Amendment to
Stormwater Pollution Control Plan

Connecticut Resources Recovery Authority
Hartford Landfill
Hartford, Connecticut

December 2011

FUSS & O'NEILL

146 Hartford Road
Manchester, CT 06040

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STORMWATER POLLUTION CONTROL PLAN
Connecticut Resources Recovery Authority
Hartford Landfill - Hartford, Connecticut
Amended December 2011

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SHEETS **SEPARATELY BOUND**

1 INTRODUCTION

This Amendment to the Hartford Landfill Stormwater Pollution Control Plan (SWPCP) is being submitted by the Connecticut Resources Recovery Authority (CRRA) in support of the amendment to the Hartford Landfill Closure Plan submitted to the Connecticut Department of Energy and Environmental Protection (CT DEEP), Waste Engineering and Enforcement Division (WEED) in July 2011. The proposed Closure Plan amendment includes two alternate final cover system designs intended to facilitate the installation of a grid-connected solar photovoltaic (PV) renewable energy system. Pending approval of the alternate cover systems by the CT DEEP, CRRA will close the Phase II (eastern) area with either the previously approved traditional capping system or one of the two alternate capping systems described below.

- *Closure Turf™ Alternate* – a proprietary synthetic turf system manufactured by Agru-America, Inc. The turf is placed above a liner and sand ballast is installed to hold the turf in place. This system would allow for the use of rigid PV panels affixed to a ground mounted racking system. Manufacturer's product information is provided as *Appendix A.*
- *Exposed TPO Alternate* – an exposed geomembrane cap using Thermoplastic Polyolefin (TPO). This system would include flexible, thin-film PV panels adhered to the membrane. Manufacturer's product information is provided as *Appendix B.*

This plan is intended to supplement the previously approved SWPCP dated July 2006, revised January 2007. As such, only the relevant, modified sections are included in this submission. Taken in its entirety (i.e., the approved SWPCP plus this amendment), the SWPCP is intended to address the erosion and sedimentation control requirements both during and after construction. Erosion and sedimentation control requirements are also shown on the Drawings for this project (separately bound). In addition, drainage calculations for both alternates are included in this report.

2 SITE DESCRIPTION

2.1 Project Description

The MSW Area of the Hartford Landfill occupies approximately 80 acres of an approximately 124 acre parcel in the north meadows section of Hartford, Connecticut (Figure 1). Sixteen acres of the parcel, located immediately north of the 80-acre MSW Area, was developed as a lined ash landfill in 1998 (Phase I Ash Disposal Area). The remaining area is occupied by site facilities (e.g., Scale House, Maintenance Garage, etc.) on the southerly portion of the parcel and undisturbed land to the north of the Phase I Ash Disposal Area.

Access to the landfill is off of Jennings Road (Exit 33 off of Interstate 91) with a turn onto Leibert Road, heading north, into the south end of the landfill. The landfill parcel is bounded on the south by the City of Hartford Department of Public Works facility; on the

west by Interstate 91; on the north by Weston Street and the Army Corps of Engineers (USACE) Flood Control Dike (herein referred to as the "USACE Dike"); and on the east by the USACE Dike.

CRRA closed approximately 46 acres of the MSW disposal area using a traditional geomembrane cap system. This system consists of a six inch bedding layer of sand overlain by a polyethylene membrane, overlain with a nine inch drainage layer and a 9 inch topsoil layer.

The proposed amendment to the Landfill Closure plan would allow CRRA to close the remaining 34 acres of the MSW disposal area using an alternative capping system as part of a "Phase II" construction project. The remainder of this SWPCP Amendment will focus on the Phase II work. The proposed alternative systems are more particularly described below.

2.2 Existing Conditions

Currently precipitation falling on the Eastern half of the landfill flows east over un-capped portions of the landfill until it is intercepted by one of several existing riprap and concrete drainage channels. These various channels convey the stormwater toward the southeast corner of the property where it discharges to a vegetated drainage ditch that ultimately enters North Meadows Pond. The total upland area discharging to the vegetated ditch is approximately 44.4 acres. Approximately 6.3 acres of this drainage area was capped under the Phase I construction project, and will not be disturbed during the Phase II construction.

2.3 Proposed Conditions

The proposed final landform will not substantially alter the drainage patterns described above. Only slight adjustments to the relative drainage areas will result from closure. However, due to the improved drainage characteristics of both alternates, total runoff volume and peak flow rates are expected to increase (refer to *Table 1* in *Section 2.4*). . Several existing drainage features will be replaced or upgraded during closure in order to accommodate these increased flows and new permanent drainage features will be added.

In accordance with state solid waste regulations, proposed drainage features have been engineered to safely convey at least a 25-year storm event. However, due to the possible adverse impact to the levee from larger storm events, key components of the drainage system have been designed to convey a 100-year storm event.

2.3.1 Proposed Southeastern Culvert

As depicted in *Sheets C-1.23* thru *C-1.34* (bound separately), both alternates use the same general methods of conveying stormwater. The critical design point for both alternates is a proposed culvert at the southeast corner of the landfill. This culvert conveys stormwater from the eastern portion of the landfill under an access drive to the vegetated drainage ditch. Water flows from the culvert to the swale via an existing concrete-lined downchute. The southeast culvert was designed based on peak flows for the 100-year storm. The design contemplates the development of headwater condition upstream of the culvert during the

design storm; thus the eastern swale provides a modest amount of detention. Three 36" pipes were selected to convey flows. Based on the results of peak flows flowing through the culvert, elevations were determined for headwalls to prevent water from over-topping the emergency overflow. Design calculations demonstrate that the system shall function as intended even if one of the three culvert barrels is completely obstructed. Should more than one barrel be completely blocked during a major storm event, the access drive has been designed to function as an emergency overflow weir.

The proposed design incorporates improvements to this swale, which includes rehabilitation of existing concrete as well as new concrete armoring to achieve increased capacity and a consistent cross section. Once water passes through the southeast culvert, it is conveyed via the vegetated drainage ditch to the North Meadows Storage Pond. The major difference in stormwater management between the two alternates is how runoff is conveyed from the landfill to the eastern swale.

2.3.2 Closure Turf™ Alternate

The Closure Turf™ alternate incorporates side slope diversion swales to intercept runoff running down the sides of the landfill. Based on manufacturer's recommendations, these swales were placed at a maximum 40 vertical feet spacing (120 feet horizontal) on the 3H:1V slopes. This allows stormwater to collect before flow depths become excessive. Two such diversion swales will be constructed on the eastern side of the landfill. The diversion swales convey water to reinforced downchutes which in turn convey water to the eastern swale. Energy dissipaters are located at the base of each downchute. Grading and drainage features specific to this alternate are shown on *Sheets C-1.23* thru *C-1.24*. Construction details are provided on *Sheet C-5.02*.

2.3.3 Exposed TPO Alternate

Since the TPO liner is exposed with no erosive overlying components, stormwater runoff will be conveyed directly to the eastern swale via sheet flow over the surface of the TPO. Therefore, the exposed TPO alternate does not have any side slope diversion swales or downchutes. Runoff will sheet flow down the landfill and pass through an energy dissipation system that runs the entire length of the eastern toe of slope. Grading and drainage features specific to this alternate are shown on *Sheets C-1.33* thru *C-1.34*. Construction details are provided on *Sheet C-5.03*.

2.4 Stormwater Discharge Information

Several calculations were performed for each alternate. For both alternates, a detailed watershed analysis was completed to determine peak flows for the 25-year design storm. The calculated total runoff and peak discharge for each alternate was compared to both the existing conditions and previously approved capping system. The following table provides a summary of the discharge characteristics for each scenario. As expected, the proposed alternates will result in modest increases in both peak and total discharges when compared to the previously approved cover system.

Table 1 – Comparison of Discharge Characteristics

Closure Method	Total Runoff (ac-ft)	Peak Flow (cfs)
Existing Conditions*	10.3	111.6
Traditional Soil Cap*	16.1	104.7
Closure Turf™ Alternate	15.4	126.4
Exposed TPO Alternate	16.4	127.5

*Calculations for Original Conditions and Traditional Soil Cap were performed using Bentley's Pond Pack

Calculations were also prepared to determine the flow depths in the eastern swale and the vegetated drainage ditch. An analysis of the southeast culvert was performed to determine the maximum water surface elevation. Additional calculations were completed for the Closure Turf™ alternate to determine the flow depths in the side slope diversion swales and the downchutes. These calculations demonstrate that the proposed design is within the manufacturer's recommended limitations for shear stress.

The watershed analysis for the Closure Turf™ alternate can be found in *Appendix C.* The swale and culvert calculations for the Closure Turf™ alternate can be found in *Appendix D.* The watershed analysis for the exposed TPO alternate can be found in *Appendix E.* The swale and culvert calculations for the exposed TPO alternate can be found in *Appendix F.*

3 CONSTRUCTION SEQUENCE

The Phase II area is expected to be ready for closure by September 2012 and should be completed during the 2013 construction season.

This construction schedule is tentative. There are many factors, such as weather conditions, shaping of landfill subgrades, etc. which may affect the proposed schedule. CT DEEP will be kept apprised of changes in schedule as new information becomes available.

4 CONTROLS

4.1 Temporary Controls

Temporary Erosion control measures were designed in accordance with the 2002 edition of the "Connecticut Guidelines for Soil Erosion and Sediment Control" (CT DEP bulletin 34) as published by The Connecticut Council on Soil and Water Conservation in cooperation with the Connecticut Department of Environmental Protection. Temporary measures for this project include:

- Construction Entrance
- Silt Fence
- Temporary Pipe Slope Drain
- Temporary Sediment Trap
- Temporary Diversions
- Catch Basin Inserts

We have provided installation details and detailed erosion and sediment control notes in the plans (refer to *Sheets C-1.53, C-1.54* and *C-5.01*). These notes are in accordance with DEP Bulletin 34.

4.2 Permanent Controls

4.2.1 Closure Turf™ Alternate

Permanent erosion control measures incorporated into the design of the Closure Turf™ alternate include:

- Side slope diversion swales
- Reinforced downchutes
- Energy dissipaters

These features are shown on *Sheets C-1.23* thru *C-1.24*. Construction details are provided on *Sheet C-3.01* and *C-5.02*.

4.2.2 Exposed TPO Alternate

The only permanent erosion control measure incorporated into the TPO Alternate design is the proposed energy dissipation system that runs the entire length of the eastern toe of slope.

4.2.3 Permanent Off-Cap Control

Off-cap drainage features, such as the concrete lined swale, riprap stilling basin, etc. will be as described in the original project SWPCP.

5 INSPECTION

Inspection shall occur in the same manner as described in the original SWPCP.

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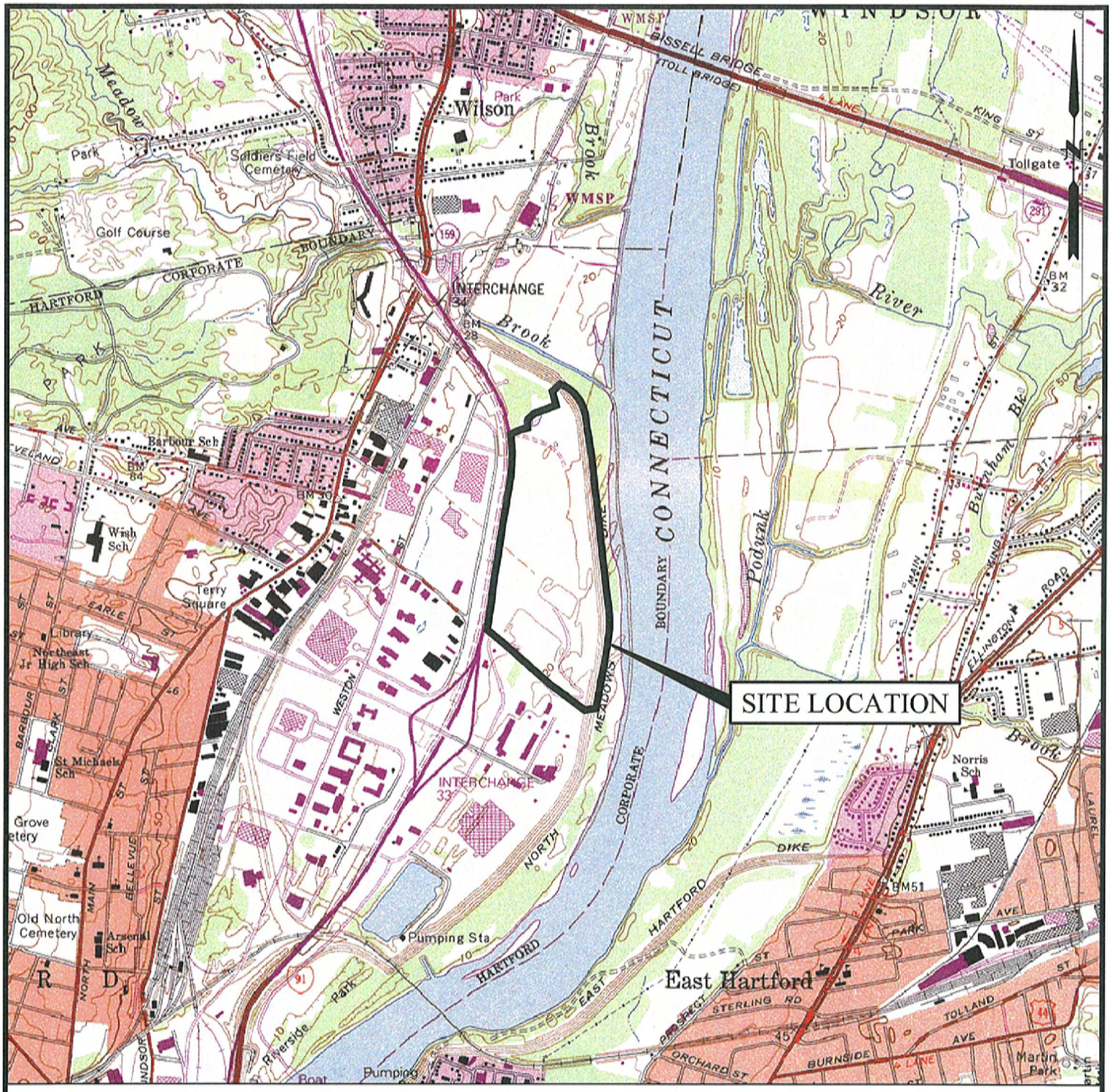
Figures

Site Location Map



MAP REFERENCE:
THIS MAP WAS PREPARED FROM THE FOLLOWING 7.5 MINUTE SERIES TOPOGRAPHIC MAP:
HARTFORD NORTH, CONN. 1964, PHOTOREVISED 1992.

QUADRANGLE LOCATION

SCALE:	
HORZ.:	1" = 2,000'
VERT.:	
DATUM:	
HORZ.:	
VERT.:	
0 1000 2000	
GRAPHIC SCALE	

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CONNECTICUT RESOURCES RECOVERY AUTHORITY
SITE LOCATION MAP
HARTFORD LANDFILL
HARTFORD CONNECTICUT

PROJ. No.:	2004 0174.H10
DATE:	2006/06/15

FIG.1

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Appendix A

Closure Turf™ Manufacturer's Product Data

Product Advantages

- Rapid closure for odor control & gas management compliance.
- Provides a solution to soil cover failures due to gas pressure buildup and/or seismic events.
- Eliminates expensive soil cover and borrow source issues while providing additional airspace.
- Significant reduction of annual operation/maintenance costs.
- Excellent in arid regions because no irrigation is needed.
- Reduces the cost of post-closure maintenance.
- Superior and reliable aesthetics.
- Eliminates common erosion issues.
- The friction characteristics of the product allows for installation on slopes steeper than 2H:1V.
- Minimizes infiltration due to no head build-up on the geomembrane.
- Reduce or eliminate riprap channels and drainage benches.
- Prevent erosion or siltation problems, even during severe weather events.
- Reduction of leachate generation due to faster closures.
- Allows for future "piggyback" areas or vertical expansions without having to remove the existing cover soils.
- Provides required transmissivity if post-closure use or exit closure requires a soil cap.
- Improved Vector control.

Sand is applied as a ballast eliminating the need for anchoring.

The Agru America plant in Georgetown, South Carolina.

The Agru America plant in Fernley, Nevada.

agru america

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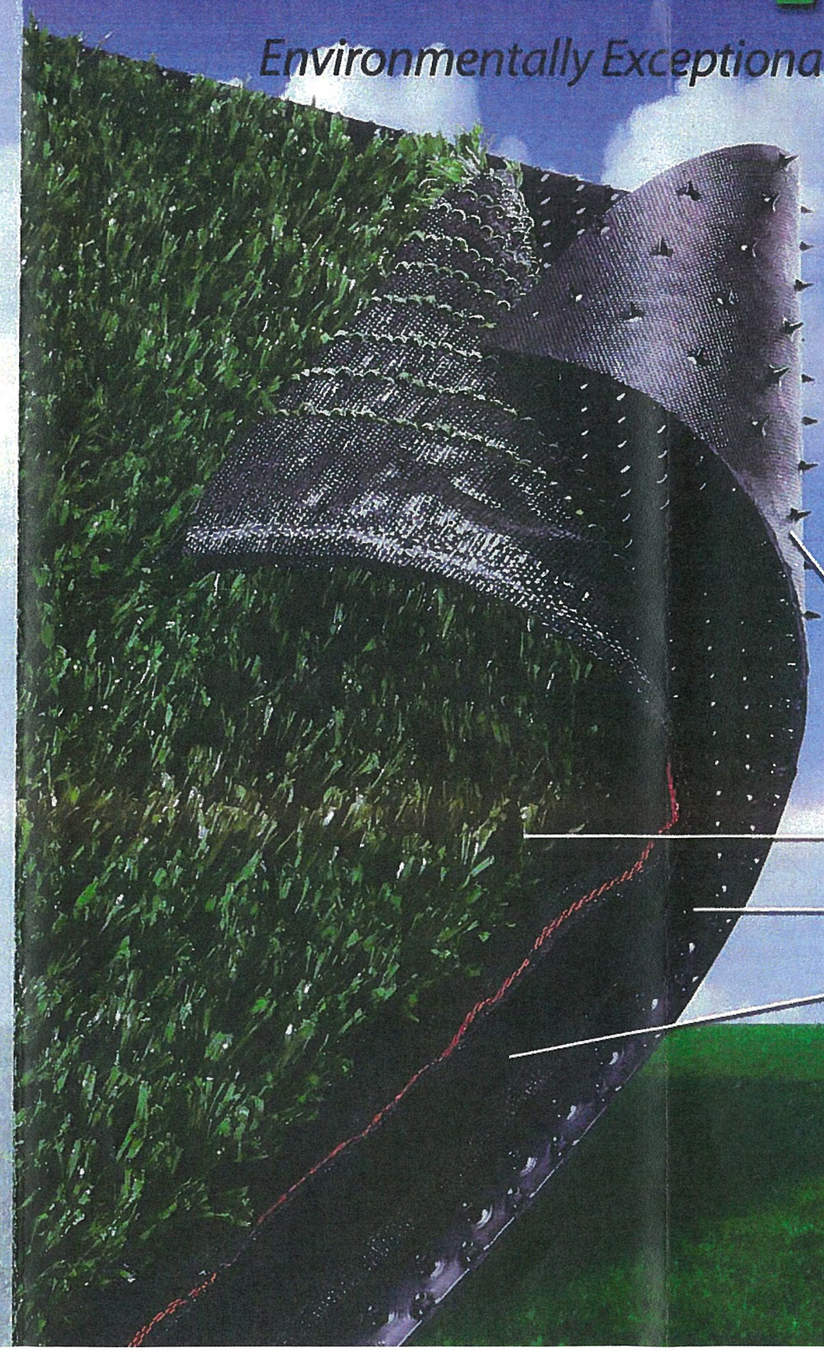
Closure Turf™

Environmentally Exceptional and Economical



Integral spikes to ensure high friction to subgrade

UV resistant blades interlocked with sand ballast

Integral studs for high capacity drainage

Geotextiles for dimensional stability

agru america

Take a Closer Look at Closure Turf™

Closure Turf ™ is an impermeable synthetic grass for an economical and environmentally sound closure of landfills, mine spoils and hazardous sites.

It can dramatically reduce construction and long-term maintenance costs, while providing improved stability, erosion protection, emission control and leachate reduction.

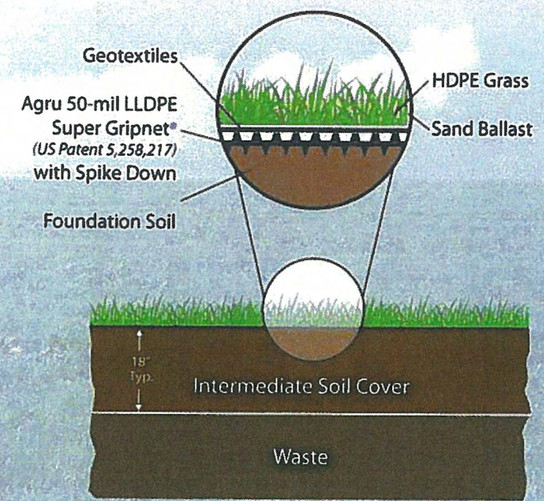
Combines a drainage system and a geomembrane barrier with a durable synthetic turf for a long life of superior performance and aesthetics with Closure Turf™.

agru america

Product Features

- Allows faster capping during the operational life of the landfill. Faster capping reduces odors, improves gas collection efficiency and enhances compliance with Title V air quality rules.
- Significant savings in soil cover. The product will eliminate the need for final soil cover and natural vegetation and give increased waste quantity potential. The resulting savings can be significant based on the location and availability of soil cover.
- Better for landfills in sensitive areas where soil erosion and sedimentation are a major concern. Soil loss is non-existent during operations and post closure.
- Eliminates the need for borrow sources, siltation ponds and associated environmental construction impacts.
- Allows for steeper waste slopes since there will not be soil stability problems either thru earthquakes or gas pressure build-up.

Closure Turf™ cross-section



Installation of the drainage membrane.

- Landfill
- Mining
- Coal Ash
- Brownfield
- Superfund

Rapid installation of 2 acres per day.

- Internal ballast system withstands hurricane force winds.
- The five durable components of this system provide for a long-life of protection against operational and natural forces while maintaining an excellent appearance with minimal maintenance.
- Reduces wildlife impacts and bird attraction by minimizing organic matter and food sources. This is important in landfills located in coastal areas or those facilities located near airports.

Consistent aesthetics with no maintenance required after major storm events.

Closure Turf™

Linear Low Density Polyethylene Super Gripnet® Liner

Product Data

Property	Test Method	Values			
Thickness (min. ave.), mil (mm)	ASTM D5994*	50 (1.25)	60 (1.5)	80 (2.0)	100 (2.5)
Thickness (lowest indiv.), mil (mm)	ASTM D5994*	50 (1.25)	54 (1.35)	72 (1.8)	90 (2.25)
*The thickness values may be changed due to project specifications (i.e., absolute minimum thickness)					
Drainage Stud Height (min. ave.), mil (mm)	GRI GM12/ASTM D7466	145 (3.68)	145 (3.68)	145 (3.68)	145 (3.68)
Friction Spike Height (min. ave.), mil (mm)	GRI GM12/ASTM D7466	175 (4.45)	175 (4.45)	175 (4.45)	175 (4.45)
Density, g/cc, maximum	ASTM D792, Method B	0.939	0.939	0.939	0.939
Tensile Properties (ave. both directions)	ASTM D6693, Type IV				
Strength @ Break (min. ave.), lb/in width (N/mm)	2 in/minute	105 (18.4)	126 (22.1)	168 (29.4)	210 (36.8)
Elongation @ Break (min. ave.), % (GL=2.0in)	5 specimens in each direction	300	300	300	300
Tear Resistance (min. ave.), lbs. (N)	ASTM D1004	30 (133)	40 (178)	53 (236)	67 (298)
Puncture Resistance (min. ave.), lbs. (N)	ASTM D4833	55 (245)	70 (311)	90 (400)	110 (489)
Carbon Black Content (range in %)	ASTM D4218	2 - 3	2 - 3	2 - 3	2 - 3
Carbon Black Dispersion (Category)	ASTM D5596	Only near spherical agglomerates for 10 views: 9 views in Cat. 1 or 2, and 1 view in Cat. 3			
Oxidative Induction Time, minutes	ASTM D3895, 200°C, 1 atm O_2	≥100	≥100	≥100	≥100
Melt Flow Index, g/10 minutes	ASTM D1238, 190°C, 2.16kg	≤1.0	≤1.0	≤1.0	≤1.0
Oven Aging	ASTM D5721	60	60	60	60
with HP OIT, (% retained after 90 days)	ASTM D5885, 150°C, 500psi O_2				
UV Resistance	GRI GM11	20hr. Cycle @ 75°C/4 hr. dark condensation @ 60°C			
with HP OIT, (% retained after 1600 hours)	ASTM D5885, 150°C, 500psi O_2	35	35	35	35
2% Secant Modulus (max.), lb/in. (N/mm)	ASTM D5323	3000 (520)	3600 (630)	4800 (840)	6000 (1050)
Axi-Symmetric Break Resistance Strain, % (min.)	ASTM D5617	30	30	30	30

These product specifications meet or exceed GRI's GM17

Supply Information (Standard Roll Dimensions)

Thickness		Width		Length		Area (approx.)		Weight (average)*	
mil	mm	ft	m	ft	m	ft^2	m^2	lbs	kg
50	1.25	23	7	300	91.435	6,900	640.05	2,800	1,270.06
60	1.5	23	7	300	91.435	6,900	640.05	2,900	1,315.42
80	2.0	23	7	300	91.435	6,900	640.05	3,100	1,406.14
100	2.5	23	7	300	91.435	6,900	640.05	4,000	1,814.40

Notes:

All rolls are supplied with two slings. All rolls are wound on a 6 inch core. Special lengths are available on request. All roll lengths and widths have a tolerance of ±1%

**The weight values may change due to project specifications (i.e. absolute minimum thickness or special roll lengths) or shipping requirements (i.e. international containerized shipments).*

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email: salesmkg@agruamerica.com www.agruamerica.com

Closure Turf™

Product Data

Property (50 mil Super Gripnet)	Test Method	LLDPE Values	HDPE
Thickness (min. ave.), mil (mm)	ASTM D5994	50 (1.25)	50 (1.25)
Drainage Stud Height (min. ave.), mil (mm)	ASTM D7466	145 (3.68)	145 (3.68)
Friction Spike Height (min. ave.), mil (mm)	ASTM D7466	175 (4.45)	175 (4.45)
Density, g/cc	ASTM D792, Method B	0.939 (max.)	0.94 (min.)
Tensile Properties (ave. both directions)	ASTM D6693, Type IV		
Strength @ Yield (min. ave.), lb/in width (N/mm)	2 in/minute	N/A	110 (19.3)
Strength @ Break (min. ave.), lb/in width (N/mm)	2 in/minute	110 (19.3)	110 (19.3)
Elongation @ Break (min. ave.), % (GL=2.0in)	5 specimens in each direction	300	200
Tear Resistance (min. ave.), lbs. (N)	ASTM D1004	30 (133)	38 (169)
Puncture Resistance (min. ave.), lbs. (N)	ASTM D4833	55 (245)	80 (356)
Carbon Black Content (range in %)	ASTM D4218	2 - 3	2 - 3
Carbon Black Dispersion (Category)	ASTM D5596	Only near spherical agglomerates for 10 views: 9 views in Cat. 1 or 2, and 1 view in Cat. 3	
Stress Crack Resistance (Single Point NCTL), hours	ASTM D5397, Appendix	N/A	300
Oxidative Induction Time, minutes	ASTM D3895, 200°C, 1 atm O_2	≥100	≥100
Melt Flow Index, g/10 minutes	ASTM D1238, 190°C, 2.16kg	≤1.0	≤1.0
Oven Aging	ASTM D5721	60	80
with HP OIT, (% retained after 90 days)	ASTM D5885, 150°C, 500psi O_2		
UV Resistance	GRI GM11	20hr. Cycle @ 75°C/4 hr. dark condensation @ 60°C	
with HP OIT, (% retained after 1600 hours)	ASTM D5885, 150°C, 500psi O_2	35	50
2% Secant Modulus (max.), lb/in. (N/mm)	ASTM D5323	3000 (520)	N/A
Axi-Symmetric Break Resistance Strain, % (min.)	ASTM D5617	30	N/A

Property (Turf Component)	Test Method	Values
Yarn count (Denier)	ASTM D1907	8,000 (min. 7300)
Tensile Grass @ Break lbs. (N)	ASTM D2256	20 lbs. (88) ±5 lbs.
Elongation @ Break %	ASTM D2256	30-80%
Shrinkage @ 90°C	N/A	N/A
Tape Thickness (micron)	ASTM D3218	100 (Varies based on client request)
Width (mm)	N/A	9±1%
Coating Temp.	N/A	N/A
Yarn Weight Minimum (grams per sq. cm)	ASTM D5261	19 oz./sy (0.063)
Double 13/18 Pic Polybag (grams per sq. cm)	ASTM D5261	6 oz./sy (0.020)
Product Weight w/o ballast (grams per sq. cm)	ASTM D5261	23 oz./sy (0.080) ±1%
Pile Height Minimum (cm)	Varies on client request	1.25 in. (3.17)
Tufting Gauge (cm)	N/A	.75 in. (1.9) ±1%
CBR Puncture	ASTM D6241	650lb., Min.
Tensile Product	ASTM D4595	1,000 lb./ft., Min.
Transmissivity with underlying structured geomembrane Normal stress 50 psf and 0.33 gradient (m_2/sec)	ASTM D4716	2.5E-03 m_2/sec., Min.
Internal Friction of combined components	ASTM D5321	35°, Min.
UV Resistance & Stability. Tensile testing after weathering Climate Zone 200W/m_2 30 years exposure – accelerated or projected	ASTM G147 (02)	55% Retained Strength, Min.
Sand in-fill Gradation and Ballast	ASTM D 6913	SP/SW at a minimum of .5" thick of source material & ballast weight to be determined based on site specific conditions.

Supply Information (Standard Roll Dimensions)

Thickness	Thickness mil	Thickness mm	Width ft	Width m	Length ft	Length m	Area (approx.) ft^2	Area (approx.) m^2	Weight (average) lbs	Weight (average) kg
Super Gripnet	50	1.25	23	7	300	91.44	6,900	640	2,855	1,300
Turf Component	N/A	N/A	15	4.6	300	91.44	4,500	418	840	381

Notes:

All liner and turf roll lengths and widths have a tolerance of ±1%. All liner rolls are supplied with 2 slings. Both liner and turf rolls are wound on a 6 inch core. Turf rolls are strapped and wrapped for shipment. Special roll lengths are available on request.

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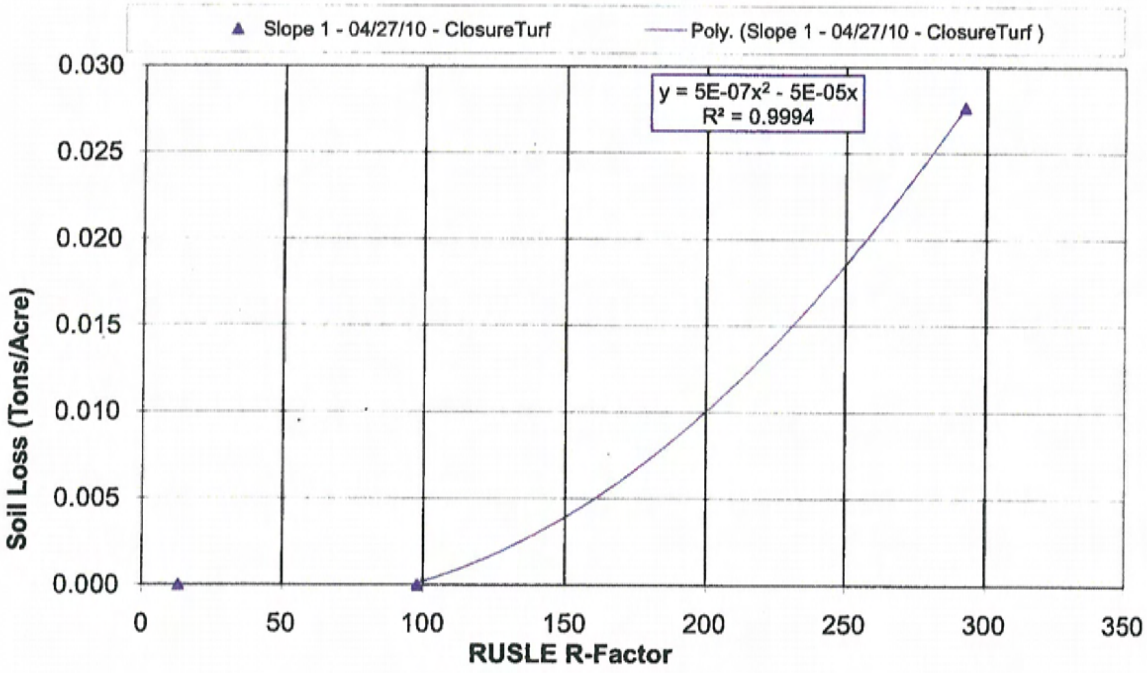
email: salesmkg@agruamerica.com www.agruamerica.com

Project: ASTM D 6459
Client: RPH
Test Date: 4/26/2010
Rainfall Rates: 2,4,6 in/hr (target); 20 minutes at each intensity (60 min. total)
Bed Size & Slope: 8-ft wide x 40-ft long; 3H:1V
Sand Ballast Layer, lbs: 1130 (approximately 1/2-inch thick, hand spread)

Plot	Intensity (in/hr)	Runoff (gallons)	Cumm. R-Factor	Soil Loss (lbs/slope)	Sediment Yield (tons/acre)	% of Ballast in Runoff/Seepage
ClosureTurf	2.36	93	13.13	0.00	0.00	0.04%
	4.65	258	97.99	0.00	0.00	
	6.57	360	292.43	0.41	0.03	

Time (min)	Cumm. Rainfall (in)	Cumm. Runoff (in)	Peak Runoff (cfs)	CN[1]	Rational "C"[2]
20	0.79	0.46	0.013	96.2	0.74
40	2.34	1.76	0.026	94.5	0.76
60	4.53	3.56	0.038	91.3	0.78

Soil Loss vs RUSLE R-Factor



1. The effective runoff curve number was determined by solving for S in the equation Q = [(P-0.2S)2/(P+0.8S)] where Q is the depth of runoff (in) and P is the rainfall depth (in). Then, CN = 1000/(S+10).

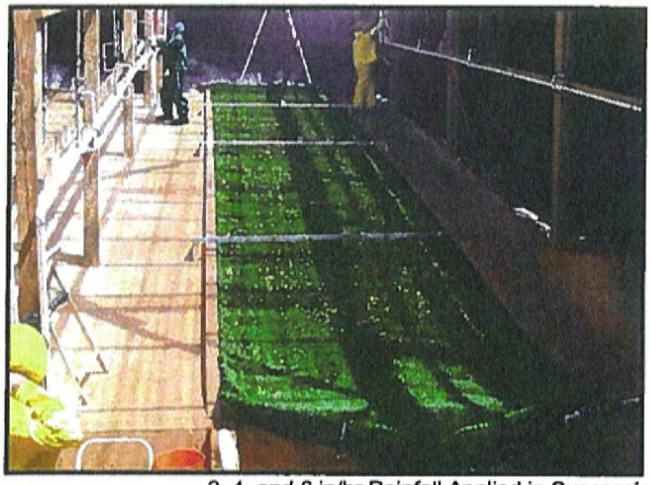
2. The rational "C" coefficient was determined by solving for C in Q = C I A where Q is the peak discharge rate (cfs), I is the peak rainfall intensity (in/hr) and A is the drainage area (acre).

