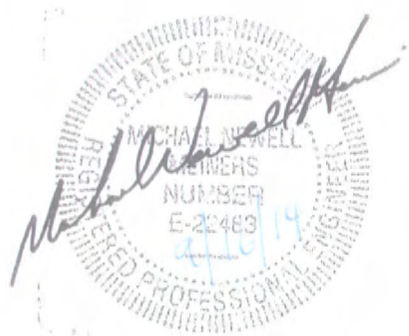
HYDRAULIC SUMMARY REPORT

Highway K Retail
City of O'Fallon, Missouri

Project Number 12-0170



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Sept, 2014

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Introduction

The Highway K Retail development is a 7.37-acre commercial development. The site is zoned C-2 General Business District and located in the City of O'Fallon, Missouri.

An underground detention basin has been designed on the east side of the property south of the proposed access drive.

Site Conditions

Existing Conditions

The approximately 7.37-acre site is currently occupied by a single family residential home. The existing home is to be demolished and the remainder of the property is currently vacant. Approximately 36 acres of offsite runoff passes through this property. The property discharges to an existing culvert pipe under Bramblett Road. Stormwater runoff from this property currently leaves the site undetained.

Existing Utilities

All underground utilities have been plotted from available information and their locations should be considered approximate only. Utilities have been marked in the field by the respective utility companies or their contracted locators and have been located by SCES surveyors. Utility information has been obtained from available maps and depicted on the plans as accurately as possible. The verification of the location of all underground utilities, either shown or not shown on the plans, shall be the responsibility of the contractor, and shall be located prior to any grading and/or construction of improvements.

Many existing utilities located on the property will require relocation as a result of the proposed construction. The existing sanitary sewer service, electric service and water service will all require relocation. Verification of the location of all underground utilities shall be the responsibility of the contractor, and shall be located prior to any grading and/or construction of improvements.

Developed Conditions

Proposed Drainage Basins

The site drainage patterns will not be changed significantly. The site will still discharge into a tributary of Belleau Creek.

Design Standards

The stormwater sewers have been designed by the Rational Method to the specifications of the City of O'Fallon. The Detention basin has been designed in accordance with the City of O'Fallon Municipal Code.

Design Frequency

For all storm sewer design a fifteen (15) year, twenty (20) minute rainfall frequency was used.

For the underground detention basin the 2-year, 10-year, 25-year and 100-year inflow hydrographs were determined by the SCS method.

Hydrologic and Hydraulic Design

Storm Sewer Design

The proposed stormwater system, including the detention basin outfall pipe, were designed using the fifteen (15) year, twenty (20) minute rainfall frequency. The hydraulics were analyzed using Hydraflow Storm Sewers. A copy of the output can be found in the appendix. The 15-yr water surface elevation in the existing tributary to Belleau Creek was used as a starting hydraulic grade elevation for the storm sewer system. A Channel Report may be found as Appendix C.

Underground Detention Basin Design

The underground detention basin has been designed in accordance with the City of O'Fallon requirements and was analyzed with Hydraflow Hydrographs. The 2-year, 10-year, 25-year and 100-year inflow hydrographs were determined by SCS method. The pre-developed stormwater release rates were determined and used as allowable release rates for the developed runoff. Stormwater detention has been provided for the entire 7.37 Acre site.

The underground detention basin has been designed using "Stormtech MC-4500" underground chambers. These chambers are aligned in 6 parallel rows of 21 to 26 chambers, totaling 150 in the basin. There are three separate inflow locations into this basin and one outflow location into an outfall structure with an outflow control weir. The outflow from the basin into the outfall structure is routed through a 15" pipe at the bottom of the base rock as well as a 36" pipe set at an elevation that ensures the required Water Quality Volume will only drain through the perforated underdrain system. The outfall control weir contains a 15" low flow orifice, a mid range weir, and an overflow weir.

A summary for the basin analysis results can be found in Appendix B.

Water Quality Design

The water quality has been calculated and designed in accordance with the City of O'Fallon requirements as stated in Ordinance Section 405.247. The Water Quality Calculations have been provided in Appendix F of this report.

The water quality BMP selected to treat the required volume is the Stormtech Isolator Row. This BMP is designed to satisfy the 80% TSS requirement by providing the required volume below the direct outflow pipe of the Stormtech chambers. The required volume is released from the basin through the perforated underdrain system. A Performance Evaluation Report of the Isolator row has been provided in Appendix G of this report.

Appendix A

MyReport

Line No.	Line ID	Line Length (ft)	Line Size (in)	Line Slope (%)	Invert Up (ft)	Invert Dn (ft)	Gnd/Rim El Up (ft)	Gnd/Rim El Dn (ft)	HGL Up (ft)	HGL Dn (ft)	Rim-Hw (ft)	Flow Rate (cfs)	Capac Full (cfs)	Vel Dn (ft/s)	Q Capt (cfs)	Q Carry (cfs)	Q Byp (cfs)	Byp Ln No
1	MH100-FE99	44.000	36	2.18	516.96	516.00	528.42	520.00	519.05 j	519.00	9.37	41.27	98.51	5.84	....	....	....	n/a
2	MH101-MH100	20.000	36	2.00	522.86	522.46	530.16	528.42	524.95	523.85	5.21	41.27	94.31	12.90	....	....	....	n/a
3	MH102-MH101	314.400	36	2.00	529.25	522.96	549.14	530.16	531.34	524.95	17.80	41.27	94.33	8.29	....	....	....	n/a
4	MH103-MH102	33.250	36	2.02	530.02	529.35	548.68	549.14	531.92 j	531.34	16.76	34.27	94.68	6.88	....	....	....	n/a
5	EXAI-MH103	132.288	36	3.45	536.00	531.43	551.87	548.68	537.90	532.51	13.97	34.27	123.96	14.98	34.27	0.00	0.00	Sag
6	EXCI-MH102	56.870	15	2.44	542.54	541.15	552.86	549.14	543.60	541.92	9.26	7.01	10.10	8.88	7.01	0.00	0.00	Sag
7	MH201-EP200A	64.000	48	0.45	513.70	513.41	521.50	517.41	517.57	517.41	3.35	75.91	96.70	6.04	....	....	....	n/a
8	EP202A-MH201	112.000	48	0.46	514.21	513.70	518.21	521.50	518.36	518.15	-0.54	63.05	96.93	5.02	63.05	0.00	0.00	n/a
9	MH201-EP200B	64.220	48	0.45	513.70	513.41	521.50	517.41	517.57	517.41	3.35	75.91	96.54	6.04	....	....	....	n/a
10	EP202B-MH201	112.370	48	0.45	514.21	513.70	518.21	521.50	518.36	518.15	-0.54	63.05	96.77	5.02	63.05	0.00	0.00	n/a
11	GI203-MH201	22.000	15	1.00	515.50	515.28	519.17	521.50	516.53	516.53	2.62	1.27	6.46	1.04	3.66	2.78	0.00	Sag
12	GI204-GI203	55.899	12	1.00	516.16	515.60	519.25	519.17	516.42	516.55	2.83	0.39	3.56	0.50	0.39	0.00	0.00	Sag
13	MH206-MH201	16.400	24	2.99	515.40	514.91	522.80	521.50	517.15 j	516.91	5.65	24.45	39.10	7.78	....	....	....	n/a
14	MH207-MH206	41.242	24	10.18	522.00	517.80	533.61	522.80	523.69	518.57	9.92	22.52	72.18	20.30	....	....	....	n/a
15	MH207A-MH207	9.000	36	0.67	527.42	527.36	536.27	533.61	528.95	528.71	7.32	22.52	54.45	7.33	....	....	....	n/a
16	GI205-MH206	41.263	12	0.99	516.01	515.60	519.81	522.80	517.27	517.15	2.45	1.93	3.55	2.45	1.93	0.00	0.00	Sag
17	CI210-MH209	26.298	18	8.48	527.42	525.19	533.26	526.69	528.80	525.90	2.90	13.98	30.58	16.91	0.78	1.37	0.71	11
18	CI211-CI210	70.052	15	12.56	536.42	527.62	541.69	533.26	537.63	528.80	4.06	11.40	22.89	9.50	1.13	0.00	1.37	17
19	CI212-CI211	294.885	15	2.00	542.52	536.62	548.70	541.69	543.59	537.63	5.11	7.20	9.13	6.78	2.66	0.00	0.00	Sag
20	CI213-CI212	34.000	12	2.00	543.40	542.72	548.70	548.70	544.29	543.59	4.41	4.54	5.04	6.25	4.54	0.00	0.00	Sag
21	CI214-CI210	34.000	12	1.26	527.95	527.52	532.72	533.26	530.53	530.36	2.04	2.46	4.00	3.14	1.17	0.77	2.07	11
22	CI215-CI211	36.196	12	1.99	538.20	537.48	542.77	541.69	538.75	537.88	4.02	1.69	5.02	5.77	0.92	0.00	0.77	21

Project File: 2014-10-10 THOELE HWY K RETAIL 120170.stm | Number of lines: 25 | Date: 10/13/2014

NOTES: ** Critical depth

MyReport

Line No.	Line ID	Line Length (ft)	Line Size (in)	Line Slope (%)	Invert Up (ft)	Invert Dn (ft)	Gnd/Rim El Up (ft)	Gnd/Rim El Dn (ft)	HGL Up (ft)	HGL Dn (ft)	Rim-Hw (ft)	Flow Rate (cfs)	Capac Full (cfs)	Vel Dn (ft/s)	Q Capt (cfs)	Q Carry (cfs)	Q Byp (cfs)	Byp Ln No	
23	EXGI-EXEP	32.301	18	0.62	539.77	539.57	542.77	541.07	540.31	540.08	2.46	2.08	8.26	3.89	0.39	0.00	0.00	Sag	
24	MH216-EXGI	133.688	18	2.35	542.94	539.80	544.44	542.77	543.43 j	540.31	0.98	1.69	16.09	3.17	....	....	....	n/a	
25	AI217-MH216	20.000	18	2.35	537.41	536.94	547.30	544.44	543.46	543.46	3.82	1.69	16.10	0.96	1.69	0.00	0.00	Sag	

Project File: 2014-10-10 THOELE HWY K RETAIL 120170.stm

Number of lines: 25

Date: 10/13/2014

NOTES: ** Critical depth

Appendix B

Hydrograph Return Period Recap

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. v10

Hyd. No.	Hydrograph type (origin)	Inflow hyd(s)	Peak Outflow (cfs)								Hydrograph Description
			1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr	
1	SCS Runoff	------	-------	18.96	-------	-------	35.40	38.19	-------	53.16	Predeveloped
2	SCS Runoff	------	-------	7.093	-------	-------	11.20	11.87	-------	15.48	Developed-Bypass
3	SCS Runoff	------	-------	27.68	-------	-------	42.16	44.57	-------	57.40	Developed-To Basin
4	Reservoir	3	-------	10.64	-------	-------	20.49	23.19	-------	37.65	Underground Basin
5	Combine	2, 4	-------	17.53	-------	-------	31.32	34.66	-------	53.13	Outfall

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. v10

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph Description
1	SCS Runoff	18.96	2	720	49,181	------	------	------	Predeveloped
2	SCS Runoff	7.093	2	720	19,425	------	------	------	Developed-Bypass
3	SCS Runoff	27.68	2	716	65,030	------	------	------	Developed-To Basin
4	Reservoir	10.64	2	722	65,023	3	526.78	15,602	Underground Basin
5	Combine	17.53	2	720	84,449	2, 4	------	------	Outfall

Hydrograph Report

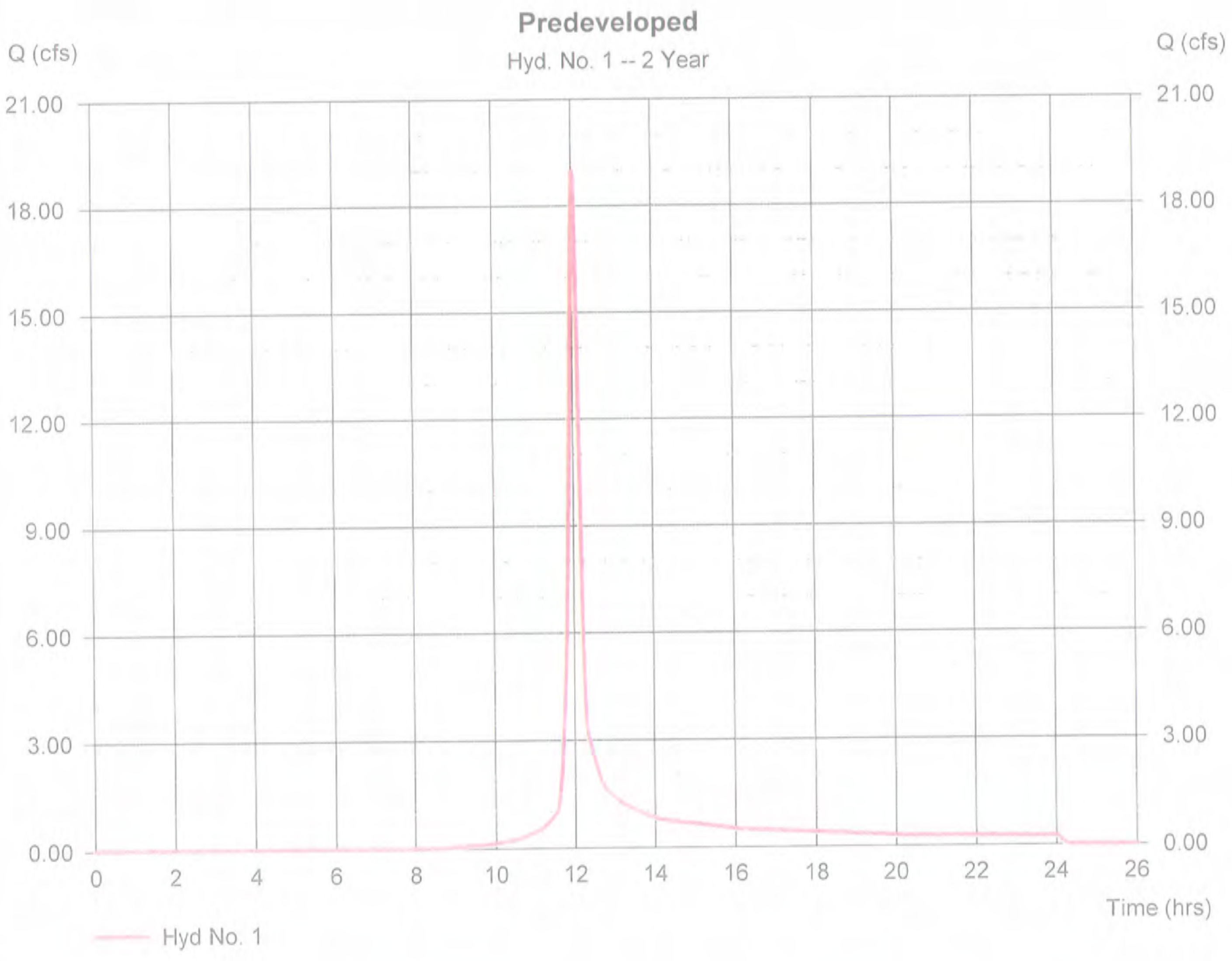
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. v10 Thursday, 07 / 17 / 2014

Hyd. No. 1

Predeveloped

Hydrograph type	= SCS Runoff	Peak discharge	= 18.96 cfs
Storm frequency	= 2 yrs	Time to peak	= 12.00 hrs
Time interval	= 2 min	Hyd. volume	= 49,181 cuft
Drainage area	= 7.370 ac	Curve number	= 82*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 10.00 min
Total precip.	= 3.50 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(25.850 x 92) + (8.010 x 61) + (4.490 x 55) + (3.010 x 94) + (0.550 x 74) + (1.390 x 70)] / 7.370



TR55 Tc Worksheet

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. v10

Hyd. No. 1

Predeveloped

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.013		0.011		0.011		
Flow length (ft)	= 300.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.50		0.00		0.00		
Land slope (%)	= 2.30		0.00		0.00		
Travel Time (min)	**= 3.02**	**+**	**0.00**	**+**	**0.00**	**=**	**3.02**
Shallow Concentrated Flow							
Flow length (ft)	= 900.00		420.00		0.00		
Watercourse slope (%)	= 4.50		4.30		0.00		
Surface description	= Paved		Unpaved		Paved		
Average velocity (ft/s)	=4.31		3.35		0.00		
Travel Time (min)	**= 3.48**	**+**	**2.09**	**+**	**0.00**	**=**	**5.57**
Channel Flow							
X sectional flow area (sqft)	= 18.20		27.30		0.00		
Wetted perimeter (ft)	= 20.10		32.20		0.00		
Channel slope (%)	= 2.30		1.00		0.00		
Manning's n-value	= 0.020		0.020		0.015		
Velocity (ft/s)	=10.57		6.67		0.00		
Flow length (ft)	({0})350.0		350.0		0.0		
Travel Time (min)	**= 0.55**	**+**	**0.87**	**+**	**0.00**	**=**	**1.43**

Total Travel Time, Tc .... 10.00 min

Hydrograph Report

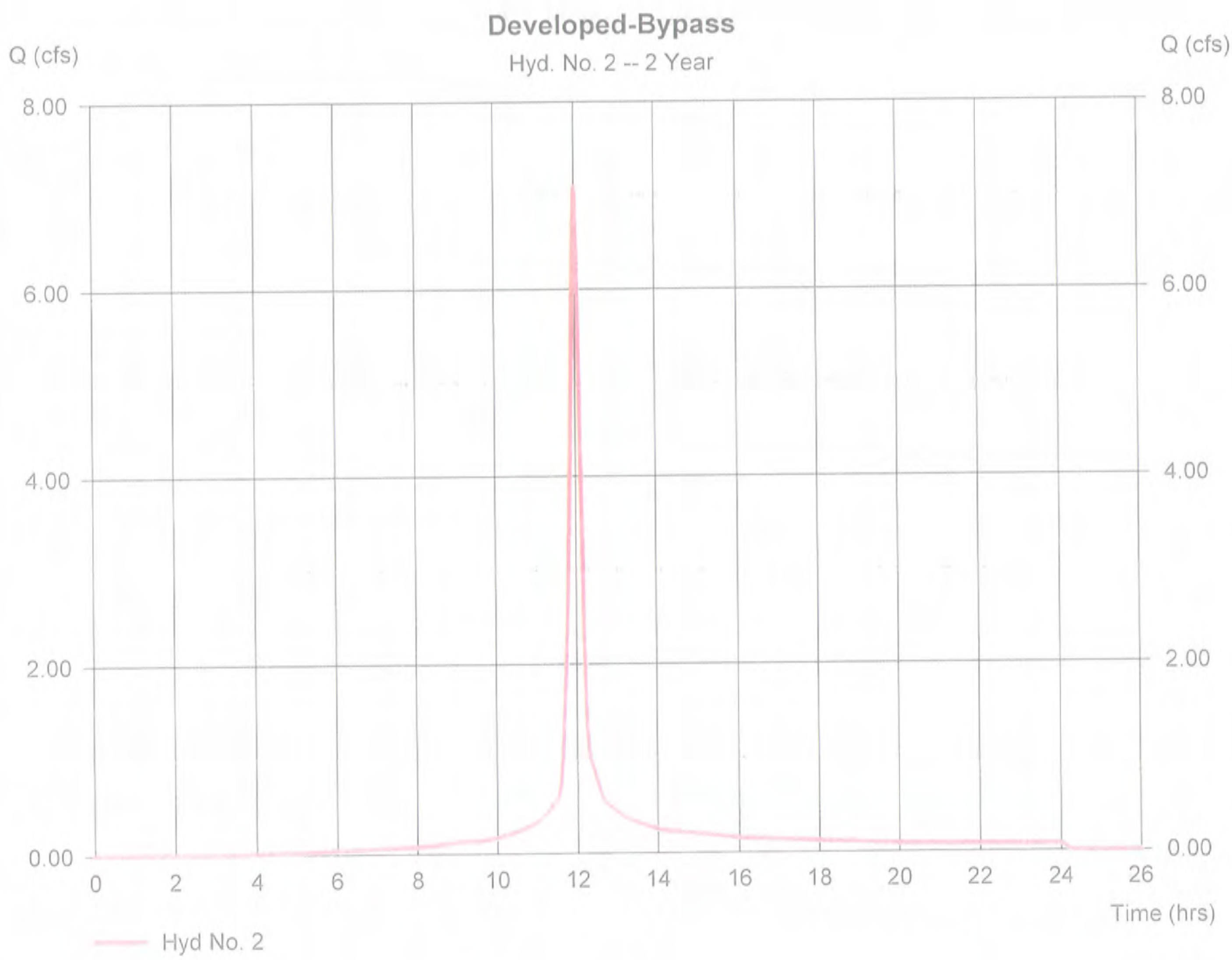
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. v10 — Thursday, 07 / 17 / 2014

Hyd. No. 2

Developed-Bypass

Hydrograph type	= SCS Runoff	Peak discharge	= 7.093 cfs
Storm frequency	= 2 yrs	Time to peak	= 12.00 hrs
Time interval	= 2 min	Hyd. volume	= 19,425 cuft
Drainage area	= 1.830 ac	Curve number	= 94*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 10.00 min
Total precip.	= 3.50 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(25.850 x 92) + (4.935 x 61) + (3.410 x 55) + (3.010 x 94) + (1.220 x 70)] / 1.830



TR55 Tc Worksheet

Hyd. No. 2

Developed-Bypass

Description	A	B	C	Totals
Sheet Flow				
Manning's n-value	= 0.013	0.011	0.011	
Flow length (ft)	= 300.0	0.0	0.0	
Two-year 24-hr precip. (in)	= 3.50	0.00	0.00	
Land slope (%)	= 2.30	0.00	0.00	
Travel Time (min)	**= 3.02**	**+ 0.00**	**+ 0.00**	**= 3.02**
Shallow Concentrated Flow				
Flow length (ft)	= 900.00	420.00	0.00	
Watercourse slope (%)	= 4.50	4.30	0.00	
Surface description	= Paved	Unpaved	Paved	
Average velocity (ft/s)	=4.31	3.35	0.00	
Travel Time (min)	**= 3.48**	**+ 2.09**	**+ 0.00**	**= 5.57**
Channel Flow				
X sectional flow area (sqft)	= 18.20	27.30	0.00	
Wetted perimeter (ft)	= 20.10	32.20	0.00	
Channel slope (%)	= 2.30	1.00	0.00	
Manning's n-value	= 0.020	0.020	0.015	
Velocity (ft/s)	=10.57	6.67	0.00	
Flow length (ft)	({0})350.0	350.0	0.0	
Travel Time (min)	**= 0.55**	**+ 0.87**	**+ 0.00**	**= 1.43**

Total Travel Time, Tc .... 10.00 min

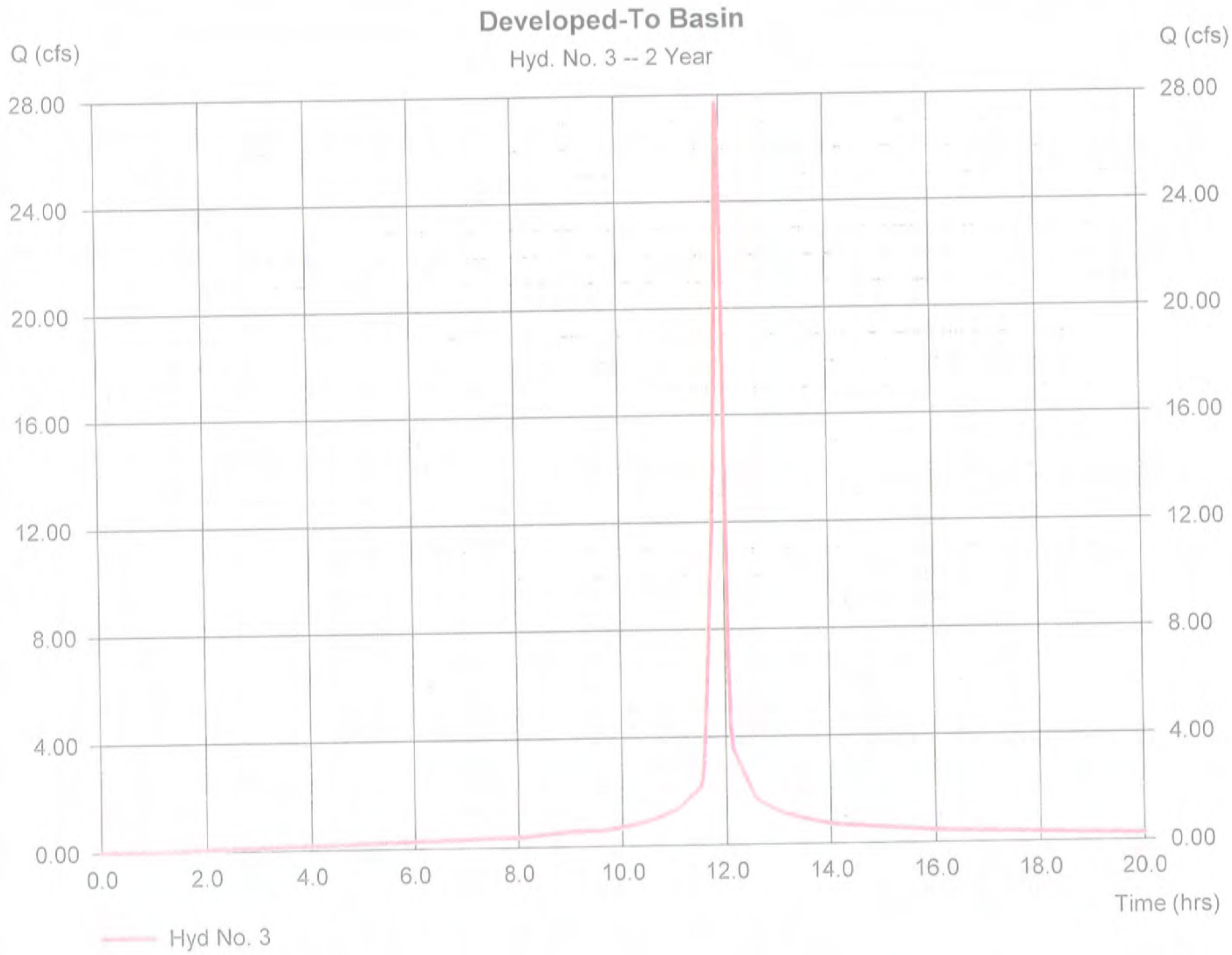
Hydrograph Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. v10 — Thursday, 07 / 17 / 2014

Hyd. No. 3

Developed-To Basin

Hydrograph type	= SCS Runoff	Peak discharge	= 27.68 cfs
Storm frequency	= 2 yrs	Time to peak	= 11.93 hrs
Time interval	= 2 min	Hyd. volume	= 65,030 cuft
Drainage area	= 5.850 ac	Curve number	= 98
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 6.50 min
Total precip.	= 3.50 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



TR55 Tc Worksheet

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. v10

Hyd. No. 3

Developed-To Basin

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.013		0.011		0.011		
Flow length (ft)	= 300.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.50		0.00		0.00		
Land slope (%)	= 1.00		0.00		0.00		
Travel Time (min)	**= 4.21**	**+**	**0.00**	**+**	**0.00**	**=**	**4.21**
Shallow Concentrated Flow							
Flow length (ft)	= 300.00		0.00		0.00		
Watercourse slope (%)	= 1.20		0.00		0.00		
Surface description	= Paved		Paved		Paved		
Average velocity (ft/s)	=2.23		0.00		0.00		
Travel Time (min)	**= 2.25**	**+**	**0.00**	**+**	**0.00**	**=**	**2.25**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00		0.00		0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc .... 6.50 min

Hydrograph Report

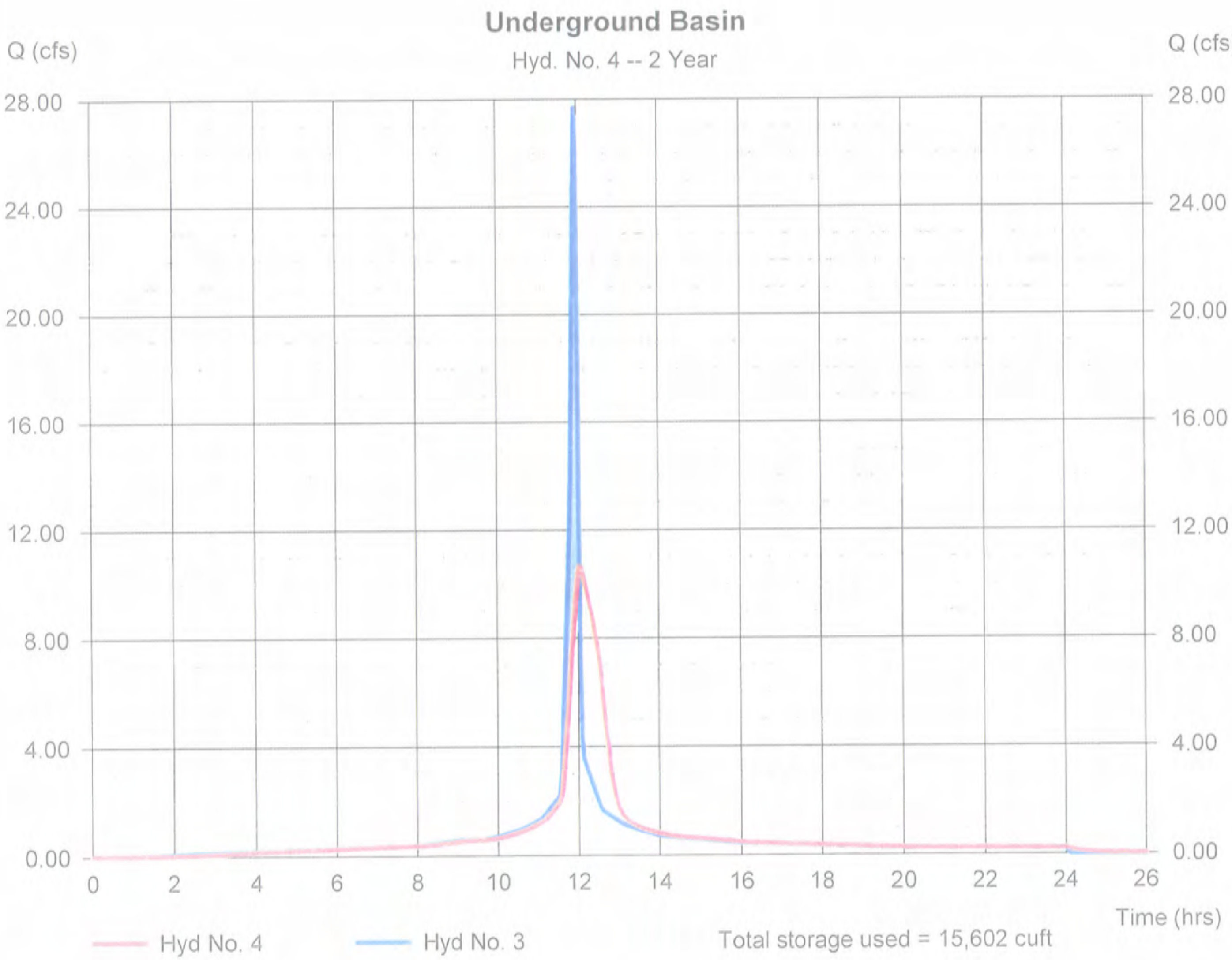
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. v10 — Thursday, 07 / 17 / 2014

Hyd. No. 4

Underground Basin

Hydrograph type	= Reservoir	Peak discharge	= 10.64 cfs
Storm frequency	= 2 yrs	Time to peak	= 12.03 hrs
Time interval	= 2 min	Hyd. volume	= 65,023 cuft
Inflow hyd. No.	= 3 - Developed-To Basin	Max. Elevation	= 526.78 ft
Reservoir name	= Stormtech MC-4500	Max. Storage	= 15,602 cuft

Storage Indication method used.



Pond Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. v10

Thursday, 07 / 17 / 2014

Pond No. 1 - Stormtech MC-4500

Pond Data

UG Chambers -Invert elev. = 525.00 ft, Rise x Span = 5.00 x 8.33 ft, Barrel Len = 4.03 ft, No. Barrels = 150, Slope = 0.00%, Headers = No
Encasement -Invert elev. = 522.00 ft, Width = 9.08 ft, Height = 9.00 ft, Voids = 40.00%

Stage / Storage Table

Stage (ft)	Elevation (ft)	Contour area (sqft)	Incr. Storage (cuft)	Total storage (cuft)
0.00	522.00	n/a	0	0
0.90	522.90	n/a	1,976	1,976
1.80	523.80	n/a	1,976	3,953
2.70	524.70	n/a	1,976	5,929
3.60	525.60	n/a	3,785	9,714
4.50	526.50	n/a	4,632	14,346
5.40	527.40	n/a	4,476	18,822
6.30	528.30	n/a	4,204	23,026
7.20	529.20	n/a	3,762	26,789
8.10	530.10	n/a	2,866	29,654
9.00	531.00	n/a	1,976	31,631

Culvert / Orifice Structures

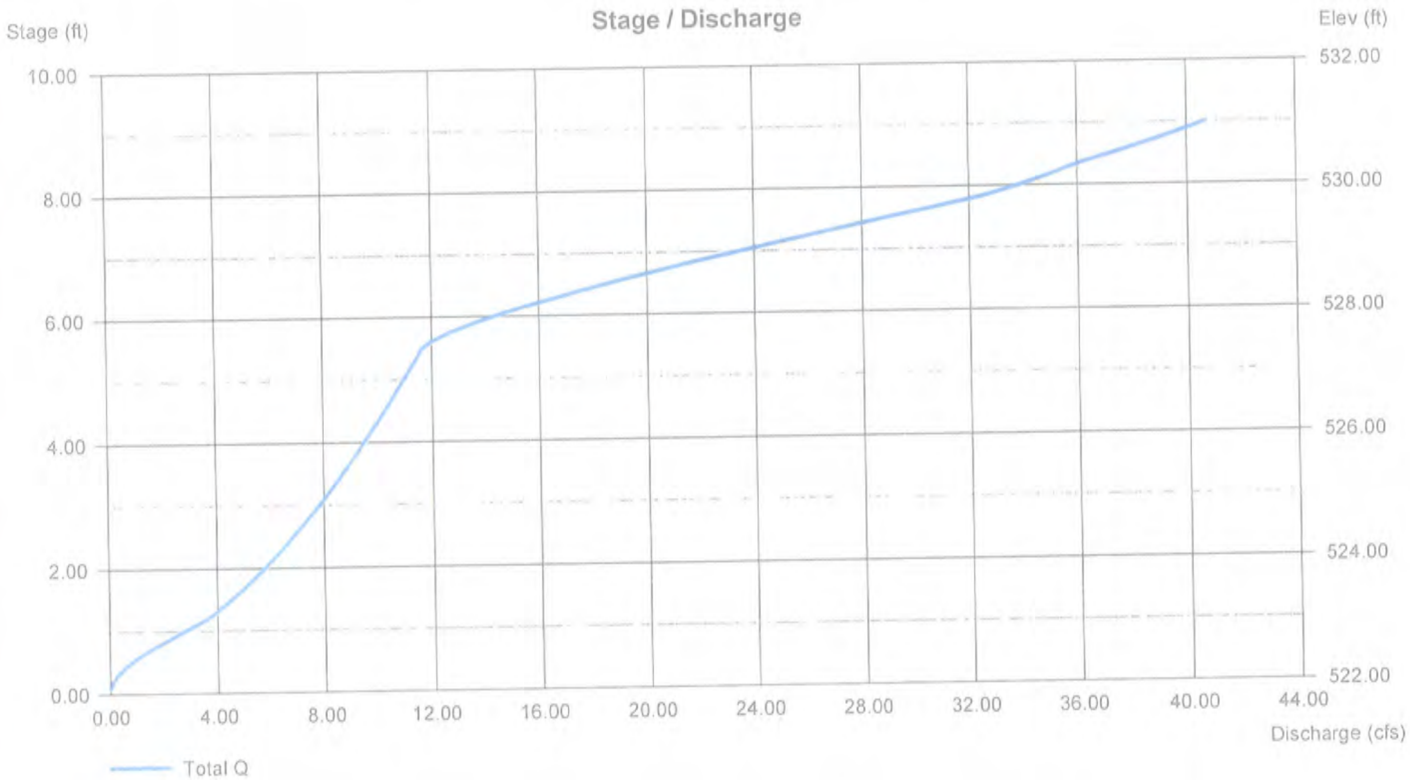
	[A]	[B]	[C]	[PrfRsr]
Rise (in)	= 24.00	15.00	0.00	0.00
Span (in)	= 24.00	15.00	0.00	0.00
No. Barrels	= 1	1	0	0
Invert El. (ft)	= 522.00	522.00	0.00	0.00
Length (ft)	= 30.81	0.50	0.00	0.00
Slope (%)	= 5.00	1.00	0.00	n/a
N-Value	= .013	.013	.013	n/a
Orifice Coeff.	= 0.60	0.60	0.60	0.60
Multi-Stage	= n/a	Yes	No	No

Weir Structures

	[A]	[B]	[C]	[D]
Crest Len (ft)	= 4.00	2.00	0.00	0.00
Crest El. (ft)	= 530.30	527.50	0.00	0.00
Weir Coeff.	= 3.33	3.33	3.33	3.33
Weir Type	= Rect	Rect	---	---
Multi-Stage	= Yes	Yes	No	No

Exfil.(in/hr) = 0.000 (by Wet area)
TW Elev. (ft) = 0.00

Note: Culvert/Orifice outflows are analyzed under inlet (ic) and outlet (oc) control. Weir risers checked for orifice conditions (ic) and submergence (s).



