacity	Q_i =			cfs
Under Clogging Condition		MINOR	MAJOR	
Clogging Coefficient for Multiple-unit Grate Inlet	GrateCoef =			
Clogging Factor for Multiple-unit Grate Inlet	GrateClog =			
Effective (unclogged) Length of Multiple-unit Grate Inlet	L_e =			ft
Minimum Velocity Where Grate Spash-Over Begins	V_o =			fps
Interception Rate of Frontal Flow	R_f =			
Interception Rate of Side Flow	R_x =			
Actual Interception Capacity	**Q_a =**	**N/A**	**N/A**	**cfs**
Carry-Over Flow = Q_o-Q_a (to be applied to curb opening or next d/s inlet)	**Q_b =**	**N/A**	**N/A**	**cfs**
Curb or Slotted Inlet Opening Analysis (Calculated)		MINOR	MAJOR	
Equivalent Slope S_e (based on grate carry-over)	S_e =	0.1472	0.1026	ft/ft
Required Length L_T to Have 100% Interception	L_T =	10.92	20.95	ft
Under No-Clogging Condition		MINOR	MAJOR	
Effective Length of Curb Opening or Slotted Inlet (minimum of L, L_T)	L =	10.91	20.00	ft
Interception Capacity	Q_i =	3.90	10.95	cfs
Under Clogging Condition		MINOR	MAJOR	
Clogging Coefficient	CurbCoef =	1.00	1.00	
Clogging Factor for Multiple-unit Curb Opening or Slotted Inlet	CurbClog =	0.10	0.10	
Effective (Unclogged) Length	L_e =	10.91	18.00	ft
Actual Interception Capacity	**Q_a =**	**3.90**	**10.67**	**cfs**
Carry-Over Flow = $Q_{b(GRATE)}$-Q_a	**Q_b =**	**0.00**	**0.32**	**cfs**
Summary		MINOR	MAJOR	
Total Inlet Interception Capacity	**Q =**	**3.90**	**10.67**	**cfs**
Total Inlet Carry-Over Flow (flow bypassing inlet)	**Q_b =**	**0.00**	**0.32**	**cfs**
Capture Percentage = Q_a/Q_o =	**C% =**	**100.0**	**97.1**	**%**


Q Intercepted & Bypassed (cfs), Flow Spread T & T-Crown (ft), Flow Depth (inches)
Q for 1/2 Street (cfs)
Q Intercepted (cfs)
Q Bypassed (cfs)
Spread T (ft), Limited by T-CROWN
Spread T (ft), Not Limited by T-CROWN
Flow Depth d (inches)

Q for 1/2 Street (cfs)	Q Intercepted (cfs)	Q Bypassed (cfs)	Spread T (ft), Limited by T_{-CROWN}	Spread T (ft), Not Limited by T_{-CROWN}	Flow Depth d (inches)
0.00	0.00	0.00	0.00	0.00	0.00
0.50	0.50	0.00	1.91	1.91	2.37
1.00	1.00	0.00	4.19	4.19	3.01
1.50	1.50	0.00	5.81	5.81	3.39
2.00	2.00	0.00	7.00	7.00	3.68
2.50	2.50	0.00	7.97	7.97	3.91
3.00	3.00	0.00	8.79	8.79	4.11
3.50	3.50	0.00	9.51	9.51	4.28
4.00	4.00	0.00	10.16	10.16	4.44
4.50	4.50	0.00	10.75	10.75	4.58
5.00	5.00	0.00	11.29	11.29	4.71
5.50	5.50	0.00	11.80	11.80	4.83
6.00	6.00	0.00	12.27	12.27	4.95
6.50	6.50	0.00	12.72	12.72	5.05
7.00	7.00	0.00	13.14	13.14	5.15
7.50	7.50	0.00	13.55	13.55	5.25
8.00	8.00	0.00	13.93	13.93	5.34
8.50	8.50	0.00	14.30	14.30	5.43
9.00	8.99	0.01	14.50	14.66	5.52
9.50	9.44	0.06	14.50	15.00	5.60
10.00	9.87	0.13	14.50	15.33	5.68
10.50	10.28	0.22	14.50	15.65	5.76
11.00	10.67	0.33	14.50	15.97	5.83
11.50	11.05	0.45	14.50	16.27	5.91
12.00	11.42	0.58	14.50	16.57	5.98
12.50	11.77	0.73	14.50	16.86	6.05
13.00	12.11	0.89	14.50	17.15	6.12
13.50	12.44	1.06	14.50	17.43	6.18
14.00	12.76	1.24	14.50	17.70	6.25
14.50	13.08	1.42	14.50	17.97	6.31
15.00	13.38	1.62	14.50	18.23	6.38
15.50	13.68	1.82	14.50	18.49	6.44
16.00	13.98	2.02	14.50	18.75	6.50
16.50	14.26	2.24	14.50	19.00	6.56
17.00	14.54	2.46	14.50	19.24	6.62
17.50	14.82	2.68	14.50	19.48	6.68
18.00	15.09	2.91	14.50	19.72	6.73
18.50	15.36	3.14	14.50	19.96	6.79
19.00	15.62	3.38	14.50	20.19	6.85
19.50	15.88	3.62	14.50	20.41	6.90
20.00	16.13	3.87	14.50	20.64	6.95

Calculation of Peak Runoff using Rational Method

Designer: Nathan Laudick
Company: Laudick & Laudick Engineering
Date: 12/21/2018
Project: Geos Neighborhood Blocks 1-4
Location: Arvada, CO

Version 2.00 released May 2017

Cells of this color are for required user-input
Cells of this color are for optional override values
Cells of this color are for calculated results based on overrides

$$t_i = \frac{0.395(1.1 - C_5)\sqrt{L_i}}{S_i^{0.33}}$$

$$t_t = \frac{L_t}{60K\sqrt{S_t}} = \frac{L_t}{60V_t}$$

$$\text{Computed } t_c = t_i + t_t$$

$$\text{Regional } t_c = (26 - 17i) + \frac{L_t}{60(14i + 9)\sqrt{S_t}}$$

$t_{minimum}$ = 5 (urban)
$t_{minimum}$ = 10 (non-urban)

$$\text{Selected } t_c = \max\{t_{minimum}, \min(\text{Computed } t_c, \text{Regional } t_c)\}$$

Select UDFCD location for NOAA Atlas 14 Rainfall Depths from the pulldown list OR enter your own depths obtained from the NOAA website (click this link)

