



Coulter Jewell Thames, P.A.

**COLUMBIA STREET ANNEX
STORMWATER IMPACT STATEMENT**

SPECIAL USE PERMIT SUBMITTAL

PIN

9788 20 4502

9788 21 5049



Calculations By: Tiffany R. McCormack, EI
Checked By: Charles N. Hill, Jr, PE

Coulter Jewell Thames, P.A.
111 West Main Street
Durham, NC 27701
Ph: 919-682-0368
Fax: 919-688-5646

Project # 1306

April 25, 2018

Project Description and Summary

The Columbia Street Annex project is located at the northwest corner of the intersection of South Columbia Street and the on-ramp to NC 54 with the right-of-way for Monroe Street running through the site in Chapel Hill, North Carolina. The proposed project involves the conversion of a wooded lot into a seven story multi-use development with associated parking. The existing right-of-way will be closed and this area will become a part of the proposed development. Soils on the site and contributing drainage area are Wedowee, Appling and Urban (hydrologic soil groups B & D). The site is comprised of mostly B soils. The proposed site is located in the Cape Fear River Basin, the Jordan Lake protected watershed, and WS-IV NSW state designations.

Per the Town of Chapel Hill stormwater ordinance, the stormwater discharge rate leaving the site under post-development conditions may not exceed the stormwater discharge rate under pre-development conditions for the 1-year, 2-year, and 25-year storms. The stormwater runoff volume post-development may not exceed the stormwater runoff volume pre-development for the 2-year storm event. Stormwater treatment must be used to achieve an 85% Total Suspended Solids (TSS) reduction from the post development water quality volume runoff.

Methodology

- HydroCAD software is used to calculate the time of concentration for each sub-basin. HydroCAD uses the SCS segmental approach to estimate the time of concentration.
- HydroCAD software is used to calculate the composite curve number for each sub-basin. HydroCAD uses the NRCS TR-55 method for calculation composite curve numbers.
- HydroCAD software is used to calculate pre- and post-development peak flow rates and volumes for each sub-basin. HydroCAD uses the SCS TR-20 method to develop hydrographs.
- The Orange County Soil Survey is used to identify the soil types located on the site.

Discussion of Results

Peak Flow Analysis

For peak flow analysis, the site was analyzed as two basins. Basin 1 drains south, to an unnamed tributary of Morgan Creek. Basin 2 also drains to the south, eventually discharging to the same unnamed tributary of Morgan Creek. The proposed development will increase the runoff for the design storms to the analysis point for Basin 1. An underground detention system is proposed to attenuate the discharge from Basin 1 for the design storms. There is no change to ground cover for Basin 2. Analysis of the 1-, 2- and 10-year storm events result in no increase to peak flow following development for Basin 2. (See spreadsheet *Peak Flow Analysis Summary*).

Stormwater Runoff Volume Analysis

For stormwater runoff analysis, only Basin 1 was analyzed. The underground detention system is sized to achieve no increase of the 2-year storm event to the runoff volume following development. (See spreadsheet *Runoff Volume Analysis Summary*).

Stormwater Pollutant Analysis

TSS Reduction:

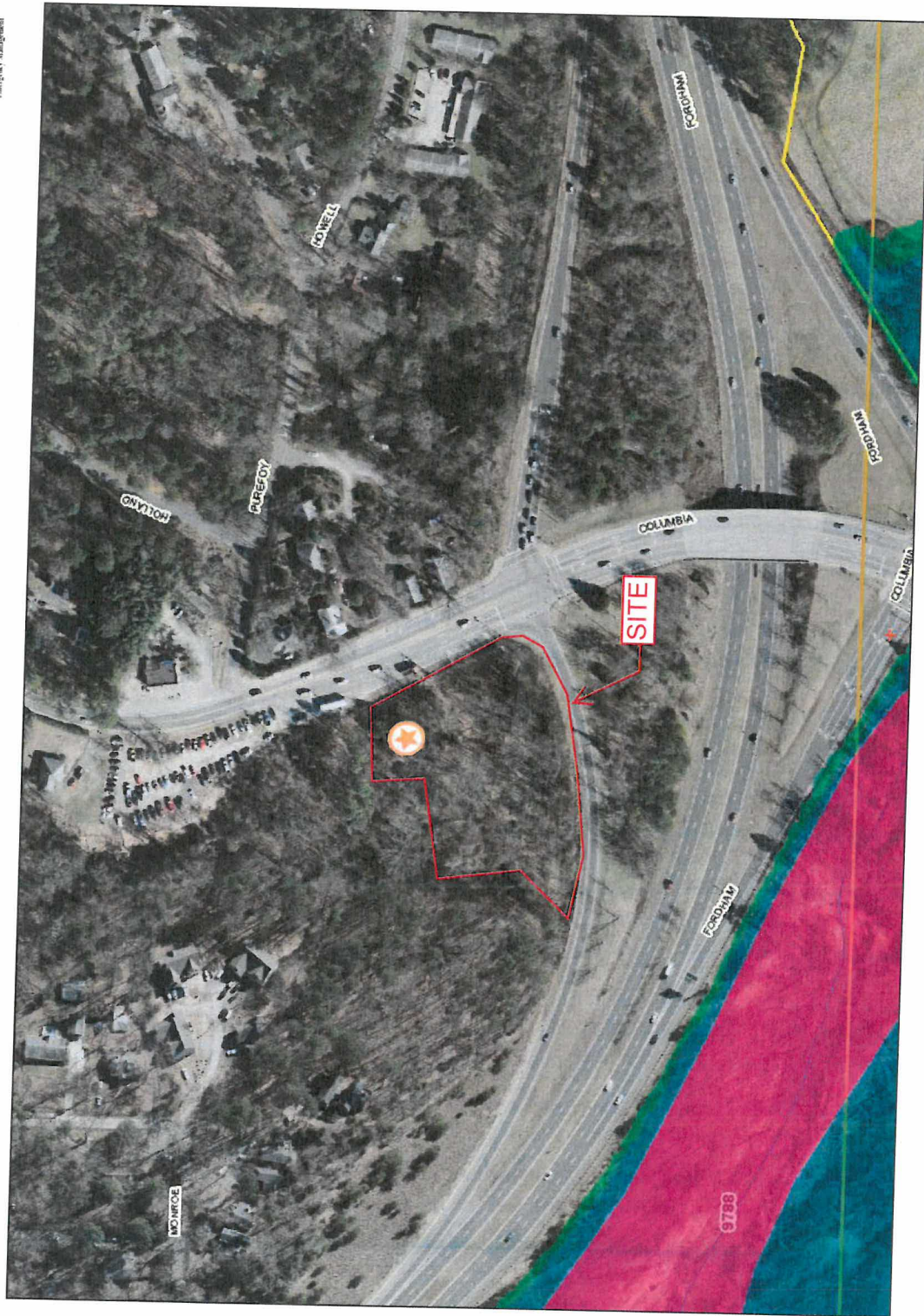
The proposed development of this site requires a TSS reduction for the increases in impervious areas per the Town of Chapel Hill Ordinance. A Storm Filter is proposed to meet the 85% TSS reduction for the new impervious surfaces. The drainage area to this stormwater facility is equals the required treatment area (See spreadsheet *TSS Reduction Summary*).

Results

Based on the Town of Chapel Hill Land Use Management Ordinance and all applicable amendments to it, development of this site requires peak flow, volume, and TSS reductions. These requirements are met with the installation of an underground detention facility, and a StormFilter. All applicable calculations and maps follow in this report.

MISCELLANEOUS MAPS

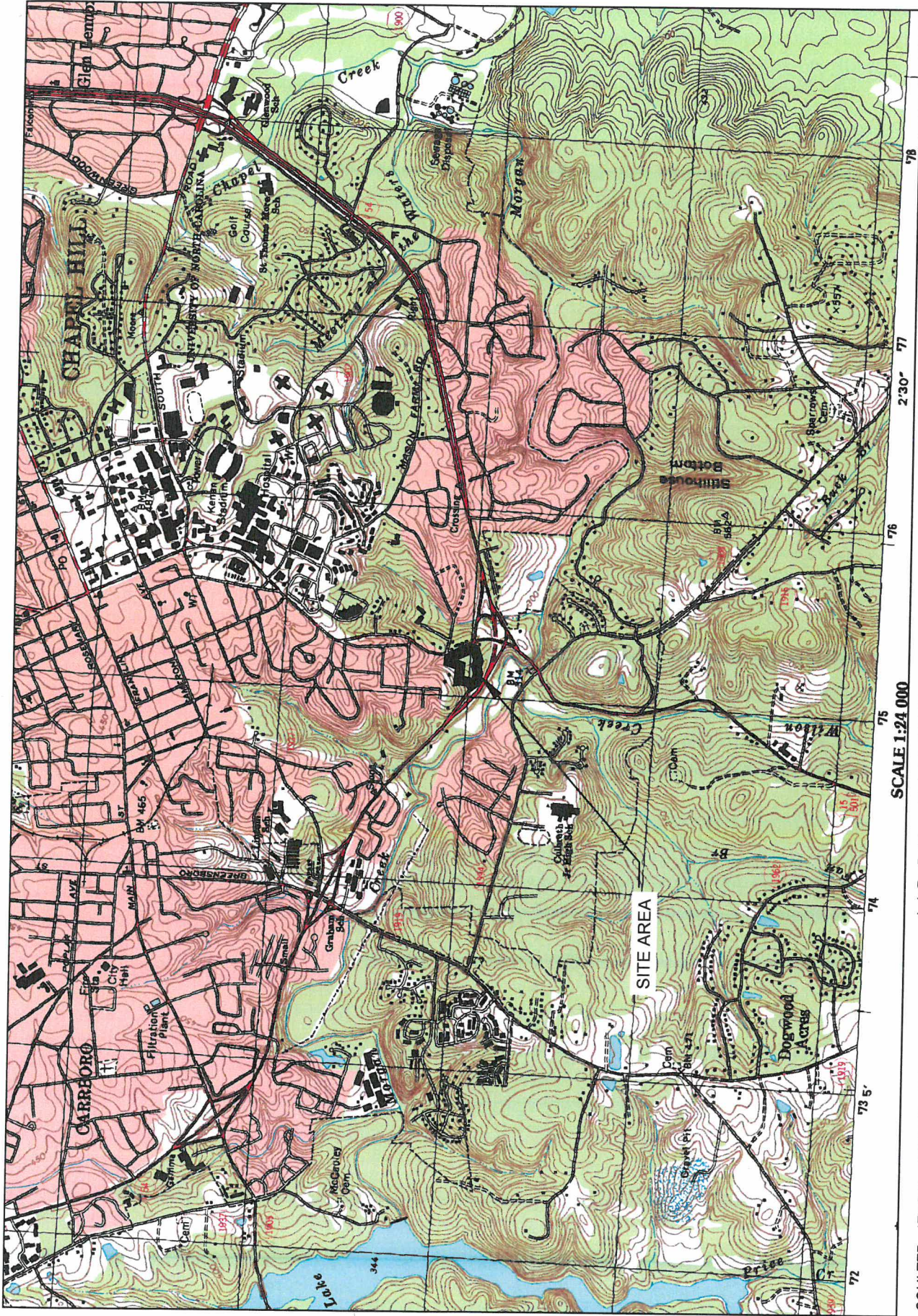
Columbia St. Annex



- ★ Major Cities
- + Benchmarks
- DPIRM Grid
- Rivers and Streams
- Transects (Coastal)
- County Boundaries
- Coastal Barrier Resource Systems
- Roads
- NC Highway
- US Highway
- Interstate Highway
- Political Areas
- Extraterritorial Jurisdictions
- Coastal Sounds
- 100yr Flooding - Floodway (AE)
- 100yr Flooding - Has BFE's (AE)
- 100yr Flooding - No BFE's (A)
- 100yr Flooding - Velocity Zone
- 500yr Flooding (Shaded X)
- Base Flood Elevation (Symbol)
- Cross Sections



North Carolina
Floodplain Mapping Program



SCALE 1:24,000

USGS CHAPEL HILL QUADRANGLE

COULTER JEWELL THAMES, P.A.
 111 WEST MAIN ST
 DURHAM, NC 27701
 (919) 682-0368

FEBRUARY 20, 2013
 SCALE: 1"=2000'
 DRAWN BY: TRM

PEAK FLOW ANALYSIS



Coulter|Jewell|Thames, PA

Project Name: Columbia Street Annex
 Project Number: 1306

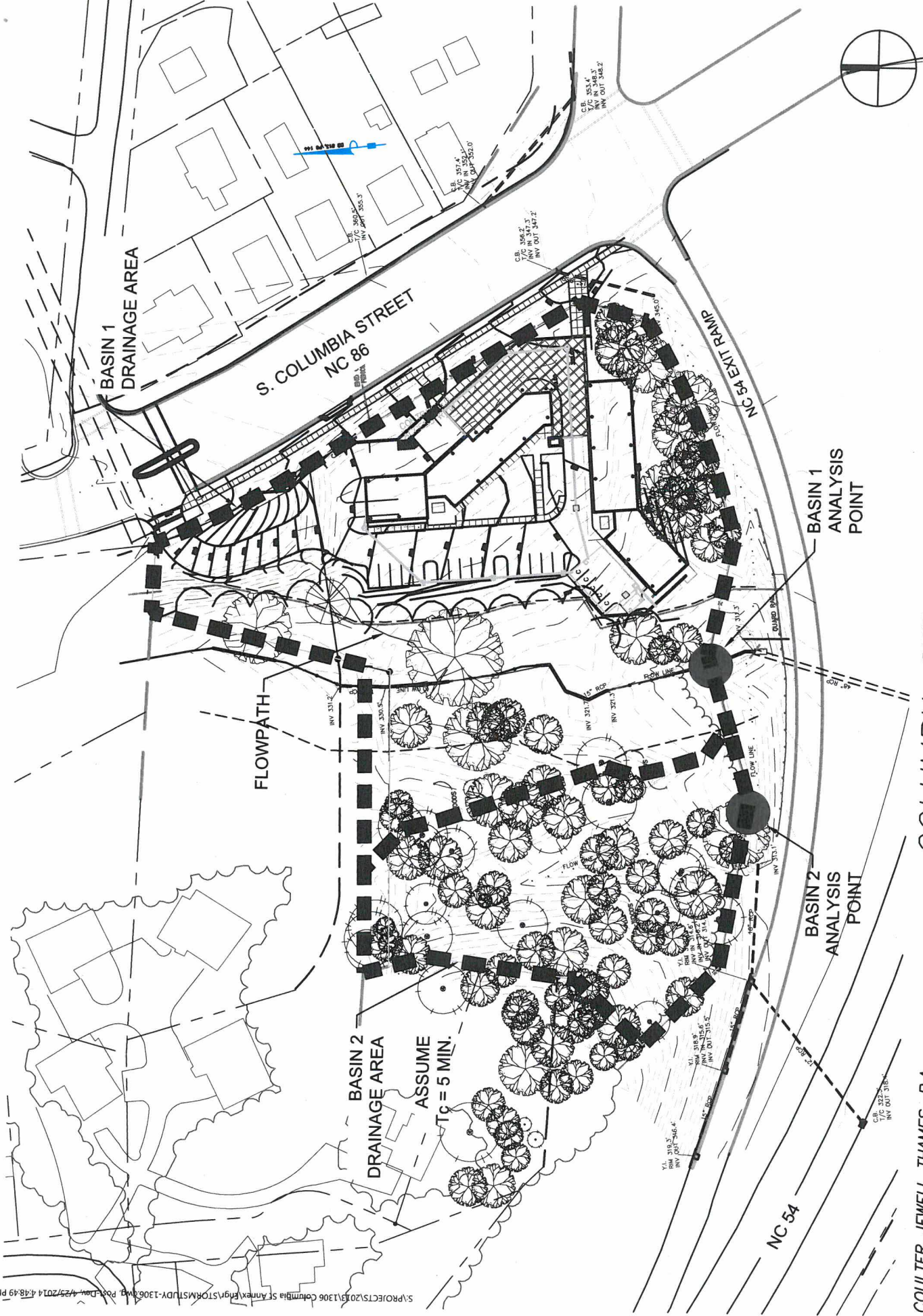
By: TRM
 Date: 04.25.14

Revised:
 Date:

Peak Flow Analysis Summary

| Drainage Basin 1 | Tc (min) | Area (ac) | CN | Q1 (cfs) | Q2 (cfs) | Q25 (cfs) |
|--|-------------|--------------|-----|-------------|-------------|--------------|
| Pre-Development | 6.5 | 2.75 | 57 | 0.57 | 1.40 | 7.73 |
| Post Development | 5.8 | 2.75 | 73 | 4.04 | 5.64 | 14.72 |
| Post-Development with Treatment | --- | --- | --- | 0.57 | 1.14 | 6.90 |
| Percent difference between Pre-Development and Post Development with Treatment | | | | 0% | -19% | -11% |

| Drainage Basin 2 | Tc (min) | Area (ac) | CN | Q1 (cfs) | Q2 (cfs) | Q25 (cfs) |
|---|-------------|--------------|----|-------------|-------------|--------------|
| Pre-Development | 5 | 1.06 | 55 | 0.14 | 0.42 | 2.77 |
| Post Development | 5 | 1.06 | 55 | 0.14 | 0.42 | 2.77 |
| Percent difference between Pre-Development and Post Development | | | | 0% | 0% | 0% |

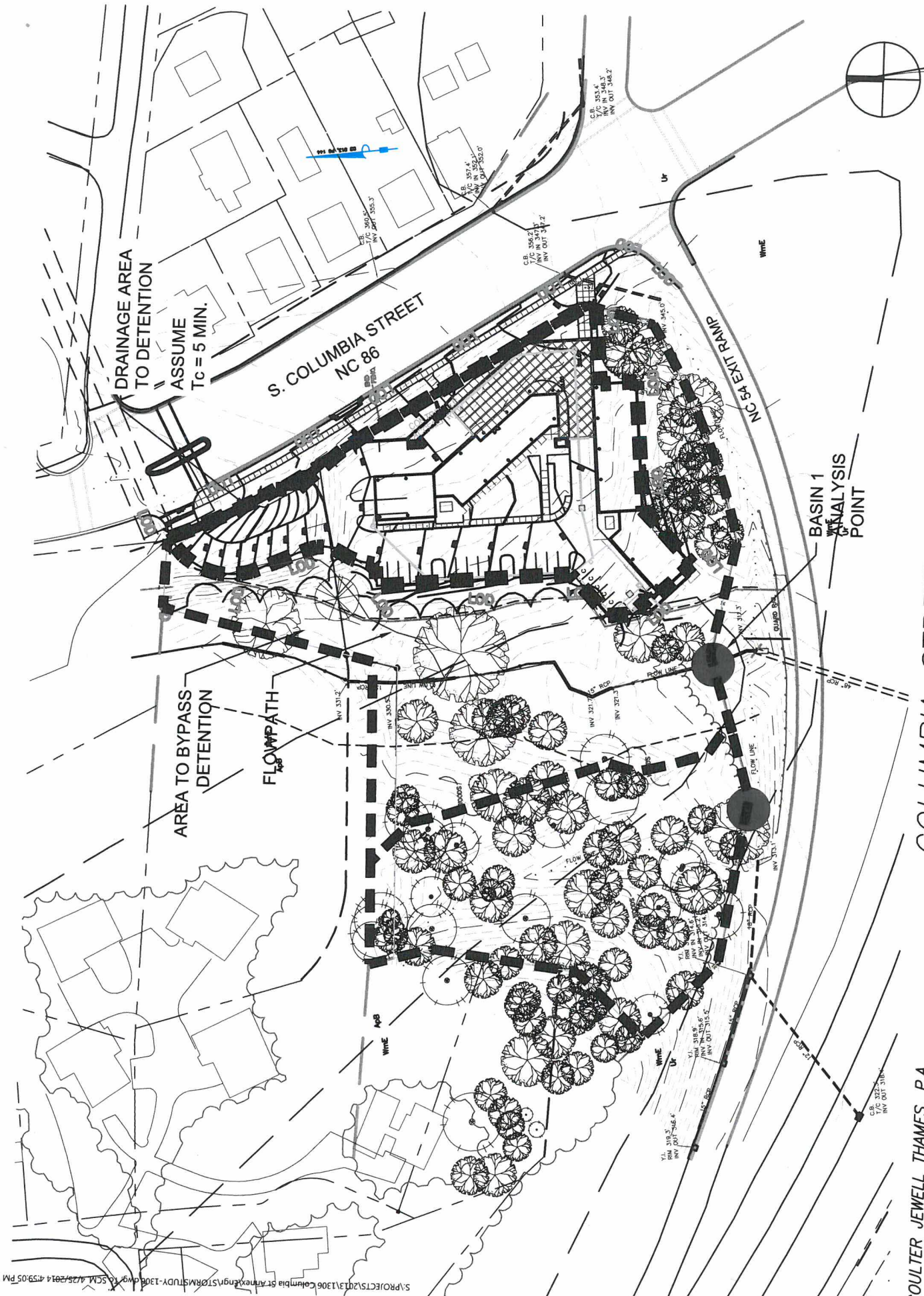


DATE: 04.25.2014
 SCALE: 1" = 100'
 DRAWN BY: TRM

COLUMBIA STREET ANNEX
 POST-DEVELOPMENT DRAINAGE AREA MAP

COULTER JEWELL THAMES, P.A.
 111 WEST MAIN ST
 DURHAM, NC 27701
 (919) 682-0368

S:\PROJECTS\2013\1306 Columbia St Annex\STORMSTUDY-1306.dwg 1/25/2014 4:59:05 PM



COULTER JEWELL THAMES, P.A.
 111 WEST MAIN ST
 DURHAM, NC 27701
 (919) 682-0368

COLUMBIA STREET ANNEX
 DRAINAGE AREA MAP TO BMP

DATE: 04.17.2014
 SCALE: 1" = 100'
 DRAWN BY: TRM



Basin 1 -
Predevelopment



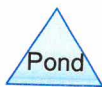
Basin 2 -
Predevelopment



Basin 1 -
Postdevelopment



Basin 2 -
Postdevelopment



STORM STUDY - 1306

Type II 24-hr 1-Year Rainfall=3.00"

