ENGINEERING
PLANNING
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Stormwater Detention Analysis
Prepared By: Bax Engineering CO., INC.
Buffalo Tools Parking Lot and Building Addition
Bax Project No. 01-11691C
January 29, 2013

INTRODUCTION:

This exiting site is located in the City of O'Fallon, Missouri and is currently being used as an office/warehouse. The 7.99-acre tract of land shall be analyzed for additions to the existing building and parking area. 2.43 Acres of the site is tributary to the proposed detention basin and all contains all of the new impervious areas. The detention basin shall be designed to provide the Stormwater quantity required of the development. The storage volume and outflow rates shall be proportioned to insure that the peak rate of runoff leaving the tract under post-developed conditions is less than or equal to the peak rate of runoff under pre-developed conditions for the 2, 15, 25 and 100 year 20 minute design storms and also analyzed for the safe passage of the 100 year 20 minute design storm assuming the low flow slot is blocked.

GENERAL SITE DATA AND RUNOFF CALCULATIONS

The pre-developed curve numbers used for the analysis are:

2 year	0-5%	Impervious	1.15	cfs/ac
15 year	0-5%	Impervious	1.87	cfs/ac
25 year	0-5%	Impervious	2.31	cfs/ac
100 year	0-5%	Impervious	2.95	cfs/ac

The post-developed curve numbers used for the analysis are:

2 year	0-5%	Impervious	1.15	cfs/ac
15 year	0-5%	Impervious	1.87	cfs/ac
25 year	0-5%	Impervious	2.31	cfs/ac
100 year	0-5%	Impervious	2.95	cfs/ac
2 year	100%	Impervious	2.39	cfs/ac
15 year	100%	Impervious	3.85	cfs/ac
25 year	100%	Impervious	4.75	cfs/ac
100 year	100%	Impervious	6.08	cfs/ac

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PREDEVELOPED CONDITIONS:

The Predeveloped watershed discharges to a discharge point in the Southwest area of the site. The total runoff from the watershed will be calculated using the rational method to determine the Predeveloped Runoff rates leavening the site. For this analysis the Predeveloped runoff for the 2, 15, 25, and 100 year 20 minute design storms will be calculated for comparison to the Postdeveloped runoff to determine the quantity of detention that will be required.

25 Year

2.43 ac	x	2.31 cfs/ac	=	5.61 cfs
		Total	=	5.61 cfs

2 year-20 minute storm:	2.79 cfs
15 year-20 minute storm:	4.54 cfs
25 year-20 minute storm:	5.61 cfs
100 year-20 minute storm:	7.17 cfs

POSTDEVELOPED CONDITIONS:

The Predeveloped watershed discharges to a discharge point in the Southwest area of the site. The total runoff from the watershed will be calculated using the rational method to determine the Postdeveloped Runoff rates leavening the site. For this analysis the Postdeveloped runoff for the 2, 15, 25, and 100 year 20 minute design storms will be calculated for comparison to the previously calculated Predeveloped runoff to determine the quantity of detention that will be required.

25 Year

Green Space	1.59 ac	x	2.31 cfs/ac	=	3.67 cfs
Pavement / Building	0.84 ac	x	4.75 cfs/ac	=	3.99 cfs
			Total	=	7.66 cfs

2 year-20 minute storm:	3.84 cfs
15 year-20 minute storm:	6.21 cfs
25 year-20 minute storm:	7.66 cfs
100 year-20 minute storm:	9.80 cfs

DIFFERENTIAL RUNOFF

The differential runoff for each discharge point is determined by subtracting the predeveloped runoff rate from the postdeveloped runoff rate.

Design Storm	Postdeveloped Runoff	Predeveloped Runoff	Differential Runoff
2 yr	3.84 cfs	2.79 cfs	1.05 cfs
15 yr	6.21 cfs	4.54 cfs	1.67 cfs
25 yr	7.66 cfs	5.61 cfs	2.05 cfs
100 yr	9.80 cfs	7.17 cfs	2.63 cfs

TIME OF CONCENTRATION:

Of the inflows to the basin, the most remote point lies in the northwest area of the site adjacent to the entrance off Hoff Road. Flows will travel approximately 460 feet overland to the detention basin. Time of concentration is estimated as follows:

T(overland): L = 460 feet
Elevation difference = 16
T(overland) = 3.84 minutes: See figure 1 in Appendix A

Total time = 3.84 use **4 minutes**

DETENTION BASIN CALCULATIONS:

Basin Peak Inflow

25 Year

Green Space	1.59 ac x	2.31 cfs/ac	=	3.67 cfs
Pavement / Building	0.84 ac x	4.75 cfs/ac	=	3.99 cfs
		Total	=	7.66 cfs

2 year-20 minute storm:	3.84 cfs
15 year-20 minute storm:	6.21 cfs
25 year-20 minute storm:	7.66 cfs
100 year-20 minute storm:	9.80 cfs

Allowable Release Rate

STORM	BASIN INFLOW	-	DIFFERENTIAL RUNOFF RATE	=	ALLOWABLE RELEASE RATE
2 yr	3.84 cfs	-	1.05 cfs	=	2.79 cfs
15 yr	6.21 cfs	-	1.67 cfs	=	4.54 cfs
25 yr	7.66 cfs	-	2.05 cfs	=	5.61 cfs
100 yr	9.80 cfs	-	2.63 cfs	=	7.17 cfs

Storm Routing Calculations and Results

A computer program PONDPACK was used in routing the 2, 15, 25 and 100 year storms through the basin. The routing calculations can be found in Appendix B for the 2, 15, 25 100 year storms for the watershed. The 100 year calculations with the low flow slots blocked and water ponded to the crest of the structure are found in Appendixes C. As found in the routing calculations, the results are as follows:

STORM (24 HR)	PEAK INFLOW	ALLOWABLE RELEASE RATE	CALCULATED RELEASE	PEAK ELEVATION
2 yr	3.84 cfs	2.79 cfs	2.67 cfs	563.03 ft
15 yr	6.21 cfs	4.54 cfs	3.63 cfs	563.51 ft
25 yr	7.66 cfs	5.61 cfs	4.08 cfs	563.75 ft
100 yr	9.80 cfs	7.17 cfs	4.62 cfs	564.07 ft
100 yr (Low Flow Blocked)	9.80 cfs	-------	8.37 cfs	564.91 ft

SUMMARY:

	Flow Rate	High Water
2 Year	2.67 cfs	563.03 ft
15 Year	3.63 cfs	563.51 ft
25 Year	4.08 cfs	563.75 ft
100 Year	4.62 cfs	564.07 ft
100 Year –LOW FLOW BLOCKED	8.37 cfs	564.91 ft

LOW FLOW SLOT	12" H x 12" W
ELEVATION	561.78
STRUCTURE TYPE	42" Precast Manhole Base
CREST ELEVATION	564.50
TOP OF BASIN BERM	566.10 ft
FREEBOARD	1.16 ft

Appendix A

-Structure Details

-Misc Figures

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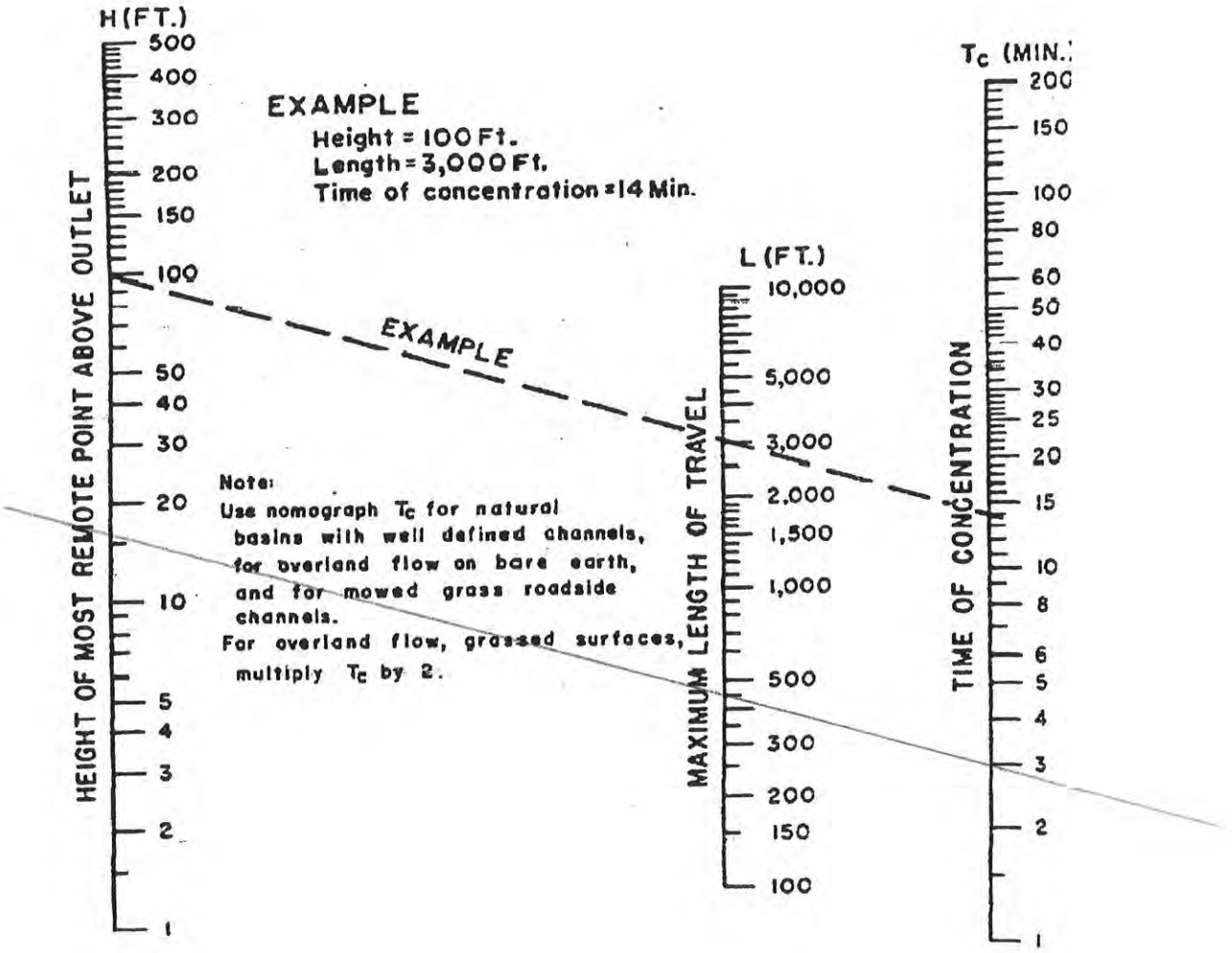
Project: Buffalo Tools
Date: 1/29/13 Project No: 01-11691 C
Designer: TCF Checked: TCF