	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
1-hour rainfall depth, P1 (in) =	0.78	1.05	1.30	1.66	1.95	2.27	3.08
	a	b	c				
Rainfall Intensity Equation Coefficients =	28.50	10.00	0.786				

$$I(in/hr) = \frac{a * P_1}{(b + t_c)^c}$$

$$Q(cfs) = CIA$$

Subcatchment Name	Area (ac)	NRCS Hydrologic Soil Group	Percent Imperviousness	Runoff Coefficient, C							Overland (Initial) Flow Time					Channelized (Travel) Flow Time							Time of Concentration			Rainfall Intensity, I (in/hr)							Peak Flow, Q (cfs)						
				2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr	Overland Flow Length L_i (ft)	U/S Elevation (ft) (Optional)	D/S Elevation (ft) (Optional)	Overland Flow Slope S_i (ft/ft)	Overland Flow Time t_i (min)	Channelized Flow Length L_t (ft)	U/S Elevation (ft) (Optional)	D/S Elevation (ft) (Optional)	Channelized Flow Slope S_t (ft/ft)	NRCS Conveyance Factor K	Channelized Flow Velocity V_t (ft/sec)	Channelized Flow Time t_t (min)	Computed t_c (min)	Regional t_c (min)	Selected t_c (min)	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
A + D1 (to DP7)	2.77	C	56.2	0.44	0.49	0.55	0.63	0.67	0.71	0.77															12.70	1.92	2.57	3.18	4.07	4.78	5.56	7.54	2.32	3.51	4.81	7.14	8.87	10.99	15.99
A3 (Example calc showing no increase in flow due to higher imperviousness due to updated rainfall data in ATLAS 14)	0.64	C	56.2	0.44	0.49	0.55	0.63	0.67	0.71	0.77															11.80	1.98	2.65	3.29	4.20	4.93	5.74	7.79	0.55	0.84	1.15	1.70	2.12	2.62	3.81

CITY OF ARVADA

Post-Construction Stormwater Management Design Standards

Developer must complete and submit this form for each project that disturbs >1 acre. Attach completed form(s) to Drainage Report.

PROJECT AND SITE INFORMATION

Project and Site Name:	GEOS BLOCKS 1-4 - POND A	**Project Location:**	ARVADA, CO
Owner Name:	GEOS NEIGHBORHOOD, LLC	**Total Site Acreage:**	3.80
Date Submitted:	08/30/2019	**Submitted by:**	Nathan Laudick, PE - Laudick & Laudick Engineering, LLC
Existing Impervious Area:	2%	**Proposed Impervious Area:**	56.21
Description of Source Control or nonstructural BMPs:	Extended Detention Basin	**Does this project overlap multiple MS4 jurisdictions?**	☐ YES ☒ NO

4-STEP PROCESS FOR STORMWATER QUALITY MANAGEMENT (REQUIRED)

STEP	YES/NO	COMMENTS
STEP 1: Does the project employ runoff reduction practices by implementing low impact development (LID) strategies such as minimizing directly connected impervious area, implementing swales, rain gardens or permeable pavements?	YES	
STEP 2: Does the project implement Best Management Practices (BMPs) that provide a Water Quality Capture Volume (WQCV) with slow release such as detention and retention ponds, sand filters, or permeable pavers with subsurface storage?	YES	
STEP 3: Does the project stabilize drainage ways to maintain natural functions such as stream bank stabilization or drop structures?	NO	
STEP 4: Does the project implement site specific or other source control BMPs (both structural and procedural) such as covering storage areas or removing pollutants?	YES	

Select only ONE base or ONE constrained redevelopment sites design standard below for each proposed BMP.

If multiple BMPs are used on a single site, a separate form must be completed for each BMP detailing the base design standard and portion of the project being addressed.

Are multiple BMPs being implemented?	☒ YES ☐ NO	**If yes, how many BMPs are being implemented?**	4

BASE DESIGN STANDARDS

	BASE DESIGN STANDARD	DESIGN DETAILS	YES	NO	COMMENTS
☒	**A) WQCV Standard** *The control measure(s) is designed to provide treatment and/or infiltration of the WQCV and:* *1) 100% of the applicable development site is captured, except the permittee may exclude up to 20%, not to exceed 1 acre, of the applicable development site area when the permittee has determined that it is not practicable to capture runoff from portions of the site that will not drain towards control measures. In addition, the permittee must also determine that the implementation of a separate control measure for that portion of the site is not practicable (e.g., driveway access that drains directly to the street).* *2) Evaluation of the minimum drain time shall be based on the pollutant removal mechanism and functionality of the control measure implemented. Consideration of the drain time shall include maintaining vegetation necessary for operation of the control measure (e.g., wetland vegetation).*	**Provides treatment/infiltration of WQCV for 100% of the site?**	☒	☐	
		BMP Type:	EXTENDED DETENTION BASIN		
		OR			
		Provides for LESS THAN 100% of the site?	☐	☐	
		% of site not treated:			
		Acreage of site not treated:			
		Why is the excluded area impractical to treat?			
		Why is another BMP not practicable for the untreated area?			
☐	**B) Pollutant Removal Standard** *The control measure(s) is designed to treat at a minimum the 80th percentile storm event. The control measure(s) shall be designed to treat stormwater runoff in a manner expected to reduce the event mean concentration of total suspended solids (TSS) to a median value of 30 mg/L or less.* *1) 100% of the applicable site is captured, except the permittee may exclude up to 20% not to exceed 1 acre of the applicable development site area when the permittee has determined that it is not practicable to capture runoff from portions of the site that will not drain towards control measures. In addition, the permittee must also determine that the implementation of a separate control measure for that portion of the site is not practicable (e.g., driveway access that drains directly to the street).*	**Meets design standards and requirements?**	☐	☐	
		BMP type:			
		Storm event:			
		Median TSS mg/L Expected:			
		Documentation for basis of expected TSS result:			
		OR			
		Provides for LESS THAN 100% of the site?	☐	☐	
		% of site not treated:			
		Acreage of site not treated:			
		Why is the excluded area impractical to treat?			
		Why is another BMP not practicable for the untreated area?			