Prepared by {enter your company name here}

Printed 4/28/2014

HydroCAD® 9.00 s/n 02109 © 2009 HydroCAD Software Solutions LLC

Page 2

Summary for Subcatchment 1S: Basin 1 - Predevelopment

Runoff = 0.57 cfs @ 12.02 hrs, Volume= 0.047 af, Depth> 0.20"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 1-Year Rainfall=3.00"

| Area (ac) | CN | Description |
|-----------|----|-------------------------------|
| 0.020 | 98 | Unconnected pavement, HSG B |
| 0.720 | 61 | >75% Grass cover, Good, HSG B |
| 2.010 | 55 | Woods, Good, HSG B |
| 2.750 | 57 | Weighted Average |
| 2.730 | | 99.27% Pervious Area |
| 0.020 | | 0.73% Impervious Area |
| 0.020 | | 100.00% Unconnected |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|----------|---------------|---------------|-------------------|----------------|---|
| 3.3 | 75 | 0.1467 | 0.38 | | Sheet Flow, Grass: Short n= 0.150 P2= 3.60" |
| 0.9 | 96 | 0.0625 | 1.75 | | Shallow Concentrated Flow, Short Grass Pasture Kv= 7.0 fps |
| 0.8 | 92 | 0.1415 | 1.88 | | Shallow Concentrated Flow, Woodland Kv= 5.0 fps |
| 1.5 | 237 | 0.0634 | 2.65 | 0.53 | Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=1.00' Z= 0.2 '/' Top.W=0.40' n= 0.030 Earth, grassed & winding |
| 6.5 | 500 | Total | | | |

STORM STUDY - 1306

Prepared by {enter your company name here}

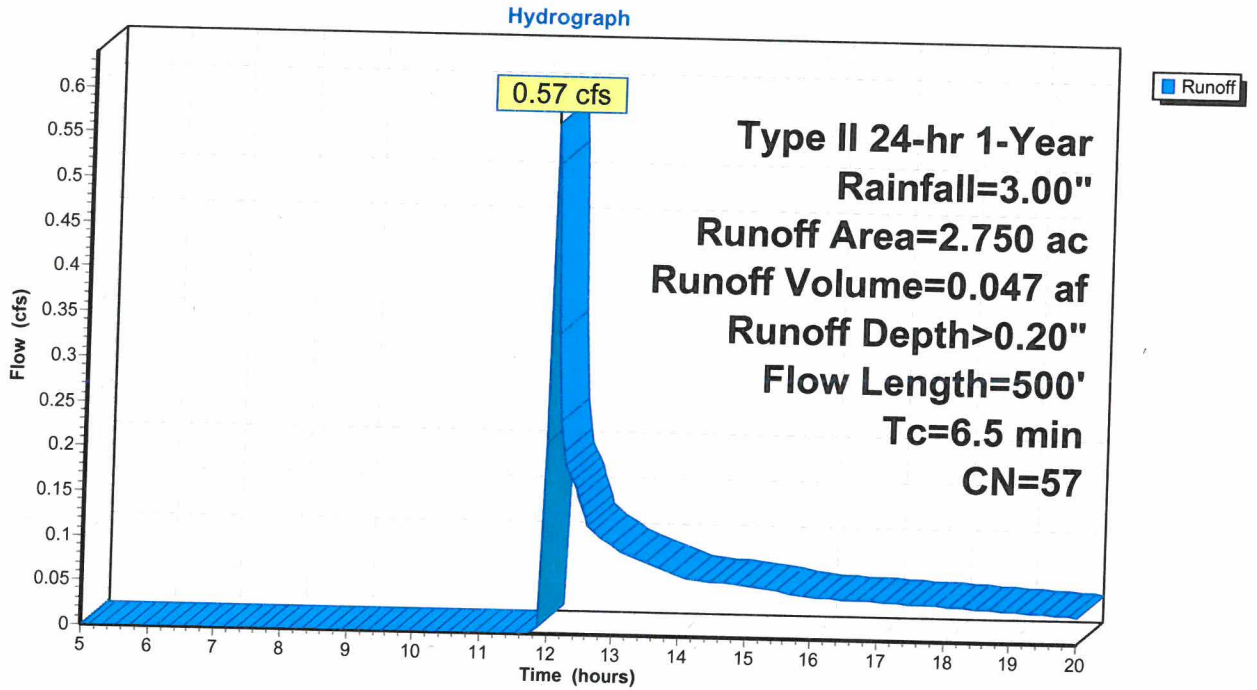
HydroCAD® 9.00 s/n 02109 © 2009 HydroCAD Software Solutions LLC

Type II 24-hr 1-Year Rainfall=3.00"

Printed 4/28/2014

Page 3

Subcatchment 1S: Basin 1 - Predevelopment



STORM STUDY - 1306

Type II 24-hr 1-Year Rainfall=3.00"

Prepared by {enter your company name here}

Printed 4/28/2014

HydroCAD® 9.00 s/n 02109 © 2009 HydroCAD Software Solutions LLC

Page 4

Summary for Subcatchment 2S: Basin 2 - Predevelopment

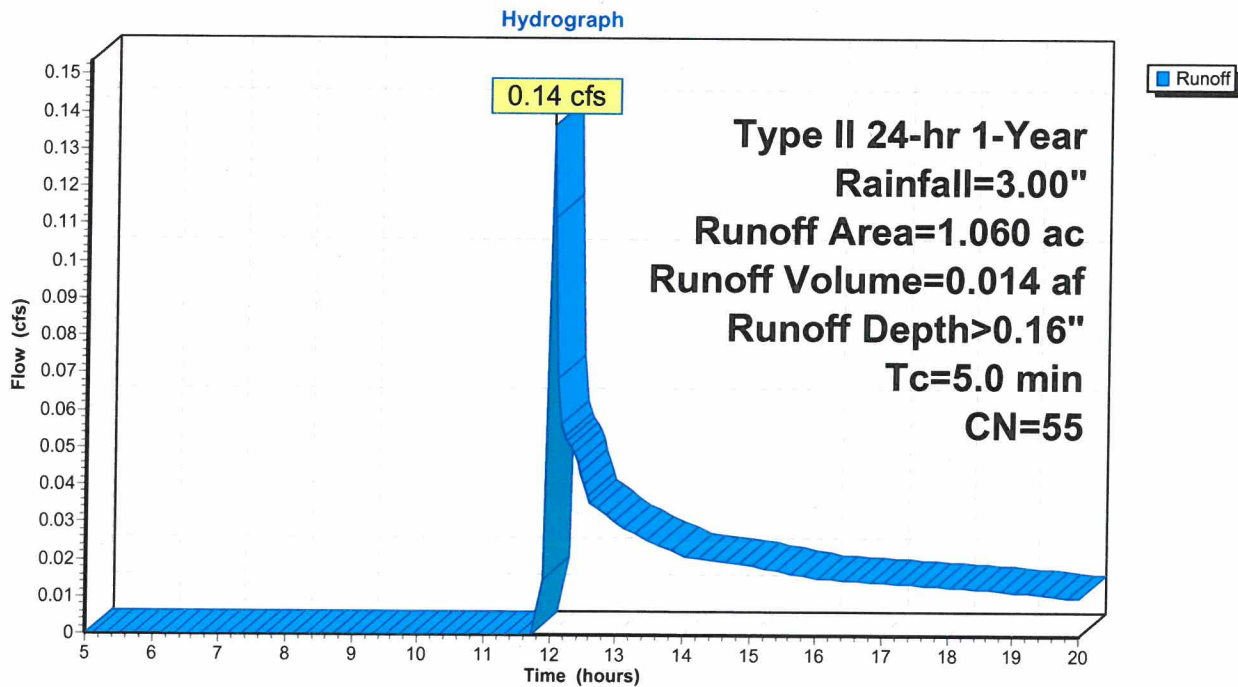
Runoff = 0.14 cfs @ 12.02 hrs, Volume= 0.014 af, Depth> 0.16"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
 Type II 24-hr 1-Year Rainfall=3.00"

| Area (ac) | CN | Description |
|-----------|----|-------------------------------|
| 0.030 | 61 | >75% Grass cover, Good, HSG B |
| 1.020 | 55 | Woods, Good, HSG B |
| 0.010 | 80 | >75% Grass cover, Good, HSG D |
| 1.060 | 55 | Weighted Average |
| 1.060 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|----------|---------------|---------------|-------------------|----------------|---------------|
| 5.0 | | | | | Direct Entry, |

Subcatchment 2S: Basin 2 - Predevelopment



STORM STUDY - 1306

Prepared by {enter your company name here}
 HydroCAD® 9.00 s/n 02109 © 2009 HydroCAD Software Solutions LLC

Type II 24-hr 1-Year Rainfall=3.00"

Printed 4/28/2014

Page 5

Summary for Subcatchment 3S: Basin 1 - Postdevelopment

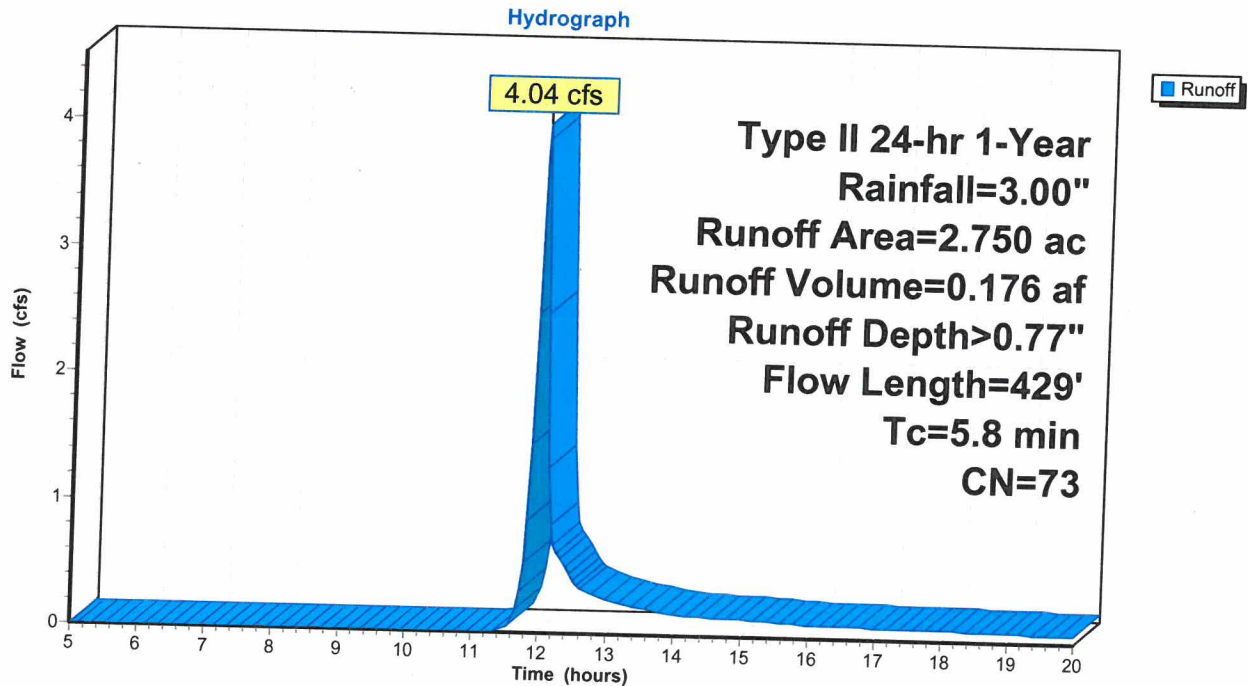
Runoff = 4.04 cfs @ 11.98 hrs, Volume= 0.176 af, Depth> 0.77"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
 Type II 24-hr 1-Year Rainfall=3.00"

| Area (ac) | CN | Description |
|-----------|----|-------------------------------|
| 1.070 | 98 | Paved parking, HSG B |
| 0.430 | 61 | >75% Grass cover, Good, HSG B |
| 1.250 | 55 | Woods, Good, HSG B |
| 2.750 | 73 | Weighted Average |
| 1.680 | | 61.09% Pervious Area |
| 1.070 | | 38.91% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|----------|---------------|---------------|-------------------|----------------|--|
| 3.0 | 75 | 0.1867 | 0.42 | | Sheet Flow, |
| 1.3 | 117 | 0.0939 | 1.53 | | Grass: Short n= 0.150 P2= 3.60" |
| 1.5 | 237 | 0.0634 | 2.65 | 0.53 | Shallow Concentrated Flow, Woodland Kv= 5.0 fps |
| 5.8 | 429 | Total | | | Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=1.00' Z= 0.2 ' /' Top.W=0.40' n= 0.030 |

Subcatchment 3S: Basin 1 - Postdevelopment



STORM STUDY - 1306

Type II 24-hr 1-Year Rainfall=3.00"

Prepared by {enter your company name here}

Printed 4/28/2014

HydroCAD® 9.00 s/n 02109 © 2009 HydroCAD Software Solutions LLC

Page 6

Summary for Subcatchment 4S: Basin 2 - Postdevelopment

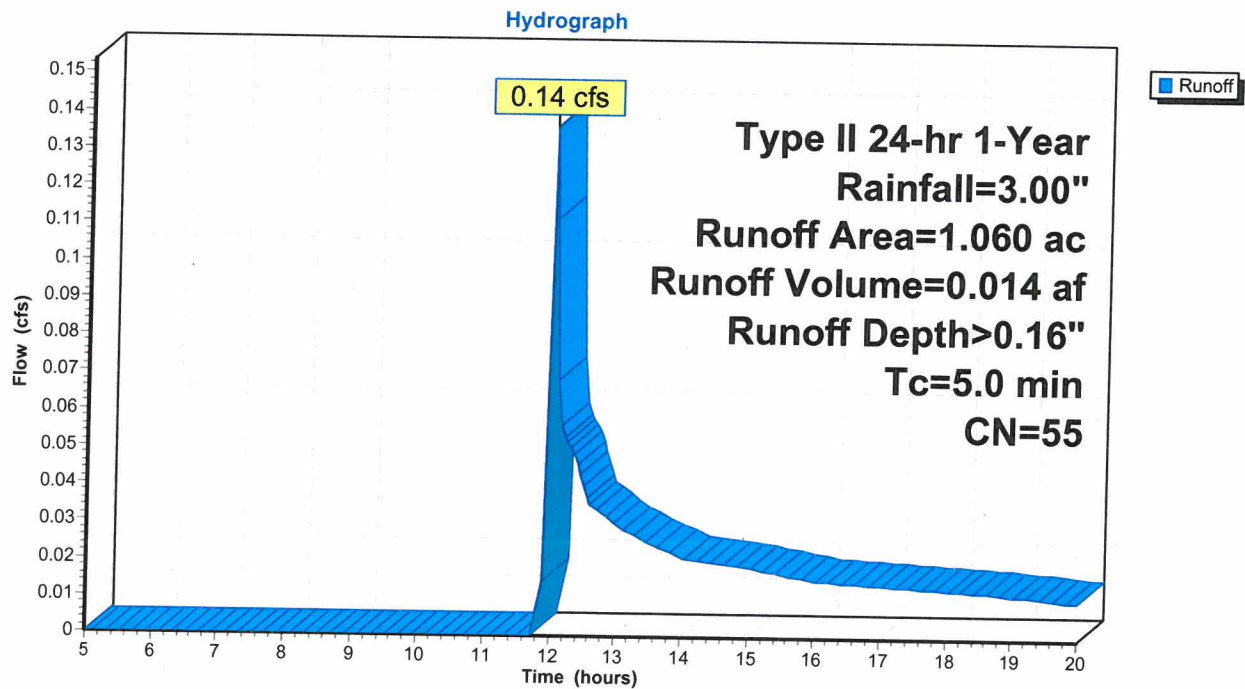
Runoff = 0.14 cfs @ 12.02 hrs, Volume= 0.014 af, Depth> 0.16"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 1-Year Rainfall=3.00"

| Area (ac) | CN | Description |
|-----------|----|-------------------------------|
| 0.030 | 61 | >75% Grass cover, Good, HSG B |
| 1.020 | 55 | Woods, Good, HSG B |
| 0.010 | 80 | >75% Grass cover, Good, HSG D |
| 1.060 | 55 | Weighted Average |
| 1.060 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|----------|---------------|---------------|-------------------|----------------|---------------|
| 5.0 | | | | | Direct Entry, |

Subcatchment 4S: Basin 2 - Postdevelopment



STORM STUDY - 1306

Type II 24-hr 2-Year Rainfall=3.50"

Prepared by {enter your company name here}
 HydroCAD® 9.00 s/n 02109 © 2009 HydroCAD Software Solutions LLC

Printed 4/28/2014

Page 4

Summary for Subcatchment 1S: Basin 1 - Predevelopment

Runoff = 1.40 cfs @ 12.01 hrs, Volume= 0.081 af, Depth> 0.35"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
 Type II 24-hr 2-Year Rainfall=3.50"

| Area (ac) | CN | Description |
|-----------|----|-------------------------------|
| 0.020 | 98 | Unconnected pavement, HSG B |
| 0.720 | 61 | >75% Grass cover, Good, HSG B |
| 2.010 | 55 | Woods, Good, HSG B |
| 2.750 | 57 | Weighted Average |
| 2.730 | | 99.27% Pervious Area |
| 0.020 | | 0.73% Impervious Area |
| 0.020 | | 100.00% Unconnected |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|----------|---------------|---------------|-------------------|----------------|---|
| 3.3 | 75 | 0.1467 | 0.38 | | Sheet Flow, |
| | | | | | Grass: Short n= 0.150 P2= 3.60" |
| 0.9 | 96 | 0.0625 | 1.75 | | Shallow Concentrated Flow, |
| | | | | | Short Grass Pasture Kv= 7.0 fps |
| 0.8 | 92 | 0.1415 | 1.88 | | Shallow Concentrated Flow, |
| | | | | | Woodland Kv= 5.0 fps |
| 1.5 | 237 | 0.0634 | 2.65 | 0.53 | Trap/Vee/Rect Channel Flow, |
| | | | | | Bot.W=0.00' D=1.00' Z= 0.2 ' /' Top.W=0.40' |
| | | | | | n= 0.030 Earth, grassed & winding |
| 6.5 | 500 | Total | | | |

STORM STUDY - 1306

Prepared by {enter your company name here}

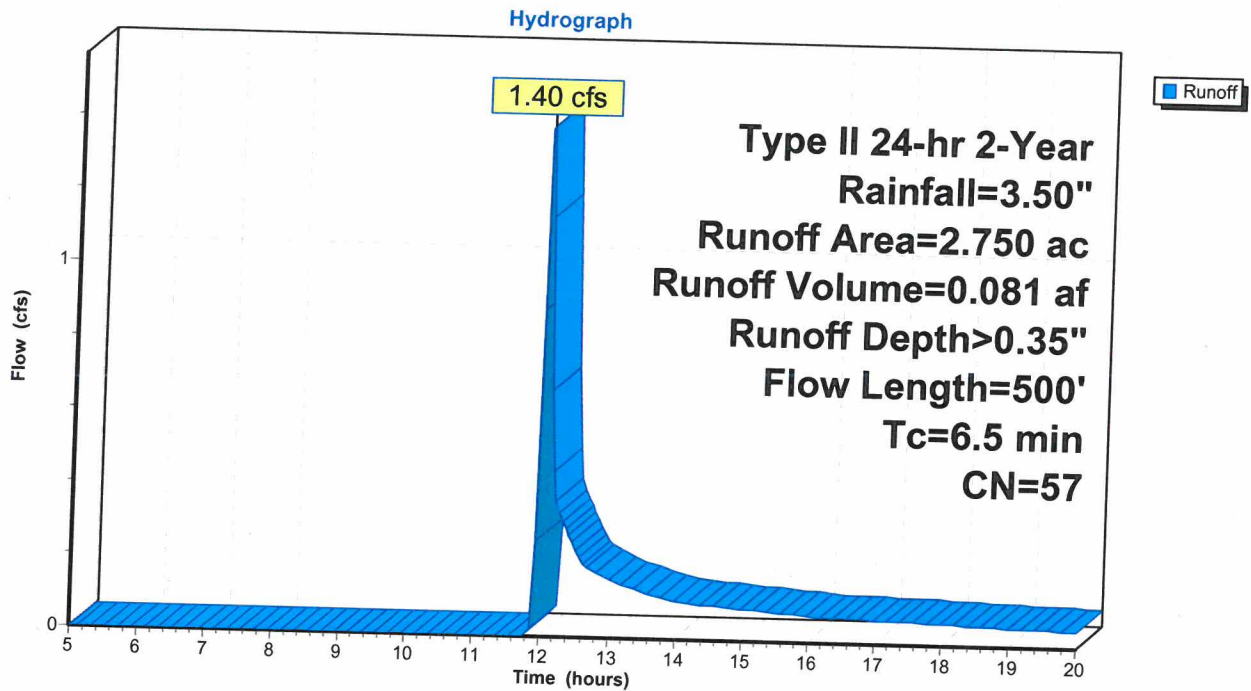
HydroCAD® 9.00 s/n 02109 © 2009 HydroCAD Software Solutions LLC

Type II 24-hr 2-Year Rainfall=3.50"

Printed 4/28/2014

Page 5

Subcatchment 1S: Basin 1 - Predevelopment



STORM STUDY - 1306

Prepared by {enter your company name here}

HydroCAD® 9.00 s/n 02109 © 2009 HydroCAD Software Solutions LLC

Type II 24-hr 2-Year Rainfall=3.50"