Note: The testing is based upon accepted industry practice as well as the test method listed. Test results reported herein do not apply to samples other than those tested. TRI neither accepts responsibility for nor makes claim as to the final use and purpose

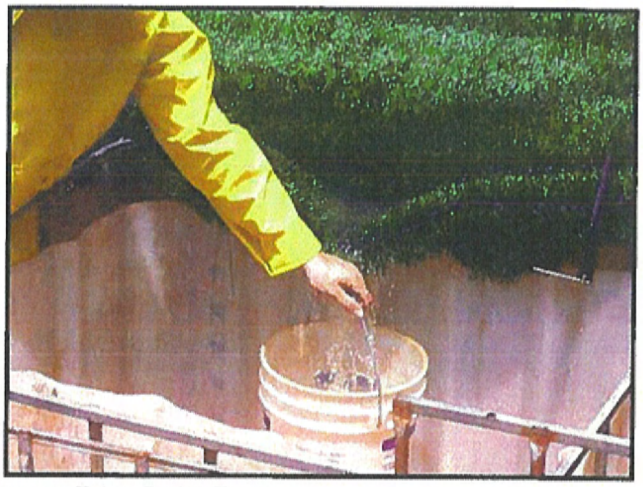
CJS 5/5/10
Quality Review / Date


Test Slope Prepared and Liner Installed

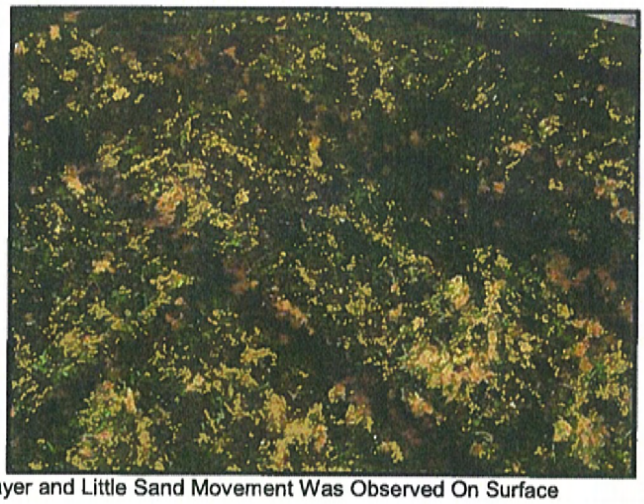

Synthetic Turf Deployed and Sand Ballast Layer Hand-Applied



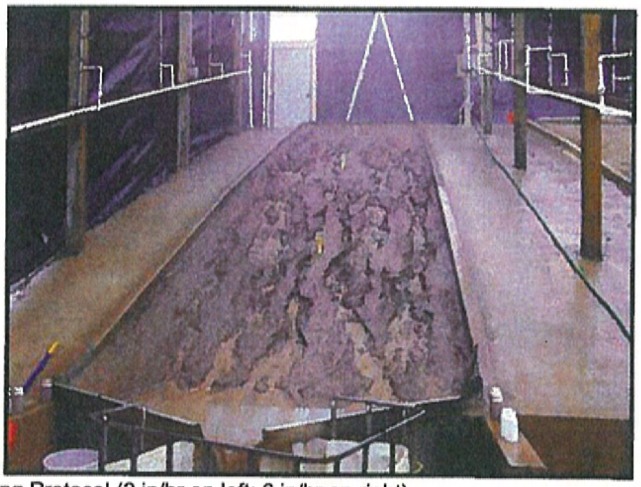

2, 4, and 6 in/hr Rainfall Applied in Succession and Substantial In-Plane Drainage Observed

Bottle Grab Samples and Flow Rate Measurements Taken During Testing

Only Small Amounts of Sand Migrated Within the Drainage Layer and Little Sand Movement Was Observed On Surface

Typical Unprotected Slope Erosion from Testing Protocol (2 in/hr on left; 6 in/hr on right)

APPENDIX - DATA

DDRF Rainfall Testing

Slope #: 1 | **Target Rain: 2 in/hr**

Date: 4/26/2010 | Start Rain: 12:25 PM | End Rain: 12:45 PM

Sampling interval: 0:03 | End Runoff: 12:47 PM

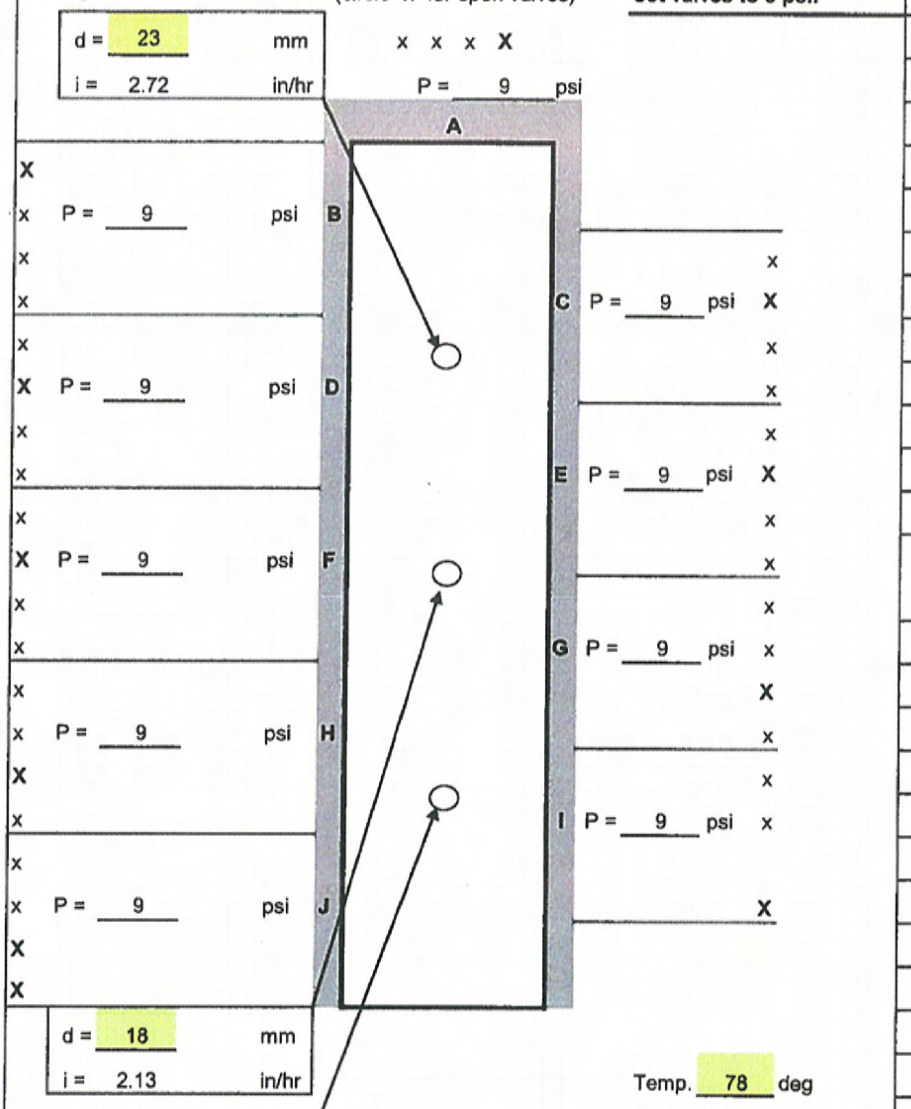
Rain Time (min): 20.00 | Test Time (min): 22.00

Product: ClosureTurf | Descr:. Membrane and Synthetic Turf Capping System

Lot #: n/a | Anchors: Sand | Anchorage: 1/2-inch Thick

TOP OF SLOPE

(circle "x" for open valves) **Set valves to 9 psi.**



Temp. 78 deg

Hum. 78 %

Average Depth: 20.00 mm

Avg Rainfall Intensity: 2.36 in/hr

Sediment Concentration Grab Samples Followed by Runoff Rate Measurements

#	Time	
1	12:28	
2	12:31	
3	12:34	
4	12:37	
5	12:40	
6	12:43	
7		
8		
9		
10		
11		
12		
13		
14		
15		
12		
13		
14		
15		

Runoff Rate Measurements

#	Time	Time to Collect 1 Gallon, Seconds
1	2	180
2	6	31
3	10	15
4	14	10
5	18	10
6	20	9
7		
8		
9		
10		
11		
12		
13		
14		
15		
12		
13		
14		
15		

Notes:

0 mph breeze.

Approx 92 gal collected.

DDRF Rainfall Testing

Slope #: 1 | **Target Rain: 4 in/hr**

Date: 4/26/2010 | Start Rain: 12:53 PM | End Rain: 1:13 PM

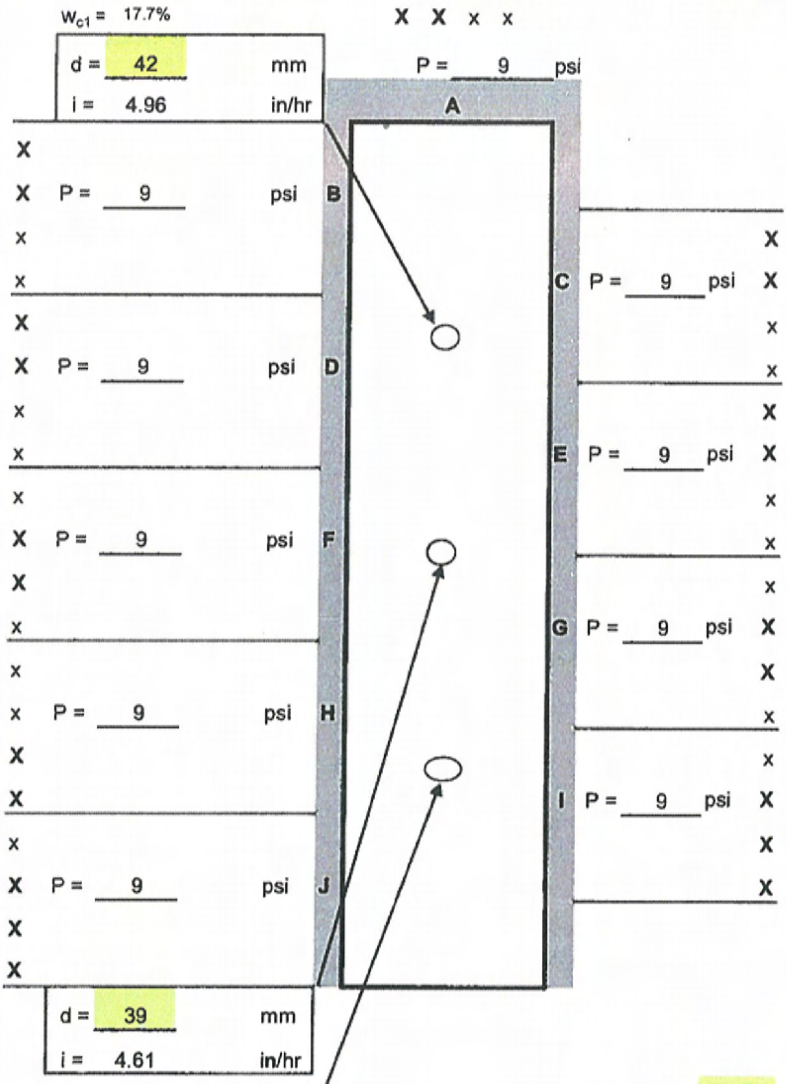
Sampling interval: 0:02 | End Runoff: 1:17 PM

Rain Time (min): 20.00 | Test Time (min): 24.00

Product: ClosureTurf | Descr:. Membrane and Synthetic Turf Capping System

Lot #: n/a | Anchors: Sand | Anchorage: 1/2-inch Thick

TOP OF SLOPE | **Set valves to 9 psi.**



Temp. 77 deg

Hum. 86 %

Average Depth: 39.33 mm

Avg Rainfall Intensity: 4.65 in/hr

Sediment Concentration Grab Samples Followed by Runoff Rate Measurements

#	Time	
1	12:55	
2	12:57	
3	12:59	
4	13:01	
5	13:03	
6	13:05	
7	13:07	
8	13:09	
9	13:11	
10	13:13	
11		
12		
13		
14		
15		
12		
13		
14		
15		

Runoff Rate Measurements

#	Time	Time to Collect 1 Gallon, Seconds
1	2	8
2	4	6
3	6	6
4	8	6
5	10	6
6	12	6
7	14	5
8	16	5
9	18	5
10	20	5
11		
12		
13		
14		
15		
12		
13		
14		
15		

Notes:

0 mph breeze.

Approx 260 gal collected.

DDRF Rainfall Testing

Slope #: 1 | **Target Rain: 6 in/hr**

Date: 4/26/2010 | Start Rain: 12:53 PM | End Rain: 1:13 PM

Sampling interval: 0:02 | End Runoff: 1:17 PM

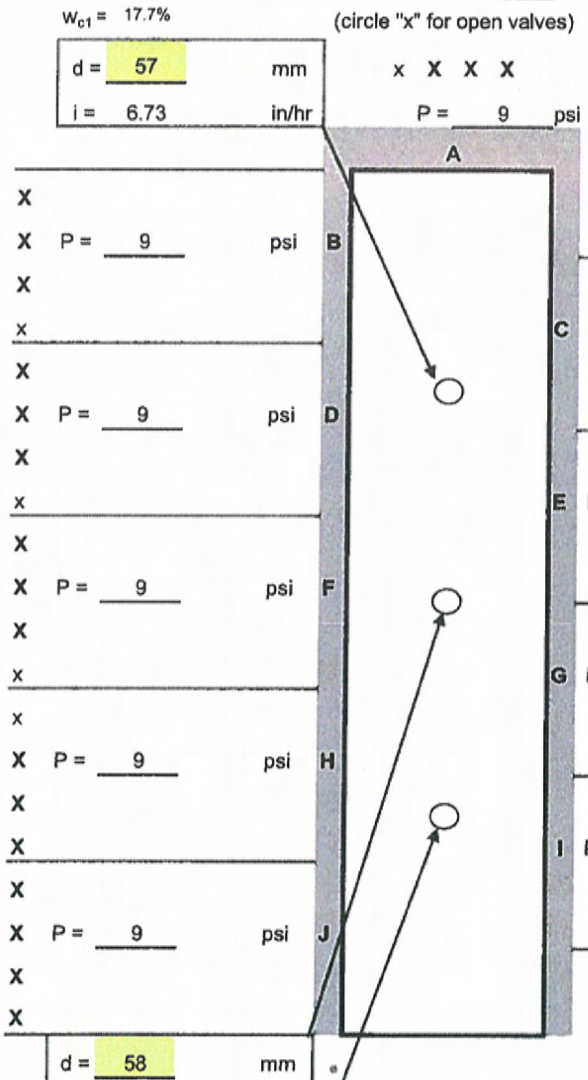
Rain Time (min): 20.00 | Test Time (min): 24.00

Product: ClosureTurf | Descr:. Membrane and Synthetic Turf Capping System

Lot #: n/a | Anchors: Sand | Anchorage: 1/2-inch Thick

TOP OF SLOPE

(circle "x" for open valves) **Set valves to 9 psi.**



Temp. 69 deg

Hum. 88 %

Average Depth: 55.67 mm

Avg Rainfall Intensity: 6.57 in/hr

Sediment Concentration Grab Samples Followed by Runoff Rate Measurements

#	Time	
1	12:55	
2	12:57	
3	12:59	
4	13:01	
5	13:03	
6	13:05	
7	13:07	
8	13:09	
9	13:11	
10	13:13	
11		
12		
13		
14		
15		
12		
13		
14		
15		

Runoff Rate Measurements

#	Time	Time to Collect 1 Gallon, Seconds
1	2	4
2	4	4
3	6	4
4	8	4
5	10	4
6	12	4
7	14	4
8	16	4
9	18	4
10	20	4
11		
12		
13		
14		
15		
12		
13		
14		
15		

Notes:

0 mph breeze.

Approx 360 gal collected.

0-Jan-00

Slope #1

Sample Number	Test Time, minutes	Time per Gallon, sec	Interval Time, min	Total Time, min	Collection Mid-Time, min	Runoff Rate, gal/min	Associated Runoff, gal	Cumulative Runoff, gal	
2.36 in/hr									
2	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	
2-1	2.00	180	5.00	5.00	3.50	0.33	1.67	1.67	
2-2	6.00	31	1.52	6.52	6.26	1.94	2.94	4.60	
2-3	10.00	15	3.73	10.25	10.13	4.00	14.93	19.54	
2-4	14.00	10	3.92	14.17	28.17	6.00	23.50	43.04	
2-5	18.00	10	4.00	18.17	36.17	6.00	24.00	67.04	
2-6	20.00	9	1.98	20.15	40.15	6.67	13.22	80.26	
2-end	22.00		1.85	22.00			12.33	**92.59**	**Total Collected Runoff (approx)**
4.65 in/hr									
4	0	0	0.00	0.00	0.00	0.00	0.00	0.00	
4-1	2	8	2.13	2.13	2.07	7.50	16.00	16.00	
4-2	4	6	1.97	4.10	4.05	10.00	19.67	35.67	
4-3	6	6	2.00	6.10	6.05	10.00	20.00	55.67	
4-4	8	6	2.00	8.10	8.05	10.00	20.00	75.67	
4-5	10	6	2.00	10.10	10.05	10.00	20.00	95.67	
4-6	12	6	2.00	12.10	12.05	10.00	20.00	115.67	
4-7	14	5	1.98	14.08	14.04	12.00	23.80	139.47	
4-8	16	5	2.00	16.08	16.04	12.00	24.00	163.47	
4-9	18	5	2.00	18.08	18.04	12.00	24.00	187.47	
4-10	20	5	2.00	20.08	20.04	12.00	24.00	211.47	
4-end	24.00		3.92	24.00			47.00	**258.47**	**Total Collected Runoff (approx)**
5.90 in/hr									
6	0	0	0.00	0.00	0.00	0.00	0.00	0.00	
6-1	2	4	2.07	2.07	2.03	15.00	31.00	31.00	
6-2	4	4	2.00	4.07	4.03	15.00	30.00	61.00	
6-3	6	4	2.00	6.07	6.03	15.00	30.00	91.00	
6-4	8	4	2.00	8.07	8.03	15.00	30.00	121.00	
6-5	10	4	2.00	10.07	10.03	15.00	30.00	151.00	
6-6	12	4	2.00	12.07	12.03	15.00	30.00	181.00	
6-7	14	4	2.00	14.07	14.03	15.00	30.00	211.00	
6-8	16	4	2.00	16.07	16.03	15.00	30.00	241.00	
6-9	18	4	2.00	18.07	18.03	15.00	30.00	271.00	
6-10	20	4	2.00	20.07	20.03	15.00	30.00	301.00	
6-end	24.00		3.93	24.00			59.00	**360.00**	**Total Collected Runoff (approx)**

Slope #1 - Sediment Concentration

	Sample Number	Test Time, minutes	Total Weight, g	Decanted Weight, g	Dry Weight, g	Bottle Weight, g	Dry Sediment Weight, mg	Total Collected Water Wt., g	Total Collected Volume of Water, l	Sediment Concentration, mg/l	Runoff Sampling Time	Time to Collect 1 gal	Associated Runoff, gal	Associated Sediment Conc, mg/l	Associated Solids Loss, lbs
#DIV/0! in/hr	avg														
0-Jan-00	2-1	3.00	300.51	32.92	32.92	32.92	0.00	267.59	0.27	0.00	2.00	180	1.67	0.00	0.00
	2-2	6.00	310.76	32.92	32.92	32.92	0.00	277.84	0.28	0.00	6.00	31	2.94	0.00	0.00
	2-3	9.00	305.13	32.92	32.92	32.92	0.00	272.21	0.27	0.00	10.00	15	14.93	0.00	0.00
	2-4	12.00	311.56	32.92	32.92	32.92	0.00	278.64	0.28	0.00	14.00	10	23.50	0.00	0.00
	2-5	15.00	298.63	32.92	32.92	32.92	0.00	265.71	0.27	0.00	18.00	10	24.00	0.00	0.00
	2-6	18.00	304.77	32.92	32.92	32.92	0.00	271.85	0.27	0.00	20.00	9	13.22	0.00	0.00
									AVG =	**0.00**	22.00	0	12.33	0.00	0.00
4.24 in/hr	avg												**Total Solids Lost:**		**0.00**
11/5/2009	4-1	2.00	311.17	32.92	32.92	32.92	0.00	278.25	0.28	0.00	2.00	8	16.00	0.00	0.00
	4-2	4.00	308.34	32.92	32.92	32.92	0.00	275.42	0.28	0.00	4.00	6	19.67	0.00	0.00
	4-3	6.00	290.56	32.92	32.92	32.92	0.00	257.64	0.26	0.00	6.00	6	20.00	0.00	0.00
	4-4	8.00	313.40	32.92	32.92	32.92	0.00	280.48	0.28	0.00	8.00	6	20.00	0.00	0.00
	4-5	10.00	313.35	32.92	32.92	32.92	0.00	280.43	0.28	0.00	10.00	6	20.00	0.00	0.00
	4-6	12.00	310.89	32.92	32.92	32.92	0.00	277.97	0.28	0.00	12.00	6	20.00	0.00	0.00
	4-7	14.00	314.63	32.92	32.92	32.92	0.00	281.71	0.28	0.00	14.00	5	23.80	0.00	0.00
	4-8	16.00	317.22	32.92	32.92	32.92	0.00	284.30	0.28	0.00	16.00	5	24.00	0.00	0.00
	4-9	18.00	315.58	32.92	32.92	32.92	0.00	282.66	0.28	0.00	18.00	5	24.00	0.00	0.00
	4-10	20.00	313.87	32.92	32.92	32.92	0.00	280.95	0.28	0.00	20.00	5	24.00	0.00	0.00
									AVG =	**0.00**	24.00	0	47.00	0.00	0.00
5.90 in/hr	avg												**Total Solids Lost:**		**0.00**
6/11/2009	6-1	2.00	317.68	32.92	32.92	32.92	0.00	284.76	0.28	0.00	2.00	4.00	31.00	0.00	0.00
	6-2	4.00	315.42	32.92	32.92	32.92	0.00	282.50	0.28	0.00	4.00	4.00	30.00	0.00	0.00
	6-3	6.00	314.68	32.92	32.92	32.92	0.00	281.76	0.28	0.00	6.00	4.00	30.00	0.00	0.00
	6-4	8.00	312.89	32.92	32.92	32.92	0.00	279.97	0.28	0.00	8.00	4.00	30.00	0.00	0.00
	6-5	10.00	313.42	32.92	32.92	32.92	0.00	280.50	0.28	0.00	10.00	4.00	30.00	0.00	0.00
	6-6	12.00	309.16	32.92	32.92	32.92	0.00	276.24	0.28	0.00	12.00	4.00	30.00	0.00	0.00
	6-7	14.00	313.41	32.92	32.92	32.92	0.00	280.49	0.28	0.00	14.00	4.00	30.00	0.00	0.00
	6-8	16.00	315.77	32.92	32.92	32.92	0.00	282.85	0.28	0.00	16.00	4.00	30.00	0.00	0.00
	6-9	18.00	309.69	32.92	32.92	32.92	0.00	276.77	0.28	0.00	18.00	4.00	30.00	0.00	0.00
	6-10	20.00	310.70	32.92	32.92	32.92	0.00	277.78	0.28	0.00	20.00	4.00	30.00	0.00	0.00
									AVG =	**0.00**	24.00	0.00	59.00	0.00	0.00
													Total Solids Lost:		**0.00**

SLOPE #1 - Sediment Weights

Total Dry Sediments: 0.00

2 in/hr	Collected	Typ. TSS in Decanted Collected Runoff, lb/gal
Wt. Of pan + wet soil, g	0	
Wt. Of pan + dry soil, g	0	
Wt. Of pan, g	0	
Wt. Of dry soil, g	0	0
Wt. Of water, g		Collected Runoff, gal
Water Content, w%		
Total Wet Sediments,g		
% dry solids		92.6
Dry Collected Sediments, g	0.00	0.00

Total Dry Sediments: 0.00

4 in/hr	Collected	Typ. TSS in Decanted Collected Runoff, lb/gal
Wt. Of pan + wet soil, g	0	
Wt. Of pan + dry soil, g	0	
Wt. Of pan, g	0	
Wt. Of dry soil, g	0	0
Wt. Of water, g		Collected Runoff, gal
Water Content, w%		
Total Wet Sediments, g		
% dry solids		258.5
Dry Collected Sediments, g	0.00	0.00

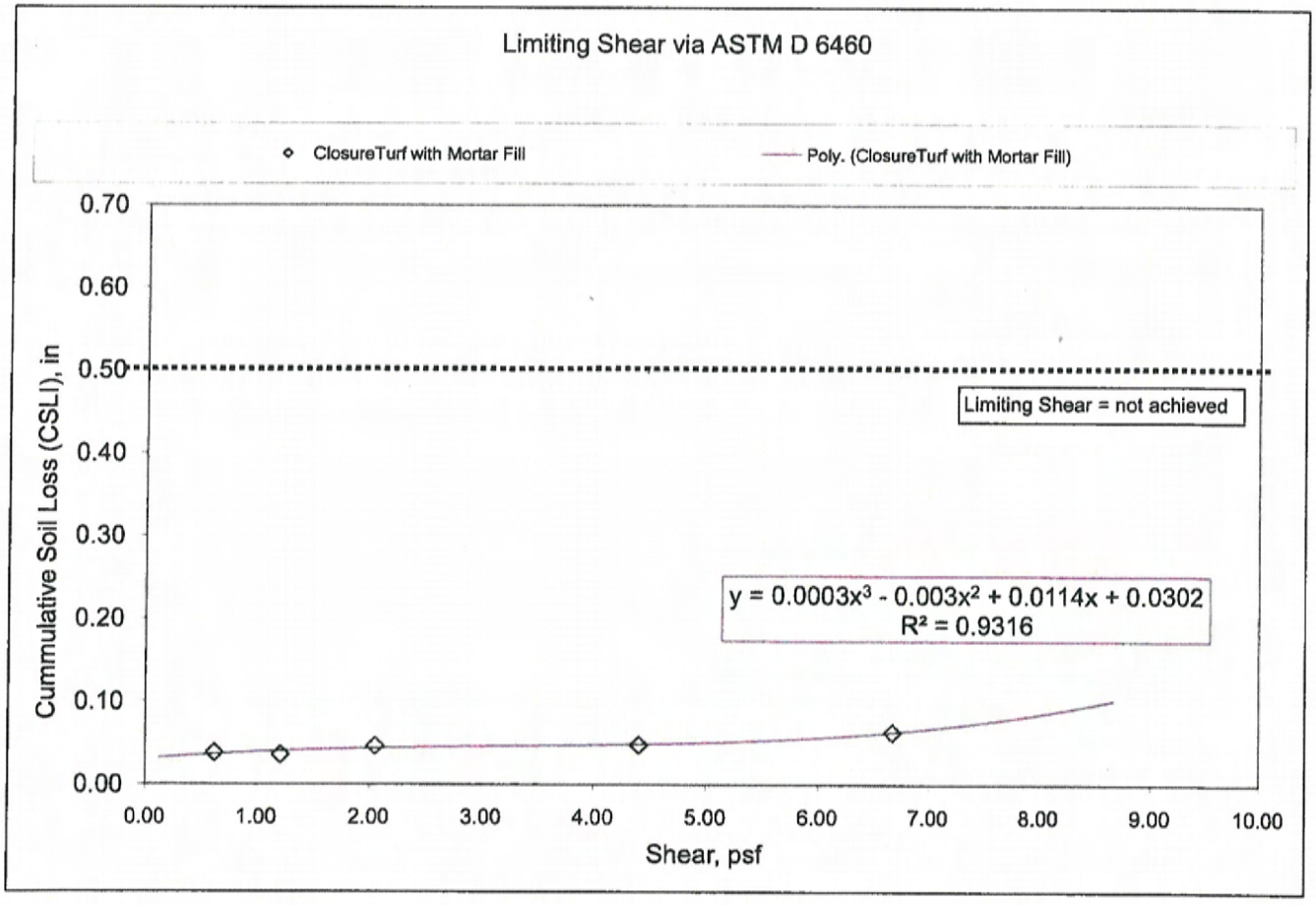
Total Dry Sediments, lbs: 0.41

6 in/hr	Collected	Typ. TSS in Decanted Collected Runoff, lb/gal
Wt. Of pan + wet soil, g	402.35	
Wt. Of pan + dry soil, g	400.76	
Wt. Of pan, g	216.31	
Wt. Of dry soil, g	184.45	0
Wt. Of water, g	1.59	Collected Runoff, gal
Water Content, w%	0.9	
Total Wet Sediments, g		
% dry solids		360.0
Dry Collected Sediments, g	184.45	0.00

TRI/ENVIRONMENTAL, INC.
A Texas Research International Company

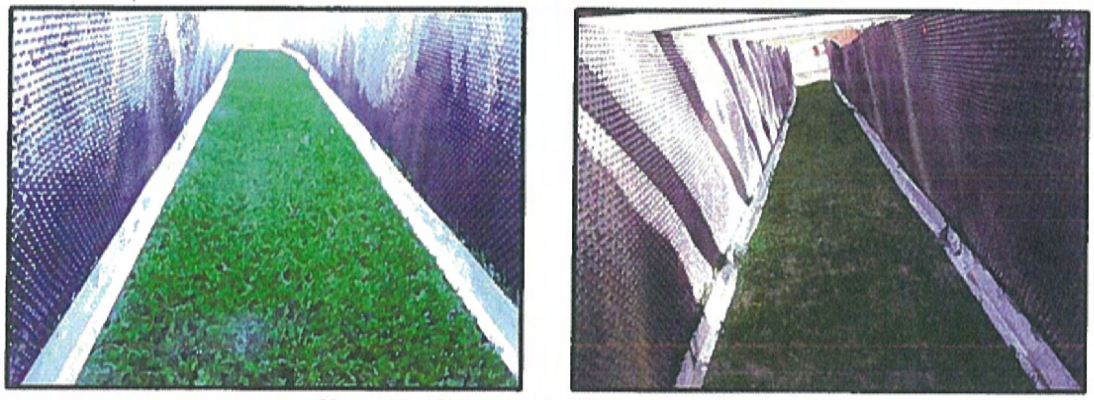
Project: ASTM D 6460: Large-scale Channel Testing (Single Replicate Results)
ClosureTurf with Mortar (3 parts sand; 2 parts powdered lime; 1 part cement)
Client: ClosureTurf
Test Date: 2/2/2011
Shear Range: 0.5 - 7.0 psf (target)
Flume Size & Slope: 2-ft wide x 40-ft long; 10% Bed
Event: 30 minutes at each shear

Shear Level	Flow depth (in)	Flow velocity (fps)	Flow (cfs)	Manning's roughness, n	Max Bed Shear Stress (psf)	CSLI (in)	Cumm. CSLI, (in)
1	1.20	2.01	0.41	0.052	0.62	0.04	0.04
2	2.34	5.53	2.16	0.029	1.21	0.00	0.04
3	3.95	8.40	5.52	0.027	2.05	0.01	0.05
4	8.49	14.52	20.53	0.026	4.41	0.00	0.05
5	12.85	19.24	41.12	0.026	6.67	0.02	0.06

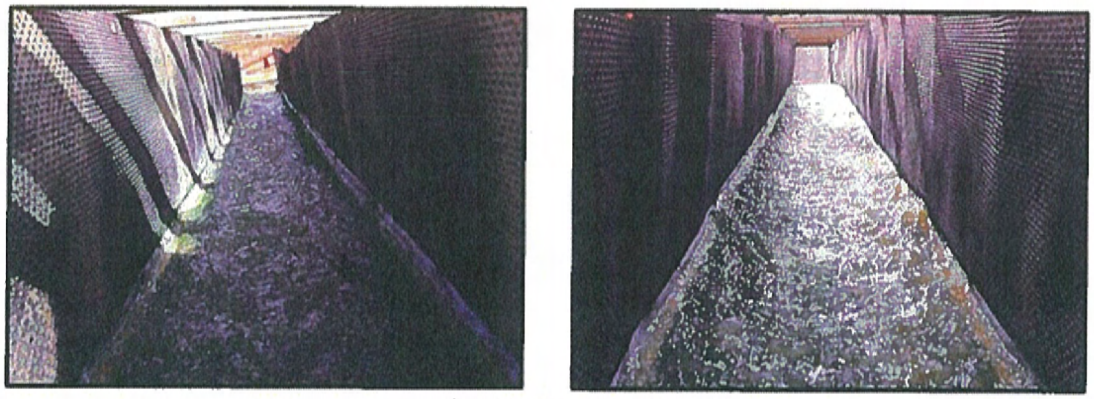


The testing is based upon accepted industry practice as well as the test method listed. Test results reported herein do not apply to samples other than those tested. TRI neither accepts responsibility for nor makes claim as to the final use and purpose

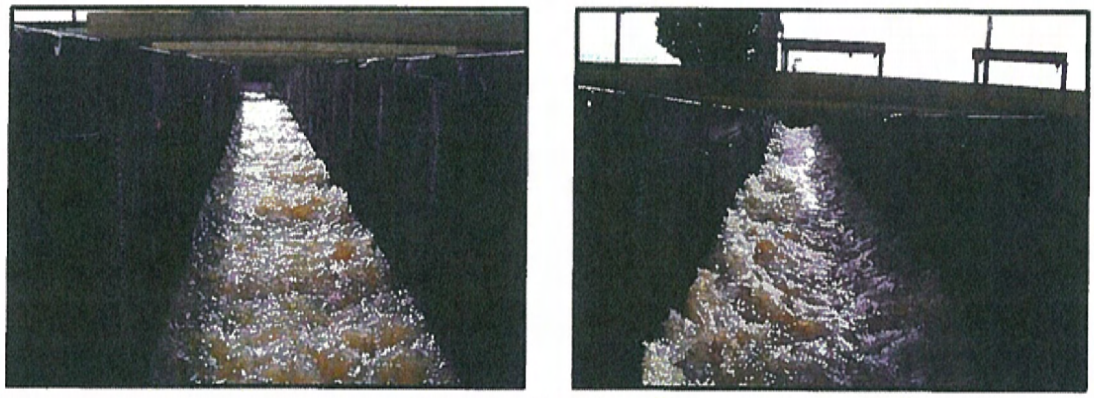
CJS 2/14/11
Quality Review / Date



ClosureTurf Before & After Mortar Mix Applied



Low Shear Flows



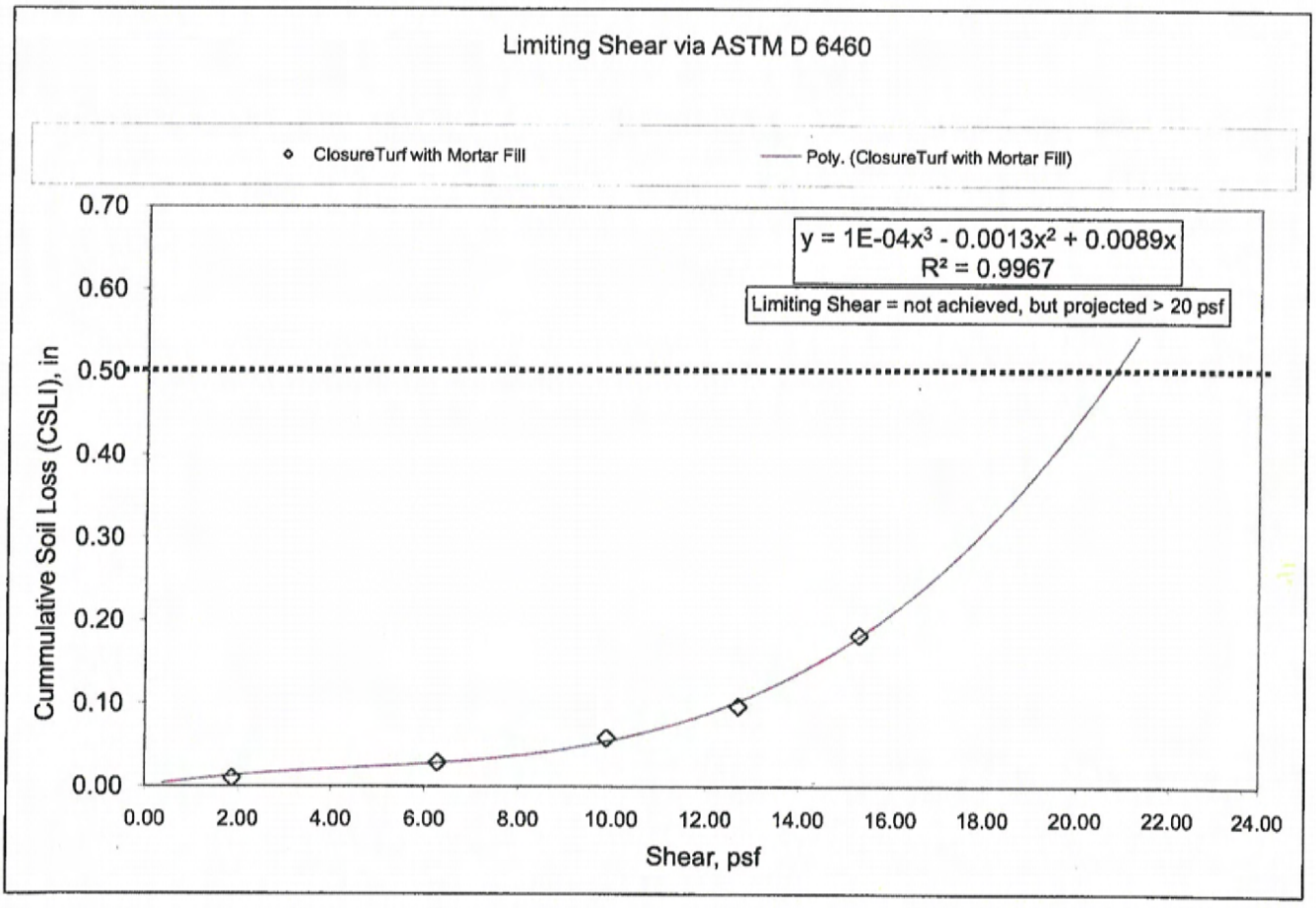
Increasing Shear Flows

Highest Flow and Final Channel Condition after Testing (no significant loss of mortar mix)

TRI/ENVIRONMENTAL, INC.
A Texas Research International Company

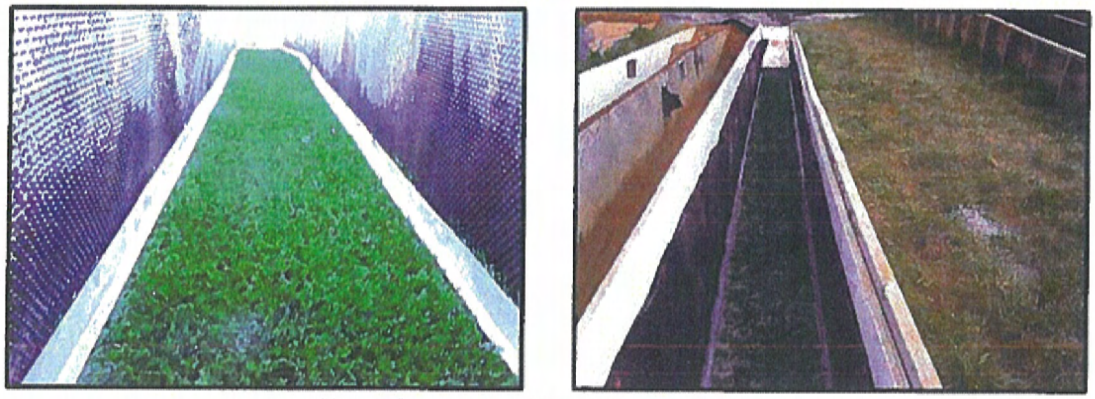
Project: ASTM D 6460: Large-scale Channel Testing (Single Replicate Results)
ClosureTurf with Mortar (3 parts sand; 2 parts powdered lime; 1 part cement)
Client: ClosureTurf
Test Date: 2/16&18/2011
Shear Range: 2.0 - 16.0 psf (target)
Flume Size & Slope: 2-ft wide x 40-ft long; 30% Bed
Event: 30 minutes at each shear

Shear Level	Flow depth (in)	Flow velocity (fps)	Flow (cfs)	Manning's roughness, n	Max Bed Shear Stress (psf)	CSLI (in)	Cumm. CSLI, (in)
1	1.22	4.90	0.99	0.036	1.87	0.01	0.01
2	4.08	12.35	8.39	0.032	6.27	0.02	0.03
3	6.44	18.23	19.54	0.030	9.89	0.03	0.06
4	8.27	21.59	29.73	0.029	12.70	0.04	0.10
5	9.96	24.55	40.73	0.029	15.30	0.09	0.18

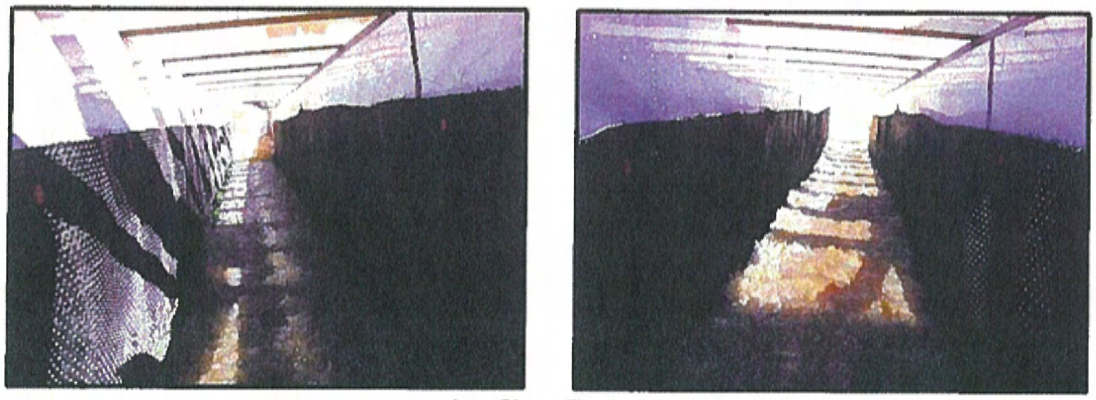


The testing is based upon accepted industry practice as well as the test method listed. Test results reported herein do not apply to samples other than those tested. TRI neither accepts responsibility for nor makes claim as to the final use and purpose

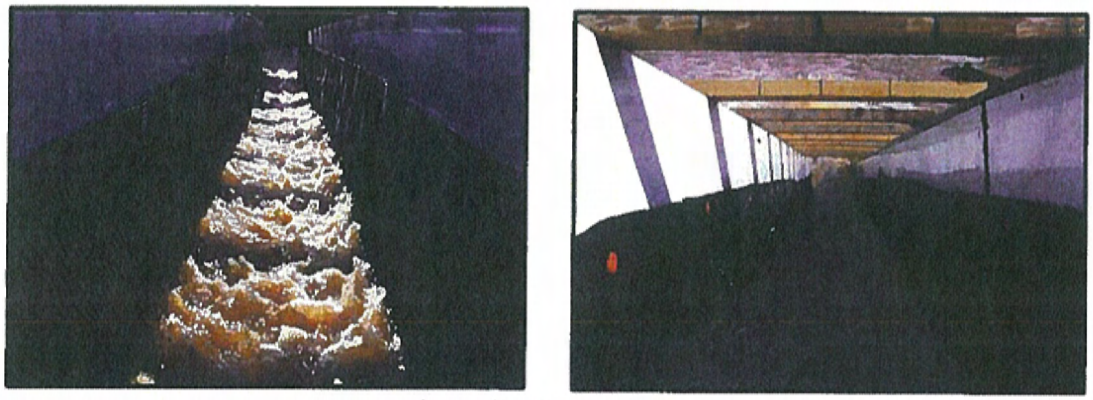
CJS 2/21/11
Quality Review / Date



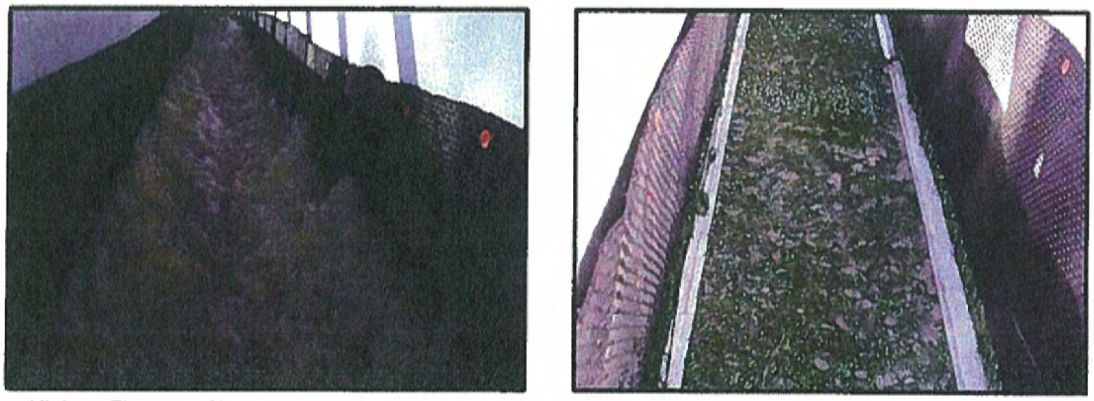
ClosureTurf Before & After Mortar Mix Applied



Low Shear Flows



Increasing Shear Flows



Highest Flow and Final Channel Condition after Testing (mortar mix showing cracks, some spalling at end)

FUSS & O'NEILL

Appendix B

Exposed TPO Manufacturer's Product Data

TPO vs. HDPE Geomembrane Performance

Designed for exposed geomembrane applications on landfills, Carlisle's GeoTPO provides enhanced, long-term performance especially when compared to traditional geomembranes, such as high-density polyethylene (HDPE). The superior performance characteristics of GeoTPO are portrayed in the chart below, which compares its performance to that of HDPE geomembrane.