	BASE DESIGN STANDARD (continued)	DESIGN DETAILS	YES	NO	COMMENTS
☐	**C) Runoff Reduction Standard** *The control measure(s) is design to infiltrate into the ground where site geology permits, evaporate, or evapotranspire a quantity of water equal to 60% of what the calculated WQCV would be if all impervious area for the applicable development site discharged without infiltration. This base design standard can be met through practices such as green infrastructure. "Green infrastructure" generally refers to control measures that use vegetation, soils, and natural processes or mimic natural processes to manage stormwater. Green infrastructure can be used in place of or in addition to low impact development principles.*	**Meets design standards and requirements?**	☐	☐	
		% of WQCV infiltrated, evaporated or evapotranspired:			
		BMP type:			
☐	**D) Applicable Development Site Draining to a Regional WQCV Control Measure** *The regional WQCV control measure must be designed to accept the drainage from the applicable development site. Stormwater from the site must not discharge to a water of the state before being discharged to the regional WQCV control measure. The regional WQCV control measure must meet the requirements of the WQCV in part I.E.4.a.iv(A) (see below):* *Part I.E.4.a.iv(A)* *1) 100% of the applicable development site is captured, except the permittee may exclude up to 20%, not to exceed 1 acre, of the applicable development site area when the permittee has determined that it is not practicable to capture runoff from portions of the site that will not drain towards control measures. In addition, the permittee must also determine that the implementation of a separate control measure for that portion of the site is not practicable (e.g., driveway access that drains directly to the street).* *2) Evaluation of the minimum drain time shall be based on the pollutant removal mechanism and functionality of the control measure implemented. Consideration of the drain time shall include maintaining vegetation necessary for operation of the control measure (e.g., wetland vegetation).*	**Designed to accept drainage from site?**	☐	☐	
		Does stormwater discharge to Waters of the State before being discharged to Regional WQCV Control Measure?	☐	☐	**IF YES, GO TO NEXT DESIGN STANDARD.**
		Provides treatment/infiltration of WQCV for 100% of the site?	☐	☐	
		OR			
		Provides for LESS THAN 100% of the site?	☐	☐	
		% of site not treated:			
		Acreage of site not treated:			
		Why is the excluded area impractical to treat?			
		Why is another BMP not practicable for the untreated area?			
☐	**E) Applicable Development Site Draining to a Regional WQCV Facility** *The regional WQCV facility is designed to accept drainage from the applicable development site. Stormwater from the site may discharge to a water of the state before being discharged to the regional WQCV facility. Before discharging to a water of the state, at least 20% of the upstream imperviousness of the applicable development site must be disconnected from the storm drainage system and drain through a receiving pervious area control measure comprising a footprint of at least 10% of the upstream disconnected impervious area of the applicable development site. The control measure must be designed in accordance with a design manual identified by the permittee (USDCM Vol 3 Preferred). In addition, the stream channel between the discharge point of the applicable development site and the regional WQCV facility must be stabilized.*	***The regional WQCV facility must be implemented, functional, and maintained following good engineering, hydrologic and pollution control practices (Part I.E.4.a.iv.E.1).***	☐	☐	
		The regional WQCV facility must be designed and maintained for 100% WQCV for its entire drainage area (Part I.E.4.a.iv.E.2).	☐	☐	
		The regional WQCV facility must have capacity to accommodate the drainage from the applicable development site (Part I.E.4.a.iv.E.3).	☐	☐	
		The regional WQCV facility must be designed and built to comply with all assumptions for the development activities planned by the permittee within its drainage area, including the imperviousness of its drainage area and the applicable development site (Part I.E.4.a.iv.E.4).	☐	☐	
		Evaluation of the minimum drain time shall be based on the pollutant removal mechanism and functionality of the facility. Consideration of drain time shall include maintaining vegetation necessary for operation of the facility (e.g., wetland vegetation) (Part I.E.4.a.iv.E.5).	☐	☐	
		Regional facilities must be designed, constructed, and implemented with flood control and water quality as the primary use. Recreational ponds and reservoirs may not be considered Regional Facilities. Water bodies listed by name in surface water quality classifications and standards regulations (5CCR 1002-32 - 5CCR 1002-38) may not be considered regional facilities (Part I.E.4.a.iv.E.8).	☐	☐	
		Stream channel stabilized? (include documentation)	☐	☐	
		Method of stabilization:			
		Name of stream reach stabilized:			
		Square footage of unconnected impervious area (UIA) going to receiving pervious area (RPA): (RPA ≥10% UIA)			
		Square footage of receiving pervious area:			
		Receiving Pervious Area BMP type:			
		Name and location of Regional WQCV Facility:			
		Regional WQCV Facility type:			

CONSTRAINED REDEVELOPMENT SITES DESIGN STANDARDS

"Redevelopment" includes a site that is already substantially developed with 35% or more of existing imperviousness.
A constrained redevelopment site that implements a constrained redevelopment site design standard must have greater than 75% impervious area existing.

CONSTRAINED REDEVELOPMENT SITES DESIGN STANDARD		DESIGN DETAILS	YES	NO	COMMENTS
REQUIRED	**F.1) Constrained Redevelopment Site Standards** a) *The applicable redevelopment site is for a site that has greater than 75% impervious area, and* *b) The permittee has determined that is it not practicable to meet any of the base design standards. The permittee's determination shall include an evaluation of the applicable redevelopment sites ability to install a control measure without reducing surface area covered with the structures .*	**The applicable redevelopment site has greater than 75% impervious area?**	☐	☐	
		Provide an evaluation of the infeasibility of Base Design Standards and justification for use of Constrained Site Standard.			
☐	**F.2.a) Constrained WQCV Standard** *The control measure(s) is designed to provide treatment of the WQCV for the area captured. The captured area shall be 50% or more of the impervious area of the applicable redevelopment site. Evaluation of the minimum drain time shall be based on the pollutant removal mechanism and functionality of the control measure implemented.*	**Provides treatment of WQCV?**	☐	☐	
		BMP type:			
		% of site treated:			
☐	**F.2.b) Constrained Pollutant Removal Standard** *The control measure is designed to provide treatment for the 80th percentile storm event. The control measure(s) shall be designed to treat stormwater runoff in a manner expected to reduce the event mean concentration of total suspended solids (TSS) to a median value of 30 mg/L or less.* *A minimum of 50% of the applicable development area including 50% or more of the impervious area of applicable development area shall drain to the control measure(s). This standard does not require that 100% of the applicable redevelopment site area be directed to a control measure(s) as long as the overall removal goal is met or exceeded.*	**Meets Design Standards and Requirements for TSS removal?**	☐	☐	
		BMP type:			
		% of site treated:			
		Median TSS mg/L expected:			
		Documentation for basis of expected TSS result:			
☐	**F.2.c) Constrained Runoff Reduction Standard** *The control measure(s) is designed to infiltrate, evaporate, or evapotranspire, through practices such as green infrastructure, a quantity of water equal to 30% of what the calculated WQCV would be if all impervious area for the applicable redevelopment site discharged without infiltration.*	**Meets design standards and requirements for infiltration?**	☐	☐	
		BMP type:			
		% of WQCV infiltrated, evaporated or evapotranspired:			

This Post-Construction Stormwater Management Design Standards form is to be completed to address water quality requirements only.
Flood control may also be required and should be included in project proposals.

DATE	REVISION
09/20/2018	City of Arvada
10/02/2018	City of Arvada
10/12/2018	City of Arvada
11/07/2018	City of Arvada

CITY OF ARVADA

Post-Construction Stormwater Management Design Standards

Developer must complete and submit this form for each project that disturbs >1 acre. Attach completed form(s) to Drainage Report.