Printed 4/28/2014

Page 9

Summary for Subcatchment 2S: Basin 2 - Predevelopment

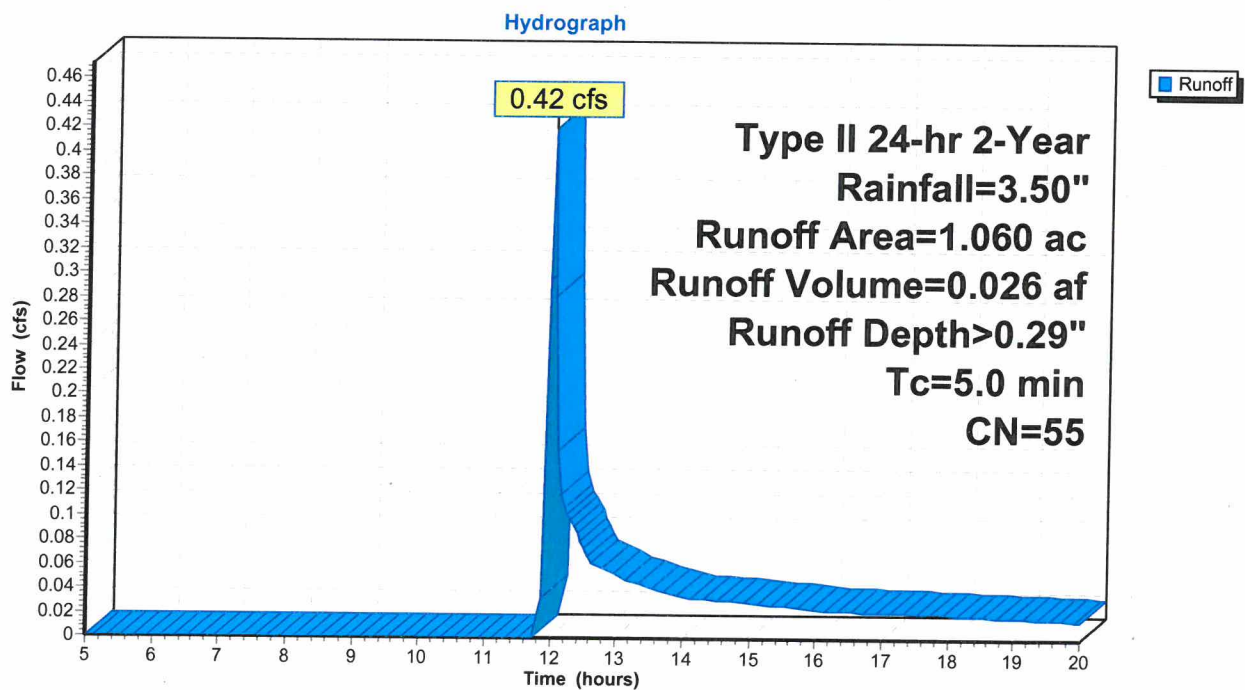
Runoff = 0.42 cfs @ 12.00 hrs, Volume= 0.026 af, Depth> 0.29"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 2-Year Rainfall=3.50"

| Area (ac) | CN | Description |
|-----------|----|-------------------------------|
| 0.030 | 61 | >75% Grass cover, Good, HSG B |
| 1.020 | 55 | Woods, Good, HSG B |
| 0.010 | 80 | >75% Grass cover, Good, HSG D |
| 1.060 | 55 | Weighted Average |
| 1.060 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|----------|---------------|---------------|-------------------|----------------|---------------|
| 5.0 | | | | | Direct Entry, |

Subcatchment 2S: Basin 2 - Predevelopment



STORM STUDY - 1306

Type II 24-hr 2-Year Rainfall=3.50"

Prepared by {enter your company name here}

Printed 4/28/2014

HydroCAD® 9.00 s/n 02109 © 2009 HydroCAD Software Solutions LLC

Page 10

Summary for Subcatchment 3S: Basin 1 - Postdevelopment

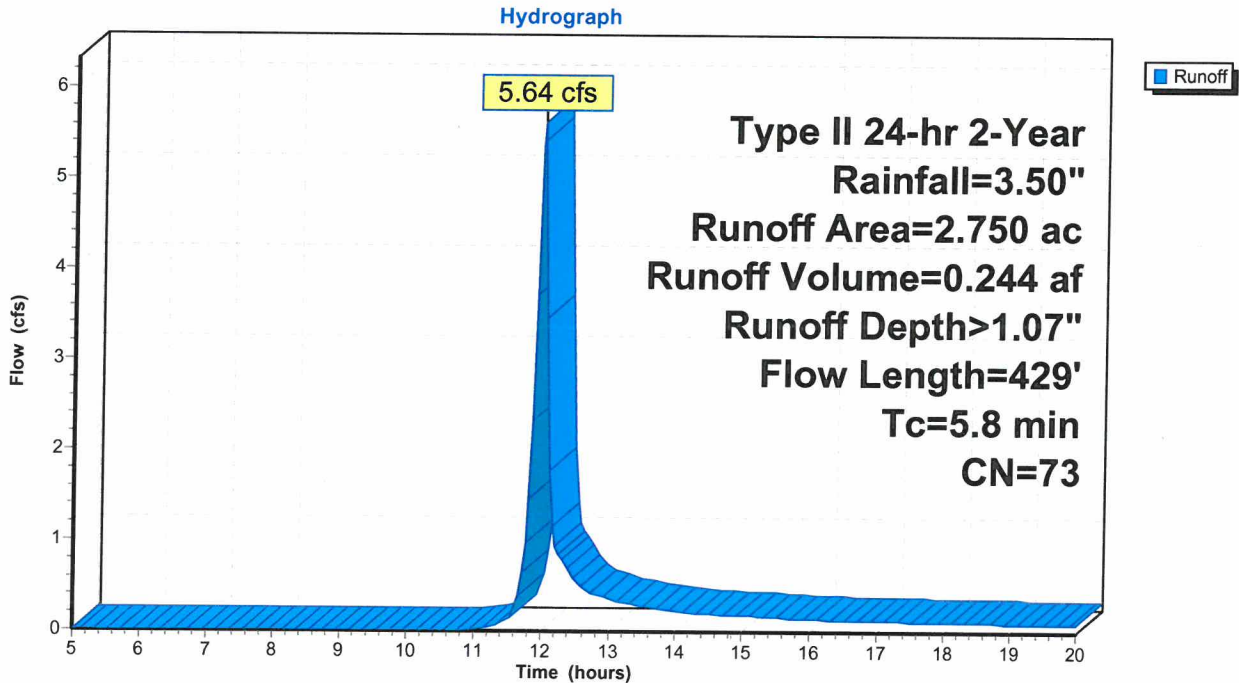
Runoff = 5.64 cfs @ 11.98 hrs, Volume= 0.244 af, Depth> 1.07"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 2-Year Rainfall=3.50"

| Area (ac) | CN | Description |
|-----------|----|-------------------------------|
| 1.070 | 98 | Paved parking, HSG B |
| 0.430 | 61 | >75% Grass cover, Good, HSG B |
| 1.250 | 55 | Woods, Good, HSG B |
| 2.750 | 73 | Weighted Average |
| 1.680 | | 61.09% Pervious Area |
| 1.070 | | 38.91% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|----------|---------------|---------------|-------------------|----------------|--|
| 3.0 | 75 | 0.1867 | 0.42 | | Sheet Flow, Grass: Short n= 0.150 P2= 3.60" |
| 1.3 | 117 | 0.0939 | 1.53 | | Shallow Concentrated Flow, Woodland Kv= 5.0 fps |
| 1.5 | 237 | 0.0634 | 2.65 | 0.53 | Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=1.00' Z= 0.2 '/' Top.W=0.40' n= 0.030 |
| 5.8 | 429 | Total | | | |

Subcatchment 3S: Basin 1 - Postdevelopment



STORM STUDY - 1306

Prepared by {enter your company name here}

HydroCAD® 9.00 s/n 02109 © 2009 HydroCAD Software Solutions LLC

Type II 24-hr 2-Year Rainfall=3.50"

Printed 4/28/2014

Page 11

Summary for Subcatchment 4S: Basin 2 - Postdevelopment

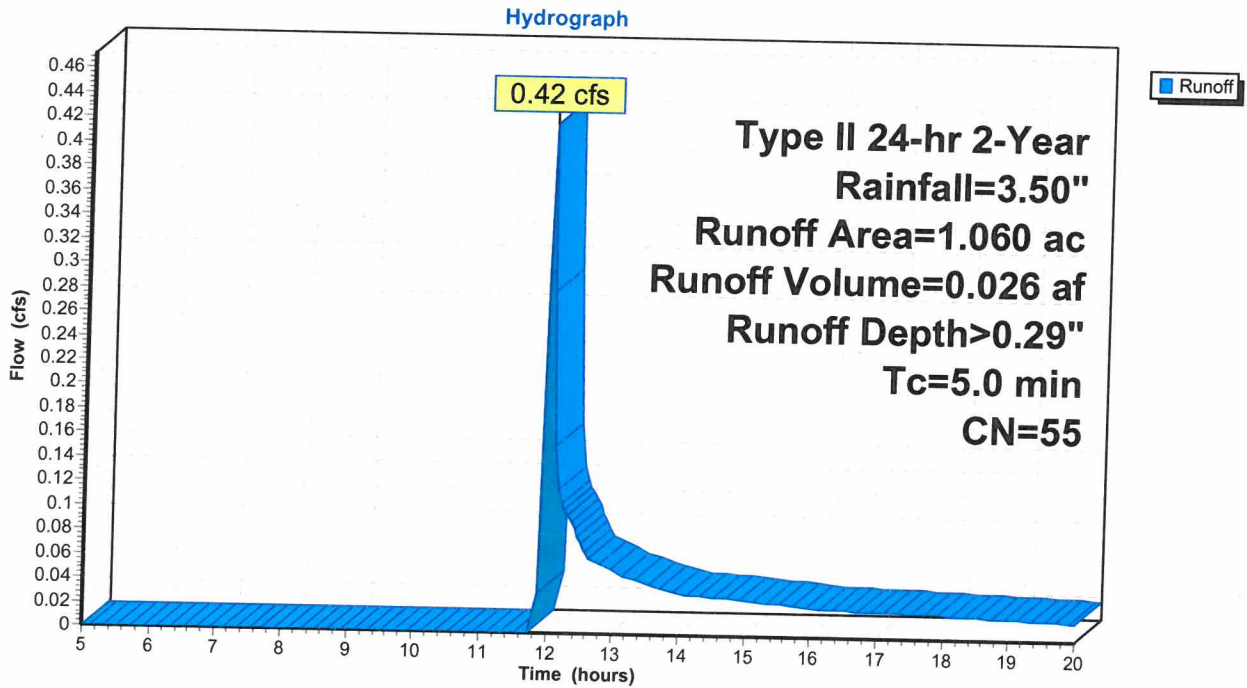
Runoff = 0.42 cfs @ 12.00 hrs, Volume= 0.026 af, Depth> 0.29"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 2-Year Rainfall=3.50"

| Area (ac) | CN | Description |
|-----------|----|-------------------------------|
| 0.030 | 61 | >75% Grass cover, Good, HSG B |
| 1.020 | 55 | Woods, Good, HSG B |
| 0.010 | 80 | >75% Grass cover, Good, HSG D |
| 1.060 | 55 | Weighted Average |
| 1.060 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|----------|---------------|---------------|-------------------|----------------|---------------|
| 5.0 | | | | | Direct Entry, |

Subcatchment 4S: Basin 2 - Postdevelopment



STORM STUDY - 1306

Type II 24-hr 25-Year Rainfall=6.00"

Prepared by {enter your company name here}

Printed 4/28/2014

HydroCAD® 9.00 s/n 02109 © 2009 HydroCAD Software Solutions LLC

Page 6

Summary for Subcatchment 1S: Basin 1 - Predevelopment

Runoff = 7.71 cfs @ 11.99 hrs, Volume= 0.344 af, Depth> 1.50"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-Year Rainfall=6.00"

| Area (ac) | CN | Description |
|-----------|----|-------------------------------|
| 0.020 | 98 | Unconnected pavement, HSG B |
| 0.720 | 61 | >75% Grass cover, Good, HSG B |
| 2.010 | 55 | Woods, Good, HSG B |
| 2.750 | 57 | Weighted Average |
| 2.730 | | 99.27% Pervious Area |
| 0.020 | | 0.73% Impervious Area |
| 0.020 | | 100.00% Unconnected |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|----------|---------------|---------------|-------------------|----------------|---|
| 3.3 | 75 | 0.1467 | 0.38 | | Sheet Flow, Grass: Short n= 0.150 P2= 3.60" |
| 0.9 | 96 | 0.0625 | 1.75 | | Shallow Concentrated Flow, Short Grass Pasture Kv= 7.0 fps |
| 0.8 | 92 | 0.1415 | 1.88 | | Shallow Concentrated Flow, Woodland Kv= 5.0 fps |
| 1.5 | 237 | 0.0634 | 2.65 | 0.53 | Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=1.00' Z= 0.2 '/' Top.W=0.40' n= 0.030 Earth, grassed & winding |
| 6.5 | 500 | Total | | | |

STORM STUDY - 1306

Prepared by {enter your company name here}

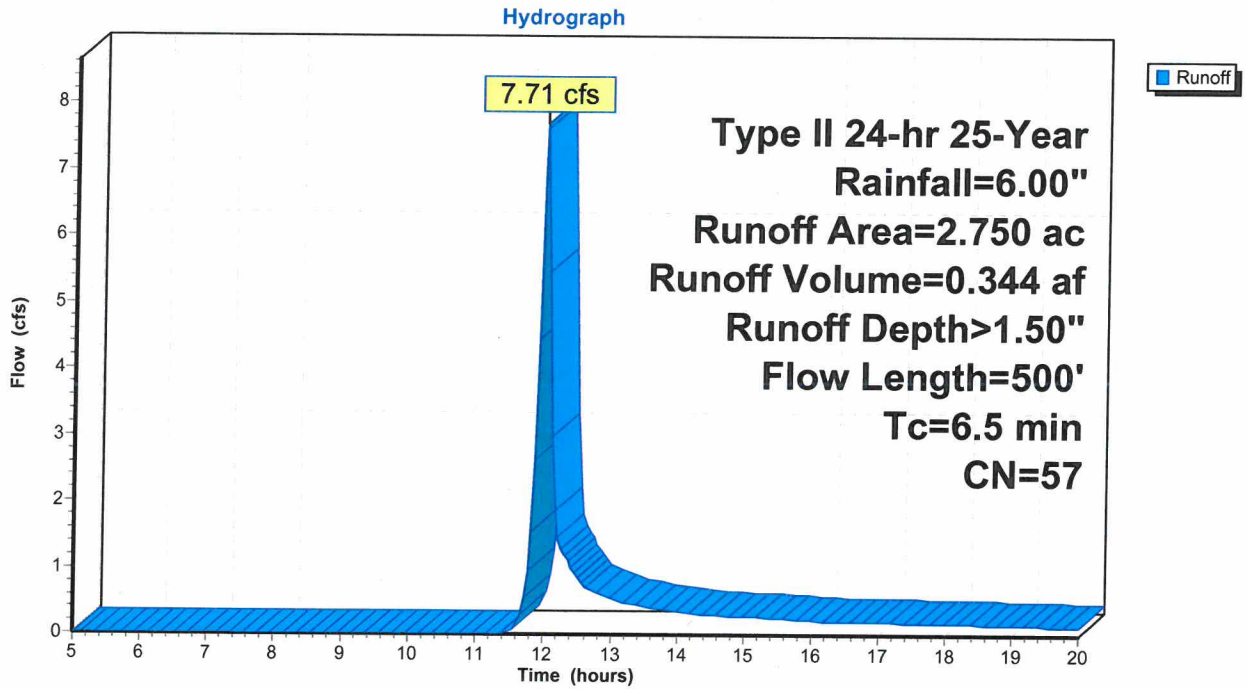
HydroCAD® 9.00 s/n 02109 © 2009 HydroCAD Software Solutions LLC

Type II 24-hr 25-Year Rainfall=6.00"

Printed 4/28/2014

Page 7

Subcatchment 1S: Basin 1 - Predevelopment



STORM STUDY - 1306

Prepared by {enter your company name here}

HydroCAD® 9.00 s/n 02109 © 2009 HydroCAD Software Solutions LLC

Type II 24-hr 25-Year Rainfall=6.00"

Printed 4/28/2014

Page 14

Summary for Subcatchment 2S: Basin 2 - Predevelopment

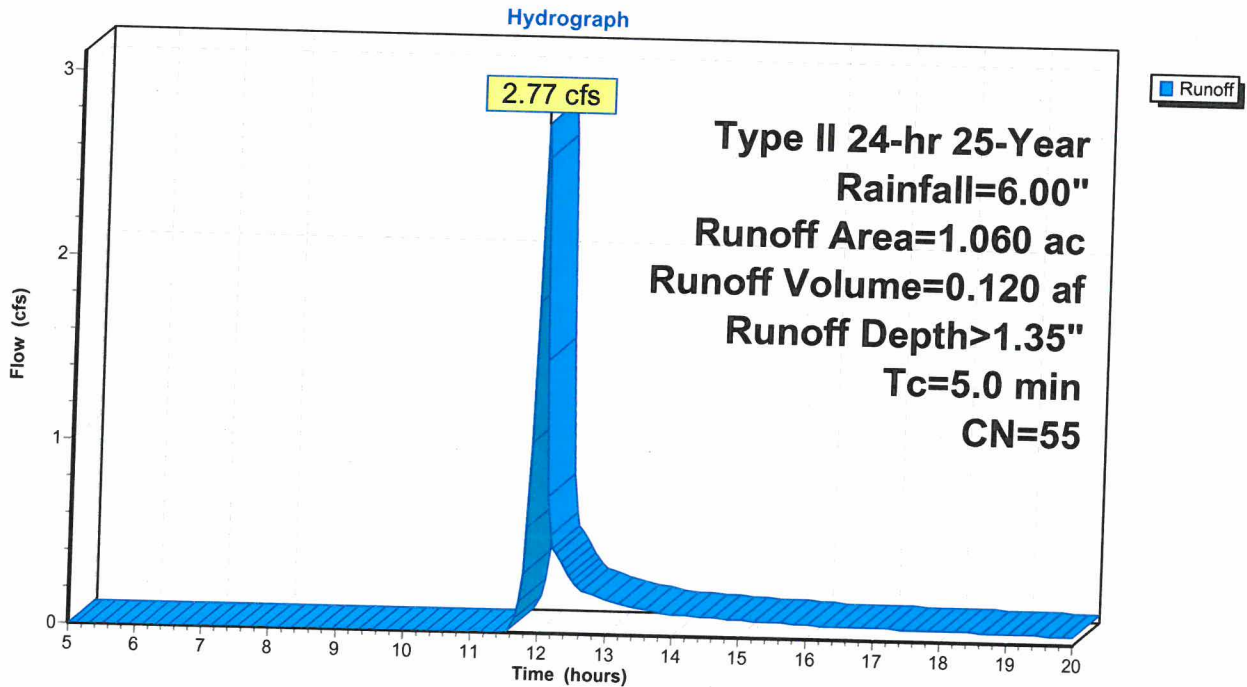
Runoff = 2.77 cfs @ 11.97 hrs, Volume= 0.120 af, Depth> 1.35"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-Year Rainfall=6.00"

| Area (ac) | CN | Description |
|-----------|----|-------------------------------|
| 0.030 | 61 | >75% Grass cover, Good, HSG B |
| 1.020 | 55 | Woods, Good, HSG B |
| 0.010 | 80 | >75% Grass cover, Good, HSG D |
| 1.060 | 55 | Weighted Average |
| 1.060 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|----------|---------------|---------------|-------------------|----------------|---------------|
| 5.0 | | | | | Direct Entry, |

Subcatchment 2S: Basin 2 - Predevelopment



STORM STUDY - 1306

Type II 24-hr 25-Year Rainfall=6.00"

Prepared by {enter your company name here}

Printed 4/28/2014

HydroCAD® 9.00 s/n 02109 © 2009 HydroCAD Software Solutions LLC

Page 15

Summary for Subcatchment 3S: Basin 1 - Postdevelopment

Runoff = 14.72 cfs @ 11.97 hrs, Volume= 0.652 af, Depth> 2.85"

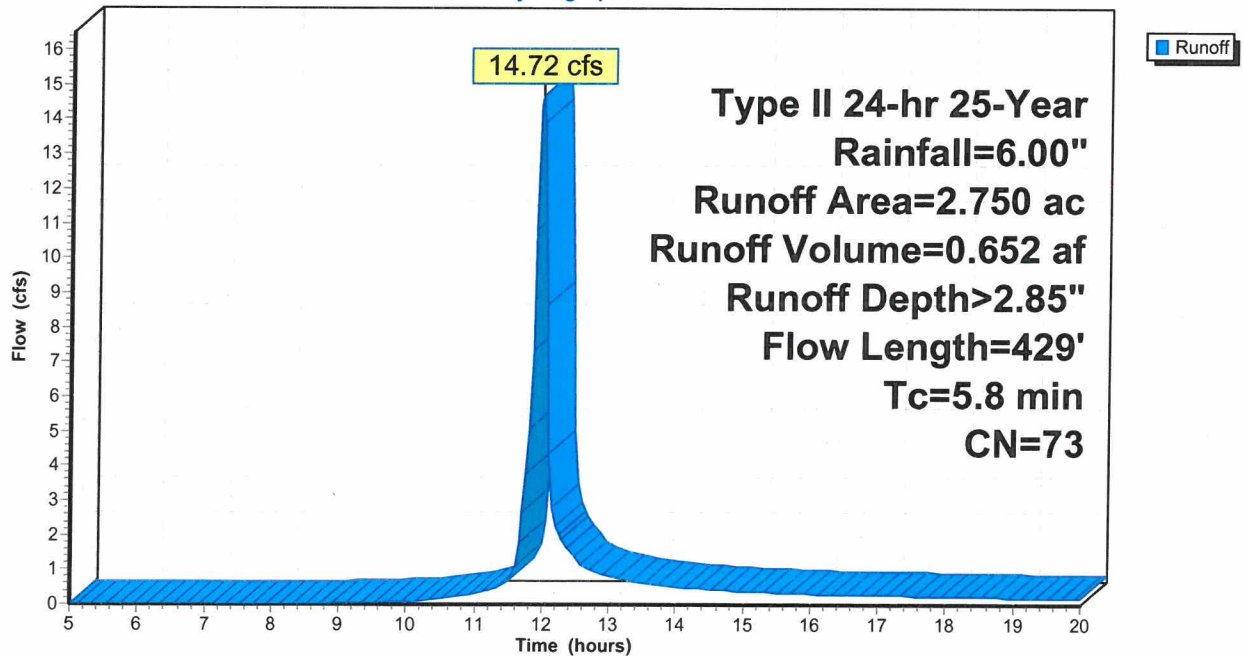
Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-Year Rainfall=6.00"

| Area (ac) | CN | Description |
|-----------|----|-------------------------------|
| 1.070 | 98 | Paved parking, HSG B |
| 0.430 | 61 | >75% Grass cover, Good, HSG B |
| 1.250 | 55 | Woods, Good, HSG B |
| 2.750 | 73 | Weighted Average |
| 1.680 | | 61.09% Pervious Area |
| 1.070 | | 38.91% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|----------|---------------|---------------|-------------------|----------------|---|
| 3.0 | 75 | 0.1867 | 0.42 | | Sheet Flow, Grass: Short n= 0.150 P2= 3.60" |
| 1.3 | 117 | 0.0939 | 1.53 | | Shallow Concentrated Flow, Woodland Kv= 5.0 fps |
| 1.5 | 237 | 0.0634 | 2.65 | 0.53 | Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=1.00' Z= 0.2 '/' Top.W=0.40' n= 0.030 |
| 5.8 | 429 | Total | | | |