Property or Characteristic	Test Frequency	Test Method (If Applicable)	Minimum Requirements	Carlisle TPO 60-Mil Geomembrane	Leading NR 60-Mil Smooth HDPE Geomembrane
Roll Length, ft (m)				480 (146.6)	560 (171)
Roll Length Tolerance, inches (mm)				-0, +1%	+/-1%
Roll Width, ft (m)				12 (3.7)	22.5 (6.9)
Roll Width Tolerance, inches (mm)				-0, +1%	+/-1%
Roll Area, ft² (m²)				5,760 (535.3)	12,600 (1,171)
Membrane Thickness, inches (mm)				.060, .072, .080 (1.5, 1.8, 2)	.060 (1.5)
Membrane Thickness Tolerance	Every roll			+/-10%	+/-10%
Roll Length/Width Tolerance					+/-1%
Fabric Internal Reinforcement				Yes, high strength polyester	None
Plasticizer Free				Yes	Yes
Melt Index (g/10min)	Resin Batch	ASTM D1238		N/A	<0.5
Melt Flow Index		ASTM D1238		1.3	N/A
Weathering Package Content (%)				4	None Listed
Carbon Black Content (%)	100,000 ft	ASTM D1603		0.5	2.0-3.0
Notched Constant Load ESCR		ASTM D5397		N/A	300 hours
Flex Modulas, PSI		D790		11,600	Not listed
Heat Seamable				Yes	Yes
Weld Method				Lap Joint, Single Weld with Wedge Welder	Double Wedge Weld
Seam Strength Inspection Method				Air Lance	Air Lance
Field Seam Strength, lbf/in (kN/m) Seam tested in peel mode after weld		ASTM D4437 1 in. wide		Shear Strength (PPI) - 100 (17.7) Fusion Peel (PPI) - 30 (5.3) N/A	Shear Strength (PPI) - 121 Fusion Peel (PPI) - 98 Extrusion Peel (PPI) - 78
Tensile Properties (each direction) Strength at Break, lb/in-width (N/mm) Strength at Yield, lb/in-width (N/mm)		ASTM D6693, Type IV Dumbell, 2 ipm		N/A	243 (42) 132 (23)
Breaking Strength, lbf (kN) - 60-mil - 72-mil - 80-mil		ASTM D751 grab method ASTM D4885 (8 by 8 in. sample)		Machine Direction/Cross Machine 360 (1.6) 150 (26.3) 400 (1.8) 170 (29.8) 425 (1.9) 180 (931.5)	N/A
Elongation at Yield, %		G.L. 1.3 in (33 mm)		N/A	13
Elongation at Break, % (sheet)		G.L. 2.0 in (51 mm)		25	700
Elongation at Break,% (fabric)		ASTM D6693 or ASTM D751		25	N/A
Elongation at Break, % (compound)		ASTM D6693 or ASTM D751		800	700
Density, g/cm³	200,000 lb	ASTM D 1505		1	0.94
Strength at Break, lbf/in. (N/mm)		ASTM D6693 or ASTM D751		250 (44)	243 (42)
Strength at Yield, lbf/in. (N/mm)		ASTM D6693 or ASTM D751		No yield due to fabric reinforcement	132 (23)
Tear Resistance, lbf (N)	45,000 lb	ASTM D1004 or ASTM D751		55 (245)	42 (186)
Puncture Resistance, lbf (N)	45,000 lb	ASTM D4833		120 (534)	125 (556)
Puncture Resistance, lbf (N)		FTM 101C, M2031		300 (1334)	Not listed
Linear Dimensional Change, %		ASTM D1204		±1 max	±2
Water Absorption Resistance, mass % top surface only		ASTM D471 166 h @ 158°F		3.0 max	Not listed
Hydrostatic Resistance, lbf/in² (MPa)		ASTM D751 Procedure A		350 (2.4)	Not listed
Resistance to Xenon-arc Weathering (UV, heat, water spray, etc.) 20,160 kJ/m² (8000 hours)		ASTM G155 0.70 W/m2 80 oC B.P.T.		No cracks No loss of strength	No comparable heat aging test listed
Resistance to Heat Aging (oxidation)		ASTM D573 8 weeks at 275 Of		No visible cracks after bending aged specimen around 0.25 in. diameter mandrel	No comparable heat aging test listed
Brittle Point		ASTM D2137		-50°F (-46°C)	Not listed
Resistance to Ozone		ASTM D1149 100 pphm, 168 hours		No visible cracks under 7X magnification	No comparable ozone test listed

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Technical Data Bulletin

CARLISLE'S

REINFORCED GEOTPO

General

Carlisle's GeoTPO is a premium heat-weldable single-ply thermoplastic polyolefin (TPO) sheet designed for geomembrane exposed applications particularly municipal solid waste (MSW) landfill caps. It is ideal as a base for attached (fully adhered) photovoltaic (PV) flexible panels.

GeoTPO with OctaGuard XT™ weathering package technology withstands extreme durability testing intended to simulate exposure to severe climates. (See Extreme Testing section for specific information). GeoTPO membrane is based on advanced polymerization technology that combines the flexibility of ethylene-propylene (EP) rubber with the heat weldability of polypropylene.

Physical properties of the membrane are enhanced by a strong, polyester fabric that is encapsulated between the TPO-based top and bottom plies. The combination of the fabric and TPO plies provide GeoTPO with high breaking strength, tearing strength and puncture resistance. The relatively smooth surface of GeoTPO membrane produces a total surface fusion-weld that creates a consistent, watertight monolithic assembly. The membrane is also environmentally friendly and safe to install.

GeoTPO products are available in white (highly reflective), tan and gray at 60-, 72- and 80-mil nominal thicknesses. Sixteen special colors including Dark Ivy are also available (see color palette on last page). Standard width is 12 feet and custom-size lengths of up to 500 feet are available in one continuous sheet without seams.

Features

- Wide window of weldability
- Outstanding puncture resistance
- Chlorine free with no halogenated flame retardants
- Plasticizer free - does not contain liquid or polymeric plasticizers
- Excellent low-temperature impact resistance
- Excellent chemical resistance to acids and bases
- Exceptional resistance to solar UV, ozone and oxidation
- Low water-vapor permeance and water absorption
- Hot-melt extrusion processed for complete scrim encapsulation
- Warp knitted fabric (non woven) for smooth surface and greater thickness over scrim
- Polyester reinforcing fabric is resistant to degradation by bacteria, mildew and fungi
- GeoTPO is 100% recyclable (refer to Carlisle's Recyclability Statement)

Technical Data Bulletin

Installation

Contact Carlisle for the specific design requirements and installation procedures for this system.

Typical Weights

60-mil - 0.30 lb/ft² (1.46 kg/m²)
72-mil - 0.35 lb/ft² (1.71 kg/m²)
80-mil - 0.40 lb/ft² (1.95 kg/m²)

Carlisle Reinforced GeoTPO
Basic Properties and Characteristics

Physical Property	ASTM D6878 Requirement	60-MIL	72-MIL	80-MIL
Tolerance on nominal thickness, % **- ASTM D751 test method**	+15, -10	± 10	± 10	± 10
Thickness over scrim, in. (mm) **- ASTM D6878 optical method, average of 3 areas**	0.012 min (0.305)	0.024 typical (0.610)	0.030 typical (0.762)	0.034 typical (0.864)
Breaking strength, lbf (kN) **- ASTM D751 grab method** **- ASTM D4885 lbf/in. (kN/m)**	220 (976 N) min none	250 (1.1) min 360 (1.6) typ 150 (26.3) typ	350 (1.6) min 400 (1.8) typ 170 (29.8) typ	350 (1.6) min 425 (1.9) typ 180 (31.5) typ
Elongation break of reinforcement, % **- ASTM D751 grab method** **- ASTM D4885 (8 by 8 in. sample)**	15 min	15 min 25 typ	15 min 25 typ	15 min 25 typ
Tearing strength, lbf (N) **- ASTM D751 proc. B 8 by 8 in.**	55 (245) min	55 (245) min 130 (578) typ	55 (245) min 130 (578) typ	55 (245) min 130 (578) typ
Brittleness point, °F (°C) **- ASTM D2137**	-40 (-40) max	-40 (-40) max -50 (-46) typ	-40 (-40) max -50 (-46) typ	-40 (-40) max -50 (-46) typ
Linear dimensional change, % **- ASTM D1204, 6 hours at 158°F**	± 1 max	± 1 max -0.2 typ	± 1 max -0.2 typ	± 1 max -0.2 typ
Ozone resistance, no cracks 7X **- ASTM D1149, 100 pphm, 168 hrs**	Pass	Pass	Pass	Pass
Water absorption resistance, mass % **- ASTM D471 top surface only 166 hours at 158°F water**	± 3.0 max	3.0 max 1.0 typ	3.0 max 1.0 typ	3.0 max 1.0 typ
Field seam strength, lbf/in. (kN/m) **- ASTM D1876 tested in peel**	No requirement	25 (4.4) min 60 (10.5) typ	40 (7.0) min 65 (11.4) typ	40 (7.0) min 70 (12.3) typ
Water vapor permeance, Perms **- ASTM E96 proc. B**	No requirement	0.10 max 0.05 typ	0.10 max 0.05 typ	0.10 max 0.05 typ
Puncture resistance, lbf (kN) **- FTM 101C, method 2031** **(see supplemental section)**	No requirement	300 (1.3) min 350 (1.6) typ	350 (1.6) min 400 (1.8) typ	400 (1.8) min 450 (2.0) typ
Properties after heat aging **- ASTM D573, 670 hrs at 240°F** **- Breaking strength, % retained** **- Elongation reinf., % retained** **- Tearing strength, % retained** **- Weight change, %**	 90 min 90 min 60 min ± 1.0 max	 90 min 90 min 60 min ± 1.0 max	 90 min 90 min 60 min ± 1.0 max	 90 min 90 min 60 min ± 1.0 max

Extreme Testing For Severe Climates

ASTM Standard D6878 is the material specification for Thermoplastic Polyolefin Based Sheet. It covers material property requirements for TPO sheet and includes initial and aged properties after heat and xenon-arc exposure. As stated in the Scope of the standard, "the tests and property limits used to characterize the sheet are values intended to ensure minimum quality for the intended purpose". Carlisle's goal is to produce TPO that ensures maximum performance for the intended purpose of geomembrane. Maximum performance requires the membrane to far exceed the requirements of ASTM D6878. For severe climates like Miami, FL and Phoenix, AZ, EXTREME testing is required.

Heat Aging to accelerate oxidation rate that roughly doubles for each 18°F (10°C) increase in membrane temperature. Oxidation (reaction with oxygen) is one of the primary chemical degradation mechanisms of polymeric construction materials.

ASTM requirement – 670 hours (about 28 days) at 240°F (116°C)
Carlisle EXTREME test – 8 weeks (56 days) at 275°F (135°C)
Comparable to 32 weeks (224 days) at 240°F or 1024 weeks (20 years) at 185°F for 6 hours per day

- Test specimen is 1 by 4 inch piece of 60-mil membrane, un-backed, placed in circulating hot-air oven
- Criteria – no visible cracks after bending aged test specimen around 0.25-inch-diameter mandrel

Xenon-Arc exposes the membrane samples to the combined affect of ultraviolet, visible and infrared radiation as well as ozone, heat and water spray to greatly accelerate the affects of outdoor weathering. The radiation dose is measured in kilojoules per square meter (kJ/m^2) at 340 nm machine UV wavelength. The irradiance power of the xenon-arc lamp is measured in Watts per square meter (W/m^2).

	ASTM D6878 Requirement	45-MIL	60-MIL	72-MIL	80-MIL
kJ/m^2 at 340 nm	10,080	17,640	20,160	25,200	27,720
Hours at 0.35 W/m^2	8,000	14,000	16,000	20,000	22,000
Hours at 0.70 W/m^2	4,000	7,000	8,000	10,000	11,000
Total UV in MJ/m^2 (300 to 400 nm)	1210	2118	2420	3025	3328

- Test specimen is 2.75 by 5.5 inch piece of membrane, un-backed, weathering side facing arc lamp
- Criteria – no visible cracks viewed under 10X magnification while wrapped around 3-inch-diameter mandrel

Environmental Cycling subjects the membrane to repeated cycles of heat aging, hot-water immersion or acid fog followed by xenon-arc exposure. The acid fog accelerates acid etching that may be caused by acid rain if the membrane is not resistant to acidic conditions.

ASTM requirement – none
Carlisle EXTREME test – one cycle is represented by the series below:

- 10 days heat aging at 240°F (116°C) followed by;
- 5 days water immersion at 158°F (70°C) or with another specimen set;
- 5 eight-hour cycles in Kesternich sulfur dioxide chamber (sulfurous acid fog) followed by;
- 5040 kJ/m^2 (2000 hrs at 0.70 W/m^2 irradiance) xenon-arc exposure
- Test specimen is 2.75 by 5.5 inch piece of membrane with edges sealed
- Criteria – after 3 completed cycles, test specimens shall remain flexible and not have any cracking under 10X magnification while wrapped around a 3-inch-diameter mandrel.

Cautions and Warnings: (GeoTPO White has very high sunlight reflectance)

- Sunglasses that filter out ultraviolet light are strongly recommended as tan and white surfaces are highly reflective to sunlight. Technicians should dress appropriately and wear sunscreen to protect skin from the sun.
- Surfaces may be slippery due to frost and ice buildup. Exercise caution during cold conditions to prevent falls. Membrane may be slippery when wet. Exercise caution when walking on wet membrane.
- Care must be exercised when working close to an edge when surrounding area is snow covered as the edge may not be clearly visible.
- Use proper stacking procedures to ensure sufficient stability of the rolls.
- Store GeoTPO membrane in the original undisturbed plastic wrap in a cool, shaded area and cover with light-colored, breathable, waterproof tarpaulins. GeoTPO membrane that has been exposed to the weather for approximately 7 days or longer must be prepared with Weathered Membrane Cleaner prior to hot-air welding. Rolls should be elevated above the ground so they are not resting directly on soil, vegetation or water ponds.

Technical Data Bulletin

Supplemental Approvals, Statements And Characteristics:

1. GeoTPO meets or exceeds the requirements of **ASTM D6878**[1] Standard Specification for Thermoplastic Polyolefin Based Sheet

2. GeoTPO membranes conform to requirements of the U.S.E.P.A. **Toxic Leachate Test** (40 CFR part 136) performed by an independent analytical laboratory.

3. Reinforced GeoTPO was tested for **dynamic puncture resistance** per ASTM D5635-04 using the most recently modified impact head. 60-mil membrane was watertight after an impact energy of 22.5 J (16.6 ft-lbf). Both 72-mil and 80-mil products were watertight after an impact energy of 30.0 J (22.1 ft-lbf).

[1] Copyright © ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, USA.

GeoTPO Color Pallete

CUMBERLAND GEOSCIENCE CONSULTANTS
A Division of Duffield Associates

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Carlisle, PA 17013-4002
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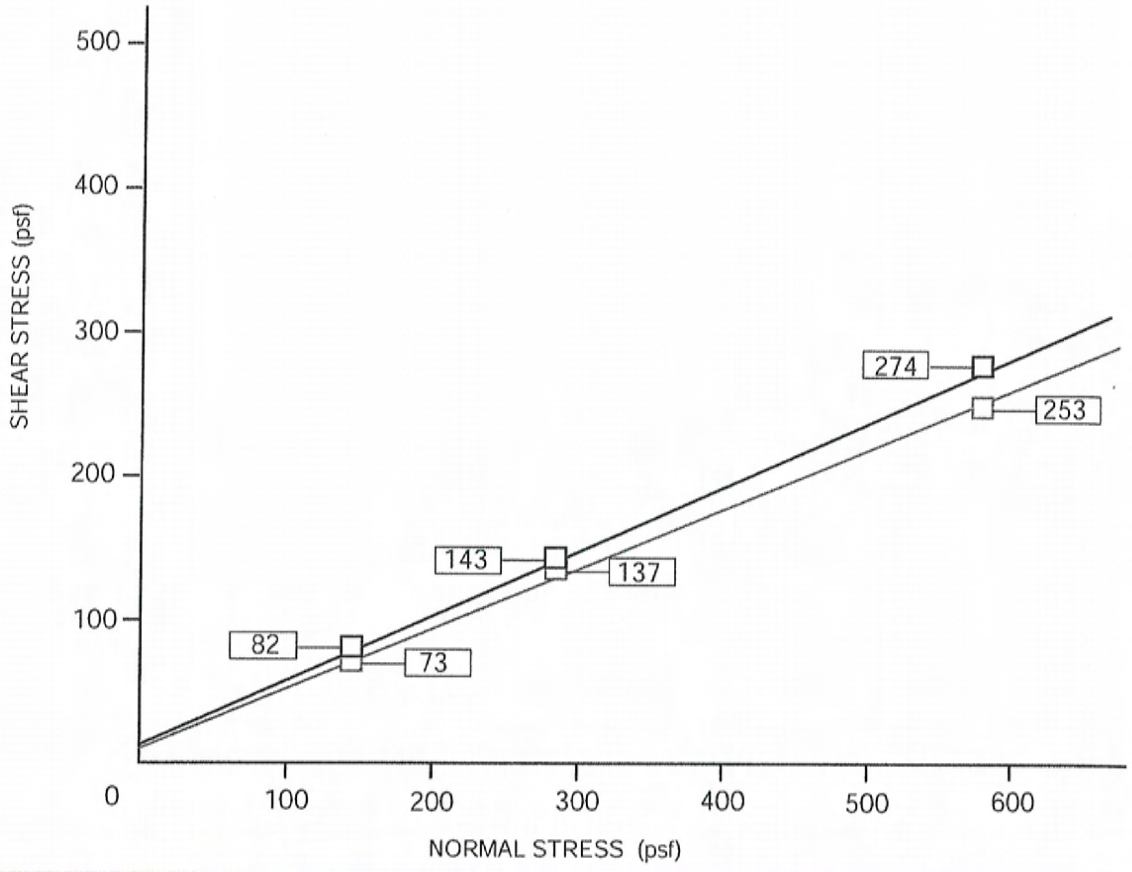
Standard Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method ASTM Test Method D 5321

Test No. 1

Interface Shear: TPO Geomembrane / Skaps 16 oz. Nonwoven Geotextile



TEST RESULTS

Shear Strength	
Peak Friction Angle:	24.0°
Adhesion:	16.5 psf
Residual Friction Angle:	22.5°
Adhesion:	15.0 psf

Project No. 08317.ZA
Carlisle Syntech
TPO Geomembrane Laboratory Testing
Carlsile, Pennsylvania
March 19, 2010

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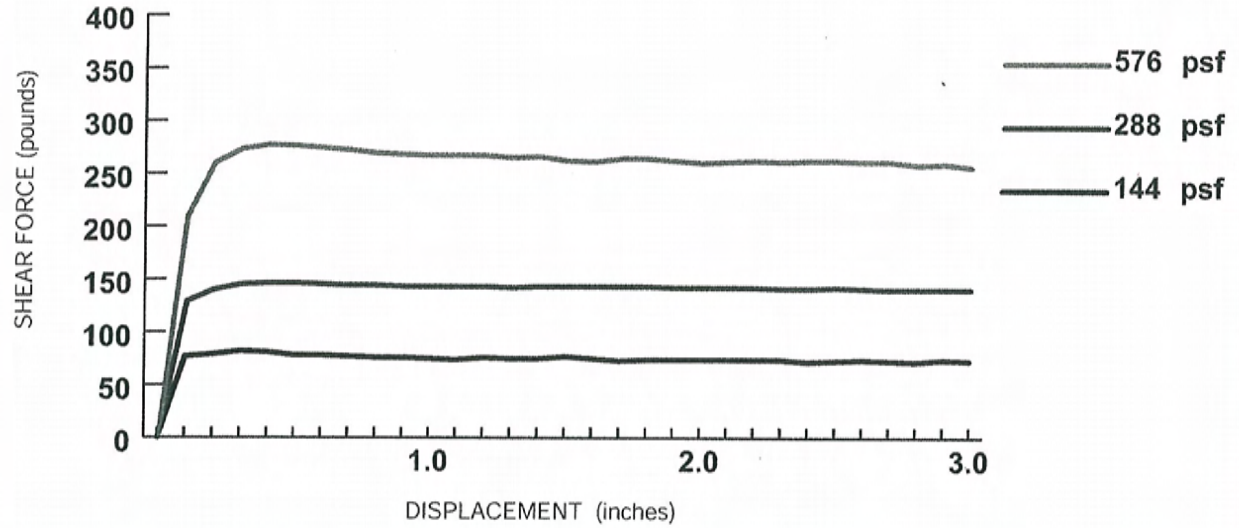


Components in S hear Box

Material	Material Description
Superstrata	Rigid steel support, Normal load
Geomembrane	TPO Geomembrane (Green side up)
Geotextile	Skaps 16 oz. Nonwoven Geotextile (wet)
Substrata	Rigid steel, wood support

Traveling Box (12" x 12" x 3")

Shear P lane

Stationary Box (12"x12" x 3")

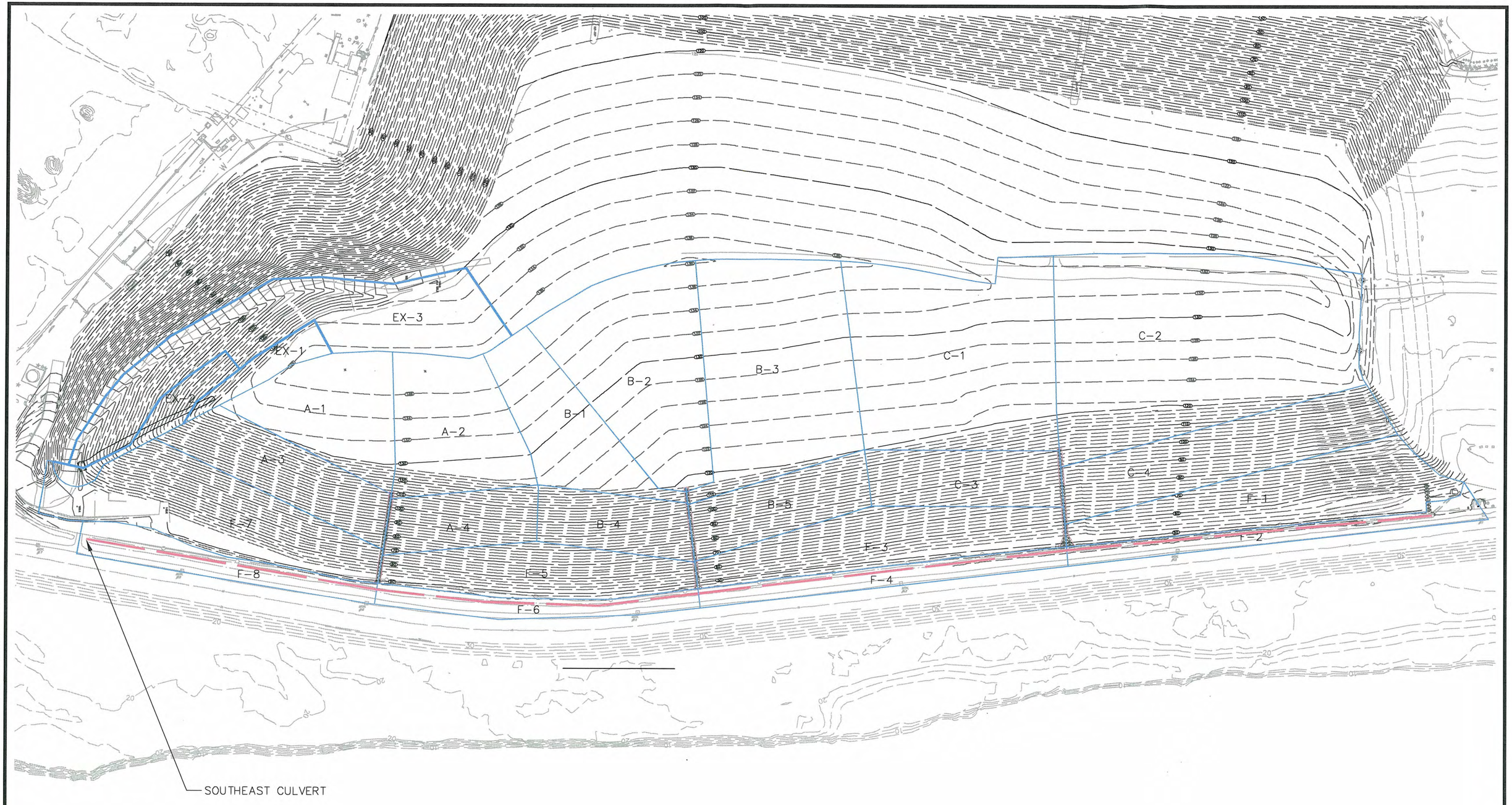
Speed of Displacement = 0.2 inch/minute

Project No. 08317.ZA
Carlisle Syntech
TPO Geomembrane Laboratory Testing
Carlsile, Pennsylvania
March 19, 2010

FUSS & O'NEILL

Appendix C

Closure Turf™ Watershed Analysis



No.	DATE	DESCRIPTION	DESIGNER	REVIEWER
1.			XX/XX	XX

SCALE:
HORZ.: 1" = 200'
VERT.:
DATUM:
HORZ.:
VERT.:
0 100 200
GRAPHIC SCALE

FUSS & O'NEILL
146 HARTFORD ROAD
MANCHESTER, CONNECTICUT 06040
860.646.2469
www.fando.com

CONNECTICUT RESOURCES RECOVERY AUTHORITY

PROPOSED DRAINAGE AREAS CLOSURE TURF ALTERNATIVE

AMENDMENT TO THE
HARTFORD LANDFILL CLOSURE PLAN

HARTFORD CONNECTICUT

PROJ. No.: 2010 0123.H20
DATE: JULY 2011

DRA-10

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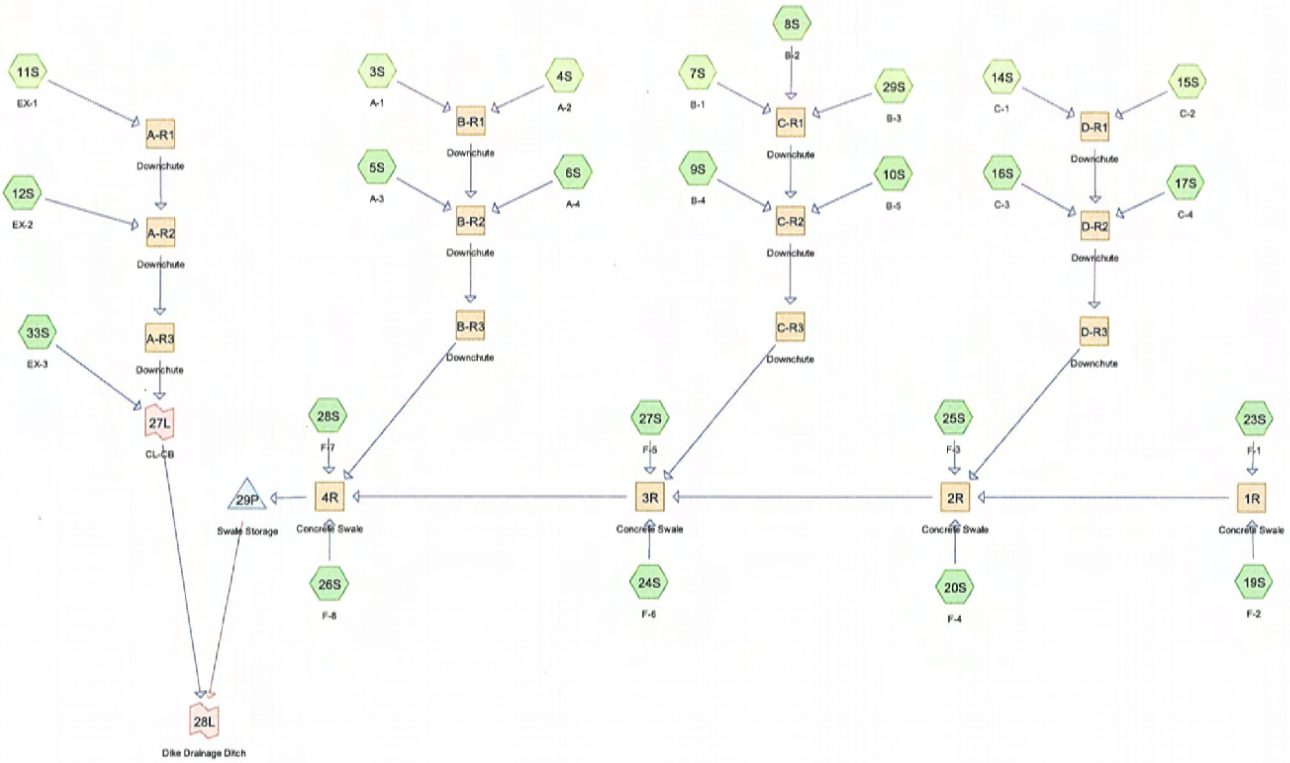


Subcat Reach Pond Link

Drainage Diagram for Proposed_Agru_Turf
Prepared by Fuss & O'Neill Inc., Printed 12/7/2011
HydroCAD® 9.10 s/n 06397 © 2009 HydroCAD Software Solutions LLC

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
3.650	77	Existing Landfill (11S, 12S, 33S)
3.100	89	Gravel roads, HSG C (19S, 20S, 24S, 26S)
35.060	95	AgruTURF (3S, 4S, 5S, 6S, 7S, 8S, 9S, 10S, 14S, 15S, 16S, 17S, 23S, 25S, 27S, 28S, 29S)
41.810		**TOTAL AREA**

Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
0.000	HSG A	
0.000	HSG B	
3.100	HSG C	19S, 20S, 24S, 26S
0.000	HSG D	
38.710	Other	3S, 4S, 5S, 6S, 7S, 8S, 9S, 10S, 11S, 12S, 14S, 15S, 16S, 17S, 23S, 25S, 27S, 28S, 29S, 33S
41.810		**TOTAL AREA**

Time span=0.00-20.00 hrs, dt=0.05 hrs, 401 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 3S: A-1 Runoff Area=1.510 ac 0.00% Impervious Runoff Depth>4.68"
Tc=5.0 min CN=95 Runoff=7.99 cfs 0.589 af

Subcatchment 4S: A-2 Runoff Area=1.730 ac 0.00% Impervious Runoff Depth>4.68"
Tc=5.0 min CN=95 Runoff=9.16 cfs 0.674 af

Subcatchment 5S: A-3 Runoff Area=1.310 ac 0.00% Impervious Runoff Depth>4.68"
Tc=5.0 min CN=95 Runoff=6.94 cfs 0.511 af

Subcatchment 6S: A-4 Runoff Area=0.880 ac 0.00% Impervious Runoff Depth>4.68"
Tc=5.0 min CN=95 Runoff=4.66 cfs 0.343 af

Subcatchment 7S: B-1 Runoff Area=1.430 ac 0.00% Impervious Runoff Depth>4.68"
Tc=5.0 min CN=95 Runoff=7.57 cfs 0.557 af

Subcatchment 8S: B-2 Runoff Area=2.730 ac 0.00% Impervious Runoff Depth>4.68"
Tc=5.0 min CN=95 Runoff=14.45 cfs 1.064 af

Subcatchment 9S: B-4 Runoff Area=0.920 ac 0.00% Impervious Runoff Depth>4.68"
Tc=5.0 min CN=95 Runoff=4.87 cfs 0.359 af

Subcatchment 10S: B-5 Runoff Area=1.090 ac 0.00% Impervious Runoff Depth>4.68"
Tc=5.0 min CN=95 Runoff=5.77 cfs 0.425 af

Subcatchment 11S: EX-1 Runoff Area=0.380 ac 0.00% Impervious Runoff Depth>2.84"
Tc=5.0 min CN=77 Runoff=1.36 cfs 0.090 af

Subcatchment 12S: EX-2 Runoff Area=0.440 ac 0.00% Impervious Runoff Depth>2.84"
Tc=5.0 min CN=77 Runoff=1.57 cfs 0.104 af

Subcatchment 14S: C-1 Runoff Area=3.880 ac 0.00% Impervious Runoff Depth>4.68"
Tc=5.0 min CN=95 Runoff=20.54 cfs 1.512 af

Subcatchment 15S: C-2 Runoff Area=5.420 ac 0.00% Impervious Runoff Depth>4.68"
Tc=5.0 min CN=95 Runoff=28.69 cfs 2.112 af

Subcatchment 16S: C-3 Runoff Area=1.130 ac 0.00% Impervious Runoff Depth>4.68"
Tc=5.0 min CN=95 Runoff=5.98 cfs 0.440 af

Subcatchment 17S: C-4 Runoff Area=1.950 ac 0.00% Impervious Runoff Depth>4.68"
Tc=5.0 min CN=95 Runoff=10.32 cfs 0.760 af

Subcatchment 19S: F-2 Runoff Area=0.790 ac 0.00% Impervious Runoff Depth>4.02"
Tc=5.0 min CN=89 Runoff=3.82 cfs 0.265 af