PROJECT AND SITE INFORMATION

Project and Site Name:	GEOS BLOCKS 1-4 - POND B	**Project Location:**	ARVADA, CO
Owner Name:	GEOS NEIGHBORHOOD, LLC	**Total Site Acreage:**	3.70
Date Submitted:	08/30/2019	**Submitted by:**	Nathan Laudick, PE - Laudick & Laudick Engineering, LLC
Existing Impervious Area:	2%	**Proposed Impervious Area:**	60.21
Description of Source Control or nonstructural BMPs:	Extended Detention Basin	**Does this project overlap multiple MS4 jurisdictions?**	☐ YES ☒ NO

4-STEP PROCESS FOR STORMWATER QUALITY MANAGEMENT (REQUIRED)

STEP	YES/NO	COMMENTS
STEP 1: Does the project employ runoff reduction practices by implementing low impact development (LID) strategies such as minimizing directly connected impervious area, implementing swales, rain gardens or permeable pavements?	YES	
STEP 2: Does the project implement Best Management Practices (BMPs) that provide a Water Quality Capture Volume (WQCV) with slow release such as detention and retention ponds, sand filters, or permeable pavers with subsurface storage?	YES	
STEP 3: Does the project stabilize drainage ways to maintain natural functions such as stream bank stabilization or drop structures?	NO	
STEP 4: Does the project implement site specific or other source control BMPs (both structural and procedural) such as covering storage areas or removing pollutants?	YES	

Select only ONE base or ONE constrained redevelopment sites design standard below for each proposed BMP.

If multiple BMPs are used on a single site, a separate form must be completed for each BMP detailing the base design standard and portion of the project being addressed.

Are multiple BMPs being implemented?	☒ YES ☐ NO	**If yes, how many BMPs are being implemented?**	4

BASE DESIGN STANDARDS

	BASE DESIGN STANDARD	DESIGN DETAILS	YES	NO	COMMENTS
☒	**A) WQCV Standard** *The control measure(s) is designed to provide treatment and/or infiltration of the WQCV and:* *1) 100% of the applicable development site is captured, except the permittee may exclude up to 20%, not to exceed 1 acre, of the applicable development site area when the permittee has determined that it is not practicable to capture runoff from portions of the site that will not drain towards control measures. In addition, the permittee must also determine that the implementation of a separate control measure for that portion of the site is not practicable (e.g., driveway access that drains directly to the street).* *2) Evaluation of the minimum drain time shall be based on the pollutant removal mechanism and functionality of the control measure implemented. Consideration of the drain time shall include maintaining vegetation necessary for operation of the control measure (e.g., wetland vegetation).*	**Provides treatment/infiltration of WQCV for 100% of the site?**	☒	☐	
		BMP Type:	EXTENDED DETENTION BASIN		
		OR			
		Provides for LESS THAN 100% of the site?	☐	☐	
		% of site not treated:			
		Acreage of site not treated:			
		Why is the excluded area impractical to treat?			
		Why is another BMP not practicable for the untreated area?			
☐	**B) Pollutant Removal Standard** *The control measure(s) is designed to treat at a minimum the 80th percentile storm event. The control measure(s) shall be designed to treat stormwater runoff in a manner expected to reduce the event mean concentration of total suspended solids (TSS) to a median value of 30 mg/L or less.* *1) 100% of the applicable site is captured, except the permittee may exclude up to 20% not to exceed 1 acre of the applicable development site area when the permittee has determined that it is not practicable to capture runoff from portions of the site that will not drain towards control measures. In addition, the permittee must also determine that the implementation of a separate control measure for that portion of the site is not practicable (e.g., driveway access that drains directly to the street).*	**Meets design standards and requirements?**	☐	☐	
		BMP type:			
		Storm event:			
		Median TSS mg/L Expected:			
		Documentation for basis of expected TSS result:			
		OR			
		Provides for LESS THAN 100% of the site?	☐	☐	
		% of site not treated:			
		Acreage of site not treated:			
		Why is the excluded area impractical to treat?			
		Why is another BMP not practicable for the untreated area?			

	BASE DESIGN STANDARD (continued)	DESIGN DETAILS	YES	NO	COMMENTS
☐	**C) Runoff Reduction Standard** *The control measure(s) is design to infiltrate into the ground where site geology permits, evaporate, or evapotranspire a quantity of water equal to 60% of what the calculated WQCV would be if all impervious area for the applicable development site discharged without infiltration. This base design standard can be met through practices such as green infrastructure. "Green infrastructure" generally refers to control measures that use vegetation, soils, and natural processes or mimic natural processes to manage stormwater. Green infrastructure can be used in place of or in addition to low impact development principles.*	**Meets design standards and requirements?**	☐	☐	
		% of WQCV infiltrated, evaporated or evapotranspired:			
		BMP type:			
☐	**D) Applicable Development Site Draining to a Regional WQCV Control Measure** *The regional WQCV control measure must be designed to accept the drainage from the applicable development site. Stormwater from the site must not discharge to a water of the state before being discharged to the regional WQCV control measure. The regional WQCV control measure must meet the requirements of the WQCV in part I.E.4.a.iv(A) (see below):* *Part I.E.4.a.iv(A)* *1) 100% of the applicable development site is captured, except the permittee may exclude up to 20%, not to exceed 1 acre, of the applicable development site area when the permittee has determined that it is not practicable to capture runoff from portions of the site that will not drain towards control measures. In addition, the permittee must also determine that the implementation of a separate control measure for that portion of the site is not practicable (e.g., driveway access that drains directly to the street).* *2) Evaluation of the minimum drain time shall be based on the pollutant removal mechanism and functionality of the control measure implemented. Consideration of the drain time shall include maintaining vegetation necessary for operation of the control measure (e.g., wetland vegetation).*	**Designed to accept drainage from site?**	☐	☐	
		Does stormwater discharge to Waters of the State before being discharged to Regional WQCV Control Measure?	☐	☐	**IF YES, GO TO NEXT DESIGN STANDARD.**
		Provides treatment/infiltration of WQCV for 100% of the site?	☐	☐	
		OR			
		Provides for LESS THAN 100% of the site?	☐	☐	
		% of site not treated:			
		Acreage of site not treated:			
		Why is the excluded area impractical to treat?			
		Why is another BMP not practicable for the untreated area?			
☐	**E) Applicable Development Site Draining to a Regional WQCV Facility** *The regional WQCV facility is designed to accept drainage from the applicable development site. Stormwater from the site may discharge to a water of the state before being discharged to the regional WQCV facility. Before discharging to a water of the state, at least 20% of the upstream imperviousness of the applicable development site must be disconnected from the storm drainage system and drain through a receiving pervious area control measure comprising a footprint of at least 10% of the upstream disconnected impervious area of the applicable development site. The control measure must be designed in accordance with a design manual identified by the permittee (USDCM Vol 3 Preferred). In addition, the stream channel between the discharge point of the applicable development site and the regional WQCV facility must be stabilized.*	***The regional WQCV facility must be implemented, functional, and maintained following good engineering, hydrologic and pollution control practices (Part I.E.4.a.iv.E.1).***	☐	☐	
		The regional WQCV facility must be designed and maintained for 100% WQCV for its entire drainage area (Part I.E.4.a.iv.E.2).	☐	☐	
		The regional WQCV facility must have capacity to accommodate the drainage from the applicable development site (Part I.E.4.a.iv.E.3).	☐	☐	
		The regional WQCV facility must be designed and built to comply with all assumptions for the development activities planned by the permittee within its drainage area, including the imperviousness of its drainage area and the applicable development site (Part I.E.4.a.iv.E.4).	☐	☐	
		Evaluation of the minimum drain time shall be based on the pollutant removal mechanism and functionality of the facility. Consideration of drain time shall include maintaining vegetation necessary for operation of the facility (e.g., wetland vegetation) (Part I.E.4.a.iv.E.5).	☐	☐	
		Regional facilities must be designed, constructed, and implemented with flood control and water quality as the primary use. Recreational ponds and reservoirs may not be considered Regional Facilities. Water bodies listed by name in surface water quality classifications and standards regulations (5CCR 1002-32 - 5CCR 1002-38) may not be considered regional facilities (Part I.E.4.a.iv.E.8).	☐	☐	
		Stream channel stabilized? (include documentation)	☐	☐	
		Method of stabilization:			
		Name of stream reach stabilized:			
		Square footage of unconnected impervious area (UIA) going to receiving pervious area (RPA): (RPA ≥10% UIA)			
		Square footage of receiving pervious area:			
		Receiving Pervious Area BMP type:			
		Name and location of Regional WQCV Facility:			
		Regional WQCV Facility type:			