TIME OF CONCENTRATION FOR SMALL DRAINAGE BASINS



Δ Height = 16

Length = 460

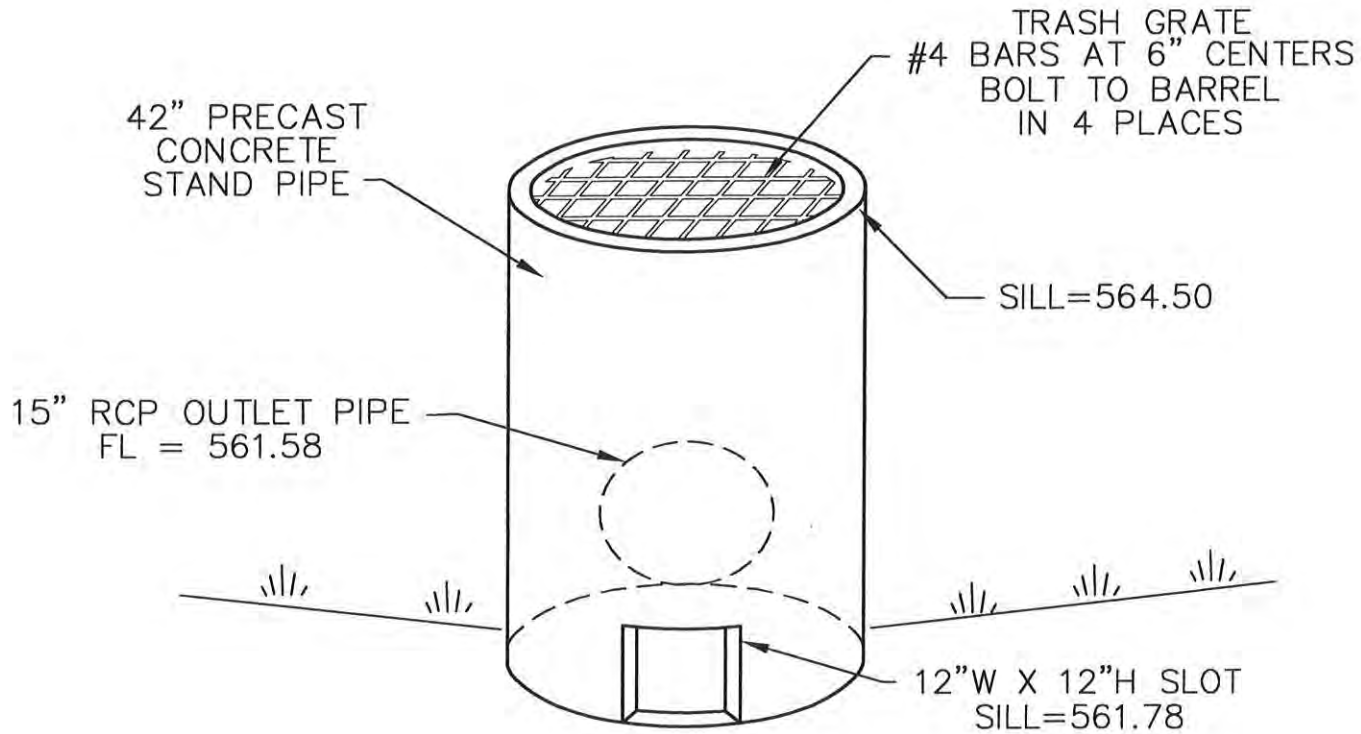
T_c = 3 min

Flow path
45% over Pavement (0.4) Factor
55% over grass (2) Factor

$45\% \cdot (0.4) \cdot (3) + 55\% \cdot (2) \cdot (3)$

$T_c = 3.84 \Rightarrow$ USE 4 min

Figure 1



OVERFLOW STRUCTURE '1' DETAIL

NOT TO SCALE

2 YEAR HIGHWATER 563.03
15 YEAR HIGHWATER 563.51
25 YEAR HIGHWATER 563.75
100 YEAR HIGHWATER 564.07

Appendix B

- Basin Routing

-Basin Inflow

-2 year Detention Routing

-15 year Detention Routing

-25 year Detention Routing

-100 year Detention Routing

Table of Contents

Subsection: Master Network Summary

Catchments Summary

Label	Scenario	Return Event (years)	Hydrograph Volume (ac-ft)	Time to Peak (min)	Peak Flow (ft^3/s)
Hyd Queue 10	Watershed - 002	0	0.101	5.000	3.84
Hyd Queue 10	Watershed - 015	0	0.163	5.000	6.21
Hyd Queue 10	Watershed - 025	0	0.201	5.000	7.66
Hyd Queue 10	Watershed - 100	0	0.256	5.000	9.80

Node Summary

Label	Scenario	Return Event (years)	Hydrograph Volume (ac-ft)	Time to Peak (min)	Peak Flow (ft^3/s)
Out 10	Watershed - 002	0	0.099	21.000	2.67
Out 10	Watershed - 015	0	0.160	21.000	3.63
Out 10	Watershed - 025	0	0.198	21.000	4.08
Out 10	Watershed - 100	0	0.253	21.000	4.62

Pond Summary

Label	Scenario	Return Event (years)	Hydrograph Volume (ac-ft)	Time to Peak (min)	Peak Flow (ft^3/s)	Maximum Water Surface Elevation (ft)	Maximum Pond Storage (ac-ft)
Pond 10 (IN)	Watershed - 002	0	0.099	6.000	3.84	(N/A)	(N/A)
Pond 10 (OUT)	Watershed - 002	0	0.099	21.000	2.67	563.03	0.048
Pond 10 (IN)	Watershed - 015	0	0.160	6.000	6.21	(N/A)	(N/A)
Pond 10 (OUT)	Watershed - 015	0	0.160	21.000	3.63	563.51	0.087
Pond 10 (IN)	Watershed - 025	0	0.198	6.000	7.66	(N/A)	(N/A)
Pond 10 (OUT)	Watershed - 025	0	0.198	21.000	4.08	563.75	0.113
Pond 10 (IN)	Watershed - 100	0	0.253	6.000	9.80	(N/A)	(N/A)
Pond 10 (OUT)	Watershed - 100	0	0.253	21.000	4.62	564.07	0.154

Subsection: Elevation-Area Volume Curve
Label: Pond 10

Return Event: 2 years
Storm Event:

Elevation (ft)	Planimeter (ft^2)	Area (ft^2)	A1+A2+sqr (A1*A2) (ft^2)	Volume (ac-ft)	Volume (Total) (ac-ft)
561.78	0.0	0.000	0.000	0.000	0.000
562.00	0.0	1,165.000	1,165.000	0.002	0.002
563.00	0.0	2,790.000	5,757.873	0.044	0.046
564.00	0.0	6,009.000	12,893.522	0.099	0.145
565.00	0.0	12,466.000	27,129.952	0.208	0.352
566.00	0.0	19,024.000	46,889.779	0.359	0.711
566.10	0.0	19,658.000	58,020.402	0.044	0.756