Subcatchment 20S: F-4 Runoff Area=0.790 ac 0.00% Impervious Runoff Depth>4.02"
Tc=5.0 min CN=89 Runoff=3.82 cfs 0.265 af

Subcatchment 23S: F-1 Runoff Area=2.100 ac 0.00% Impervious Runoff Depth>4.68"
Tc=5.0 min CN=95 Runoff=11.12 cfs 0.818 af

Subcatchment 24S: F-6 Runoff Area=0.670 ac 0.00% Impervious Runoff Depth>4.02"
Tc=5.0 min CN=89 Runoff=3.24 cfs 0.225 af

Subcatchment 25S: F-3 Runoff Area=1.840 ac 0.00% Impervious Runoff Depth>4.68"
Tc=5.0 min CN=95 Runoff=9.74 cfs 0.717 af

Subcatchment 26S: F-8 Runoff Area=0.850 ac 0.00% Impervious Runoff Depth>4.02"
Tc=5.0 min CN=89 Runoff=4.11 cfs 0.285 af

Subcatchment 27S: F-5 Runoff Area=1.470 ac 0.00% Impervious Runoff Depth>4.68"
Tc=5.0 min CN=95 Runoff=7.78 cfs 0.573 af

Subcatchment 28S: F-7 Runoff Area=2.280 ac 0.00% Impervious Runoff Depth>4.68"
Tc=5.0 min CN=95 Runoff=12.07 cfs 0.889 af

Subcatchment 29S: B-3 Runoff Area=3.390 ac 0.00% Impervious Runoff Depth>4.68"
Tc=5.0 min CN=95 Runoff=17.95 cfs 1.321 af

Subcatchment 33S: EX-3 Runoff Area=2.830 ac 0.00% Impervious Runoff Depth>2.84"
Tc=5.0 min CN=77 Runoff=10.12 cfs 0.670 af

Reach 1R: Concrete Swale Avg. Flow Depth=0.60' Max Vel=3.45 fps Inflow=14.94 cfs 1.083 af
n=0.013 L=785.0' S=0.0031 '/' Capacity=785.22 cfs Outflow=13.02 cfs 1.078 af

Reach 2R: Concrete Swale Avg. Flow Depth=1.78' Max Vel=4.06 fps Inflow=86.81 cfs 6.883 af
n=0.013 L=806.0' S=0.0011 '/' Capacity=456.44 cfs Outflow=79.46 cfs 6.856 af

Reach 3R: Concrete Swale Avg. Flow Depth=2.16' Max Vel=4.58 fps Inflow=123.31 cfs 11.378 af
n=0.013 L=673.0' S=0.0010 '/' Capacity=453.30 cfs Outflow=120.14 cfs 11.346 af

Reach 4R: Concrete Swale Avg. Flow Depth=2.49' Max Vel=4.40 fps Inflow=145.22 cfs 14.635 af
n=0.013 L=628.0' S=0.0008 '/' Capacity=396.60 cfs Outflow=142.75 cfs 14.595 af

Reach A-R1: Downchute Avg. Flow Depth=0.03' Max Vel=4.17 fps Inflow=1.36 cfs 0.090 af
n=0.017 L=101.0' S=0.2178 '/' Capacity=881.84 cfs Outflow=1.35 cfs 0.090 af

Reach A-R2: Downchute Avg. Flow Depth=0.05' Max Vel=5.77 fps Inflow=2.91 cfs 0.194 af
n=0.017 L=157.0' S=0.2357 '/' Capacity=917.26 cfs Outflow=2.87 cfs 0.194 af

Reach A-R3: Downchute Avg. Flow Depth=0.05' Max Vel=5.98 fps Inflow=2.87 cfs 0.194 af
n=0.017 L=48.0' S=0.2708 '/' Capacity=983.31 cfs Outflow=2.86 cfs 0.194 af

Reach B-R1: Downchute Avg. Flow Depth=0.18' Max Vel=8.84 fps Inflow=17.15 cfs 1.263 af
n=0.030 L=67.0' S=0.3284 '/' Capacity=613.54 cfs Outflow=17.00 cfs 1.263 af

Reach B-R2: Downchute Avg. Flow Depth=0.25' Max Vel=10.81 fps Inflow=28.59 cfs 2.116 af
n=0.030 L=121.8' S=0.3366 '/' Capacity=621.21 cfs Outflow=28.22 cfs 2.115 af

Reach B-R3: Downchute Avg. Flow Depth=0.25' Max Vel=10.78 fps Inflow=28.22 cfs 2.115 af
n=0.030 L=42.0' S=0.3333 '/' Capacity=618.17 cfs Outflow=28.16 cfs 2.115 af

Reach C-R1: Downchute Avg. Flow Depth=0.31' Max Vel=12.17 fps Inflow=39.97 cfs 2.943 af
n=0.030 L=67.0' S=0.3284 '/' Capacity=613.54 cfs Outflow=39.70 cfs 2.942 af

Reach C-R2: Downchute Avg. Flow Depth=0.35' Max Vel=13.34 fps Inflow=50.34 cfs 3.726 af
n=0.030 L=121.8' S=0.3366 '/' Capacity=621.21 cfs Outflow=49.75 cfs 3.725 af

Reach C-R3: Downchute Avg. Flow Depth=0.35' Max Vel=13.30 fps Inflow=49.75 cfs 3.725 af
n=0.030 L=42.0' S=0.3333 '/' Capacity=618.17 cfs Outflow=49.67 cfs 3.724 af

Reach D-R1: Downchute Avg. Flow Depth=0.35' Max Vel=13.15 fps Inflow=49.24 cfs 3.625 af
n=0.030 L=67.0' S=0.3284 '/' Capacity=613.54 cfs Outflow=48.93 cfs 3.624 af

Reach D-R2: Downchute Avg. Flow Depth=0.41' Max Vel=14.65 fps Inflow=65.23 cfs 4.825 af
n=0.030 L=121.8' S=0.3366 '/' Capacity=621.21 cfs Outflow=64.47 cfs 4.824 af

Reach D-R3: Downchute Avg. Flow Depth=0.41' Max Vel=14.62 fps Inflow=64.47 cfs 4.824 af
n=0.030 L=42.0' S=0.3333 '/' Capacity=618.17 cfs Outflow=64.38 cfs 4.823 af

Pond 29P: Swale Storage Peak Elev=45.20' Storage=0.975 af Inflow=142.75 cfs 14.595 af
Primary=121.51 cfs 14.581 af Secondary=0.00 cfs 0.000 af Outflow=121.51 cfs 14.581 af

Link 27L: CL-CB Inflow=12.91 cfs 0.864 af
Primary=12.91 cfs 0.864 af

Link 28L: Dike Drainage Ditch Inflow=126.38 cfs 15.446 af
Primary=126.38 cfs 15.446 af

Total Runoff Area = 41.810 ac Runoff Volume = 15.568 af Average Runoff Depth = 4.47"
100.00% Pervious = 41.810 ac 0.00% Impervious = 0.000 ac

Summary for Subcatchment 3S: A-1

[49] Hint: Tc<2dt may require smaller dt

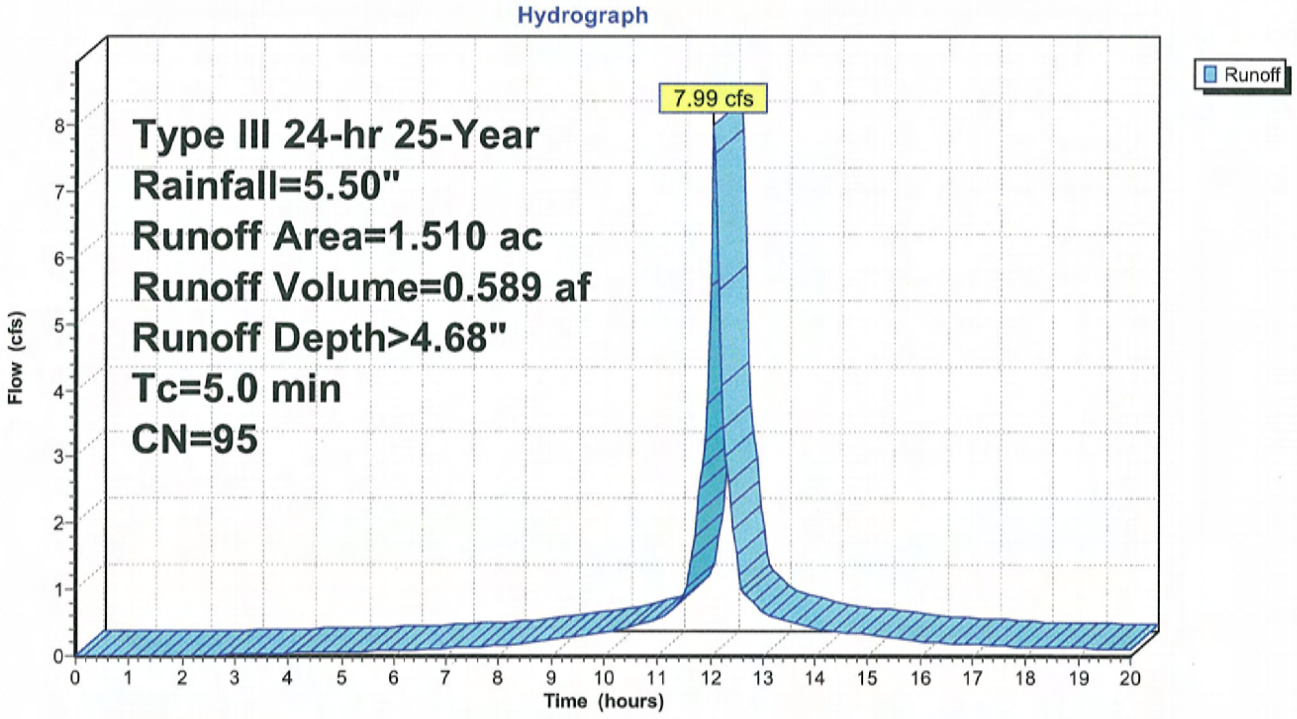
Runoff = 7.99 cfs @ 12.07 hrs, Volume= 0.589 af, Depth> 4.68"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=5.50"

	Area (ac)	CN	Description
*	1.510	95	AgruTURF
	1.510		100.00% Pervious Area

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

Subcatchment 3S: A-1



Summary for Subcatchment 4S: A-2

[49] Hint: Tc<2dt may require smaller dt

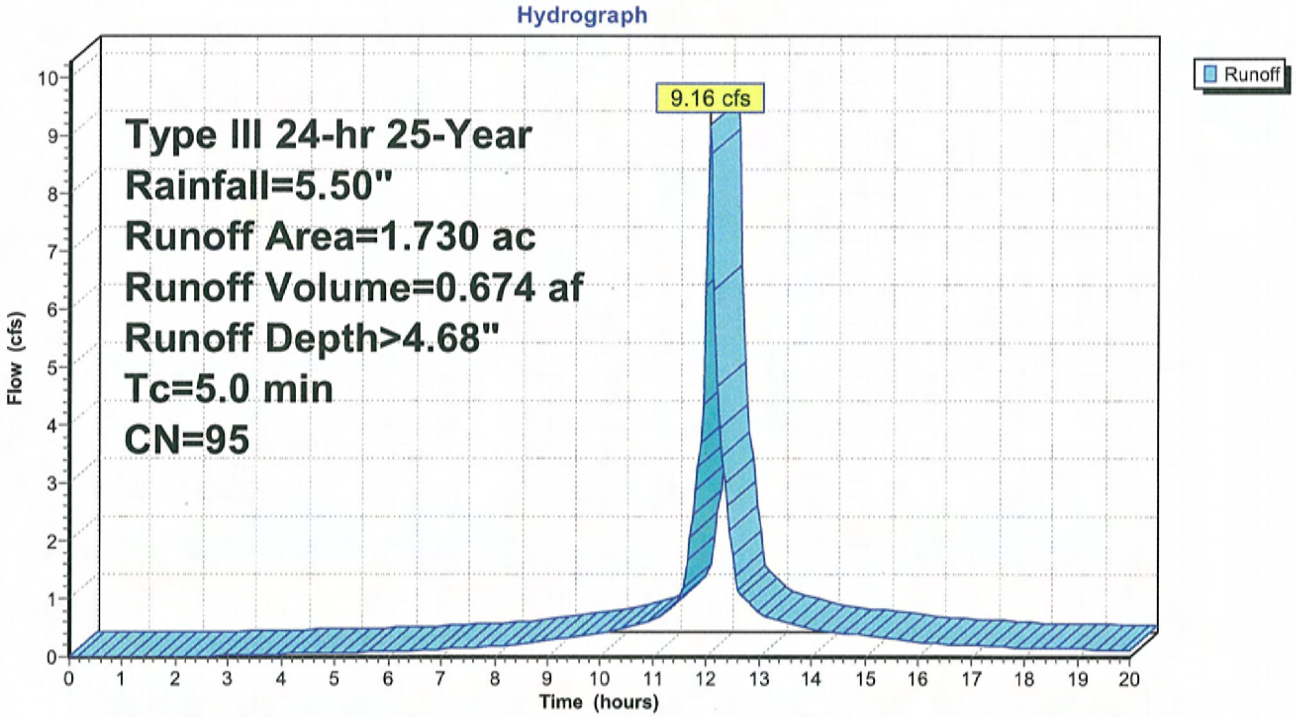
Runoff = 9.16 cfs @ 12.07 hrs, Volume= 0.674 af, Depth> 4.68"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=5.50"

	Area (ac)	CN	Description
*	1.730	95	AgruTURF
	1.730		100.00% Pervious Area

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

Subcatchment 4S: A-2



Summary for Subcatchment 5S: A-3

[49] Hint: Tc<2dt may require smaller dt

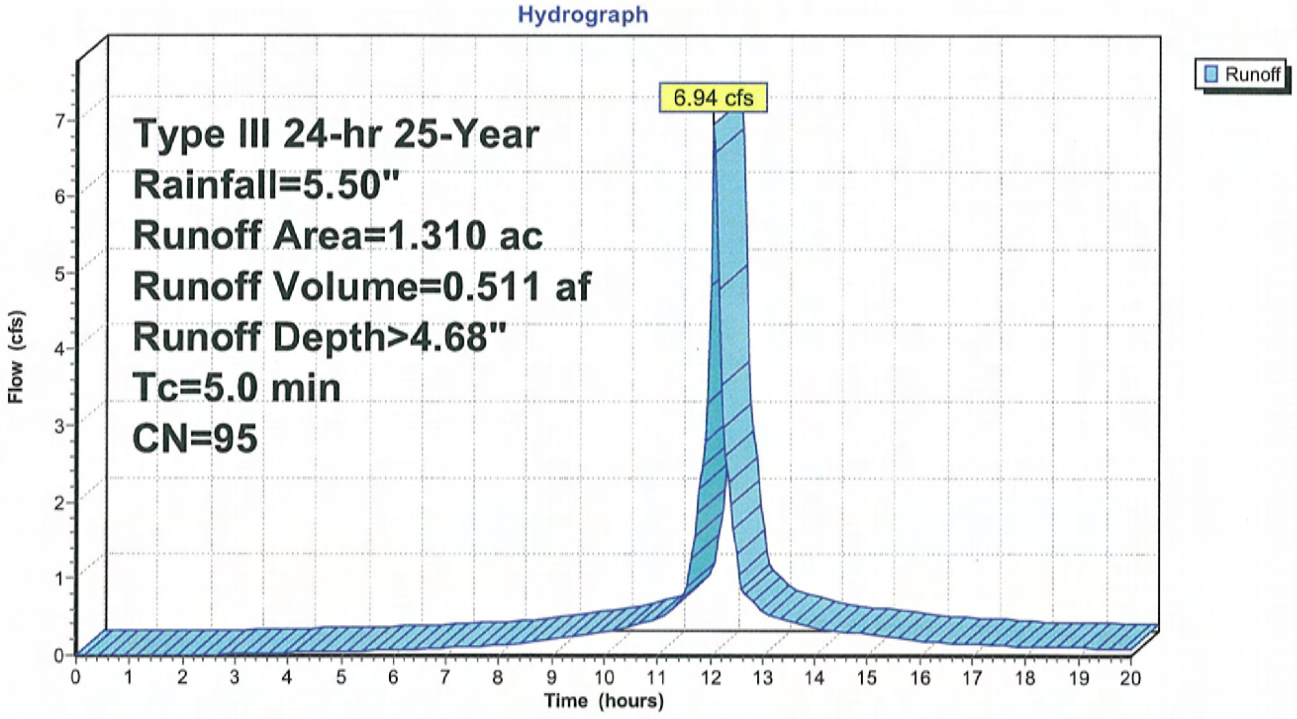
Runoff = 6.94 cfs @ 12.07 hrs, Volume= 0.511 af, Depth> 4.68"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=5.50"

	Area (ac)	CN	Description
*	1.310	95	AgruTURF
	1.310		100.00% Pervious Area

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

Subcatchment 5S: A-3



Summary for Subcatchment 6S: A-4

[49] Hint: Tc<2dt may require smaller dt

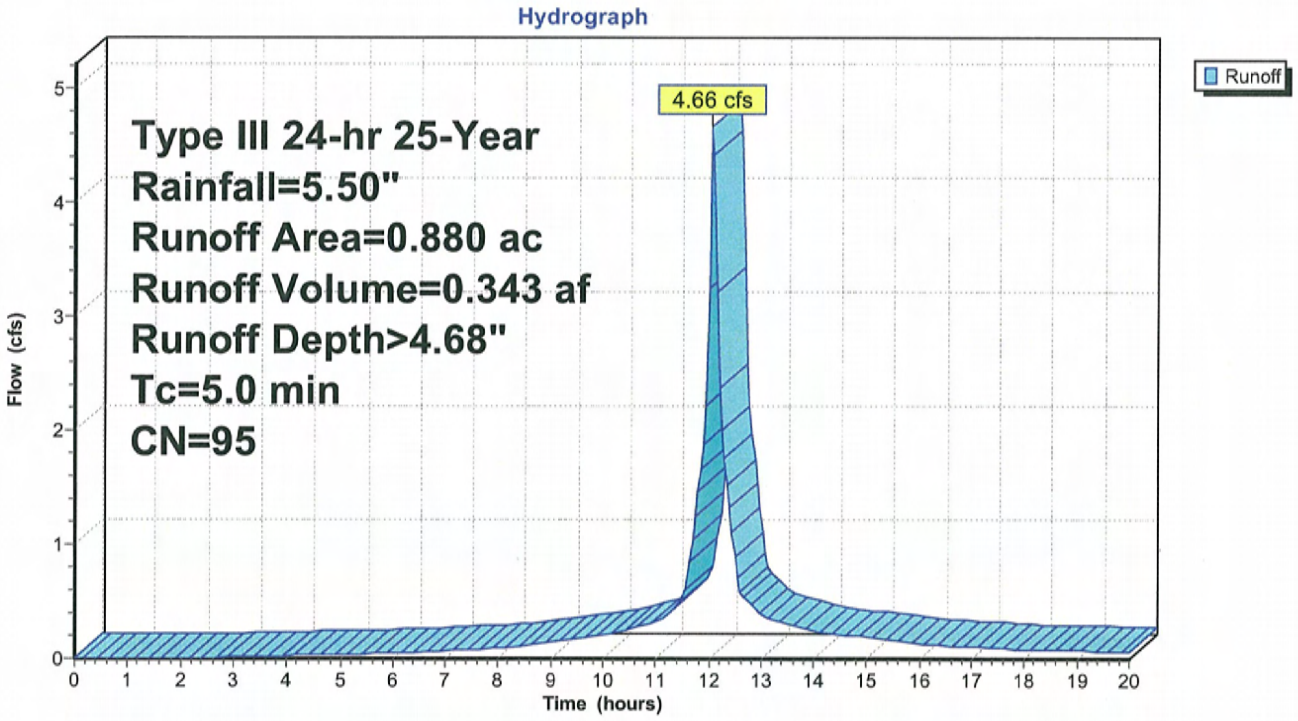
Runoff = 4.66 cfs @ 12.07 hrs, Volume= 0.343 af, Depth> 4.68"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=5.50"

	Area (ac)	CN	Description
*	0.880	95	AgruTURF
	0.880		100.00% Pervious Area

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

Subcatchment 6S: A-4



Summary for Subcatchment 7S: B-1

[49] Hint: Tc<2dt may require smaller dt

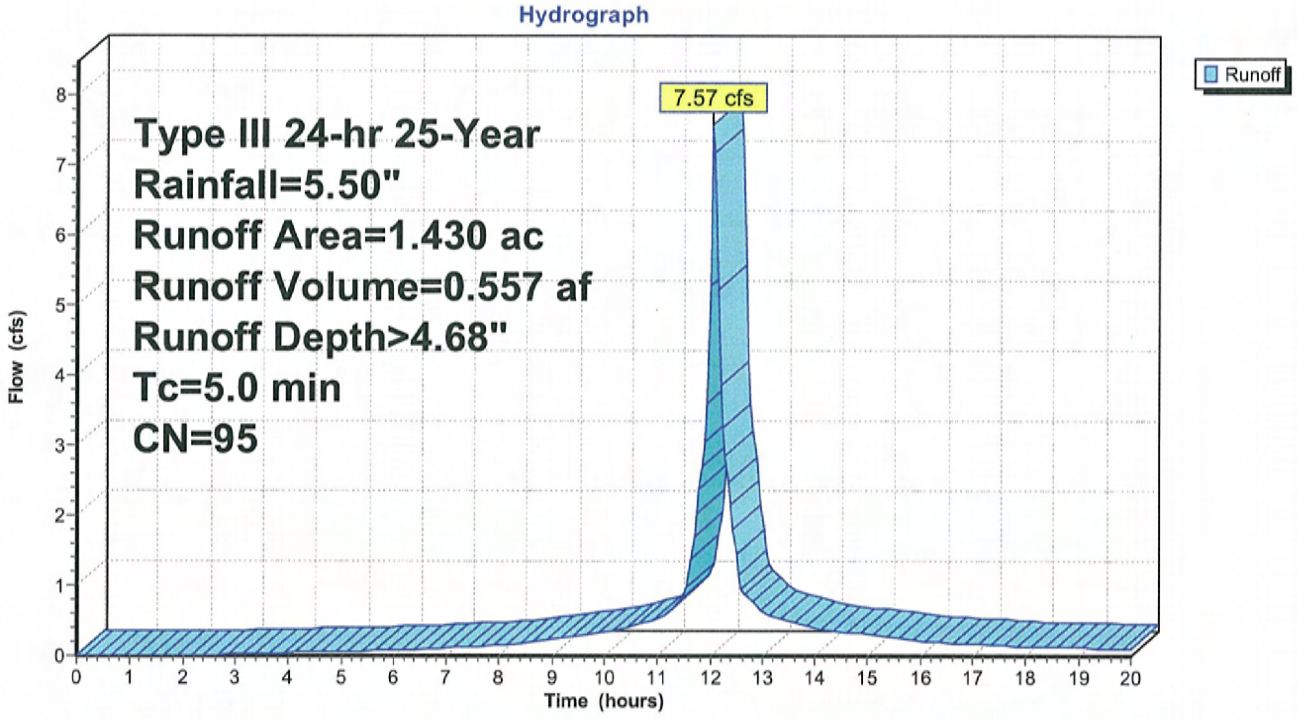
Runoff = 7.57 cfs @ 12.07 hrs, Volume= 0.557 af, Depth> 4.68"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=5.50"

	Area (ac)	CN	Description
*	1.430	95	AgruTURF
	1.430		100.00% Pervious Area

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

Subcatchment 7S: B-1



Summary for Subcatchment 8S: B-2

[49] Hint: Tc<2dt may require smaller dt

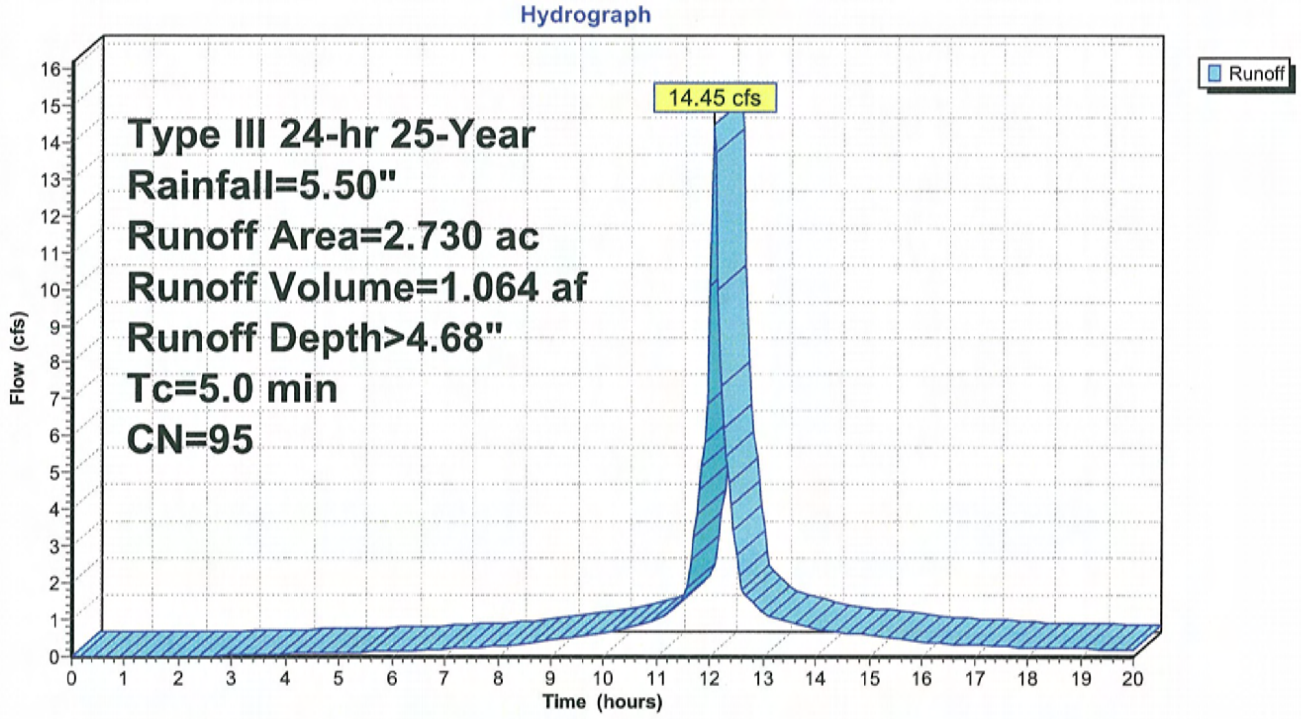
Runoff = 14.45 cfs @ 12.07 hrs, Volume= 1.064 af, Depth> 4.68"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=5.50"

	Area (ac)	CN	Description
*	2.730	95	AgruTURF
	2.730		100.00% Pervious Area

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

Subcatchment 8S: B-2



Summary for Subcatchment 9S: B-4

[49] Hint: Tc<2dt may require smaller dt

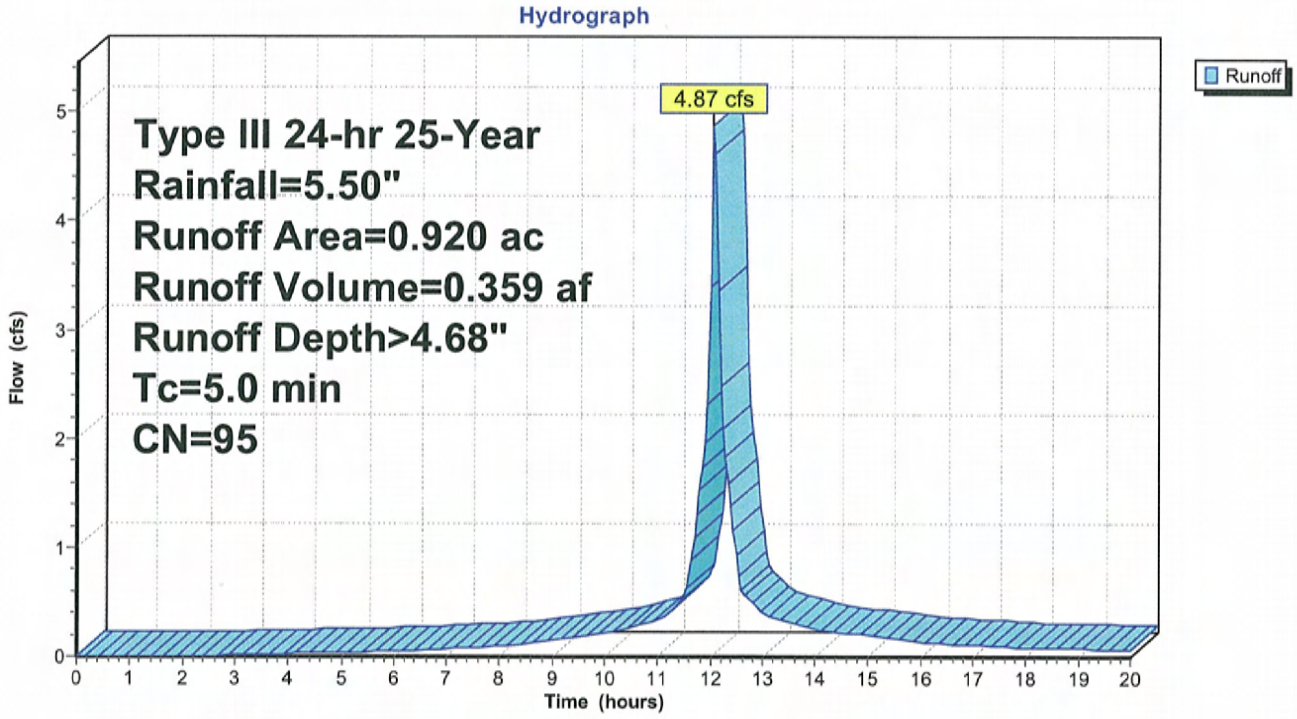
Runoff = 4.87 cfs @ 12.07 hrs, Volume= 0.359 af, Depth> 4.68"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=5.50"

	Area (ac)	CN	Description
*	0.920	95	AgruTURF
	0.920		100.00% Pervious Area

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

Subcatchment 9S: B-4



Summary for Subcatchment 10S: B-5

[49] Hint: Tc<2dt may require smaller dt

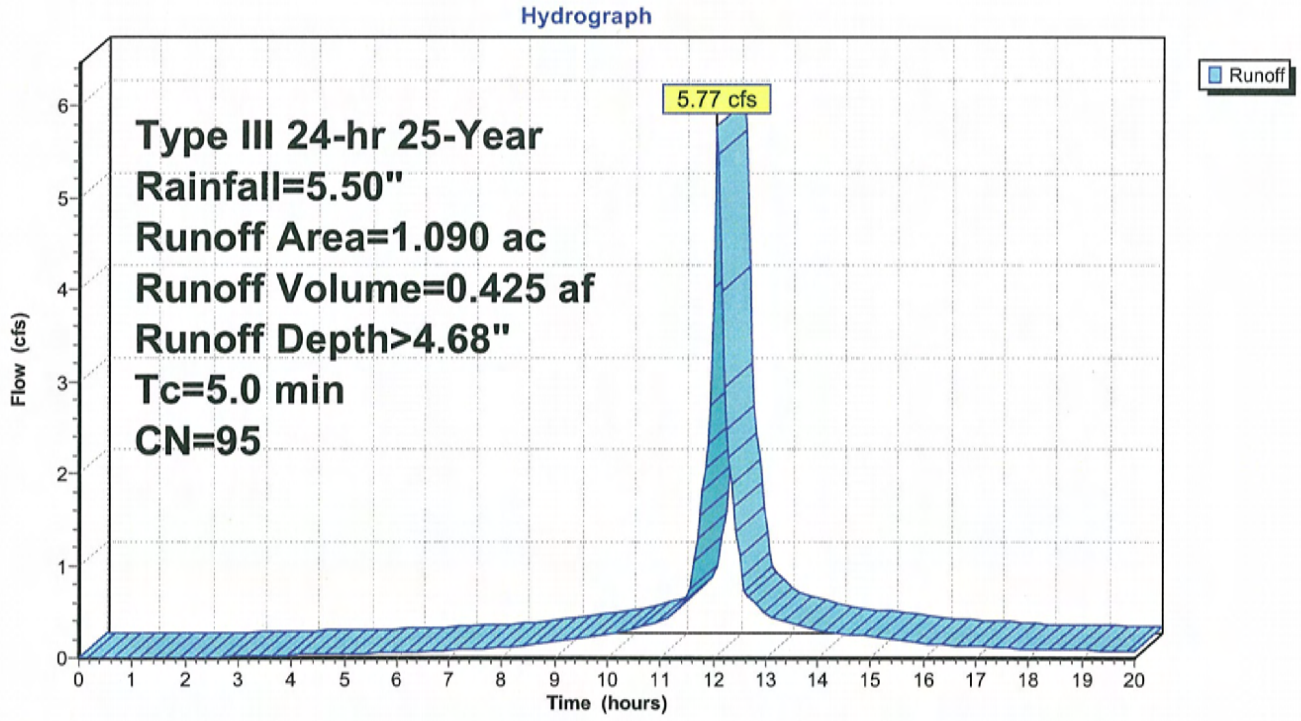
Runoff = 5.77 cfs @ 12.07 hrs, Volume= 0.425 af, Depth> 4.68"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=5.50"

	Area (ac)	CN	Description
*	1.090	95	AgruTURF
	1.090		100.00% Pervious Area

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

Subcatchment 10S: B-5



Summary for Subcatchment 11S: EX-1

[49] Hint: Tc<2dt may require smaller dt

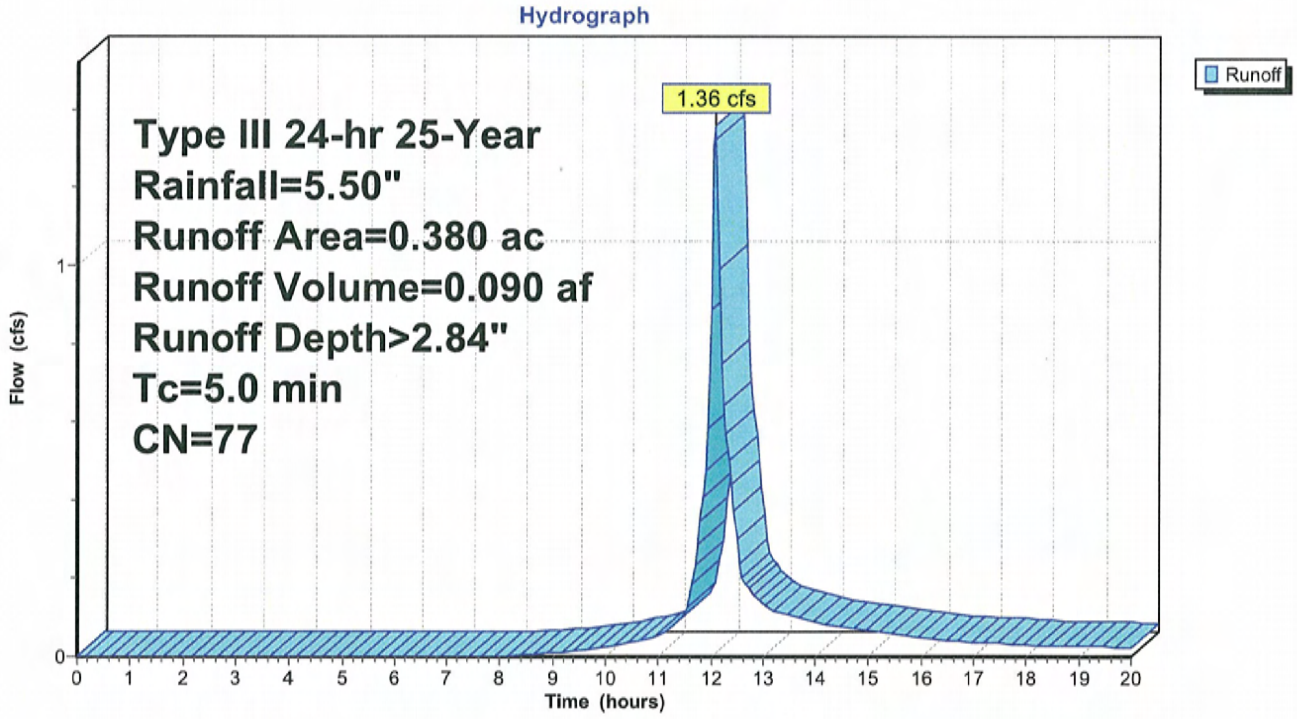
Runoff = 1.36 cfs @ 12.08 hrs, Volume= 0.090 af, Depth> 2.84"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=5.50"

	Area (ac)	CN	Description
*	0.380	77	Existing Landfill
	0.380		100.00% Pervious Area