CONSTRAINED REDEVELOPMENT SITES DESIGN STANDARDS

"Redevelopment" includes a site that is already substantially developed with 35% or more of existing imperviousness.
A constrained redevelopment site that implements a constrained redevelopment site design standard must have greater than 75% impervious area existing.

CONSTRAINED REDEVELOPMENT SITES DESIGN STANDARD		DESIGN DETAILS	YES	NO	COMMENTS
REQUIRED	**F.1) Constrained Redevelopment Site Standards** a) *The applicable redevelopment site is for a site that has greater than 75% impervious area, and* *b) The permittee has determined that is it not practicable to meet any of the base design standards. The permittee's determination shall include an evaluation of the applicable redevelopment sites ability to install a control measure without reducing surface area covered with the structures .*	**The applicable redevelopment site has greater than 75% impervious area?**	☐	☐	
		Provide an evaluation of the infeasibility of Base Design Standards and justification for use of Constrained Site Standard.			
☐	**F.2.a) Constrained WQCV Standard** *The control measure(s) is designed to provide treatment of the WQCV for the area captured. The captured area shall be 50% or more of the impervious area of the applicable redevelopment site. Evaluation of the minimum drain time shall be based on the pollutant removal mechanism and functionality of the control measure implemented.*	**Provides treatment of WQCV?**	☐	☐	
		BMP type:			
		% of site treated:			
☐	**F.2.b) Constrained Pollutant Removal Standard** *The control measure is designed to provide treatment for the 80th percentile storm event. The control measure(s) shall be designed to treat stormwater runoff in a manner expected to reduce the event mean concentration of total suspended solids (TSS) to a median value of 30 mg/L or less.* *A minimum of 50% of the applicable development area including 50% or more of the impervious area of applicable development area shall drain to the control measure(s). This standard does not require that 100% of the applicable redevelopment site area be directed to a control measure(s) as long as the overall removal goal is met or exceeded.*	**Meets Design Standards and Requirements for TSS removal?**	☐	☐	
		BMP type:			
		% of site treated:			
		Median TSS mg/L expected:			
		Documentation for basis of expected TSS result:			
☐	**F.2.c) Constrained Runoff Reduction Standard** *The control measure(s) is designed to infiltrate, evaporate, or evapotranspire, through practices such as green infrastructure, a quantity of water equal to 30% of what the calculated WQCV would be if all impervious area for the applicable redevelopment site discharged without infiltration.*	**Meets design standards and requirements for infiltration?**	☐	☐	
		BMP type:			
		% of WQCV infiltrated, evaporated or evapotranspired:			

This Post-Construction Stormwater Management Design Standards form is to be completed to address water quality requirements only.
Flood control may also be required and should be included in project proposals.

DATE	REVISION
09/20/2018	City of Arvada
10/02/2018	City of Arvada
10/12/2018	City of Arvada
11/07/2018	City of Arvada

CITY OF ARVADA

Post-Construction Stormwater Management Design Standards

Developer must complete and submit this form for each project that disturbs >1 acre. Attach completed form(s) to Drainage Report.

PROJECT AND SITE INFORMATION

Project and Site Name:	GEOS BLOCKS 1-4 - POND D	**Project Location:**	ARVADA, CO
Owner Name:	GEOS NEIGHBORHOOD, LLC	**Total Site Acreage:**	2.27
Date Submitted:	08/30/2019	**Submitted by:**	Nathan Laudick, PE - Laudick & Laudick Engineering, LLC
Existing Impervious Area:	2%	**Proposed Impervious Area:**	49.00
Description of Source Control or nonstructural BMPs:	Extended Detention Basin	**Does this project overlap multiple MS4 jurisdictions?**	☐ YES ☒ NO

4-STEP PROCESS FOR STORMWATER QUALITY MANAGEMENT (REQUIRED)

STEP	YES/NO	COMMENTS
STEP 1: Does the project employ runoff reduction practices by implementing low impact development (LID) strategies such as minimizing directly connected impervious area, implementing swales, rain gardens or permeable pavements?	YES	
STEP 2: Does the project implement Best Management Practices (BMPs) that provide a Water Quality Capture Volume (WQCV) with slow release such as detention and retention ponds, sand filters, or permeable pavers with subsurface storage?	YES	
STEP 3: Does the project stabilize drainage ways to maintain natural functions such as stream bank stabilization or drop structures?	NO	
STEP 4: Does the project implement site specific or other source control BMPs (both structural and procedural) such as covering storage areas or removing pollutants?	YES	

Select only ONE base or ONE constrained redevelopment sites design standard below for each proposed BMP.

If multiple BMPs are used on a single site, a separate form must be completed for each BMP detailing the base design standard and portion of the project being addressed.