Subcatchment 3S: Basin 1 - Postdevelopment

Hydrograph



STORM STUDY - 1306

Type II 24-hr 25-Year Rainfall=6.00"

Prepared by {enter your company name here}

Printed 4/28/2014

HydroCAD® 9.00 s/n 02109 © 2009 HydroCAD Software Solutions LLC

Page 16

Summary for Subcatchment 4S: Basin 2 - Postdevelopment

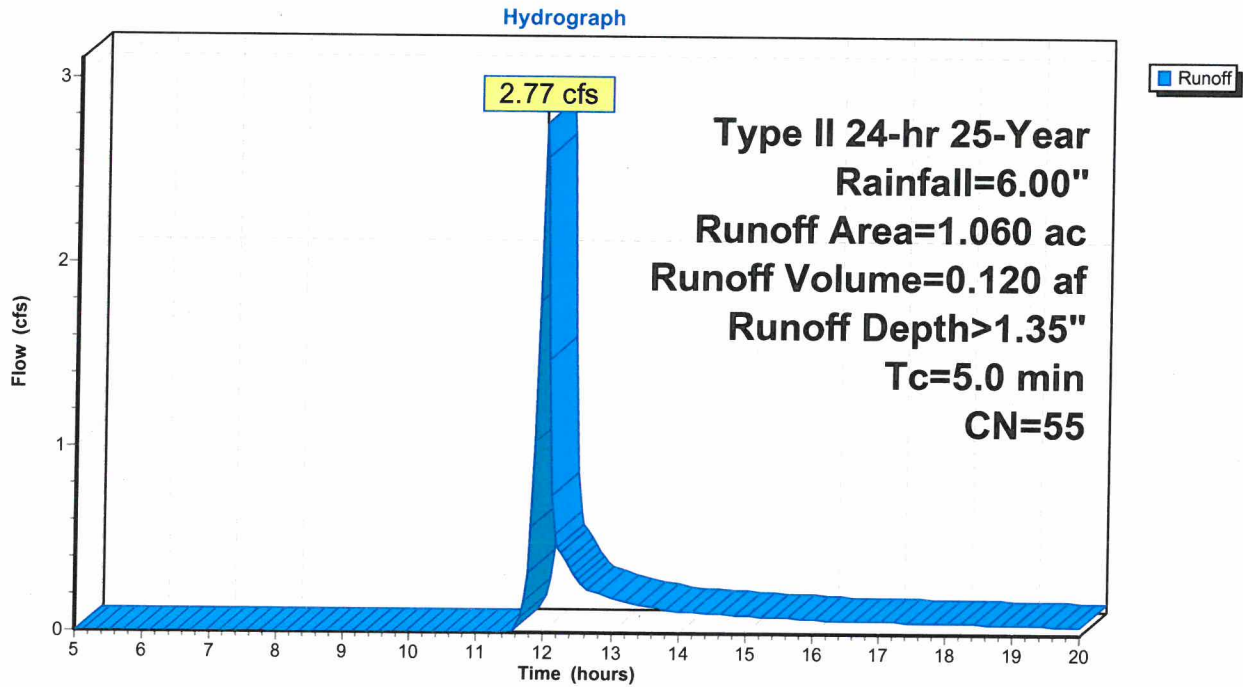
Runoff = 2.77 cfs @ 11.97 hrs, Volume= 0.120 af, Depth> 1.35"

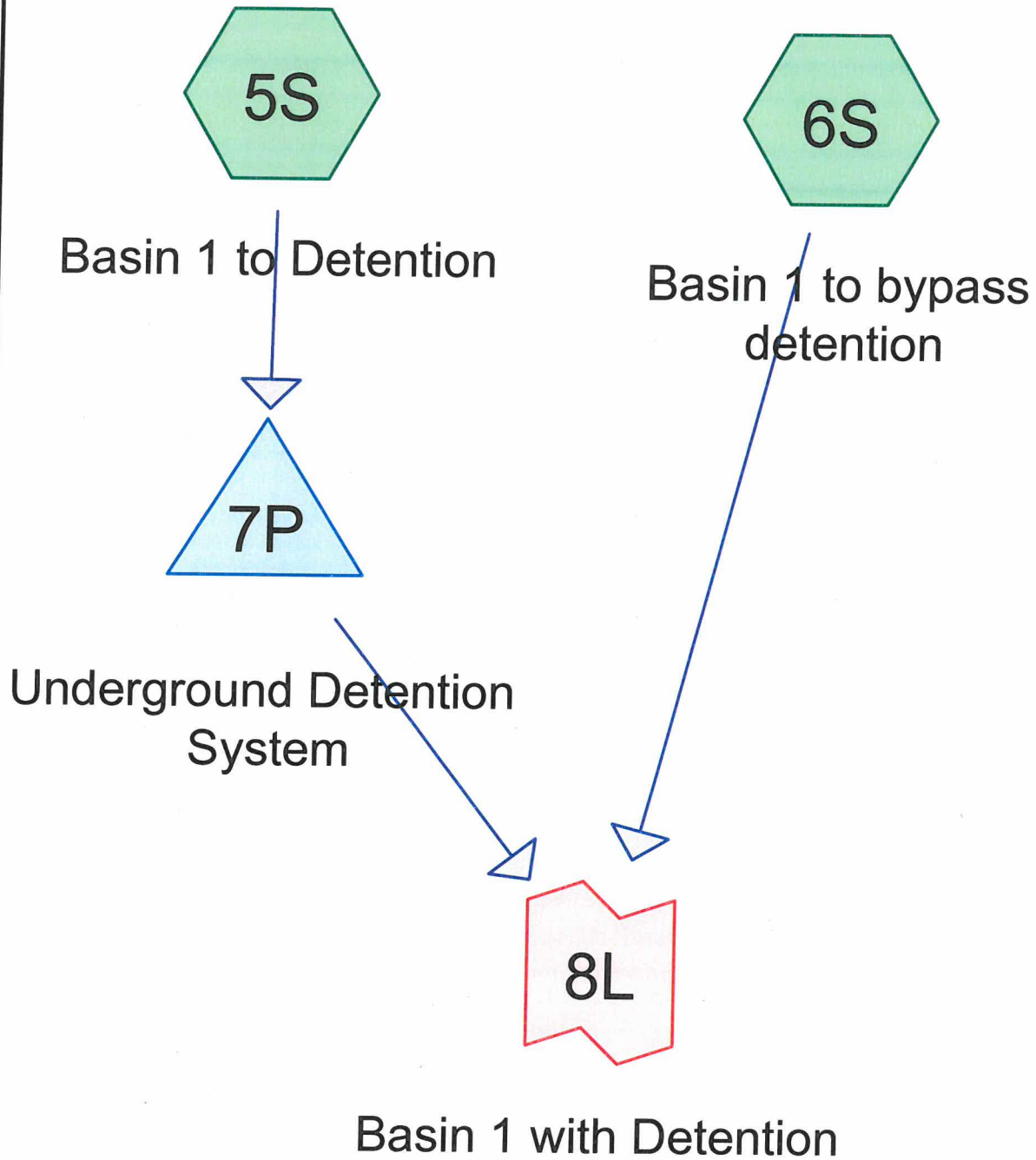
Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-Year Rainfall=6.00"

| Area (ac) | CN | Description |
|-----------|----|-------------------------------|
| 0.030 | 61 | >75% Grass cover, Good, HSG B |
| 1.020 | 55 | Woods, Good, HSG B |
| 0.010 | 80 | >75% Grass cover, Good, HSG D |
| 1.060 | 55 | Weighted Average |
| 1.060 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|----------|---------------|---------------|-------------------|----------------|---------------|
| 5.0 | | | | | Direct Entry, |

Subcatchment 4S: Basin 2 - Postdevelopment





STORM STUDY - 1306

Type II 24-hr 1-Year Rainfall=3.00"

Prepared by {enter your company name here}

Printed 4/28/2014

HydroCAD® 9.00 s/n 02109 © 2009 HydroCAD Software Solutions LLC

Page 2

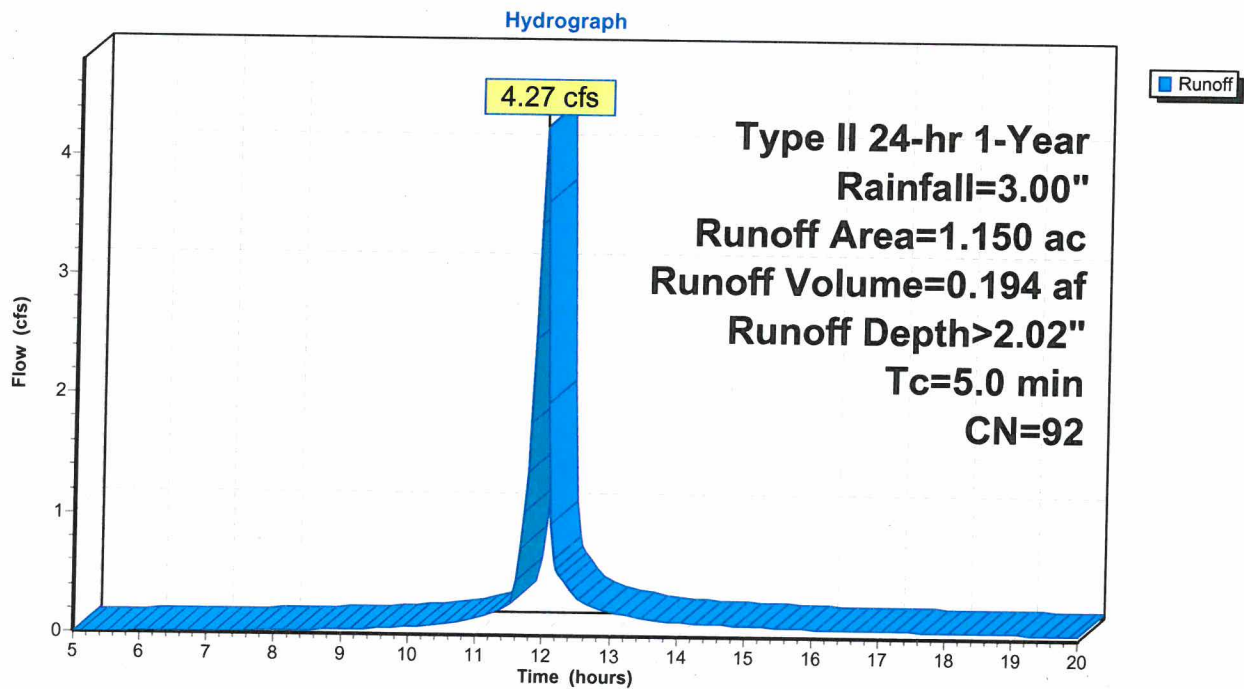
Summary for Subcatchment 5S: Basin 1 to Detention

Runoff = 4.27 cfs @ 11.95 hrs, Volume= 0.194 af, Depth> 2.02"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 1-Year Rainfall=3.00"

| Area (ac) | CN | Description |
|-----------|----|-------------------------------|
| 0.960 | 98 | Paved parking, HSG B |
| 0.190 | 61 | >75% Grass cover, Good, HSG B |
| 1.150 | 92 | Weighted Average |
| 0.190 | | 16.52% Pervious Area |
| 0.960 | | 83.48% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|----------|---------------|---------------|-------------------|----------------|---------------|
| 5.0 | | | | | Direct Entry, |

Subcatchment 5S: Basin 1 to Detention

STORM STUDY - 1306

Type II 24-hr 1-Year Rainfall=3.00"

Prepared by {enter your company name here}

Printed 4/28/2014

HydroCAD® 9.00 s/n 02109 © 2009 HydroCAD Software Solutions LLC

Page 3

Summary for Subcatchment 6S: Basin 1 to bypass detention

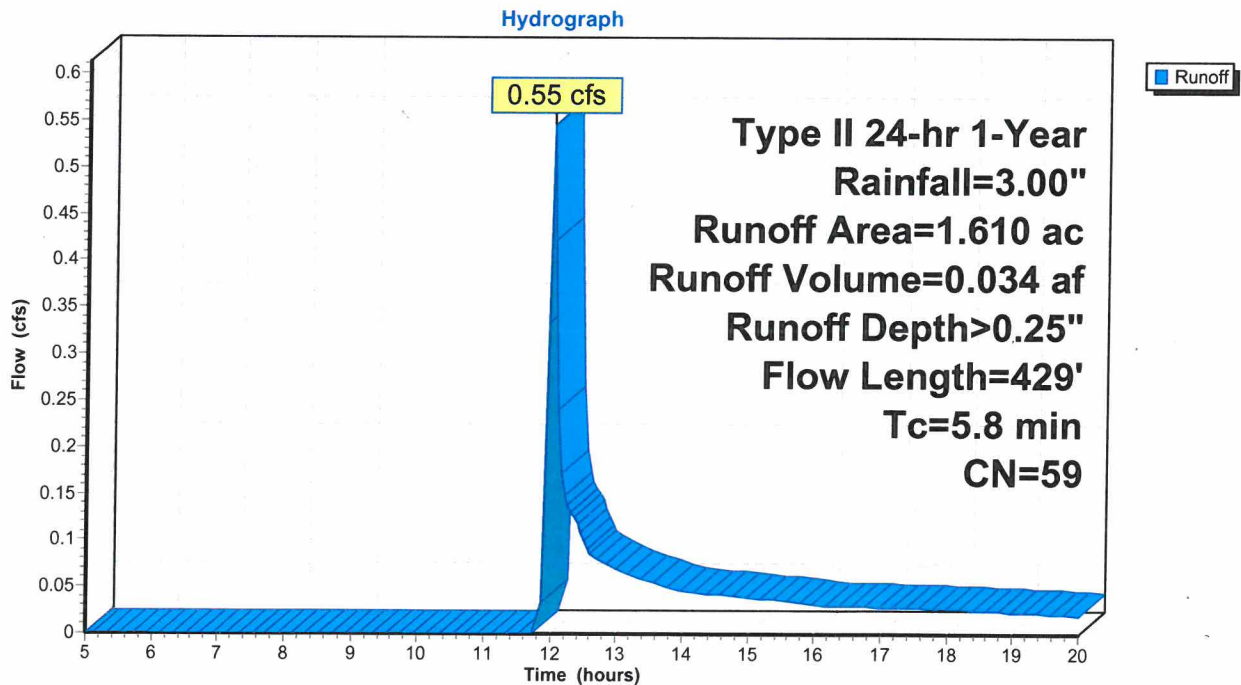
Runoff = 0.55 cfs @ 12.01 hrs, Volume= 0.034 af, Depth> 0.25"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 1-Year Rainfall=3.00"

| Area (ac) | CN | Description |
|-----------|----|-------------------------------|
| 0.120 | 98 | Paved parking, HSG B |
| 0.240 | 61 | >75% Grass cover, Good, HSG B |
| 1.250 | 55 | Woods, Good, HSG B |
| 1.610 | 59 | Weighted Average |
| 1.490 | | 92.55% Pervious Area |
| 0.120 | | 7.45% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|----------|---------------|---------------|-------------------|----------------|--|
| 3.0 | 75 | 0.1867 | 0.42 | | Sheet Flow, Grass: Short n= 0.150 P2= 3.60" |
| 1.3 | 117 | 0.0939 | 1.53 | | Shallow Concentrated Flow, Woodland Kv= 5.0 fps |
| 1.5 | 237 | 0.0634 | 2.65 | 0.53 | Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=1.00' Z= 0.2 '/' Top.W=0.40' n= 0.030 |
| 5.8 | 429 | Total | | | |

Subcatchment 6S: Basin 1 to bypass detention



STORM STUDY - 1306

Prepared by {enter your company name here}

HydroCAD® 9.00 s/n 02109 © 2009 HydroCAD Software Solutions LLC

Type II 24-hr 1-Year Rainfall=3.00"

Printed 4/28/2014

Page 4

Summary for Pond 7P: Underground Detention System

Inflow Area = 1.150 ac, 83.48% Impervious, Inflow Depth > 2.02" for 1-Year event
 Inflow = 4.27 cfs @ 11.95 hrs, Volume= 0.194 af
 Outflow = 0.03 cfs @ 20.00 hrs, Volume= 0.021 af, Atten= 99%, Lag= 482.8 min
 Primary = 0.03 cfs @ 20.00 hrs, Volume= 0.021 af

Routing by Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
 Peak Elev= 328.81' @ 20.00 hrs Surf.Area= 1,511 sf Storage= 7,522 cf

Plug-Flow detention time= 342.3 min calculated for 0.021 af (11% of inflow)
 Center-of-Mass det. time= 161.4 min (921.8 - 760.5)

| Volume | Invert | Avail.Storage | Storage Description |
|--------|---------|---------------|--|
| #1 | 323.83' | 12,852 cf | Custom Stage Data (Prismatic) Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|------------------|-------------------|------------------------|------------------------|
| 323.83 | 1,511 | 0 | 0 |
| 331.33 | 1,511 | 11,333 | 11,333 |
| 332.33 | 1,527 | 1,519 | 12,852 |

| Device | Routing | Invert | Outlet Devices |
|--------|----------|---------|--|
| #1 | Primary | 323.50' | 15.0" Round Culvert L= 20.0' RCP, groove end w/headwall, Ke= 0.200 Outlet Invert= 322.50' S= 0.0500 '/' Cc= 0.900 n= 0.013 |
| #2 | Device 1 | 323.83' | 0.5" Vert. Orifice/Grate X 2.00 C= 0.600 |
| #3 | Device 1 | 330.33' | 1.0' long x 0.5' breadth Broad-Crested Rectangular Weir Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32 |
| #4 | Device 1 | 331.33' | 8.0' long x 0.5' breadth Broad-Crested Rectangular Weir Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32 |

Primary OutFlow Max=0.03 cfs @ 20.00 hrs HW=328.81' (Free Discharge)

- 1=Culvert (Passes 0.03 cfs of 15.98 cfs potential flow)
- 2=Orifice/Grate (Orifice Controls 0.03 cfs @ 10.72 fps)
- 3=Broad-Crested Rectangular Weir (Controls 0.00 cfs)
- 4=Broad-Crested Rectangular Weir (Controls 0.00 cfs)

STORM STUDY - 1306

Prepared by {enter your company name here}

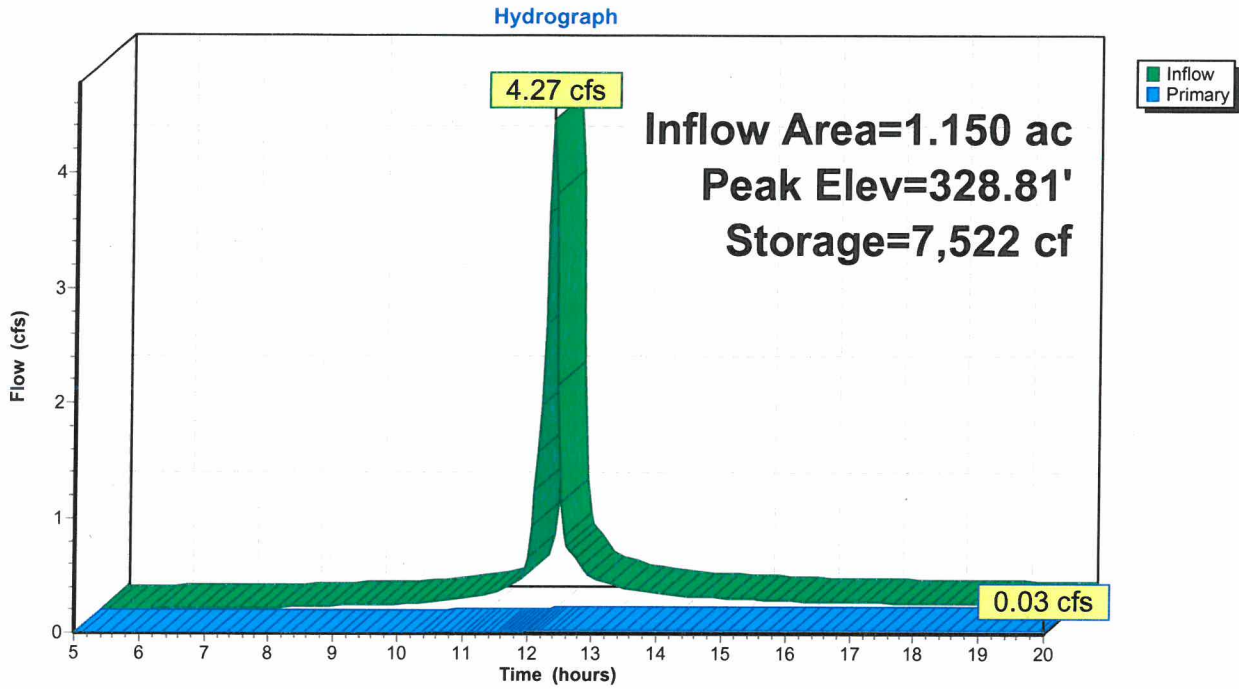
HydroCAD® 9.00 s/n 02109 © 2009 HydroCAD Software Solutions LLC

Type II 24-hr 1-Year Rainfall=3.00"

Printed 4/28/2014

Page 5

Pond 7P: Underground Detention System



STORM STUDY - 1306

Type II 24-hr 1-Year Rainfall=3.00"