Hydrograph Report

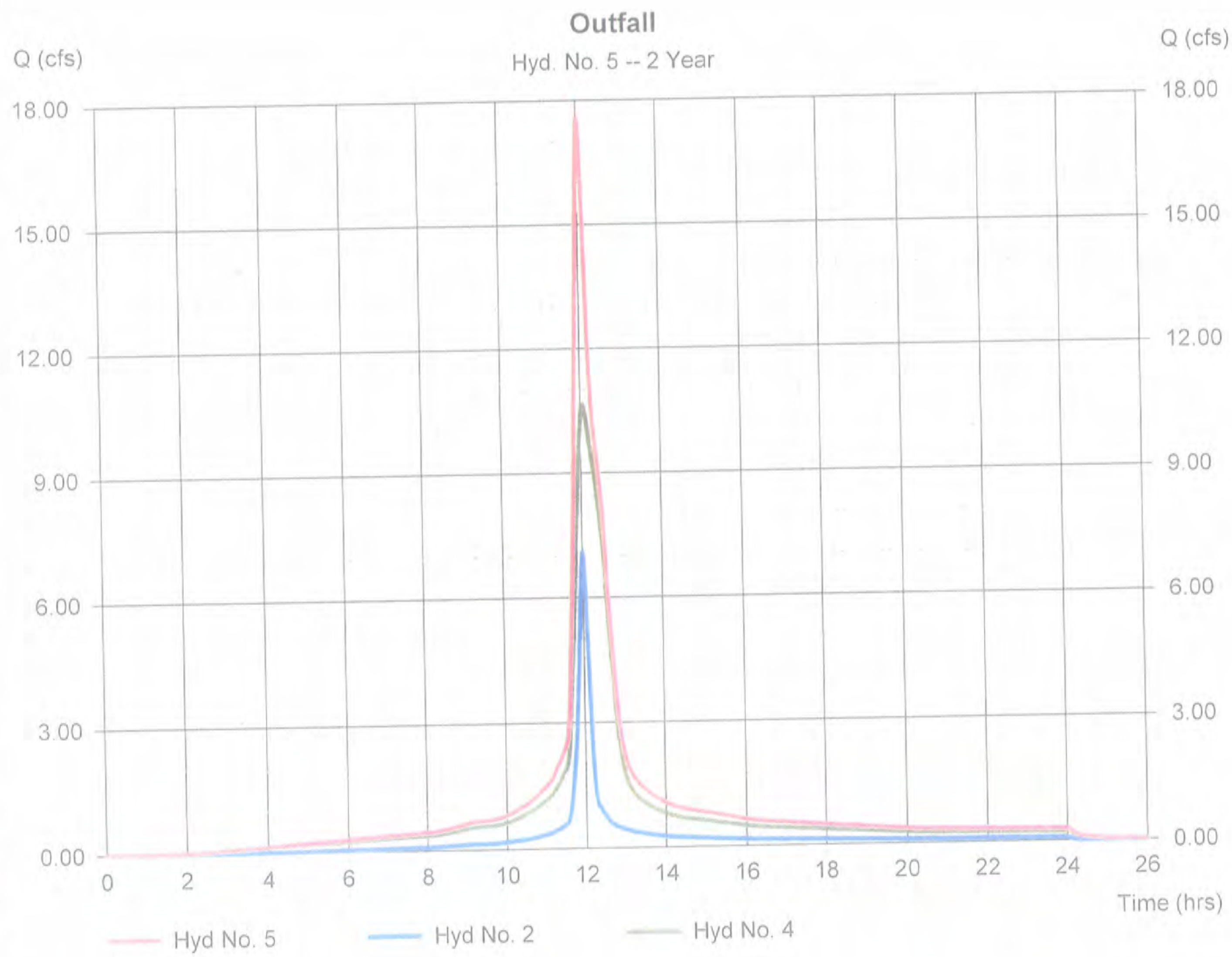
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. v10

Thursday, 07 / 17 / 2014

Hyd. No. 5

Outfall

Hydrograph type	= Combine	Peak discharge	= 17.53 cfs
Storm frequency	= 2 yrs	Time to peak	= 12.00 hrs
Time interval	= 2 min	Hyd. volume	= 84,449 cuft
Inflow hyds.	= 2, 4	Contrib. drain. area	= 1.830 ac



Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. v10

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph Description
1	SCS Runoff	35.40	2	720	92,389	------	------	------	Predeveloped
2	SCS Runoff	11.20	2	720	31,541	------	------	------	Developed-Bypass
3	SCS Runoff	42.16	2	716	100,790	------	------	------	Developed-To Basin
4	Reservoir	20.49	2	722	100,784	3	528.72	24,737	Underground Basin
5	Combine	31.32	2	722	132,324	2, 4	------	------	Outfall

Hydrograph Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. v10

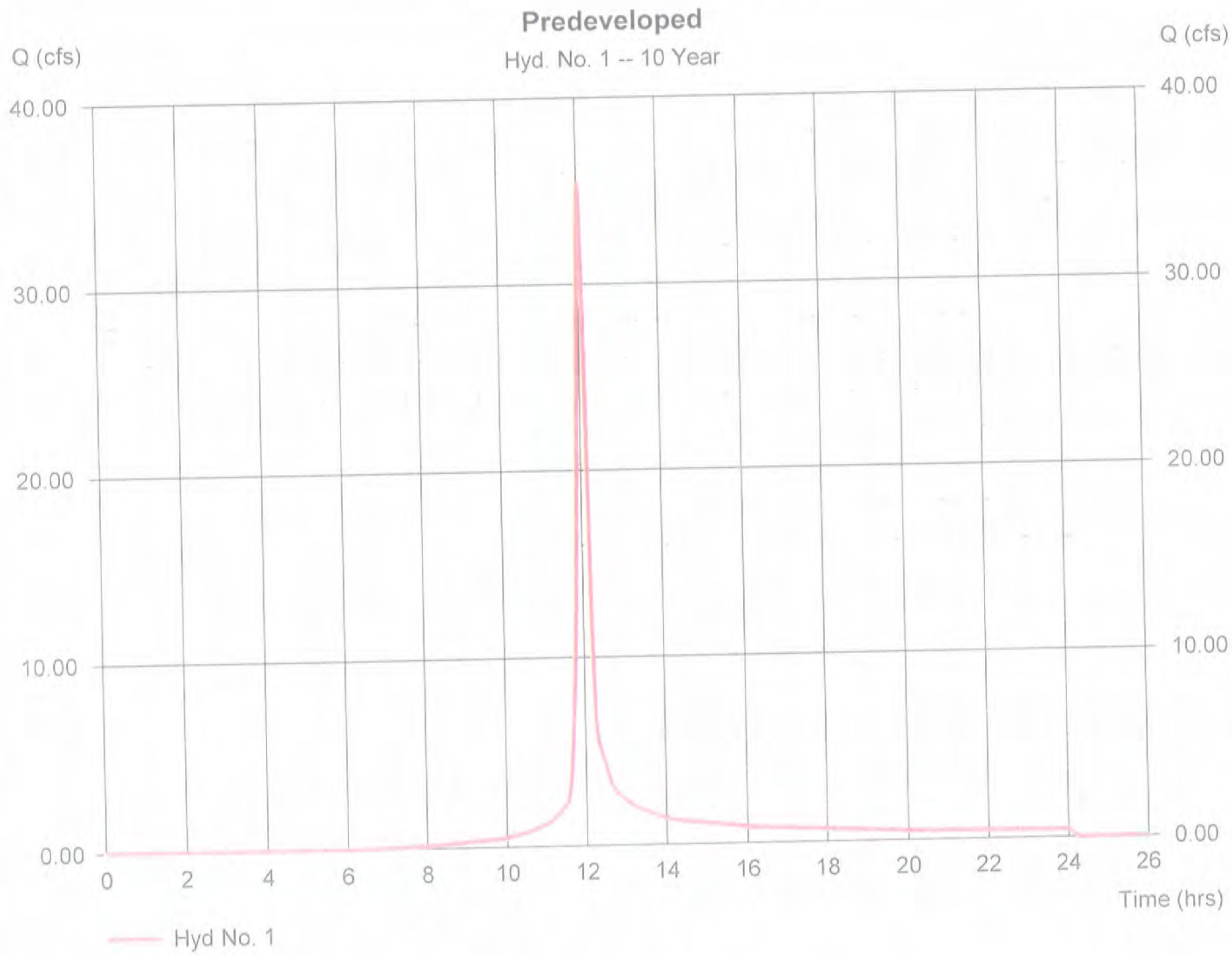
Thursday, 07 / 17 / 2014

Hyd. No. 1

Predeveloped

Hydrograph type	= SCS Runoff	Peak discharge	= 35.40 cfs
Storm frequency	= 10 yrs	Time to peak	= 12.00 hrs
Time interval	= 2 min	Hyd. volume	= 92,389 cuft
Drainage area	= 7.370 ac	Curve number	= 82*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 10.00 min
Total precip.	= 5.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(25.850 x 92) + (8.010 x 61) + (4.490 x 55) + (3.010 x 94) + (0.550 x 74) + (1.390 x 70)] / 7.370



Hydrograph Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. v10

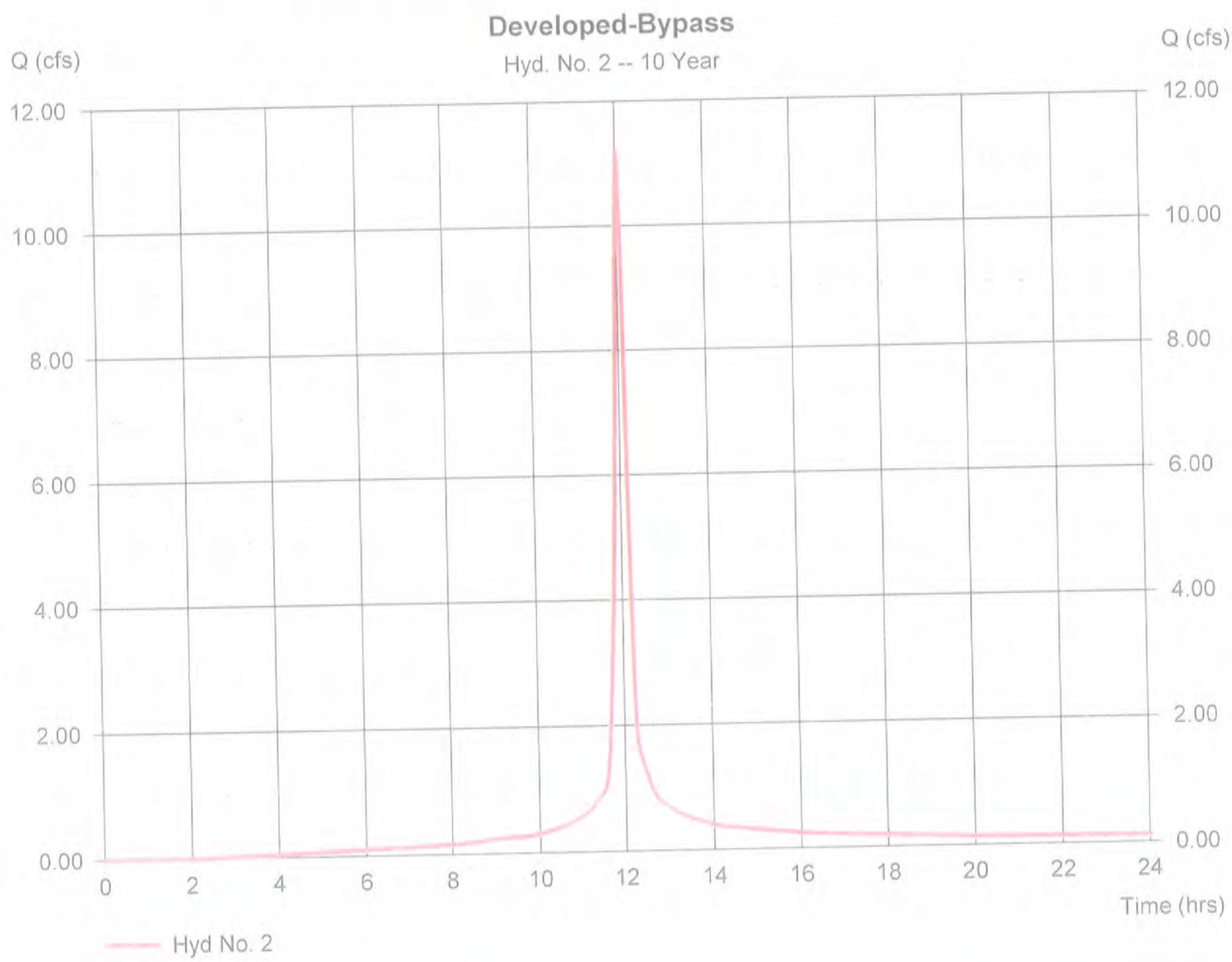
Thursday, 07 / 17 / 2014

Hyd. No. 2

Developed-Bypass

Hydrograph type	= SCS Runoff	Peak discharge	= 11.20 cfs
Storm frequency	= 10 yrs	Time to peak	= 12.00 hrs
Time interval	= 2 min	Hyd. volume	= 31,541 cuft
Drainage area	= 1.830 ac	Curve number	= 94*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 10.00 min
Total precip.	= 5.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(25.850 x 92) + (4.935 x 61) + (3.410 x 55) + (3.010 x 94) + (1.220 x 70)] / 1.830



Hydrograph Report

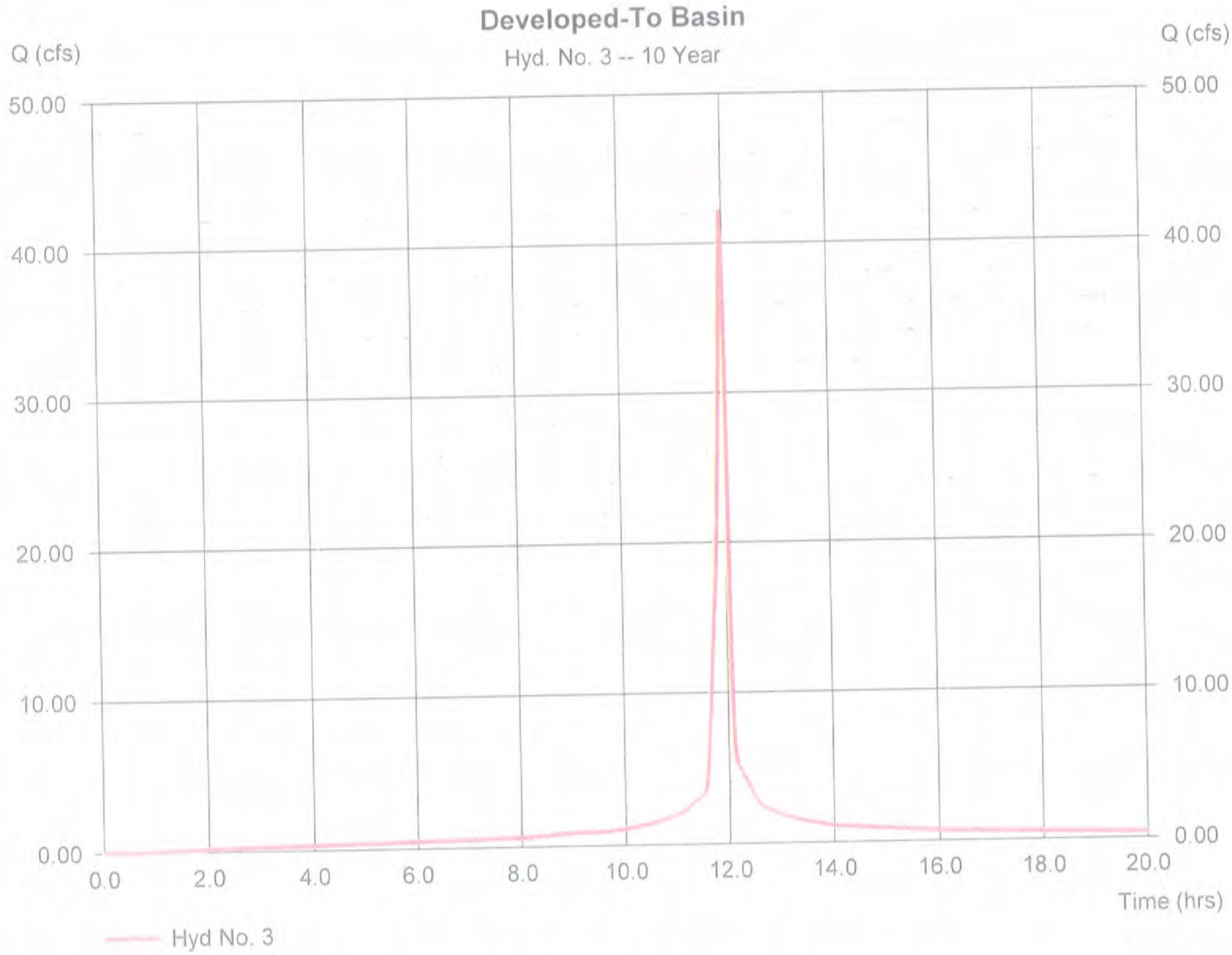
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. v10

Thursday, 07 / 17 / 2014

Hyd. No. 3

Developed-To Basin

Hydrograph type	= SCS Runoff	Peak discharge	= 42.16 cfs
Storm frequency	= 10 yrs	Time to peak	= 11.93 hrs
Time interval	= 2 min	Hyd. volume	= 100,790 cuft
Drainage area	= 5.850 ac	Curve number	= 98
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 6.50 min
Total precip.	= 5.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydrograph Report

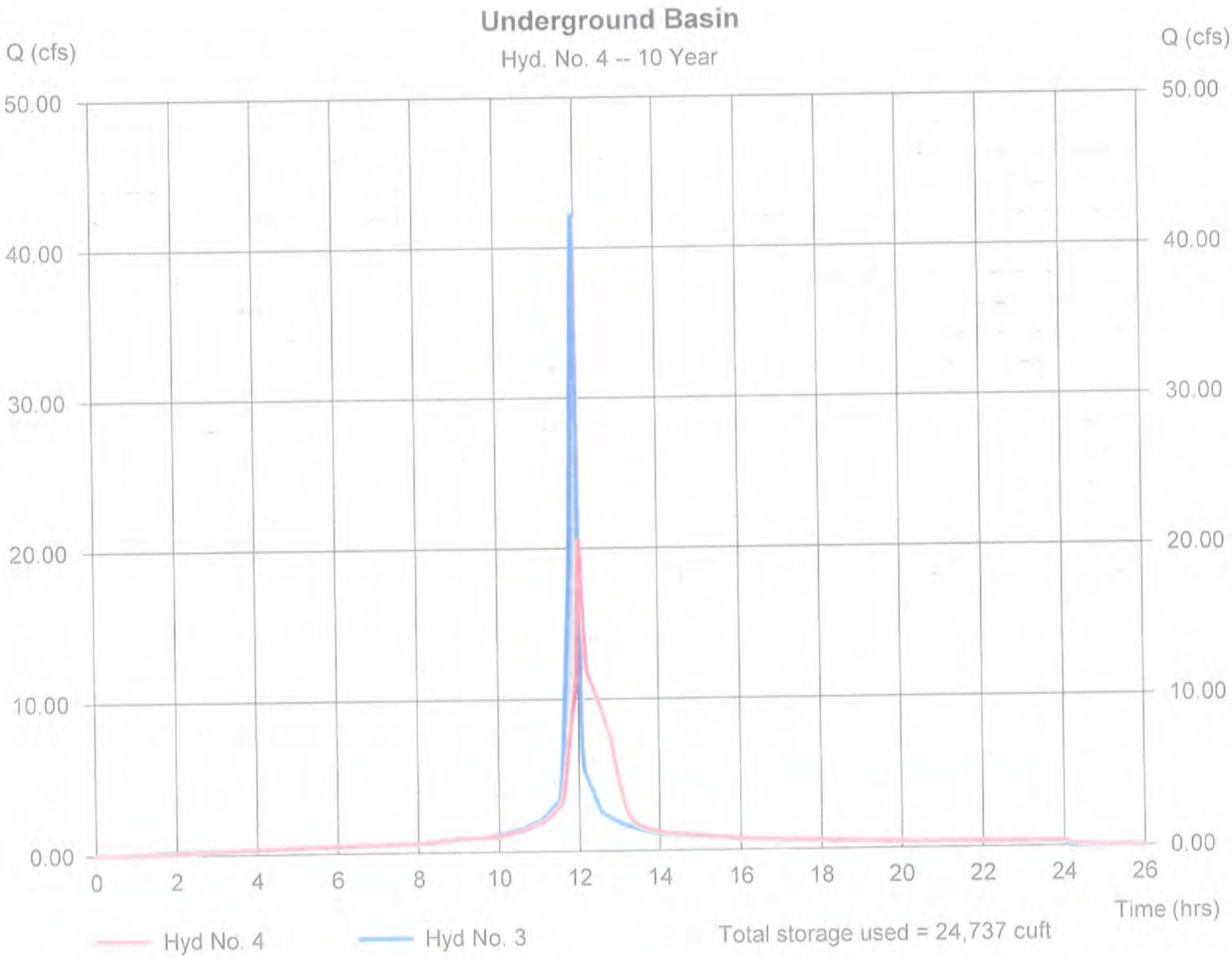
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. v10 — Thursday, 07 / 17 / 2014

Hyd. No. 4

Underground Basin

Hydrograph type	= Reservoir	Peak discharge	= 20.49 cfs
Storm frequency	= 10 yrs	Time to peak	= 12.03 hrs
Time interval	= 2 min	Hyd. volume	= 100,784 cuft
Inflow hyd. No.	= 3 - Developed-To Basin	Max. Elevation	= 528.72 ft
Reservoir name	= Stormtech MC-4500	Max. Storage	= 24,737 cuft

Storage Indication method used.



Hydrograph Report

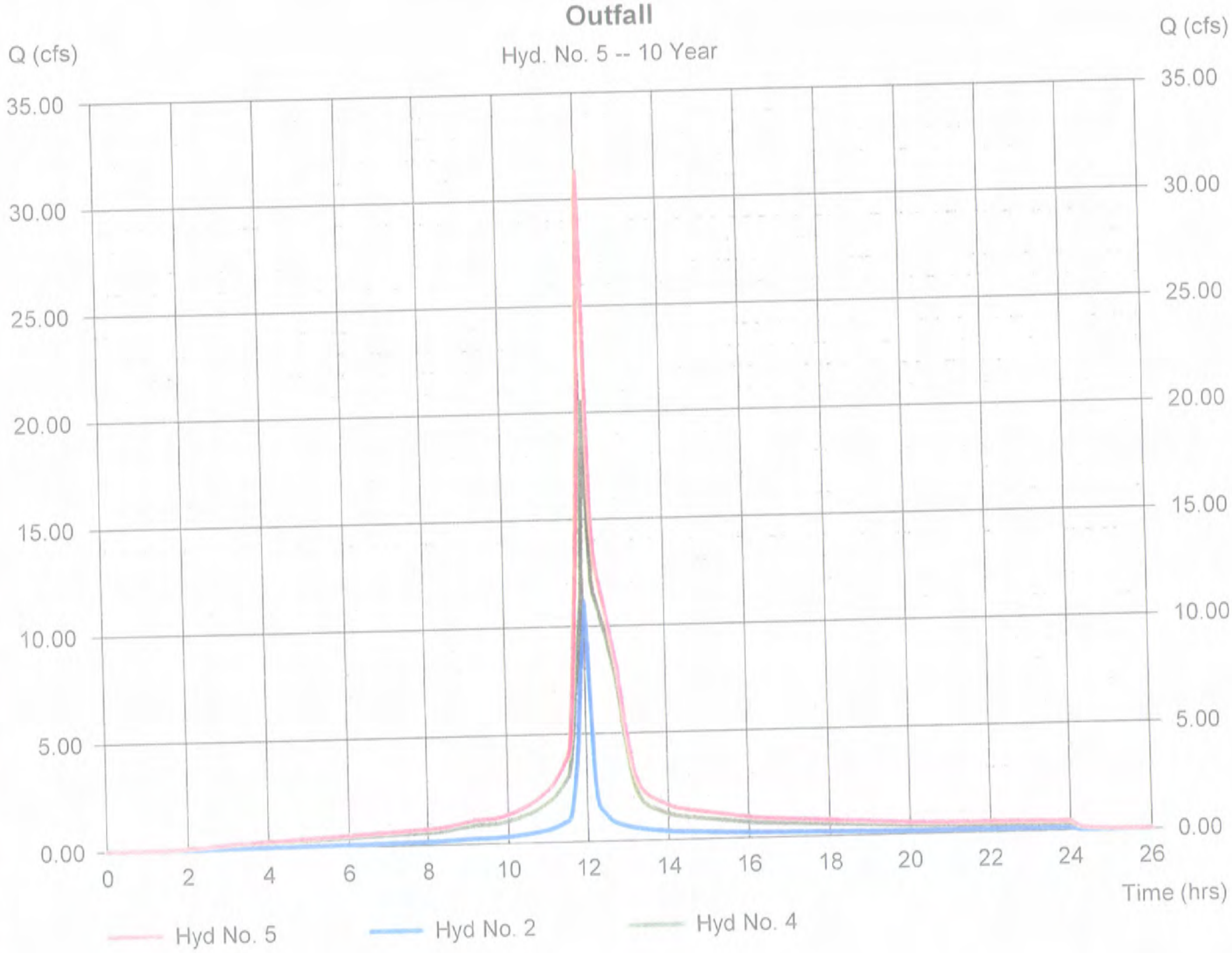
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. v10

Thursday, 07 / 17 / 2014

Hyd. No. 5

Outfall

Hydrograph type	= Combine	Peak discharge	= 31.32 cfs
Storm frequency	= 10 yrs	Time to peak	= 12.03 hrs
Time interval	= 2 min	Hyd. volume	= 132,324 cuft
Inflow hyds.	= 2, 4	Contrib. drain. area	= 1.830 ac



Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. v10

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph Description
1	SCS Runoff	38.19	2	720	99,897	------	------	------	Predeveloped
2	SCS Runoff	11.87	2	720	33,572	------	------	------	Developed-Bypass
3	SCS Runoff	44.57	2	716	106,755	------	------	------	Developed-To Basin
4	Reservoir	23.19	2	722	106,748	3	529.01	25,849	Underground Basin
5	Combine	34.66	2	722	140,321	2, 4	------	------	Outfall

Hydrograph Report

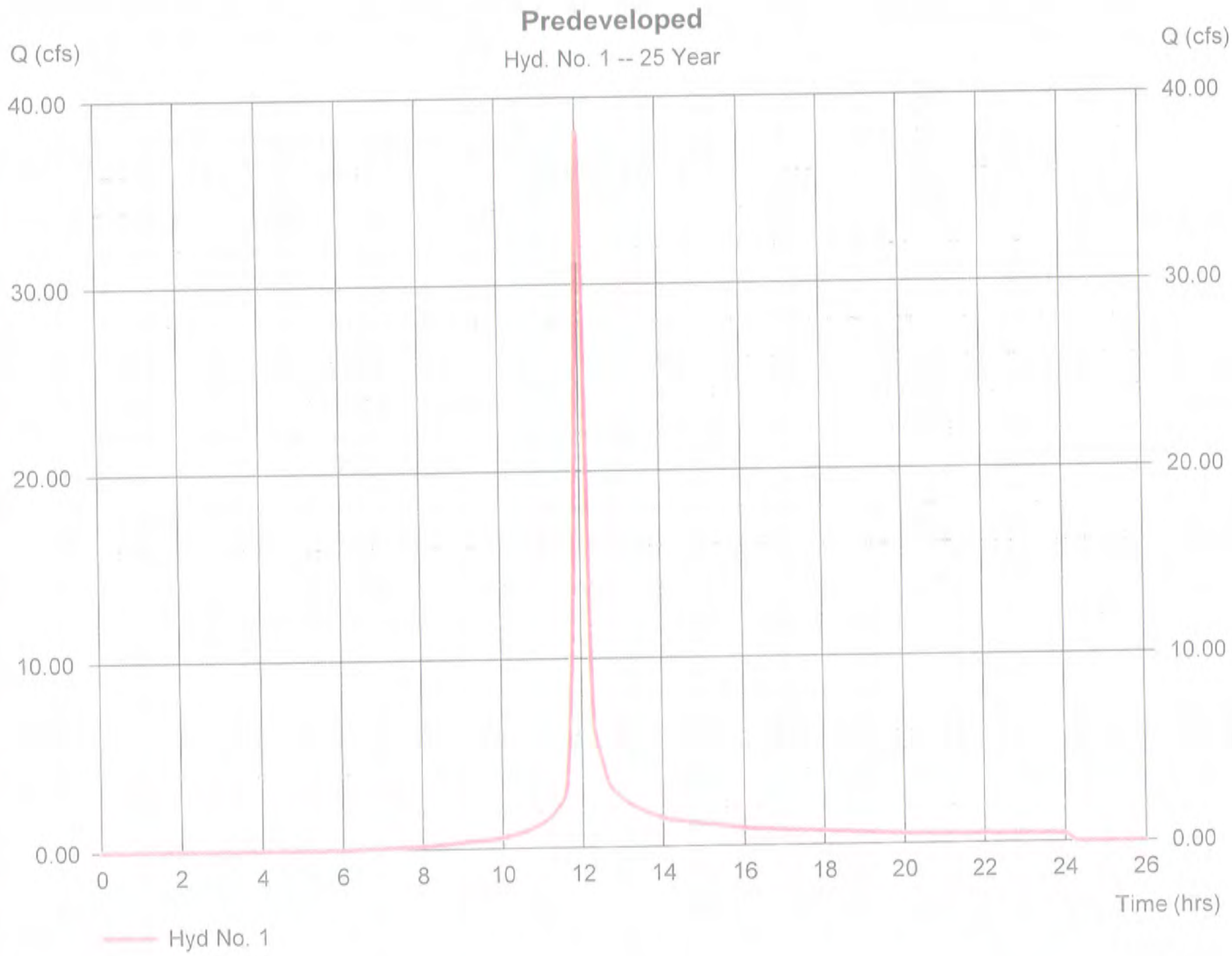
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. v10 — Thursday, 07 / 17 / 2014

Hyd. No. 1

Predeveloped

Hydrograph type	= SCS Runoff	Peak discharge	= 38.19 cfs
Storm frequency	= 25 yrs	Time to peak	= 12.00 hrs
Time interval	= 2 min	Hyd. volume	= 99,897 cuft
Drainage area	= 7.370 ac	Curve number	= 82*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 10.00 min
Total precip.	= 5.60 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(25.850 x 92) + (8.010 x 61) + (4.490 x 55) + (3.010 x 94) + (0.550 x 74) + (1.390 x 70)] / 7.370



Hydrograph Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. v10

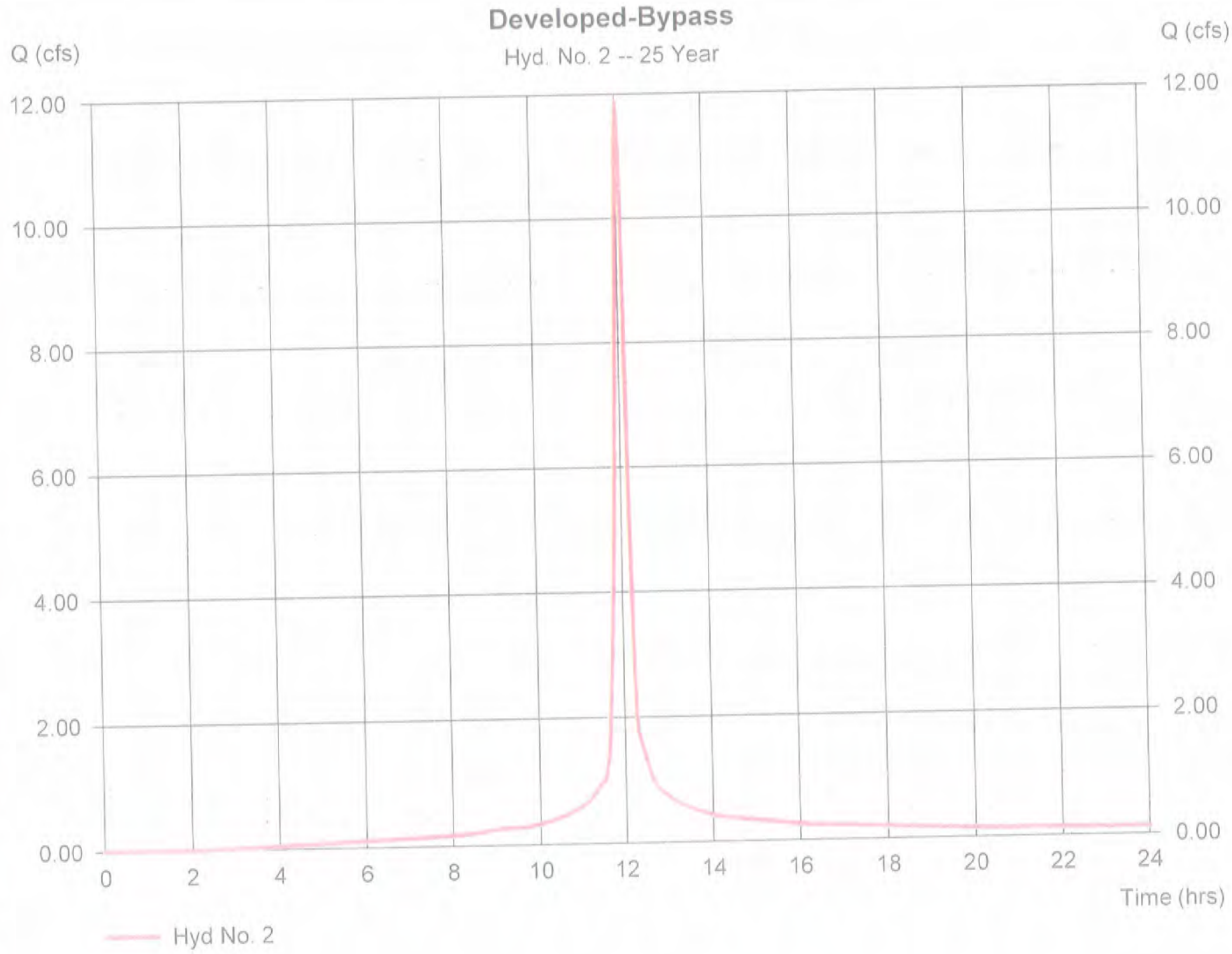
Thursday, 07 / 17 / 2014

Hyd. No. 2

Developed-Bypass

Hydrograph type	= SCS Runoff	Peak discharge	= 11.87 cfs
Storm frequency	= 25 yrs	Time to peak	= 12.00 hrs
Time interval	= 2 min	Hyd. volume	= 33,572 cuft
Drainage area	= 1.830 ac	Curve number	= 94*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 10.00 min
Total precip.	= 5.60 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(25.850 x 92) + (4.935 x 61) + (3.410 x 55) + (3.010 x 94) + (1.220 x 70)] / 1.830



Hydrograph Report

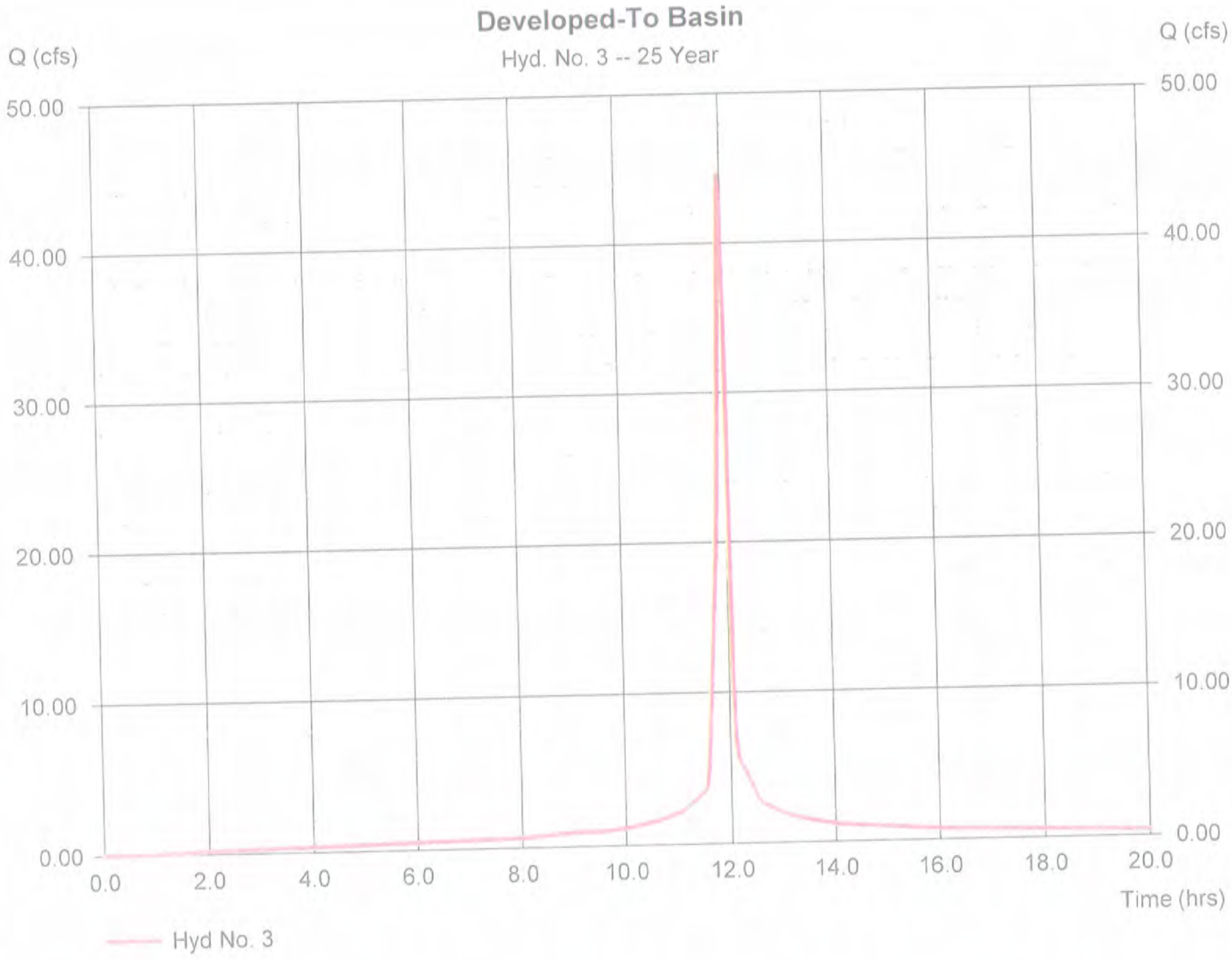
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. v10

Thursday, 07 / 17 / 2014

Hyd. No. 3

Developed-To Basin

Hydrograph type	= SCS Runoff	Peak discharge	= 44.57 cfs
Storm frequency	= 25 yrs	Time to peak	= 11.93 hrs
Time interval	= 2 min	Hyd. volume	= 106,755 cuft
Drainage area	= 5.850 ac	Curve number	= 98
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 6.50 min
Total precip.	= 5.60 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydrograph Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. v10

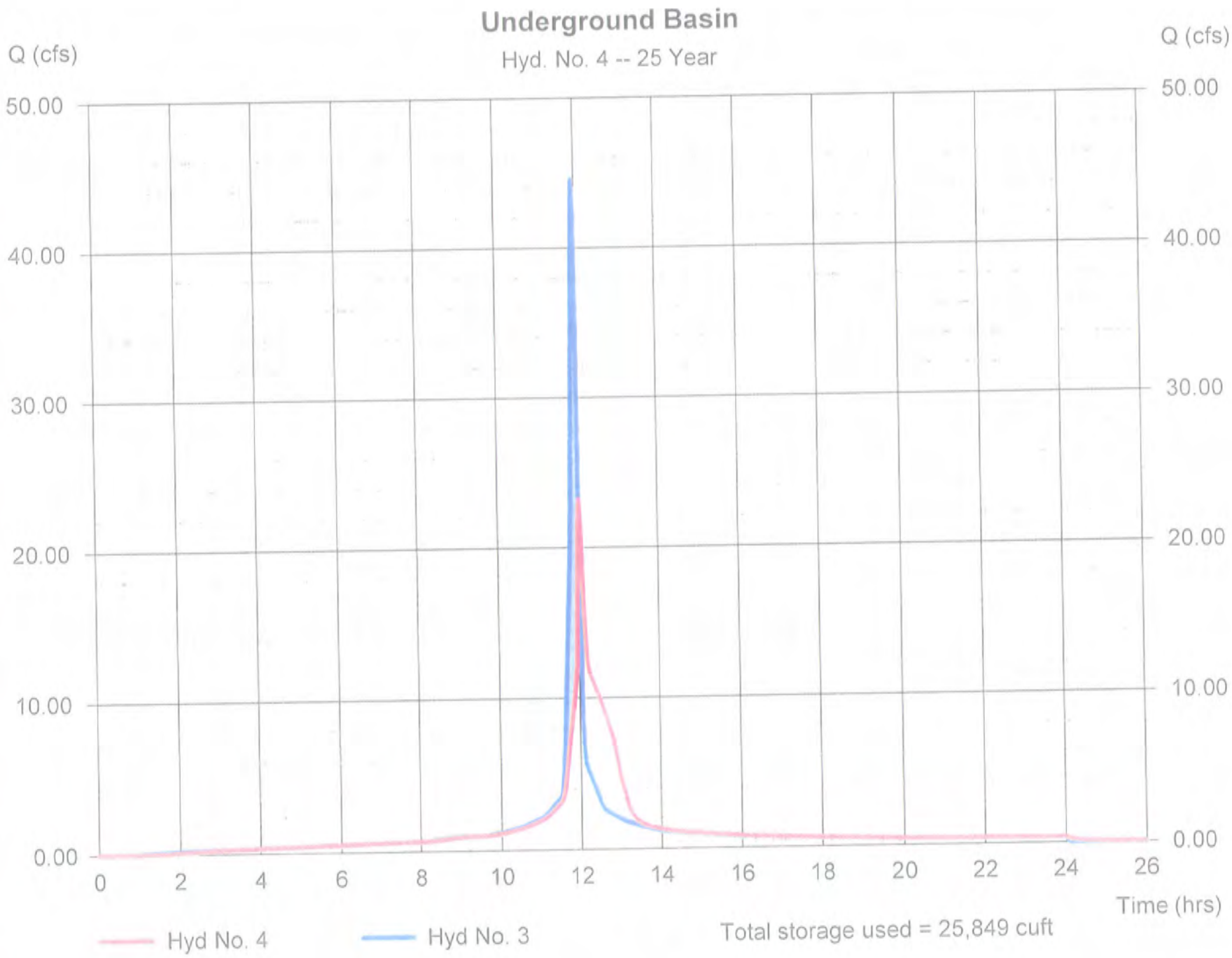
Thursday, 07 / 17 / 2014

Hyd. No. 4

Underground Basin

Hydrograph type	= Reservoir	Peak discharge	= 23.19 cfs
Storm frequency	= 25 yrs	Time to peak	= 12.03 hrs
Time interval	= 2 min	Hyd. volume	= 106,748 cuft
Inflow hyd. No.	= 3 - Developed-To Basin	Max. Elevation	= 529.01 ft
Reservoir name	= Stormtech MC-4500	Max. Storage	= 25,849 cuft

Storage Indication method used.