Pond Volume Equations
*** Incremental volume computed by the Conic Method for Reservoir Volumes.**

Volume = (1/3) * (EL2 - El1) * (Area1 + Area2 + sqr(Area1 * Area2))

where:	EL1, EL2	Lower and upper elevations of the increment
	Area1, Area2	Areas computed for EL1, EL2, respectively
	Volume	Incremental volume between EL1 and EL2

Requested Pond Water Surface Elevations	
Minimum (Headwater)	561.78 ft
Increment (Headwater)	0.10 ft
Maximum (Headwater)	566.10 ft

Outlet Connectivity

Structure Type	Outlet ID	Direction	Outfall	E1 (ft)	E2 (ft)
Rectangular Weir	1	Forward	cv	561.78	562.78
Stand Pipe	3	Forward	cv	564.50	566.10
Orifice-Area	2	Forward	cv	562.78	566.10
Culvert-Circular	cv	Forward	TW	561.68	566.10
Tailwater Settings	Tailwater			(N/A)	(N/A)

Structure ID: 1 Structure Type: Rectangular Weir	
Number of Openings	1
Elevation	561.78 ft
Weir Length	1.00 ft
Weir Coefficient	3.00 (ft^0.5)/s

Structure ID: 2 Structure Type: Orifice-Area	
Number of Openings	1
Elevation	561.78 ft
Orifice Area	1.0 ft²
Top Elevation	562.78 ft
Datum Elevation	562.28 ft
Orifice Coefficient	0.600

Structure ID: 3 Structure Type: Stand Pipe	
Number of Openings	1
Elevation	564.50 ft
Diameter	42.0 in
Orifice Area	9.6 ft²
Orifice Coefficient	0.600
Weir Length	11.00 ft
Weir Coefficient	3.00 (ft^0.5)/s
K Reverse	1.000
Manning's n	0.000
Kev, Charged Riser	0.000
Weir Submergence	False
Orifice H to crest	False

Structure ID: cv Structure Type: Culvert-Circular	
Number of Barrels	1
Diameter	15.0 in
Length	43.41 ft
Length (Computed Barrel)	43.64 ft
Slope (Computed)	0.103 ft/ft

Outlet Control Data	
Manning's n	0.010
Ke	0.500
Kb	0.014
Kr	0.000

Outlet Control Data	
Convergence Tolerance	0.00 ft

Inlet Control Data	
Equation Form	Form 1
K	0.0098
M	2.0000
C	0.0398
Y	0.6700
T1 ratio (HW/D)	1.109
T2 ratio (HW/D)	1.256
Slope Correction Factor	-0.500

Use unsubmerged inlet control 0 equation below T1 elevation.
Use submerged inlet control 0 equation above T2 elevation

In transition zone between unsubmerged and submerged inlet control,
interpolate between flows at T1 & T2...

T1 Elevation	563.07 ft	T1 Flow	4.80 ft³/s
T2 Elevation	563.25 ft	T2 Flow	5.49 ft³/s

Structure ID: TW
Structure Type: TW Setup, DS Channel

Tailwater Type	Free Outfall
Convergence Tolerances	
Maximum Iterations	40
Tailwater Tolerance (Minimum)	0.01 ft
Tailwater Tolerance (Maximum)	0.50 ft
Headwater Tolerance (Minimum)	0.01 ft
Headwater Tolerance (Maximum)	0.50 ft
Flow Tolerance (Minimum)	0.001 ft^3/s
Flow Tolerance (Maximum)	10.000 ft^3/s

Subsection: Composite Rating Curve
Label: Base Outfall

Return Event: 2 years
Storm Event:

Composite Outflow Summary

Water Surface Elevation (ft)	Flow (ft^3/s)	Tailwater Elevation (ft)	Convergence Error (ft)
561.78	0.00	(N/A)	0.00
561.88	0.08	(N/A)	0.00
561.98	0.18	(N/A)	0.00
562.08	0.32	(N/A)	0.00
562.18	0.48	(N/A)	0.00
562.28	0.67	(N/A)	0.00
562.38	0.89	(N/A)	0.00
562.48	1.12	(N/A)	0.00
562.58	1.38	(N/A)	0.00
562.68	1.65	(N/A)	0.00
562.78	2.09	(N/A)	0.00
562.88	2.32	(N/A)	0.00
562.98	2.55	(N/A)	0.00
563.08	2.77	(N/A)	0.00
563.18	2.98	(N/A)	0.00
563.28	3.18	(N/A)	0.00
563.38	3.38	(N/A)	0.00
563.48	3.58	(N/A)	0.00
563.58	3.77	(N/A)	0.00
563.68	3.95	(N/A)	0.00
563.78	4.13	(N/A)	0.00
563.88	4.30	(N/A)	0.00
563.98	4.47	(N/A)	0.00
564.08	4.64	(N/A)	0.00
564.18	4.80	(N/A)	0.00
564.28	4.96	(N/A)	0.00
564.38	5.11	(N/A)	0.00
564.48	5.26	(N/A)	0.00
564.50	5.30	(N/A)	0.00
564.58	5.92	(N/A)	0.00
564.68	7.08	(N/A)	0.00
564.78	8.29	(N/A)	0.00
564.88	9.35	(N/A)	0.00
564.98	9.78	(N/A)	0.00
565.08	9.97	(N/A)	0.00
565.18	10.16	(N/A)	0.00
565.28	10.34	(N/A)	0.00
565.38	10.52	(N/A)	0.00
565.48	10.70	(N/A)	0.00
565.58	10.88	(N/A)	0.00
565.68	11.05	(N/A)	0.00
565.78	11.22	(N/A)	0.00
565.88	11.39	(N/A)	0.00
565.98	11.55	(N/A)	0.00