Prepared by {enter your company name here}

Printed 4/28/2014

HydroCAD® 9.00 s/n 02109 © 2009 HydroCAD Software Solutions LLC

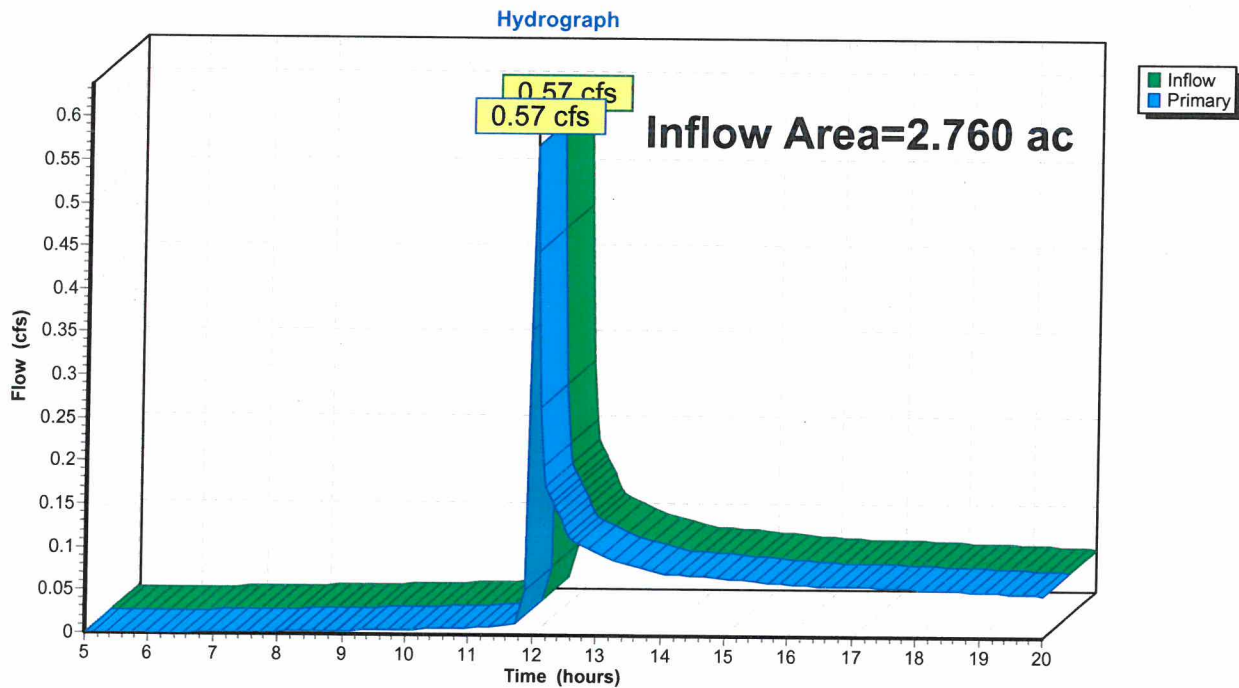
Page 6

Summary for Link 8L: Basin 1 with Detention

Inflow Area = 2.760 ac, 39.13% Impervious, Inflow Depth > 0.24" for 1-Year event
Inflow = 0.57 cfs @ 12.01 hrs, Volume= 0.055 af
Primary = 0.57 cfs @ 12.01 hrs, Volume= 0.055 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

Link 8L: Basin 1 with Detention



STORM STUDY - 1306

Prepared by {enter your company name here}

HydroCAD® 9.00 s/n 02109 © 2009 HydroCAD Software Solutions LLC

Type II 24-hr 2-Year Rainfall=3.50"

Printed 4/28/2014

Page 7

Summary for Subcatchment 5S: Basin 1 to Detention

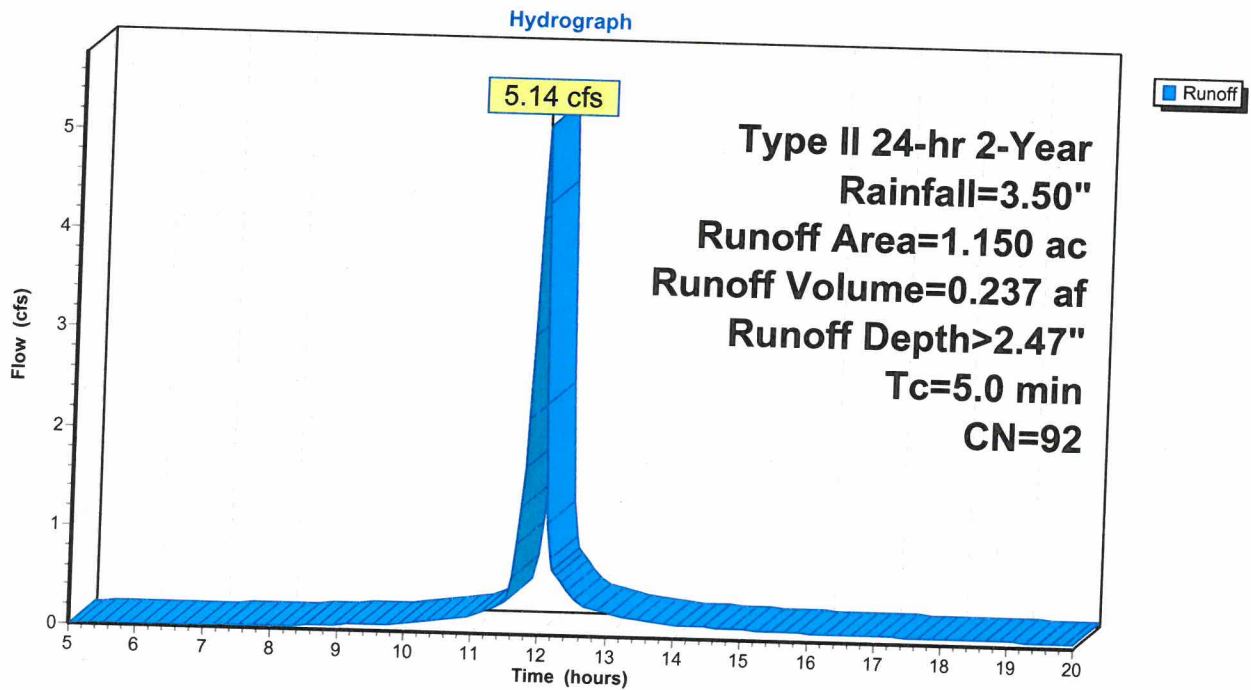
Runoff = 5.14 cfs @ 11.95 hrs, Volume= 0.237 af, Depth> 2.47"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 2-Year Rainfall=3.50"

| Area (ac) | CN | Description |
|-----------|----|-------------------------------|
| 0.960 | 98 | Paved parking, HSG B |
| 0.190 | 61 | >75% Grass cover, Good, HSG B |
| 1.150 | 92 | Weighted Average |
| 0.190 | | 16.52% Pervious Area |
| 0.960 | | 83.48% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|----------|---------------|---------------|-------------------|----------------|---------------|
| 5.0 | | | | | Direct Entry, |

Subcatchment 5S: Basin 1 to Detention



STORM STUDY - 1306

Prepared by {enter your company name here}

HydroCAD® 9.00 s/n 02109 © 2009 HydroCAD Software Solutions LLC

Type II 24-hr 2-Year Rainfall=3.50"

Printed 4/28/2014

Page 8

Summary for Subcatchment 6S: Basin 1 to bypass detention

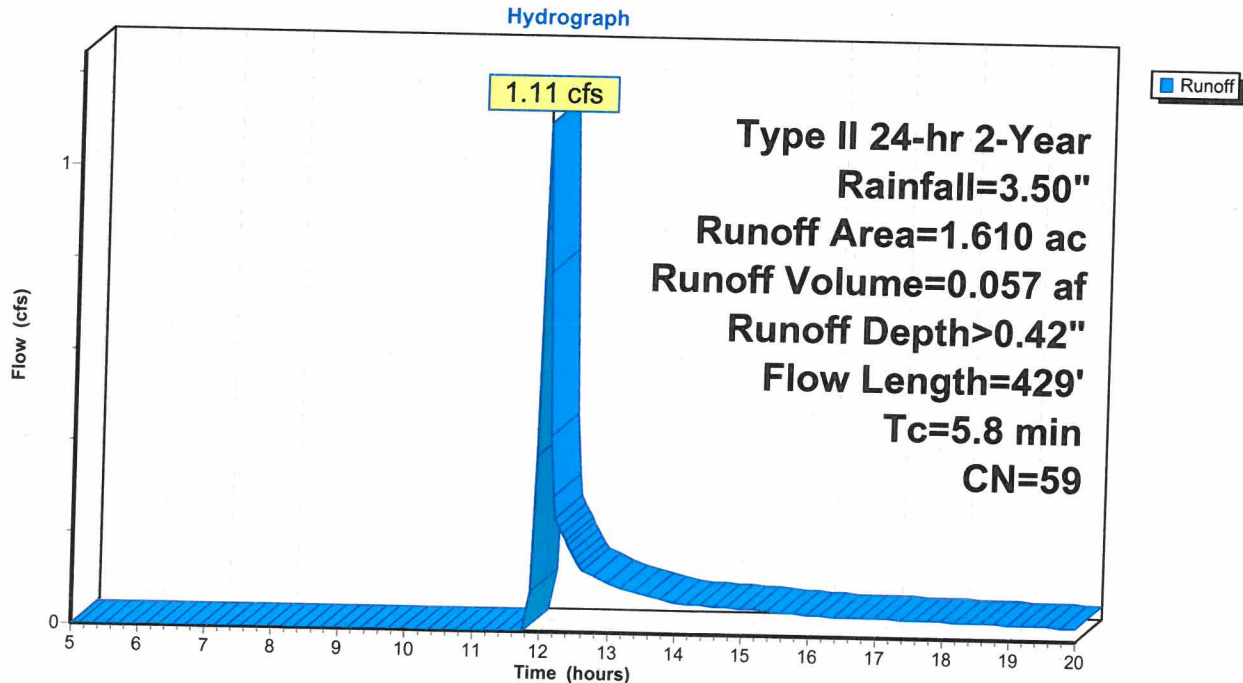
Runoff = 1.11 cfs @ 12.00 hrs, Volume= 0.057 af, Depth> 0.42"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 2-Year Rainfall=3.50"

| Area (ac) | CN | Description |
|-----------|----|-------------------------------|
| 0.120 | 98 | Paved parking, HSG B |
| 0.240 | 61 | >75% Grass cover, Good, HSG B |
| 1.250 | 55 | Woods, Good, HSG B |
| 1.610 | 59 | Weighted Average |
| 1.490 | | 92.55% Pervious Area |
| 0.120 | | 7.45% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|----------|---------------|---------------|-------------------|----------------|---|
| 3.0 | 75 | 0.1867 | 0.42 | | Sheet Flow, Grass: Short n= 0.150 P2= 3.60" |
| 1.3 | 117 | 0.0939 | 1.53 | | Shallow Concentrated Flow, Woodland Kv= 5.0 fps |
| 1.5 | 237 | 0.0634 | 2.65 | 0.53 | Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=1.00' Z= 0.2 ' /' Top.W=0.40' n= 0.030 |
| 5.8 | 429 | Total | | | |

Subcatchment 6S: Basin 1 to bypass detention



STORM STUDY - 1306

Type II 24-hr 2-Year Rainfall=3.50"

Prepared by {enter your company name here}

Printed 4/28/2014

HydroCAD® 9.00 s/n 02109 © 2009 HydroCAD Software Solutions LLC

Page 9

Summary for Pond 7P: Underground Detention System

Inflow Area = 1.150 ac, 83.48% Impervious, Inflow Depth > 2.47" for 2-Year event
 Inflow = 5.14 cfs @ 11.95 hrs, Volume= 0.237 af
 Outflow = 0.03 cfs @ 20.00 hrs, Volume= 0.024 af, Atten= 99%, Lag= 482.9 min
 Primary = 0.03 cfs @ 20.00 hrs, Volume= 0.024 af

Routing by Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
 Peak Elev= 329.97' @ 20.00 hrs Surf.Area= 1,511 sf Storage= 9,276 cf

Plug-Flow detention time= 362.2 min calculated for 0.024 af (10% of inflow)
 Center-of-Mass det. time= 159.4 min (915.4 - 756.0)

| Volume | Invert | Avail.Storage | Storage Description |
|------------------|-------------------|------------------------|--|
| #1 | 323.83' | 12,852 cf | Custom Stage Data (Prismatic) Listed below (Recalc) |
| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
| 323.83 | 1,511 | 0 | 0 |
| 331.33 | 1,511 | 11,333 | 11,333 |
| 332.33 | 1,527 | 1,519 | 12,852 |

| Device | Routing | Invert | Outlet Devices |
|--------|----------|---------|--|
| #1 | Primary | 323.50' | 15.0" Round Culvert L= 20.0' RCP, groove end w/headwall, Ke= 0.200 Outlet Invert= 322.50' S= 0.0500 '/' Cc= 0.900 n= 0.013 |
| #2 | Device 1 | 323.83' | 0.5" Vert. Orifice/Grate X 2.00 C= 0.600 |
| #3 | Device 1 | 330.33' | 1.0' long x 0.5' breadth Broad-Crested Rectangular Weir Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32 |
| #4 | Device 1 | 331.33' | 8.0' long x 0.5' breadth Broad-Crested Rectangular Weir Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32 |

Primary OutFlow Max=0.03 cfs @ 20.00 hrs HW=329.97' (Free Discharge)

- 1=Culvert (Passes 0.03 cfs of 17.86 cfs potential flow)
- 2=Orifice/Grate (Orifice Controls 0.03 cfs @ 11.91 fps)
- 3=Broad-Crested Rectangular Weir (Controls 0.00 cfs)
- 4=Broad-Crested Rectangular Weir (Controls 0.00 cfs)

STORM STUDY - 1306

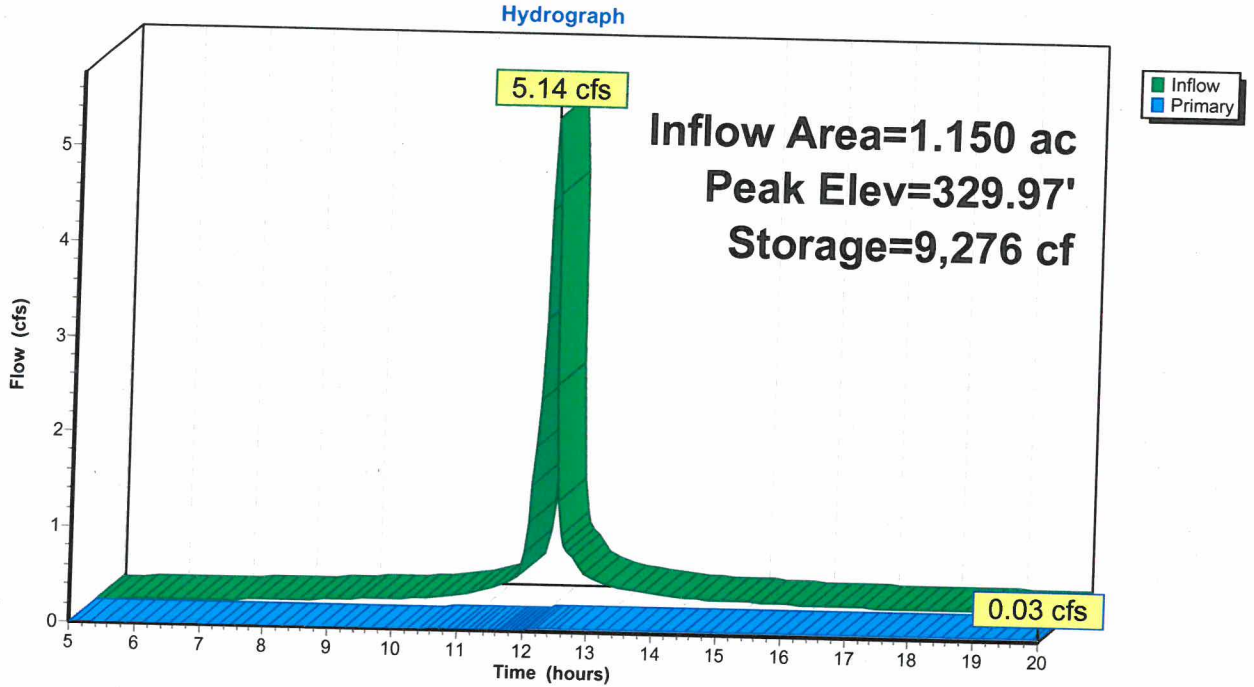
Prepared by {enter your company name here}
HydroCAD® 9.00 s/n 02109 © 2009 HydroCAD Software Solutions LLC

Type II 24-hr 2-Year Rainfall=3.50"

Printed 4/28/2014

Page 10

Pond 7P: Underground Detention System



STORM STUDY - 1306

Type II 24-hr 2-Year Rainfall=3.50"

Prepared by {enter your company name here}

Printed 4/28/2014

HydroCAD® 9.00 s/n 02109 © 2009 HydroCAD Software Solutions LLC

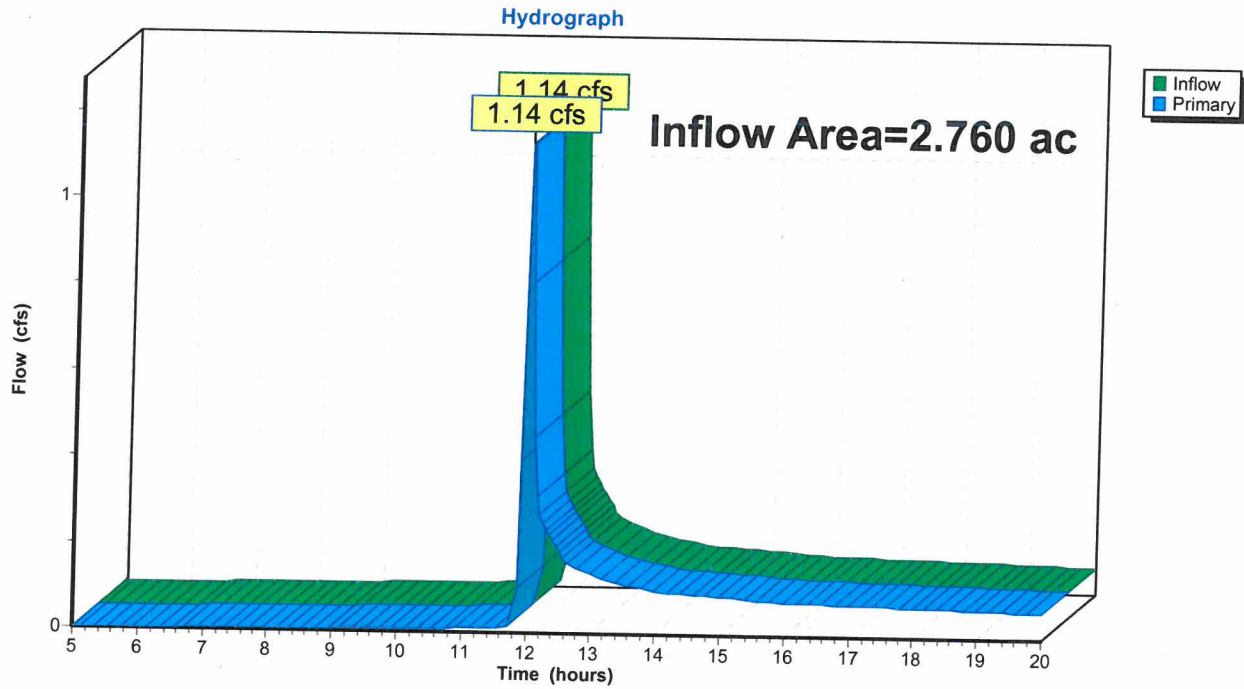
Page 11

Summary for Link 8L: Basin 1 with Detention

Inflow Area = 2.760 ac, 39.13% Impervious, Inflow Depth > 0.35" for 2-Year event
Inflow = 1.14 cfs @ 12.00 hrs, Volume= 0.081 af
Primary = 1.14 cfs @ 12.00 hrs, Volume= 0.081 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

Link 8L: Basin 1 with Detention



STORM STUDY - 1306

Prepared by {enter your company name here}

HydroCAD® 9.00 s/n 02109 © 2009 HydroCAD Software Solutions LLC

Type II 24-hr 25-Year Rainfall=6.00"

Printed 4/28/2014

Page 12

Summary for Subcatchment 5S: Basin 1 to Detention

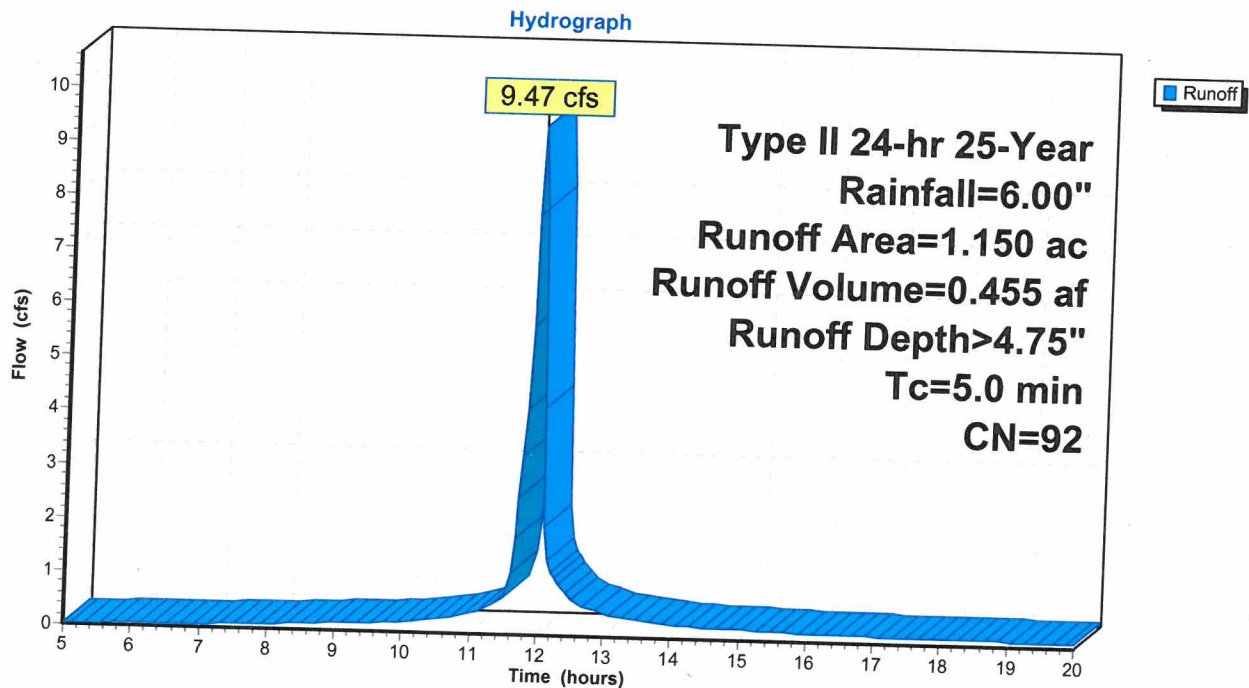
Runoff = 9.47 cfs @ 11.95 hrs, Volume= 0.455 af, Depth> 4.75"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-Year Rainfall=6.00"

| Area (ac) | CN | Description |
|-----------|----|-------------------------------|
| 0.960 | 98 | Paved parking, HSG B |
| 0.190 | 61 | >75% Grass cover, Good, HSG B |
| 1.150 | 92 | Weighted Average |
| 0.190 | | 16.52% Pervious Area |
| 0.960 | | 83.48% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|----------|---------------|---------------|-------------------|----------------|---------------|
| 5.0 | | | | | Direct Entry, |