Hydrograph Report

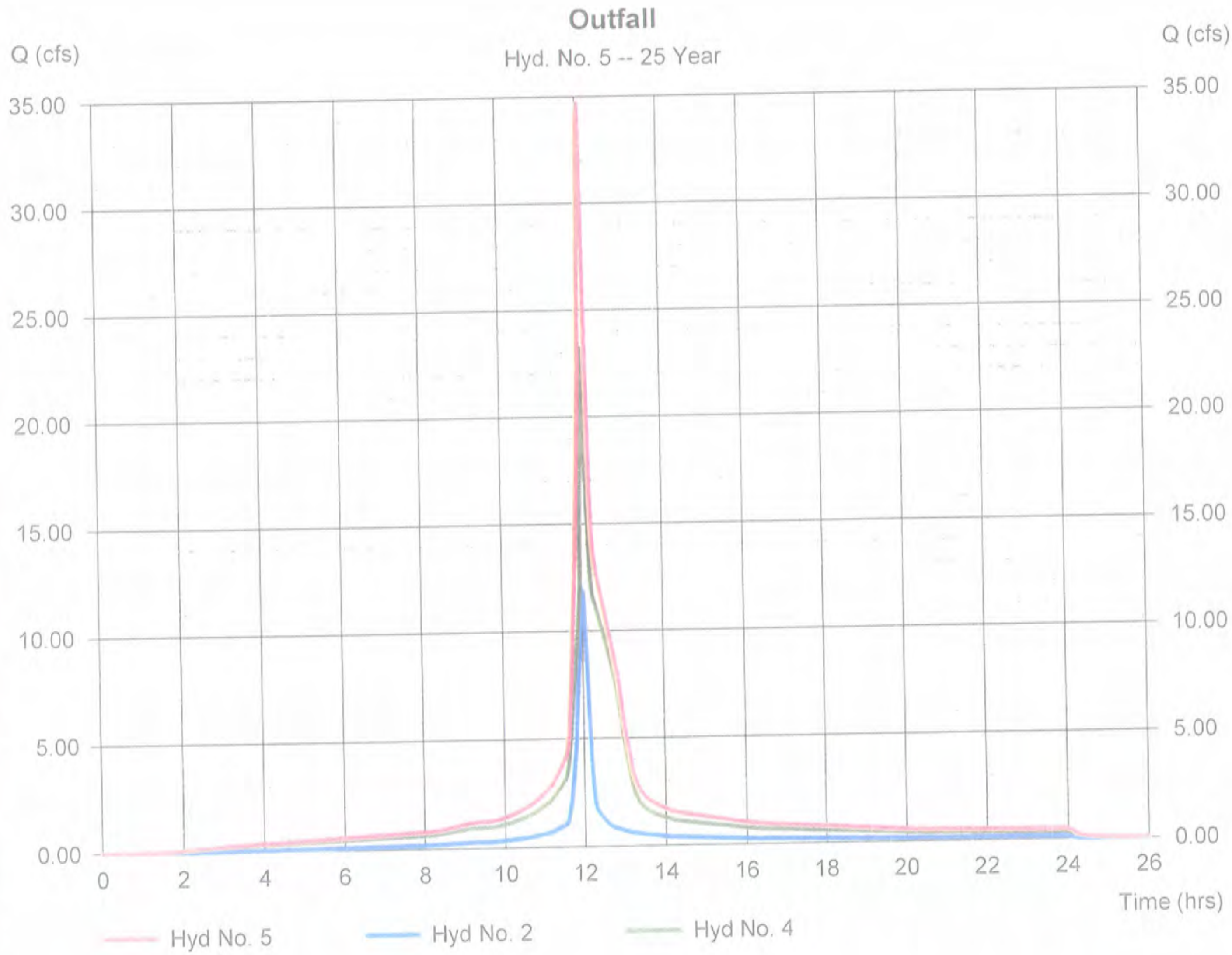
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. v10

Thursday, 07 / 17 / 2014

Hyd. No. 5

Outfall

Hydrograph type	= Combine	Peak discharge	= 34.66 cfs
Storm frequency	= 25 yrs	Time to peak	= 12.03 hrs
Time interval	= 2 min	Hyd. volume	= 140,321 cuft
Inflow hyds.	= 2, 4	Contrib. drain. area	= 1.830 ac



Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. v10

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph Description
1	SCS Runoff	53.16	2	720	140,812	------	------	------	Predeveloped
2	SCS Runoff	15.48	2	720	44,438	------	------	------	Developed-Bypass
3	SCS Runoff	57.40	2	716	138,577	------	------	------	Developed-To Basin
4	Reservoir	37.64	2	720	138,570	3	530.69	30,662	Underground Basin
5	Combine	53.12	2	720	183,008	2, 4	------	------	Outfall

120170.gpw	Return Period: 100 Year	Thursday, 07 / 17 / 2014

Hydrograph Report

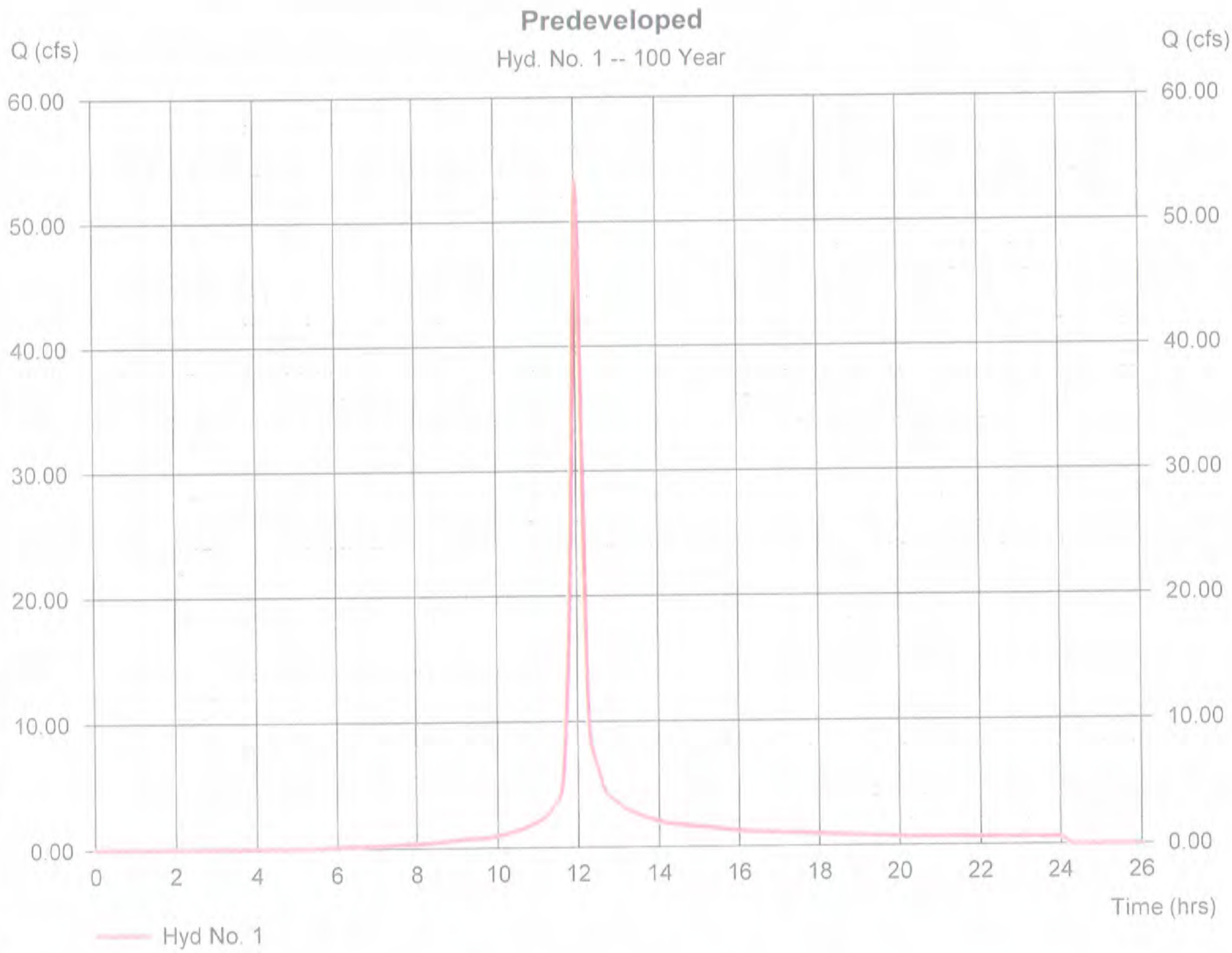
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. v10 — Thursday, 07 / 17 / 2014

Hyd. No. 1

Predeveloped

Hydrograph type	= SCS Runoff	Peak discharge	= 53.16 cfs
Storm frequency	= 100 yrs	Time to peak	= 12.00 hrs
Time interval	= 2 min	Hyd. volume	= 140,812 cuft
Drainage area	= 7.370 ac	Curve number	= 82*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 10.00 min
Total precip.	= 7.20 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(25.850 x 92) + (8.010 x 61) + (4.490 x 55) + (3.010 x 94) + (0.550 x 74) + (1.390 x 70)] / 7.370



Hydrograph Report

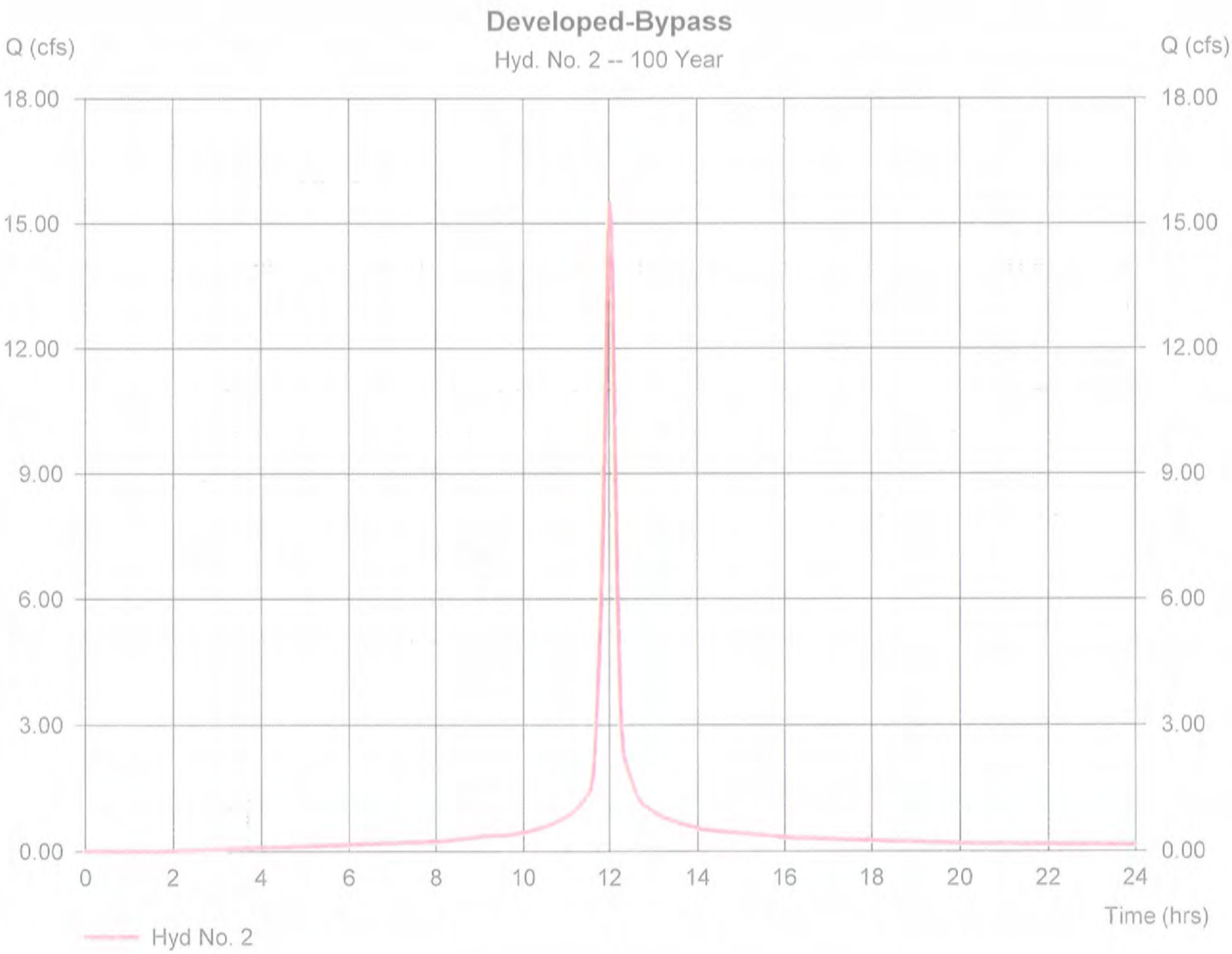
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. v10 — Thursday, 07 / 17 / 2014

Hyd. No. 2

Developed-Bypass

Hydrograph type	= SCS Runoff	Peak discharge	= 15.48 cfs
Storm frequency	= 100 yrs	Time to peak	= 12.00 hrs
Time interval	= 2 min	Hyd. volume	= 44,438 cuft
Drainage area	= 1.830 ac	Curve number	= 94*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 10.00 min
Total precip.	= 7.20 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(25.850 x 92) + (4.935 x 61) + (3.410 x 55) + (3.010 x 94) + (1.220 x 70)] / 1.830



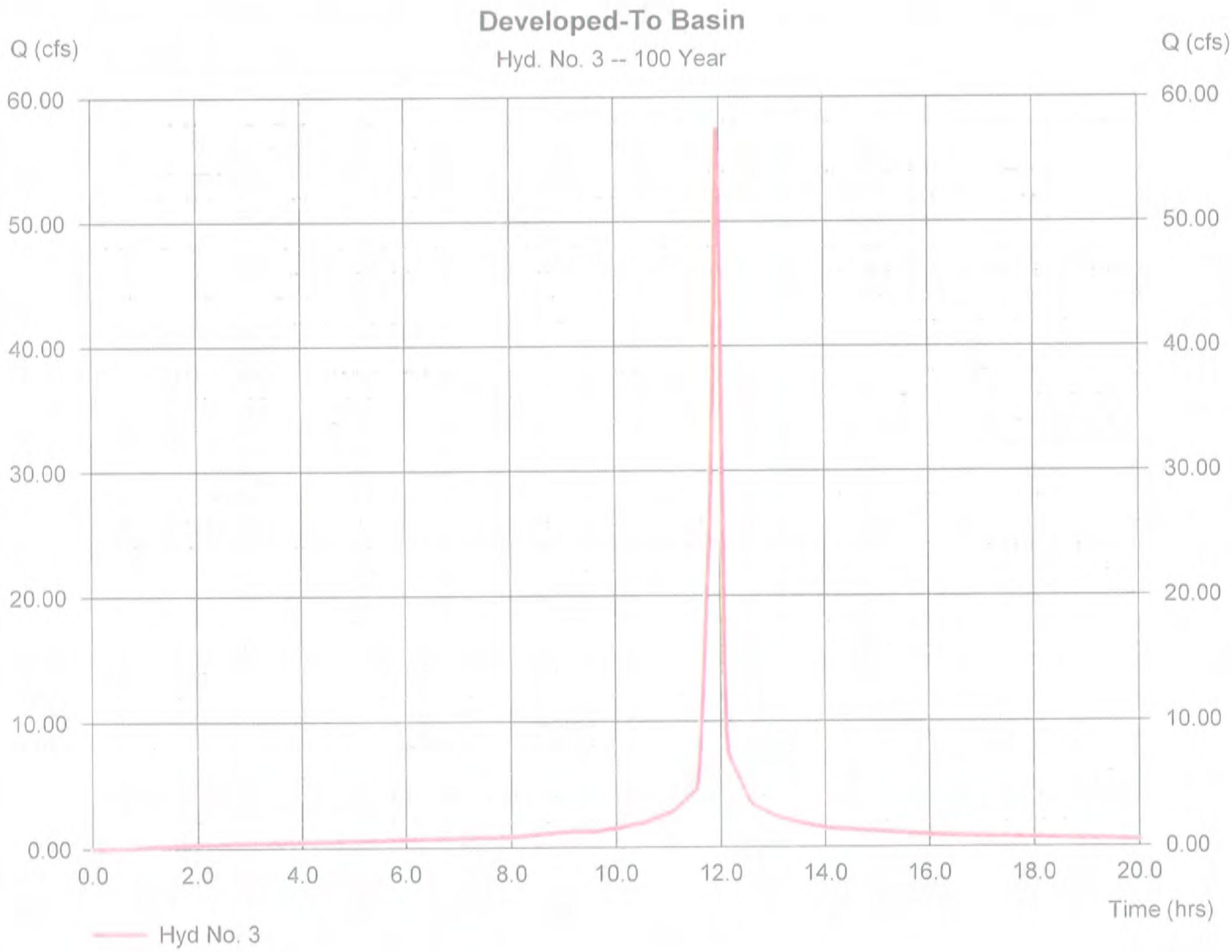
Hydrograph Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. v10 — Thursday, 07 / 17 / 2014

Hyd. No. 3

Developed-To Basin

Hydrograph type	= SCS Runoff	Peak discharge	= 57.40 cfs
Storm frequency	= 100 yrs	Time to peak	= 11.93 hrs
Time interval	= 2 min	Hyd. volume	= 138,577 cuft
Drainage area	= 5.850 ac	Curve number	= 98
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 6.50 min
Total precip.	= 7.20 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydrograph Report

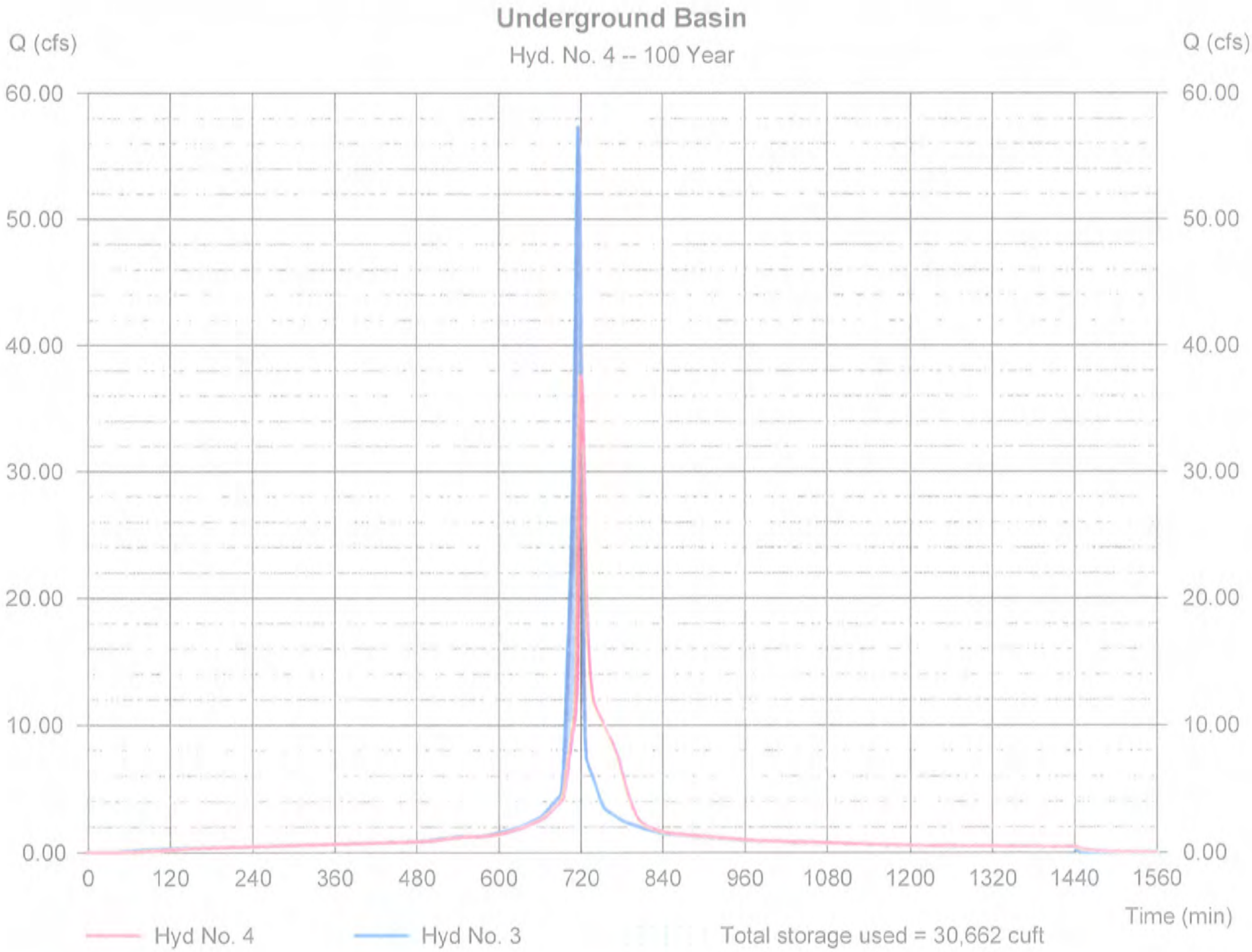
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. v10 | Thursday, 07 / 17 / 2014

Hyd. No. 4

Underground Basin

Hydrograph type	= Reservoir	Peak discharge	= 37.65 cfs
Storm frequency	= 100 yrs	Time to peak	= 720 min
Time interval	= 2 min	Hyd. volume	= 138,570 cuft
Inflow hyd. No.	= 3 - Developed-To Basin	Max. Elevation	= 530.69 ft
Reservoir name	= Stormtech MC-4500	Max. Storage	= 30,662 cuft

Storage Indication method used.



Hydrograph Report

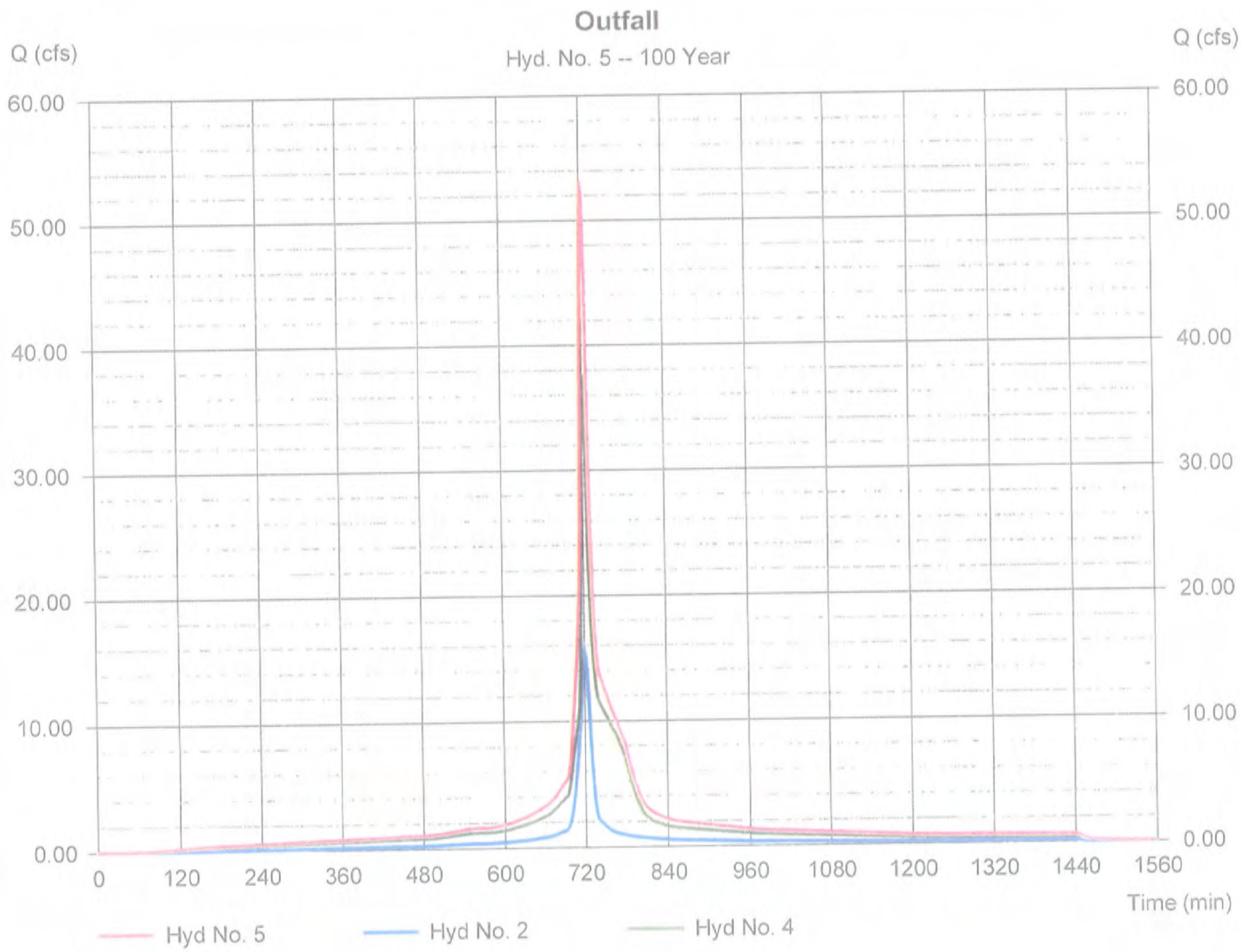
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. v10

Thursday, 07 / 17 / 2014

Hyd. No. 5

Outfall

Hydrograph type	= Combine	Peak discharge	= 53.13 cfs
Storm frequency	= 100 yrs	Time to peak	= 720 min
Time interval	= 2 min	Hyd. volume	= 183,008 cuft
Inflow hyds.	= 2, 4	Contrib. drain. area	= 1.830 ac



Appendix C

Channel Report

Hydraflow Express Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc.

Wednesday, Oct 16 2013

Bramblett Hollow Channel

User-defined

Invert Elev (ft)	=	510.20
Slope (%)	=	1.00
N-Value	=	0.024

Calculations

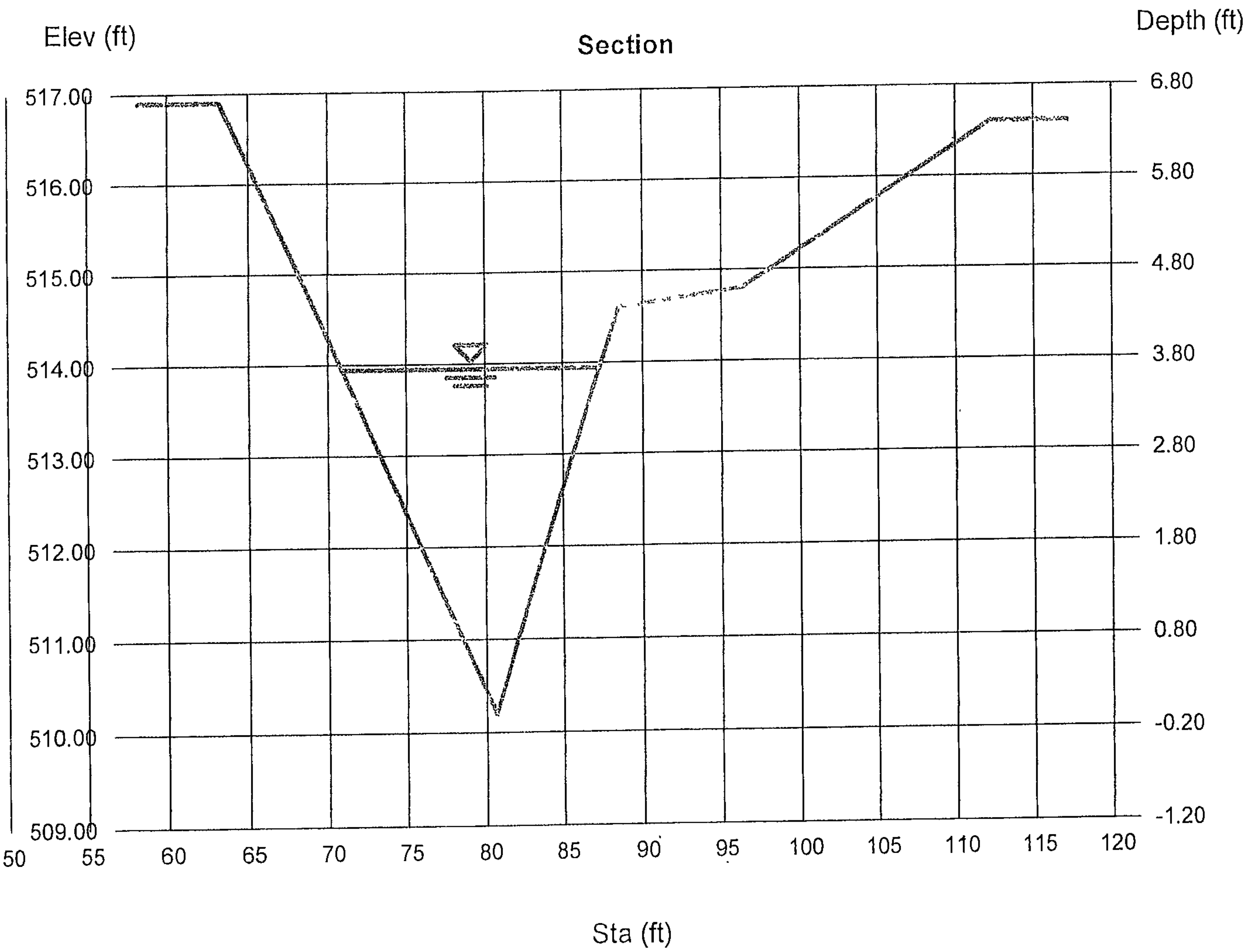
Compute by:		Known Q
Known Q (cfs)	=	271.00

Highlighted

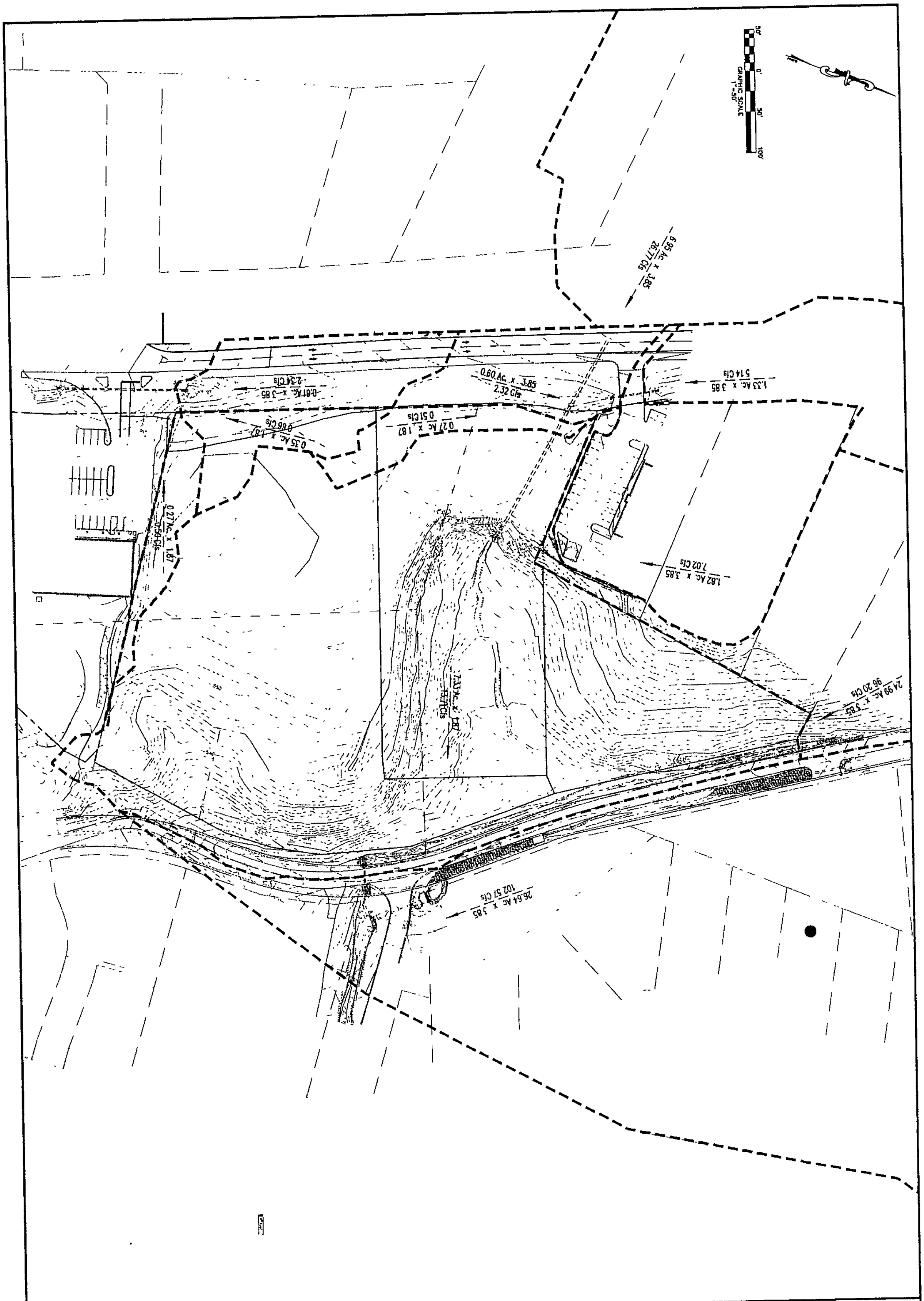
Depth (ft)	=	3.74
Q (cfs)	=	271.00
Area (sqft)	=	30.72
Velocity (ft/s)	=	8.82
Wetted Perim (ft)	=	18.09
Crit Depth, Yc (ft)	=	3.94
Top Width (ft)	=	16.43
EGL (ft)	=	4.95

(Sta, El, n)-(Sta, El, n)...