Subsection: Composite Rating Curve
Label: Base Outfall

Return Event: 2 years
Storm Event:

Composite Outflow Summary

Water Surface Elevation (ft)	Flow (ft^3/s)	Tailwater Elevation (ft)	Convergence Error (ft)
566.08	11.72	(N/A)	0.00
566.10	11.75	(N/A)	0.00

Contributing Structures
(no Q: 1,3,2,cv)
1,cv (no Q: 3,2)
1,cv (no Q: 3,2)
1,cv (no Q: 3,2)
1,cv (no Q: 3,2)
1,cv (no Q: 3,2)
1,cv (no Q: 3,2)
1,cv (no Q: 3,2)
1,cv (no Q: 3,2)
1,cv (no Q: 3,2)
2,cv (no Q: 1,3)
2,cv (no Q: 1,3)
2,cv (no Q: 1,3)
2,cv (no Q: 1,3)
2,cv (no Q: 1,3)
2,cv (no Q: 1,3)
2,cv (no Q: 1,3)
2,cv (no Q: 1,3)
2,cv (no Q: 1,3)
2,cv (no Q: 1,3)
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3,2,cv (no Q: 1)
3,2,cv (no Q: 1)
3,2,cv (no Q: 1)
3,2,cv (no Q: 1)
3,cv (no Q: 1,2)
3,cv (no Q: 1,2)
3,cv (no Q: 1,2)
3,cv (no Q: 1,2)
3,cv (no Q: 1,2)
3,cv (no Q: 1,2)
3,cv (no Q: 1,2)
3,cv (no Q: 1,2)

Subsection: Composite Rating Curve
Label: Base Outfall

Return Event: 2 years
Storm Event:

Composite Outflow Summary

Contributing Structures
3,cv (no Q: 1,2)
3,cv (no Q: 1,2)
3,cv (no Q: 1,2)
3,cv (no Q: 1,2)
3,cv (no Q: 1,2)

Infiltration	
Infiltration Method (Computed)	No Infiltration

Initial Conditions	
Elevation (Water Surface, Initial)	561.78 ft
Volume (Initial)	0.000 ac-ft
Flow (Initial Outlet)	0.00 ft³/s
Flow (Initial Infiltration)	0.00 ft³/s
Flow (Initial, Total)	0.00 ft³/s
Time Increment	3.000 min

Inflow/Outflow Hydrograph Summary			
Flow (Peak In)	3.84 ft³/s	Time to Peak (Flow, In)	6.000 min
Flow (Peak Outlet)	2.67 ft³/s	Time to Peak (Flow, Outlet)	21.000 min

Elevation (Water Surface, Peak)	563.03 ft
Volume (Peak)	0.048 ac-ft

Mass Balance (ac-ft)	
Volume (Initial)	0.000 ac-ft
Volume (Total Inflow)	0.099 ac-ft
Volume (Total Infiltration)	0.000 ac-ft
Volume (Total Outlet Outflow)	0.099 ac-ft
Volume (Retained)	0.000 ac-ft
Volume (Unrouted)	0.000 ac-ft
Error (Mass Balance)	0.0 %

Subsection: Level Pool Pond Routing Summary
Label: Pond 10 (IN)

Return Event: 15 years
Storm Event:

Infiltration	
Infiltration Method (Computed)	No Infiltration

Initial Conditions	
Elevation (Water Surface, Initial)	561.78 ft
Volume (Initial)	0.000 ac-ft
Flow (Initial Outlet)	0.00 ft³/s
Flow (Initial Infiltration)	0.00 ft³/s
Flow (Initial, Total)	0.00 ft³/s
Time Increment	3.000 min

Inflow/Outflow Hydrograph Summary			
Flow (Peak In)	6.21 ft³/s	Time to Peak (Flow, In)	6.000 min
Flow (Peak Outlet)	3.63 ft³/s	Time to Peak (Flow, Outlet)	21.000 min

Elevation (Water Surface, Peak)	563.51 ft
Volume (Peak)	0.087 ac-ft

Mass Balance (ac-ft)	
Volume (Initial)	0.000 ac-ft
Volume (Total Inflow)	0.160 ac-ft
Volume (Total Infiltration)	0.000 ac-ft
Volume (Total Outlet Outflow)	0.160 ac-ft
Volume (Retained)	0.000 ac-ft
Volume (Unrouted)	0.000 ac-ft
Error (Mass Balance)	0.0 %

Infiltration	
Infiltration Method (Computed)	No Infiltration

Initial Conditions	
Elevation (Water Surface, Initial)	561.78 ft
Volume (Initial)	0.000 ac-ft
Flow (Initial Outlet)	0.00 ft³/s
Flow (Initial Infiltration)	0.00 ft³/s
Flow (Initial, Total)	0.00 ft³/s
Time Increment	3.000 min

Inflow/Outflow Hydrograph Summary			
Flow (Peak In)	7.66 ft³/s	Time to Peak (Flow, In)	6.000 min
Flow (Peak Outlet)	4.08 ft³/s	Time to Peak (Flow, Outlet)	21.000 min

Elevation (Water Surface, Peak)	563.75 ft
Volume (Peak)	0.113 ac-ft

Mass Balance (ac-ft)	
Volume (Initial)	0.000 ac-ft
Volume (Total Inflow)	0.198 ac-ft
Volume (Total Infiltration)	0.000 ac-ft
Volume (Total Outlet Outflow)	0.198 ac-ft
Volume (Retained)	0.000 ac-ft
Volume (Unrouted)	0.000 ac-ft
Error (Mass Balance)	0.0 %

Subsection: Level Pool Pond Routing Summary
Label: Pond 10 (IN)

Return Event: 100 years
Storm Event:

Infiltration	
Infiltration Method (Computed)	No Infiltration

Initial Conditions	
Elevation (Water Surface, Initial)	561.78 ft
Volume (Initial)	0.000 ac-ft
Flow (Initial Outlet)	0.00 ft³/s
Flow (Initial Infiltration)	0.00 ft³/s
Flow (Initial, Total)	0.00 ft³/s
Time Increment	3.000 min