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

Subcatchment 11S: EX-1



Summary for Subcatchment 12S: EX-2

[49] Hint: Tc<2dt may require smaller dt

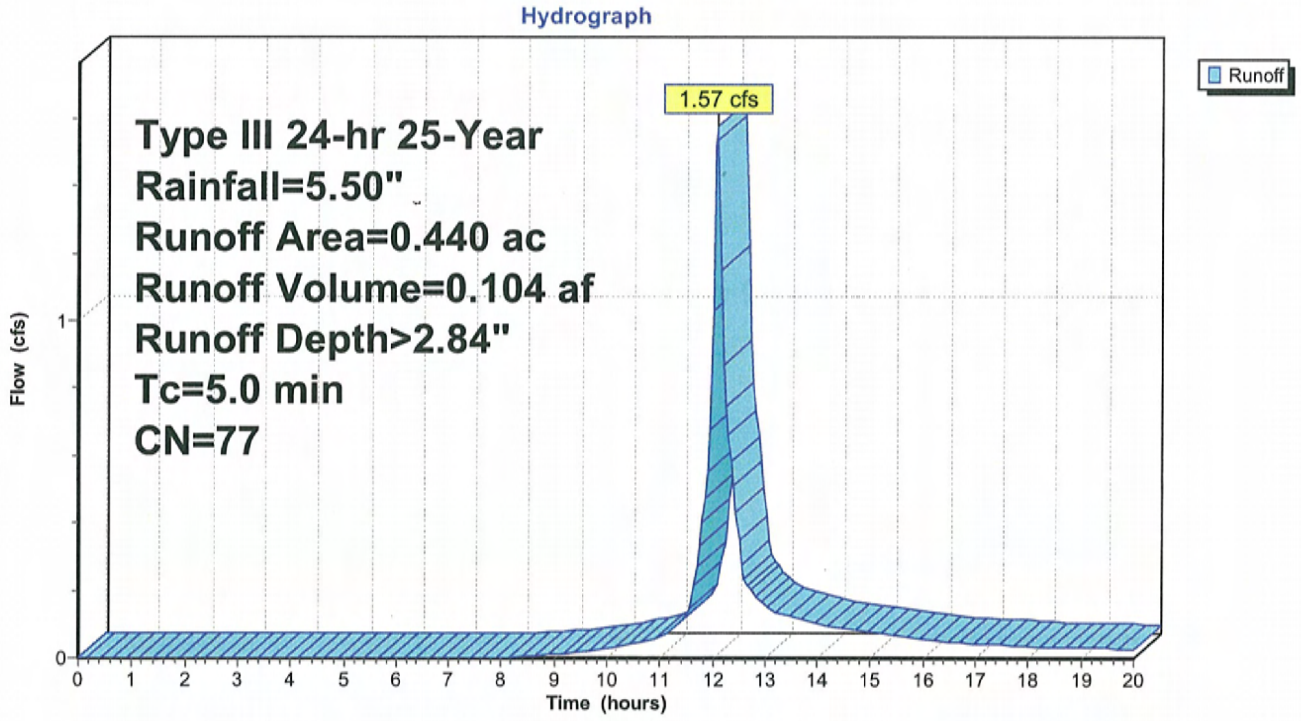
Runoff = 1.57 cfs @ 12.08 hrs, Volume= 0.104 af, Depth> 2.84"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=5.50"

	Area (ac)	CN	Description
*	0.440	77	Existing Landfill
	0.440		100.00% Pervious Area

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

Subcatchment 12S: EX-2



Summary for Subcatchment 14S: C-1

[49] Hint: Tc<2dt may require smaller dt

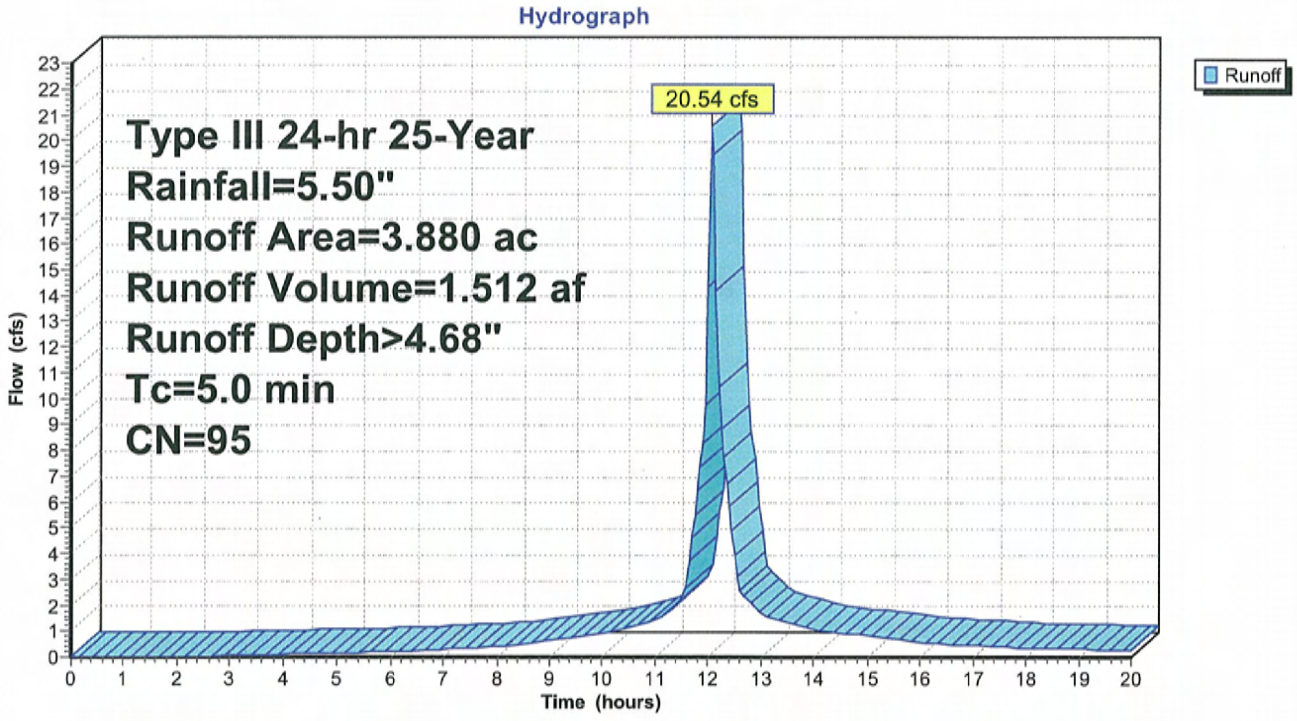
Runoff = 20.54 cfs @ 12.07 hrs, Volume= 1.512 af, Depth> 4.68"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=5.50"

	Area (ac)	CN	Description
*	3.880	95	AgruTURF
	3.880		100.00% Pervious Area

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

Subcatchment 14S: C-1



Summary for Subcatchment 15S: C-2

[49] Hint: Tc<2dt may require smaller dt

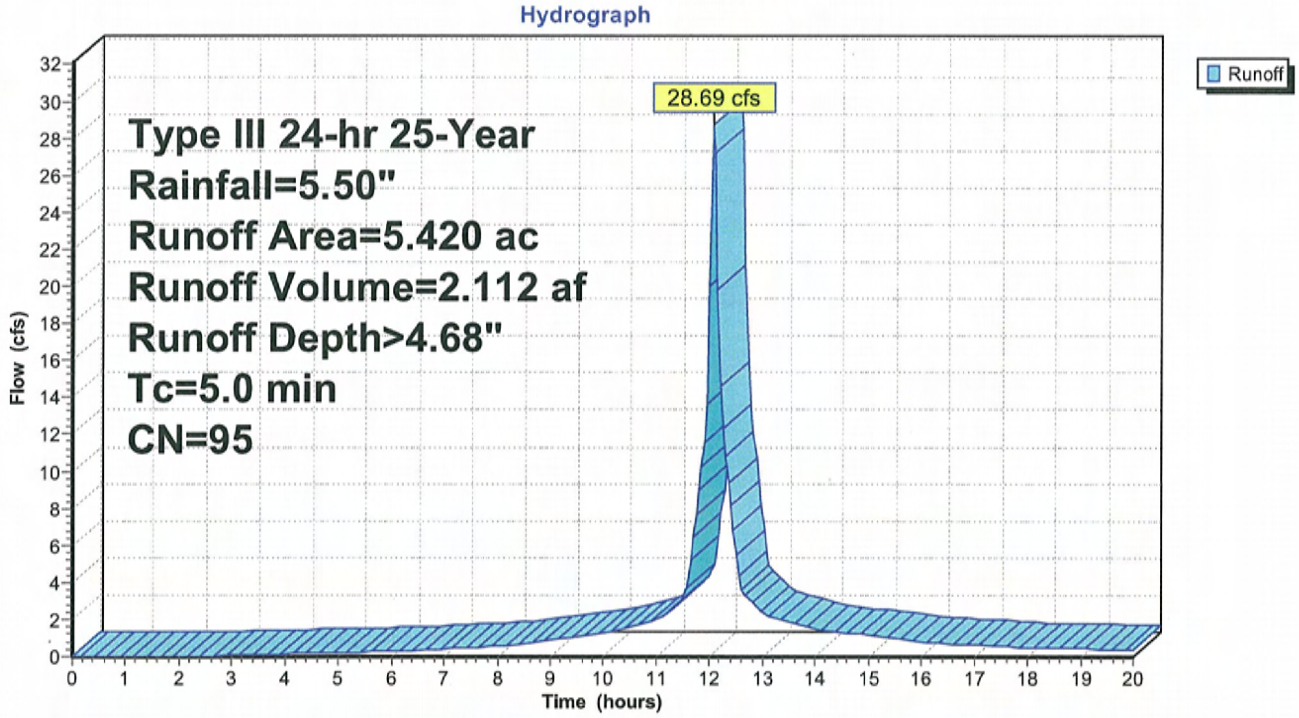
Runoff = 28.69 cfs @ 12.07 hrs, Volume= 2.112 af, Depth> 4.68"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=5.50"

	Area (ac)	CN	Description
*	5.420	95	AgruTURF
	5.420		100.00% Pervious Area

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

Subcatchment 15S: C-2



Summary for Subcatchment 16S: C-3

[49] Hint: Tc<2dt may require smaller dt

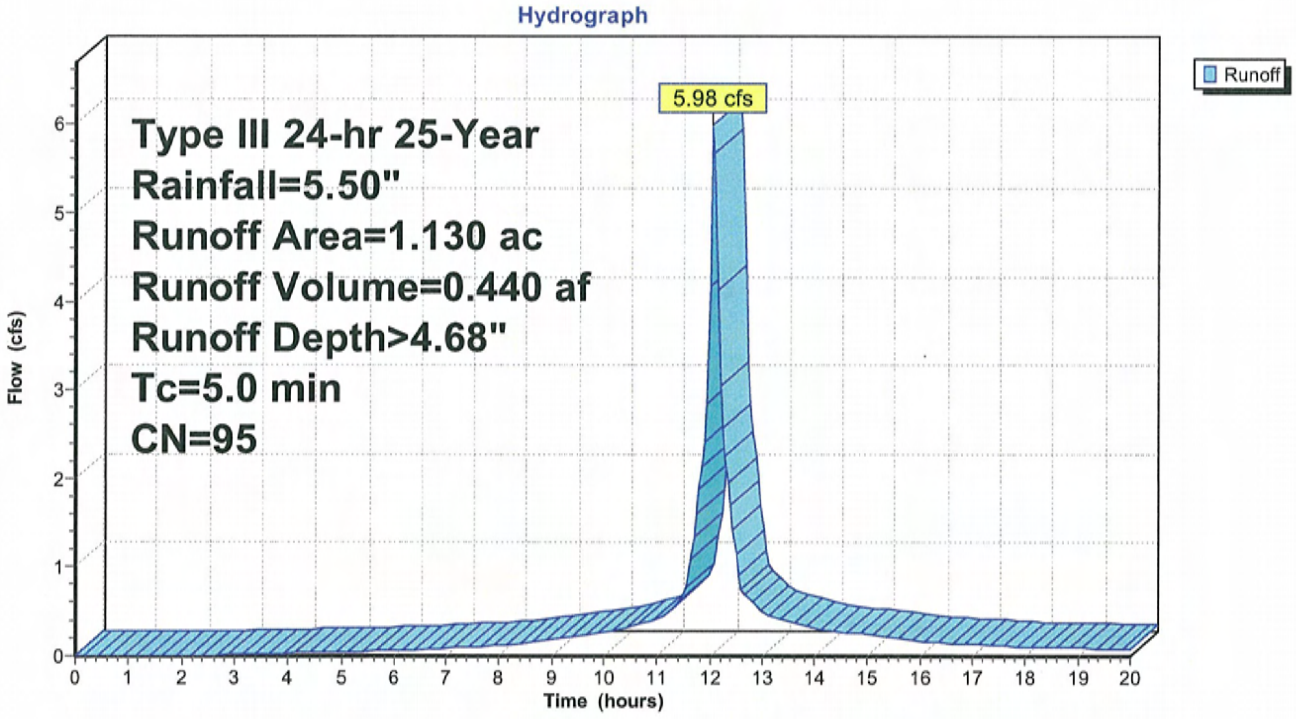
Runoff = 5.98 cfs @ 12.07 hrs, Volume= 0.440 af, Depth> 4.68"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=5.50"

	Area (ac)	CN	Description
*	1.130	95	AgruTURF
	1.130		100.00% Pervious Area

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

Subcatchment 16S: C-3



Summary for Subcatchment 17S: C-4

[49] Hint: Tc<2dt may require smaller dt

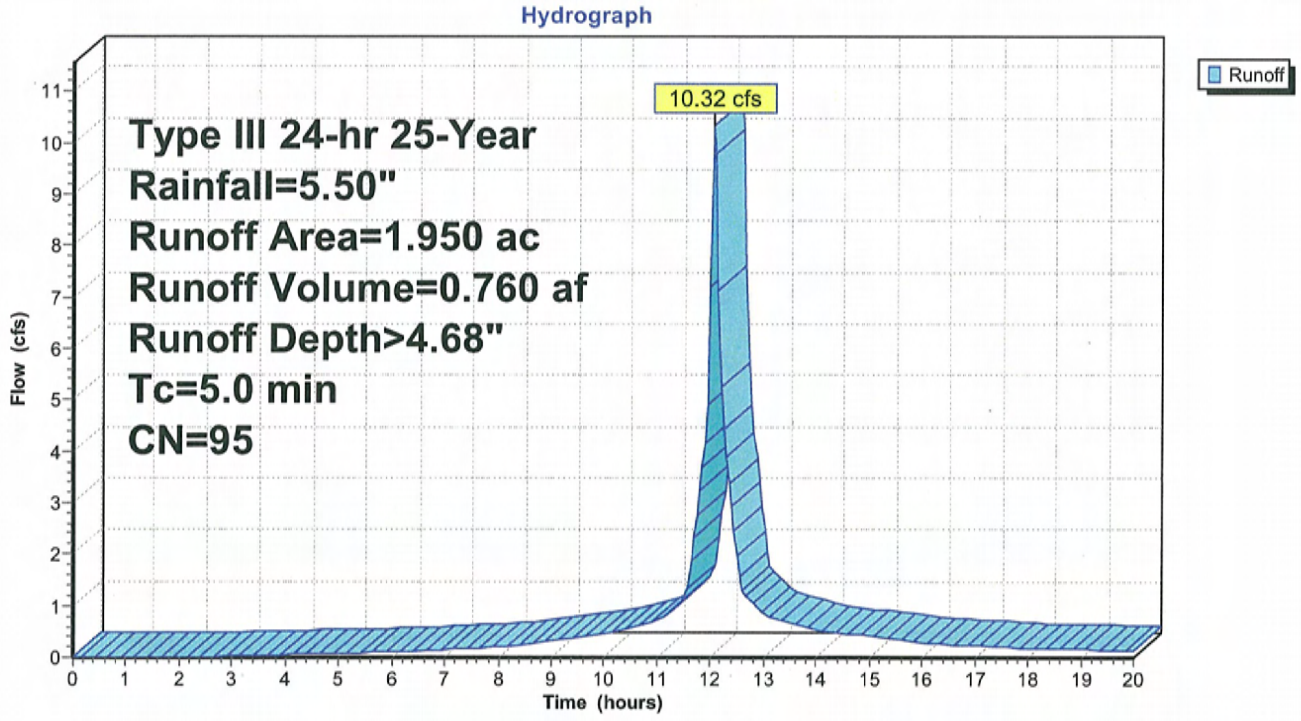
Runoff = 10.32 cfs @ 12.07 hrs, Volume= 0.760 af, Depth> 4.68"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=5.50"

	Area (ac)	CN	Description
*	1.950	95	AgruTURF
	1.950		100.00% Pervious Area

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

Subcatchment 17S: C-4



Summary for Subcatchment 19S: F-2

[49] Hint: Tc<2dt may require smaller dt

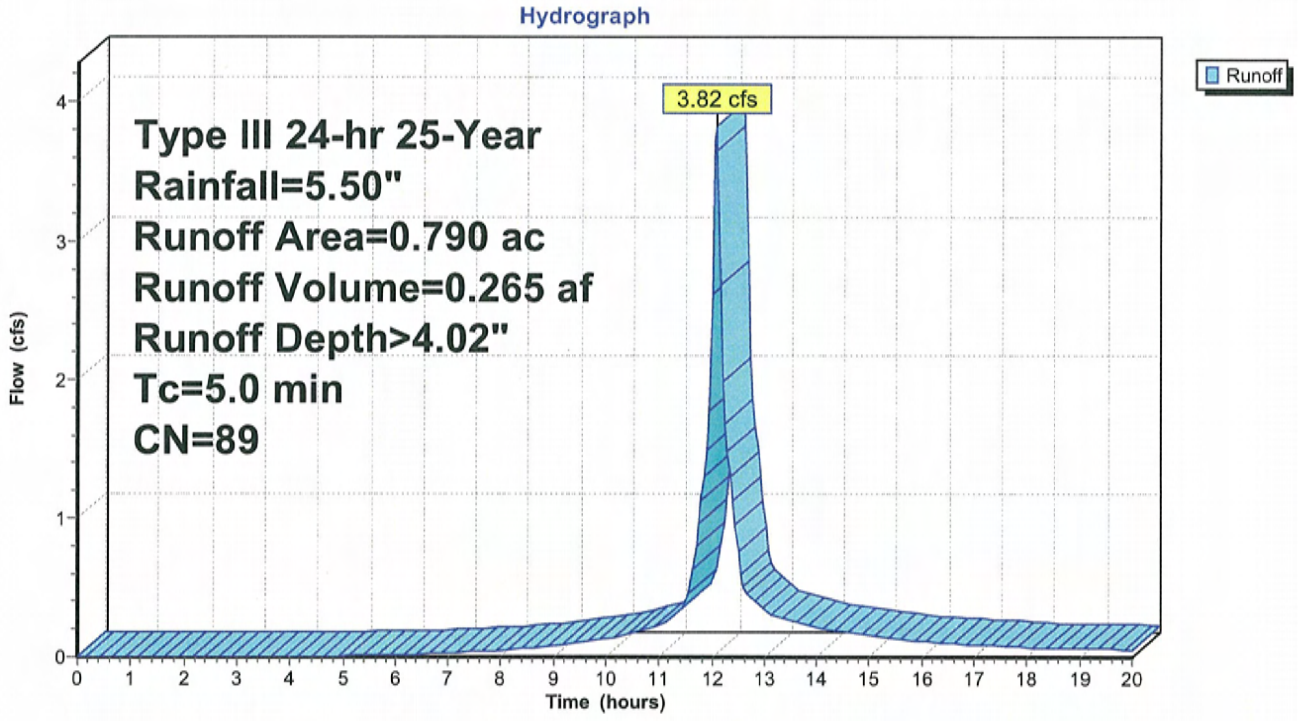
Runoff = 3.82 cfs @ 12.07 hrs, Volume= 0.265 af, Depth> 4.02"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=5.50"

Area (ac)	CN	Description
0.790	89	Gravel roads, HSG C
0.790		100.00% Pervious Area

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

Subcatchment 19S: F-2



Summary for Subcatchment 20S: F-4

[49] Hint: Tc<2dt may require smaller dt

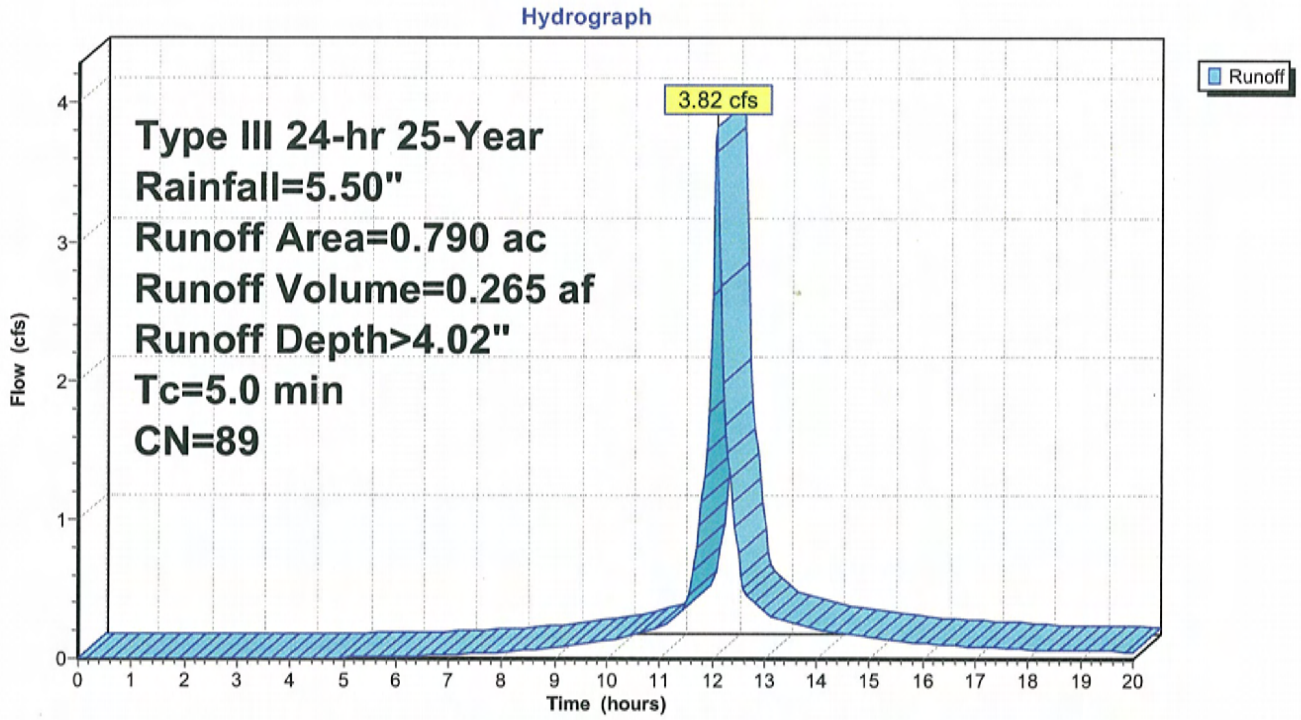
Runoff = 3.82 cfs @ 12.07 hrs, Volume= 0.265 af, Depth> 4.02"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=5.50"

Area (ac)	CN	Description
0.790	89	Gravel roads, HSG C
0.790		100.00% Pervious Area

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

Subcatchment 20S: F-4



Summary for Subcatchment 23S: F-1

[49] Hint: Tc<2dt may require smaller dt

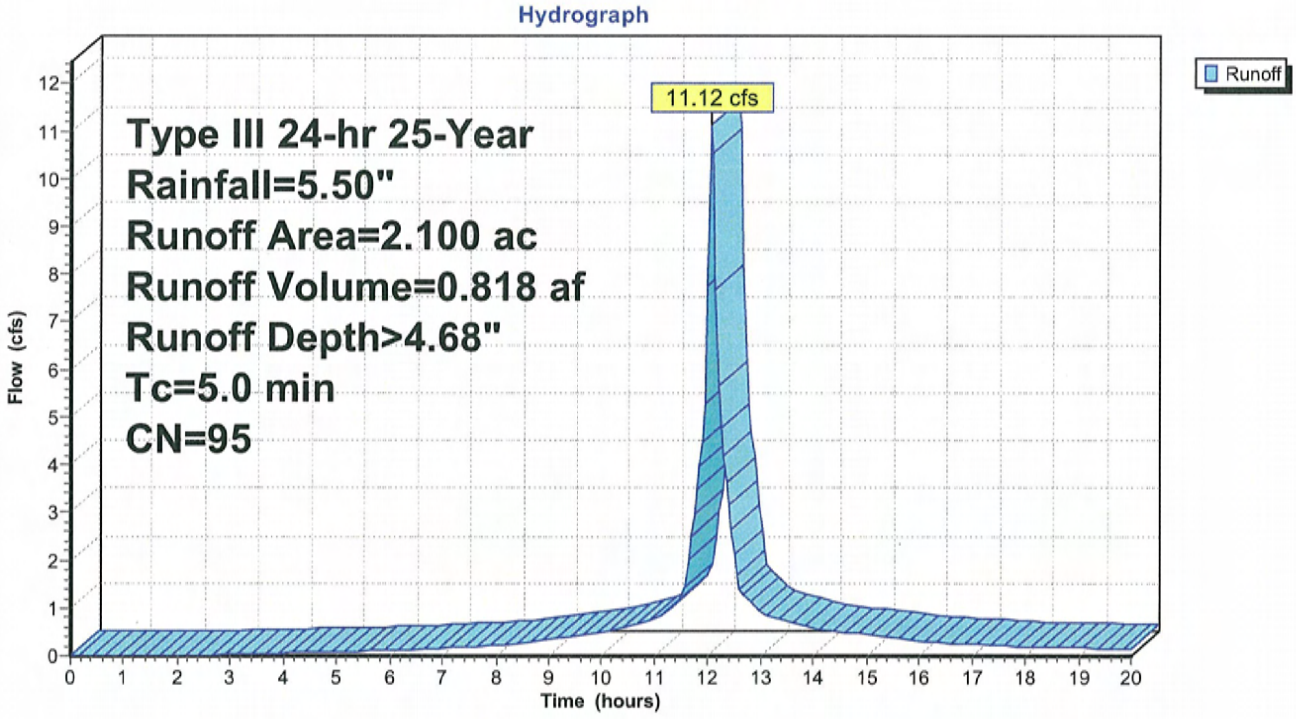
Runoff = 11.12 cfs @ 12.07 hrs, Volume= 0.818 af, Depth> 4.68"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=5.50"

	Area (ac)	CN	Description
*	2.100	95	AgruTURF
	2.100		100.00% Pervious Area

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

Subcatchment 23S: F-1



Summary for Subcatchment 24S: F-6

[49] Hint: Tc<2dt may require smaller dt

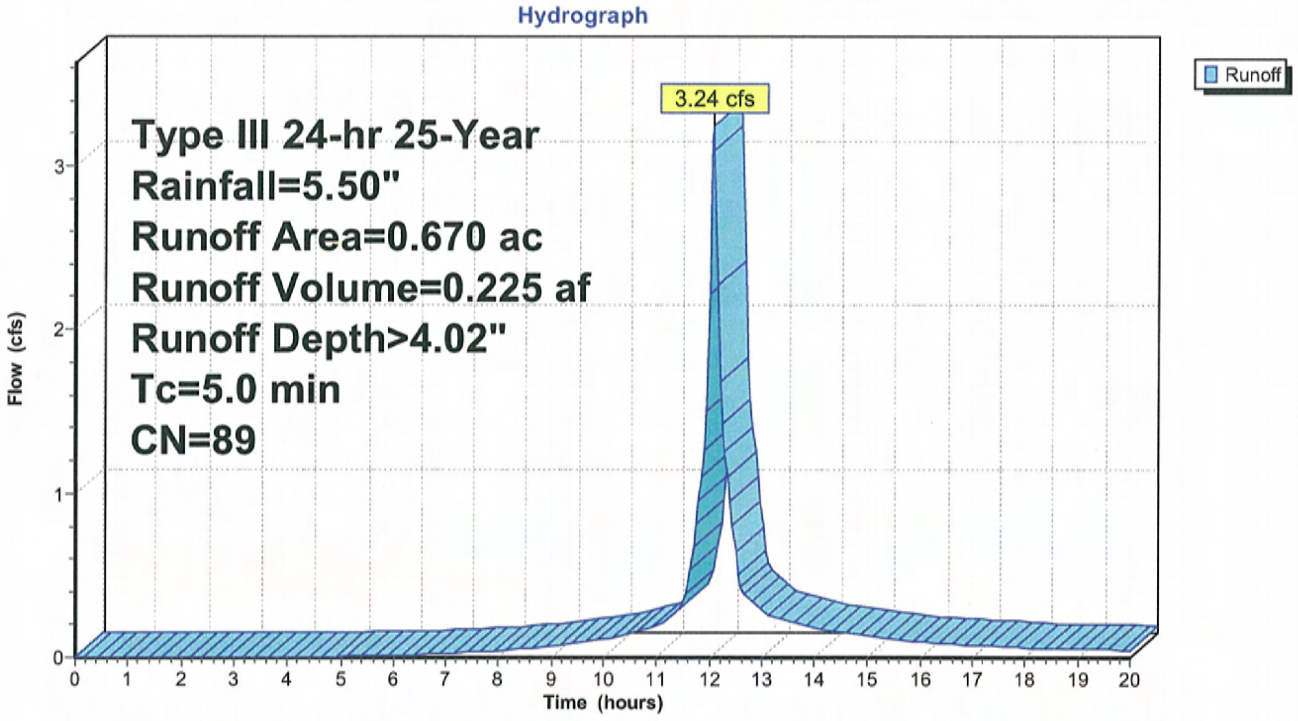
Runoff = 3.24 cfs @ 12.07 hrs, Volume= 0.225 af, Depth> 4.02"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=5.50"

Area (ac)	CN	Description
0.670	89	Gravel roads, HSG C
0.670		100.00% Pervious Area

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

Subcatchment 24S: F-6



Summary for Subcatchment 25S: F-3

[49] Hint: Tc<2dt may require smaller dt

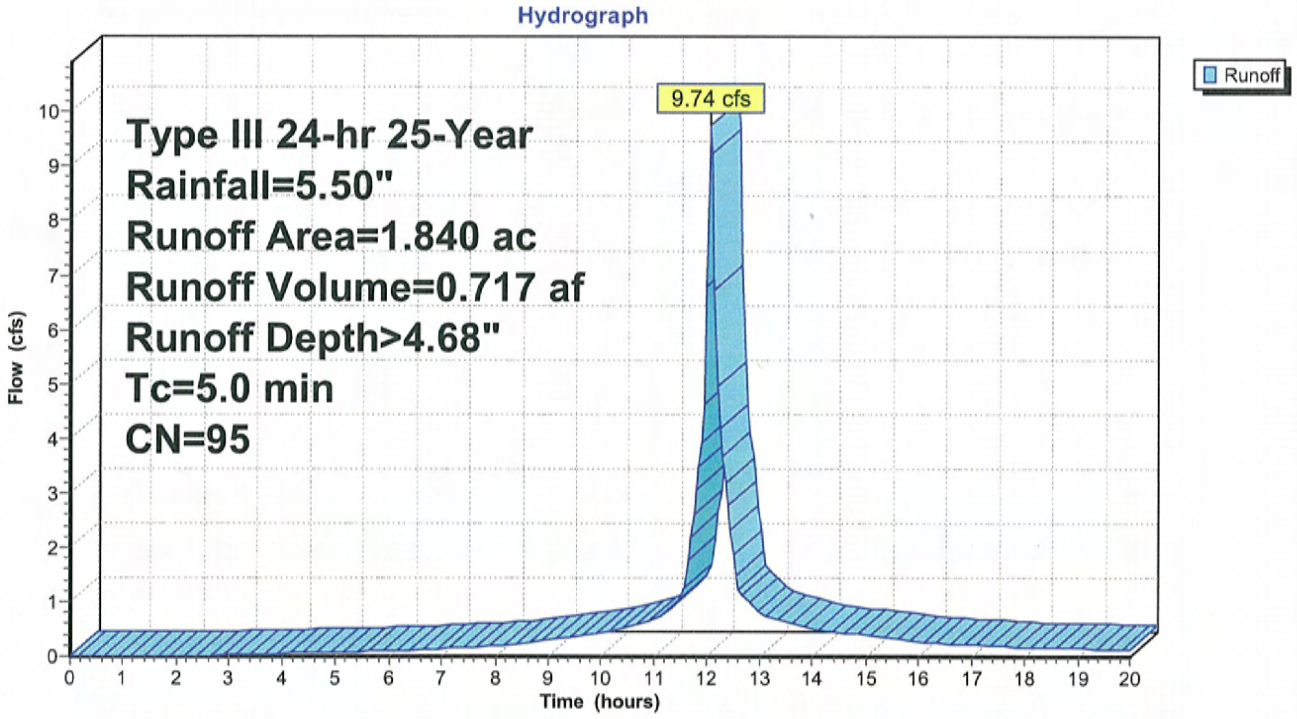
Runoff = 9.74 cfs @ 12.07 hrs, Volume= 0.717 af, Depth> 4.68"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=5.50"

	Area (ac)	CN	Description
*	1.840	95	AgruTURF
	1.840		100.00% Pervious Area

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

Subcatchment 25S: F-3



Summary for Subcatchment 26S: F-8

[49] Hint: Tc<2dt may require smaller dt

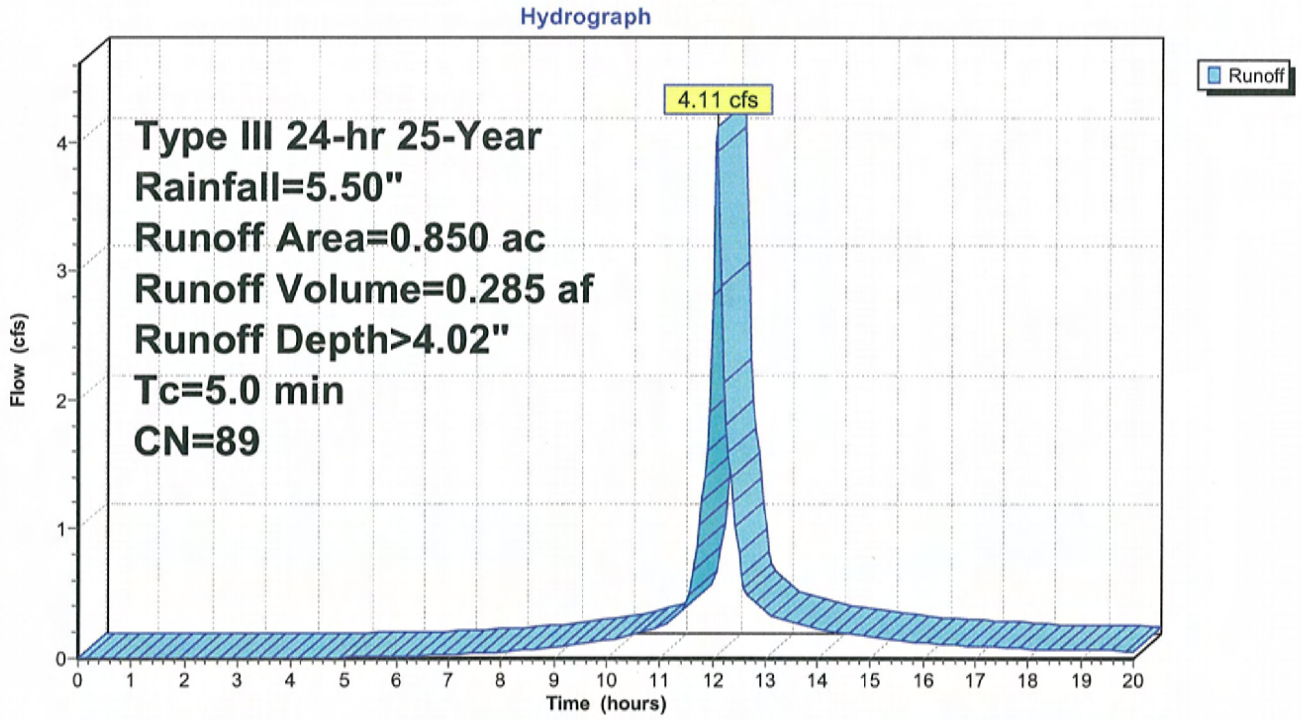
Runoff = 4.11 cfs @ 12.07 hrs, Volume= 0.285 af, Depth> 4.02"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=5.50"

Area (ac)	CN	Description
0.850	89	Gravel roads, HSG C
0.850		100.00% Pervious Area

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

Subcatchment 26S: F-8



Summary for Subcatchment 27S: F-5

[49] Hint: Tc<2dt may require smaller dt

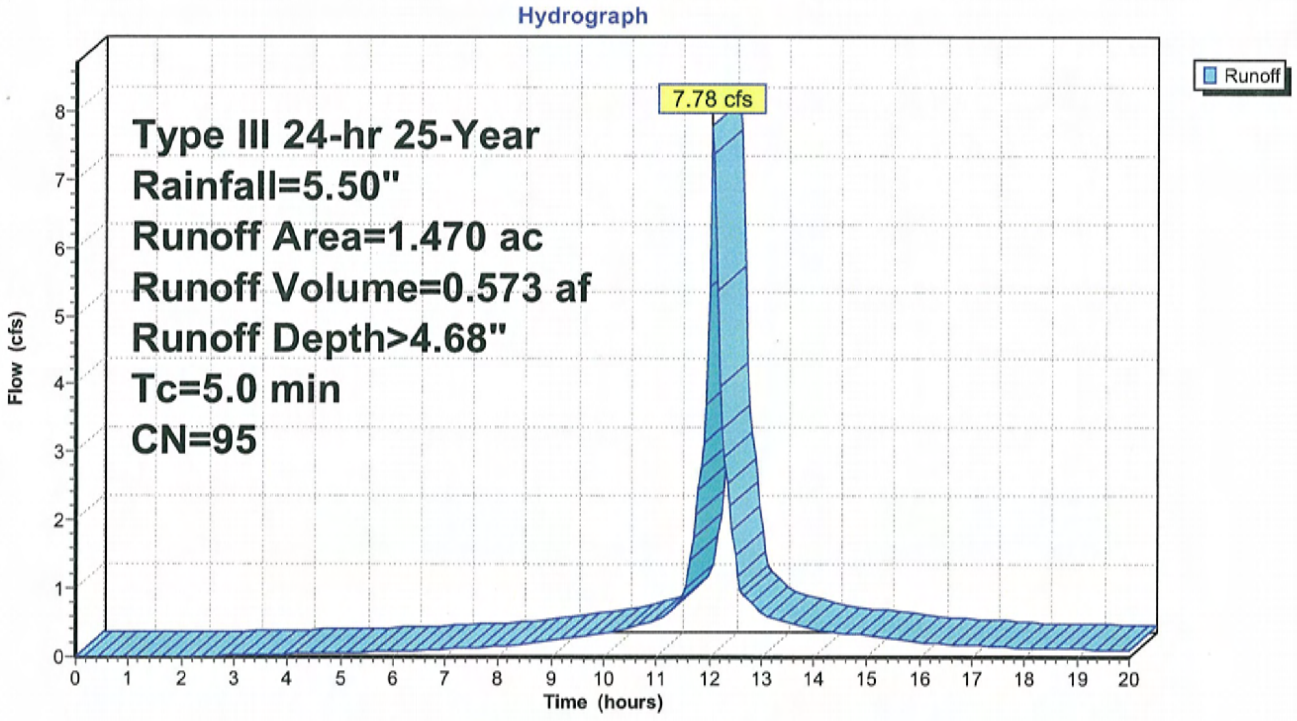
Runoff = 7.78 cfs @ 12.07 hrs, Volume= 0.573 af, Depth> 4.68"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=5.50"