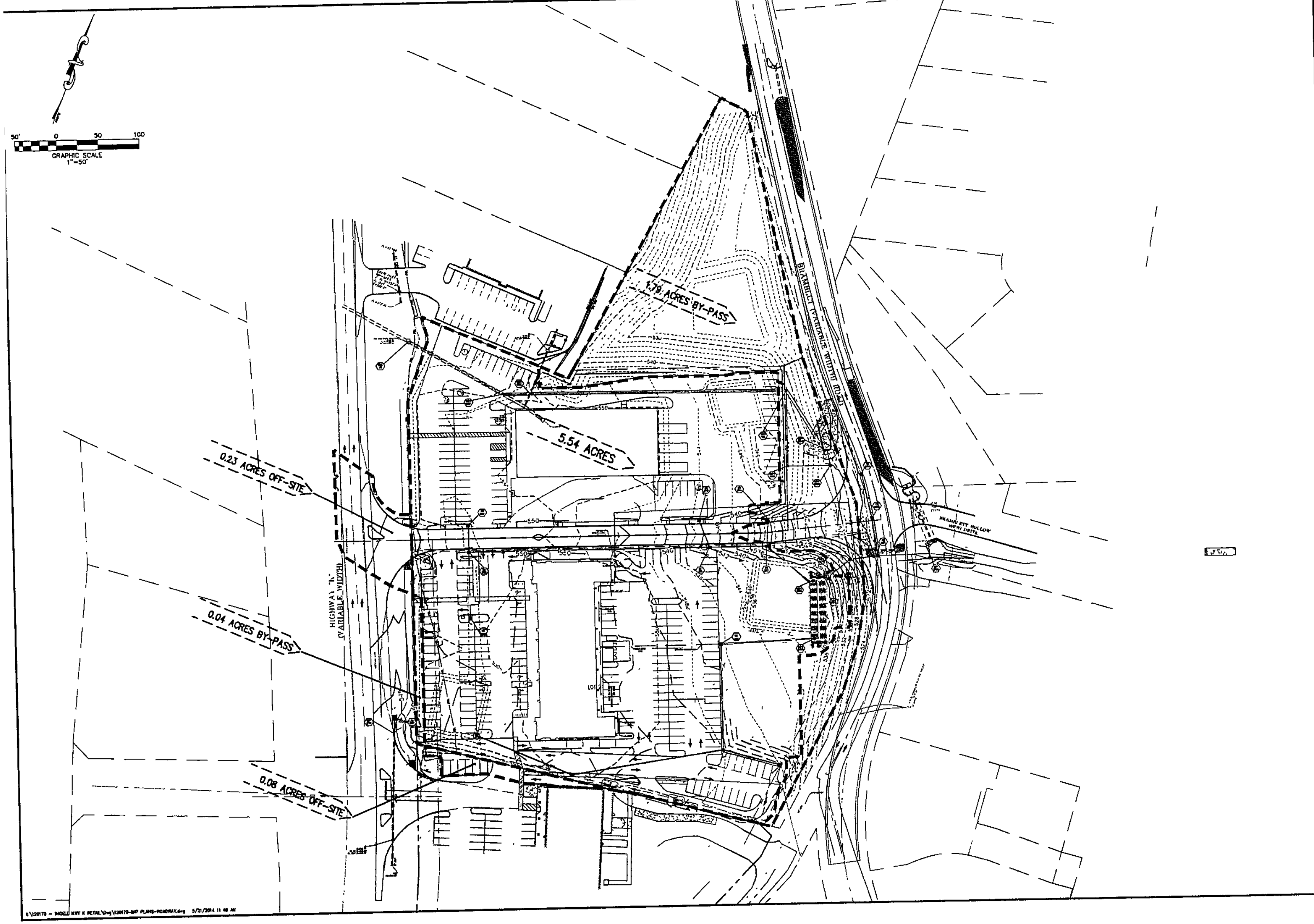
(63.20, 516.90)-(80.60, 510.20, 0.024)-(88.50, 514.60, 0.024)-(96.30, 514.80, 0.024)-(112.20, 516.60, 0.024)



Appendix D



Page No. 13	P+Z No. 18-12.05 Approval Date May 2, 2013 City No.	Developer / Owner Information K PROPERTIES HOLDINGS, LLC 1704 NORTH FOURTH STREET ST. CHARLES, MO 63301 CONTACT: MIKE THOELE (314) 220-1205 DRAINAGE AREA MAP–EXISTING	ENGINEER SIGNATURE BLOCK	ST. CHARLES ENGINEERING & SURVEYING, INC. 801 S. FIFTH STREET SUITE 202 ST. CHARLES, MO 63301 TEL: (636) 947-0607 FAX: (636) 947-0440	HIGHWAY "K" RETAIL – ACCESS DRIVE



HIGHWAY "K" RETAIL
- ACCESS DRIVE

ST. CHARLES ENGINEERING & SURVEYING, INC.

ENGINEER SIGNATURE BLOCK

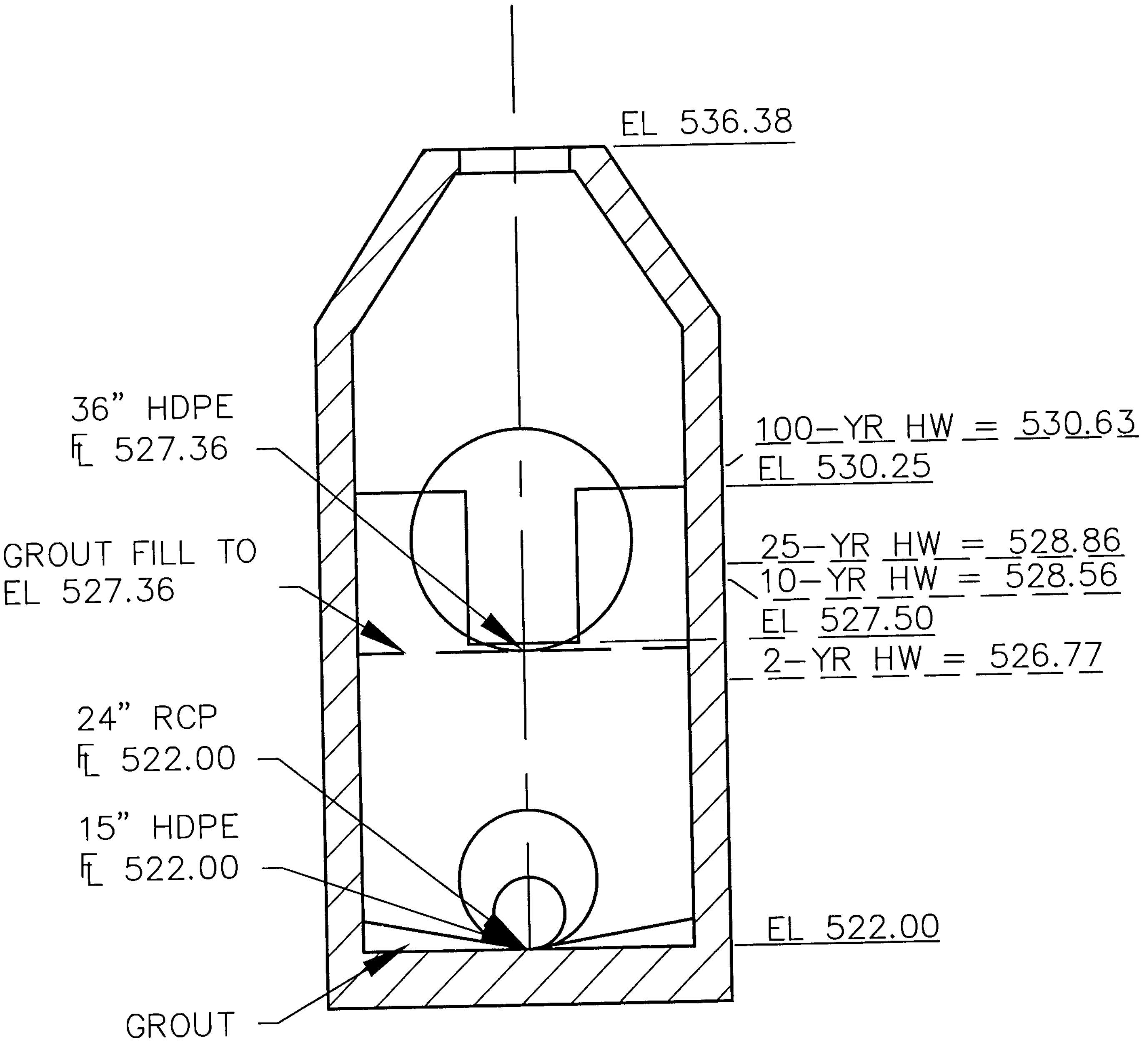
Developer / Owner Information
K PROPERTIES HOLDINGS, LLC
1704 NORTH FOURTH STREET
ST. CHARLES, MO 63301
CONTACT: MIKE THOELE
(314) 220-1205

DRAINAGE AREA MAP - DEVELOPED

P+Z No. 18-12.05
Approval Date: May 2, 2013
City No.

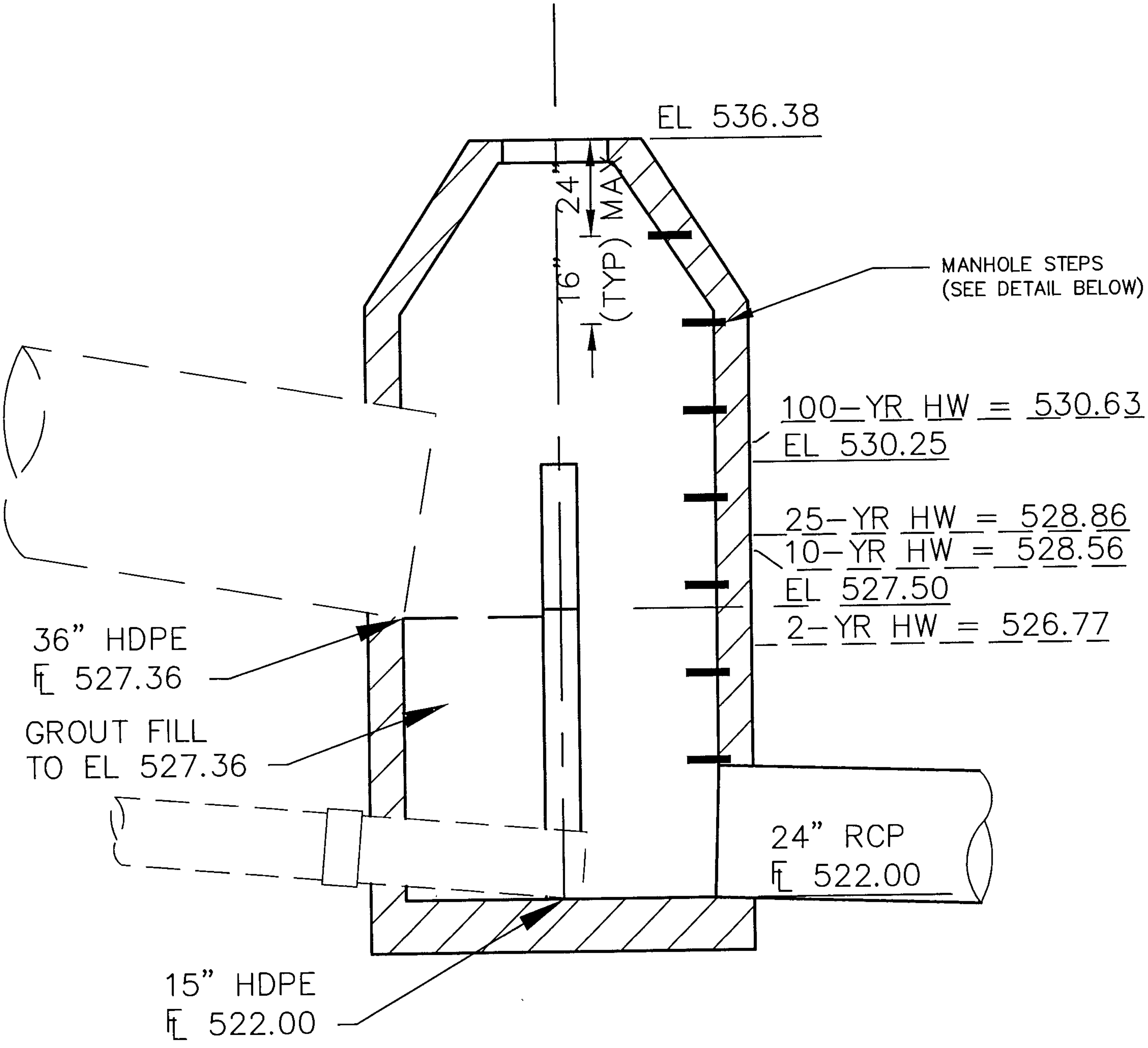
Page No.
14A

Appendix E



MH 207 OUTFALL STRUCTURE ELEVATION

NOT TO SCALE



MH 207
OUTFALL STRUCTURE
ELEVATION
NOT TO SCALE

Appendix F

WATER QUALITY VOLUME CALCULATIONS

Project: Hwy K
Date: 6/25/2014

REQUIRED WATER QUALITY VOLUME
(Per Maryland Manual Rev 2009, Chapter 2)

Post Developed Site Information

Value	Description
318,422	A = Site Disturbed Area (SF)
70.3	I = Impervious Precentage (%)
1.14	P = Rainfall Depth (in)

Rv = 0.05 + 0.009 x I = 0.6827

WQv = P x Rv x A / 12 = **20,652** **CF**

Project: HIGHWAY K RETAIL

StormTech

Chamber Model	MC-4500	
Units -	Imperial	Click here for Metric
Number of Chambers -	150	
Number of End Caps -	14	
Voids in the stone (porosity) -	40	%
Base of Stone Elevation -	522.00	ft
Amount of Stone Above Chambers -	12	in
Amount of Stone Below Chambers -	36	in
Area of system -	6798	sf Min. Area - 5937 sf min area

☑ Include Perimeter Stone in Calculations

Height of System (inches)	Incremental Single Chamber (cubic feet)	Incremental Single End Cap (cubic feet)	Incremental Chambers (cubic feet)	Incremental End Cap (cubic feet)	Incremental Stone (cubic feet)	Incremental Ch, EC and Stone (cubic feet)	Cumulative System (cubic feet)	Elevation (feet)
108	0.00	0.00	0.00	0.00	226.60	226.60	34358.35	531.00
107	0.00	0.00	0.00	0.00	226.60	226.60	34131.75	530.92
106	0.00	0.00	0.00	0.00	226.60	226.60	33905.15	530.83
105	0.00	0.00	0.00	0.00	226.60	226.60	33678.55	530.75
104	0.00	0.00	0.00	0.00	226.60	226.60	33451.95	530.67
103	0.00	0.00	0.00	0.00	226.60	226.60	33225.35	530.58
102	0.00	0.00	0.00	0.00	226.60	226.60	32998.75	530.50
101	0.00	0.00	0.00	0.00	226.60	226.60	32772.15	530.42
100	0.00	0.00	0.00	0.00	226.60	226.60	32545.55	530.33
99	0.00	0.00	0.00	0.00	226.60	226.60	32318.95	530.25
98	0.00	0.00	0.00	0.00	226.60	226.60	32092.35	530.17
97	0.00	0.00	0.00	0.00	226.60	226.60	31865.75	530.08
96	0.04	0.00	6.14	0.00	224.14	230.29	31639.15	530.00
95	0.12	0.01	17.41	0.14	219.58	237.13	31408.86	529.92
94	0.16	0.03	24.71	0.37	216.57	241.65	31171.73	529.83
93	0.21	0.05	31.31	0.67	213.81	245.79	30930.08	529.75
92	0.27	0.07	40.25	0.95	210.12	251.32	30684.29	529.67
91	0.45	0.09	67.92	1.23	198.94	268.09	30432.97	529.58
90	0.67	0.11	99.79	1.58	186.05	287.42	30164.89	529.50
89	0.80	0.14	119.85	1.98	177.87	299.70	29877.46	529.42
88	0.91	0.17	136.22	2.35	171.17	309.74	29577.76	529.33
87	1.00	0.19	150.44	2.68	165.35	318.47	29268.03	529.25
86	1.09	0.22	163.10	3.01	160.16	326.27	28949.56	529.17
85	1.16	0.24	174.52	3.38	155.44	333.34	28623.29	529.08
84	1.23	0.27	185.10	3.78	151.05	339.93	28289.95	529.00
83	1.30	0.30	194.95	4.17	146.95	346.07	27950.02	528.92
82	1.36	0.32	204.15	4.53	143.13	351.81	27603.94	528.83
81	1.42	0.35	212.81	4.87	139.53	357.21	27252.13	528.75
80	1.47	0.37	221.00	5.20	136.12	362.32	26894.93	528.67
79	1.53	0.39	228.77	5.52	132.88	367.17	26532.61	528.58
78	1.57	0.42	236.17	5.84	129.79	371.81	26165.44	528.50
77	1.62	0.44	243.21	6.16	126.85	376.22	25793.63	528.42
76	1.67	0.46	249.93	6.46	124.04	380.45	25417.41	528.33
75	1.71	0.48	256.37	6.78	121.34	384.49	25036.96	528.25
74	1.75	0.50	262.51	7.07	118.77	388.35	24652.47	528.17
73	1.79	0.53	268.39	7.35	116.30	392.05	24264.12	528.08
72	1.83	0.55	274.08	7.63	113.92	395.63	23872.08	528.00
71	1.86	0.56	279.52	7.90	111.63	399.05	23476.45	527.92
70	1.90	0.58	284.75	8.17	109.43	402.35	23077.40	527.83
69	1.93	0.60	289.78	8.42	107.32	405.52	22675.05	527.75
68	1.96	0.62	294.61	8.68	105.28	408.57	22269.53	527.67
67	2.00	0.64	299.27	8.93	103.32	411.52	21860.96	527.58
66	2.03	0.65	303.76	9.18	101.43	414.36	21449.44	527.50
65	2.06	0.67	308.07	9.43	99.60	417.10	21035.08	527.42
64	2.08	0.69	312.22	9.67	97.84	419.73	20617.98	527.33
63	2.11	0.71	316.21	9.90	96.15	422.27	20198.25	527.25
62	2.13	0.72	320.08	10.13	94.52	424.73	19775.98	527.17
61	2.16	0.74	323.80	10.36	92.94	427.10	19351.25	527.08
60	2.18	0.76	327.38	10.58	91.41	429.38	18924.16	527.00
59	2.21	0.77	330.83	10.80	89.95	431.58	18494.78	526.92
58	2.23	0.79	334.15	11.02	88.53	433.70	18063.20	526.83
57	2.25	0.80	337.33	11.23	87.18	435.73	17629.50	526.75
56	2.27	0.82	340.40	11.49	85.84	437.74	17193.77	526.67
55	2.29	0.84	343.35	11.77	84.55	439.67	16756.03	526.58
54	2.31	0.85	346.18	11.84	83.39	441.41	16316.36	526.50
53	2.33	0.86	348.89	12.02	82.23	443.15	15874.95	526.42
52	2.34	0.87	351.49	12.21	81.12	444.82	15431.80	526.33
51	2.36	0.89	353.99	12.39	80.05	446.43	14986.98	526.25
50	2.38	0.90	356.37	12.57	79.02	447.96	14540.55	526.17
49	2.39	0.91	358.65	12.74	78.04	449.43	14092.59	526.08
48	2.41	0.92	360.82	12.91	77.11	450.84	13643.15	526.00
47	2.42	0.93	362.89	13.08	76.21	452.18	13192.31	525.92
46	2.43	0.95	364.86	13.24	75.36	453.46	12740.13	525.83
45	2.44	0.96	366.73	13.39	74.55	454.67	12286.67	525.75
44	2.46	0.97	368.50	13.54	73.78	455.82	11832.00	525.67
43	2.47	0.98	370.17	13.69	73.06	456.91	11376.18	525.58
42	2.48	0.99	371.74	13.83	72.37	457.94	10919.26	525.50
41	2.49	1.00	373.24	13.97	71.72	458.92	10461.32	525.42
40	2.50	1.01	374.65	14.10	71.10	459.85	10002.40	525.33
39	2.51	1.02	375.98	14.22	70.52	460.72	9542.55	525.25
38	2.51	1.02	377.21	14.34	69.98	461.53	9081.83	525.17
37	2.53	1.03	379.04	14.46	69.20	462.70	8620.30	525.08
36	0.00	0.00	0.00	0.00	226.60	226.60	8157.60	525.00
35	0.00	0.00	0.00	0.00	226.60	226.60	7931.00	524.92
34	0.00	0.00	0.00	0.00	226.60	226.60	7704.40	524.83
33	0.00	0.00	0.00	0.00	226.60	226.60	7477.80	524.75
32	0.00	0.00	0.00	0.00	226.60	226.60	7251.20	524.67
31	0.00	0.00	0.00	0.00	226.60	226.60	7024.60	524.58
30	0.00	0.00	0.00	0.00	226.60	226.60	6798.00	524.50
29	0.00	0.00	0.00	0.00	226.60	226.60	6571.40	524.42
28	0.00	0.00	0.00	0.00	226.60	226.60	6344.80	524.33
27	0.00	0.00	0.00	0.00	226.60	226.60	6118.20	524.25
26	0.00	0.00	0.00	0.00	226.60	226.60	5891.60	524.17
25	0.00	0.00	0.00	0.00	226.60	226.60	5665.00	524.08
24	0.00	0.00	0.00	0.00	226.60	226.60	5438.40	524.00
23	0.00	0.00	0.00	0.00	226.60	226.60	5211.80	523.92
22	0.00	0.00	0.00	0.00	226.60	226.60	4985.20	523.83
21	0.00	0.00	0.00	0.00	226.60	226.60	4758.60	523.75
20	0.00	0.00	0.00	0.00	226.60	226.60	4532.00	523.67
19	0.00	0.00	0.00	0.00	226.60	226.60	4305.40	523.58
18	0.00	0.00	0.00	0.00	226.60	226.60	4078.80	523.50
17	0.00	0.00	0.00	0.00	226.60	226.60	3852.20	523.42
16	0.00	0.00	0.00	0.00	226.60	226.60	3625.60	523.33
15	0.00	0.00	0.00	0.00	226.60	226.60	3399.00	523.25
14	0.00	0.00	0.00	0.00	226.60	226.60	3172.40	523.17
13	0.00	0.00	0.00	0.00	226.60	226.60	2945.80	523.08
12	0.00	0.00	0.00	0.00	226.60	226.60	2719.20	523.00
11	0.00	0.00	0.00	0.00	226.60	226.60	2492.60	522.92
10	0.00	0.00	0.00	0.00	226.60	226.60	2266.00	522.83
9	0.00	0.00	0.00	0.00	226.60	226.60	2039.40	522.75
8	0.00	0.00	0.00	0.00	226.60	226.60	1812.80	522.67
7	0.00	0.00	0.00	0.00	226.60	226.60	1586.20	522.58
6	0.00	0.00	0.00	0.00	226.60	226.60	1359.60	522.50
5	0.00	0.00	0.00	0.00	226.60	226.60	1133.00	522.42
4	0.00	0.00	0.00	0.00	226.60	226.60	906.40	522.33
3	0.00	0.00	0.00	0.00	226.60	226.60	679.80	522.25
2	0.00	0.00	0.00	0.00	226.60	226.60	453.20	522.17
1	0.00	0.00	0.00	0.00	226.60	226.60	226.60	522.08

WATER QUALITY BELOW OUTLET ELEVATION

Appendix G

SC

STORMWATER CENTER

PERFORMANCE EVALUATION REPORT OF THE STORMTECH ISOLATOR ROW® TREATMENT UNIT

Submitted to

STORMTECH LLC

STATE OF NEW HAMPSHIRE
ROBERT M. ROSEEN
No. 12215
LICENSED
PROFESSIONAL ENGINEER

September 2010

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FINAL REPORT ON FIELD VERIFICATION TESTING OF THE STORMTECH ISOLATOR ROW®
TREATMENT UNIT
BY THE UNIVERSITY OF NEW HAMPSHIRE STORMWATER CENTER

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FINAL REPORT ON FIELD VERIFICATION TESTING OF THE STORMTECH ISOLATOR ROW® TREATMENT UNIT May, 2010

1.0 EXECUTIVE SUMMARY

The StormTech Isolator Row® was monitored from December 2006 through September 2009 in Durham, NH at the University of New Hampshire Stormwater Center test facility. The system was installed in September 2006. The Isolator Row® system was designed and sized by Stormtech LLC for a 1 cubic foot per second water quality flow and a corresponding water quality volume equivalent to runoff from 1" of runoff from an impervious area or 3300 cubic feet. This system was comprised of 5 chambers wrapped in a combination of filter fabric and geotextile. The hydraulic configuration included a high flow bypass weir structure located at the entrance to the chambers. Bypass flows were not monitored for water quality, only for occurrence. The Isolator Row® was monitored for performance for six major water quality contaminants, hydrologic performance, sediment capture, and sediment accumulation as it relates to hydraulic efficiency of the filter bed. The water quality results are based on treated flows only.

After 3 years of operation, sediment (TSS and SSC) performance and effluent EMCs reveal strong performance and low effluent concentrations that do not vary significantly across fluxuations in loading concentration, seasons, or time. A median performance was observed for TSS >80% removal for both years, and SSC >90% for the end of year 2. Five of the seven events with poor performance were attributed to events exceeding the water quality design flow (WQF=1 cfs). Metals performance as measured by TZn increased from 53% for year 1 to 81% removal by the end of year 2. TPH and TP removal efficiencies and effluent EMCs demonstrate strong performance that was enhanced over the course of the study. As would be expected for non-vegetated filtration systems, dissolved inorganic nitrogen (DIN = NO3, N02, NH4) removal efficiencies and effluent EMCs reveal poor performance and high effluent concentrations relative to influent values.

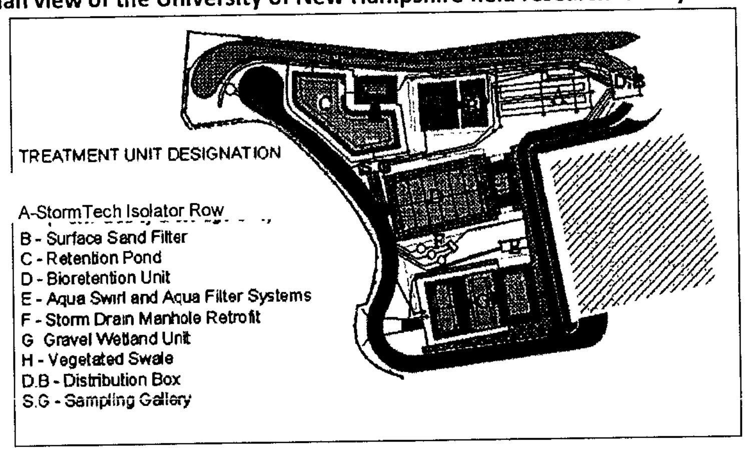
Sediment depths over the 3 year installation and monitoring period (September 2006 September 2009) had accumulated to 1.2 in, nearly half of the manufacturers recommended depth for maintenance (3 inches). By this measure, it would take another 3 years of operation before maintenance would be required, or a total of 6 years of operation.

2.0 INTRODUCTION

Under an agreement from STORMTECH LLC, field verification testing of a StormTech Isolator Row® stormwater treatment unit was conducted at the University of New Hampshire Stormwater Center, Durham NH. Testing consisted of determining the water quality performance for a range of parameters including sediments, metals, nutrients, and petroleum hydrocarbons.

Performance tests were conducted under normalized conditions across a range of seasons, rainfall conditions, and pollutant concentrations; all important variables reflective of natural

Figure 1: Site Plan: Plan view of the University of New Hampshire field research facility



field performance conditions. This report reflects analyses performed from September 2007 through July 2009. This included monitoring of 23 rainfall runoff events in total.

The Isolator Row® treatment unit is one of 10 devices that are currently configured and tested in parallel, with a single influent source providing uniform loading to all devices. All treatment strategies were uniformly sized to target either a water quality volume (WQV), or a water quality flow (WQF). Under the parallel and uniformly sized configuration, a normalized performance evaluation is possible because different treatment strategies of the same scale receive runoff from events of the same duration, intensity, peak flow, volume, antecedent dry period, and pollutant loading.

Primary funding for the Center program has been provided by the Cooperative Institute for Coastal and Estuarine Environmental Technology (CICEET) and the National Oceanic and Atmospheric Administration (NOAA).The UNH Stormwater Center is housed within the Environmental Research Group (ERG) of the Department of Civil Engineering at the University of New Hampshire (UNH) in Durham, New Hampshire.

3.0 TEST FACILITY DESCRIPTION

The UNH Stormwater Center studies stormwater-related water quality and quantity issues. The Stormwater Center's field facility is designed to evaluate and verify the performance of stormwater management devices and technologies in a parallel, event normalized setting. Ten different management systems are currently undergoing side-by-side comparison testing under strictly monitored natural conditions (Figure 1).

The site was designed to function as a field testing site for numerous, uniformly sized, isolated, parallel treatment systems. Rainfall-runoff is evenly divided at the head of the facility in a distribution box, designed with the floor slightly higher than the outlet invert elevations to allow for particulate scour into the pipe network. Effluent from all systems is piped into a central sampling gallery, where system sampling and flow monitoring occurs. The parallel configuration normalizes the treatment processes for event and watershed-loading variations.

The testing facility is located on the perimeter of a 9 acre commuter parking lot at the University of New Hampshire in Durham. The parking lot is standard dense mix asphalt that was installed in 1996, and is used to near capacity throughout the academic year. The sub-catchment area is large enough to generate substantial runoff, which is gravity fed to the parallel treatment processes. The lot is curbed and entirely impervious. Activity is a combination of passenger vehicles and routine bus traffic. The runoff time of concentration for the lot is 22 minutes, with slopes ranging from 1.5-2.5%. The area is subject to frequent plowing, salting, and sanding during the winter months. Literature reviews indicate that contaminant concentrations are above or equal to national norms for commercial parking lot runoff. The climatology of the area is characterized as a coastal, cool temperate forest. Average annual precipitation is 48 inches uniformly distributed throughout the year, with average monthly precipitation of 4.02 in +/- 0.5. The mean annual temperature is 48°F, with the average low in January at 15.8°F, and the average high in July at 82°F.

2.1 System Configuration and Sizing

A 5 chambered Isolator Row® system was tested in an offline configuration. A 6 foot diameter manhole with a 4 foot sump was installed upstream of the Isolator Row®. The manhole was connected to the Isolator Row® with a short length of 24 inch diameter HDPE pipe. Within the manhole a high-flow bypass was constructed using a broad-crested weir. A 12" bypass pipe routes bypass flows around the Isolator Row® to discharge downstream. The bypass and treated effluent are monitored separately. The crest of the overflow weir was set 0.2 feet below the top of the Isolator Row chamber, this allows stormwater in excess of the Isolator Row's storage capacity to bypass in an offline configuration without routing through the system and avoids any potential for pressurized flow through the underlying geotextile. Each chamber of the Isolator Row is 51" in width, 30" in height, and 85.4" in length. 5 chambers are connected. The system has a design peak flow rate of 1 cfs (cubic feet per second). The system is lined with HDPE liner and effluent is collected by a 6" perforated underdrain that is continuously monitored. As mentioned, non-design flow (flow rates > 1 cfs) bypass the treatment system and are monitored for occurrence only. Figures 2 and 3 show system installation and construction drawings. The system was installed in late September 2006. System monitoring began in early 2007 to allow for system flushing and to prevent influences that may be construction associated.

Figure 2: Installation of Isolator Row September 2006; (a, top left) HDPE liner installation to monitor full treated effluent; (b, top right) Crushed stone subbase 12" thick installation; (c, bottom left) Installation of Isolator Row chambers on top of double layer of woven geotextile fabric (bottom) non-woven geotextile fabric (sides) and stone subbase; (d, bottom right) Installation of hydraulic inlet structure, chamber entrance (left), influent source (top right), and high flow bypass weir bottom right.

2.2 Reference TSS Information

Comparisons of the TSS concentrations for varied land uses are presented in Figure 4. Urban highway pollutant concentrations tend to be twice the mean concentration measured for parking lots and residential uses. The data collected from the UNH facility is within the national norm for commercial parking lots and is within the range of typical concentrations observed for a range of land uses. Occasional storms are monitored that have exceptionally high solids concentrations.

Figure 3: System Drawings for Isolator Row (top, plan view; bottom, cross-section)

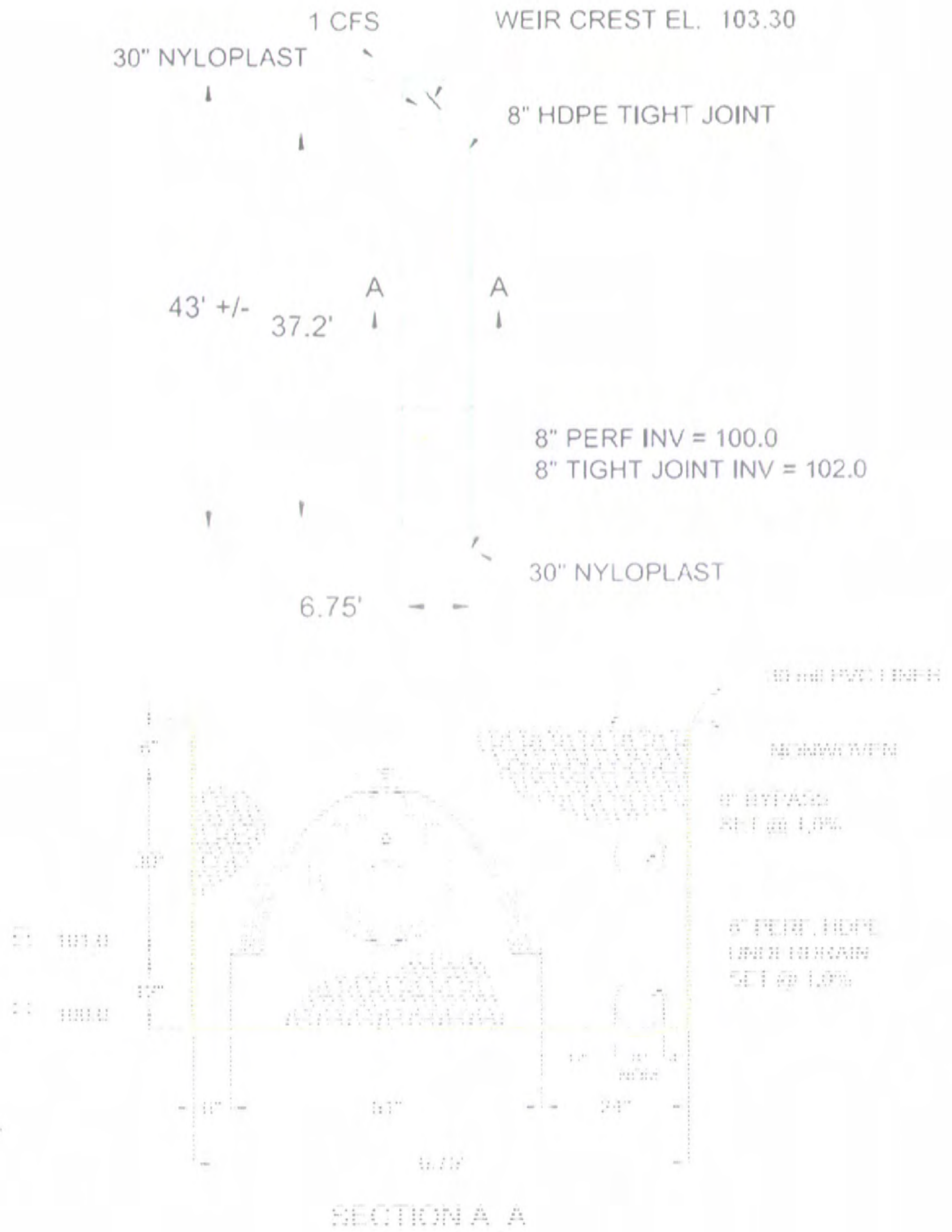
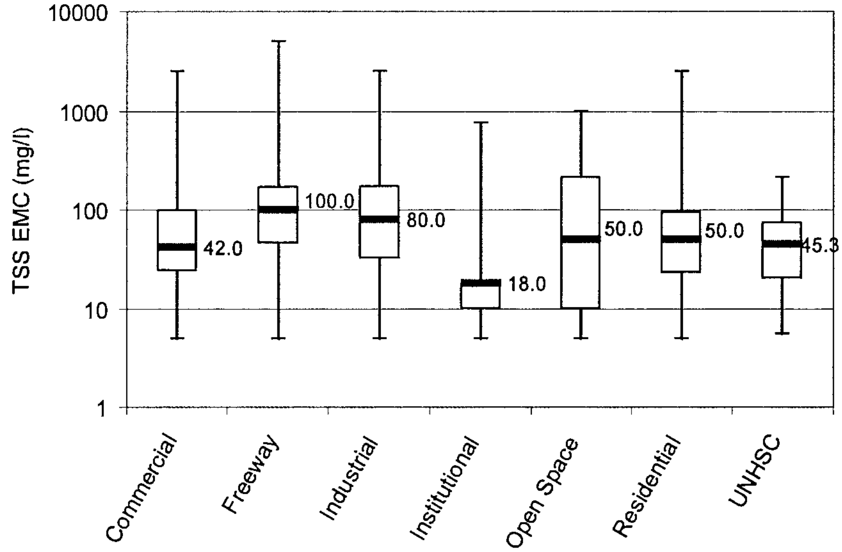


Figure 4: Total Suspended Solids (TSS) for varied land uses and at the UNH Stormwater Center (UNHSC); (Source: National Stormwater Quality Database, 2005[1], UNHSC, 2007[2])



3.0 INSTRUMENTATION AND MEASURING TECHNIQUES

3.1 Flow

Influent flows were monitored using Teledyne Isco 6712 Automated samplers accompanied by Teledyne Isco 750 Area Velocity probes. The influent depths were also secondarily monitored using Teledyne Isco 730 Bubbler Flow Modules and flows generated from a stage vs discharge rating curve for redundancy. Effluent flow depths were measured using Teledyne Isco 6712 Automated samplers accompanied by Teledyne Isco 730 Bubbler Flow Modules in combination with Thelmar compound weirs with laboratory developed rating curves to yield flows.