Are multiple BMPs being implemented?	☒ YES ☐ NO	**If yes, how many BMPs are being implemented?**	4

BASE DESIGN STANDARDS

	BASE DESIGN STANDARD	DESIGN DETAILS	YES	NO	COMMENTS
☒	**A) WQCV Standard** *The control measure(s) is designed to provide treatment and/or infiltration of the WQCV and:* *1) 100% of the applicable development site is captured, except the permittee may exclude up to 20%, not to exceed 1 acre, of the applicable development site area when the permittee has determined that it is not practicable to capture runoff from portions of the site that will not drain towards control measures. In addition, the permittee must also determine that the implementation of a separate control measure for that portion of the site is not practicable (e.g., driveway access that drains directly to the street).* *2) Evaluation of the minimum drain time shall be based on the pollutant removal mechanism and functionality of the control measure implemented. Consideration of the drain time shall include maintaining vegetation necessary for operation of the control measure (e.g., wetland vegetation).*	**Provides treatment/infiltration of WQCV for 100% of the site?**	☒	☐	
		BMP Type:	EXTENDED DETENTION BASIN		
		OR			
		Provides for LESS THAN 100% of the site?	☐	☐	
		% of site not treated:			
		Acreage of site not treated:			
		Why is the excluded area impractical to treat?			
		Why is another BMP not practicable for the untreated area?			
☐	**B) Pollutant Removal Standard** *The control measure(s) is designed to treat at a minimum the 80th percentile storm event. The control measure(s) shall be designed to treat stormwater runoff in a manner expected to reduce the event mean concentration of total suspended solids (TSS) to a median value of 30 mg/L or less.* *1) 100% of the applicable site is captured, except the permittee may exclude up to 20% not to exceed 1 acre of the applicable development site area when the permittee has determined that it is not practicable to capture runoff from portions of the site that will not drain towards control measures. In addition, the permittee must also determine that the implementation of a separate control measure for that portion of the site is not practicable (e.g., driveway access that drains directly to the street).*	**Meets design standards and requirements?**	☐	☐	
		BMP type:			
		Storm event:			
		Median TSS mg/L Expected:			
		Documentation for basis of expected TSS result:			
		OR			
		Provides for LESS THAN 100% of the site?	☐	☐	
		% of site not treated:			
		Acreage of site not treated:			
		Why is the excluded area impractical to treat?			
		Why is another BMP not practicable for the untreated area?			

	BASE DESIGN STANDARD (continued)	DESIGN DETAILS	YES	NO	COMMENTS
☐	**C) Runoff Reduction Standard** *The control measure(s) is design to infiltrate into the ground where site geology permits, evaporate, or evapotranspire a quantity of water equal to 60% of what the calculated WQCV would be if all impervious area for the applicable development site discharged without infiltration. This base design standard can be met through practices such as green infrastructure. "Green infrastructure" generally refers to control measures that use vegetation, soils, and natural processes or mimic natural processes to manage stormwater. Green infrastructure can be used in place of or in addition to low impact development principles.*	**Meets design standards and requirements?**	☐	☐	
		% of WQCV infiltrated, evaporated or evapotranspired:			
		BMP type:			
☐	**D) Applicable Development Site Draining to a Regional WQCV Control Measure** *The regional WQCV control measure must be designed to accept the drainage from the applicable development site. Stormwater from the site must not discharge to a water of the state before being discharged to the regional WQCV control measure. The regional WQCV control measure must meet the requirements of the WQCV in part I.E.4.a.iv(A) (see below):* *Part I.E.4.a.iv(A)* *1) 100% of the applicable development site is captured, except the permittee may exclude up to 20%, not to exceed 1 acre, of the applicable development site area when the permittee has determined that it is not practicable to capture runoff from portions of the site that will not drain towards control measures. In addition, the permittee must also determine that the implementation of a separate control measure for that portion of the site is not practicable (e.g., driveway access that drains directly to the street).* *2) Evaluation of the minimum drain time shall be based on the pollutant removal mechanism and functionality of the control measure implemented. Consideration of the drain time shall include maintaining vegetation necessary for operation of the control measure (e.g., wetland vegetation).*	**Designed to accept drainage from site?**	☐	☐	
		Does stormwater discharge to Waters of the State before being discharged to Regional WQCV Control Measure?	☐	☐	**IF YES, GO TO NEXT DESIGN STANDARD.**
		Provides treatment/infiltration of WQCV for 100% of the site?	☐	☐	
		OR			
		Provides for LESS THAN 100% of the site?	☐	☐	
		% of site not treated:			
		Acreage of site not treated:			
		Why is the excluded area impractical to treat?			
		Why is another BMP not practicable for the untreated area?			
☐	**E) Applicable Development Site Draining to a Regional WQCV Facility** *The regional WQCV facility is designed to accept drainage from the applicable development site. Stormwater from the site may discharge to a water of the state before being discharged to the regional WQCV facility. Before discharging to a water of the state, at least 20% of the upstream imperviousness of the applicable development site must be disconnected from the storm drainage system and drain through a receiving pervious area control measure comprising a footprint of at least 10% of the upstream disconnected impervious area of the applicable development site. The control measure must be designed in accordance with a design manual identified by the permittee (USDCM Vol 3 Preferred). In addition, the stream channel between the discharge point of the applicable development site and the regional WQCV facility must be stabilized.*	***The regional WQCV facility must be implemented, functional, and maintained following good engineering, hydrologic and pollution control practices (Part I.E.4.a.iv.E.1).***	☐	☐	
		The regional WQCV facility must be designed and maintained for 100% WQCV for its entire drainage area (Part I.E.4.a.iv.E.2).	☐	☐	
		The regional WQCV facility must have capacity to accommodate the drainage from the applicable development site (Part I.E.4.a.iv.E.3).	☐	☐	
		The regional WQCV facility must be designed and built to comply with all assumptions for the development activities planned by the permittee within its drainage area, including the imperviousness of its drainage area and the applicable development site (Part I.E.4.a.iv.E.4).	☐	☐	
		Evaluation of the minimum drain time shall be based on the pollutant removal mechanism and functionality of the facility. Consideration of drain time shall include maintaining vegetation necessary for operation of the facility (e.g., wetland vegetation) (Part I.E.4.a.iv.E.5).	☐	☐	
		Regional facilities must be designed, constructed, and implemented with flood control and water quality as the primary use. Recreational ponds and reservoirs may not be considered Regional Facilities. Water bodies listed by name in surface water quality classifications and standards regulations (5CCR 1002-32 - 5CCR 1002-38) may not be considered regional facilities (Part I.E.4.a.iv.E.8).	☐	☐	
		Stream channel stabilized? (include documentation)	☐	☐	
		Method of stabilization:			
		Name of stream reach stabilized:			
		Square footage of unconnected impervious area (UIA) going to receiving pervious area (RPA): (RPA ≥10% UIA)			
		Square footage of receiving pervious area:			
		Receiving Pervious Area BMP type:			
		Name and location of Regional WQCV Facility:			
		Regional WQCV Facility type:			

CONSTRAINED REDEVELOPMENT SITES DESIGN STANDARDS

"Redevelopment" includes a site that is already substantially developed with 35% or more of existing imperviousness.
A constrained redevelopment site that implements a constrained redevelopment site design standard must have greater than 75% impervious area existing.