Subcatchment 5S: Basin 1 to Detention



STORM STUDY - 1306

Type II 24-hr 25-Year Rainfall=6.00"

Prepared by {enter your company name here}

Printed 4/28/2014

HydroCAD® 9.00 s/n 02109 © 2009 HydroCAD Software Solutions LLC

Page 13

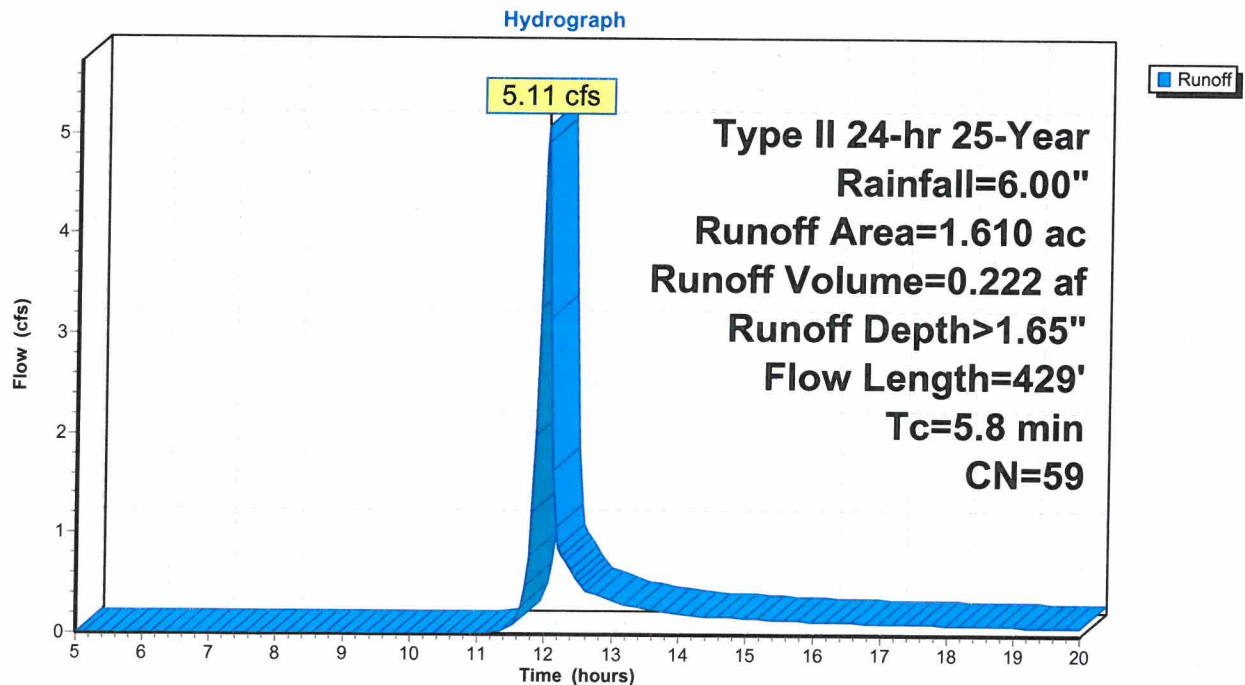
Summary for Subcatchment 6S: Basin 1 to bypass detention

Runoff = 5.11 cfs @ 11.98 hrs, Volume= 0.222 af, Depth> 1.65"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-Year Rainfall=6.00"

| Area (ac) | CN | Description |
|-----------|----|-------------------------------|
| 0.120 | 98 | Paved parking, HSG B |
| 0.240 | 61 | >75% Grass cover, Good, HSG B |
| 1.250 | 55 | Woods, Good, HSG B |
| 1.610 | 59 | Weighted Average |
| 1.490 | | 92.55% Pervious Area |
| 0.120 | | 7.45% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|----------|---------------|---------------|-------------------|----------------|---|
| 3.0 | 75 | 0.1867 | 0.42 | | Sheet Flow, Grass: Short n= 0.150 P2= 3.60" |
| 1.3 | 117 | 0.0939 | 1.53 | | Shallow Concentrated Flow, Woodland Kv= 5.0 fps |
| 1.5 | 237 | 0.0634 | 2.65 | 0.53 | Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=1.00' Z= 0.2 '/' Top.W=0.40' n= 0.030 |
| 5.8 | 429 | Total | | | |

Subcatchment 6S: Basin 1 to bypass detention

STORM STUDY - 1306

Type II 24-hr 25-Year Rainfall=6.00"

Prepared by {enter your company name here}

Printed 4/28/2014

HydroCAD® 9.00 s/n 02109 © 2009 HydroCAD Software Solutions LLC

Page 14

Summary for Pond 7P: Underground Detention System

Inflow Area = 1.150 ac, 83.48% Impervious, Inflow Depth > 4.75" for 25-Year event
 Inflow = 9.47 cfs @ 11.95 hrs, Volume= 0.455 af
 Outflow = 3.78 cfs @ 12.07 hrs, Volume= 0.227 af, Atten= 60%, Lag= 7.0 min
 Primary = 3.78 cfs @ 12.07 hrs, Volume= 0.227 af

Routing by Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
 Peak Elev= 331.39' @ 12.07 hrs Surf.Area= 1,512 sf Storage= 11,429 cf

Plug-Flow detention time= 172.5 min calculated for 0.226 af (50% of inflow)
 Center-of-Mass det. time= 89.2 min (832.8 - 743.6)

| Volume | Invert | Avail.Storage | Storage Description |
|------------------|-------------------|------------------------|--|
| #1 | 323.83' | 12,852 cf | Custom Stage Data (Prismatic) Listed below (Recalc) |
| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
| 323.83 | 1,511 | 0 | 0 |
| 331.33 | 1,511 | 11,333 | 11,333 |
| 332.33 | 1,527 | 1,519 | 12,852 |

| Device | Routing | Invert | Outlet Devices |
|--------|----------|---------|--|
| #1 | Primary | 323.50' | 15.0" Round Culvert L= 20.0' RCP, groove end w/headwall, Ke= 0.200 Outlet Invert= 322.50' S= 0.0500 ' /' Cc= 0.900 n= 0.013 |
| #2 | Device 1 | 323.83' | 0.5" Vert. Orifice/Grate X 2.00 C= 0.600 |
| #3 | Device 1 | 330.33' | 1.0' long x 0.5' breadth Broad-Crested Rectangular Weir Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32 |
| #4 | Device 1 | 331.33' | 8.0' long x 0.5' breadth Broad-Crested Rectangular Weir Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32 |

Primary OutFlow Max=3.43 cfs @ 12.07 hrs HW=331.34' (Free Discharge)

1=Culvert (Passes 3.43 cfs of 19.84 cfs potential flow)

2=Orifice/Grate (Orifice Controls 0.04 cfs @ 13.18 fps)

3=Broad-Crested Rectangular Weir (Weir Controls 3.37 cfs @ 3.34 fps)

4=Broad-Crested Rectangular Weir (Weir Controls 0.02 cfs @ 0.28 fps)

STORM STUDY - 1306

Prepared by {enter your company name here}

HydroCAD® 9.00 s/n 02109 © 2009 HydroCAD Software Solutions LLC

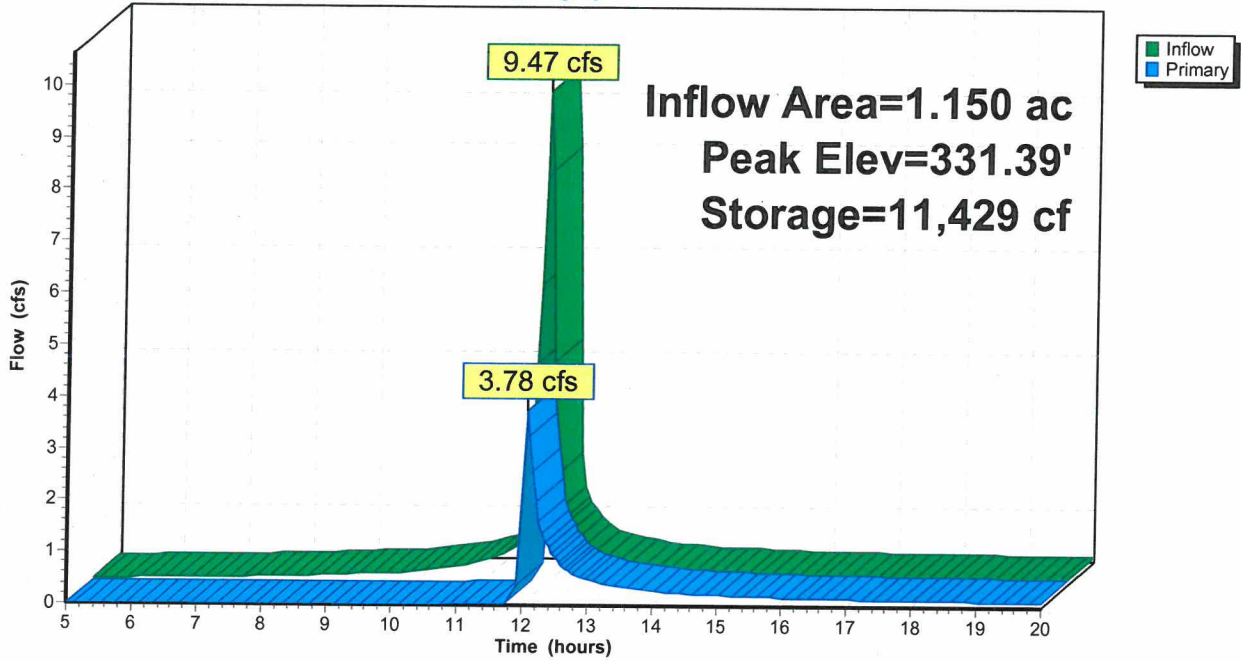
Type II 24-hr 25-Year Rainfall=6.00"

Printed 4/28/2014

Page 15

Pond 7P: Underground Detention System

Hydrograph



STORM STUDY - 1306

Prepared by {enter your company name here}

HydroCAD® 9.00 s/n 02109 © 2009 HydroCAD Software Solutions LLC

Type II 24-hr 25-Year Rainfall=6.00"

Printed 4/28/2014

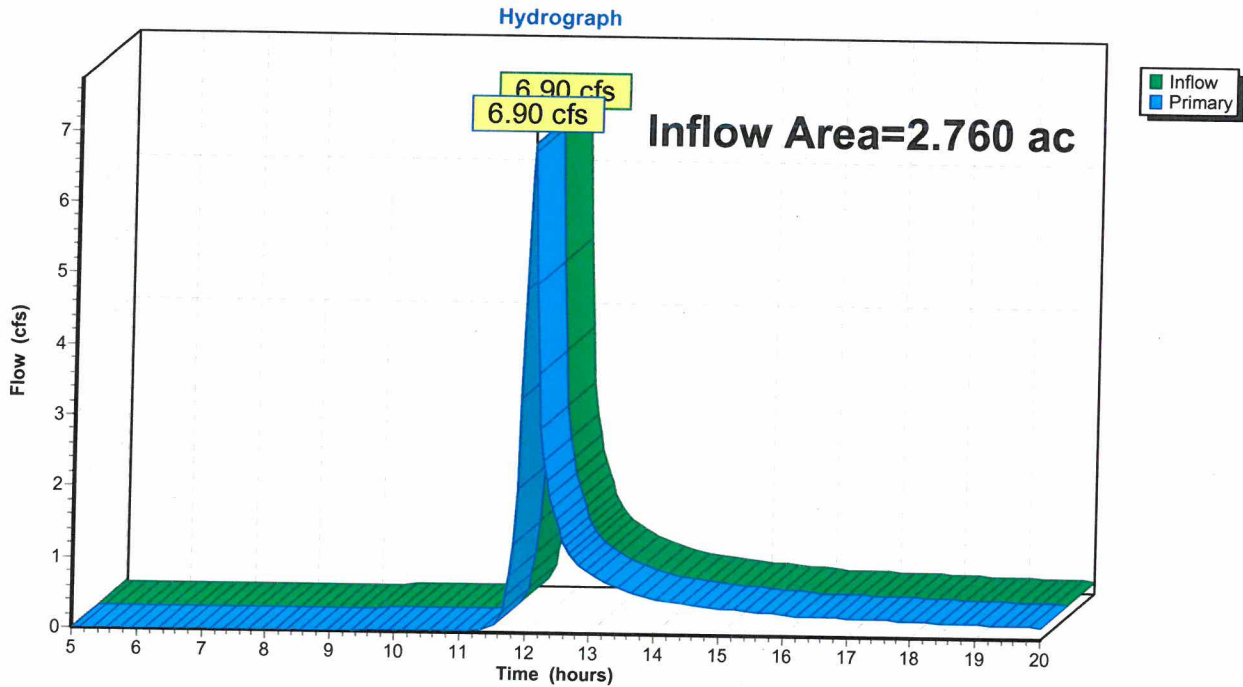
Page 16

Summary for Link 8L: Basin 1 with Detention

Inflow Area = 2.760 ac, 39.13% Impervious, Inflow Depth > 1.95" for 25-Year event
Inflow = 6.90 cfs @ 12.03 hrs, Volume= 0.449 af
Primary = 6.90 cfs @ 12.03 hrs, Volume= 0.449 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

Link 8L: Basin 1 with Detention



STORMWATER RUNOFF VOLUME ANALYSIS



Coulter | Jewell | Thames, PA

Project Name: Columbia Street Annex
Project Number: 1306

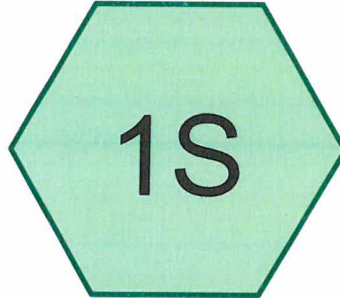
By: TRM
Date: 04.25.14

Revised:
Date:

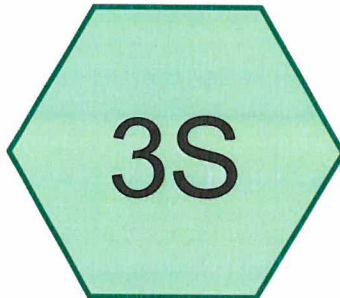
Runoff Volume Analysis Summary

| Drainage Basin 1 | Tc (min) | Area (ac) | CN | V2 (cf) |
|--|-------------|--------------|----|------------|
| Pre-Development | 6.5 | 2.75 | 57 | 3,528 |
| Post Development | 5.8 | 2.75 | 70 | 10,629 |
| Post-Development with Treatment | | | | 3,528 |
| Percent difference between Pre-Development and Post Development with Treatment | | | | 0% |

| Drainage Basin 2 | Tc (min) | Area (ac) | CN | V2 (cf) |
|---|-------------|--------------|----|------------|
| Pre-Development | 5 | 1.06 | 55 | 1,133 |
| Post Development | 5 | 1.06 | 55 | 1,133 |
| Percent difference between Pre-Development and Post Development | | | | 0% |



Basin 1 -
Predevelopment



Basin 1 -
Postdevelopment



STORM STUDY - 1306

Type II 24-hr 2-Year Rainfall=3.50"

Prepared by {enter your company name here}

Printed 4/28/2014

HydroCAD® 9.00 s/n 02109 © 2009 HydroCAD Software Solutions LLC

Page 1

Summary for Subcatchment 1S: Basin 1 - Predevelopment

Runoff = 1.40 cfs @ 12.01 hrs, Volume= 0.081 af, Depth> 0.35"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 2-Year Rainfall=3.50"

| Area (ac) | CN | Description |
|-----------|----|-------------------------------|
| 0.020 | 98 | Unconnected pavement, HSG B |
| 0.720 | 61 | >75% Grass cover, Good, HSG B |
| 2.010 | 55 | Woods, Good, HSG B |
| 2.750 | 57 | Weighted Average |
| 2.730 | | 99.27% Pervious Area |
| 0.020 | | 0.73% Impervious Area |
| 0.020 | | 100.00% Unconnected |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|----------|---------------|---------------|-------------------|----------------|---|
| 3.3 | 75 | 0.1467 | 0.38 | | Sheet Flow, Grass: Short n= 0.150 P2= 3.60" |
| 0.9 | 96 | 0.0625 | 1.75 | | Shallow Concentrated Flow, Short Grass Pasture Kv= 7.0 fps |
| 0.8 | 92 | 0.1415 | 1.88 | | Shallow Concentrated Flow, Woodland Kv= 5.0 fps |
| 1.5 | 237 | 0.0634 | 2.65 | 0.53 | Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=1.00' Z= 0.2 '/' Top.W=0.40' n= 0.030 Earth, grassed & winding |
| 6.5 | 500 | Total | | | |

STORM STUDY - 1306

Prepared by {enter your company name here}

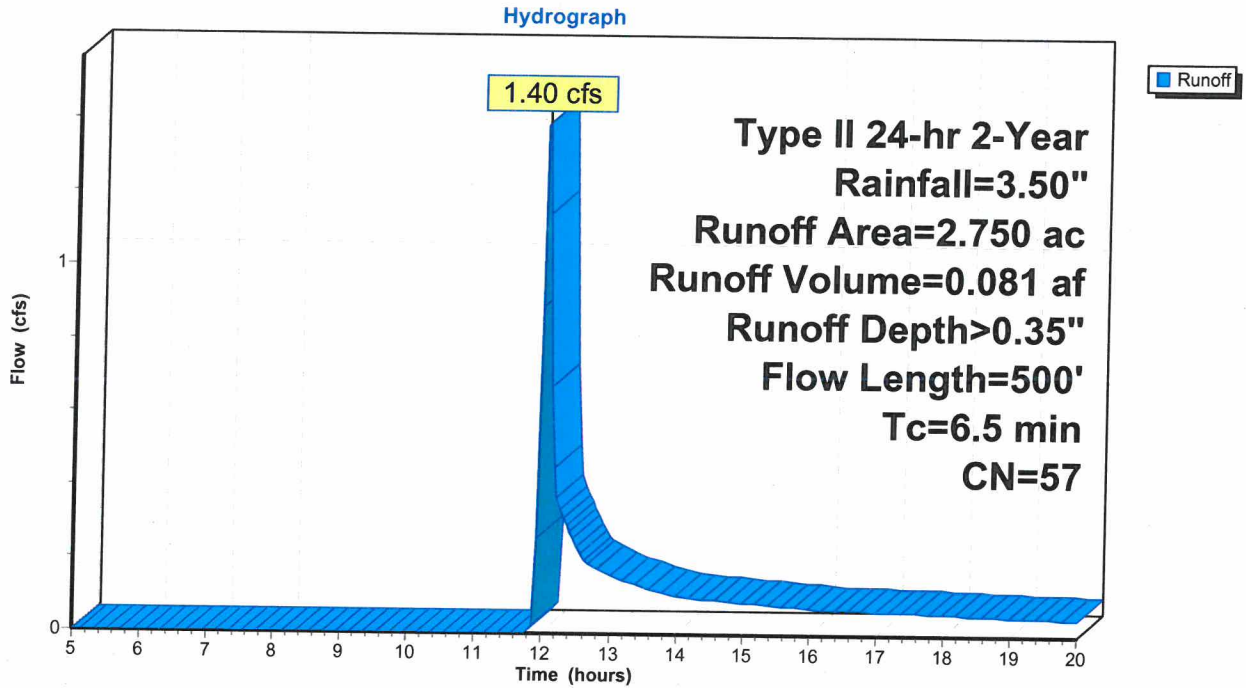
HydroCAD® 9.00 s/n 02109 © 2009 HydroCAD Software Solutions LLC

Type II 24-hr 2-Year Rainfall=3.50"

Printed 4/28/2014

Page 2

Subcatchment 1S: Basin 1 - Predevelopment



STORM STUDY - 1306

Type II 24-hr 2-Year Rainfall=3.50"