Inflow/Outflow Hydrograph Summary			
Flow (Peak In)	9.80 ft³/s	Time to Peak (Flow, In)	6.000 min
Flow (Peak Outlet)	4.62 ft³/s	Time to Peak (Flow, Outlet)	21.000 min

Elevation (Water Surface, Peak)	564.07 ft
Volume (Peak)	0.154 ac-ft

Mass Balance (ac-ft)	
Volume (Initial)	0.000 ac-ft
Volume (Total Inflow)	0.253 ac-ft
Volume (Total Infiltration)	0.000 ac-ft
Volume (Total Outlet Outflow)	0.253 ac-ft
Volume (Retained)	0.000 ac-ft
Volume (Unrouted)	0.000 ac-ft
Error (Mass Balance)	0.0 %

Summary for Hydrograph Addition at 'Pond 10'

Upstream Link	Upstream Node
<Catchment to Outflow Node>	Hyd Queue 10

Node Inflows

Inflow Type	Element	Volume (ac-ft)	Time to Peak (min)	Flow (Peak) (ft^3/s)
Flow (From)	Hyd Queue 10	0.100	5.000	3.84
Flow (In)	Pond 10	0.099	6.000	3.84

Summary for Hydrograph Addition at 'Pond 10'

Upstream Link	Upstream Node
<Catchment to Outflow Node>	Hyd Queue 10

Node Inflows

Inflow Type	Element	Volume (ac-ft)	Time to Peak (min)	Flow (Peak) (ft^3/s)
Flow (From)	Hyd Queue 10	0.163	5.000	6.21
Flow (In)	Pond 10	0.160	6.000	6.21

Summary for Hydrograph Addition at 'Pond 10'

Upstream Link	Upstream Node
<Catchment to Outflow Node>	Hyd Queue 10

Node Inflows

Inflow Type	Element	Volume (ac-ft)	Time to Peak (min)	Flow (Peak) (ft^3/s)
Flow (From)	Hyd Queue 10	0.200	5.000	7.66
Flow (In)	Pond 10	0.198	6.000	7.66

Summary for Hydrograph Addition at 'Pond 10'

Upstream Link	Upstream Node
<Catchment to Outflow Node>	Hyd Queue 10

Node Inflows

Inflow Type	Element	Volume (ac-ft)	Time to Peak (min)	Flow (Peak) (ft^3/s)
Flow (From)	Hyd Queue 10	0.256	5.000	9.80
Flow (In)	Pond 10	0.253	6.000	9.80

Appendix C

- 100 year Low Flow Blocked

Table of Contents

Subsection: Master Network Summary

Catchments Summary

Label	Scenario	Return Event (years)	Hydrograph Volume (ac-ft)	Time to Peak (min)	Peak Flow (ft^3/s)
Hyd Queue 10	Watershed - 100	0	0.256	5.000	9.80

Node Summary

Label	Scenario	Return Event (years)	Hydrograph Volume (ac-ft)	Time to Peak (min)	Peak Flow (ft^3/s)
Out 10	Watershed - 100	0	0.253	21.000	8.37

Pond Summary

Label	Scenario	Return Event (years)	Hydrograph Volume (ac-ft)	Time to Peak (min)	Peak Flow (ft^3/s)	Maximum Water Surface Elevation (ft)	Maximum Pond Storage (ac-ft)
Pond 10 (IN)	Watershed - 100	0	0.253	6.000	9.80	(N/A)	(N/A)
Pond 10 (OUT)	Watershed - 100	0	0.253	21.000	8.37	564.91	0.328

Subsection: Elevation-Area Volume Curve
Label: Pond 10

Return Event: 100 years
Storm Event:

Elevation (ft)	Planimeter (ft^2)	Area (ft^2)	A1+A2+sqr (A1*A2) (ft^2)	Volume (ac-ft)	Volume (Total) (ac-ft)
561.78	0.0	0.000	0.000	0.000	0.000
562.00	0.0	1,165.000	1,165.000	0.002	0.002
563.00	0.0	2,790.000	5,757.873	0.044	0.046
564.00	0.0	6,009.000	12,893.522	0.099	0.145
565.00	0.0	12,466.000	27,129.952	0.208	0.352
566.00	0.0	19,024.000	46,889.779	0.359	0.711
566.10	0.0	19,658.000	58,020.402	0.044	0.756

Pond Volume Equations
*** Incremental volume computed by the Conic Method for Reservoir Volumes.**

Volume = (1/3) * (EL2 - El1) * (Area1 + Area2 + sqr(Area1 * Area2))

where:	EL1, EL2	Lower and upper elevations of the increment
	Area1, Area2	Areas computed for EL1, EL2, respectively
	Volume	Incremental volume between EL1 and EL2

Requested Pond Water Surface Elevations	
Minimum (Headwater)	561.78 ft
Increment (Headwater)	0.10 ft
Maximum (Headwater)	566.10 ft

Outlet Connectivity

Structure Type	Outlet ID	Direction	Outfall	E1 (ft)	E2 (ft)
Stand Pipe	3	Forward	cv	564.50	566.10
Culvert-Circular	cv	Forward	TW	561.68	566.10
Tailwater Settings	Tailwater			(N/A)	(N/A)

Structure ID: 3 Structure Type: Stand Pipe	
Number of Openings	1
Elevation	564.50 ft
Diameter	42.0 in
Orifice Area	9.6 ft²
Orifice Coefficient	0.600
Weir Length	11.00 ft
Weir Coefficient	3.00 (ft^0.5)/s
K Reverse	1.000
Manning's n	0.000
Kev, Charged Riser	0.000
Weir Submergence	False
Orifice H to crest	False

Structure ID: cv Structure Type: Culvert-Circular	
Number of Barrels	1
Diameter	15.0 in
Length	43.41 ft
Length (Computed Barrel)	43.64 ft
Slope (Computed)	0.103 ft/ft

Outlet Control Data	
Manning's n	0.010
Ke	0.500
Kb	0.014
Kr	0.000
Convergence Tolerance	0.00 ft

Inlet Control Data	
Equation Form	Form 1
K	0.0098
M	2.0000
C	0.0398
Y	0.6700
T1 ratio (HW/D)	1.109
T2 ratio (HW/D)	1.256
Slope Correction Factor	-0.500

Use unsubmerged inlet control 0 equation below T1 elevation.
Use submerged inlet control 0 equation above T2 elevation

In transition zone between unsubmerged and submerged inlet control,
interpolate between flows at T1 & T2...