CONSTRAINED REDEVELOPMENT SITES DESIGN STANDARD		DESIGN DETAILS	YES	NO	COMMENTS
REQUIRED	**F.1) Constrained Redevelopment Site Standards** a) *The applicable redevelopment site is for a site that has greater than 75% impervious area, and* *b) The permittee has determined that is it not practicable to meet any of the base design standards. The permittee's determination shall include an evaluation of the applicable redevelopment sites ability to install a control measure without reducing surface area covered with the structures .*	**The applicable redevelopment site has greater than 75% impervious area?**	☐	☐	
		Provide an evaluation of the infeasibility of Base Design Standards and justification for use of Constrained Site Standard.			
☐	**F.2.a) Constrained WQCV Standard** *The control measure(s) is designed to provide treatment of the WQCV for the area captured. The captured area shall be 50% or more of the impervious area of the applicable redevelopment site. Evaluation of the minimum drain time shall be based on the pollutant removal mechanism and functionality of the control measure implemented.*	**Provides treatment of WQCV?**	☐	☐	
		BMP type:			
		% of site treated:			
☐	**F.2.b) Constrained Pollutant Removal Standard** *The control measure is designed to provide treatment for the 80th percentile storm event. The control measure(s) shall be designed to treat stormwater runoff in a manner expected to reduce the event mean concentration of total suspended solids (TSS) to a median value of 30 mg/L or less.* *A minimum of 50% of the applicable development area including 50% or more of the impervious area of applicable development area shall drain to the control measure(s). This standard does not require that 100% of the applicable redevelopment site area be directed to a control measure(s) as long as the overall removal goal is met or exceeded.*	**Meets Design Standards and Requirements for TSS removal?**	☐	☐	
		BMP type:			
		% of site treated:			
		Median TSS mg/L expected:			
		Documentation for basis of expected TSS result:			
☐	**F.2.c) Constrained Runoff Reduction Standard** *The control measure(s) is designed to infiltrate, evaporate, or evapotranspire, through practices such as green infrastructure, a quantity of water equal to 30% of what the calculated WQCV would be if all impervious area for the applicable redevelopment site discharged without infiltration.*	**Meets design standards and requirements for infiltration?**	☐	☐	
		BMP type:			
		% of WQCV infiltrated, evaporated or evapotranspired:			

This Post-Construction Stormwater Management Design Standards form is to be completed to address water quality requirements only.
Flood control may also be required and should be included in project proposals.

DATE	REVISION
09/20/2018	City of Arvada
10/02/2018	City of Arvada
10/12/2018	City of Arvada
11/07/2018	City of Arvada

CITY OF ARVADA

Post-Construction Stormwater Management Design Standards

Developer must complete and submit this form for each project that disturbs >1 acre. Attach completed form(s) to Drainage Report.

PROJECT AND SITE INFORMATION

Project and Site Name:	GEOS BLOCKS 1-4 - POND F	**Project Location:**	ARVADA, CO
Owner Name:	GEOS NEIGHBORHOOD, LLC	**Total Site Acreage:**	2.05
Date Submitted:	08/30/2019	**Submitted by:**	Nathan Laudick, PE - Laudick & Laudick Engineering, LLC
Existing Impervious Area:	2%	**Proposed Impervious Area:**	13.20
Description of Source Control or nonstructural BMPs:	Extended Detention Basin	**Does this project overlap multiple MS4 jurisdictions?**	☐ YES ☒ NO

4-STEP PROCESS FOR STORMWATER QUALITY MANAGEMENT (REQUIRED)

STEP	YES/NO	COMMENTS
STEP 1: Does the project employ runoff reduction practices by implementing low impact development (LID) strategies such as minimizing directly connected impervious area, implementing swales, rain gardens or permeable pavements?	YES	
STEP 2: Does the project implement Best Management Practices (BMPs) that provide a Water Quality Capture Volume (WQCV) with slow release such as detention and retention ponds, sand filters, or permeable pavers with subsurface storage?	YES	
STEP 3: Does the project stabilize drainage ways to maintain natural functions such as stream bank stabilization or drop structures?	NO	
STEP 4: Does the project implement site specific or other source control BMPs (both structural and procedural) such as covering storage areas or removing pollutants?	YES	

Select only ONE base or ONE constrained redevelopment sites design standard below for each proposed BMP.

If multiple BMPs are used on a single site, a separate form must be completed for each BMP detailing the base design standard and portion of the project being addressed.

Are multiple BMPs being implemented?	☒ YES ☐ NO	**If yes, how many BMPs are being implemented?**	4

BASE DESIGN STANDARDS

	BASE DESIGN STANDARD	DESIGN DETAILS	YES	NO	COMMENTS
☒	**A) WQCV Standard** *The control measure(s) is designed to provide treatment and/or infiltration of the WQCV and:* *1) 100% of the applicable development site is captured, except the permittee may exclude up to 20%, not to exceed 1 acre, of the applicable development site area when the permittee has determined that it is not practicable to capture runoff from portions of the site that will not drain towards control measures. In addition, the permittee must also determine that the implementation of a separate control measure for that portion of the site is not practicable (e.g., driveway access that drains directly to the street).* *2) Evaluation of the minimum drain time shall be based on the pollutant removal mechanism and functionality of the control measure implemented. Consideration of the drain time shall include maintaining vegetation necessary for operation of the control measure (e.g., wetland vegetation).*	**Provides treatment/infiltration of WQCV for 100% of the site?**	☒	☐	
		BMP Type:	EXTENDED DETENTION BASIN		
		OR			
		Provides for LESS THAN 100% of the site?	☐	☐	
		% of site not treated:			
		Acreage of site not treated:			
		Why is the excluded area impractical to treat?			
		Why is another BMP not practicable for the untreated area?			
☐	**B) Pollutant Removal Standard** *The control measure(s) is designed to treat at a minimum the 80th percentile storm event. The control measure(s) shall be designed to treat stormwater runoff in a manner expected to reduce the event mean concentration of total suspended solids (TSS) to a median value of 30 mg/L or less.* *1) 100% of the applicable site is captured, except the permittee may exclude up to 20% not to exceed 1 acre of the applicable development site area when the permittee has determined that it is not practicable to capture runoff from portions of the site that will not drain towards control measures. In addition, the permittee must also determine that the implementation of a separate control measure for that portion of the site is not practicable (e.g., driveway access that drains directly to the street).*	**Meets design standards and requirements?**	☐	☐	
		BMP type:			
		Storm event:			
		Median TSS mg/L Expected:			
		Documentation for basis of expected TSS result:			
		OR			
		Provides for LESS THAN 100% of the site?	☐	☐	
		% of site not treated:			
		Acreage of site not treated:			
		Why is the excluded area impractical to treat?			
		Why is another BMP not practicable for the untreated area?			