Prepared by {enter your company name here}

Printed 4/28/2014

HydroCAD® 9.00 s/n 02109 © 2009 HydroCAD Software Solutions LLC

Page 4

Summary for Subcatchment 3S: Basin 1 - Postdevelopment

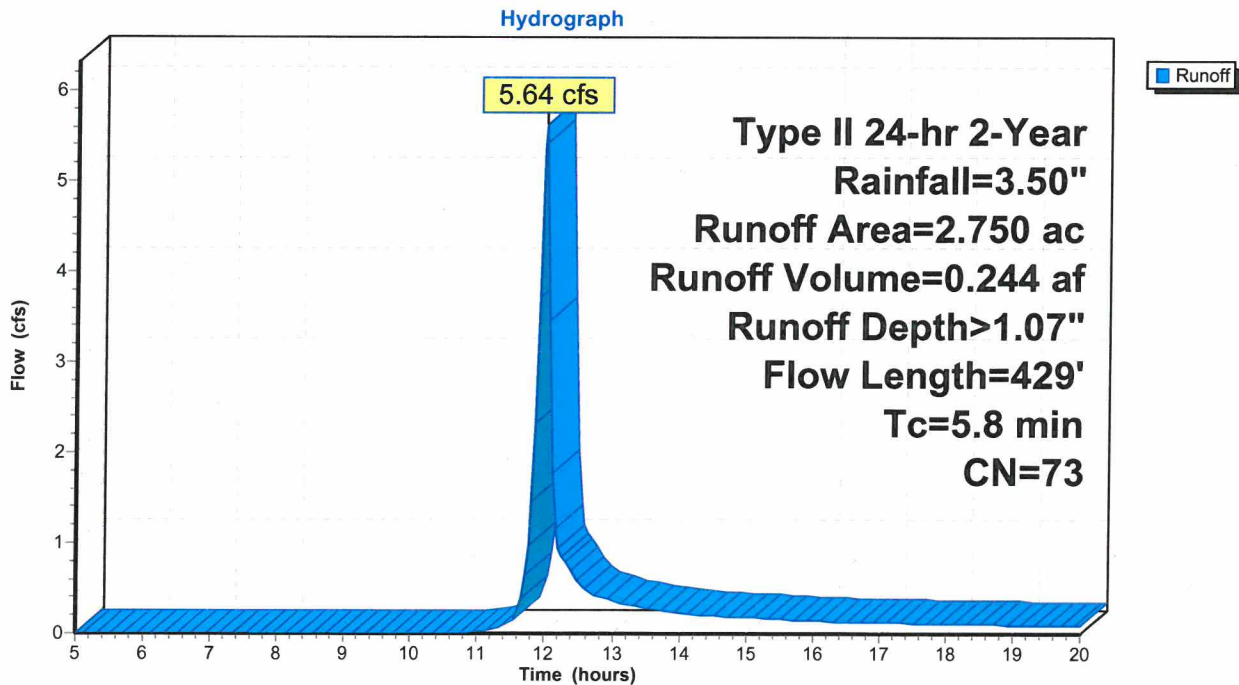
Runoff = 5.64 cfs @ 11.98 hrs, Volume= 0.244 af, Depth> 1.07"

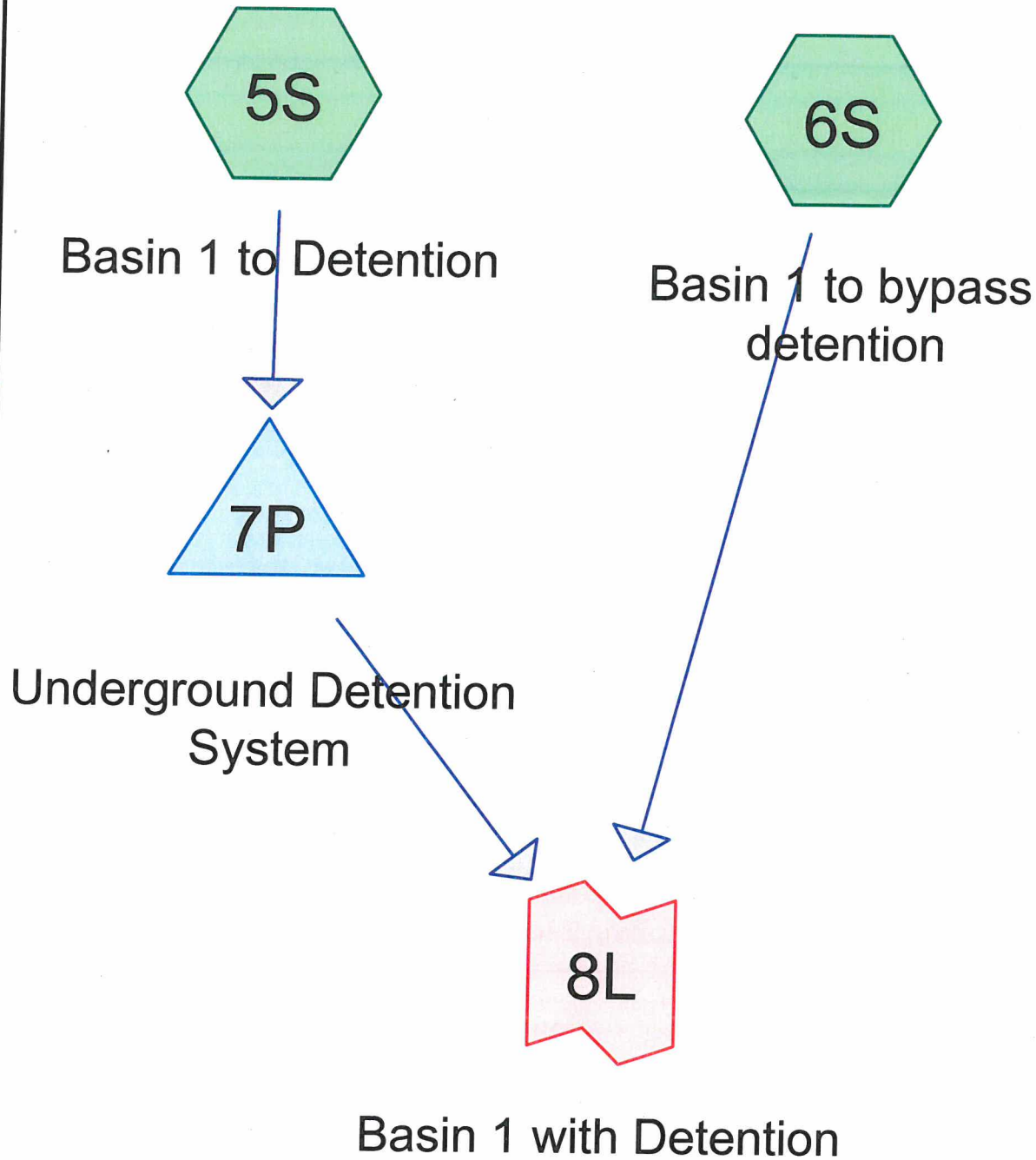
Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 2-Year Rainfall=3.50"

| Area (ac) | CN | Description |
|-----------|----|-------------------------------|
| 1.070 | 98 | Paved parking, HSG B |
| 0.430 | 61 | >75% Grass cover, Good, HSG B |
| 1.250 | 55 | Woods, Good, HSG B |
| 2.750 | 73 | Weighted Average |
| 1.680 | | 61.09% Pervious Area |
| 1.070 | | 38.91% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|----------|---------------|---------------|-------------------|----------------|---|
| 3.0 | 75 | 0.1867 | 0.42 | | Sheet Flow, Grass: Short n= 0.150 P2= 3.60" |
| 1.3 | 117 | 0.0939 | 1.53 | | Shallow Concentrated Flow, Woodland Kv= 5.0 fps |
| 1.5 | 237 | 0.0634 | 2.65 | 0.53 | Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=1.00' Z= 0.2 '/' Top.W=0.40' n= 0.030 |
| 5.8 | 429 | Total | | | |

Subcatchment 3S: Basin 1 - Postdevelopment





STORM STUDY - 1306

Prepared by {enter your company name here}
 HydroCAD® 9.00 s/n 02109 © 2009 HydroCAD Software Solutions LLC

Type II 24-hr 2-Year Rainfall=3.50"

Printed 4/28/2014

Page 2

Summary for Subcatchment 5S: Basin 1 to Detention

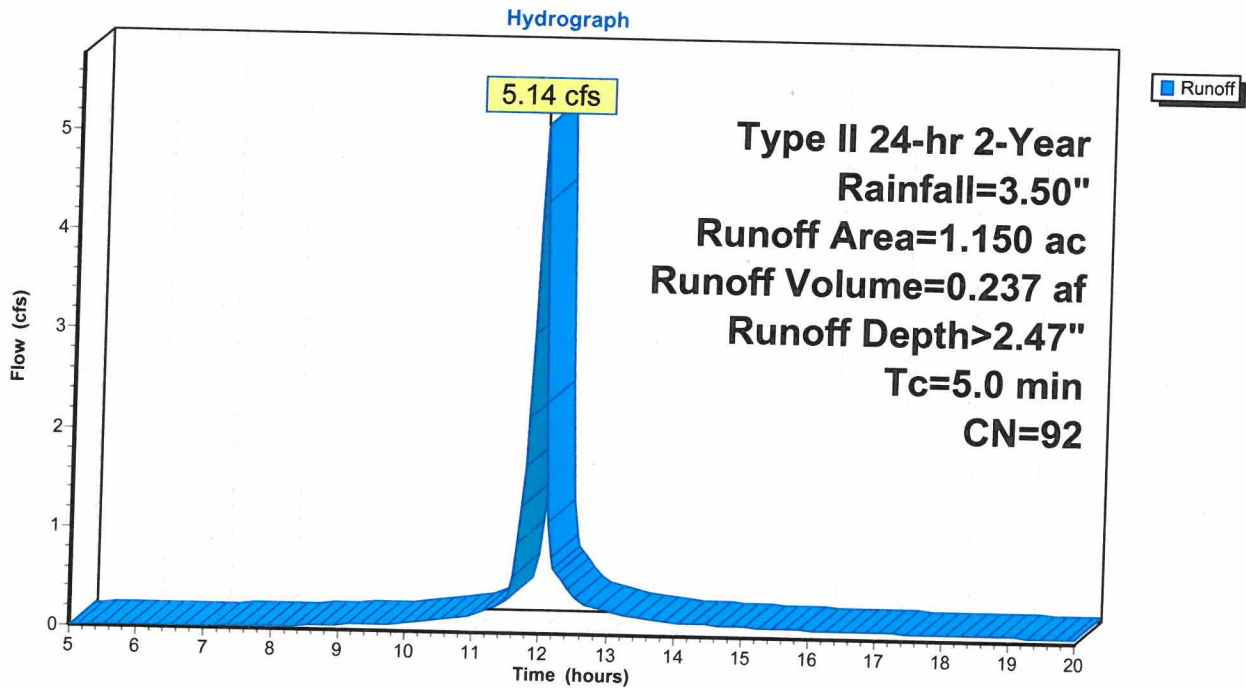
Runoff = 5.14 cfs @ 11.95 hrs, Volume= 0.237 af, Depth> 2.47"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
 Type II 24-hr 2-Year Rainfall=3.50"

| Area (ac) | CN | Description |
|-----------|----|-------------------------------|
| 0.960 | 98 | Paved parking, HSG B |
| 0.190 | 61 | >75% Grass cover, Good, HSG B |
| 1.150 | 92 | Weighted Average |
| 0.190 | | 16.52% Pervious Area |
| 0.960 | | 83.48% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|----------|---------------|---------------|-------------------|----------------|---------------|
| 5.0 | | | | | Direct Entry, |

Subcatchment 5S: Basin 1 to Detention



STORM STUDY - 1306

Type II 24-hr 2-Year Rainfall=3.50"

Prepared by {enter your company name here}

Printed 4/28/2014

HydroCAD® 9.00 s/n 02109 © 2009 HydroCAD Software Solutions LLC

Page 3

Summary for Subcatchment 6S: Basin 1 to bypass detention

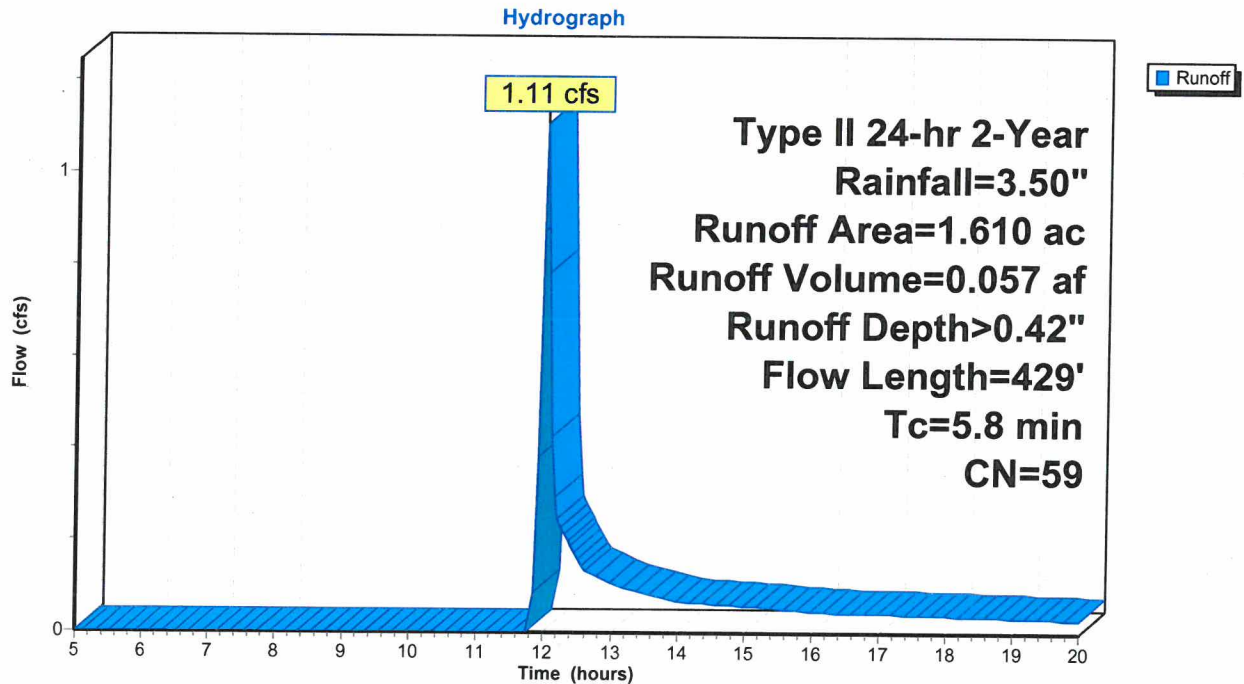
Runoff = 1.11 cfs @ 12.00 hrs, Volume= 0.057 af, Depth> 0.42"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 2-Year Rainfall=3.50"

| Area (ac) | CN | Description |
|-----------|----|-------------------------------|
| 0.120 | 98 | Paved parking, HSG B |
| 0.240 | 61 | >75% Grass cover, Good, HSG B |
| 1.250 | 55 | Woods, Good, HSG B |
| 1.610 | 59 | Weighted Average |
| 1.490 | | 92.55% Pervious Area |
| 0.120 | | 7.45% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|----------|---------------|---------------|-------------------|----------------|--|
| 3.0 | 75 | 0.1867 | 0.42 | | Sheet Flow, Grass: Short n= 0.150 P2= 3.60" |
| 1.3 | 117 | 0.0939 | 1.53 | | Shallow Concentrated Flow, Woodland Kv= 5.0 fps |
| 1.5 | 237 | 0.0634 | 2.65 | 0.53 | Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=1.00' Z= 0.2 ' / Top.W=0.40' n= 0.030 |
| 5.8 | 429 | Total | | | |

Subcatchment 6S: Basin 1 to bypass detention



STORM STUDY - 1306

Type II 24-hr 2-Year Rainfall=3.50"

Prepared by {enter your company name here}

Printed 4/28/2014

HydroCAD® 9.00 s/n 02109 © 2009 HydroCAD Software Solutions LLC

Page 4

Summary for Pond 7P: Underground Detention System

Inflow Area = 1.150 ac, 83.48% Impervious, Inflow Depth > 2.47" for 2-Year event
 Inflow = 5.14 cfs @ 11.95 hrs, Volume= 0.237 af
 Outflow = 0.03 cfs @ 20.00 hrs, Volume= 0.024 af, Atten= 99%, Lag= 482.9 min
 Primary = 0.03 cfs @ 20.00 hrs, Volume= 0.024 af

Routing by Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
 Peak Elev= 329.97' @ 20.00 hrs Surf.Area= 1,511 sf Storage= 9,276 cf

Plug-Flow detention time= 362.2 min calculated for 0.024 af (10% of inflow)
 Center-of-Mass det. time= 159.4 min (915.4 - 756.0)

| Volume | Invert | Avail.Storage | Storage Description |
|------------------|-------------------|------------------------|--|
| #1 | 323.83' | 12,852 cf | Custom Stage Data (Prismatic) Listed below (Recalc) |
| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
| 323.83 | 1,511 | 0 | 0 |
| 331.33 | 1,511 | 11,333 | 11,333 |
| 332.33 | 1,527 | 1,519 | 12,852 |

| Device | Routing | Invert | Outlet Devices |
|--------|----------|---------|--|
| #1 | Primary | 323.50' | 15.0" Round Culvert L= 20.0' RCP, groove end w/headwall, Ke= 0.200 Outlet Invert= 322.50' S= 0.0500 '/' Cc= 0.900 n= 0.013 |
| #2 | Device 1 | 323.83' | 0.5" Vert. Orifice/Grate X 2.00 C= 0.600 |
| #3 | Device 1 | 330.33' | 1.0' long x 0.5' breadth Broad-Crested Rectangular Weir Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32 |
| #4 | Device 1 | 331.33' | 8.0' long x 0.5' breadth Broad-Crested Rectangular Weir Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32 |

Primary OutFlow Max=0.03 cfs @ 20.00 hrs HW=329.97' (Free Discharge)

- 1=Culvert (Passes 0.03 cfs of 17.86 cfs potential flow)
- 2=Orifice/Grate (Orifice Controls 0.03 cfs @ 11.91 fps)
- 3=Broad-Crested Rectangular Weir (Controls 0.00 cfs)
- 4=Broad-Crested Rectangular Weir (Controls 0.00 cfs)

STORM STUDY - 1306

Prepared by {enter your company name here}

HydroCAD® 9.00 s/n 02109 © 2009 HydroCAD Software Solutions LLC

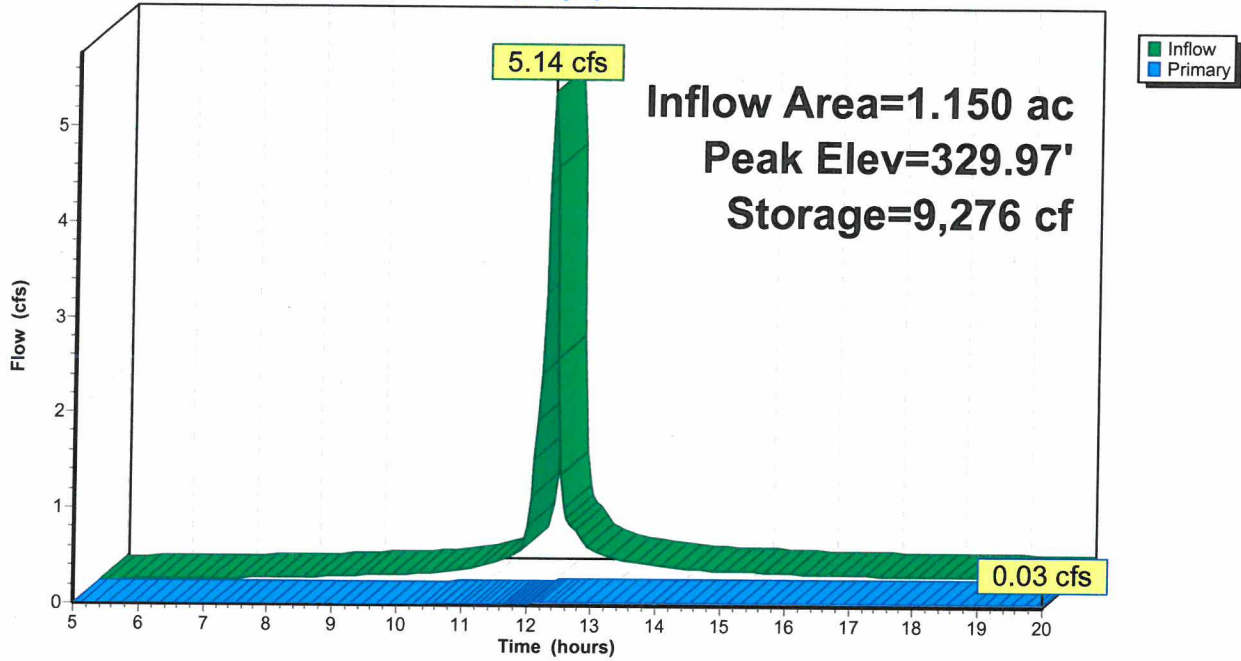
Type II 24-hr 2-Year Rainfall=3.50"

Printed 4/28/2014

Page 5

Pond 7P: Underground Detention System

Hydrograph



STORM STUDY - 1306

Prepared by {enter your company name here}
HydroCAD® 9.00 s/n 02109 © 2009 HydroCAD Software Solutions LLC

Type II 24-hr 2-Year Rainfall=3.50"

Printed 4/28/2014

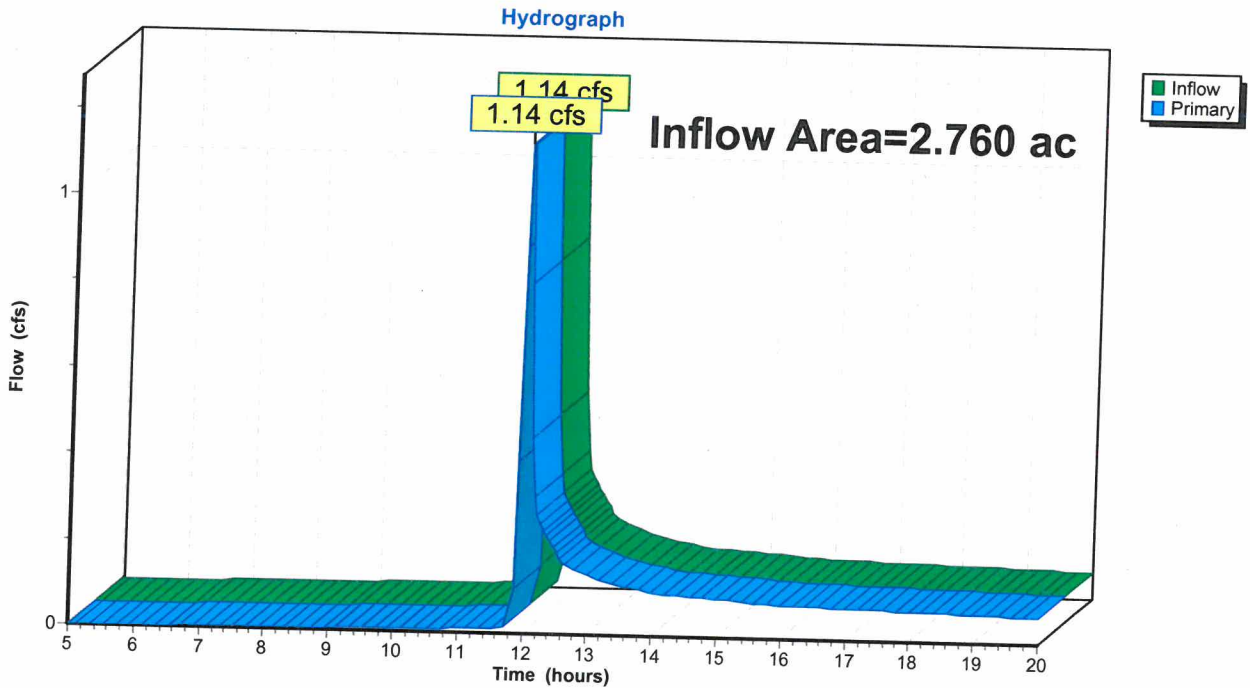
Page 6

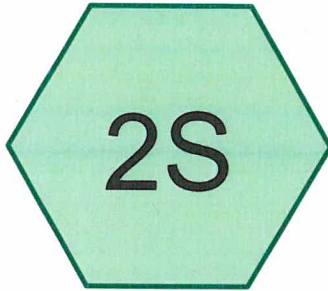
Summary for Link 8L: Basin 1 with Detention