T1 Elevation	563.07 ft	T1 Flow	4.80 ft³/s
T2 Elevation	563.25 ft	T2 Flow	5.49 ft³/s

Structure ID: TW
Structure Type: TW Setup, DS Channel

Tailwater Type	Free Outfall

Convergence Tolerances	
Maximum Iterations	40
Tailwater Tolerance (Minimum)	0.01 ft
Tailwater Tolerance (Maximum)	0.50 ft
Headwater Tolerance (Minimum)	0.01 ft
Headwater Tolerance (Maximum)	0.50 ft
Flow Tolerance (Minimum)	0.001 ft^3/s
Flow Tolerance (Maximum)	10.000 ft^3/s

Composite Outflow Summary

Water Surface Elevation (ft)	Flow (ft^3/s)	Tailwater Elevation (ft)	Convergence Error (ft)
561.78	0.00	(N/A)	0.00
561.88	0.00	(N/A)	0.00
561.98	0.00	(N/A)	0.00
562.08	0.00	(N/A)	0.00
562.18	0.00	(N/A)	0.00
562.28	0.00	(N/A)	0.00
562.38	0.00	(N/A)	0.00
562.48	0.00	(N/A)	0.00
562.58	0.00	(N/A)	0.00
562.68	0.00	(N/A)	0.00
562.78	0.00	(N/A)	0.00
562.88	0.00	(N/A)	0.00
562.98	0.00	(N/A)	0.00
563.08	0.00	(N/A)	0.00
563.18	0.00	(N/A)	0.00
563.28	0.00	(N/A)	0.00
563.38	0.00	(N/A)	0.00
563.48	0.00	(N/A)	0.00
563.58	0.00	(N/A)	0.00
563.68	0.00	(N/A)	0.00
563.78	0.00	(N/A)	0.00
563.88	0.00	(N/A)	0.00
563.98	0.00	(N/A)	0.00
564.08	0.00	(N/A)	0.00
564.18	0.00	(N/A)	0.00
564.28	0.00	(N/A)	0.00
564.38	0.00	(N/A)	0.00
564.48	0.00	(N/A)	0.00
564.50	0.00	(N/A)	0.00
564.58	0.75	(N/A)	0.00
564.68	2.52	(N/A)	0.00
564.78	4.89	(N/A)	0.00
564.88	7.72	(N/A)	0.00
564.98	9.78	(N/A)	0.00
565.08	9.97	(N/A)	0.00
565.18	10.16	(N/A)	0.00
565.28	10.34	(N/A)	0.00
565.38	10.52	(N/A)	0.00
565.48	10.70	(N/A)	0.00
565.58	10.88	(N/A)	0.00
565.68	11.05	(N/A)	0.00
565.78	11.22	(N/A)	0.00
565.88	11.39	(N/A)	0.00
565.98	11.55	(N/A)	0.00

Subsection: Composite Rating Curve | Return Event: 100 years
Label: Low Flow Blocked | Storm Event:

Composite Outflow Summary

Water Surface Elevation (ft)	Flow (ft^3/s)	Tailwater Elevation (ft)	Convergence Error (ft)
566.08	11.72	(N/A)	0.00
566.10	11.75	(N/A)	0.00

Contributing Structures

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Subsection: Composite Rating Curve
Label: Low Flow Blocked

Return Event: 100 years
Storm Event:

Composite Outflow Summary

Contributing Structures
3,cv
3,cv
3,cv
3,cv
3,cv

Subsection: Level Pool Pond Routing Summary
Label: Pond 10 (IN)

Return Event: 100 years
Storm Event:

Infiltration	
Infiltration Method (Computed)	No Infiltration

Initial Conditions	
Elevation (Water Surface, Initial)	564.50 ft
Volume (Initial)	0.230 ac-ft
Flow (Initial Outlet)	0.00 ft³/s
Flow (Initial Infiltration)	0.00 ft³/s
Flow (Initial, Total)	0.00 ft³/s
Time Increment	3.000 min

Inflow/Outflow Hydrograph Summary			
Flow (Peak In)	9.80 ft³/s	Time to Peak (Flow, In)	6.000 min
Flow (Peak Outlet)	8.37 ft³/s	Time to Peak (Flow, Outlet)	21.000 min

Elevation (Water Surface, Peak)	564.91 ft
Volume (Peak)	0.328 ac-ft

Mass Balance (ac-ft)	
Volume (Initial)	0.230 ac-ft
Volume (Total Inflow)	0.253 ac-ft
Volume (Total Infiltration)	0.000 ac-ft
Volume (Total Outlet Outflow)	0.253 ac-ft
Volume (Retained)	0.230 ac-ft
Volume (Unrouted)	0.000 ac-ft
Error (Mass Balance)	0.0 %