	Area (ac)	CN	Description
*	1.470	95	AgruTURF
	1.470		100.00% Pervious Area

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

Subcatchment 27S: F-5



Summary for Subcatchment 28S: F-7

[49] Hint: Tc<2dt may require smaller dt

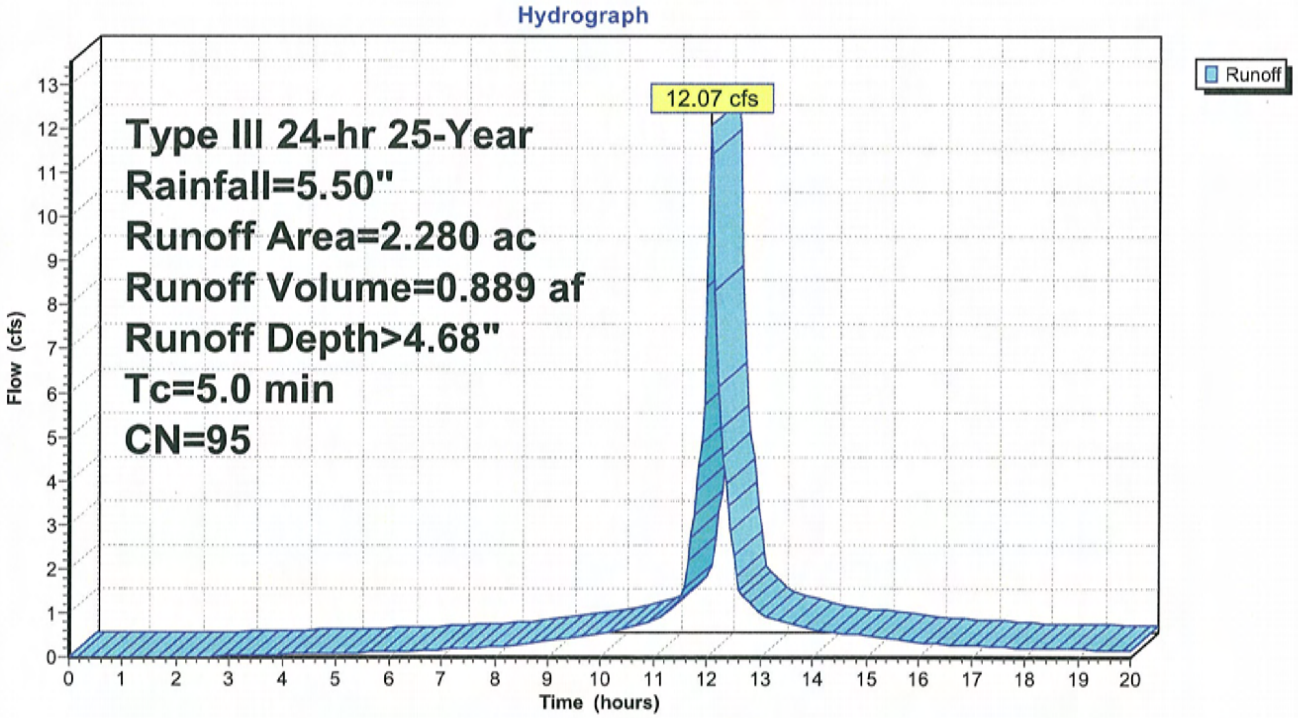
Runoff = 12.07 cfs @ 12.07 hrs, Volume= 0.889 af, Depth> 4.68"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=5.50"

	Area (ac)	CN	Description
*	2.280	95	AgruTURF
	2.280		100.00% Pervious Area

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

Subcatchment 28S: F-7



Summary for Subcatchment 29S: B-3

[49] Hint: Tc<2dt may require smaller dt

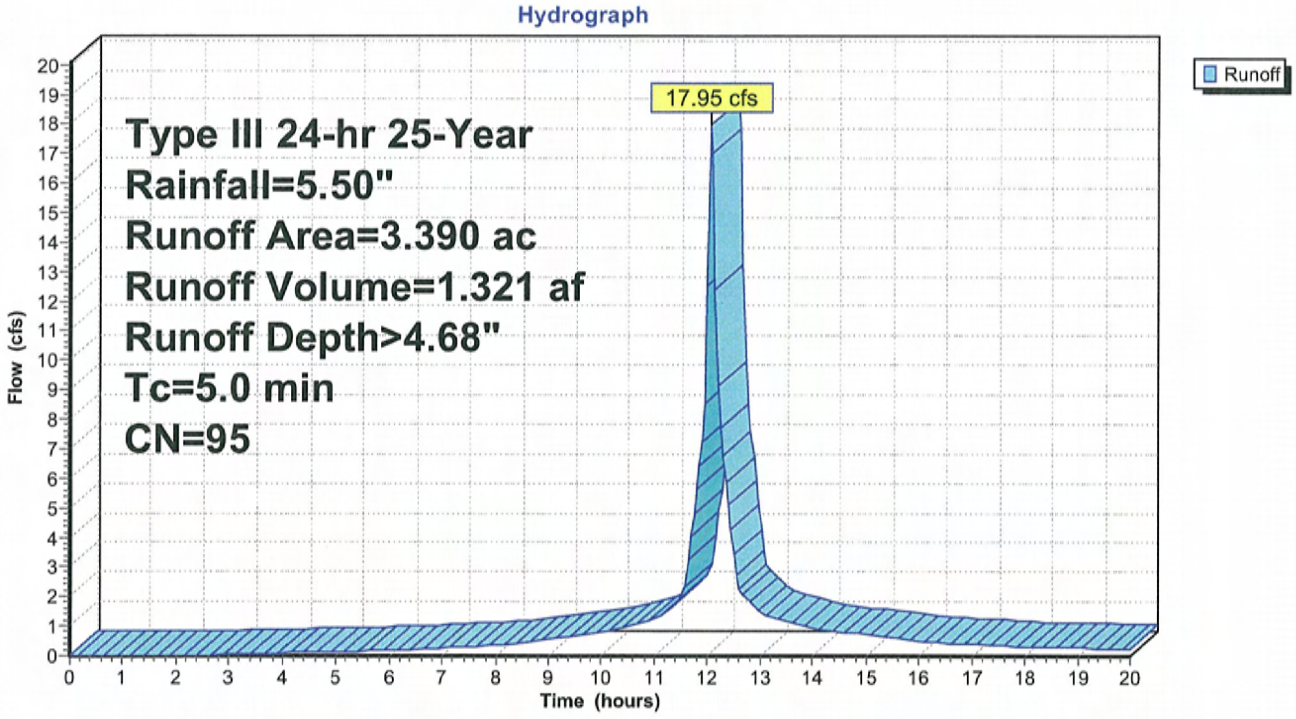
Runoff = 17.95 cfs @ 12.07 hrs, Volume= 1.321 af, Depth> 4.68"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=5.50"

	Area (ac)	CN	Description
*	3.390	95	AgruTURF
	3.390		100.00% Pervious Area

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

Subcatchment 29S: B-3



Summary for Subcatchment 33S: EX-3

[49] Hint: Tc<2dt may require smaller dt

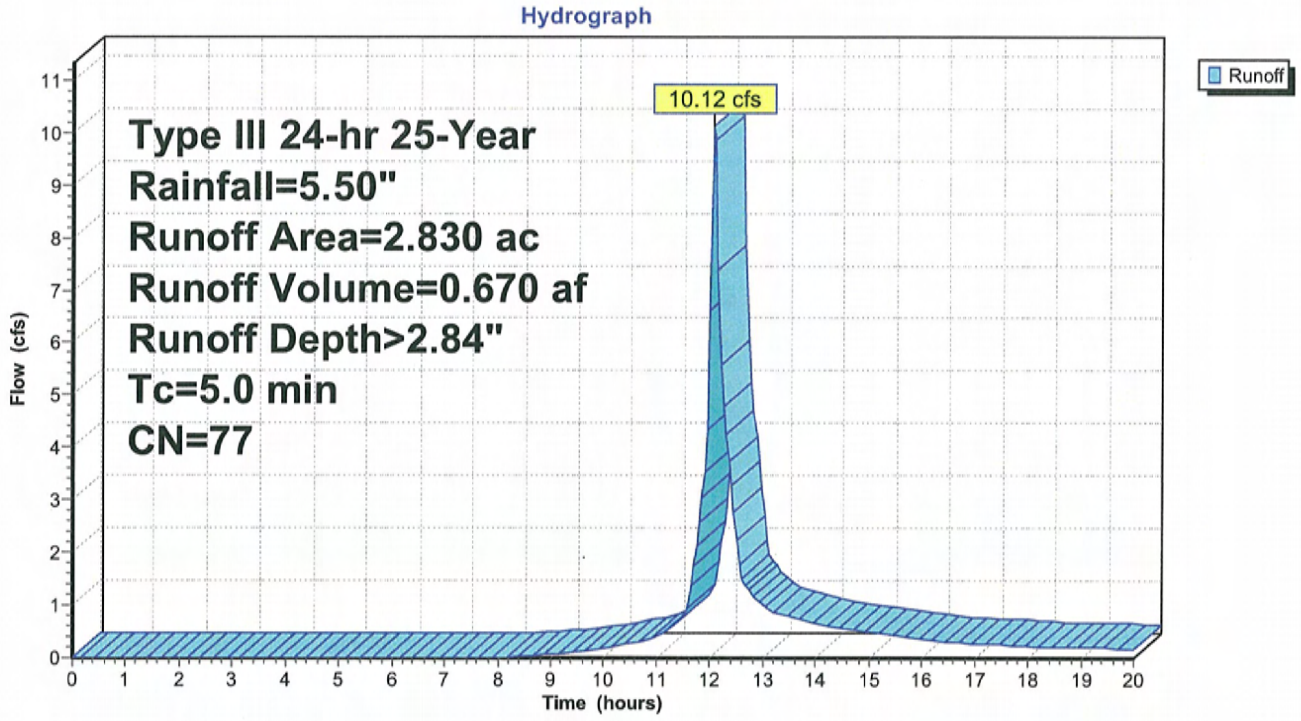
Runoff = 10.12 cfs @ 12.08 hrs, Volume= 0.670 af, Depth> 2.84"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=5.50"

	Area (ac)	CN	Description
*	2.830	77	Existing Landfill
	2.830		100.00% Pervious Area

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

Subcatchment 33S: EX-3



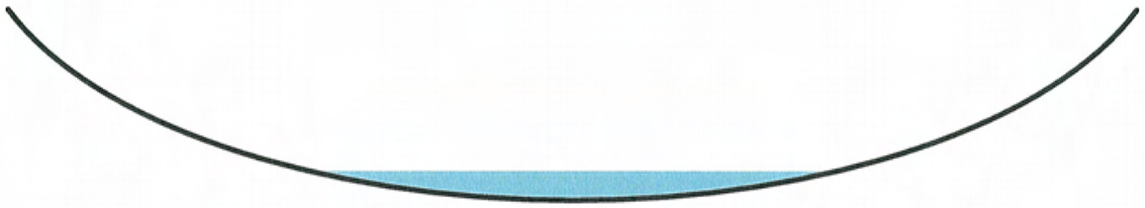
Summary for Reach 1R: Concrete Swale

Inflow Area = 2.890 ac, 0.00% Impervious, Inflow Depth > 4.50" for 25-Year event
Inflow = 14.94 cfs @ 12.07 hrs, Volume= 1.083 af
Outflow = 13.02 cfs @ 12.18 hrs, Volume= 1.078 af, Atten= 13%, Lag= 6.3 min

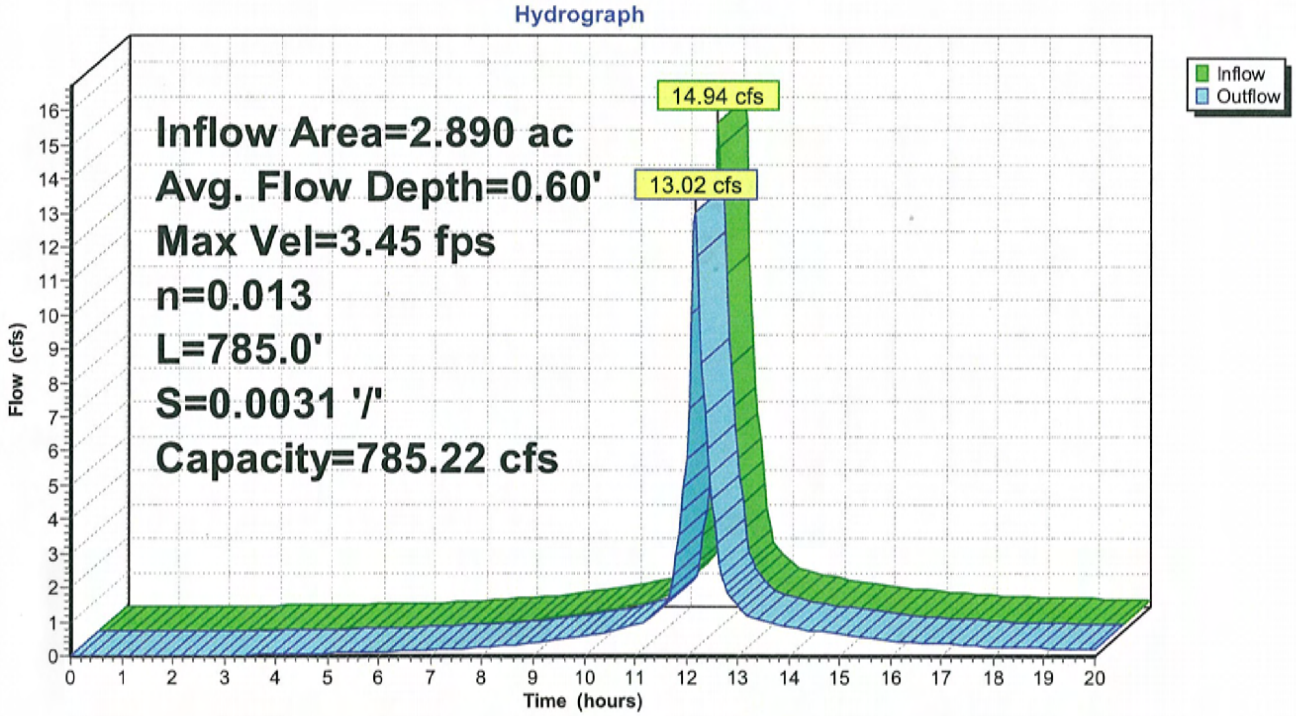
Routing by Stor-Ind+Trans method, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.45 fps, Min. Travel Time= 3.8 min
Avg. Velocity = 1.18 fps, Avg. Travel Time= 11.1 min

Peak Storage= 3,062 cf @ 12.11 hrs
Average Depth at Peak Storage= 0.60'
Bank-Full Depth= 4.00', Capacity at Bank-Full= 785.22 cfs

25.00' x 4.00' deep Parabolic Channel, n= 0.013 Concrete, trowel finish
Length= 785.0' Slope= 0.0031 '/'
Inlet Invert= 46.80', Outlet Invert= 44.35'



Reach 1R: Concrete Swale



Summary for Reach 2R: Concrete Swale

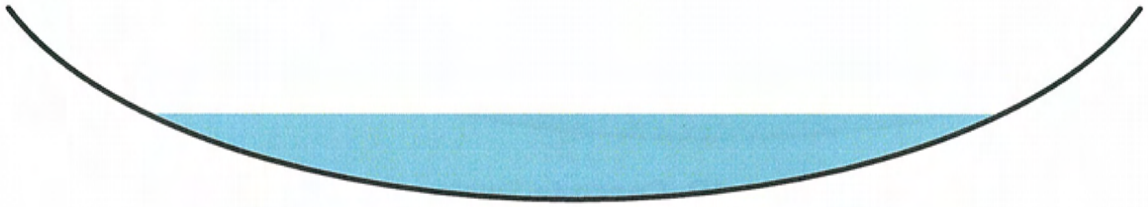
[62] Hint: Exceeded Reach 1R OUTLET depth by 1.17' @ 12.15 hrs

Inflow Area = 17.900 ac, 0.00% Impervious, Inflow Depth > 4.61" for 25-Year event
Inflow = 86.81 cfs @ 12.08 hrs, Volume= 6.883 af
Outflow = 79.46 cfs @ 12.18 hrs, Volume= 6.856 af, Atten= 8%, Lag= 5.6 min

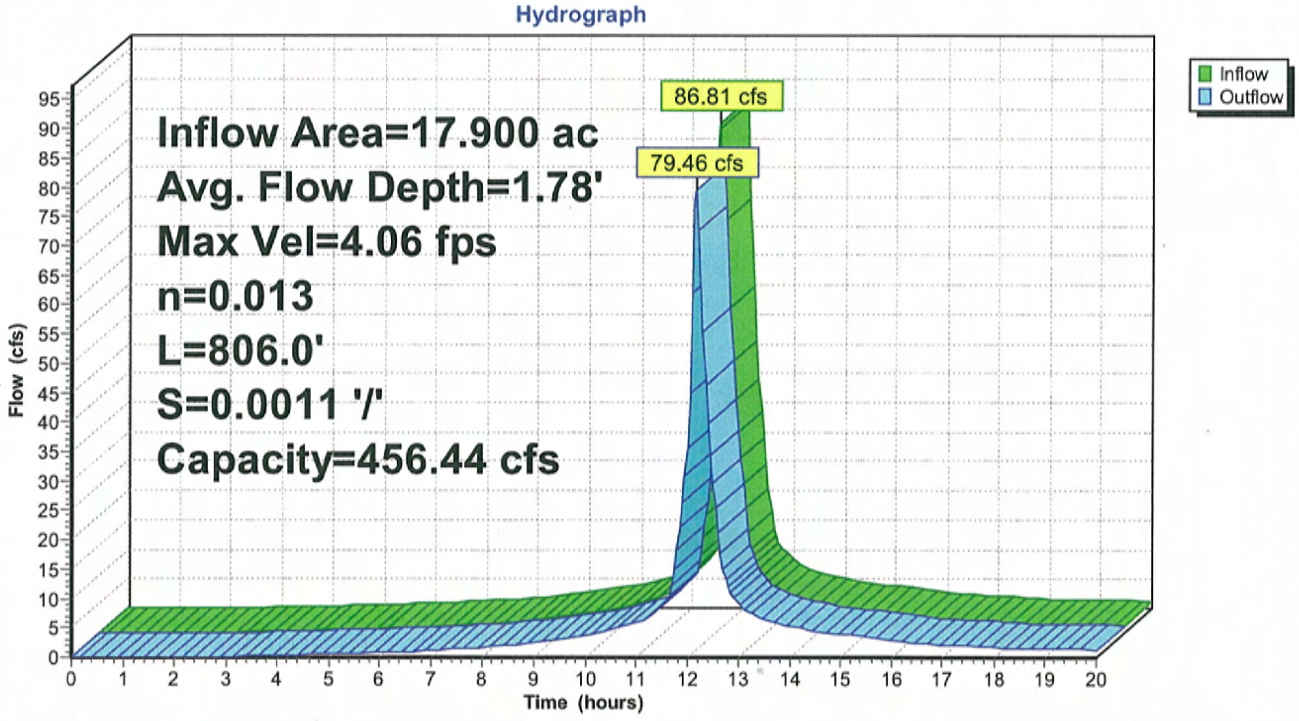
Routing by Stor-Ind+Trans method, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.06 fps, Min. Travel Time= 3.3 min
Avg. Velocity = 1.40 fps, Avg. Travel Time= 9.6 min

Peak Storage= 15,974 cf @ 12.12 hrs
Average Depth at Peak Storage= 1.78'
Bank-Full Depth= 4.00', Capacity at Bank-Full= 456.44 cfs

25.00' x 4.00' deep Parabolic Channel, n= 0.013 Concrete, trowel finish
Length= 806.0' Slope= 0.0011 '/'
Inlet Invert= 44.35', Outlet Invert= 43.50'



Reach 2R: Concrete Swale



Summary for Reach 3R: Concrete Swale

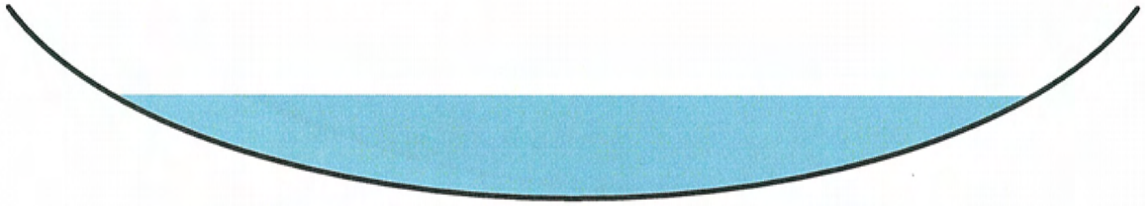
[62] Hint: Exceeded Reach 2R OUTLET depth by 0.53' @ 12.25 hrs

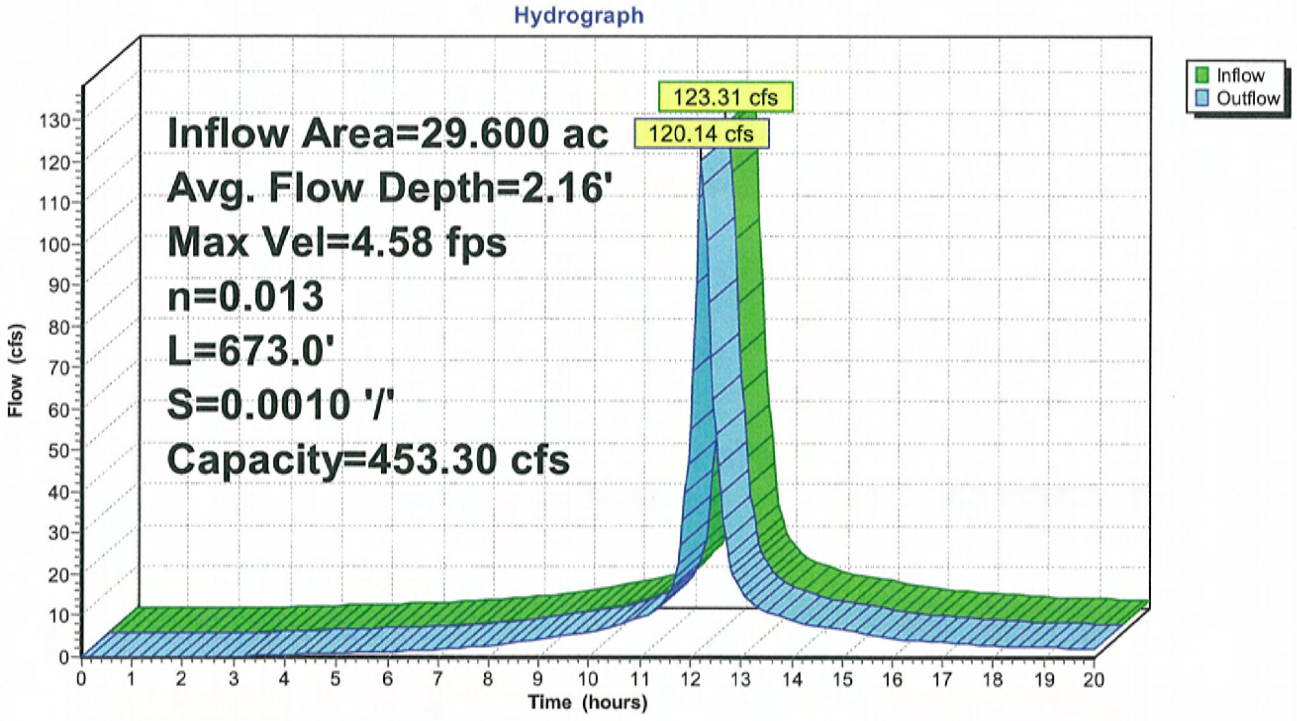
Inflow Area = 29.600 ac, 0.00% Impervious, Inflow Depth > 4.61" for 25-Year event
Inflow = 123.31 cfs @ 12.13 hrs, Volume= 11.378 af
Outflow = 120.14 cfs @ 12.21 hrs, Volume= 11.346 af, Atten= 3%, Lag= 4.5 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.58 fps, Min. Travel Time= 2.4 min
Avg. Velocity = 1.62 fps, Avg. Travel Time= 6.9 min

Peak Storage= 17,778 cf @ 12.16 hrs
Average Depth at Peak Storage= 2.16'
Bank-Full Depth= 4.00', Capacity at Bank-Full= 453.30 cfs

25.00' x 4.00' deep Parabolic Channel, n= 0.013 Concrete, trowel finish
Length= 673.0' Slope= 0.0010 '/'
Inlet Invert= 43.50', Outlet Invert= 42.80'





Summary for Reach 4R: Concrete Swale

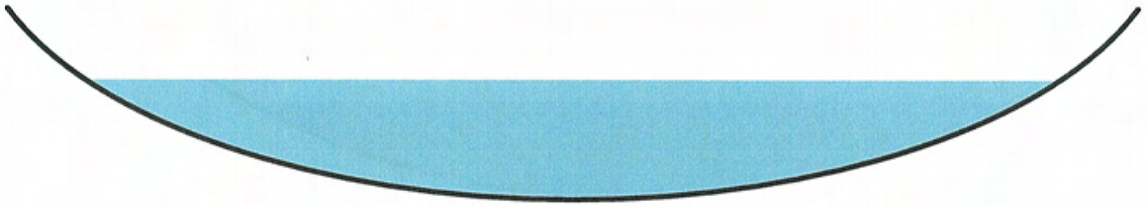
[62] Hint: Exceeded Reach 3R OUTLET depth by 0.49' @ 12.30 hrs

Inflow Area = 38.160 ac, 0.00% Impervious, Inflow Depth > 4.60" for 25-Year event
Inflow = 145.22 cfs @ 12.17 hrs, Volume= 14.635 af
Outflow = 142.75 cfs @ 12.24 hrs, Volume= 14.595 af, Atten= 2%, Lag= 4.2 min

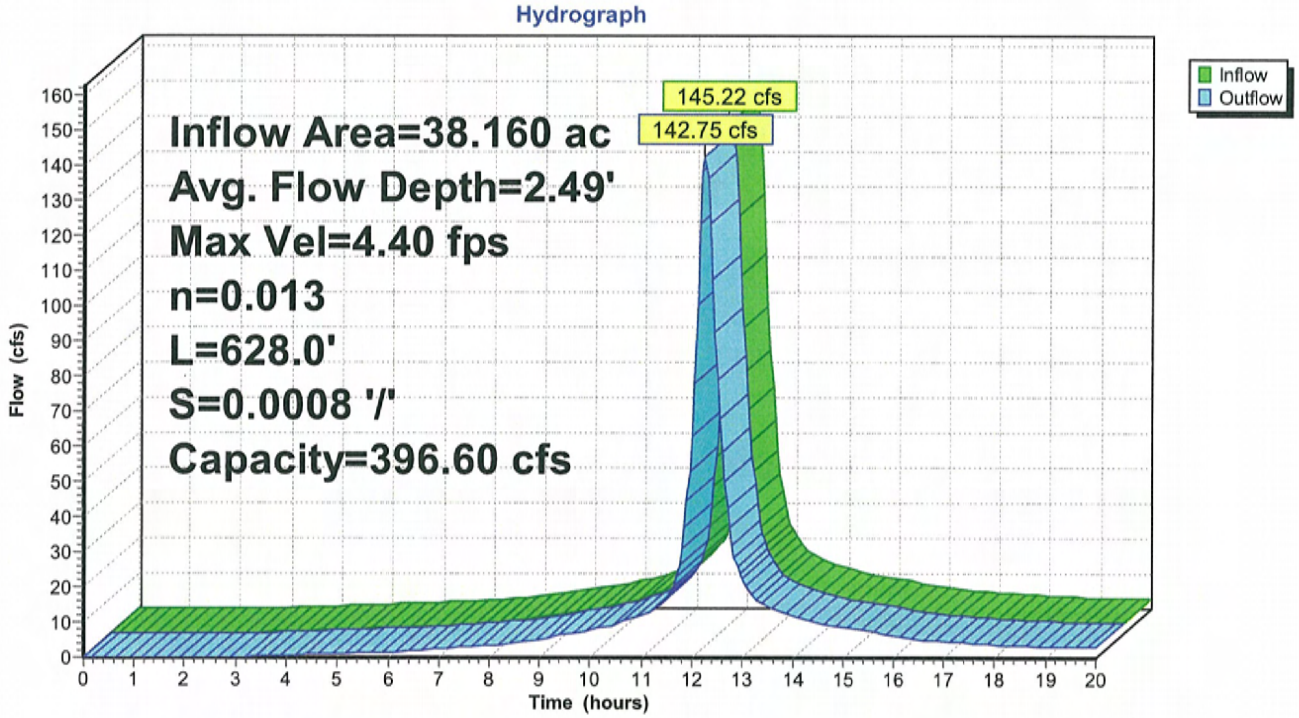
Routing by Stor-Ind+Trans method, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.40 fps, Min. Travel Time= 2.4 min
Avg. Velocity = 1.59 fps, Avg. Travel Time= 6.6 min

Peak Storage= 20,509 cf @ 12.20 hrs
Average Depth at Peak Storage= 2.49'
Bank-Full Depth= 4.00', Capacity at Bank-Full= 396.60 cfs

25.00' x 4.00' deep Parabolic Channel, n= 0.013 Concrete, trowel finish
Length= 628.0' Slope= 0.0008 '/'
Inlet Invert= 42.80', Outlet Invert= 42.30'



Reach 4R: Concrete Swale



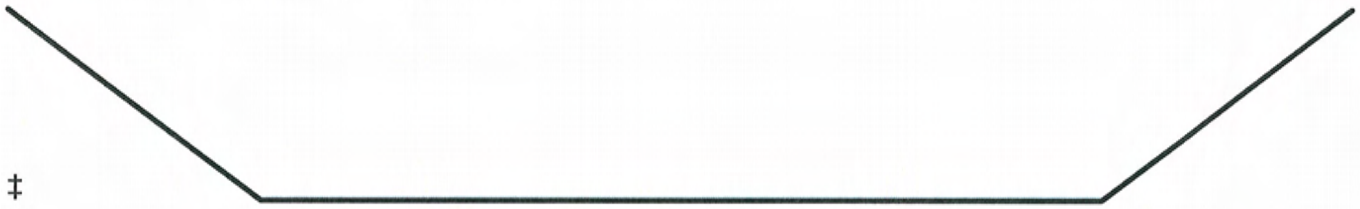
Summary for Reach A-R1: Downchute

Inflow Area = 0.380 ac, 0.00% Impervious, Inflow Depth > 2.84" for 25-Year event
Inflow = 1.36 cfs @ 12.08 hrs, Volume= 0.090 af
Outflow = 1.35 cfs @ 12.09 hrs, Volume= 0.090 af, Atten= 1%, Lag= 0.8 min

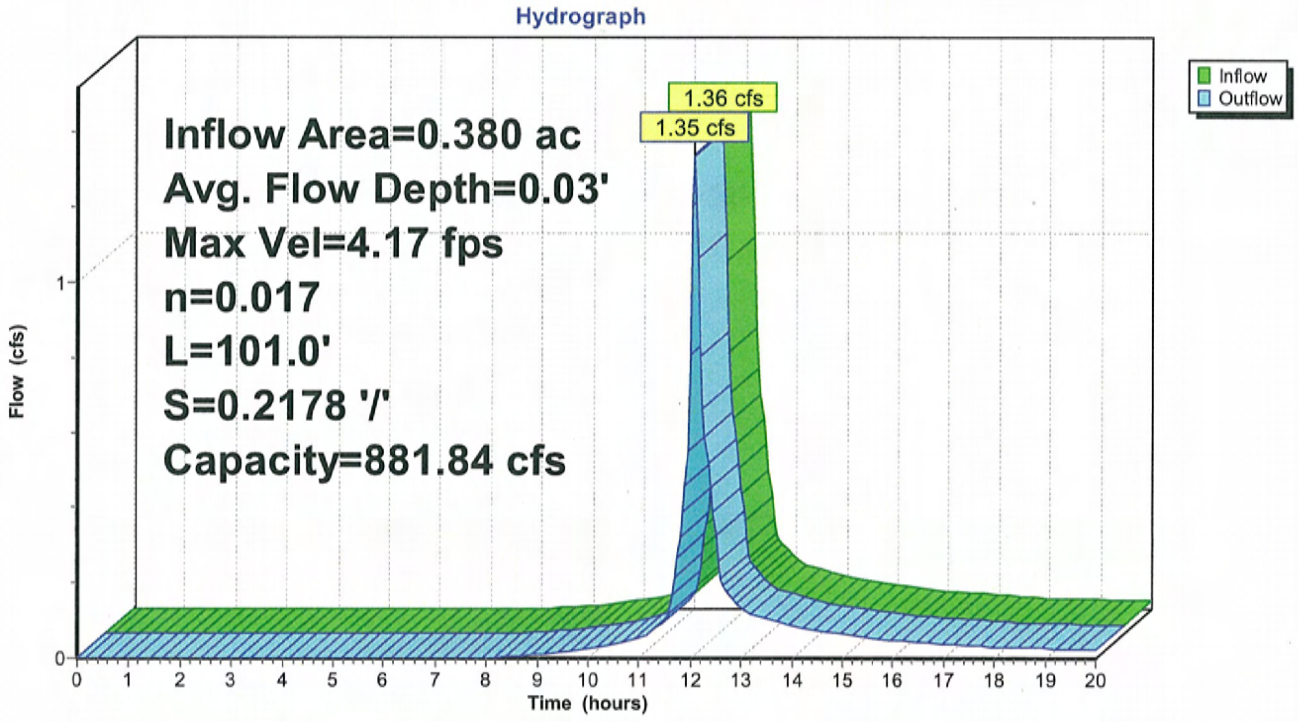
Routing by Stor-Ind+Trans method, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.17 fps, Min. Travel Time= 0.4 min
Avg. Velocity = 2.51 fps, Avg. Travel Time= 0.7 min

Peak Storage= 33 cf @ 12.08 hrs
Average Depth at Peak Storage= 0.03'
Bank-Full Depth= 1.50', Capacity at Bank-Full= 881.84 cfs

10.00' x 1.50' deep channel, n= 0.017 Concrete, unfinished
Side Slope Z-value= 2.0 '/' Top Width= 16.00'
Length= 101.0' Slope= 0.2178 '/'
Inlet Invert= 131.00', Outlet Invert= 109.00'



‡



Summary for Reach A-R2: Downchute

[62] Hint: Exceeded Reach A-R1 OUTLET depth by 0.02' @ 12.10 hrs

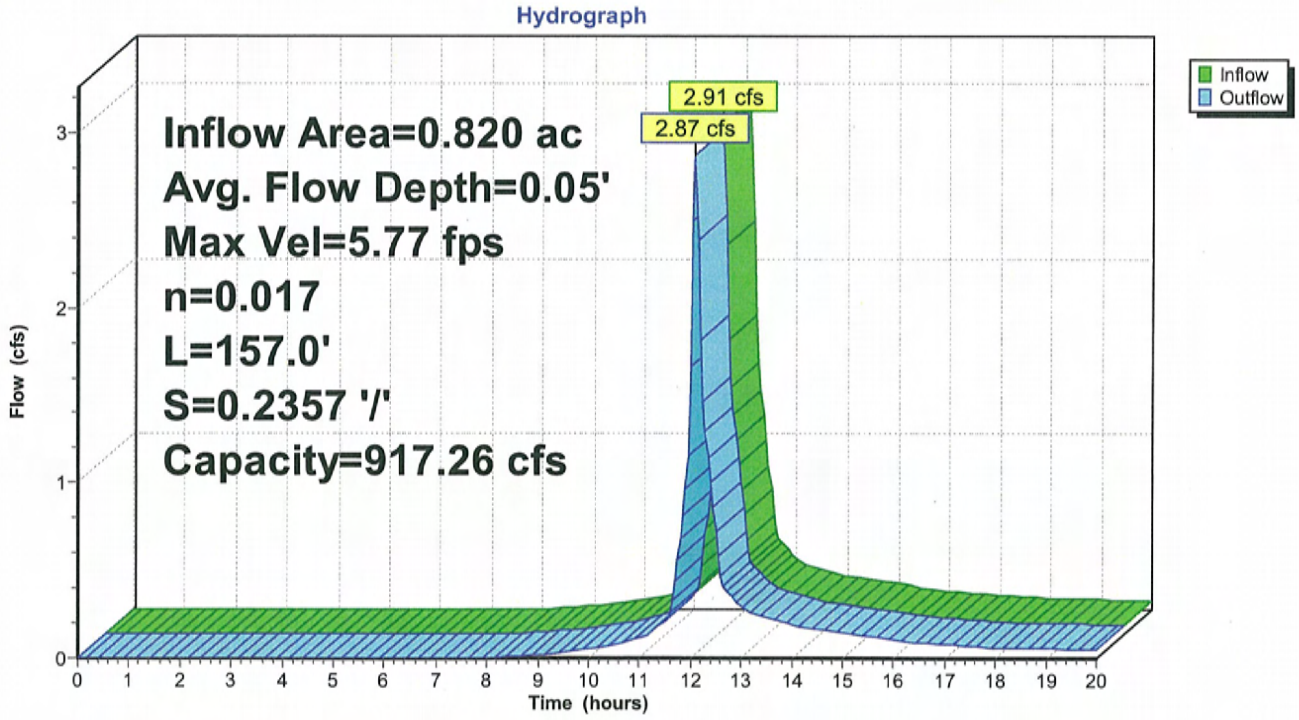
Inflow Area = 0.820 ac, 0.00% Impervious, Inflow Depth > 2.84" for 25-Year event
Inflow = 2.91 cfs @ 12.08 hrs, Volume= 0.194 af
Outflow = 2.87 cfs @ 12.10 hrs, Volume= 0.194 af, Atten= 1%, Lag= 0.8 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs
Max. Velocity= 5.77 fps, Min. Travel Time= 0.5 min
Avg. Velocity = 2.69 fps, Avg. Travel Time= 1.0 min