3.2 Other Measurements

Temperature, pH, Specific Conductivity, and Dissolved Oxygen, are collected by YSI 600XL multi-parameter sondes. These parameters are monitored real-time for the influent and effluent flows but are not included under this contract.

[1] Pitt, R. E., Maestre, A., and Center for Watershed Protection. (2005) "The National Stormwater Quality Database (NSQD, version 1.1)." USEPA Office of Water, Washington, D.C.

[2] UNHSC, Roseen, R., T. Ballestero, and Houle, J. (2007). "UNH Stormwater Center 2007 Annual Report." University of New Hampshire, Cooperative Institute for Coastal and Estuarine Environmental Technology, Durham, NH.

3.3 Water Quality Analysis

Samples were processed and analyzed by an EPA and National Environmental Laboratory Accreditation Conference (NELAC) certified laboratory using the standard methodologies outlined in Table 1.

Table 1: Laboratory analytical methods and detection limits for each analyte.

Analyte	Analytical Method	Sample Detection Limit (mg/L)	Method Detection Limit (mg/L)[a]
Nitrate/Nitrite in water	EPA 300.0A	0.1	0.008
Total Suspended Solids	SM 2540 D	Variable, 1-10	0.4
Suspended Sediment Concentration	ASTM D-3977	Variable, 1-2	1
Total Phosphorus	EPA 365.3	0.01	0.008
Zinc in water	EPA 200.7	0.05	0.001-0.05
Total Petroleum Hydrocarbons –Diesel Range	SW 3510C 8015B	Variable ≤ 3.5	0.1-3.0

[a]Method detection limit is different than sample detection limit which will be often be higher as they are based on sample volume available for analyses.

4.0 TEST PROCEDURES

4.1 Rainfall Collection and Measurement

A rainfall collection system consisting of 6"diameter 2 foot high anodized aluminum housing, HDPE funnel, debris screen, and tipping bucket mechanism is installed at a controlled site within the research complex and used rainfall measurement to 0.01"depth resolution. Specified components are the ISCO Model 674 Tipping Bucket Rain Sensor with Rain Gauge. The precipitation event data is stored in the ISCO 6712 and the accumulated rainfall is retrieved and stored through a FlowLink 4.21 database via a desktop computer located on-site.

4.2 Field Sampling Procedures

Composite samples were taken for influent and effluent waters by automated samplers. Automatic samplers are programmed to sample 100 ml aliquots at flow weighted intervals into 24 x 1L containers. The sampling program is designed to ensure adequate coverage of the storm event and adjusted to accommodate seasonal fluctuations in rainfall patterns. Rejection criteria included minimum rainfall depth of 0.1 inches, 10 aliquots per event, and minimum 70% sampling coverage of the storm event. Influent time of concentration is approximately 22 minutes. Effluent time of concentrations vary for each device depending on conveyance lengths and treatment strategies. All samples are stored in thermostatically controlled conditions at 39°F until processed.

One Liter disposable LDPE sample bags are used to assure clean, non-contaminated sample containers. Full storm composites are generated using a United States Geological Survey (USGS) Dekaport Cone Sample Splitter. Composite samples are then sealed and labeled with a unique, water proof, adhesive bar code that corresponds with a field identification number containing information relating to the stormwater treatment unit and date of sampling. Records are kept that correlate sample bar code with sample time, date, flow, and other real time water quality parameters. Detailed written and electronic records are kept identifying the date, time, and unique bar code and field identification numbers. This begins the chain-of-custody record that accompanies each sample to track handling and transportation throughout the sampling process.

All analyses and procedures comply with the Technology Acceptance and Reciprocity Partnership (TARP), and the Technology Acceptance Protocol – Ecology (TAPE) guidelines to the maximum extent possible. We operate under a detailed Quality Assurance Project Plan (QAPP) which is available on request.

5.0 DATA EVALUATION

Exploratory data analyses are presented to examine influent and effluent conditions. These data are presented along with simple statistical analyses to examine performance trends. Data analyses included a range of approaches:

- evaluation of storm characteristics
- time series scatter plots for evaluation of event mean concentrations
- time series scatter plots for evaluation of removal efficiencies
- quartile distributions with notched box and whisker plots
- influent and effluent cumulative distribution functions
- simple statistics summary
- particle size distribution (PSD) analysis
- residual solid accumulation measurements

Storm characteristics such as total depth of rainfall, peak intensity, total storm volume, antecedent dry period, among others are presented for each storm event. Results for all storms sampled are presented in Table 2.

Event mean concentrations (EMC's) are presented in time series scatter plots along with removal efficiencies across a range of seasons. EMC's are a parameter used to represent the flow-proportional average concentration of a given parameter during a storm event. It is defined as the total constituent mass divided by the total runoff volume. When combined with flow measurement data, the EMC can be used to estimate the pollutant loading from a given storm or an annual basis. Most of the EMC data collected during this study were based upon direct measurement from flow-weighted composite samples. Due to the variability of precipitation events and resultant runoff conditions sample trigger conditions and flow-weighted sample pacing were variable and adjusted on a storm by storm basis according to the most up-to-date precipitation forecasts.

Interquartile distributions are presented as notched box and whisker plots for the range of contaminants for influent and effluent. Analysis of quartile distributions helps characterize trends in terms of range, and maximum and minimum, and median.

The cumulative probability distributions of observed concentrations are presented for both influent and effluent conditions. The cumulative distributions illustrate the probability of observed EMCs for both influent runoff conditions and the Stormtech Isolator Row treatment.

EMCs are compared for each pollutant parameter using simple statistics over multiple years of observations. The data provides a basis to evaluate the primary study question; i.e., to discern whether stormwater treatment unit BMP's have served to produce observable improvement in quality and reduction in volume of stormwater runoff. Calculation of medians is used because it is a measure that is more robust in the presence of outlier values than is the mean (average).

Particle size distribution (PSD) information for 4 influent events was determined by composite samples obtained with an auto-sampler and analyzed by laser diffraction. Auto-sampler PSD is reflective of the particle size range pulled by a sampler using a 3/8th ID sampling line and a peristaltic pump.

The quantity of the solids captured by the system were assessed on an annual basis and consisted of residual solids depth measurements throughout the lateral and longitudinal profile of the system. Particle size distributions were performed for captured solids.

6.0 RESULTS

Results presented below for the Isolator Row® represent data collected from the period of monitoring from December 2006 through September 2009 conducted at the UNHSC field facility. The data set reflects rainfall across all four seasons and covers a wide range of rainfall characteristics. Table 2 displays rainfall event characteristics for the 23 monitored storm events. Storms ranged in size from low intensity to high intensity, small volume to large volume. The design flow rate for the Isolator Row is 1 cfs, or 448.8 gpm.

6.1 Event Mean Concentrations (EMC) and Removal Efficiencies (RE) and Statistics

Influent and effluent EMC and system performance values are presented for each storm for the 5 contaminants across all monitored storm events in both tabular format in tables 4-5 and graphical format in Figures 5-10. The tables display discrete storm event data including influent and effluent EMCs and event based removal efficiencies. The graphical time series plots show performance for individual storm events as well as seasonal and annual trends with a 6-month cold season, or winter period displayed in blue. When EMC results are below detection limit (BDL) a value of zero is used and plotted as a unique time series and represented as a green triangle on the plots. No clear methodology for representing BDL values in stormwater treatment system effluent currently exists especially with respect to systems that detain a large volume of runoff and exhibit a longer effluent hydrograph than influent waters. Where detection limits are low enough (< 1 mg/L for TSS) the conventional statistical approach of using 0.5 X DL[3] would be adequate however, where detection limits are higher (≥ 10 mg/L for TSS) 0.5 x DL may add artificial mass and obscure overall system performance. Influent and

[3] Helsel, D. R., and Hirsch, R. M. (2002). Statistical Methods in Water Resources, U.S. Geological Survey.

Table 2: Rainfall-Runoff event characteristics for 23 storm events.

Rainfall Event	Peak Intensity (in/hr)	Storm Duration (min)	Total Depth (in)	Peak Flow (gpm)	Volume (gal)	Antecedent Dry Period (days)	Season
3/11/2007	0.12	430	0.28	85	23,323	7.0	Winter
4/12/2007	0.12	590	0.37	115	30,421	6.0	Spring
4/27/2007	0.24	450	0.54	146	31,005	7.5	Spring
5/11/2007	0.60	115	0.26	488	13,150	8.5	Spring
7/4/2007	0.48	235	0.45	260	23,976	13.0	Summer
9/9/2007	1.32	345	0.48	923	19,228	21.0	Summer
12/24/2007	1.08	305	0.33	499	21,608	2.5	Winter
12/29/2007	0.36	655	0.42	114	29,399	1.5	Winter
1/11/2008	0.72	690	0.68	233	47,832	1.5	Winter
1/18/2008	0.48	250	0.59	146	14,423	3.5	Winter
2/1/2008	0.12	620	1.23	187	39,921	1.5	Winter
3/7/2008	0.24	365	0.34	139	27,390	1.0	Winter
5/31/2008	0.72	80	0.11	344	6,807	3.5	Spring
6/4/2008	0.24	665	0.40	158	43,908	3.5	Spring
6/20/2008	1.08	165	0.20	718	16,016	2.0	Summer
7/23/2008	0.96	745	0.86	619	63,145	1.5	Summer
10/21/2008	0.36	290	0.24	183	18,154	4.5	Fall
11/13/2008	0.60	3,875	1.17	180	147,896	3.5	Fall
12/10/2008	0.36	435	0.60	221	39,504	0.5	Winter
4/3/2009	1.32	580	0.79	153	44,928	0.5	Spring
4/21/2009	0.36	685	0.64	1,342	509,189	2.5	Spring
5/5/2009	0.36	1,345	0.72	521	54,180	3.5	Spring
6/18/2009	1.08	1,295	1.46	590	42,092	3.5	Spring

effluent EMC quartile distributions are presented in Figure 11 as box and whisker plots that displays the minimum, 25th percentile, median, 75th percentile and maximum values for the range of storms monitored and the range of contaminants measured. The range of effluent concentrations are useful in discerning overall performance trends and in comparing UNHSC results to other datasets that may exist for the treatment technology. Figure 12 displays the same range of data for EMC displayed as exceedance probabilities. The cumulative distributions of the entire dataset is ranked with influent and effluent values plotted against the percent of recurrence or exceedance. The cumulative distributions are useful as it demonstrates the probability that a given concentration has been observed, and presumably will occur.

Table 3 Influent and effluent Event Mean Concentrations Removal Efficiencies for TSS, SSC and TPH-D for 23 storm events of the Isolator Row®

	Total Suspended Solids (TSS)			Suspended Sediment Concentration (SSC)			Total Petroleum Hydrocarbons - Diesel (TPH-D)		
Date	influent EMC (mg/L)	effluent EMC (mg/L)	Removal Efficiency (%)	influent EMC (mg/L)	effluent EMC (mg/L)	Removal Efficiency (%)	influent EMC (ug/L)	effluent EMC (ug/L)	Removal Efficiency (%)
3/11/2007	66	25	62%				1648	472	71%
4/12/2007	36	5	86%				631	422	33%
4/27/2007	16	15	3%				456	45	90%
5/11/2007	123	23	81%				970	402	59%
7/4/2007	48	5	90%				927	436	53%
9/9/2007	32	20	38%				261		99%
12/24/2007	120	46	62%				890	340	62%
12/29/2007	16	0 (BDL)	99%						
1/11/2008	94	14	85%				750	0 (BDL)	99%
1/18/2008	130	18	86%				3200	300	91%
2/1/2008	21	0 (BDL)	99%						
3/7/2008	14	12	14%				850	0 (BDL)	99%
5/31/2008	200	16	92%						
6/4/2008	15	3	80%				370	0 (BDL)	99%
6/20/2008	130	50	62%						
7/23/2008	10	7	30%						
10/21/2008	11	0 (BDL)	99%	19	2	89%			
11/13/2008	15	0 (BDL)	99%	30	12	60%			
12/10/2008	29	0 (BDL)	99%	75	8	89%	480	0 (BDL)	99%
4/3/2009	240	36	85%						
4/21/2009	25	16	36%	220	22	90%			
5/5/2009	23	5	78%				310	0 (BDL)	99%
6/18/2009	260	9	97%	360	4	99%			
Median	32	16	85%	75	8	89%	750	402	91%
Average	73	18	72%	141	10	85%	903	345	81%

Table 4 Influent and effluent Event Mean Concentrations Removal Efficiencies for DIN, TZn and TP for 23 storm events of the Isolator Row®

	Dissolved Inorganic Nitrogen (DIN)			Total Zinc (TZn)			Total Phosporus (TP)		
Date	influent EMC (mg/L)	effluent EMC (mg/L)	Removal Efficiency (%)	influent EMC (mg/L)	effluent EMC (mg/L)	Removal Efficiency (%)	influent EMC (mg/L)	effluent EMC (mg/L)	Removal Efficiency (%)
3/11/2007	0 43	0 46	-8%	0 077	0 036	53%	0 18	0 10	44%
4/12/2007	0 05	0 26	-421%	0 046	0 022	53%	0 07	0 05	29%
4/27/2007	0 11	0 24	-117%	0 021	0 005	76%	0 06	0 04	33%
5/11/2007	0 26	0 46	-77%	0 087	0 036	58%	0.20	0 07	65%
7/4/2007				0 046	0 017	63%	0 17	0 08	53%
9/9/2007	0 19	0 60	-216%	0 049	0 030	37%	0 10	0 09	10%
12/24/2007				0 150	0 090	40%	0 17	0 07	59%
12/29/2007	0 50	0 70	-40%	0 030	0 020	33%	0 04	0 02	50%
1/11/2008	0 20	0 50	-150%	0 060	0 010	83%	0.12	0 04	67%
1/18/2008				0 090	0 040	56%	0 12	0 04	67%
2/1/2008	0 10	0 40	-300%	0 040	0 020	50%	0 06	0 03	50%
3/7/2008				0 020	0 020	0%	0 02	0 03	-50%
5/31/2008	0 60	1 10	-83%	0 130	0 030	77%	0 33	0 08	76%
6/4/2008	0 20	0 40	-100%	0 030	0 (BDL)	99%	0 05	0 05	0%
6/20/2008	0 50	1 20	-140%	0 080	0 030	63%	0 12	0 06	50%
7/23/2008	0 30	0 50	-67%	0 020	0 010	50%	0 01	0 02	-100%
10/21/2008	0 50	0 60	-20%	0 040	0 020	50%	0 03	0 03	0%
11/13/2008	0 20	0 40	-100%	0 030	0 (BDL)	99%	0 04	0 03	25%
12/10/2008				0 020	0 (BDL)	99%	0.05	0 01	80%
4/3/2009				0 070	0 010	86%	0 16	0 01	94%
4/21/2009	0 30	0 30	0%				0 03	0 03	0%
5/5/2009	0 40	0 60	-50%				0 04	0 03	25%
6/18/2009	0 30	0 20	33%	0 020	0 (BDL)	99%	0 02	0 02	0%
	0 30	0 46	-83%	0 046	0 020	58%	0 06	0 04	44%
	0 30	0 52	-109%	0 055	0 026	63%	0.10	0 04	32%

Figure 5: Total Suspended Solids Event Mean Concentrations at influent and effluent locations and Removal Efficiencies for 23 storm events of the Isolator Row®. A 6-month winter period (Nov-April) is displayed in blue.

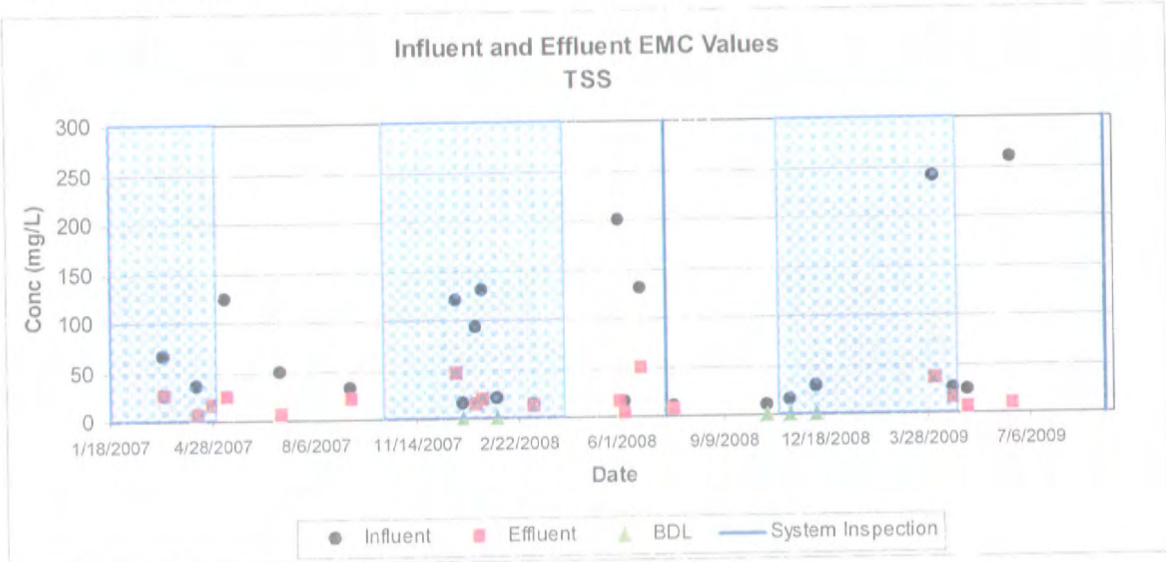


Figure 6: Suspended Sediment Concentration Event Mean Concentrations at influent and effluent points and Removal Efficiencies for 6 storm events of the Isolator Row®. A 6-month winter period (Nov-April) is displayed in blue.

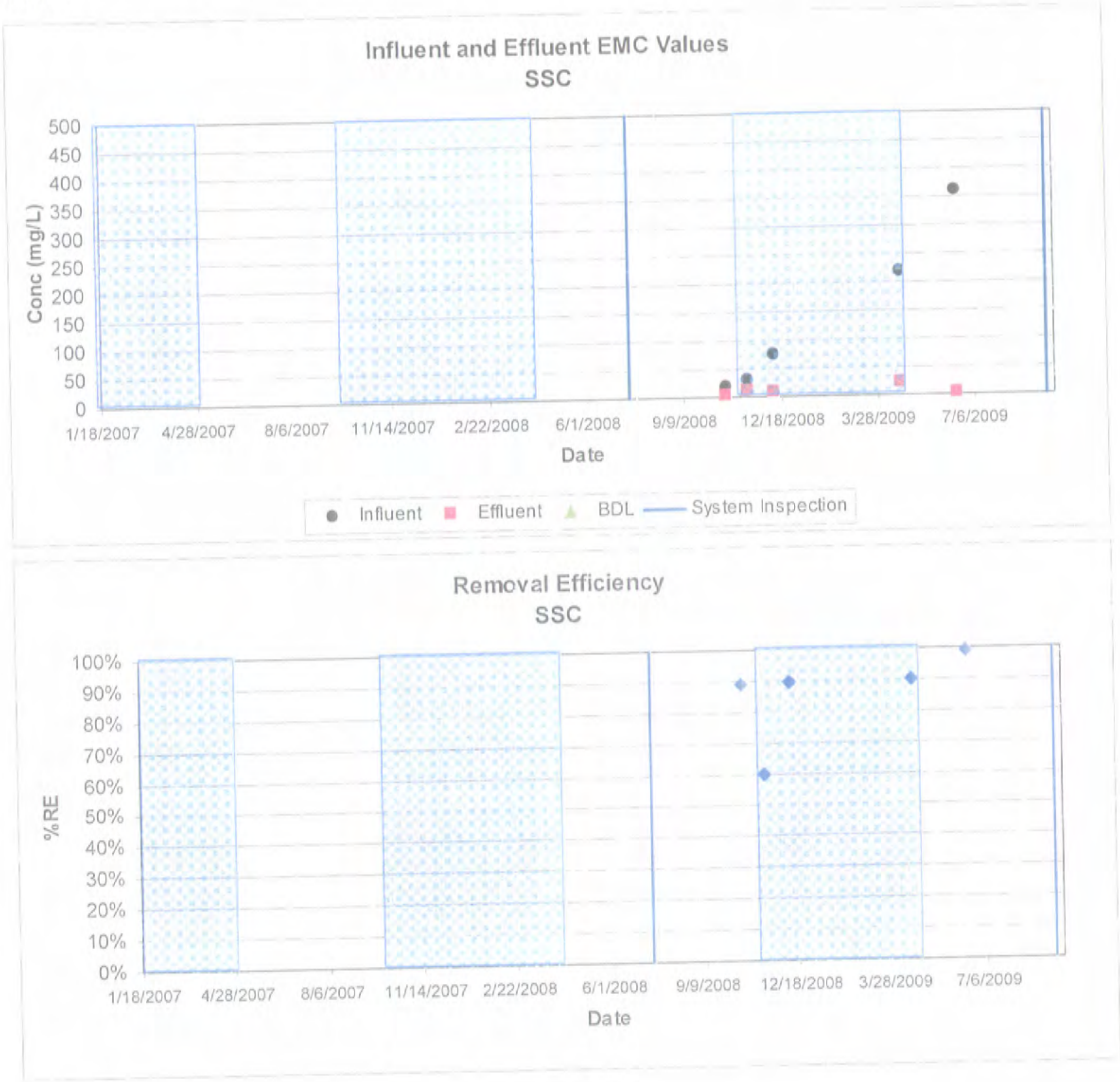
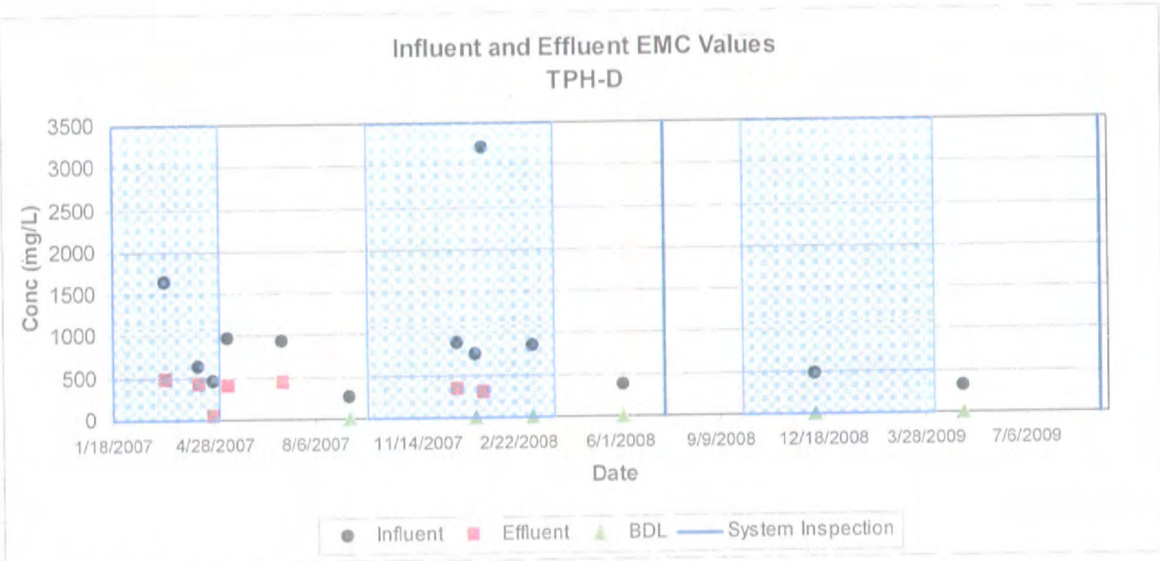


Figure 7: Total Petroleum Hydrocarbons-Diesel Range Event Mean Concentrations at influent and effluent points and Removal Efficiencies for 13 storm events of the Isolator Row®. A 6-month winter period (Nov-April) is displayed in blue.



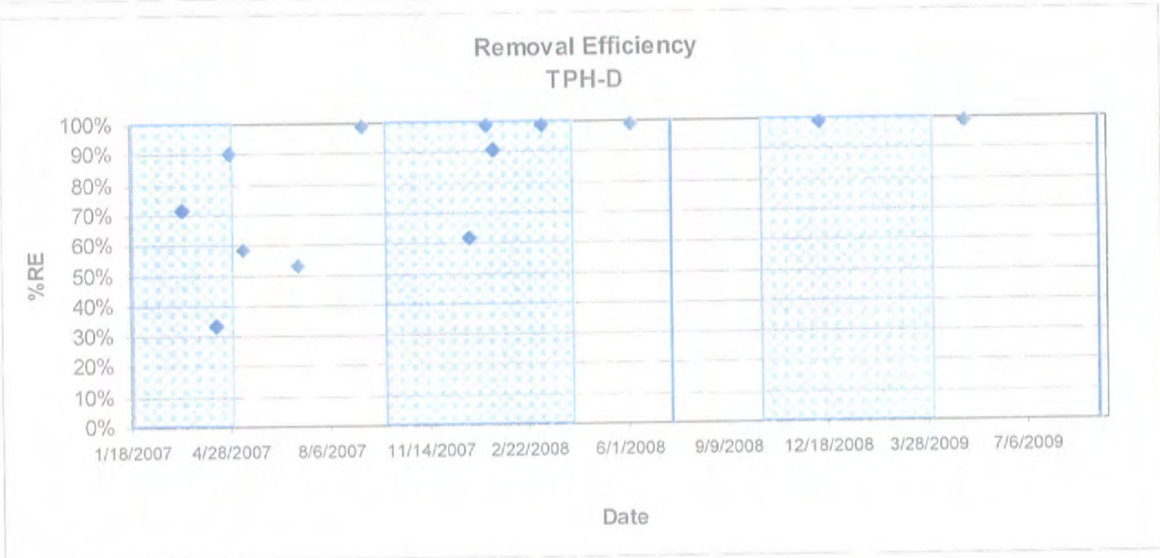


Figure 8: Total Zinc Event Mean Concentrations at influent and effluent locations and Removal Efficiencies for 21 storm events of the Isolator Row®. A 6-month winter period (Nov-April) is displayed in blue.

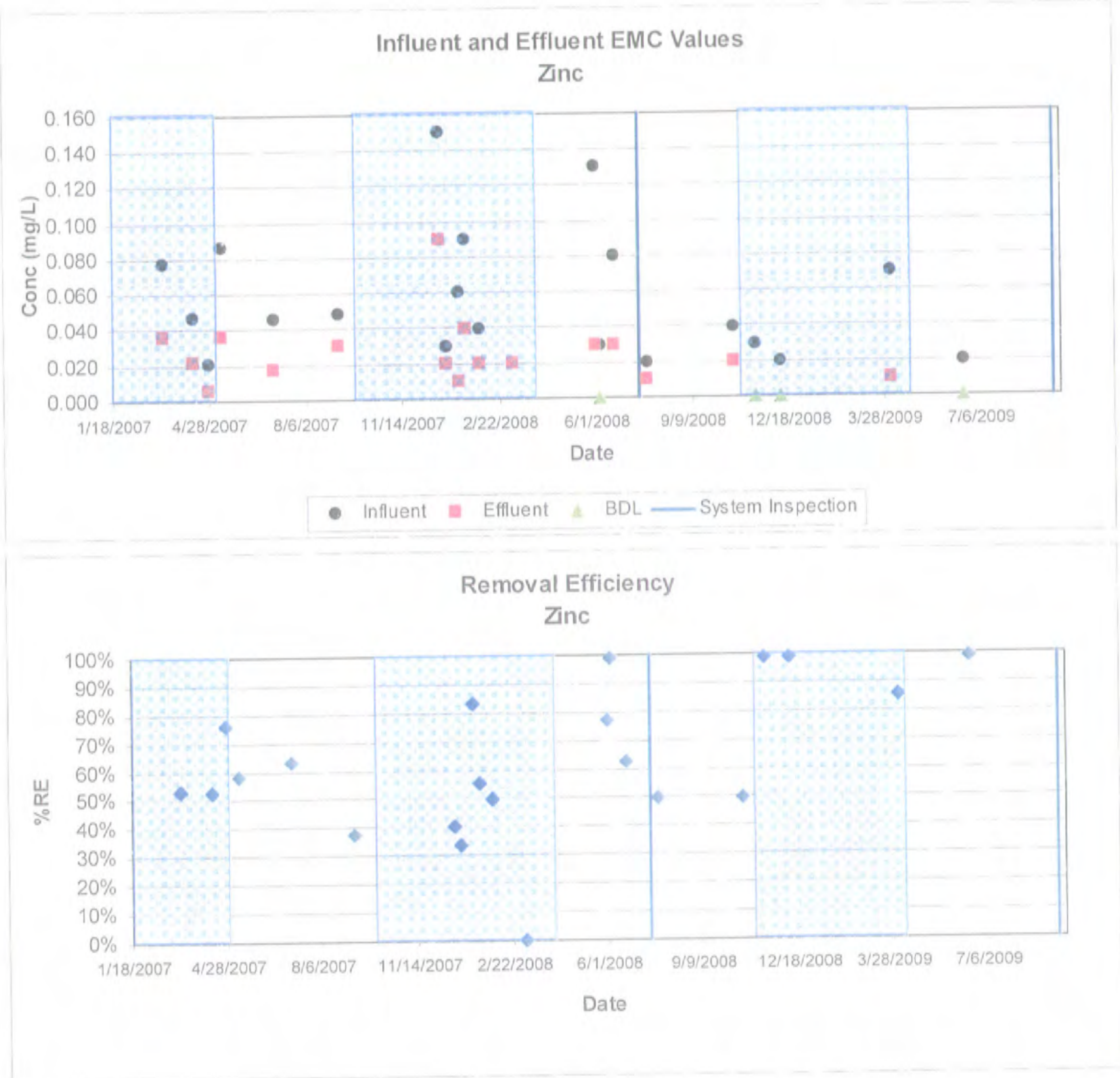


Figure 9: Nitrate Event Mean Concentrations at influent and effluent points and Removal Efficiencies for 18 storm events of the Isolator Row®. A 6-month winter period (Nov-April) is displayed in blue.

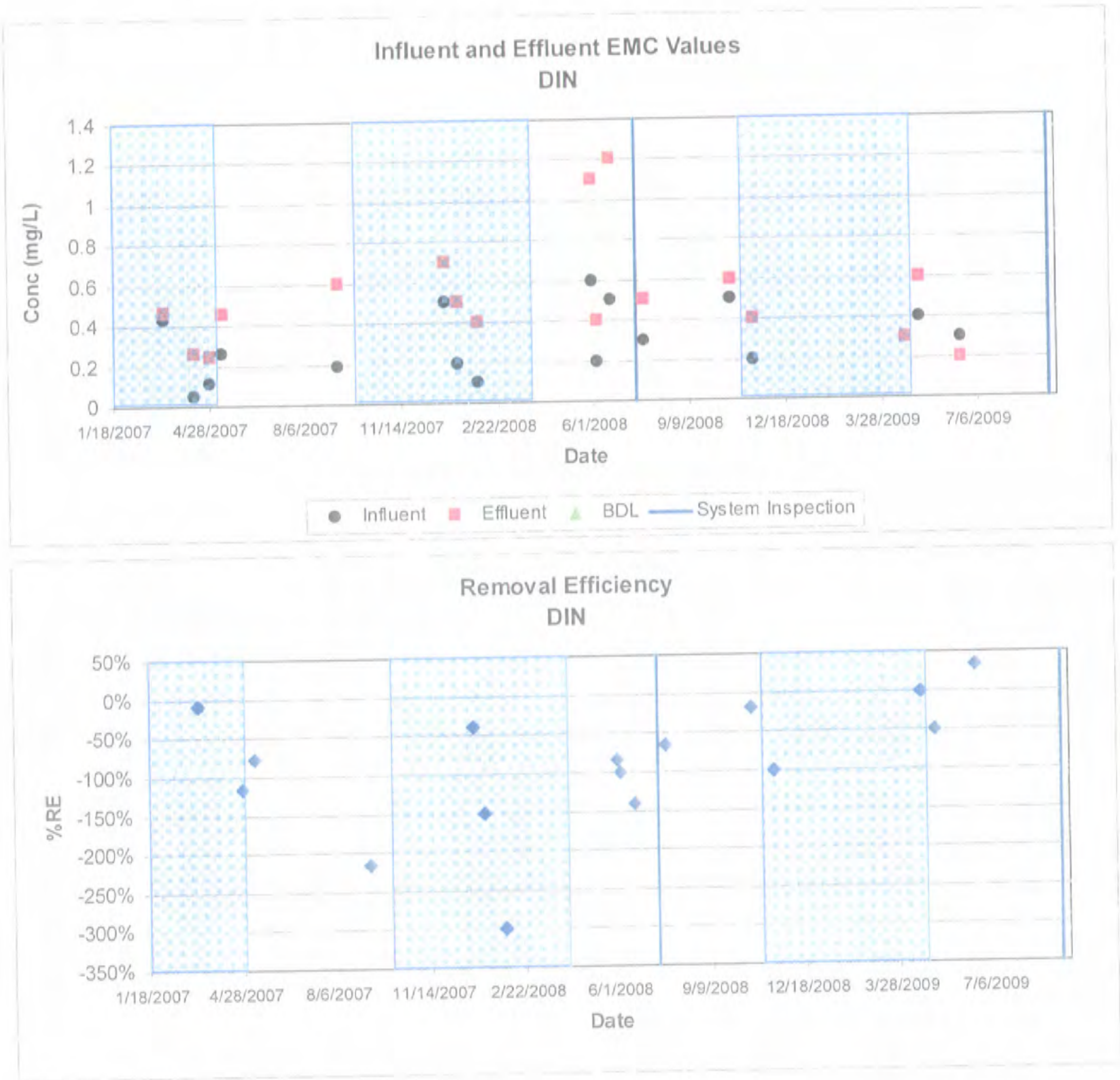


Figure 10: Total Phosphorus Event Mean Concentrations at influent and effluent points and Removal Efficiencies for 23 storm events of the Isolator Row®. A 6-month winter period (Nov-April) is displayed in blue.

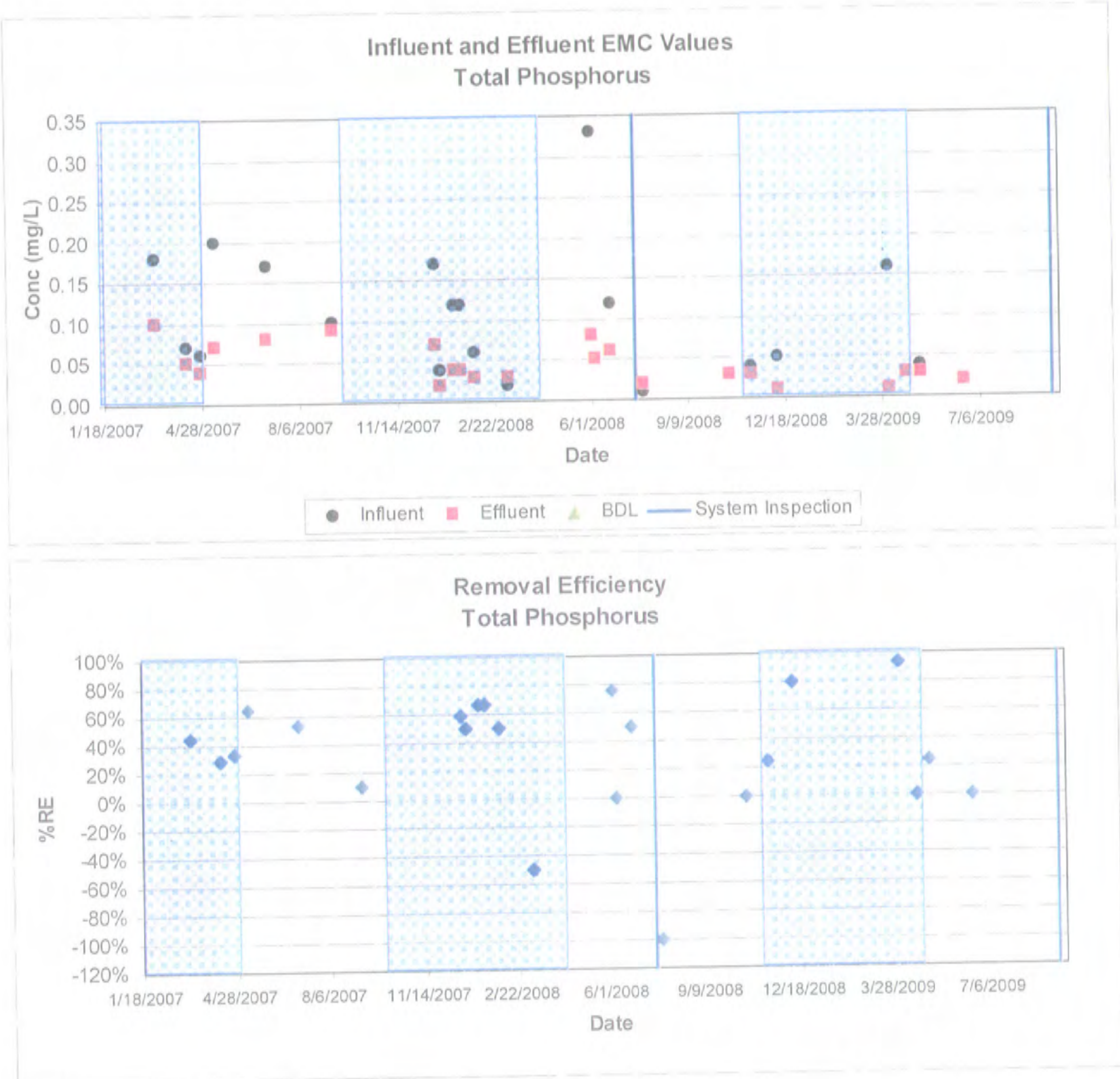


Figure 11: Effluent EMC box and whisker plot comparisons for the range of contaminants for the Isolator Row®. Box reflects the 25th and 75th percentile, the line reflects the median and the whiskers reflect minimum and maximum values of the entire dataset.