Inflow Area = 2.760 ac, 39.13% Impervious, Inflow Depth > 0.35" for 2-Year event
Inflow = 1.14 cfs @ 12.00 hrs, Volume= 0.081 af
Primary = 1.14 cfs @ 12.00 hrs, Volume= 0.081 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

Link 8L: Basin 1 with Detention

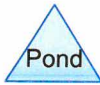




Basin 2 - Predevelopment



Basin 2 - Postdevelopment



Drainage Diagram for STORM STUDY - 1306

Prepared by {enter your company name here}, Printed 4/28/2014
HydroCAD® 9.00 s/n 02109 © 2009 HydroCAD Software Solutions LLC

STORM STUDY - 1306

Type II 24-hr 2-Year Rainfall=3.50"

Prepared by {enter your company name here}

Printed 4/28/2014

HydroCAD® 9.00 s/n 02109 © 2009 HydroCAD Software Solutions LLC

Page 2

Summary for Subcatchment 2S: Basin 2 - Predevelopment

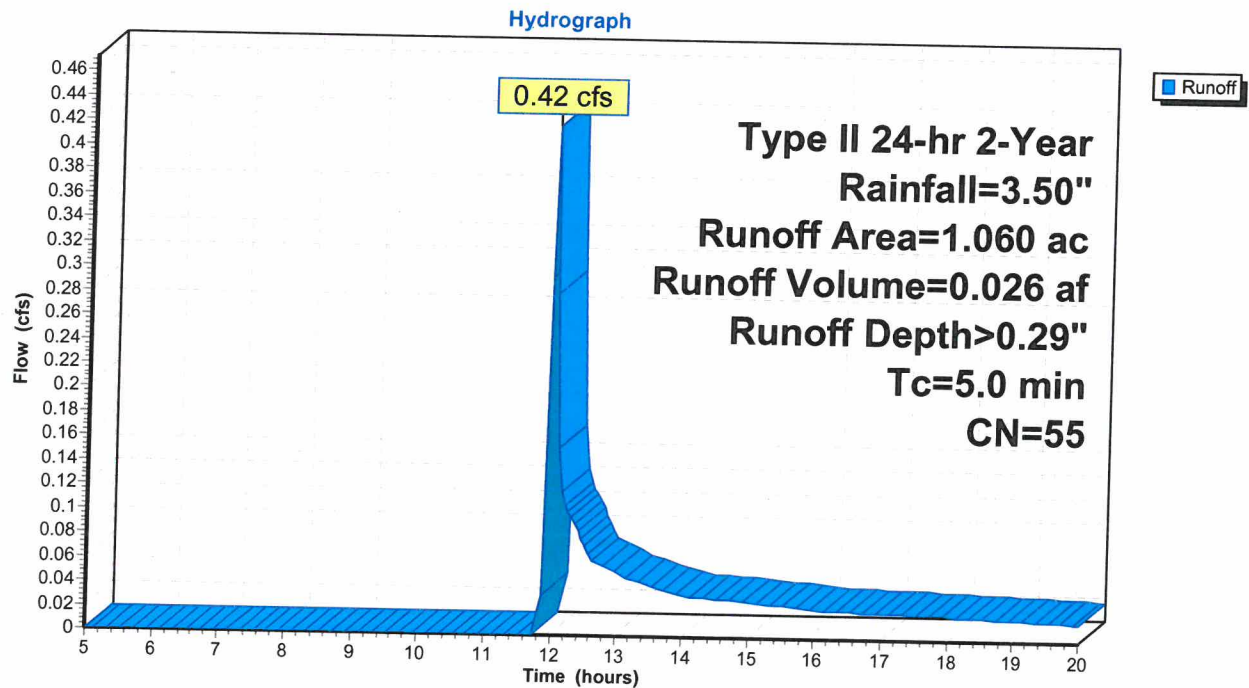
Runoff = 0.42 cfs @ 12.00 hrs, Volume= 0.026 af, Depth> 0.29"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 2-Year Rainfall=3.50"

| Area (ac) | CN | Description |
|-----------|----|-------------------------------|
| 0.030 | 61 | >75% Grass cover, Good, HSG B |
| 1.020 | 55 | Woods, Good, HSG B |
| 0.010 | 80 | >75% Grass cover, Good, HSG D |
| 1.060 | 55 | Weighted Average |
| 1.060 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|----------|---------------|---------------|-------------------|----------------|---------------|
| 5.0 | | | | | Direct Entry, |

Subcatchment 2S: Basin 2 - Predevelopment



STORM STUDY - 1306

Type II 24-hr 2-Year Rainfall=3.50"

Prepared by {enter your company name here}

Printed 4/28/2014

HydroCAD® 9.00 s/n 02109 © 2009 HydroCAD Software Solutions LLC

Page 3

Summary for Subcatchment 4S: Basin 2 - Postdevelopment

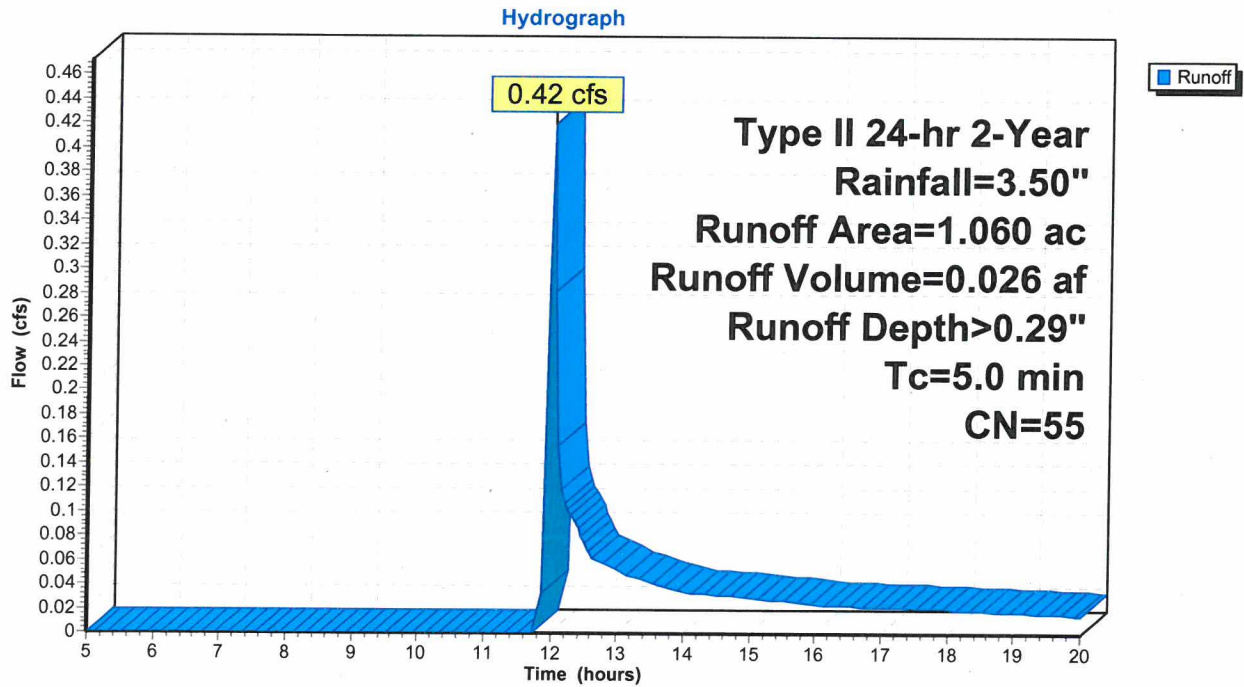
Runoff = 0.42 cfs @ 12.00 hrs, Volume= 0.026 af, Depth> 0.29"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 2-Year Rainfall=3.50"

| Area (ac) | CN | Description |
|-----------|----|-------------------------------|
| 0.030 | 61 | >75% Grass cover, Good, HSG B |
| 1.020 | 55 | Woods, Good, HSG B |
| 0.010 | 80 | >75% Grass cover, Good, HSG D |
| 1.060 | 55 | Weighted Average |
| 1.060 | | 100.00% Pervious Area |

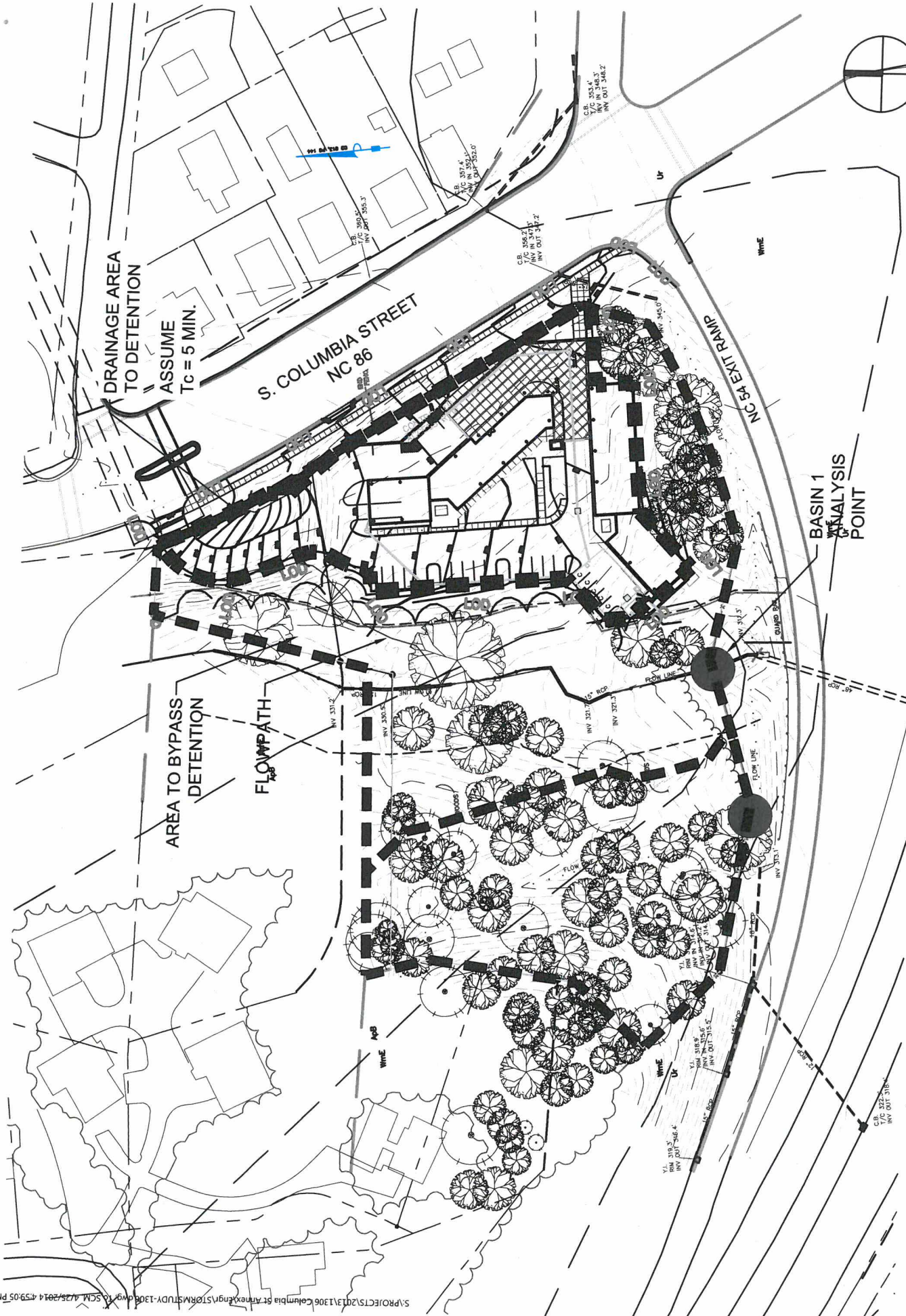
| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|----------|---------------|---------------|-------------------|----------------|---------------|
| 5.0 | | | | | Direct Entry, |

Subcatchment 4S: Basin 2 - Postdevelopment



UNDERGROUND DETENTION FACILITY DESIGN

S:\PROJECTS\2013\1306 Columbia St Annex\ENGIN\510RM\STUDY-1306.dwg 13.05.2014 4:59:05 PM



DATE: 04.17.2014
SCALE: 1" = 100'
DRAWN BY: TRM

COLUMBIA STREET ANNEX
DRAINAGE AREA MAP TO BMP

COULTER JEWELL THAMES, P.A.
111 WEST MAIN ST
DURHAM, NC 27701
(919) 682-0368

STORM STUDY - 1306

Type II 24-hr 10-Year Rainfall=5.10"

Prepared by {enter your company name here}

Printed 4/28/2014

HydroCAD® 9.00 s/n 02109 © 2009 HydroCAD Software Solutions LLC

Page 4

Summary for Pond 7P: Underground Detention System

Inflow Area = 1.150 ac, 83.48% Impervious, Inflow Depth > 3.93" for 10-Year event
 Inflow = 7.92 cfs @ 11.95 hrs, Volume= 0.376 af
 Outflow = 0.85 cfs @ 12.31 hrs, Volume= 0.149 af, Atten= 89%, Lag= 21.3 min
 Primary = 0.85 cfs @ 12.31 hrs, Volume= 0.149 af

Routing by Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
 Peak Elev= 330.75' @ 12.31 hrs Surf.Area= 1,511 sf Storage= 10,461 cf

Plug-Flow detention time= 213.2 min calculated for 0.148 af (39% of inflow)
 Center-of-Mass det. time= 117.0 min (863.9 - 746.9)

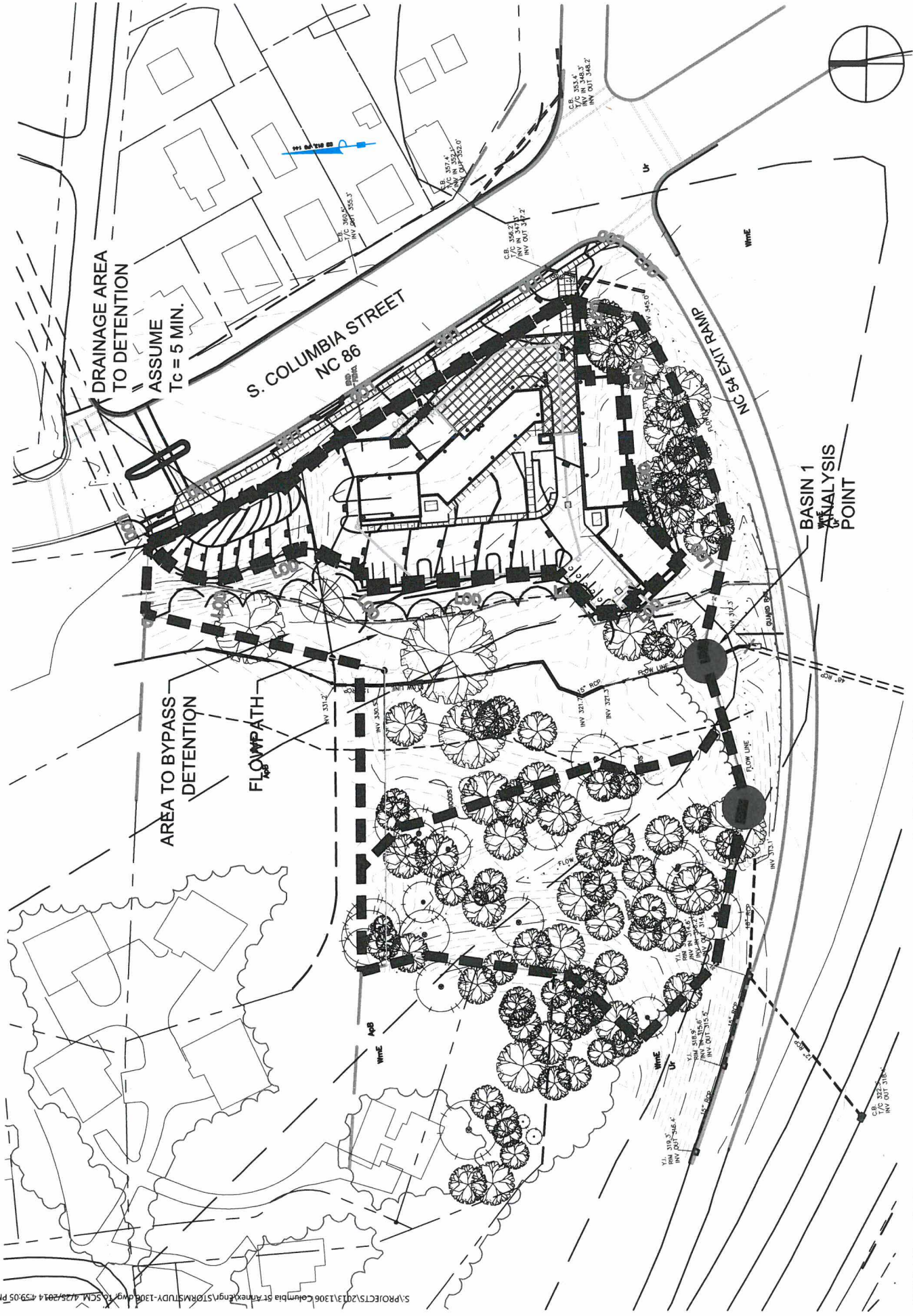
| Volume | Invert | Avail.Storage | Storage Description |
|---------------------|----------------------|---------------------------|--|
| #1 | 323.83' | 12,852 cf | Custom Stage Data (Prismatic) Listed below (Recalc) |
| | | | |
| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
| 323.83 | 1,511 | 0 | 0 |
| 331.33 | 1,511 | 11,333 | 11,333 |
| 332.33 | 1,527 | 1,519 | 12,852 |

| Device | Routing | Invert | Outlet Devices |
|--------|----------|---------|--|
| #1 | Primary | 323.50' | 15.0" Round Culvert L= 20.0' RCP, groove end w/headwall, Ke= 0.200 Outlet Invert= 322.50' S= 0.0500 '/' Cc= 0.900 n= 0.013 |
| #2 | Device 1 | 323.83' | 0.5" Vert. Orifice/Grate X 2.00 C= 0.600 |
| #3 | Device 1 | 330.33' | 1.0' long x 0.5' breadth Broad-Crested Rectangular Weir Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32 |
| #4 | Device 1 | 331.33' | 8.0' long x 0.5' breadth Broad-Crested Rectangular Weir Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32 |

Primary OutFlow Max=0.84 cfs @ 12.31 hrs HW=330.75' (Free Discharge)

- 1=Culvert (Passes 0.84 cfs of 19.02 cfs potential flow)
- 2=Orifice/Grate (Orifice Controls 0.03 cfs @ 12.65 fps)
- 3=Broad-Crested Rectangular Weir (Weir Controls 0.81 cfs @ 1.91 fps)
- 4=Broad-Crested Rectangular Weir (Controls 0.00 cfs)

STORMFILTER DESIGN



DRAINAGE AREA
TO DETENTION
ASSUME
Tc = 5 MIN.

S. COLUMBIA STREET
NC 86

AREA TO BYPASS
DETENTION

FLOWPATH

BASIN 1
ANALYSIS
POINT

COLUMBIA STREET ANNEX
DRAINAGE AREA MAP TO BMP

COULTER JEWELL THAMES, P.A.
111 WEST MAIN ST
DURHAM, NC 27701
(919) 682-0368

DATE: 04.17.2014
SCALE: 1" = 100'
DRAWN BY: TRM





Coulter | Jewell | Thames, PA

Project Name: Columbia Street Annex
Project Number: 1306

By: TRM
Date: 04.25.14

Revised:
Date:

TSS Reduction Summary

| Threshold indicating TSS Reduction is required | |
|--|-----------------------|
| | Impervious Percentage |
| Jordan Basin | 16% |

| Site Impervious Percentage | |
|----------------------------|-----|
| Pre-Development | 0% |
| Post-Development | 25% |

Additional Impervious to be treated = 0.96 acres

Impervious area Treated by SCMs for TSS = 0.96 acres



Coulter | Jewell | Thames, PA

Project Name: Columbia Street Annex
Project Number: 1306

By: TRM
Date: 04.25.14

Revised:
Date:

StormFilter BMP Sizing

Drainage Area = 1.14 ac
Impervious Area = 0.96 ac

Runoff Volume: Simple Method

$$V = 3630 * Rd * Rv * A$$

V = Runoff Volume (cf)
Rd = Design storm rainfall depth (1.0 in)
Rv = Runoff coefficient (unitless)
A = Drainage area (ac)

$$Rv = 0.5 + 0.9 * Ia$$

Ia = Impervious fraction

$$Ia = 0.842105263$$

$$Rv = 0.807894737$$

Required runoff Volume

$$V = 3,343 \text{ cf} \quad \text{min 3,630 for wetland}$$