Peak Storage= 80 cf @ 12.09 hrs
Average Depth at Peak Storage= 0.05'
Bank-Full Depth= 1.50', Capacity at Bank-Full= 917.26 cfs

10.00' x 1.50' deep channel, n= 0.017 Concrete, unfinished
Side Slope Z-value= 2.0 '/' Top Width= 16.00'
Length= 157.0' Slope= 0.2357 '/'
Inlet Invert= 109.00', Outlet Invert= 72.00'

‡



Summary for Reach A-R3: Downchute

[61] Hint: Exceeded Reach A-R2 outlet invert by 0.05' @ 12.10 hrs

Inflow Area = 0.820 ac, 0.00% Impervious, Inflow Depth > 2.84" for 25-Year event
Inflow = 2.87 cfs @ 12.10 hrs, Volume= 0.194 af
Outflow = 2.86 cfs @ 12.10 hrs, Volume= 0.194 af, Atten= 1%, Lag= 0.2 min

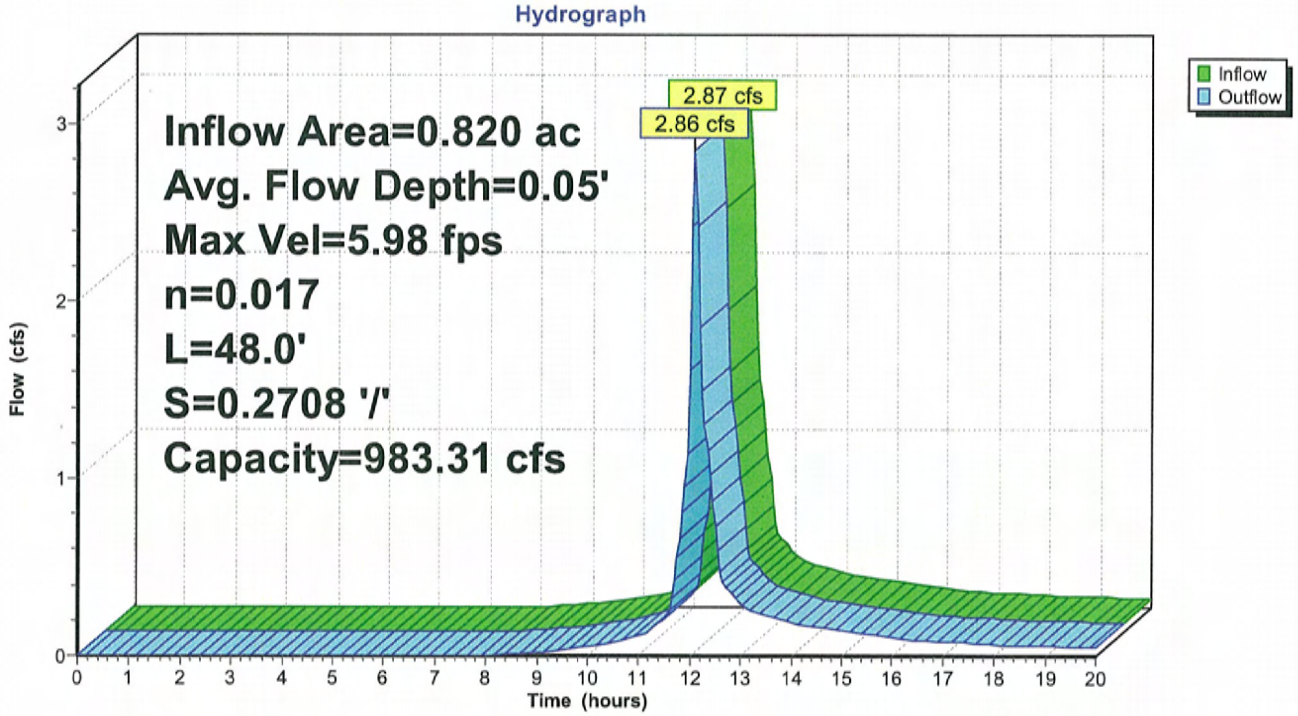
Routing by Stor-Ind+Trans method, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs
Max. Velocity= 5.98 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 2.87 fps, Avg. Travel Time= 0.3 min

Peak Storage= 23 cf @ 12.10 hrs
Average Depth at Peak Storage= 0.05'
Bank-Full Depth= 1.50', Capacity at Bank-Full= 983.31 cfs

10.00' x 1.50' deep channel, n= 0.017 Concrete, unfinished
Side Slope Z-value= 2.0 '/' Top Width= 16.00'
Length= 48.0' Slope= 0.2708 '/'
Inlet Invert= 72.00', Outlet Invert= 59.00'

‡

Reach A-R3: Downchute



Summary for Reach B-R1: Downchute

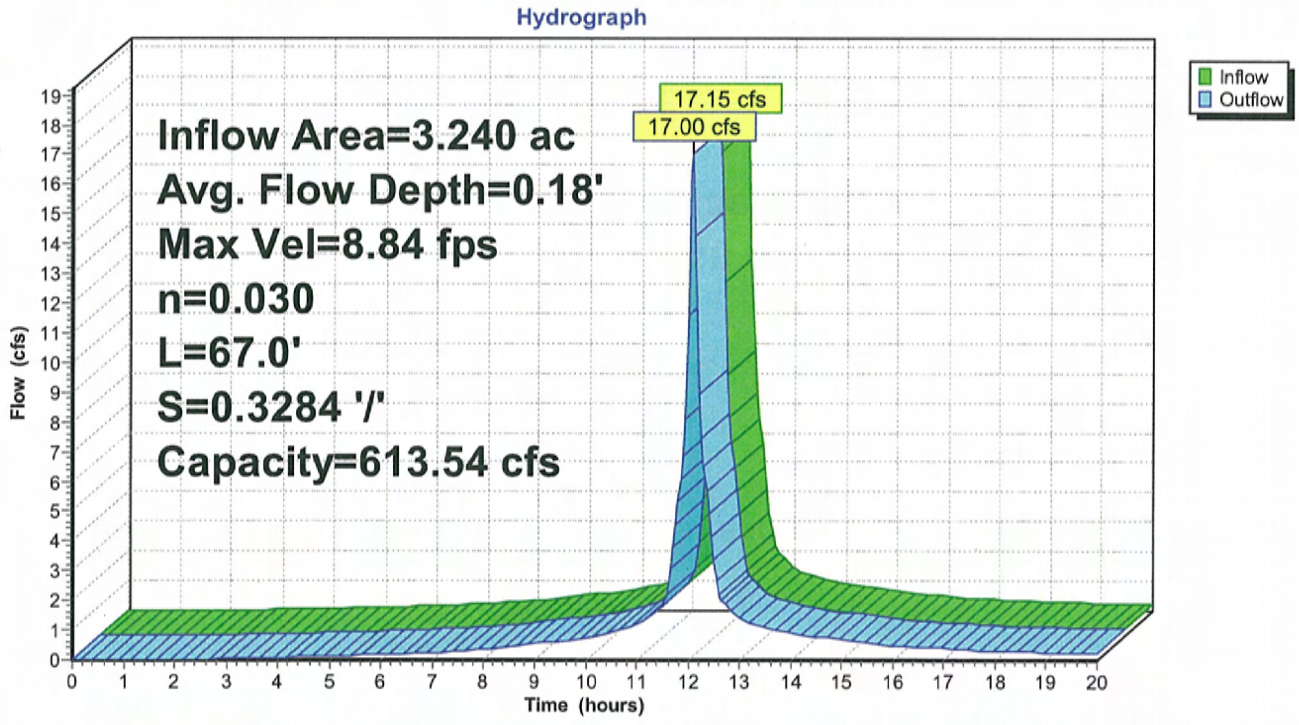
Inflow Area = 3.240 ac, 0.00% Impervious, Inflow Depth > 4.68" for 25-Year event
Inflow = 17.15 cfs @ 12.07 hrs, Volume= 1.263 af
Outflow = 17.00 cfs @ 12.07 hrs, Volume= 1.263 af, Atten= 1%, Lag= 0.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs
Max. Velocity= 8.84 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 2.42 fps, Avg. Travel Time= 0.5 min

Peak Storage= 129 cf @ 12.07 hrs
Average Depth at Peak Storage= 0.18'
Bank-Full Depth= 1.50', Capacity at Bank-Full= 613.54 cfs

10.00' x 1.50' deep channel, n= 0.030
Side Slope Z-value= 2.0 '/' Top Width= 16.00'
Length= 67.0' Slope= 0.3284 '/'
Inlet Invert= 128.00', Outlet Invert= 106.00'

‡



Summary for Reach B-R2: Downchute

[62] Hint: Exceeded Reach B-R1 OUTLET depth by 0.06' @ 12.10 hrs

Inflow Area = 5.430 ac, 0.00% Impervious, Inflow Depth > 4.68" for 25-Year event
Inflow = 28.59 cfs @ 12.07 hrs, Volume= 2.116 af
Outflow = 28.22 cfs @ 12.08 hrs, Volume= 2.115 af, Atten= 1%, Lag= 0.4 min

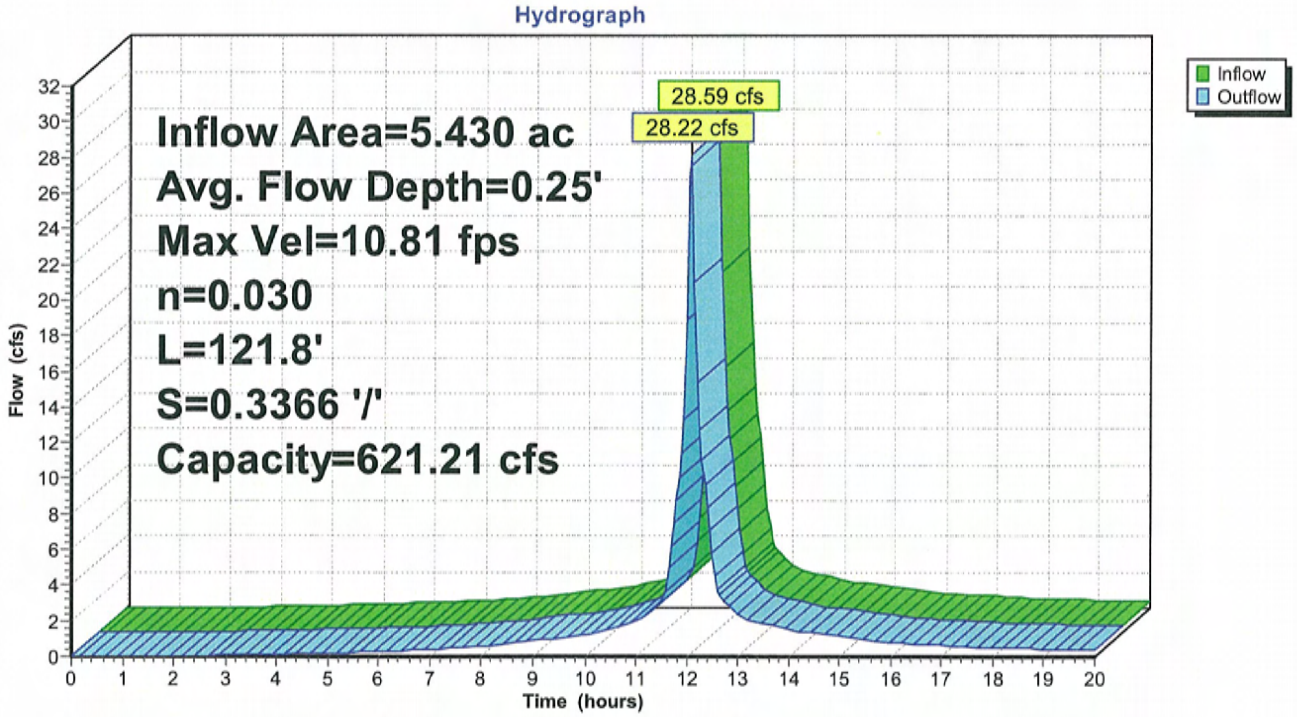
Routing by Stor-Ind+Trans method, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs
Max. Velocity= 10.81 fps, Min. Travel Time= 0.2 min
Avg. Velocity = 2.90 fps, Avg. Travel Time= 0.7 min

Peak Storage= 317 cf @ 12.08 hrs
Average Depth at Peak Storage= 0.25'
Bank-Full Depth= 1.50', Capacity at Bank-Full= 621.21 cfs

10.00' x 1.50' deep channel, n= 0.030
Side Slope Z-value= 2.0 '/' Top Width= 16.00'
Length= 121.8' Slope= 0.3366 '/'
Inlet Invert= 106.00', Outlet Invert= 65.00'

‡

Reach B-R2: Downchute



Summary for Reach B-R3: Downchute

[61] Hint: Exceeded Reach B-R2 outlet invert by 0.24' @ 12.10 hrs

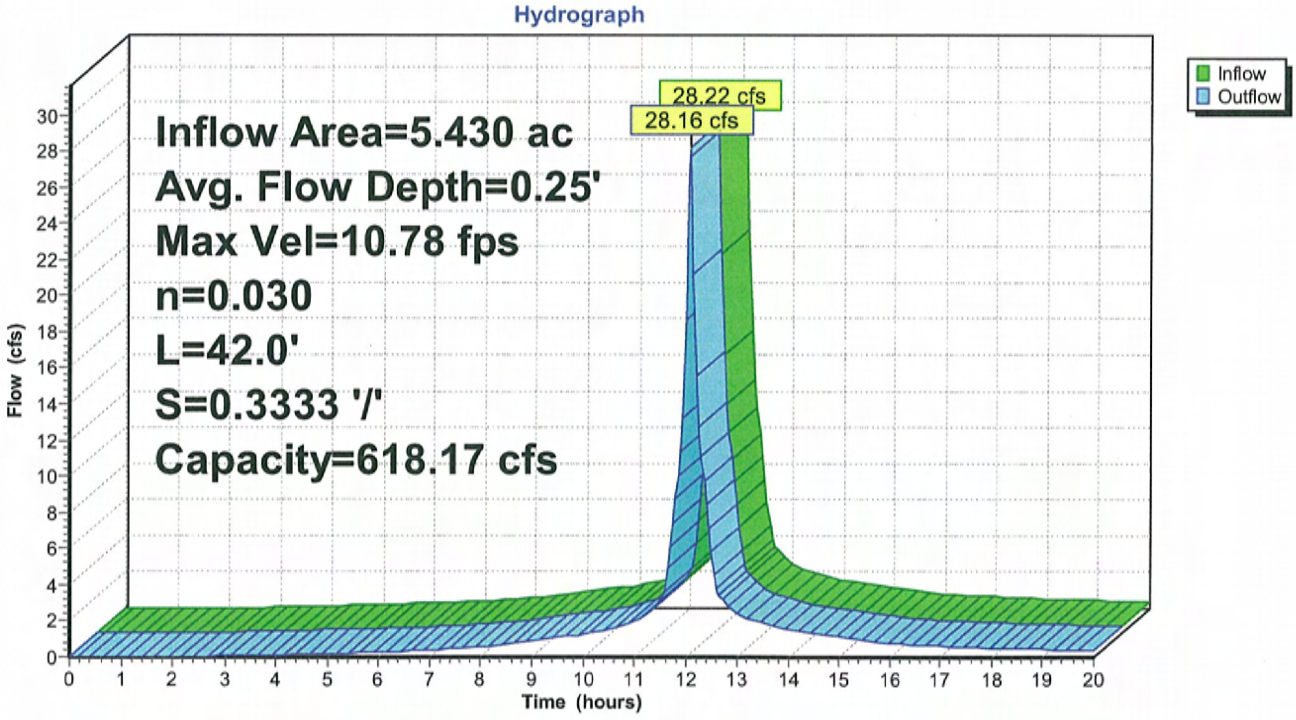
Inflow Area = 5.430 ac, 0.00% Impervious, Inflow Depth > 4.68" for 25-Year event
Inflow = 28.22 cfs @ 12.08 hrs, Volume= 2.115 af
Outflow = 28.16 cfs @ 12.08 hrs, Volume= 2.115 af, Atten= 0%, Lag= 0.1 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs
Max. Velocity= 10.78 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 2.89 fps, Avg. Travel Time= 0.2 min

Peak Storage= 109 cf @ 12.08 hrs
Average Depth at Peak Storage= 0.25'
Bank-Full Depth= 1.50', Capacity at Bank-Full= 618.17 cfs

10.00' x 1.50' deep channel, n= 0.030
Side Slope Z-value= 2.0 '/' Top Width= 16.00'
Length= 42.0' Slope= 0.3333 '/'
Inlet Invert= 65.00', Outlet Invert= 51.00'

‡



Summary for Reach C-R1: Downchute

Inflow Area = 7.550 ac, 0.00% Impervious, Inflow Depth > 4.68" for 25-Year event
Inflow = 39.97 cfs @ 12.07 hrs, Volume= 2.943 af
Outflow = 39.70 cfs @ 12.07 hrs, Volume= 2.942 af, Atten= 1%, Lag= 0.2 min

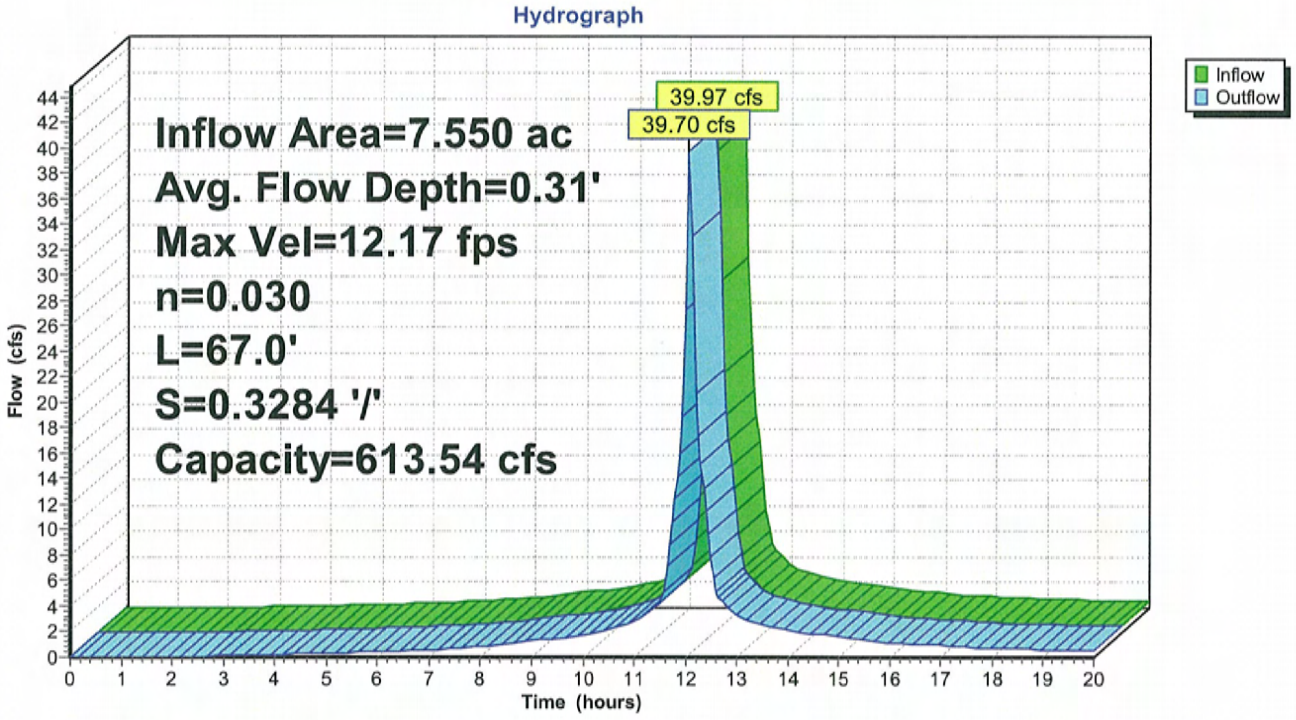
Routing by Stor-Ind+Trans method, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs
Max. Velocity= 12.17 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 3.22 fps, Avg. Travel Time= 0.3 min

Peak Storage= 218 cf @ 12.07 hrs
Average Depth at Peak Storage= 0.31'
Bank-Full Depth= 1.50', Capacity at Bank-Full= 613.54 cfs

10.00' x 1.50' deep channel, n= 0.030
Side Slope Z-value= 2.0 '/' Top Width= 16.00'
Length= 67.0' Slope= 0.3284 '/'
Inlet Invert= 128.00', Outlet Invert= 106.00'

‡

Reach C-R1: Downchute



Summary for Reach C-R2: Downchute

[62] Hint: Exceeded Reach C-R1 OUTLET depth by 0.04' @ 12.10 hrs

Inflow Area = 9.560 ac, 0.00% Impervious, Inflow Depth > 4.68" for 25-Year event
Inflow = 50.34 cfs @ 12.07 hrs, Volume= 3.726 af
Outflow = 49.75 cfs @ 12.08 hrs, Volume= 3.725 af, Atten= 1%, Lag= 0.3 min

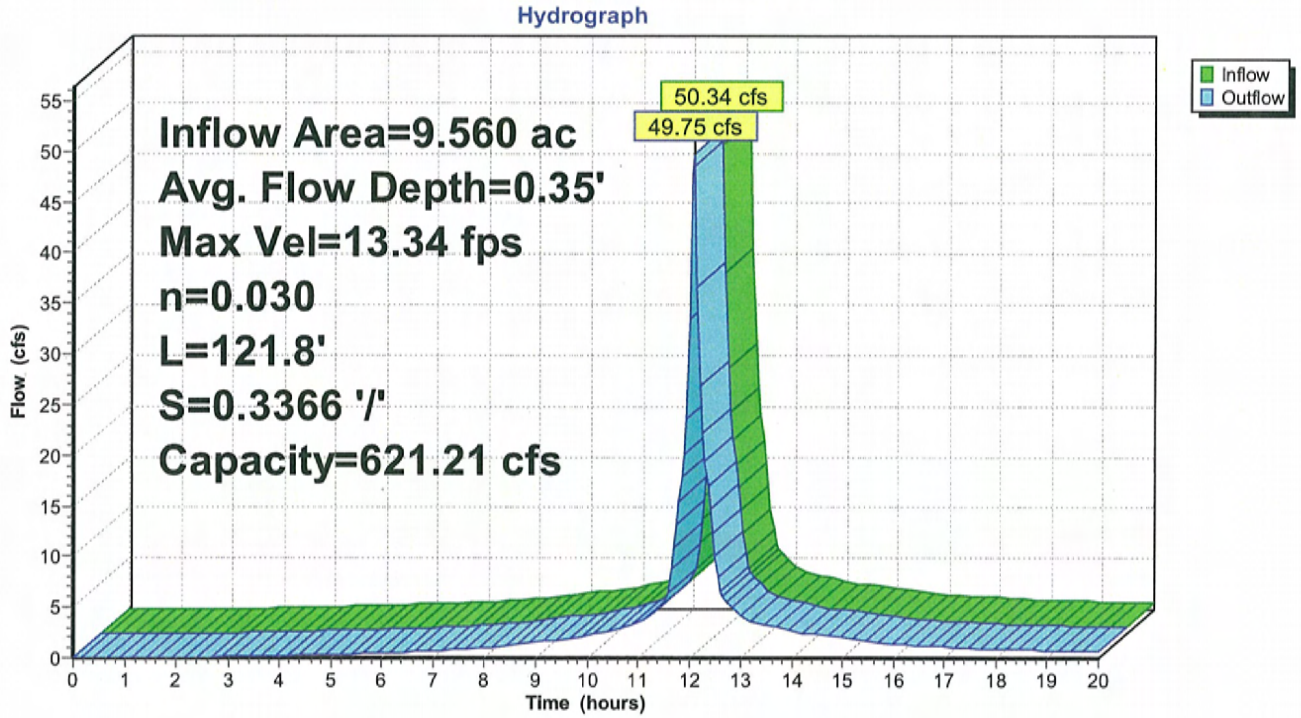
Routing by Stor-Ind+Trans method, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs
Max. Velocity= 13.34 fps, Min. Travel Time= 0.2 min
Avg. Velocity = 3.53 fps, Avg. Travel Time= 0.6 min

Peak Storage= 453 cf @ 12.08 hrs
Average Depth at Peak Storage= 0.35'
Bank-Full Depth= 1.50', Capacity at Bank-Full= 621.21 cfs

10.00' x 1.50' deep channel, n= 0.030
Side Slope Z-value= 2.0 '/' Top Width= 16.00'
Length= 121.8' Slope= 0.3366 '/'
Inlet Invert= 106.00', Outlet Invert= 65.00'

‡

Reach C-R2: Downchute



Summary for Reach C-R3: Downchute

[61] Hint: Exceeded Reach C-R2 outlet invert by 0.34' @ 12.10 hrs

Inflow Area = 9.560 ac, 0.00% Impervious, Inflow Depth > 4.68" for 25-Year event
Inflow = 49.75 cfs @ 12.08 hrs, Volume= 3.725 af
Outflow = 49.67 cfs @ 12.08 hrs, Volume= 3.724 af, Atten= 0%, Lag= 0.1 min

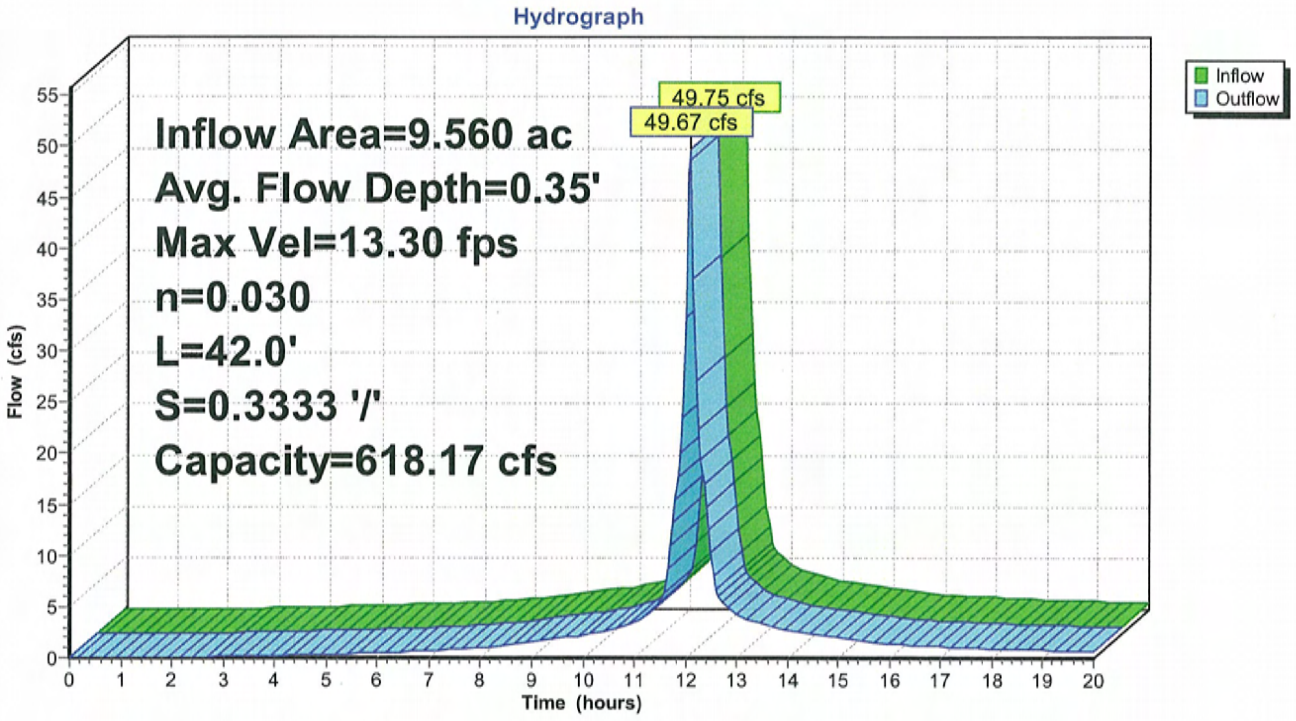
Routing by Stor-Ind+Trans method, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs
Max. Velocity= 13.30 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 3.52 fps, Avg. Travel Time= 0.2 min

Peak Storage= 156 cf @ 12.08 hrs
Average Depth at Peak Storage= 0.35'
Bank-Full Depth= 1.50', Capacity at Bank-Full= 618.17 cfs

10.00' x 1.50' deep channel, n= 0.030
Side Slope Z-value= 2.0 '/' Top Width= 16.00'
Length= 42.0' Slope= 0.3333 '/'
Inlet Invert= 65.00', Outlet Invert= 51.00'

‡

Reach C-R3: Downchute



Summary for Reach D-R1: Downchute

Inflow Area = 9.300 ac, 0.00% Impervious, Inflow Depth > 4.68" for 25-Year event
Inflow = 49.24 cfs @ 12.07 hrs, Volume= 3.625 af
Outflow = 48.93 cfs @ 12.07 hrs, Volume= 3.624 af, Atten= 1%, Lag= 0.2 min

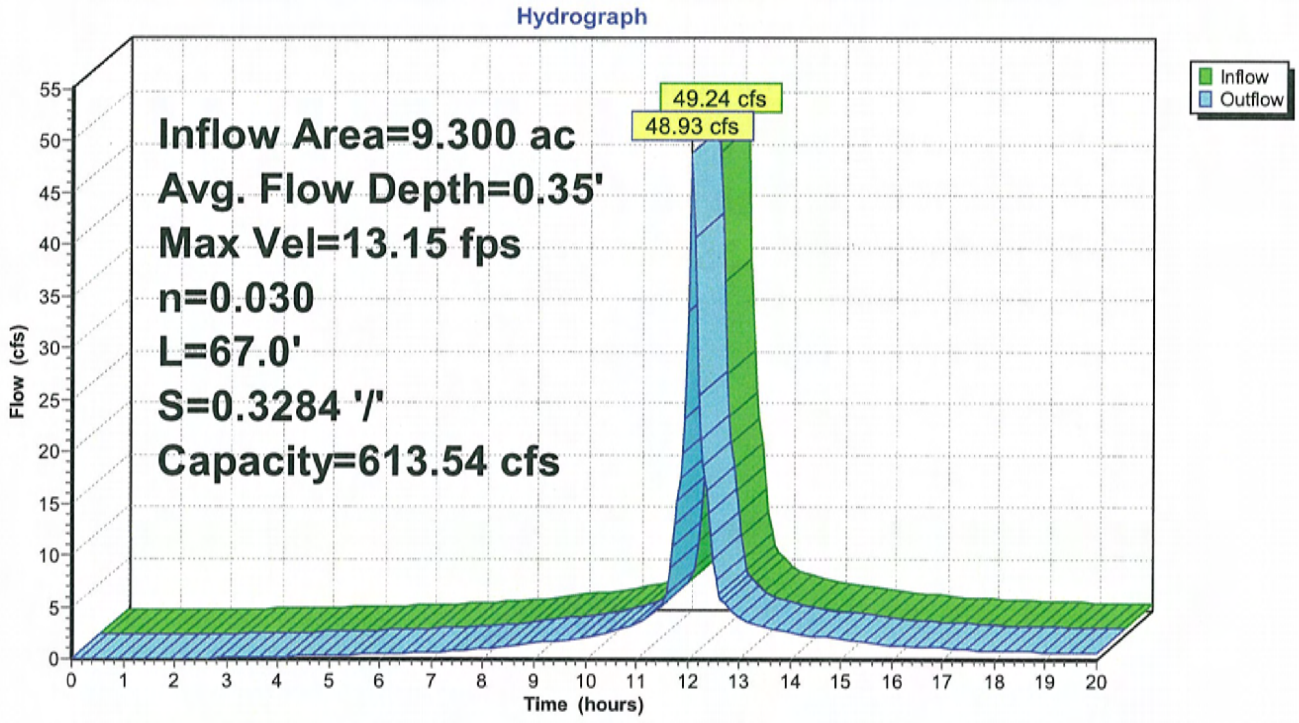
Routing by Stor-Ind+Trans method, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs
Max. Velocity= 13.15 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 3.47 fps, Avg. Travel Time= 0.3 min

Peak Storage= 248 cf @ 12.07 hrs
Average Depth at Peak Storage= 0.35'
Bank-Full Depth= 1.50', Capacity at Bank-Full= 613.54 cfs

10.00' x 1.50' deep channel, n= 0.030
Side Slope Z-value= 2.0 '/' Top Width= 16.00'
Length= 67.0' Slope= 0.3284 '/'
Inlet Invert= 128.00', Outlet Invert= 106.00'

‡

Reach D-R1: Downchute



Summary for Reach D-R2: Downchute

[62] Hint: Exceeded Reach D-R1 OUTLET depth by 0.06' @ 12.10 hrs

Inflow Area = 12.380 ac, 0.00% Impervious, Inflow Depth > 4.68" for 25-Year event
Inflow = 65.23 cfs @ 12.07 hrs, Volume= 4.825 af
Outflow = 64.47 cfs @ 12.08 hrs, Volume= 4.824 af, Atten= 1%, Lag= 0.3 min

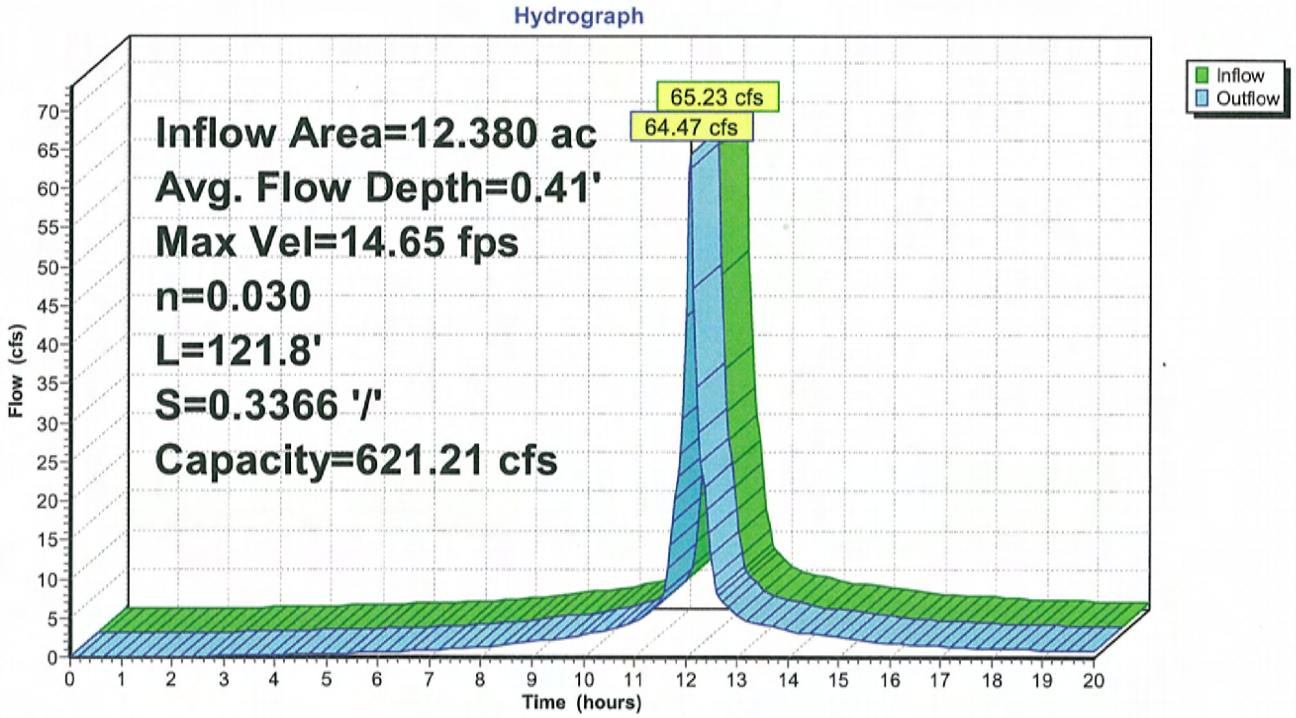
Routing by Stor-Ind+Trans method, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs
Max. Velocity= 14.65 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 3.88 fps, Avg. Travel Time= 0.5 min

Peak Storage= 533 cf @ 12.08 hrs
Average Depth at Peak Storage= 0.41'
Bank-Full Depth= 1.50', Capacity at Bank-Full= 621.21 cfs

10.00' x 1.50' deep channel, n= 0.030
Side Slope Z-value= 2.0 '/' Top Width= 16.00'
Length= 121.8' Slope= 0.3366 '/'
Inlet Invert= 106.00', Outlet Invert= 65.00'