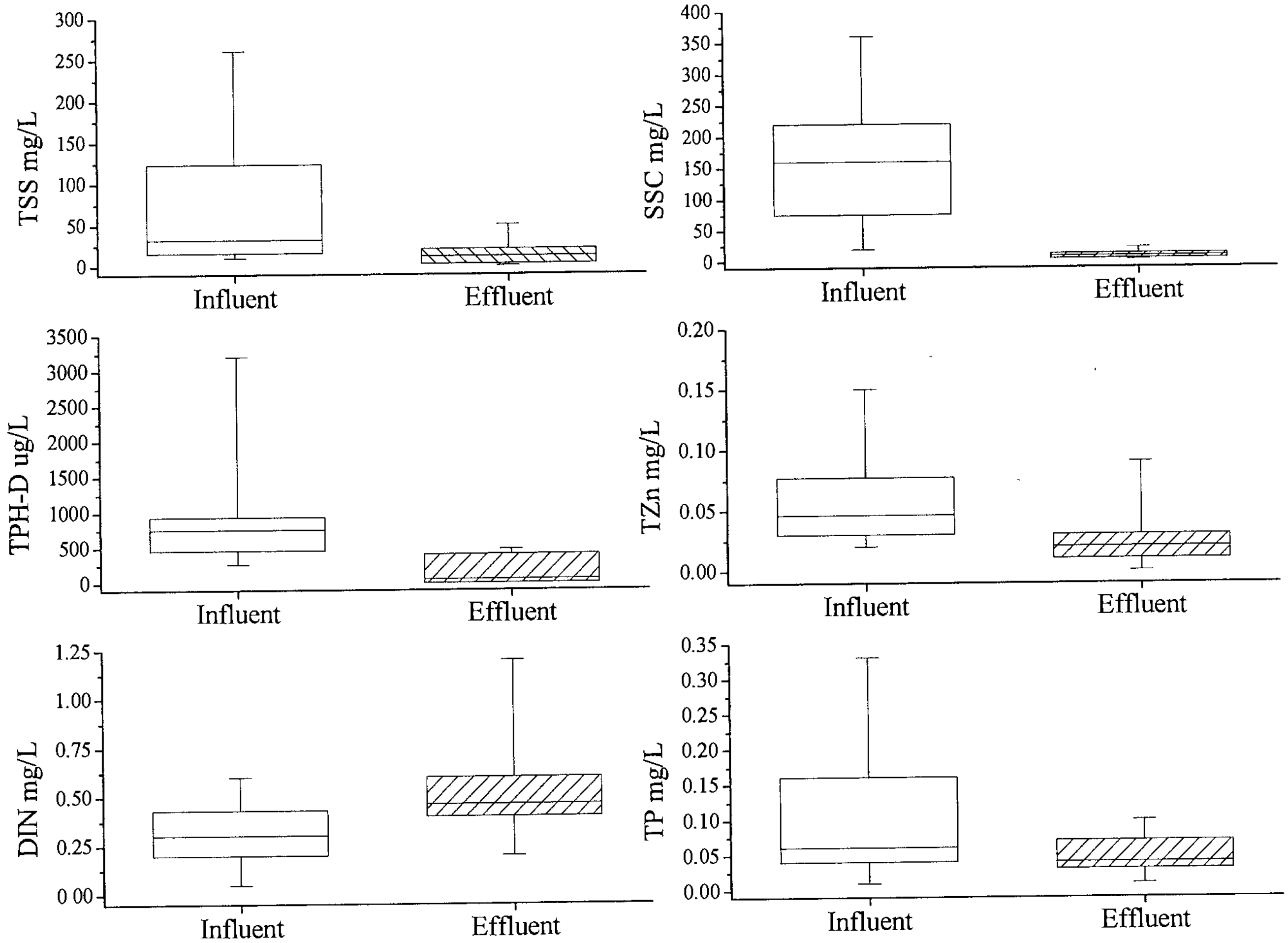


Figure 12: Exceedance probabilities for influent and effluent EMCs for TSS, SSC, TPH-D, TZn, DIN, TP

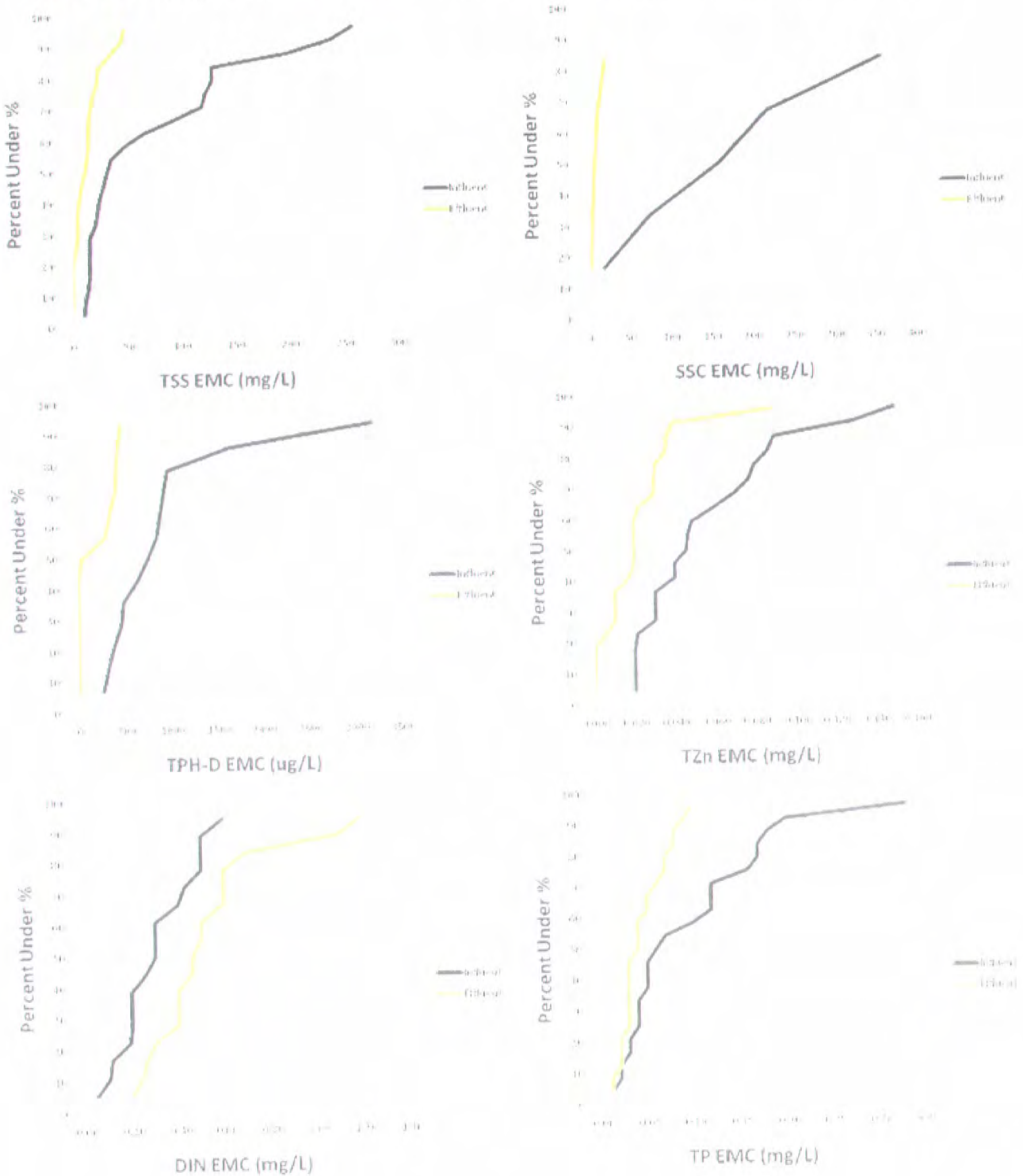


Table 5: Simple statistics for influent and effluent event mean concentrations.

System / Pollutant	Statistic	Influent year 1	StormTech Effluent year 1	Influent year 2	StormTech Effluent year 2	Influent overall	StormTech Effluent overall
TSS (mg/l)	mean	64	16	81	13	73	14
	ER		76%		84%		81%
	AVG RE		66%		73%		69%
	Median RE		83%		83%		83%
	n		11		12		23
	SD	45	14	98	15	76	14
	Cv	0.709	0.867	1.213	1.207	1.049	1.012
TPH-D (ug/l)	mean	1081	269	503	BDL	903.3	186
	ER		75%		99%		79%
	AVG RE		73%		99%		81%
	Median RE		71%		99%		91%
	n		9		4		13
	SD	885	197	242	N/A	783	206
	Cv	0.818	0.734	0.482	N/A	0.867	1.109
DIN (mg/l)	mean	0.23	0.45	0.37	0.59	0.30	0.52
	ER		-97%		-61%		-74%
	AVG RE		-129%		-52%		-97%
	Median RE		-97%		-58%		-80%
	n		8		9		17
	SD	0.16	0.16	0.14	0.34	0.16	0.27
	Cv	0.696	0.345	0.386	0.585	0.535	0.521
TZn (mg/l)	mean	0.063	0.030	0.046	0.012	0.055	0.021
	ER		53%		74%		61%
	AVG RE		50%		72%		60%
	Median RE		53%		81%		57%
	n		11		10		21
	SD	0.036	0.023	0.037	0.012	0.037	0.020
	Cv	0.575	0.770	0.795	1.024	0.665	0.954
TP (mg/l)	mean	0.12	0.06	0.08	0.03	0.09	0.04
	ER		51%		56%		53%
	AVG RE		42%		17%		29%
	Median RE		50%		13%		33%
	n		11		12		23
	SD	0.06	0.03	0.09	0.02	0.08	0.03
	Cv	0.491	0.456	1.221	0.618	0.826	0.579
SSC (mg/l)	mean	No Data		166.70	9.60	166.70	9.60
	ER				94%		94%
	AVG RE				93%		93%
	Median RE				91%		91%
	n				5		5
	SD			132.87	7.92	132.87	7.92
	Cv			0.797	0.825	0.797	0.825

Note: ER = average efficiency ratio; AVG RE = average removal efficiency; median RE= median removal efficiency; n = number of storms; SD = standard deviation; Cv = coefficient of variation

The statistical analyses presented reveal a range of performance trends. Efficiency Ratio (ER) analysis was performed on the final dataset (Table 3). For many stormwater treatment system datasets, ER is a stable estimation of overall treatment performance as it minimizes the impact of low concentration values, or relatively clean storms with low influent EMC concentrations. Where Removal Efficiencies (RE) reflect treatment unit performance on a storm by storm basis, ERs weight all storms equally and reflect overall influent and effluent averages across the entire data set. For this reason they are often discouraged as a performance measure. REs are presented as both an average and median of aggregate storm values. In general, aggregate median RE values are more reliable in highly variable, non-normally distributed datasets such as those experienced in stormwater treatment unit performance studies. A review of REs on a per event basis, ERs for the entire period of monitoring, and EMCs per event and probabilistically over the entire period of monitoring will reveal the measured performance variations attributable to season, flow, concentration, and other factors.

Sediment (TSS and SSC) performance and effluent EMCs reveal strong performance and low effluent concentrations that do not vary significantly across fluxuations in loading concentration, seasons, or time. There is little variation in performance for sediments with respect to influent concentration as can be observed in Figure 10. Mean effluent concentrations were x_{TSS}= 14.0 mg/l +/- 14.0 and x_{SSC}=9.6 +/- 7.9. Median TSS performance was >80% removal for both years, and SSC was >90% for a limited duration of monitoring for the end of year 2. Five of the seven events with poor performance can be attributable to storm events exceeding the water quality design flow (WQF=1 cfs)[4]. There were 3 other events that exceed the WQF that averaged above 80% removal. Total zinc appears to be improving over time presumably with development of the filter cake within the chambers.

TZn performance increased from 53% for year 1 to 81% removal by the end of year 2. TPH removal efficiencies and effluent EMCs demonstrate strong performance that was enhanced over the course of the study. TP removal was moderate at 33% over the course of the study. Performance was higher and effluent EMC's lower as the study progressed. While TPH removals did not indicate seasonal variability, TP results seemed to be influenced by seasonal changes and maintenance intervals although clear trends were unable to be established in this study. The enhancement of treatment over time of these analytes is of interest and seems to be associated with the development of an organic filter cake over the fabric. As the filter cake develops treatment of TPH and Phosphorus is improved.

DIN removal efficiencies and effluent EMCs reveal poor performance and high effluent concentrations relative to influent values indicating that this system offers no identifiable treatment for dissolved inorganic nitrogen.

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[4] Five of the seven events exceeding the water quality design flow had poor performance: 9/9/2007, 12/24/2007, 6/20/2008, 7/23/2008, 4/21/2009

6.2 Particle Size Distributions (PSD) & Sediment Accumulation

Particle size information for 4 influent events was determined by composite samples obtained with an auto-sampler and analyzed by laser diffraction. Particle size ranges in the influent range from 0.01 mm to 0.12 mm, with the median particle size around 0.038 mm (Figure 12). Influent and effluent PSD characterization are created using the same sampling methods. The d15, d50, and d85 runoff particle sizes are 0.015mm, 0.044mm, and 0.130mm respectively. These values represent the mean runoff values for 2006 – 2008.

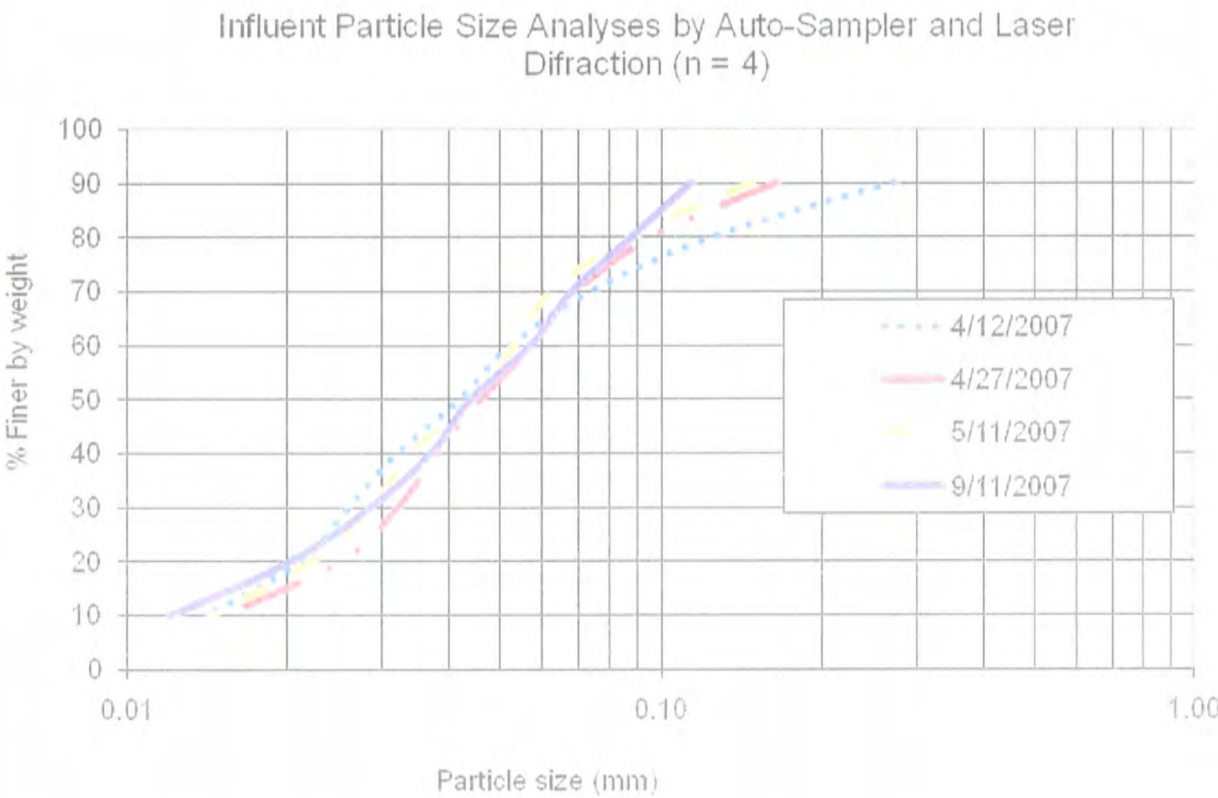


Figure 13: Influent particle size distributions by auto-sampler and laser diffraction for 4 storms

Sediments captured by the Isolator Row® were sampled and analyzed by dry sieve and hydrometer PSD analysis. Grab samples taken at 1 and 2 year monitoring intervals, along the longitudinal centerline at 2 foot and 30 foot locations from the inlet were weighed, dried, and put into a sieve set and shaker. The sieves used were 2mm, 850μm, 425 μm, 250 μm, 150 μm, and 75 μm. Figure 13 presents PSD and hydrometer test results of these sediment samples.

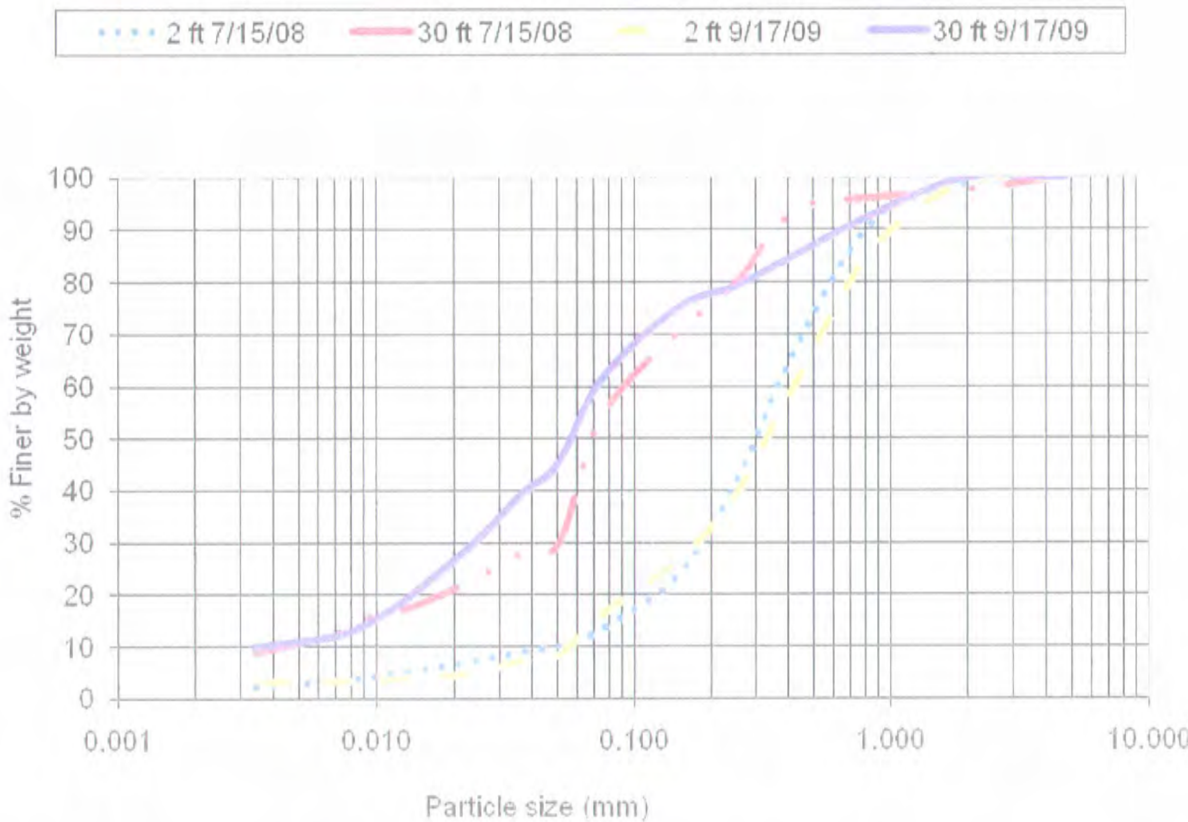


Figure 14: PSD of sediment grab samples taken at 2 feet and 30 feet from the inlet to the Isolator Row.

Depth of sediment accumulation was measured at the same time the sediment grab samples were taken. Comparison of the PSD results taken at the influent by the auto-sampler and by grab sample at 2 feet from the inlet to the chamber show that the sediments filtered out by the system are approximately a magnitude larger at the d50. The data also illustrates a longitudinal differentiation in particle settling in the chamber with larger diameter particles settling toward the front of the system and smaller diameter particles settling toward the back. Figure 15 shows depth of sediment across the longitudinal profile of the system from 2 feet to 30 feet from the inlet. The chart shows a consistent sediment depth over the 2 year monitoring period except at the 30 foot mark. An increase in depth at the 10 foot mark represents consistent sediment deposition due to flow dissipation. At the 30 foot mark there is an increase in sediment depth from 0.25 in to 1.17 in. This is likely due to sediment being pushed towards the back of the system as it experiences more intense events.

The total sediment accumulation of 1.2 inches from September 2006 September 2009, is nearly half of the manufacturers recommended depth for maintenance (3 inches). By this measure, it

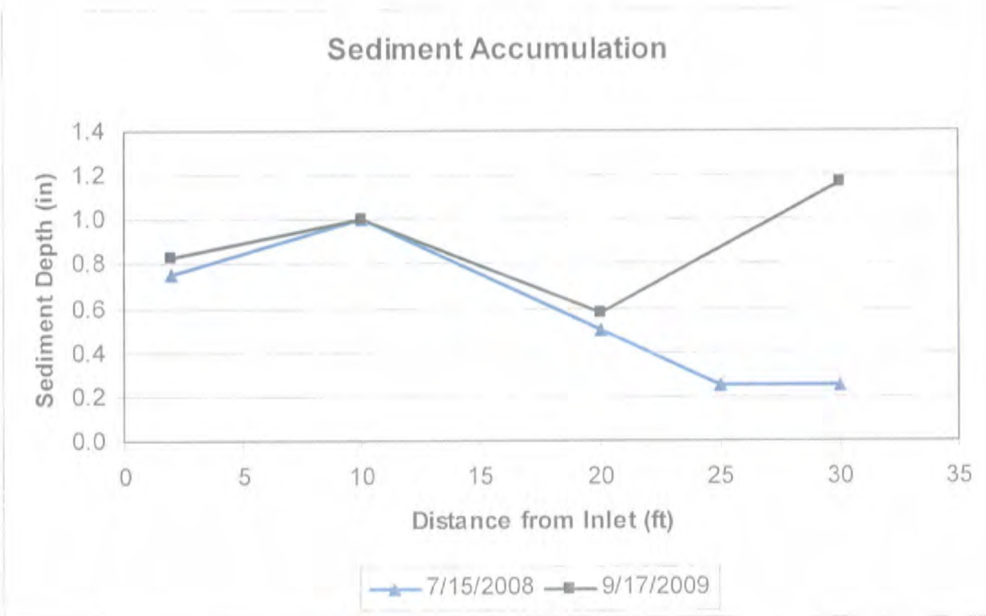


Figure 15: Record of sediment depth inside the StromTech Isolator Row at 1 and 2 year monitoring intervals.

would take another 3 years of operation before maintenance would be required, or a total of 6 years of operation.

6.4 Analysis of Water Level Drain Down

The rate of water level drain down in the Isolator Row® system is a function of depth of water (driving head) and the hydraulic conductivity of the confining layer. Initially the confining layer is the geotextile, and then becomes controlled by the development of a filter cake on top of the geotextile. The maximum specific discharge (or hydraulic conductivity) reported here (q_{max}) is calculated as discharge per square foot of filter area value (gpm/ft^2) for 12 of the monitored storms and is plotted in Figure 16. The bypass weir elevation as measured from the bottom of the chamber (27.7 in), the top of Isolator Row® chamber (30.0 in), and a sandy soil (8 in/hr or 0.08 gpm/ft^2) are plotted for reference. The plot indicates reduction in filter capacity over time. Figure 17 plots q_{max} along with the recorded maximum water depth within the Isolator Row® chamber for each of the 12 storms. Drain down for 12 storms are attached as Appendix A. These drain down plot the effluent flows along the left y-axis and water level and stage-discharge along the right y-axis versus time. Note, the stage-discharge values have been scaled up by a factor of 10 in order to display clearly.

Rate and trend of clogging was examined by monitoring of drain down for events at or near the maximum treatment flow rate. The maximum treatment flow rate for the system was calculated for seven events when in-system depths were at or near the maximum depth as regulated by the bypass (27.7 inches). Figure 16 illustrates the seven events of maximum treatment flow rate versus q_{max}, and a linear regression trendline. Examination of the linear regression shows a relatively weak correlation (r^2=0.337) due largely to the limited number of

Table 6: Tabular values for in-system hydraulic conductivity calculations

Storm Date	Effluent Peak Flow (gpm)	q max	max depth (in)	q max / max depth	Season	Antecedent Dry Period (days)
7/4/2007	80.8	0.53	20.88	0.31	Summer	13.0
12/24/2007	110.4	0.73	27.48	0.35	Winter	2.5
12/29/2007	26.0	0.17	18.00	0.12	Winter	1.5
5/31/2008	7.0	0.05	21.36	0.04	Spring	3.5
11/13/2008	23.5	0.16	18.96	0.12	Fall	3.5
12/10/2008	64.4	0.43	24.72	0.25	Winter	0.5
4/3/2009	73.8	0.49	29.52	0.22	Spring	0.5
5/5/2009	56.8	0.38	28.80	0.20	Spring	3.5
5/27/2009	32.5	0.21	27.96	0.12	Spring	9.0
6/9/2009	13.9	0.09	13.08	0.19	Spring	7.5
6/11/2009	82.2	0.54	29.76	0.28	Spring	1.5
6/18/2009	91.9	0.61	30.84	0.33	Spring	3.5

events where maximum depth at or near bypass was observed (seven of twelve). The regression was only applied to these seven events were driving head would all be nearly equivalent. Hydraulic conductivity is dependent on driving head and therefore needs to be constant.

For comparative purposes, the linear regression was solved for a condition where the filter efficiency would be equal to a sandy soil reference condition. Given the current trendline, the filter will have reduced to the reference condition (sandy soil) by September 2010, 4 years after installation (September 2006). This point does not necessarily indicate the need for maintenance, but does indicate an 89% reduction in filter efficiency by September 2010. This maintenance requirement point could be determined by monitoring of water quality and occurrence of bypass. This is not the same as a reduction in initial maximum treatment flow rate. That point is not known for the starting condition, but was determined from 12/2007-6/2009.

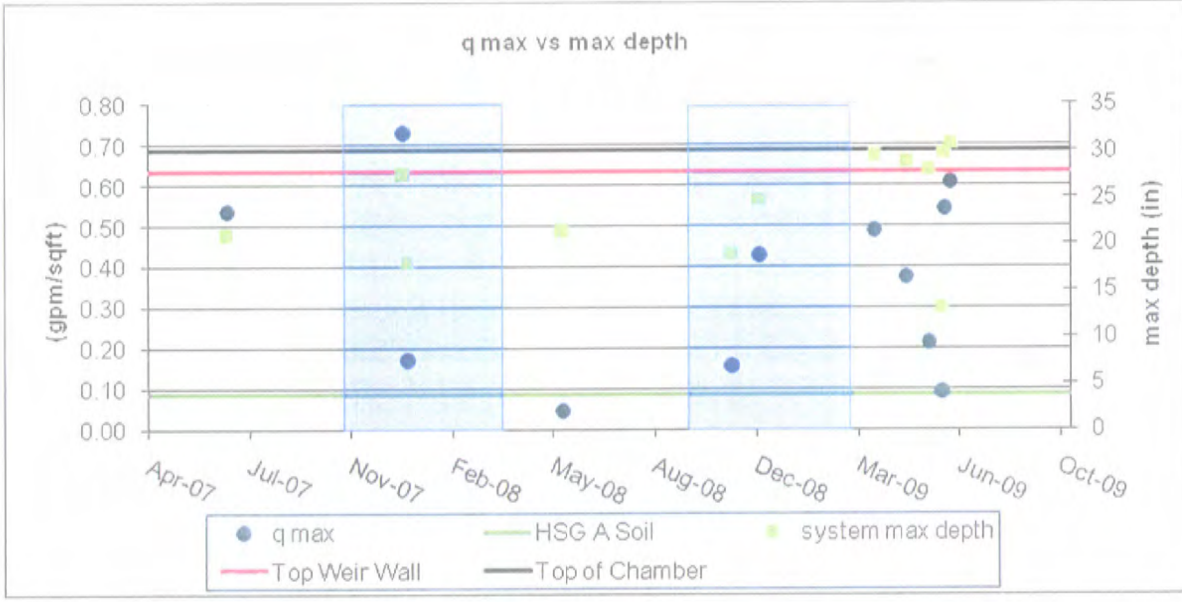


Figure 16: Plot of the stage-discharge and maximum water level measured for 12 monitored storm events. Also plotted are the hydraulic conductivity of an HSG A soil and relative elevations of the bypass weir wall and the top of the Isolator Row chamber all as horizontal lines.

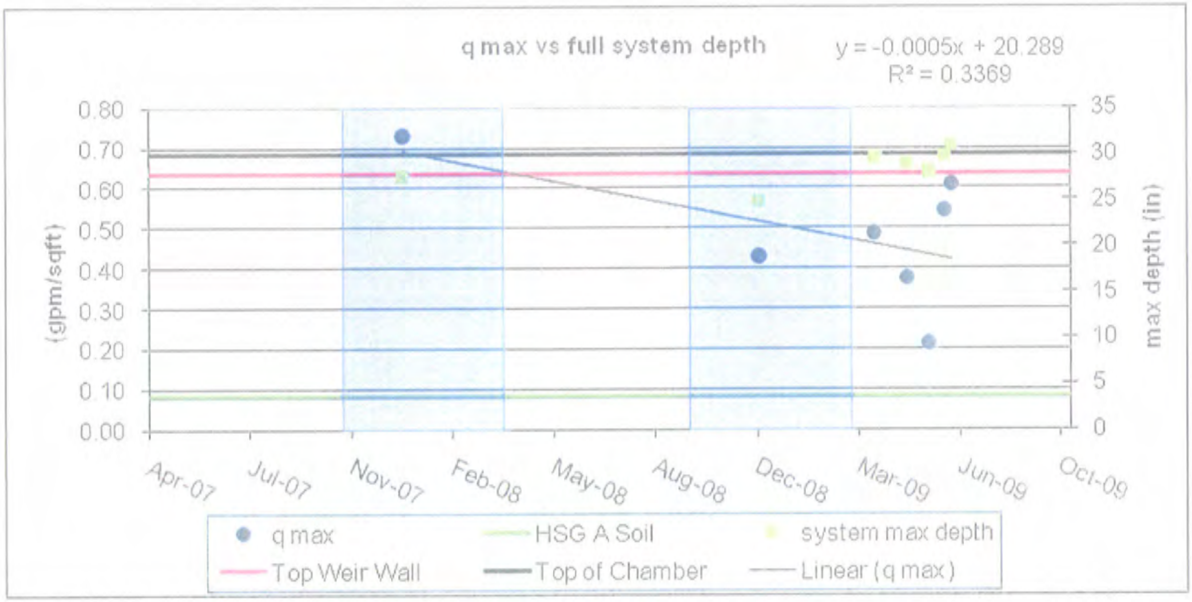


Figure 17: Plot of the stage-discharge and maximum water level measured for 7 monitored storm events with equal system depths (elevation of weir wall crest +/- 3 in.). A trendline showing gradual decline in q max is plotted with its regression equation.

6.5 INDIVIDUAL STORM REPORTS

Individual storm reports (ISR) are presented for two storms, May 5, 2009 and June 18, 2009. The ISR's illustrate performance, with respect to storm characteristics, and provide detailed information on storm coverage and sampling . Both storms exceeded the design flow rate of 448 gpm. The May5, 2009 storm was a relatively clean storm with influent TSS =23 mg/l, good removal performance was observed at 78%, and an effluent concentration of 5 mg/l. This is quite good considering both the high flow and low concentration. The June 18 storm had a high influent concentration TSS=260 mg/l, a 97% removal performance, and 9 mg/l effluent concentration was observed. Both events were less than 10 mg/l, commonly considered to be the lowest reasonable treatment threshold, sometimes referred to as irreducible concentration[5].

7.0 SUMMARY AND CONCLUSIONS

A five chamber configuration of the StormTech Isolator Row® showed strong water quality treatment performance for the three year installation. Sediment (TSS and SSC) performance and effluent EMCs reveal strong performance and low effluent concentrations that do not vary significantly across fluxuations in loading concentration, seasons, or time. The influent sediment concentrations for the period of monitoring were TSS median =32.0 mg/l, an average of 73.0 mg/l ±76.0, and for SSC a median =160.0 mg/l, and an average of 166.7 mg/l ±132.9 was observed. A median effluent concentration of TSS=12.0 mg/l, an average of 14.0 mg/l ±14.0, and a median removal efficiency of 83% was observed. A median effluent concentration of SSC=8.0 mg/l, an average of 9.6 mg/l ±7.9, and a median removal efficiency of 91% was observed. Five of the seven events with poor performance were attributed to events exceeding the water quality design flow (WQF=1 cfs). Metals performance as measured by TZn increased from 53% for year 1 to 81% removal by the end of year 2. TPH performance was very strong at 91% removal and TP removal was modest at 33%. As would be expected for non-vegetated filtration systems, dissolved inorganic nitrogen (DIN = NO3, N02, NH4) removal efficiencies and effluent EMCs reveal poor performance and high effluent concentrations relative to influent values. After 3 years of installation, sediment depths had accumulated to 1.2 in, only half of the manufacturers recommended depth for maintenance (3 inches). Presumably treatment performance will continue to improve with increase filter cake development, as will incident of bypass.

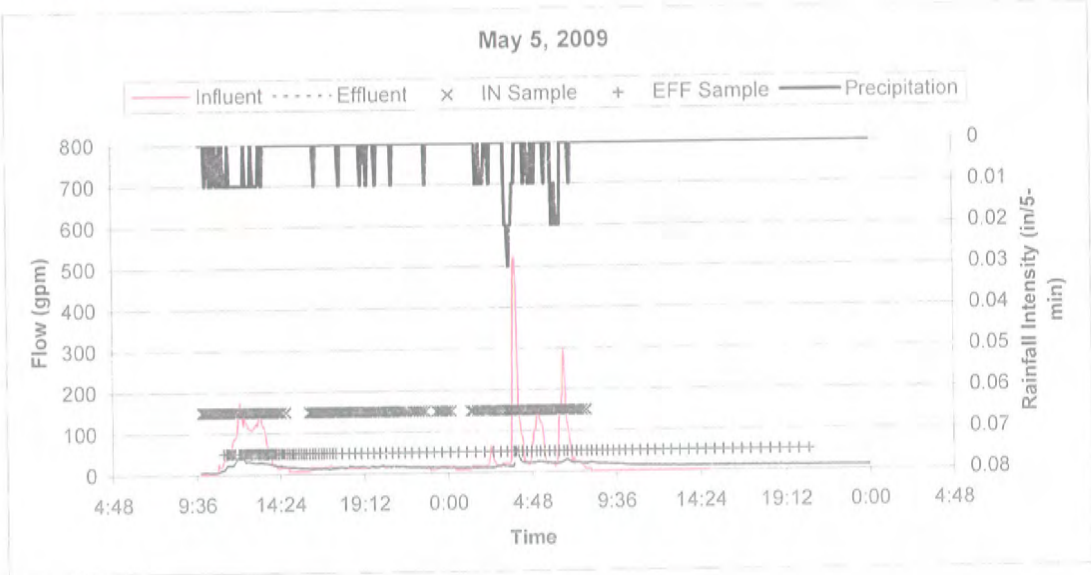
[5] Schueler, T. (2000). "National Pollutant Removal Database: for Stormwater Treatment Practices." Center for Watershed Protection.