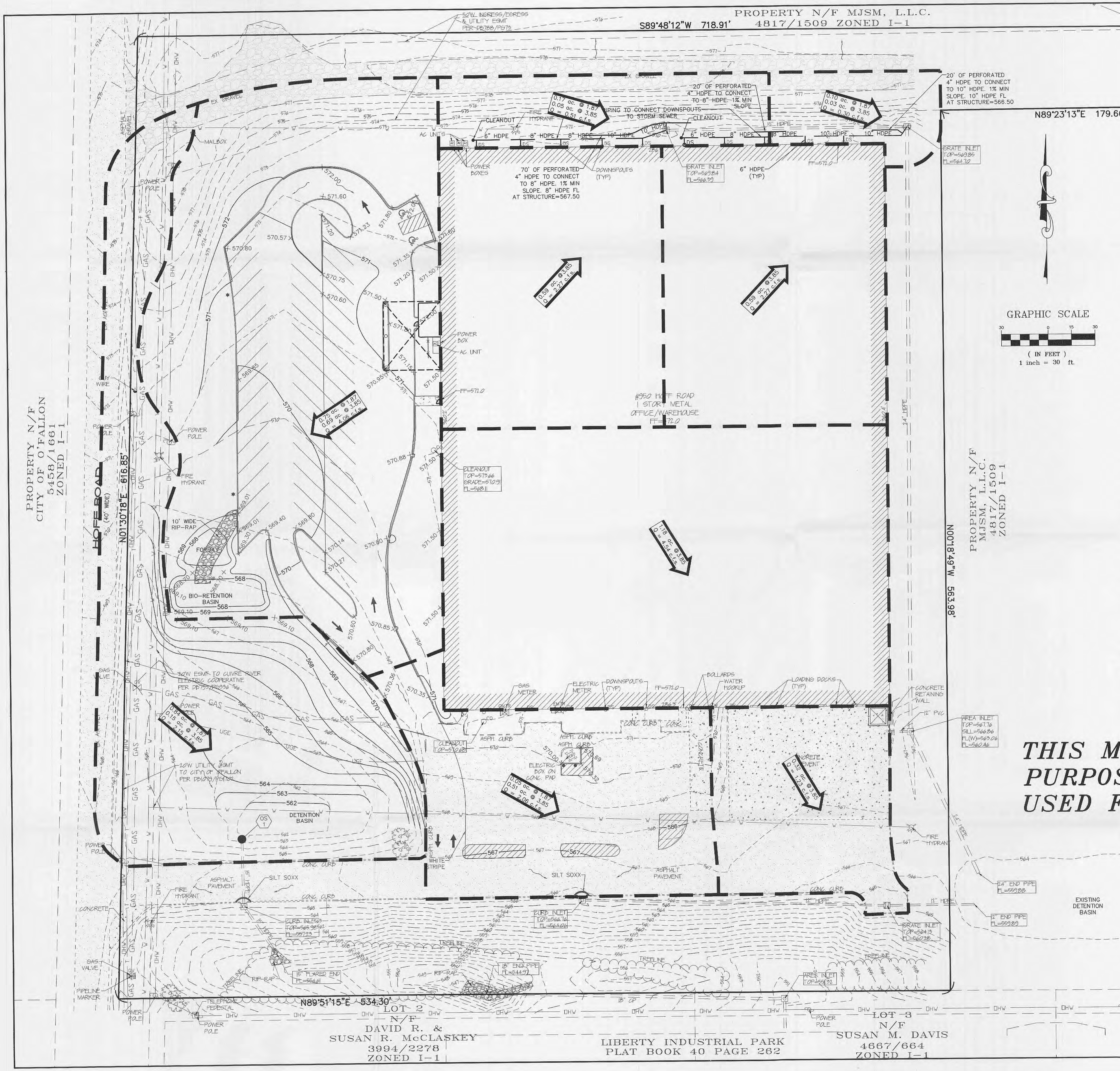
Summary for Hydrograph Addition at 'Pond 10'

Upstream Link	Upstream Node
<Catchment to Outflow Node>	Hyd Queue 10

Node Inflows

Inflow Type	Element	Volume (ac-ft)	Time to Peak (min)	Flow (Peak) (ft^3/s)
Flow (From)	Hyd Queue 10	0.256	5.000	9.80
Flow (In)	Pond 10	0.253	6.000	9.80

Appendix D
-Drawings



WATER QUALITY

Bio-Retention Volume Provided:

ELEVATION (ft)	AREAS (ft^2)	VOL. (ft^3)
568	984	0
568.7	1340	1162
	TOTAL =	1162 ft^3

Forbay Volume Provided:

ELEVATION (ft)	AREAS (ft^2)	VOL. (ft^3)
568	526	0
568.7	775	650
	TOTAL =	650 ft^3

Soil Mix Storage Volume:

– SOIL MIX IN BOTTOM OF RAIN GARDEN IS WITHIN THE 468 CONTOUR LIMIT AND HAS A VOID RATIO OF 40% BY VOLUME.

Vmix = (984 (2.7 ft. deep)) (.4) = 1062 ft^3

Vtot = 1162 + 650 + 1062 = 2874 ft^3 (Total Water Quality Volume Provided)

Water Quality Volume Required:

WQv = (P) Rv (A) / 12 = Water Quality Volume Required
Rv = (0.05 + 0.009 (I))
P = 1.14 Inches of Rainfall
A = 1.44 Acres
I = Percent Inpervious Cover
WQv = ((1.14) (0.05 + 0.009 (48%)) (1.44) (43,560) / 12 = 2,873 ft^3 Required

15 yr. 20 min. High Water Elevation

Q15 = 4.06 cfs
(3) 10" PVC Standpipes. Flow for each = 4.06 cfs / 3 = 1.35 cfs per pipe.
Q = C x L x H ^3/2 (Weir Calculation)
L = Weir Length of 10" PVC = 2.61'
C = Coeficient = 3
H = Depth of Water
H = 1.35 / 3 /2.61' ^2/3 = 0.31' (depth of water over top of pipe)
HW = 568.70' + 0.31' = 569.01' (15 yr. storm stays within basin)

THIS MAP IS FOR DRAINAGE PURPOSES ONLY. NOT TO BE USED FOR CONSTRUCTION.

PROJECT TITLE:

Developer / Owner:
NEW BUFFALO CORPORATION

P+Z No

City No.

Page No

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