	BASE DESIGN STANDARD (continued)	DESIGN DETAILS	YES	NO	COMMENTS
☐	**C) Runoff Reduction Standard** *The control measure(s) is design to infiltrate into the ground where site geology permits, evaporate, or evapotranspire a quantity of water equal to 60% of what the calculated WQCV would be if all impervious area for the applicable development site discharged without infiltration. This base design standard can be met through practices such as green infrastructure. "Green infrastructure" generally refers to control measures that use vegetation, soils, and natural processes or mimic natural processes to manage stormwater. Green infrastructure can be used in place of or in addition to low impact development principles.*	**Meets design standards and requirements?**	☐	☐	
		% of WQCV infiltrated, evaporated or evapotranspired:			
		BMP type:			
☐	**D) Applicable Development Site Draining to a Regional WQCV Control Measure** *The regional WQCV control measure must be designed to accept the drainage from the applicable development site. Stormwater from the site must not discharge to a water of the state before being discharged to the regional WQCV control measure. The regional WQCV control measure must meet the requirements of the WQCV in part I.E.4.a.iv(A) (see below):* *Part I.E.4.a.iv(A)* *1) 100% of the applicable development site is captured, except the permittee may exclude up to 20%, not to exceed 1 acre, of the applicable development site area when the permittee has determined that it is not practicable to capture runoff from portions of the site that will not drain towards control measures. In addition, the permittee must also determine that the implementation of a separate control measure for that portion of the site is not practicable (e.g., driveway access that drains directly to the street).* *2) Evaluation of the minimum drain time shall be based on the pollutant removal mechanism and functionality of the control measure implemented. Consideration of the drain time shall include maintaining vegetation necessary for operation of the control measure (e.g., wetland vegetation).*	**Designed to accept drainage from site?**	☐	☐	
		Does stormwater discharge to Waters of the State before being discharged to Regional WQCV Control Measure?	☐	☐	**IF YES, GO TO NEXT DESIGN STANDARD.**
		Provides treatment/infiltration of WQCV for 100% of the site?	☐	☐	
		OR			
		Provides for LESS THAN 100% of the site?	☐	☐	
		% of site not treated:			
		Acreage of site not treated:			
		Why is the excluded area impractical to treat?			
		Why is another BMP not practicable for the untreated area?			
☐	**E) Applicable Development Site Draining to a Regional WQCV Facility** *The regional WQCV facility is designed to accept drainage from the applicable development site. Stormwater from the site may discharge to a water of the state before being discharged to the regional WQCV facility. Before discharging to a water of the state, at least 20% of the upstream imperviousness of the applicable development site must be disconnected from the storm drainage system and drain through a receiving pervious area control measure comprising a footprint of at least 10% of the upstream disconnected impervious area of the applicable development site. The control measure must be designed in accordance with a design manual identified by the permittee (USDCM Vol 3 Preferred). In addition, the stream channel between the discharge point of the applicable development site and the regional WQCV facility must be stabilized.*	***The regional WQCV facility must be implemented, functional, and maintained following good engineering, hydrologic and pollution control practices (Part I.E.4.a.iv.E.1).***	☐	☐	
		The regional WQCV facility must be designed and maintained for 100% WQCV for its entire drainage area (Part I.E.4.a.iv.E.2).	☐	☐	
		The regional WQCV facility must have capacity to accommodate the drainage from the applicable development site (Part I.E.4.a.iv.E.3).	☐	☐	
		The regional WQCV facility must be designed and built to comply with all assumptions for the development activities planned by the permittee within its drainage area, including the imperviousness of its drainage area and the applicable development site (Part I.E.4.a.iv.E.4).	☐	☐	
		Evaluation of the minimum drain time shall be based on the pollutant removal mechanism and functionality of the facility. Consideration of drain time shall include maintaining vegetation necessary for operation of the facility (e.g., wetland vegetation) (Part I.E.4.a.iv.E.5).	☐	☐	
		Regional facilities must be designed, constructed, and implemented with flood control and water quality as the primary use. Recreational ponds and reservoirs may not be considered Regional Facilities. Water bodies listed by name in surface water quality classifications and standards regulations (5CCR 1002-32 - 5CCR 1002-38) may not be considered regional facilities (Part I.E.4.a.iv.E.8).	☐	☐	
		Stream channel stabilized? (include documentation)	☐	☐	
		Method of stabilization:			
		Name of stream reach stabilized:			
		Square footage of unconnected impervious area (UIA) going to receiving pervious area (RPA): (RPA ≥10% UIA)			
		Square footage of receiving pervious area:			
		Receiving Pervious Area BMP type:			
		Name and location of Regional WQCV Facility:			
		Regional WQCV Facility type:			

CONSTRAINED REDEVELOPMENT SITES DESIGN STANDARDS

"Redevelopment" includes a site that is already substantially developed with 35% or more of existing imperviousness.
A constrained redevelopment site that implements a constrained redevelopment site design standard must have greater than 75% impervious area existing.

CONSTRAINED REDEVELOPMENT SITES DESIGN STANDARD		DESIGN DETAILS	YES	NO	COMMENTS
REQUIRED	**F.1) Constrained Redevelopment Site Standards** a) *The applicable redevelopment site is for a site that has greater than 75% impervious area, and* *b) The permittee has determined that is it not practicable to meet any of the base design standards. The permittee's determination shall include an evaluation of the applicable redevelopment sites ability to install a control measure without reducing surface area covered with the structures .*	**The applicable redevelopment site has greater than 75% impervious area?**	☐	☐	
		Provide an evaluation of the infeasibility of Base Design Standards and justification for use of Constrained Site Standard.			
☐	**F.2.a) Constrained WQCV Standard** *The control measure(s) is designed to provide treatment of the WQCV for the area captured. The captured area shall be 50% or more of the impervious area of the applicable redevelopment site. Evaluation of the minimum drain time shall be based on the pollutant removal mechanism and functionality of the control measure implemented.*	**Provides treatment of WQCV?**	☐	☐	
		BMP type:			
		% of site treated:			
☐	**F.2.b) Constrained Pollutant Removal Standard** *The control measure is designed to provide treatment for the 80th percentile storm event. The control measure(s) shall be designed to treat stormwater runoff in a manner expected to reduce the event mean concentration of total suspended solids (TSS) to a median value of 30 mg/L or less.* *A minimum of 50% of the applicable development area including 50% or more of the impervious area of applicable development area shall drain to the control measure(s). This standard does not require that 100% of the applicable redevelopment site area be directed to a control measure(s) as long as the overall removal goal is met or exceeded.*	**Meets Design Standards and Requirements for TSS removal?**	☐	☐	
		BMP type:			
		% of site treated:			
		Median TSS mg/L expected:			
		Documentation for basis of expected TSS result:			
☐	**F.2.c) Constrained Runoff Reduction Standard** *The control measure(s) is designed to infiltrate, evaporate, or evapotranspire, through practices such as green infrastructure, a quantity of water equal to 30% of what the calculated WQCV would be if all impervious area for the applicable redevelopment site discharged without infiltration.*	**Meets design standards and requirements for infiltration?**	☐	☐	
		BMP type:			
		% of WQCV infiltrated, evaporated or evapotranspired:			

This Post-Construction Stormwater Management Design Standards form is to be completed to address water quality requirements only.
Flood control may also be required and should be included in project proposals.

DATE	REVISION
09/20/2018	City of Arvada
10/02/2018	City of Arvada
10/12/2018	City of Arvada
11/07/2018	City of Arvada