General Information

Site: University of New Hampshire Stormwater Center, Durham, NH
System Description: 5 x 40 Stormtech Infiltation Chamber
Event Date: 5/5/2010
Date of Last Maintenance: Never been maintained. Installed September 2006
Antecedent Conditions: 3.5 days

Hydrology	Influent	Effluent	Bypass
Total Precipitation (in):	0.72		
Peak Flow, (gpm):	521	57	246
Total Runoff Volume (gal):	54,180	36,139	15,281
SF Vol. Coverage (nearest 10%):	99.9%	100.0%	

Event Hydrograph



Analytical
Number of Aliquots
Influent: 200
Effluent: 129

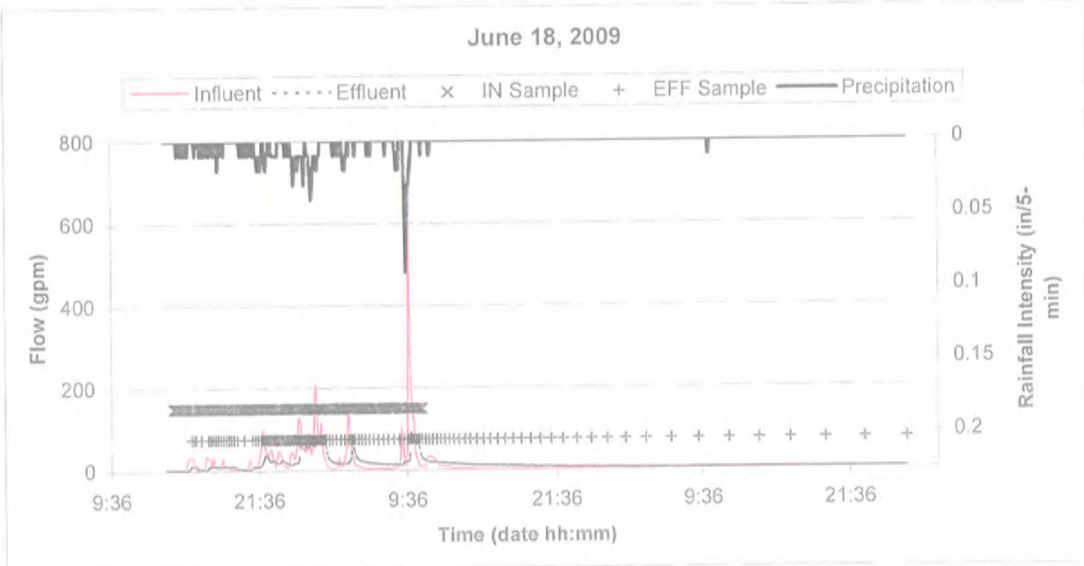
Parameter	Influent	RDL	Effluent	RDL	RE%
TSS (mg/L)	23	2	5	1	78%
TPH-D (ug/L)	310	290	< 330	330	99%
DIN (mg/L)	0.40	0.1	0.60	0.1	-50%
TZn (mg/L)	< 0.05	0.05	< 0.05	0.05	BDL
TP (mg/L)	0.04	0.01	0.03	0.01	25%

General Information

Site:	University of New Hampshire Stormwater Center, Durham, NH
System Description:	5 x 40 Stormtech Infiltation Chamber
Event Date:	6/18/2009
Date of Last Maintenance:	Never been maintained. Installed September 2006
Antecedent Conditions:	3.5 days

Hydrology	Influent	Effluent	Bypass
Total Precipitation (in):	1.46		
Peak Flow, (gpm):	590	92	100
Total Runoff Volume (gal):	42,092	38,295	1,398
SF Vol. Coverage (nearest 10%):	94.2%	100.0%	100.0%

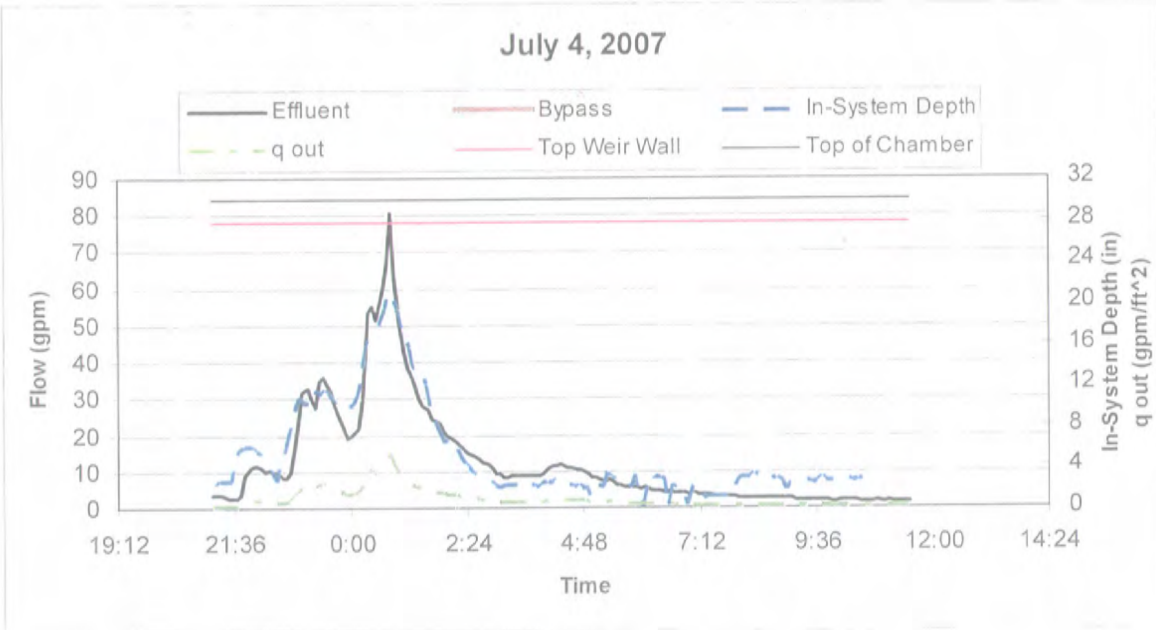
Event Hydrograph

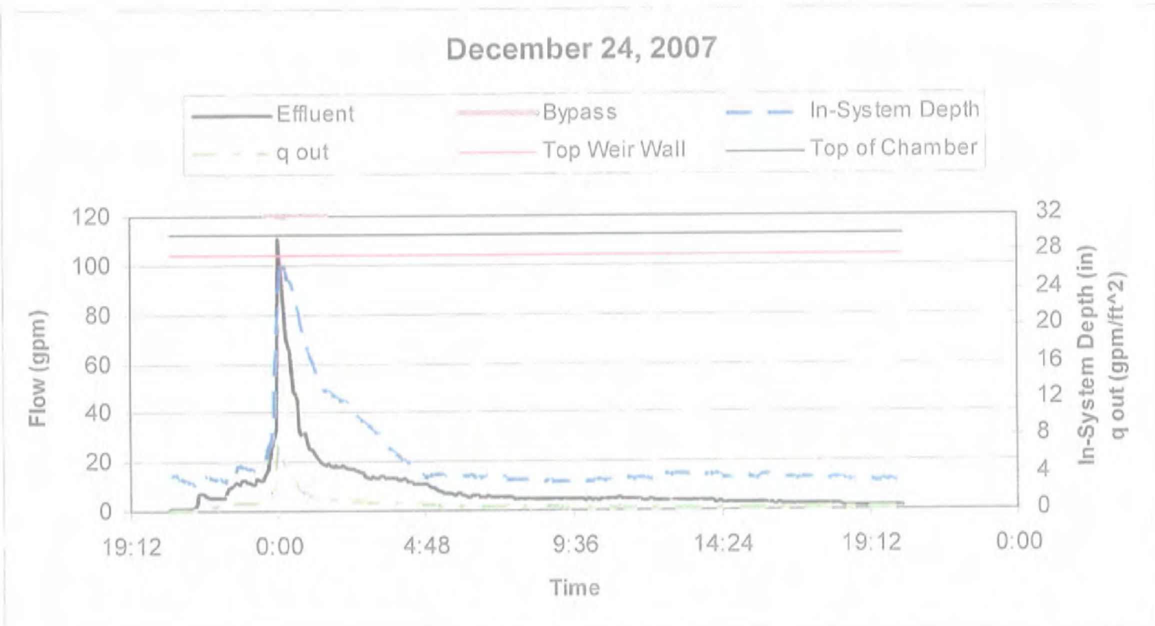


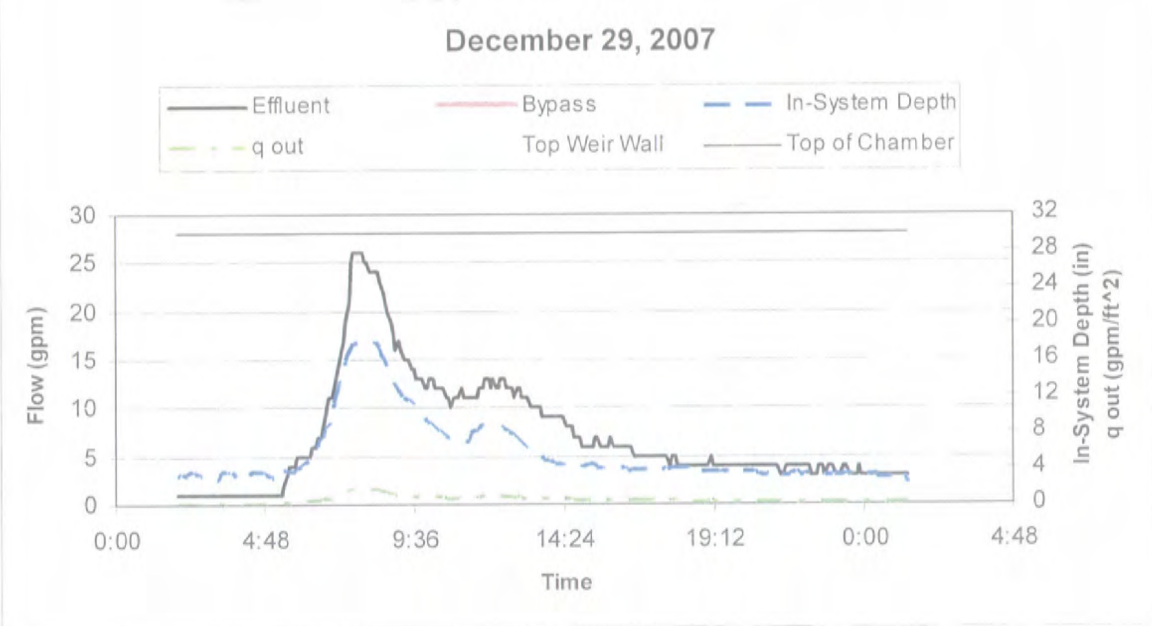
Analytical
Number of Aliquots
Influent: 240
Effluent: 150

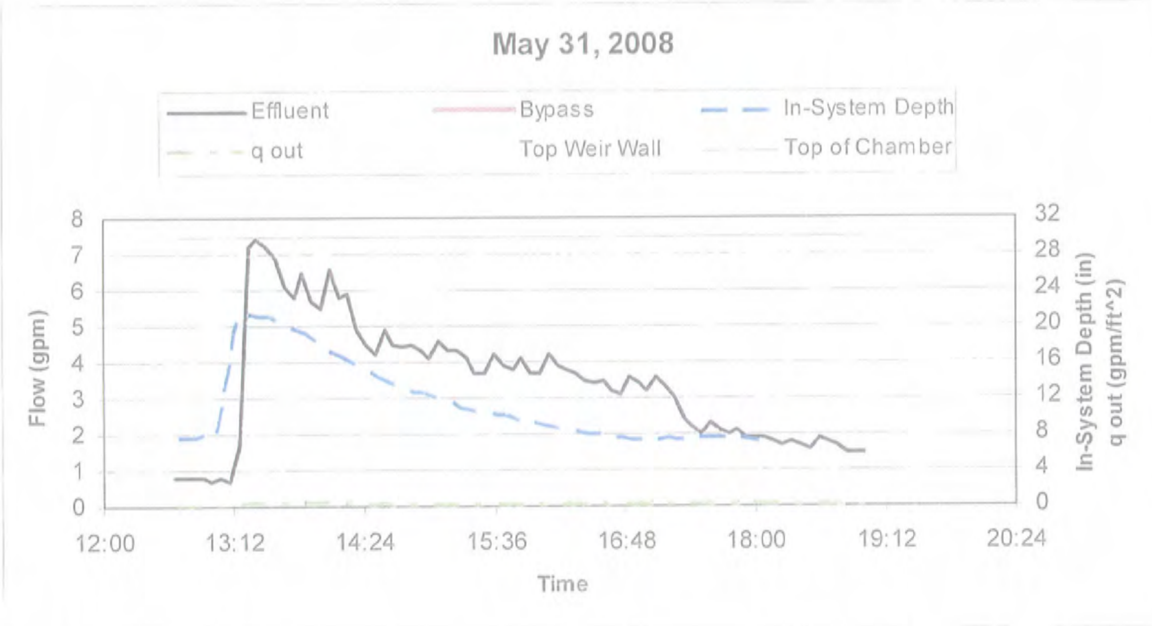
Parameter	Influent	RDL	Effluent	RDL	RE%
TSS (mg/L)	260	1	9	1	97%
TPH-D (ug/L)	< 400	400	< 300	300	BDL
DIN (mg/L)	0.30	0.1	0.20	0.1	33%
TZn (mg/L)	0.020	0.01	BDL	0.01	99%
TP (mg/L)	0.02	0.01	0.02	0.01	0%

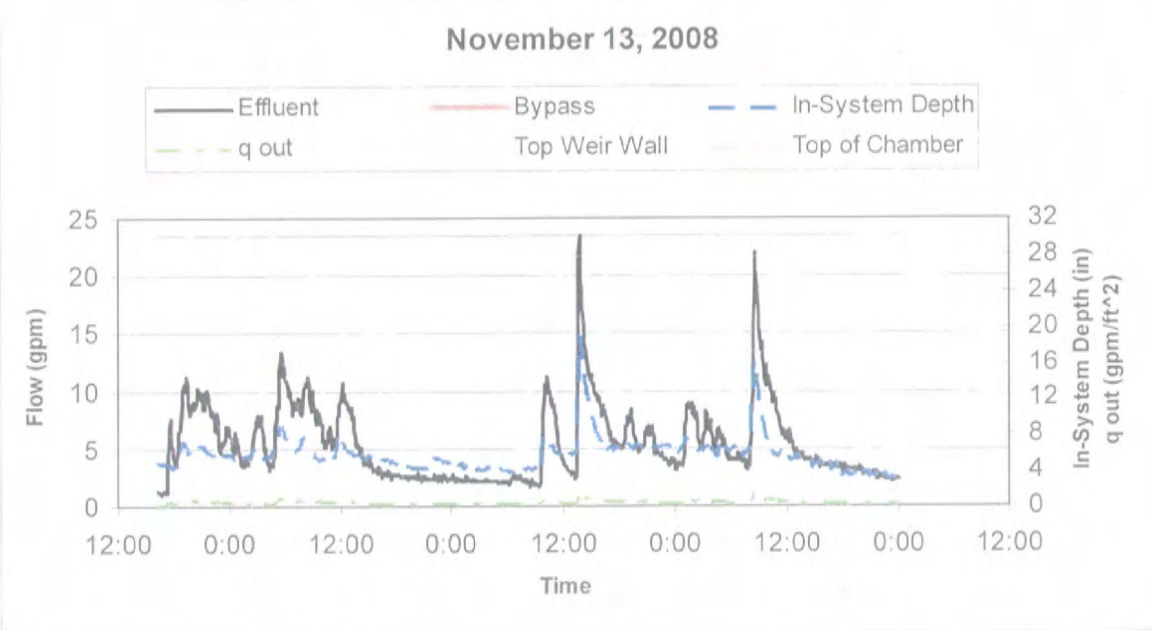
APPENDIX A: DRAIN DOWN AND FILTER CAPACITY PLOTS FOR 12 MONITORED STORM EVENTS.



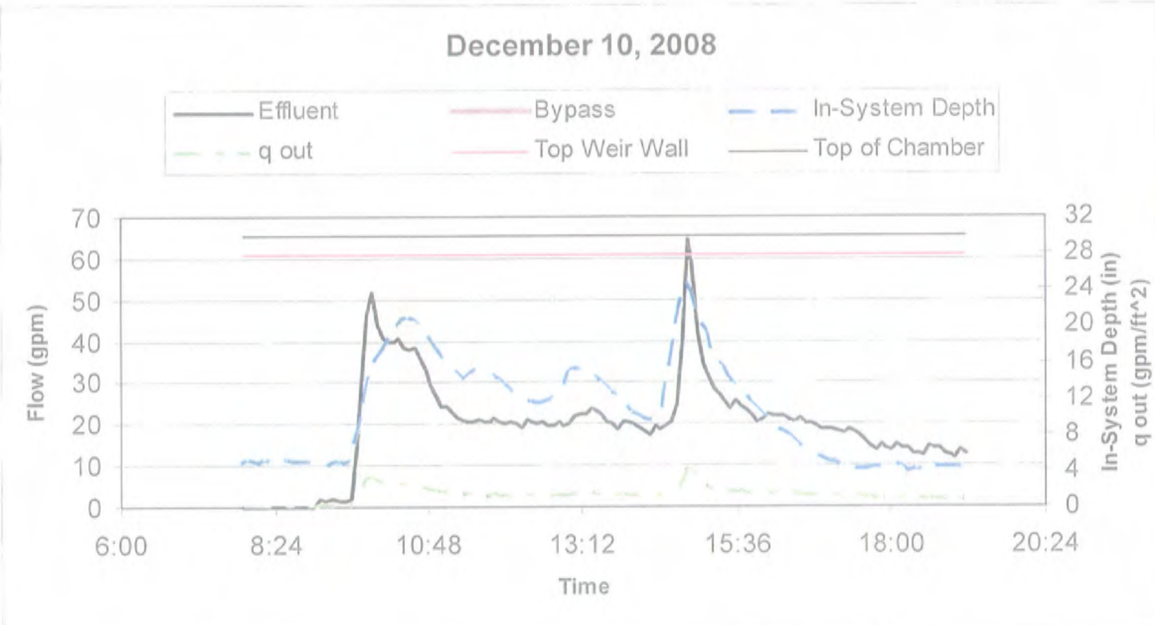



December 29, 2007
Effluent
Bypass
In-System Depth
q out
Top Weir Wall
Top of Chamber
Flow (gpm)
In-System Depth (in)
q out (gpm/ft^2)
30
25
20
15
10
5
0
32
28
24
20
16
12
8
4
0
0:00
4:48
9:36
14:24
19:12
0:00
4:48
Time

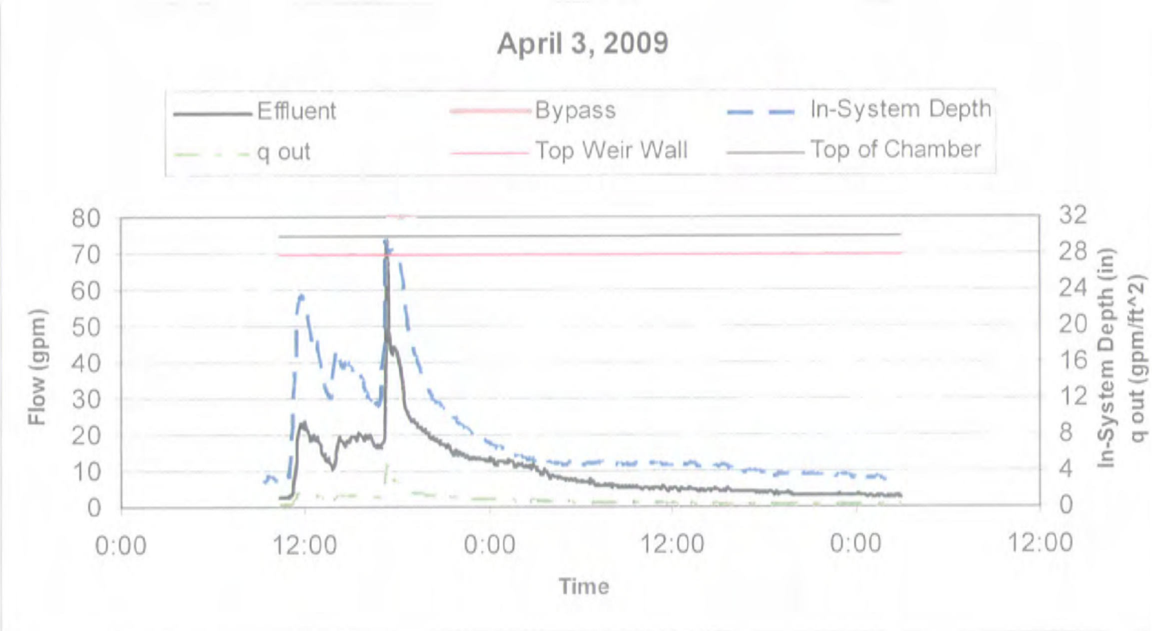

May 31, 2008
Effluent
Bypass
In-System Depth
q out
Top Weir Wall
Top of Chamber
Flow (gpm)
In-System Depth (in)
q out (gpm/ft^2)
8
7
6
5
4
3
2
1
0
32
28
24
20
16
12
8
4
0
12:00
13:12
14:24
15:36
16:48
18:00
19:12
20:24
Time

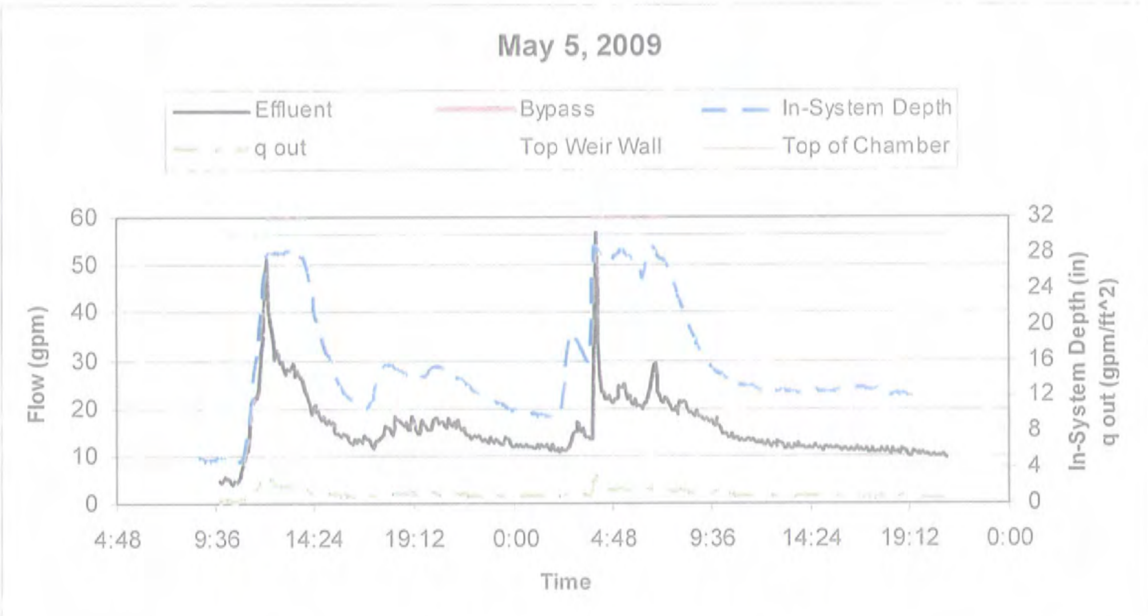


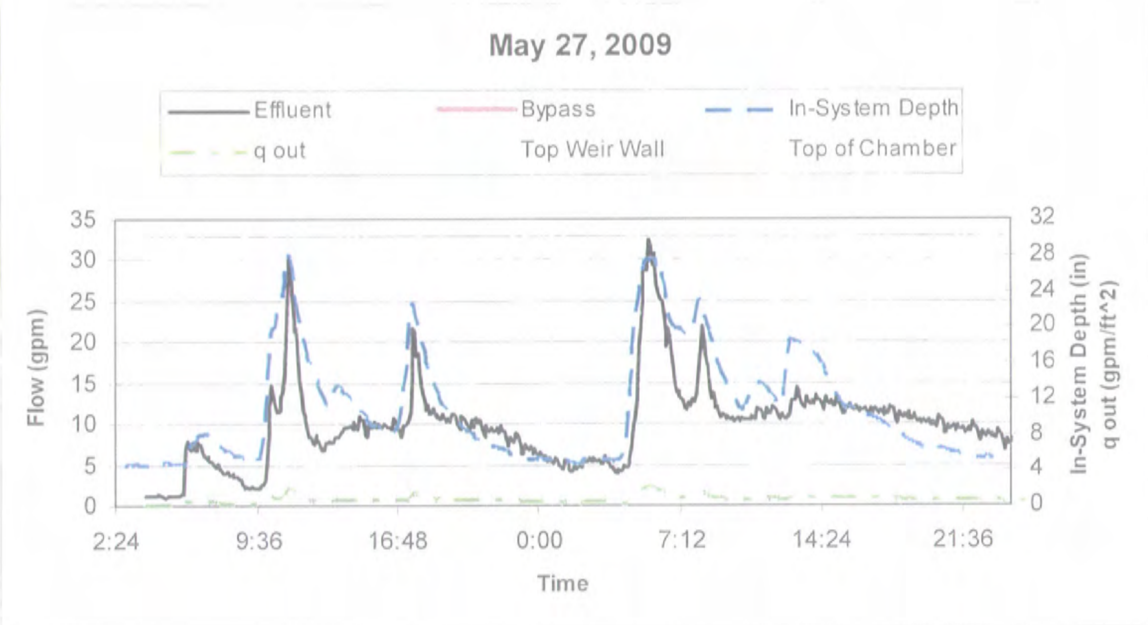
November 13, 2008
Effluent
Bypass
In-System Depth
q out
Top Weir Wall
Top of Chamber
Flow (gpm)
25
20
15
10
5
0
12:00
0:00
12:00
0:00
12:00
0:00
12:00
0:00
12:00
Time
32
28
24
20
16
12
8
4
0
In-System Depth (in)
q out (gpm/ft^2)

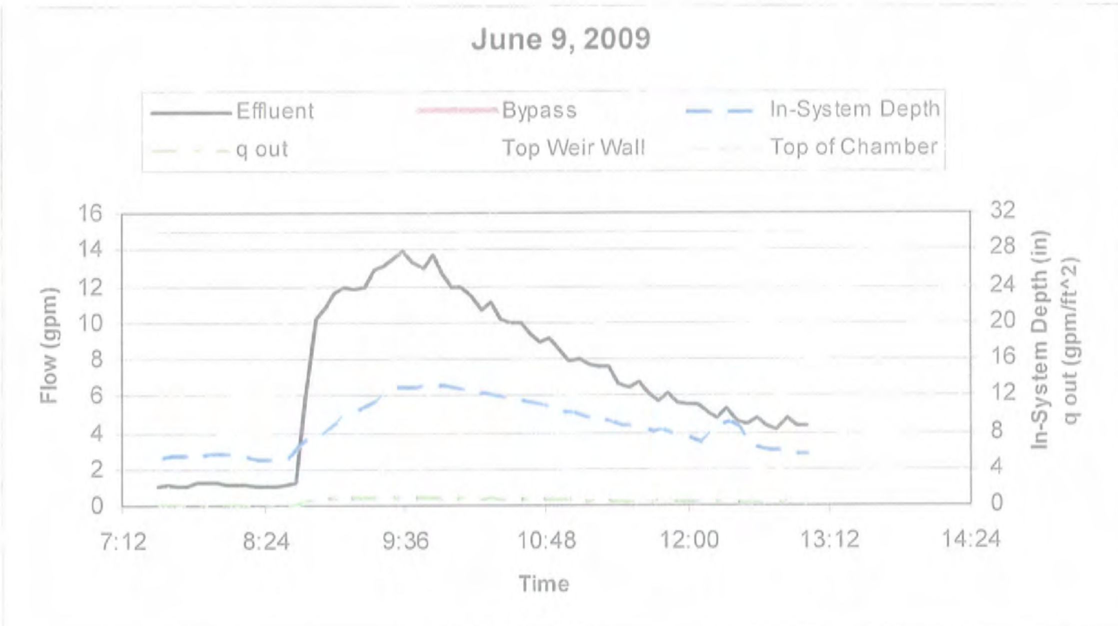


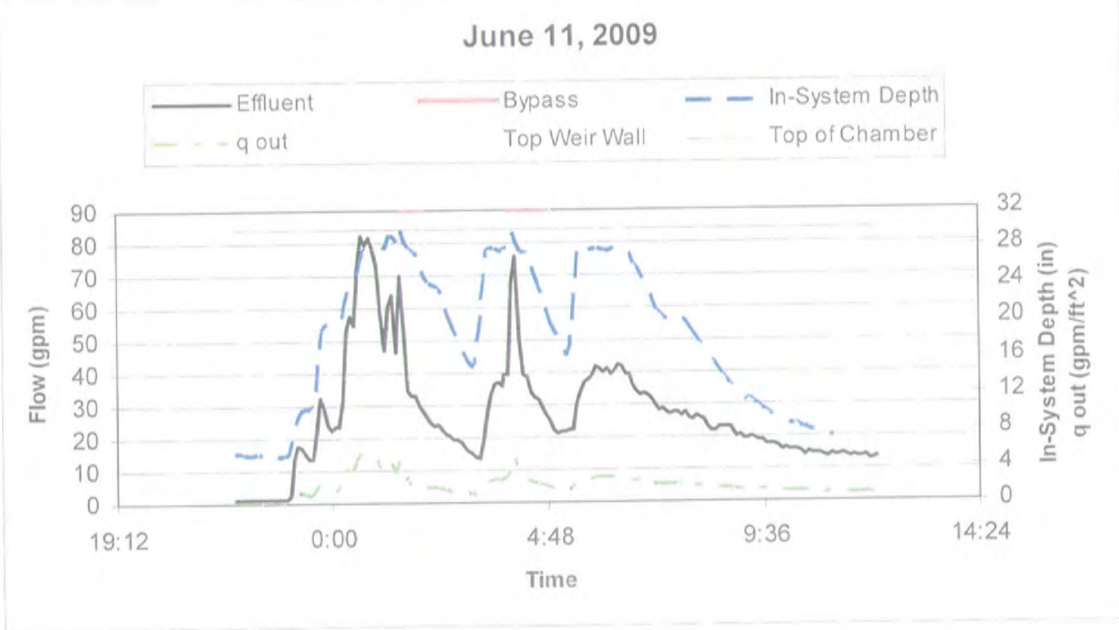
December 10, 2008
Effluent
Bypass
In-System Depth
q out
Top Weir Wall
Top of Chamber
Flow (gpm)
70
60
50
40
30
20
10
0
6:00
8:24
10:48
13:12
15:36
18:00
20:24
Time
32
28
24
20
16
12
8
4
0
In-System Depth (in)
q out (gpm/ft^2)


April 3, 2009
Effluent
Bypass
In-System Depth
q out
Top Weir Wall
Top of Chamber
80
70
60
50
40
30
20
10
0
Flow (gpm)
32
28
24
20
16
12
8
4
0
In-System Depth (in)
q out (gpm/ft^2)
0:00
12:00
0:00
12:00
0:00
12:00
Time

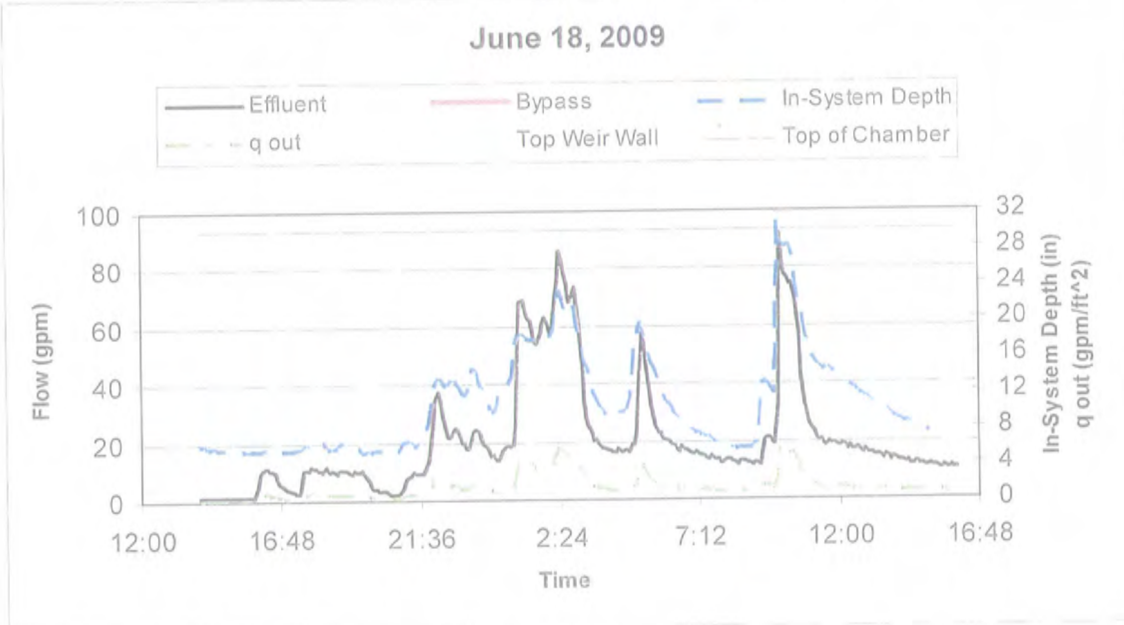

May 5, 2009
Effluent
Bypass
In-System Depth
q out
Top Weir Wall
Top of Chamber
60
50
40
30
20
10
0
Flow (gpm)
32
28
24
20
16
12
8
4
0
In-System Depth (in)
q out (gpm/ft^2)
4:48
9:36
14:24
19:12
0:00
4:48
9:36
14:24
19:12
0:00
Time


May 27, 2009
Effluent
Bypass
In-System Depth
q out
Top Weir Wall
Top of Chamber
Flow (gpm)
In-System Depth (in)
q out (gpm/ft^2)
35
30
25
20
15
10
5
0
32
28
24
20
16
12
8
4
0
2:24
9:36
16:48
0:00
7:12
14:24
21:36
Time


June 9, 2009
Effluent
Bypass
In-System Depth
q out
Top Weir Wall
Top of Chamber
Flow (gpm)
In-System Depth (in)
q out (gpm/ft^2)
16
14
12
10
8
6
4
2
0
32
28
24
20
16
12
8
4
0
7:12
8:24
9:36
10:48
12:00
13:12
14:24
Time



June 11, 2009
Effluent
Bypass
In-System Depth
q out
Top Weir Wall
Top of Chamber
90
80
70
60
50
40
30
20
10
0
Flow (gpm)
32
28
24
20
16
12
8
4
0
In-System Depth (in)
q out (gpm/ft^2)
19:12
0:00
4:48
9:36
14:24
Time



June 18, 2009
Effluent
Bypass
In-System Depth
q out
Top Weir Wall
Top of Chamber
100
80
60
40
20
0
Flow (gpm)
32
28
24
20
16
12
8
4
0
In-System Depth (in)
q out (gpm/ft^2)
12:00
16:48
21:36
2:24
7:12
12:00
16:48
Time

APPENDIX B: MANUFACTURERS PRODUCT SPECIFICATIONS, DRAWINGS, GENERAL NOTES, OPERATIONS AND MAINTENANCE MANUAL

STORMTECH PRODUCT SPECIFICATIONS

1.0 GENERAL

1.1 STORMTECH CHAMBERS ARE DESIGNED TO CONTROL STORMWATER RUNOFF. AS A SUBSURFACE RETENTION SYSTEM, STORMTECH CHAMBERS RETAIN AND ALLOW EFFECTIVE INFILTRATION OF WATER INTO THE SOIL. AS A SUBSURFACE DETENTION SYSTEM, STORMTECH CHAMBERS DETAIN AND ALLOW FOR THE METERED FLOW OF WATER TO AN OUTFALL.

2.0 CHAMBER PARAMETERS

2.1 THE CHAMBER SHALL BE INJECTION MOLDED OF POLYPROPYLENE RESIN TO BE INHERENTLY RESISTANT TO ENVIRONMENTAL STRESS CRACKING (ESCR), AND TO MAINTAIN ADEQUATE STIFFNESS THROUGH HIGHER TEMPERATURES EXPERIENCED DURING INSTALLATION AND SERVICE.

2.2 THE NOMINAL CHAMBER DIMENSIONS OF THE STORMTECH SC-740 SHALL BE 30.0 INCHES TALL, 51.0 INCHES WIDE AND 90.7 INCHES LONG. THE NOMINAL CHAMBER DIMENSIONS OF THE STORMTECH SC-310 SHALL BE 16.0 INCHES TALL, 34.0 INCHES WIDE AND 90.7 INCHES LONG. THE INSTALLED LENGTH OF A JOINED CHAMBER SHALL BE 85.4 INCHES.

2.3 THE CHAMBER SHALL HAVE A CONTINUOUSLY CURVED SECTION PROFILE.

2.4 THE CHAMBER SHALL BE OPEN-BOTTOMED.

2.5 THE CHAMBER SHALL INCORPORATE AN OVERLAPPING CORRUGATION JOINT SYSTEM TO ALLOW CHAMBER ROWS OF ALMOST ANY LENGTH TO BE CREATED. THE OVERLAPPING CORRUGATION JOINT SYSTEM SHALL BE EFFECTIVE WHILE ALLOWING A CHAMBER TO BE TRIMMED TO SHORTEN ITS OVERALL LENGTH.

2.6 THE NOMINAL STORAGE VOLUME OF A JOINED STORMTECH SC-740 CHAMBER SHALL BE 74.9 CUBIC FEET PER CHAMBER WHEN INSTALLED PER STORMTECH'S TYPICAL DETAILS (INCLUDES THE VOLUME OF CRUSHED ANGULAR STONE WITH AN ASSUMED 40% POROSITY). THIS EQUATES TO 2.2 CUBIC FEET OF STORAGE/SQUARE FOOT OF BED. THE NOMINAL STORAGE VOLUME OF AN INSTALLED STORMTECH SC-310 CHAMBER SHALL BE 31.0 CUBIC FEET PER CHAMBER WHEN INSTALLED PER STORMTECH'S TYPICAL DETAILS (INCLUDES THE VOLUME OF CRUSHED ANGULAR STONE WITH AN ASSUMED 40% POROSITY). THIS EQUATES TO 1.3 CUBIC FEET OF STORAGE/SQUARE FOOT OF BED.

2.7 THE CHAMBER SHALL HAVE FORTY-EIGHT ORIFICES PENETRATING THE SIDEWALLS TO ALLOW FOR LATERAL CONVEYANCE OF WATER.

2.8 THE CHAMBER SHALL HAVE TWO ORIFICES NEAR ITS TOP TO ALLOW FOR EQUALIZATION OF AIR PRESSURE BETWEEN ITS INTERIOR AND EXTERIOR.

2.9 THE CHAMBER SHALL HAVE BOTH OF ITS ENDS OPEN TO ALLOW FOR UNIMPEDED HYDRAULIC FLOWS AND VISUAL INSPECTIONS DOWN A ROW'S ENTIRE LENGTH.

2.10 THE CHAMBER SHALL HAVE 14 CORRUGATIONS.

2.11 THE CHAMBER SHALL HAVE A CIRCULAR, INDENTED, FLAT SURFACE ON THE TOP OF THE CHAMBER FOR AN OPTIONAL 4-INCH INSPECTION PORT.

2.12 THE CHAMBER SHALL BE ANALYZED AND DESIGNED USING AASHTO METHODS FOR THERMOPLASTIC CULVERTS CONTAINED IN THE LRFD BRIDGE DESIGN SPECIFICATIONS, 2ND EDITION, INCLUDING INTERIM SPECIFICATIONS THROUGH 2001. DESIGN LIVE LOAD SHALL BE THE AASHTO HS20 TRUCK. DESIGN SHALL CONSIDER EARTH AND LIVE LOADS AS APPROPRIATE FOR THE MINIMUM TO MAXIMUM SPECIFIED DEPTH OF FILL.

2.13 THE CHAMBER SHALL BE MANUFACTURED IN AN ISO 9001:2000 CERTIFIED FACILITY.

3.0 END CAP PARAMETERS

3.1 THE END CAP SHALL BE INJECTION MOLDED OF POLYETHYLENE RESIN TO HELP FACILITATE FACTORY MANUFACTURED PIPE FITTINGS.

3.2 THE END CAP SHALL BE DESIGNED TO FIT INTO ANY CORRUGATION OF A CHAMBER, WHICH ALLOWS: CAPPING A CHAMBER THAT HAS ITS LENGTH TRIMMED; SEGMENTING ROWS INTO STORAGE BASINS OF VARIOUS LENGTHS.

3.3 THE END CAP SHALL HAVE SAW GUIDES TO ALLOW EASY CUTTING FOR VARIOUS DIAMETERS OF PIPE THAT MAY BE USED TO INLET THE SYSTEM.

3.4 THE END CAP SHALL HAVE EXCESS STRUCTURAL ADEQUACIES TO ALLOW CUTTING AN ORIFICE OF ANY SIZE AT ANY INVERT ELEVATION.

3.5 THE PRIMARY FACE OF AN END CAP SHALL BE CURVED OUTWARD TO RESIST HORIZONTAL LOADS GENERATED NEAR THE EDGES OF BEDS.

3.6 THE END CAP SHALL BE MANUFACTURED IN AN ISO 9001:2000 CERTIFIED FACILITY.

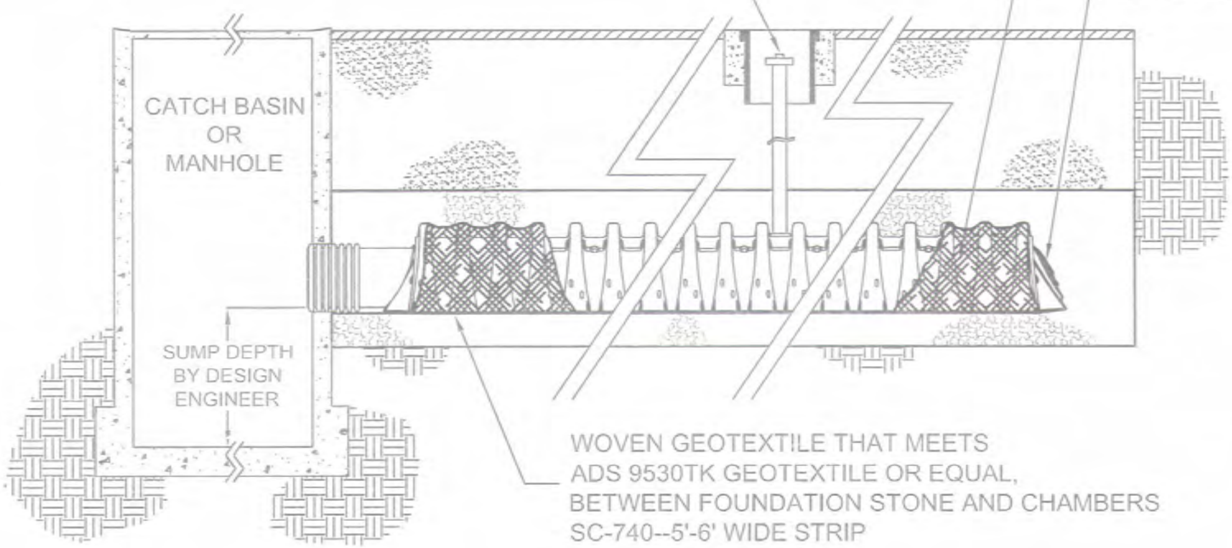
* NOTE: CHAMBER SYSTEM DESIGN MUST BE IN ACCORDANCE WITH STORMTECH DESIGN MANUAL

STORMTECH LLC CONCEPTUAL PLAN DISCLAIMER

StormTech
Subsurface Stormwater Management
20 Beaver Road, Suite 104
Wethersfield, CT 06109
Phone: 888-892-2694
Fax: 866-328-8401
www.stormtech.com

STORMTECH PRODUCT SPECIFICATIONS

SCALE: NTS	CHECKED
DATE:	ACAD No.
DRAWN BY:	SHEET OF



* NOTE: CHAMBER SYSTEM DESIGN MUST BE IN ACCORDANCE WITH STORMTECH DESIGN MANUAL

STORMTECH LLC CONCEPTUAL PLAN DISCLAIMER

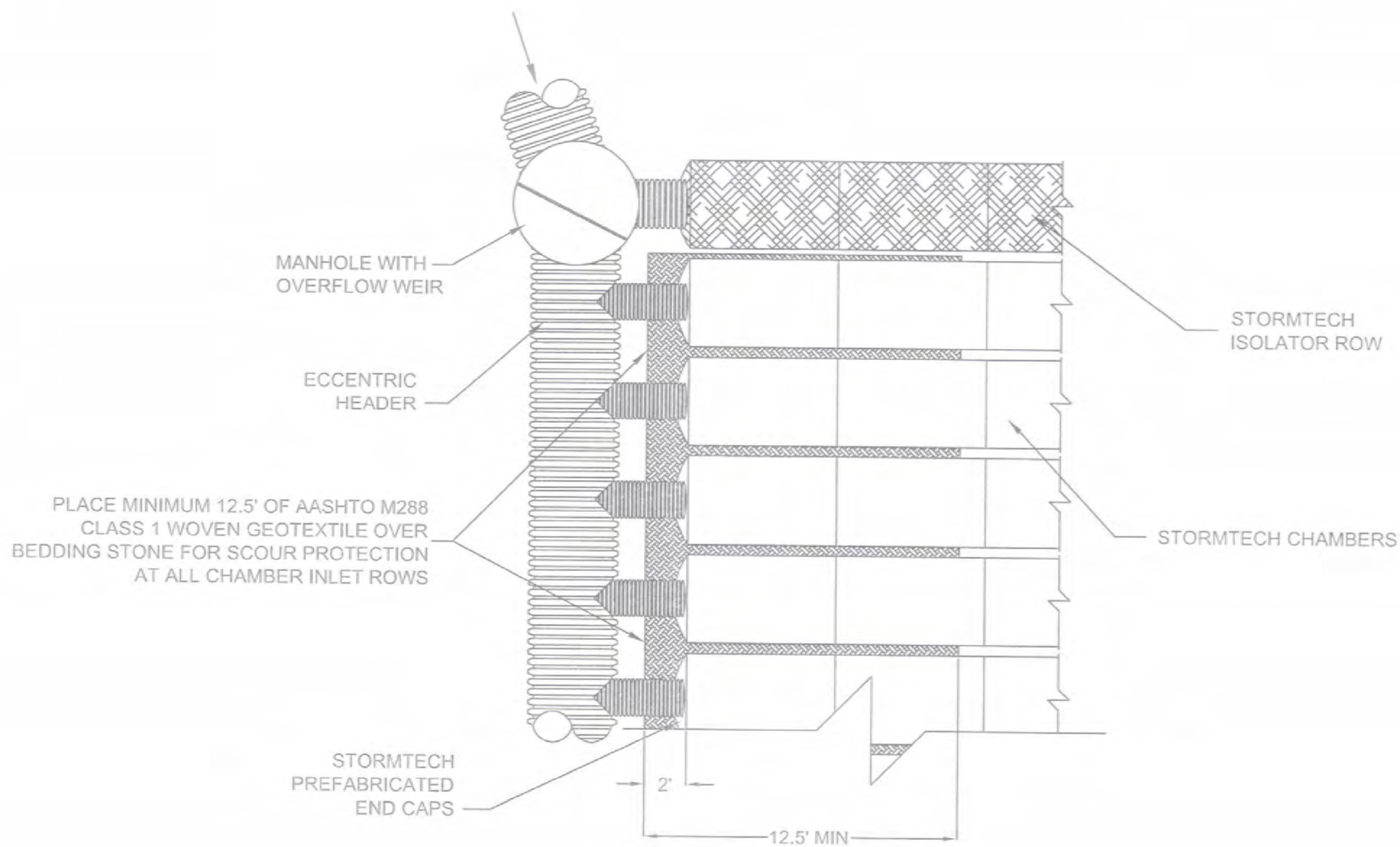
THIS STORMTECH CHAMBER SYSTEM LAYOUT WAS PRODUCED TO DEMONSTRATE A BED LAYOUT THAT WILL HANDLE THE DESIGN VOLUME LISTED ABOVE. THE SIZING, FIT AND APPLICABILITY OF THE STORMTECH CHAMBER SYSTEM FOR THIS SPECIFIC PROJECT HAS NOT BEEN DETERMINED. IT IS THE ULTIMATE RESPONSIBILITY OF THE DESIGN ENGINEER TO ASSURE THAT THE STORMWATER SYSTEM DESIGN IS IN FULL COMPLIANCE WITH ALL APPLICABLE LAWS AND REGULATIONS. STORMTECH PRODUCTS MUST BE DESIGNED AND INSTALLED IN ACCORDANCE WITH STORMTECH'S MINIMUM REQUIREMENTS. STORMTECH LLC DOES NOT APPROVE PLANS, SIZING, OR SYSTEM DESIGNS. THE DESIGNING ENGINEER IS RESPONSIBLE FOR ALL DESIGN DECISIONS.

StormTech Subsurface Stormwater Management

20 Beaver Road, Suite 104
Wethersfield, CT 06109
Phone: 888-892-2694
Fax: 866-328-8401
www.stormtech.com

STORMTECH ISOLATOR ROW PROFILE

SCALE:	NTS	CHECKED	
DATE:		ACAD No.	
DRAWN BY:		SHEET	OF



STORMTECH LLC CONCEPTUAL PLAN DISCLAIMER

THIS STORMTECH CHAMBER SYSTEM LAYOUT WAS PRODUCED TO DEMONSTRATE A BED LAYOUT THAT WILL HANDLE THE DESIGN VOLUME LISTED ABOVE. THE SIZING FIT AND APPLICABILITY OF THE STORMTECH CHAMBER SYSTEM FOR THE SPECIFIC PROJECT HAS NOT BEEN DETERMINED. IT IS THE ULTIMATE RESPONSIBILITY OF THE DESIGN ENGINEER TO ASSURE THAT THE STORMWATER SYSTEM DESIGN IS IN FULL COMPLIANCE WITH ALL APPLICABLE LAWS AND REGULATIONS. STORMTECH PRODUCTS MUST BE DESIGNED AND INSTALLED IN ACCORDANCE WITH STORMTECH'S MINIMUM REQUIREMENTS. STORMTECH LLC DOES NOT APPROVE PLANS, SIZING, OR SYSTEM DESIGNS. THE DESIGNING ENGINEER IS RESPONSIBLE FOR ALL DESIGN DECISIONS.

FOR STORMTECH INFORMATION
CALL 1-888-892-2694

* NOTE: CHAMBER SYSTEM DESIGN MUST BE IN ACCORDANCE WITH STORMTECH DESIGN MANUAL

StormTech
Subsurface Stormwater Management

20 Beaver Road, Suite 104
Wethersfield, CT 06109
Phone: 888-892-2694
Fax: 866-328-8401
www.stormtech.com

ISOLATOR ROW MANIFOLD DETAIL

SCALE:	NTS	CHECKED	
DATE:	9/25/2007	ACAD No.	
DRAWN BY:		SHEET	OF

STORMTECH GENERAL NOTES

1. STORMTECH LLC ("STORMTECH") REQUIRES INSTALLING CONTRACTORS TO USE AND UNDERSTAND STORMTECH'S LATEST INSTALLATION INSTRUCTIONS PRIOR TO BEGINNING SYSTEM INSTALLATION.

2. OUR TECHNICAL SERVICES DEPARTMENT OFFERS INSTALLATION CONSULTATIONS TO INSTALLING CONTRACTORS. CONTACT OUR TECHNICAL SERVICES REPRESENTATIVE AT LEAST 30 DAYS PRIOR TO SYSTEM INSTALLATION TO ARRANGE A PRE-INSTALLATION CONSULTATION. OUR REPRESENTATIVES CAN THEN ANSWER QUESTIONS OR ADDRESS COMMENTS ON THE STORMTECH CHAMBER SYSTEM AND INFORM THE INSTALLING CONTRACTOR OF THE MINIMUM INSTALLATION REQUIREMENTS BEFORE BEGINNING THE SYSTEM'S CONSTRUCTION. CALL **1-888-892-2694** TO SPEAK TO A TECHNICAL SERVICE REPRESENTATIVE OR VISIT **WWW.STORMTECH.COM** TO RECEIVE A COPY OF OUR INSTALLATION INSTRUCTIONS.

3. STORMTECH'S REQUIREMENTS FOR SYSTEMS WITH PAVEMENT DESIGN (ASPHALT, CONCRETE PAVERS, ETC.): MINIMUM COVER IS 18 INCHES NOT INCLUDING PAVEMENT; MAXIMUM COVER IS 96 INCHES INCLUDING PAVEMENT. FOR INSTALLATIONS THAT DO NOT INCLUDE PAVEMENT, WHERE RUTTING FROM VEHICLES MAY OCCUR, MINIMUM REQUIRED COVER IS 24 INCHES, MAXIMUM COVER IS 96 INCHES.

4. THE CONTRACTOR MUST REPORT ANY DISCREPANCIES WITH CHAMBER FOUNDATION MATERIALS BEARING CAPACITIES TO THE DESIGN ENGINEER.

5. AASHTO M288 CLASS 2 NON-WOVEN GEOTEXTILE (FILTER FABRIC) MUST BE USED AS INDICATED IN THE PROJECT PLANS.

6. STONE PLACEMENT BETWEEN CHAMBERS ROWS AND AROUND PERIMETER MUST FOLLOW INSTRUCTIONS AS INDICATED IN THE MOST CURRENT VERSION OF STORMTECH'S INSTALLATION INSTRUCTIONS.

7. BACKFILLING OVER THE CHAMBERS MUST FOLLOW REQUIREMENTS AS INDICATED IN THE MOST CURRENT VERSION OF STORMTECH'S INSTALLATION INSTRUCTIONS.

8. THE CONTRACTOR MUST REFER TO STORMTECH'S INSTALLATION INSTRUCTIONS FOR A TABLE OF ACCEPTABLE VEHICLE LOADS AT VARIOUS DEPTHS OF COVER. THIS INFORMATION IS ALSO AVAILABLE AT STORMTECH'S WEBSITE: **WWW.STORMTECH.COM**. THE CONTRACTOR IS RESPONSIBLE FOR PREVENTING VEHICLES THAT EXCEED STORMTECH'S REQUIREMENTS FROM TRAVELING ACROSS OR PARKING OVER THE STORMWATER SYSTEM. TEMPORARY FENCING, WARNING TAPE AND APPROPRIATELY LOCATED SIGNS ARE COMMONLY USED TO PREVENT UNAUTHORIZED VEHICLES FROM ENTERING SENSITIVE CONSTRUCTION AREAS.

9. THE CONTRACTOR MUST APPLY EROSION AND SEDIMENT CONTROL MEASURES TO PROTECT THE STORMWATER SYSTEM DURING ALL PHASES OF SITE CONSTRUCTION PER LOCAL CODES AND DESIGN ENGINEER'S SPECIFICATIONS.

10. STORMTECH PRODUCT WARRANTY IS LIMITED. SEE CURRENT PRODUCT WARRANTY FOR DETAILS. TO ACQUIRE A COPY CALL STORMTECH AT **1-888-892-2694** OR VISIT **WWW.STORMTECH.COM**.

* NOTE: CHAMBER SYSTEM DESIGN MUST BE IN ACCORDANCE WITH STORMTECH DESIGN MANUAL

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Wethersfield, CT 06109
Phone: 888-892-2694
Fax: 866-328-8401
www.stormtech.com

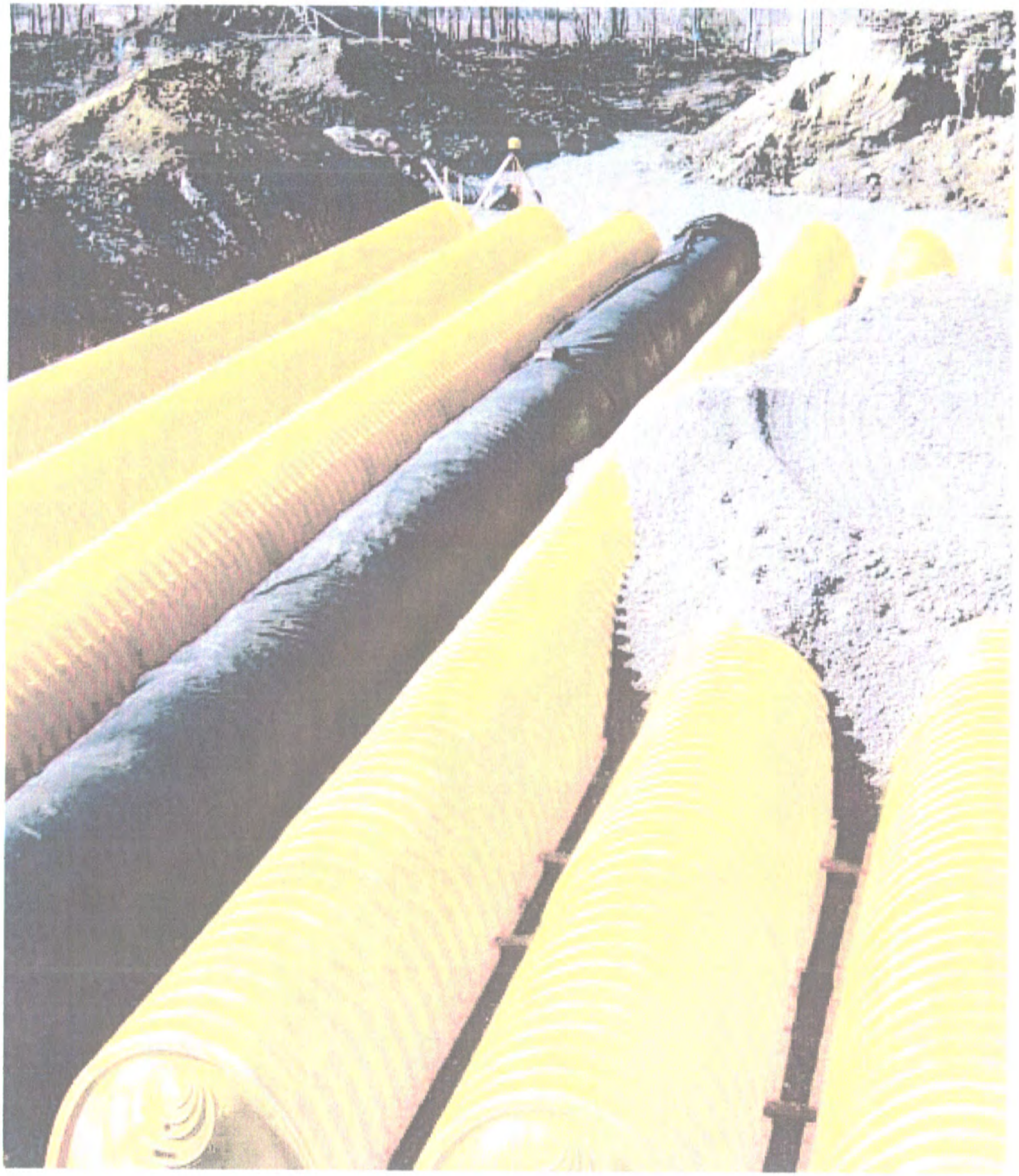
STORMTECH GENERAL NOTES

SCALE:	NTS	CHECKED	
DATE:		ACAD No.	
DRAWN BY:		SHEET	OF

StormTech®

Detention • Retention • Recharge

Subsurface Stormwater Management℠



Isolator™ Row O&M Manual

StormTech® Chamber System for Stormwater Management

1.0 The Isolator™ Row

1.1 INTRODUCTION

An important component of any Stormwater Pollution Prevention Plan is inspection and maintenance. The StormTech Isolator Row is a patent pending technique to inexpensively enhance Total Suspended Solids (TSS) removal and provide easy access for inspection and maintenance.

Looking down the Isolator Row from the manhole opening, woven geotextile is shown between the chamber and stone base.

1.2 THE ISOLATOR™ ROW

The Isolator Row is a row of StormTech chambers, either SC-740 or SC-310 models, that is surrounded with filter fabric and connected to a closely located manhole for easy access. The fabric-wrapped chambers provide for settling and filtration of sediment as storm water rises in the Isolator Row and ultimately passes through the filter fabric. The open bottom chambers and perforated sidewalls allow storm water to flow both vertically and horizontally out of the chambers. Sediments are captured in the Isolator Row protecting the storage areas of the adjacent stone and chambers from sediment accumulation.

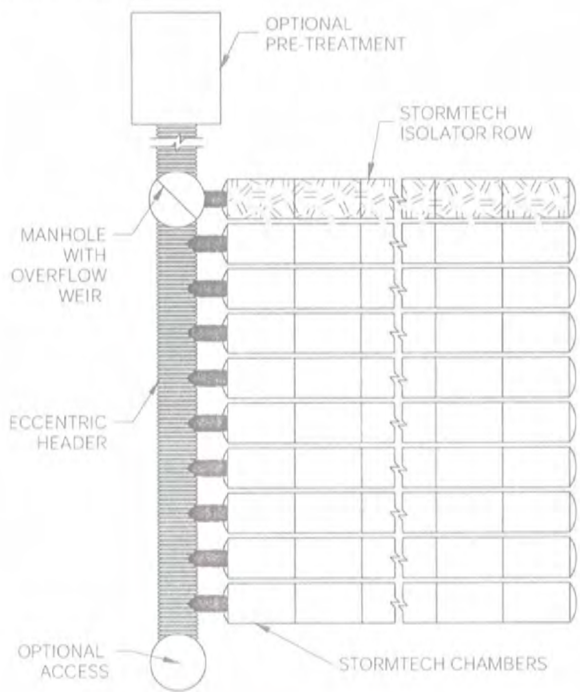
Two different fabrics are used for the Isolator Row. A woven geotextile fabric is placed between the stone and the Isolator Row chambers. The tough geotextile provides a media for storm water filtration and provides a durable surface for maintenance operations. It is also designed to prevent scour of the underlying stone and remain intact during high pressure jetting. A non-woven fabric is placed over the chambers to provide a filter media for flows passing through the perforations in the sidewall of the chamber.

The Isolator Row is typically designed to capture the "first flush" and offers the versatility to be sized on a volume basis or flow rate basis. An upstream manhole not only provides access to the Isolator Row but typically includes a high flow weir such that storm water flowrates or volumes that exceed the capacity of the Isolator Row overtop the over flow weir and discharge through a manifold to the other chambers.

The Isolator Row may also be part of a treatment train. By treating storm water prior to entry into the chamber system, the service life can be extended and pollutants such as hydrocarbons can be captured. Pre-treatment best management practices can be as simple as deep sump catch basins, oil-water separators or can be innovative storm water treatment devices. The design of the treatment train and selection of pretreatment devices by the design engineer is often driven by regulatory requirements. Whether pretreatment is used or not, the Isolator Row is recommended by StormTech as an effective means to minimize maintenance requirements and maintenance costs.

Note: See the StormTech Design Manual for detailed information on designing inlets for a StormTech system, including the Isolator Row.

StormTech Isolator Row with Overflow Spillway
(not to scale)



2.0 Isolator Row Inspection/Maintenance

2.1 INSPECTION

The frequency of Inspection and Maintenance varies by location. A routine inspection schedule needs to be established for each individual location based upon site specific variables. The type of land use (i.e. industrial, commercial residential), anticipated pollutant load, percent imperviousness, climate, etc. all play a critical role in determining the actual frequency of inspection and maintenance practices.

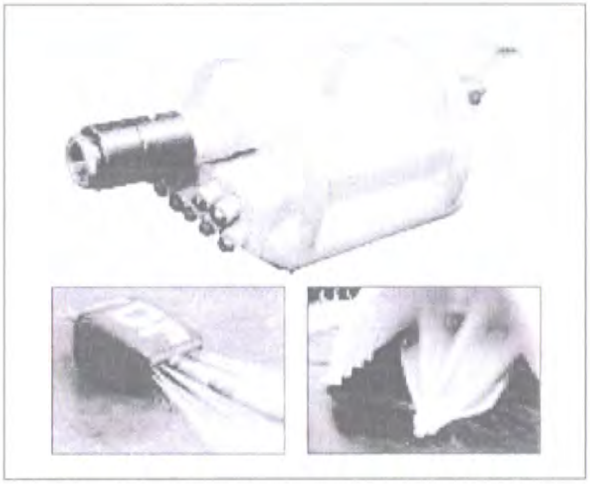
At a minimum, StormTech recommends annual inspections. Initially, the Isolator Row should be inspected every 6 months for the first year of operation. For subsequent years, the inspection should be adjusted based upon previous observation of sediment deposition.

The Isolator Row incorporates a combination of standard manhole(s) and strategically located inspection ports (as needed). The inspection ports allow for easy access to the system from the surface, eliminating the need to perform a confined space entry for inspection purposes.

If upon visual inspection it is found that sediment has accumulated, a stadia rod should be inserted to determine the depth of sediment. When the average depth of sediment exceeds 3 inches throughout the length of the Isolator Row, clean-out should be performed.

2.2 MAINTENANCE

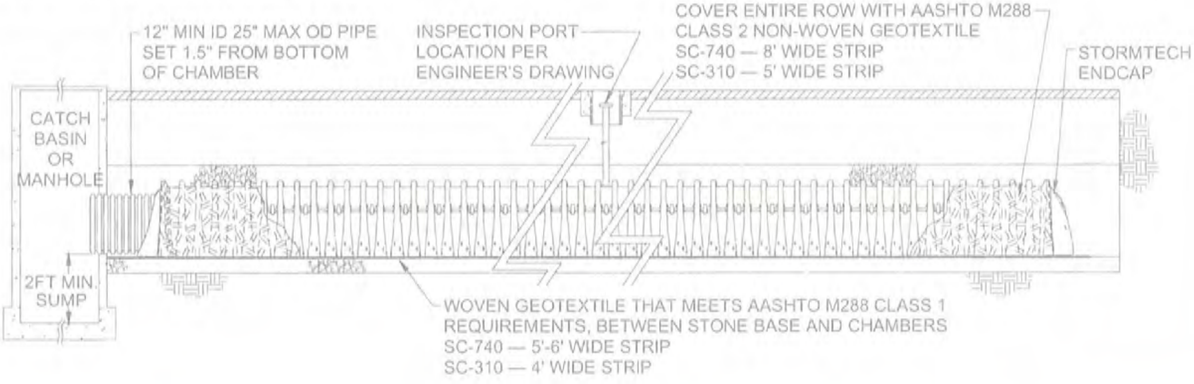
The Isolator Row was designed to reduce the cost of periodic maintenance. By "isolating" sediments to just one row, costs are dramatically reduced by eliminating the need to clean out each row of the entire storage bed. If inspection indicates the potential need for maintenance, access is provided via a manhole(s) located on the end(s) of the row for cleanout. If entry into the manhole is required, please follow local and OSHA rules for a confined space entries.



Examples of culvert cleaning nozzles appropriate for Isolator Row maintenance. (These are not StormTech products.)

Maintenance is accomplished with the JetVac process. The JetVac process utilizes a high pressure water nozzle to propel itself down the Isolator Row while scouring and suspending sediments. As the nozzle is retrieved, the captured pollutants are flushed back into the manhole for vacuuming. Most sewer and pipe maintenance companies have vacuum/JetVac combination vehicles. Selection of an appropriate JetVac nozzle will improve maintenance efficiency. Fixed nozzles designed for culverts or large diameter pipe cleaning are preferable. Rear facing jets with an effective spread of at least 45° are best. Most JetVac reels have 400 feet of hose allowing maintenance of an Isolator Row up to 50 chambers long. **The JetVac process shall only be performed on StormTech Isolator Rows that have AASHTO class 1 woven geotextile (as specified by StormTech) over their angular base stone.**

StormTech Isolator Row (not to scale)



3.0 Isolator Row Step By Step Maintenance Procedures

Step 1) Inspect Isolator Row for sediment

A) Inspection ports (if present)

i. Remove lid from floor box frame

ii. Remove cap from inspection riser

iii. Using a flashlight and stadia rod, measure depth of sediment and record results on maintenance log.

iv. If sediment is at, or above, 3 inch depth proceed to Step 2. If not proceed to step 3.

B) All Isolator Rows

i. Remove cover from manhole at upstream end of Isolator Row

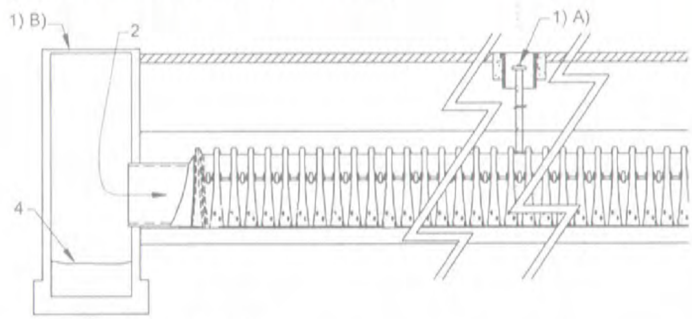
ii. Using a flashlight, inspect down Isolator Row through outlet pipe

1. Mirrors on poles or cameras may be used to avoid a confined space entry

2. Follow OSHA regulations for confined space entry if entering manhole

iii. If sediment is at or above the lower row of sidewall holes (approximately 3 inches) proceed to Step 2. If not proceed to Step 3.

StormTech Isolator Row (not to scale)



Step 2) Clean out Isolator Row using the JetVac process

A) A fixed culvert cleaning nozzle with rear facing nozzle spread of 45 inches or more is preferable

B) Apply multiple passes of JetVac until backflush water is clean

C) Vacuum manhole sump as required

Step 3) Replace all caps, lids and covers, record observations and actions

Step 4) Inspect & clean catch basins and manholes upstream of the StormTech system

Sample Maintenance Log

Date	Stadia Rod Readings		Sediment Depth (1) - (2)	Observations/Actions	Inspector
	Fixed point to chamber bottom (1)	Fixed point to top of sediment (2)			
3/15/01	6.3 ft.	none		New installation. Fixed point is CI frame at grade	djm
9/24/01		6.2	0.1 ft.	Some grit felt	sm
6/20/03		5.8	0.5 ft.	Mucky feel, debris visible in manhole and in Isolator row, maintenance due	rv
7/7/03	6.3 ft.		0	System jetted and vacuumed	djm

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Appendix H

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Detention • Retention • Water Quality

A division of ADS

Save Valuable Land and Protect Water Resources

Isolator□ Row O&M Manual

StormTech® Chamber System for Stormwater Management

U.S. GREEN BUILDING COUNCIL MEMBER

1.0 The Isolator® Row

1.1 INTRODUCTION

An important component of any Stormwater Pollution Prevention Plan is inspection and maintenance. The StormTech Isolator Row is a patented technique to inexpensively enhance Total Suspended Solids (TSS) removal and provide easy access for inspection and maintenance.

Looking down the Isolator Row from the manhole opening, woven geotextile is shown between the chamber and stone base.

1.2 THE ISOLATOR ROW

The Isolator Row is a row of StormTech chambers, either SC-310, SC-310-3, SC-740, DC-780, MC-3500 or MC-4500 models, that is surrounded with filter fabric and connected to a closely located manhole for easy access. The fabric-wrapped chambers provide for settling and filtration of sediment as storm water rises in the Isolator Row and ultimately passes through the filter fabric. The open bottom chambers and perforated sidewalls (SC-310, SC-310-3 and SC-740 models) allow storm water to flow both vertically and horizontally out of the chambers. Sediments are captured in the Isolator Row protecting the storage areas of the adjacent stone and chambers from sediment accumulation.

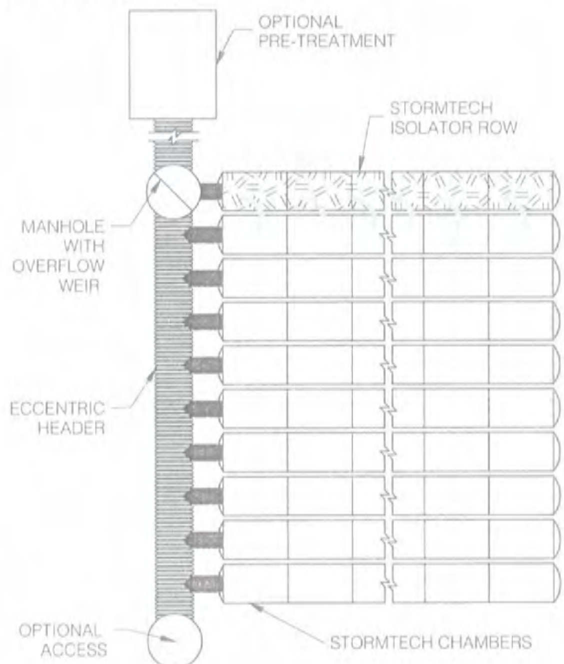
Two different fabrics are used for the Isolator Row. A woven geotextile fabric is placed between the stone and the Isolator Row chambers. The tough geotextile provides a media for storm water filtration and provides a durable surface for maintenance operations. It is also designed to prevent scour of the underlying stone and remain intact during high pressure jetting. A non-woven fabric is placed over the chambers to provide a filter media for flows passing through the perforations in the sidewall of the chamber. The non-woven fabric is not required over the DC-780, MC-3500 or MC-4500 models as these chambers do not have perforated side walls.

The Isolator Row is typically designed to capture the "first flush" and offers the versatility to be sized on a volume basis or flow rate basis. An upstream manhole not only provides access to the Isolator Row but typically includes a high flow weir such that storm water flowrates or volumes that exceed the capacity of the Isolator Row overtop the over flow weir and discharge through a manifold to the other chambers.

The Isolator Row may also be part of a treatment train. By treating storm water prior to entry into the chamber system, the service life can be extended and pollutants such as hydrocarbons can be captured. Pre-treatment best management practices can be as simple as deep sump catch basins, oil-water separators or can be innovative storm water treatment devices. The design of the treatment train and selection of pretreatment devices by the design engineer is often driven by regulatory requirements. Whether pretreatment is used or not, the Isolator Row is recommended by StormTech as an effective means to minimize maintenance requirements and maintenance costs.

Note: See the StormTech Design Manual for detailed information on designing inlets for a StormTech system, including the Isolator Row.

[illegible]
(not to scale)



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StormTech

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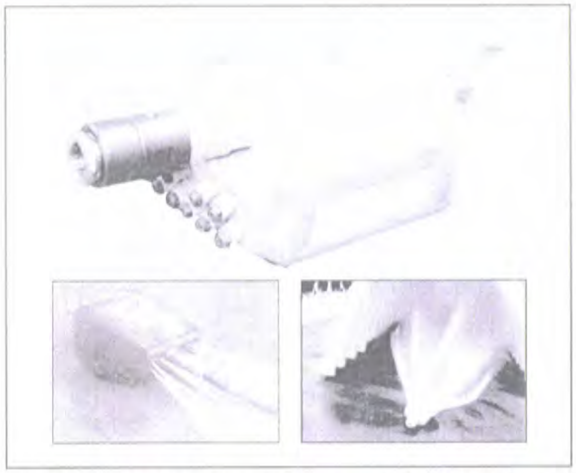

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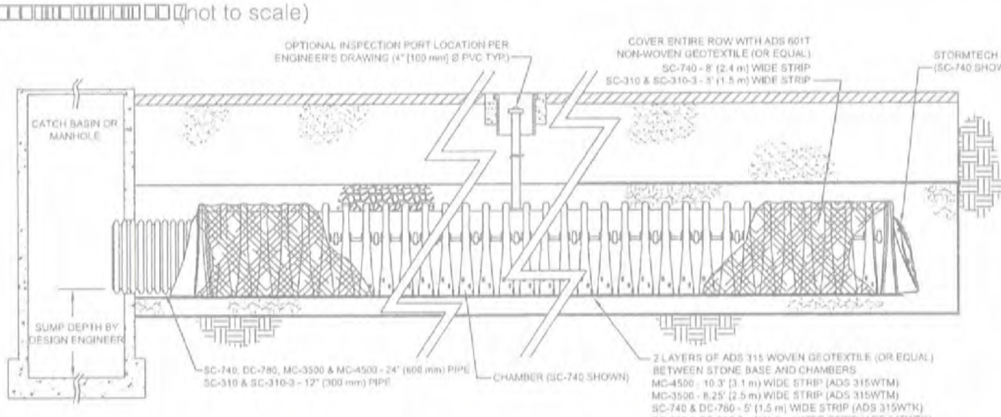
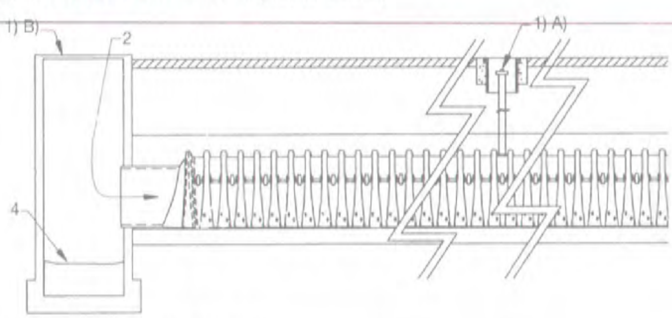


NOTE: NON-WOVEN FABRIC IS ONLY REQUIRED OVER THE INLET PIPE CONNECTION INTO THE END CAP FOR DC-780, MC-3500 AND MC-4500 CHAMBER MODELS AND IS NOT REQUIRED OVER THE ENTIRE ISOLATOR ROW.

3.0 Isolator Row Step By Step Maintenance Procedures

[illegible] (not to scale)



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[illegible]

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6/20/03		5.8	0.5 ft.	Mucky feel, debris visible in manhole and in Isolator row, maintenance due	rv
7/7/03	6.3 ft.		0	System jetted and vacuumed	djm

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