‡

Reach D-R2: Downchute



Summary for Reach D-R3: Downchute

[61] Hint: Exceeded Reach D-R2 outlet invert by 0.40' @ 12.10 hrs

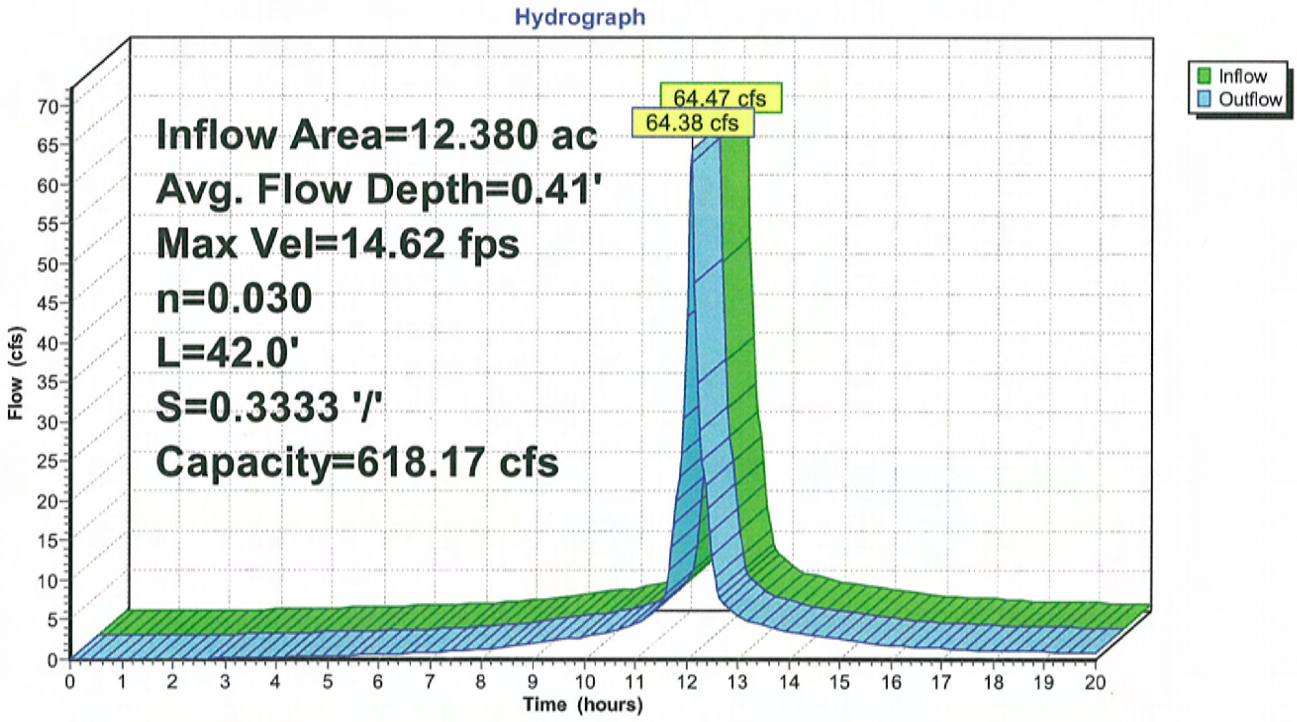
Inflow Area = 12.380 ac, 0.00% Impervious, Inflow Depth > 4.68" for 25-Year event
Inflow = 64.47 cfs @ 12.08 hrs, Volume= 4.824 af
Outflow = 64.38 cfs @ 12.08 hrs, Volume= 4.823 af, Atten= 0%, Lag= 0.1 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs
Max. Velocity= 14.62 fps, Min. Travel Time= 0.0 min
Avg. Velocity = 3.87 fps, Avg. Travel Time= 0.2 min

Peak Storage= 184 cf @ 12.08 hrs
Average Depth at Peak Storage= 0.41'
Bank-Full Depth= 1.50', Capacity at Bank-Full= 618.17 cfs

10.00' x 1.50' deep channel, n= 0.030
Side Slope Z-value= 2.0 '/' Top Width= 16.00'
Length= 42.0' Slope= 0.3333 '/'
Inlet Invert= 65.00', Outlet Invert= 51.00'

‡



Summary for Pond 29P: Swale Storage

[63] Warning: Exceeded Reach 4R INLET depth by 0.36' @ 12.45 hrs

Inflow Area = 38.160 ac, 0.00% Impervious, Inflow Depth > 4.59" for 25-Year event
Inflow = 142.75 cfs @ 12.24 hrs, Volume= 14.595 af
Outflow = 121.51 cfs @ 12.36 hrs, Volume= 14.581 af, Atten= 15%, Lag= 6.8 min
Primary = 121.51 cfs @ 12.36 hrs, Volume= 14.581 af
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs
Peak Elev= 45.20' @ 12.36 hrs Surf.Area= 0.792 ac Storage= 0.975 af

Plug-Flow detention time= 4.1 min calculated for 14.581 af (100% of inflow)
Center-of-Mass det. time= 3.7 min (757.1 - 753.5)

Volume	Invert	Avail.Storage	Storage Description
#1	42.30'	4.485 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

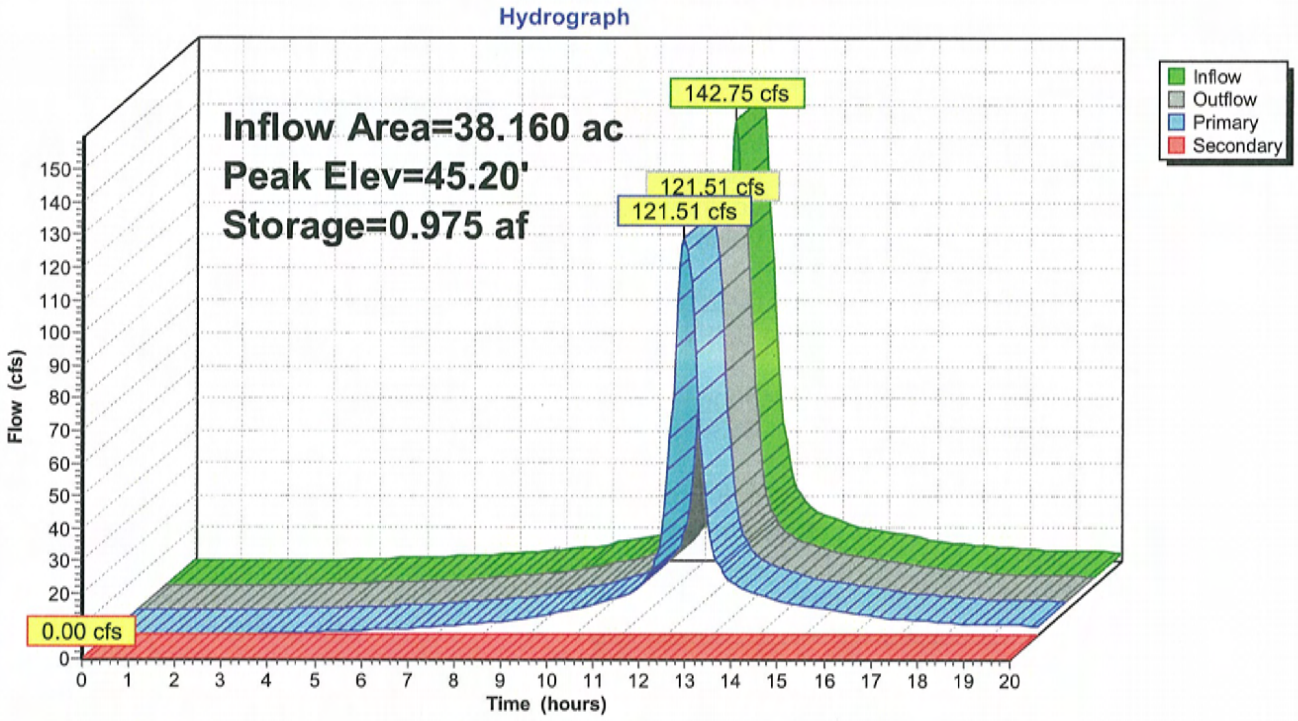
Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
42.30	0.001	0.000	0.000
44.00	0.346	0.295	0.295
46.00	1.092	1.438	1.733
48.00	1.660	2.752	4.485

Device	Routing	Invert	Outlet Devices
#1	Primary	42.30'	**36.0" Vert. Orifice/Grate X 3.00** C= 0.600
#2	Secondary	47.00'	**25.0' long x 12.0' breadth Broad-Crested Rectangular Weir**
			Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60
			Coef. (English) 2.57 2.62 2.70 2.67 2.66 2.67 2.66 2.64

Primary OutFlow Max=121.31 cfs @ 12.36 hrs HW=45.19' (Free Discharge)
↑—**1=Orifice/Grate** (Orifice Controls 121.31 cfs @ 5.79 fps)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=42.30' (Free Discharge)
↑—**2=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Pond 29P: Swale Storage

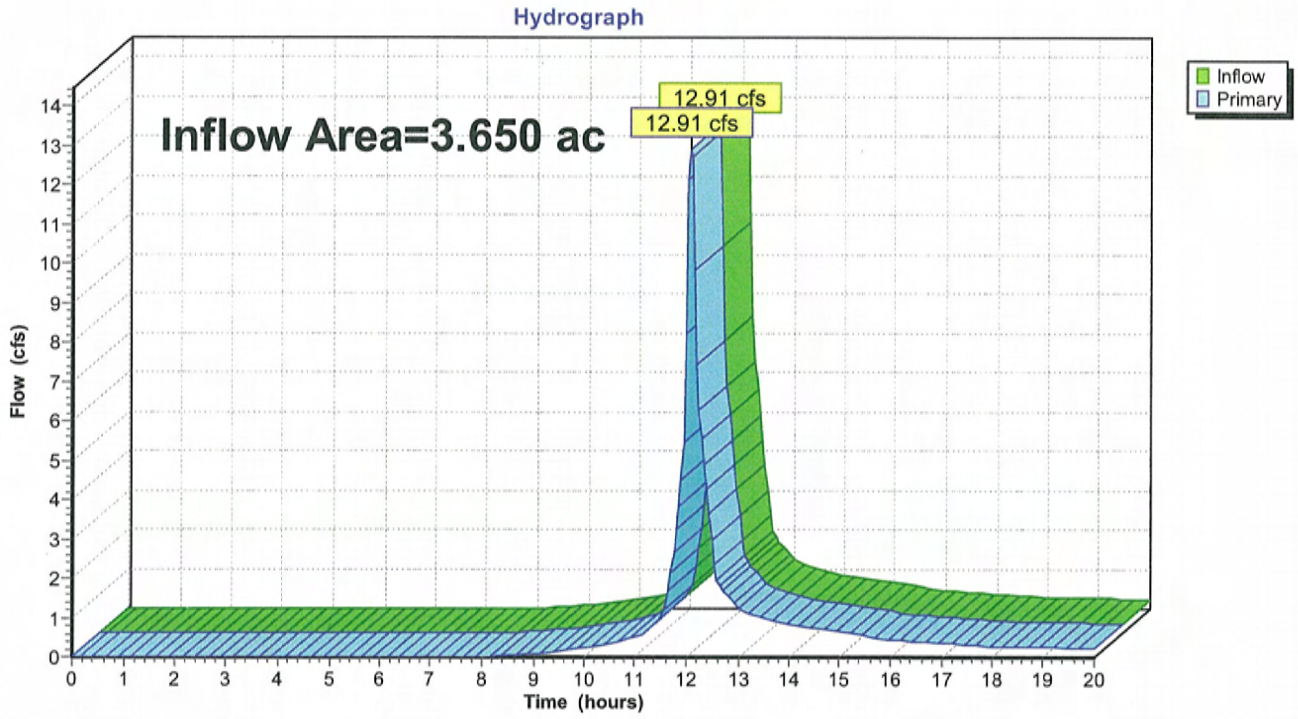


Summary for Link 27L: CL-CB

Inflow Area = 3.650 ac, 0.00% Impervious, Inflow Depth > 2.84" for 25-Year event
Inflow = 12.91 cfs @ 12.08 hrs, Volume= 0.864 af
Primary = 12.91 cfs @ 12.08 hrs, Volume= 0.864 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs

Link 27L: CL-CB

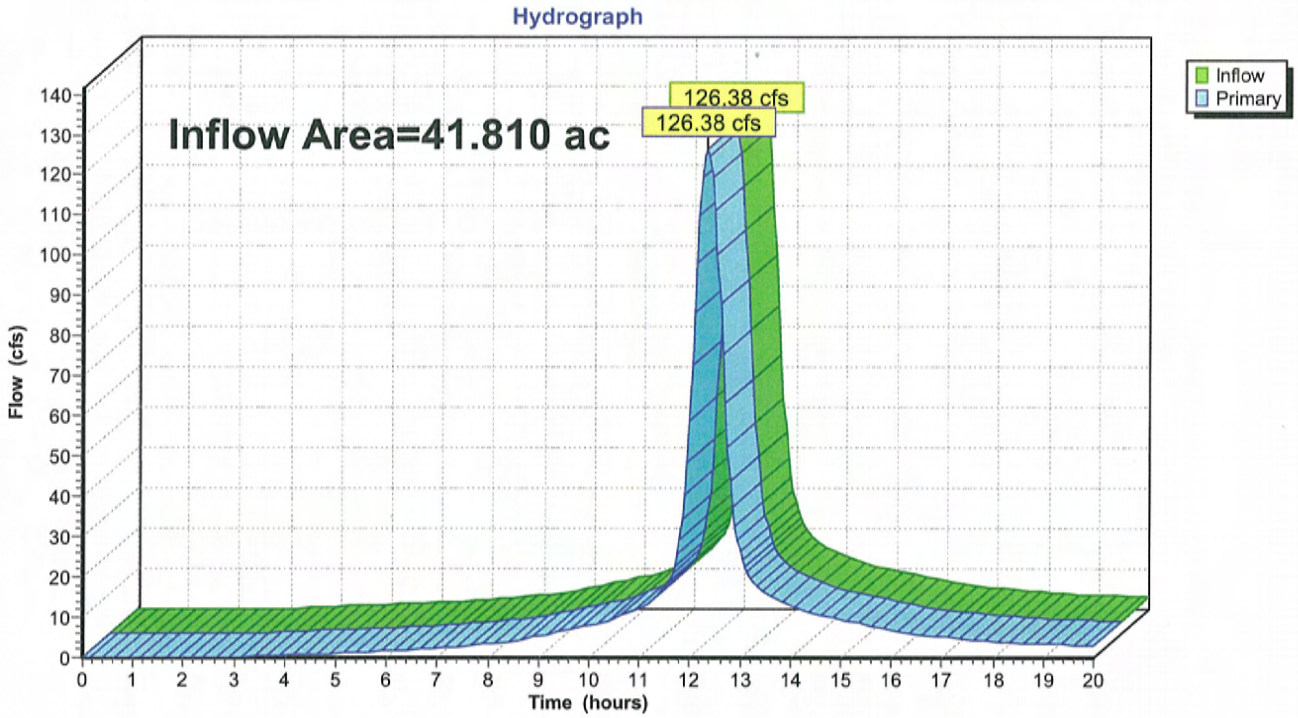


Summary for Link 28L: Dike Drainage Ditch

Inflow Area = 41.810 ac, 0.00% Impervious, Inflow Depth > 4.43" for 25-Year event
Inflow = 126.38 cfs @ 12.35 hrs, Volume= 15.446 af
Primary = 126.38 cfs @ 12.35 hrs, Volume= 15.446 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs

Link 28L: Dike Drainage Ditch



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Appendix D

Closure Turf™ Swale and Culvert Calculations

Worksheet for Alternative A - Upper Side Slope Diversion Swale

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.030	
Channel Slope	0.05000	ft/ft
Left Side Slope	2.00	ft/ft (H:V)
Right Side Slope	2.00	ft/ft (H:V)
Bottom Width	4.00	ft
Discharge	28.69	ft^3/s

Results

Normal Depth	0.72	ft
Flow Area	3.90	ft^2
Wetted Perimeter	7.21	ft
Hydraulic Radius	0.54	ft
Top Width	6.87	ft
Critical Depth	0.98	ft
Critical Slope	0.01564	ft/ft
Velocity	7.35	ft/s
Velocity Head	0.84	ft
Specific Energy	1.56	ft
Froude Number	1.72	
Flow Type	Supercritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.72	ft
Critical Depth	0.98	ft
Channel Slope	0.05000	ft/ft

Worksheet for Alternative A - Upper Side Slope Diversion Swale

GVF Output Data

Critical Slope	0.01564	ft/ft

Messages

Notes

Roughness coefficient of 0.030 provided by manufacturer.
Discharge taken from HydraCAD output.

Cross Section for Alternative A - Upper Side Slope Diversion Swale

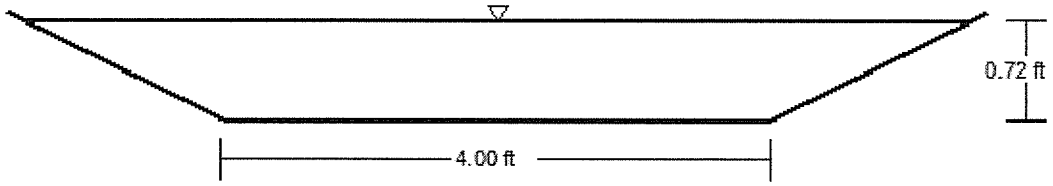
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.030	
Channel Slope	0.05000	ft/ft
Normal Depth	0.72	ft
Left Side Slope	2.00	ft/ft (H:V)
Right Side Slope	2.00	ft/ft (H:V)
Bottom Width	4.00	ft
Discharge	28.69	ft³/s

Cross Section Image



V: 1
H: 1

Worksheet for Alternative A - Lower Side Slope Diversion Swale

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.030	
Channel Slope	0.05000	ft/ft
Left Side Slope	2.00	ft/ft (H:V)
Right Side Slope	2.00	ft/ft (H:V)
Bottom Width	4.00	ft
Discharge	10.32	ft^3/s

Results

Normal Depth	0.40	ft
Flow Area	1.94	ft^2
Wetted Perimeter	5.80	ft
Hydraulic Radius	0.33	ft
Top Width	5.61	ft
Critical Depth	0.54	ft
Critical Slope	0.01814	ft/ft
Velocity	5.33	ft/s
Velocity Head	0.44	ft
Specific Energy	0.84	ft
Froude Number	1.60	
Flow Type	Supercritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.40	ft
Critical Depth	0.54	ft
Channel Slope	0.05000	ft/ft

Worksheet for Alternative A - Lower Side Slope Diversion Swale

GVF Output Data

Critical Slope	0.01814	ft/ft

Messages

Notes

Roughness coefficient of 0.030 provided by manufacturer.
Discharge taken from HydraCAD output.

Cross Section for Alternative A - Lower Side Slope Diversion Swale

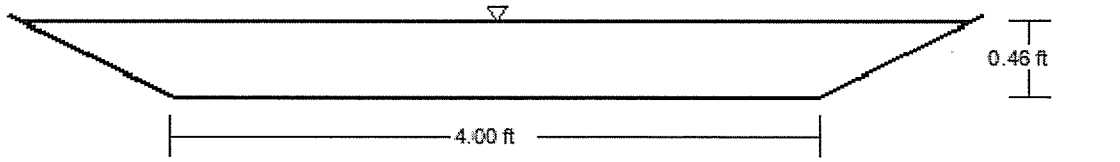
Project Description

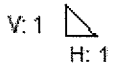
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.030	
Channel Slope	0.05000	ft/ft
Normal Depth	0.46	ft
Left Side Slope	2.00	ft/ft (H:V)
Right Side Slope	2.00	ft/ft (H:V)
Bottom Width	4.00	ft
Discharge	13.08	ft³/s

Cross Section Image





Worksheet for Alternative A - Side Slope Diversion Underdrain (Full

Project Description

Friction Method	Manning Formula
Solve For	Full Flow Capacity

Input Data

Roughness Coefficient	0.010	
Channel Slope	0.05000	ft/ft
Normal Depth	0.33	ft
Diameter	0.33	ft
Discharge	0.54	ft^3/s

Results

Discharge	0.54	ft^3/s
Normal Depth	0.33	ft
Flow Area	0.09	ft^2
Wetted Perimeter	1.04	ft
Hydraulic Radius	0.08	ft
Top Width	0.00	ft
Critical Depth	0.33	ft
Percent Full	100.0	%
Critical Slope	0.04587	ft/ft
Velocity	6.30	ft/s
Velocity Head	0.62	ft
Specific Energy	0.95	ft
Froude Number	0.00	
Maximum Discharge	0.58	ft^3/s
Discharge Full	0.54	ft^3/s
Slope Full	0.05000	ft/ft
Flow Type	SubCritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Average End Depth Over Rise	0.00	%

Worksheet for Alternative A - Side Slope Diversion Underdrain (Full

GVF Output Data

Normal Depth Over Rise	100.00	%
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.33	ft
Critical Depth	0.33	ft
Channel Slope	0.05000	ft/ft
Critical Slope	0.04587	ft/ft

Messages

Notes

Full flow for side slope diversion underdrain

Worksheet for Alternative A - Downchute

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.030	
Channel Slope	0.33000	ft/ft
Left Side Slope	2.00	ft/ft (H:V)
Right Side Slope	2.00	ft/ft (H:V)
Bottom Width	10.00	ft
Discharge	64.38	ft^3/s

Results

Normal Depth	0.41	ft
Flow Area	4.38	ft^2
Wetted Perimeter	11.81	ft
Hydraulic Radius	0.37	ft
Top Width	11.62	ft
Critical Depth	1.01	ft
Critical Slope	0.01438	ft/ft
Velocity	14.70	ft/s
Velocity Head	3.36	ft
Specific Energy	3.76	ft
Froude Number	4.22	
Flow Type	Supercritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.41	ft
Critical Depth	1.01	ft
Channel Slope	0.33000	ft/ft

Worksheet for Alternative A - Downchute

GVF Output Data

Critical Slope	0.01438	ft/ft

Messages

Notes

Roughness coefficient of 0.030 provided by manufacturer.
Discharge taken from HydraCAD output.

Cross Section for Alternative A - Downchute

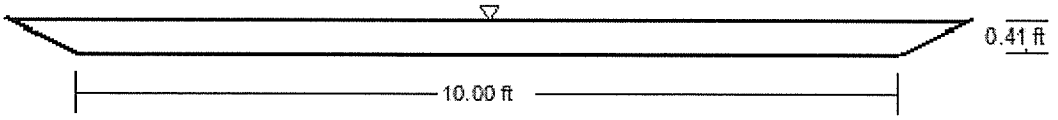
Project Description

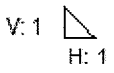
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.030	
Channel Slope	0.33000	ft/ft
Normal Depth	0.41	ft
Left Side Slope	2.00	ft/ft (H:V)
Right Side Slope	2.00	ft/ft (H:V)
Bottom Width	10.00	ft
Discharge	64.38	ft³/s

Cross Section Image





Worksheet for Alternative A - Downchute Underdrain (Full Flow)

Project Description

Friction Method	Manning Formula
Solve For	Full Flow Diameter

Input Data

Roughness Coefficient	0.010	
Channel Slope	0.33333	ft/ft
Normal Depth	0.39	ft
Diameter	0.39	ft
Discharge	2.16	ft^3/s

Results

Diameter	0.39	ft
Normal Depth	0.39	ft
Flow Area	0.12	ft^2
Wetted Perimeter	1.22	ft
Hydraulic Radius	0.10	ft
Top Width	0.00	ft
Critical Depth	0.39	ft
Percent Full	100.0	%
Critical Slope	0.33405	ft/ft
Velocity	18.17	ft/s
Velocity Head	5.13	ft
Specific Energy	5.52	ft
Froude Number	0.00	
Maximum Discharge	2.32	ft^3/s
Discharge Full	2.16	ft^3/s
Slope Full	0.33405	ft/ft
Flow Type	Critical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Average End Depth Over Rise	0.00	%

Worksheet for Alternative A - Downchute Underdrain (Full Flow)

GVF Output Data

Normal Depth Over Rise	100.00	%
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.39	ft
Critical Depth	0.39	ft
Channel Slope	0.33333	ft/ft
Critical Slope	0.33405	ft/ft

Messages

Notes

Discharge taken from the sum of 4 full side slope underdrains

Worksheet for Alternative A - Eastern Dike Swale

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.016	
Channel Slope	0.00080	ft/ft
Constructed Depth	4.00	ft
Constructed Top Width	25.00	ft
Discharge	142.75	ft^3/s

Results

Normal Depth	2.73	ft
Flow Area	37.55	ft^2
Wetted Perimeter	21.57	ft
Hydraulic Radius	1.74	ft
Top Width	20.65	ft
Critical Depth	1.92	ft
Critical Slope	0.00324	ft/ft
Velocity	3.80	ft/s
Velocity Head	0.22	ft
Specific Energy	2.95	ft
Froude Number	0.50	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	2.73	ft
Critical Depth	1.92	ft
Channel Slope	0.00080	ft/ft
Critical Slope	0.00324	ft/ft

Worksheet for Alternative A - Eastern Dike Swale

Messages

Notes

Discharge taken from HydraCAD output.

Cross Section for Alternative A - Eastern Dike Swale

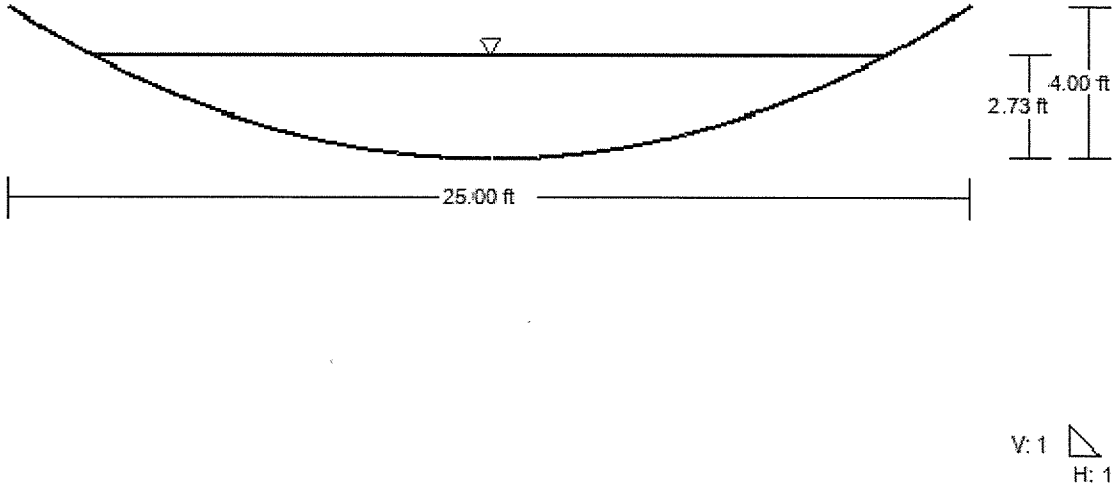
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.016	
Channel Slope	0.00080	ft/ft
Constructed Depth	4.00	ft
Normal Depth	2.73	ft
Constructed Top Width	25.00	ft
Discharge	142.75	ft³/s

Cross Section Image



Culvert Calculator Report
Alternative A - Eastern Dike Swale Culvert

Comments: Discharge taken from HydraCAD output.

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	47.00	ft	Headwater Depth/Height	1.19	
Computed Headwater Eleva	45.86	ft	Discharge	142.75	cfs
Inlet Control HW Elev.	45.81	ft	Tailwater Elevation	0.00	ft
Outlet Control HW Elev.	45.86	ft	Control Type	Entrance Control	

Grades					
Upstream Invert	42.30	ft	Downstream Invert	42.00	ft
Length	30.00	ft	Constructed Slope	0.010000	ft/ft

Hydraulic Profile					
Profile	S2		Depth, Downstream	1.99	ft
Slope Type	Steep		Normal Depth	1.87	ft
Flow Regime	Supercritical		Critical Depth	2.25	ft
Velocity Downstream	9.55	ft/s	Critical Slope	0.006141	ft/ft

Section					
Section Shape	Circular		Mannings Coefficient	0.013	
Section Material	Concrete		Span	3.00	ft
Section Size	36 inch		Rise	3.00	ft
Number Sections	3				

Outlet Control Properties					
Outlet Control HW Elev.	45.86	ft	Upstream Velocity Head	1.09	ft
Ke	0.20		Entrance Loss	0.22	ft

Inlet Control Properties					
Inlet Control HW Elev.	45.81	ft	Flow Control	Transition	
Inlet Type	Groove end w/headwall		Area Full	21.2	ft²
K	0.00180		HDS 5 Chart	1	
M	2.00000		HDS 5 Scale	2	
C	0.02920		Equation Form	1	
Y	0.74000				

Worksheet for Alternative A - Vegetated Drainage Ditch

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.045	
Channel Slope	0.06000	ft/ft
Left Side Slope	4.00	ft/ft (H:V)
Right Side Slope	4.00	ft/ft (H:V)
Bottom Width	4.00	ft
Discharge	126.38	ft^3/s

Results

Normal Depth	1.57	ft
Flow Area	16.14	ft^2
Wetted Perimeter	16.95	ft
Hydraulic Radius	0.95	ft
Top Width	16.56	ft
Critical Depth	1.85	ft
Critical Slope	0.02933	ft/ft
Velocity	7.83	ft/s
Velocity Head	0.95	ft
Specific Energy	2.52	ft
Froude Number	1.40	
Flow Type	Supercritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	1.57	ft
Critical Depth	1.85	ft
Channel Slope	0.06000	ft/ft

Worksheet for Alternative A - Vegetated Drainage Ditch

GVF Output Data

Critical Slope	0.02933	ft/ft

Messages

Notes

Roughness coefficient of 0.030 provided by manufacturer.
Discharge taken from HydraCAD output.

Cross Section for Alternative A - Vegetated Drainage Ditch

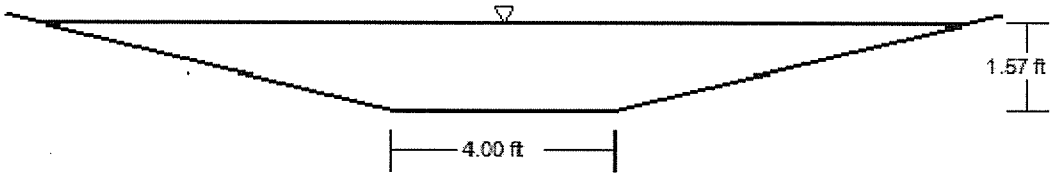
Project Description

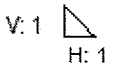
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.045	
Channel Slope	0.06000	ft/ft
Normal Depth	1.57	ft
Left Side Slope	4.00	ft/ft (H:V)
Right Side Slope	4.00	ft/ft (H:V)
Bottom Width	4.00	ft
Discharge	126.38	ft³/s

Cross Section Image





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Appendix E

Exposed TPO Watershed Analysis

No.	DATE	DESCRIPTION	DESIGNER	REVIEWER
1.			XX/XX	XX

SCALE:
HORZ.: 1" = 200'
VERT.:
DATUM:
HORZ.:
VERT.:
0 100 200
GRAPHIC SCALE

FUSS & O'NEILL
146 HARTFORD ROAD
MANCHESTER, CONNECTICUT 06040
860.646.2469
www.fando.com

CONNECTICUT RESOURCES RECOVERY AUTHORITY

PROPOSED DRAINAGE AREAS EXPOSED TPO ALTERNATIVE

AMENDMENT TO THE
HARTFORD LANDFILL CLOSURE PLAN

HARTFORD CONNECTICUT

PROJ. No.: 2010 0123.H20
DATE: JULY 2011

DRA-11

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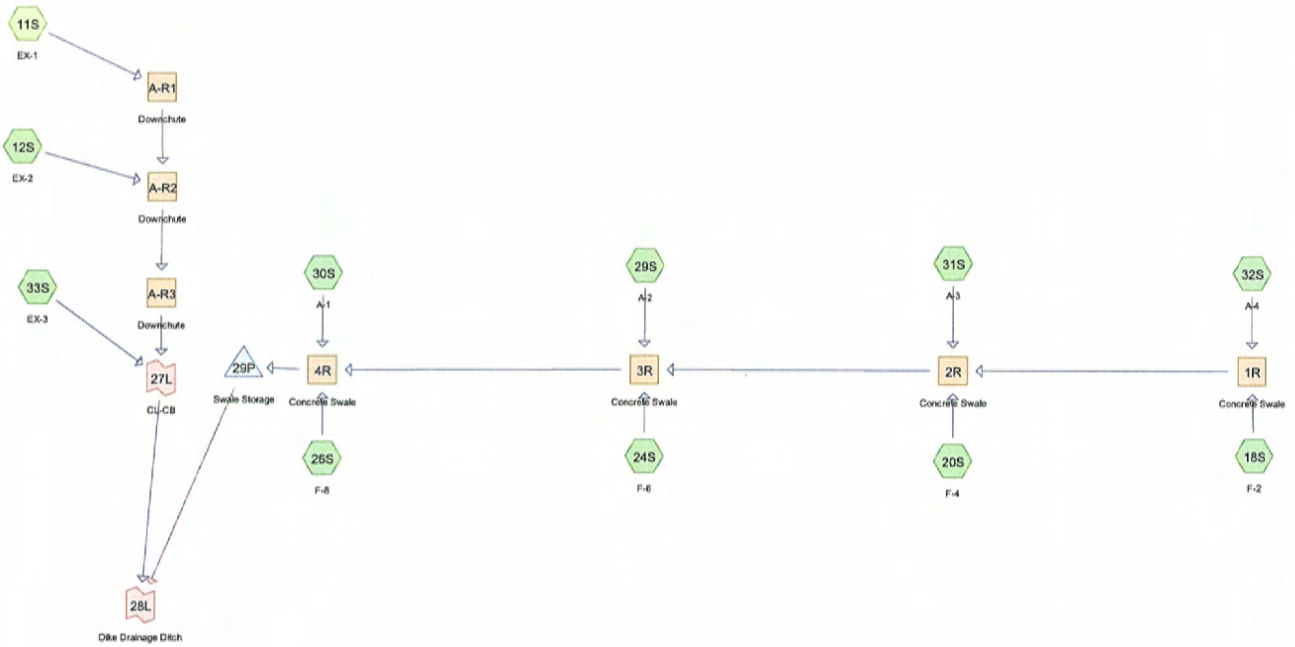
MS VIEW: LAYER STATE:



Subcat Reach Pond Link

Drainage Diagram for Proposed_Exposed_TPO
Prepared by Fuss & O'Neill Inc., Printed 12/7/2011
HydroCAD® 9.10 s/n 06397 © 2009 HydroCAD Software Solutions LLC

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
3.650	77	Existing Landfill (11S, 12S, 33S)
3.100	89	Gravel roads, HSG C (18S, 20S, 24S, 26S)
35.060	98	(29S, 30S, 31S, 32S)
41.810		**TOTAL AREA**

Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
0.000	HSG A	
0.000	HSG B	
3.100	HSG C	18S, 20S, 24S, 26S
0.000	HSG D	
38.710	Other	11S, 12S, 29S, 30S, 31S, 32S, 33S
41.810		**TOTAL AREA**

Time span=0.00-20.00 hrs, dt=0.05 hrs, 401 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 11S: EX-1 Runoff Area=0.380 ac 0.00% Impervious Runoff Depth>2.84"
Tc=5.0 min CN=77 Runoff=1.36 cfs 0.090 af

Subcatchment 12S: EX-2 Runoff Area=0.440 ac 0.00% Impervious Runoff Depth>2.84"
Tc=5.0 min CN=77 Runoff=1.57 cfs 0.104 af

Subcatchment 18S: F-2 Runoff Area=0.790 ac 0.00% Impervious Runoff Depth>4.02"
Tc=5.0 min CN=89 Runoff=3.82 cfs 0.265 af

Subcatchment 20S: F-4 Runoff Area=0.800 ac 0.00% Impervious Runoff Depth>4.02"
Tc=5.0 min CN=89 Runoff=3.87 cfs 0.268 af

Subcatchment 24S: F-6 Runoff Area=0.660 ac 0.00% Impervious Runoff Depth>4.02"
Tc=5.0 min CN=89 Runoff=3.20 cfs 0.221 af

Subcatchment 26S: F-8 Runoff Area=0.850 ac 0.00% Impervious Runoff Depth>4.02"
Tc=5.0 min CN=89 Runoff=4.11 cfs 0.285 af

Subcatchment 29S: A-2 Runoff Area=8.730 ac 100.00% Impervious Runoff Depth>5.02"
Tc=5.0 min CN=98 Runoff=47.32 cfs 3.654 af

Subcatchment 30S: A-1 Runoff Area=5.220 ac 100.00% Impervious Runoff Depth>5.02"
Tc=5.0 min CN=98 Runoff=28.30 cfs 2.185 af

Subcatchment 31S: A-3 Runoff Area=11.580 ac 100.00% Impervious Runoff Depth>5.02"
Tc=5.0 min CN=98 Runoff=62.77 cfs 4.847 af

Subcatchment 32S: A-4 Runoff Area=9.530 ac 100.00% Impervious Runoff Depth>5.02"
Tc=5.0 min CN=98 Runoff=51.66 cfs 3.989 af

Subcatchment 33S: EX-3 Runoff Area=2.830 ac 0.00% Impervious Runoff Depth>2.84"
Tc=5.0 min CN=77 Runoff=10.12 cfs 0.670 af

Reach 1R: Concrete Swale Avg. Flow Depth=1.13' Max Vel=5.23 fps Inflow=55.49 cfs 4.253 af
n=0.013 L=785.0' S=0.0031 '/' Capacity=785.22 cfs Outflow=51.49 cfs 4.241 af

Reach 2R: Concrete Swale Avg. Flow Depth=1.99' Max Vel=4.38 fps Inflow=108.97 cfs 9.356 af
n=0.013 L=806.0' S=0.0011 '/' Capacity=456.44 cfs Outflow=102.75 cfs 9.324 af

Reach 3R: Concrete Swale Avg. Flow Depth=2.24' Max Vel=4.69 fps Inflow=133.11 cfs 13.199 af
n=0.013 L=673.0' S=0.0010 '/' Capacity=453.30 cfs Outflow=130.22 cfs 13.165 af

Reach 4R: Concrete Swale Avg. Flow Depth=2.49' Max Vel=4.40 fps Inflow=145.52 cfs 15.635 af
n=0.013 L=628.0' S=0.0008 '/' Capacity=396.60 cfs Outflow=143.27 cfs 15.594 af

Reach A-R1: Downchute Avg. Flow Depth=0.03' Max Vel=4.17 fps Inflow=1.36 cfs 0.090 af
n=0.017 L=101.0' S=0.2178 '/' Capacity=881.84 cfs Outflow=1.35 cfs 0.090 af

Reach A-R2: Downchute Avg. Flow Depth=0.05' Max Vel=5.77 fps Inflow=2.91 cfs 0.194 af
n=0.017 L=157.0' S=0.2357 '/' Capacity=917.26 cfs Outflow=2.87 cfs 0.194 af

Reach A-R3: Downchute Avg. Flow Depth=0.05' Max Vel=5.98 fps Inflow=2.87 cfs 0.194 af
n=0.017 L=48.0' S=0.2708 '/' Capacity=983.31 cfs Outflow=2.86 cfs 0.194 af

Pond 29P: Swale Storage Peak Elev=45.23' Storage=1.004 af Inflow=143.27 cfs 15.594 af
Primary=122.88 cfs 15.581 af Secondary=0.00 cfs 0.000 af Outflow=122.88 cfs 15.581 af

Link 27L: CL-CB Inflow=12.91 cfs 0.864 af
Primary=12.91 cfs 0.864 af

Link 28L: Dike Drainage Ditch Inflow=127.46 cfs 16.445 af
Primary=127.46 cfs 16.445 af

Total Runoff Area = 41.810 ac Runoff Volume = 16.577 af Average Runoff Depth = 4.76"
16.14% Pervious = 6.750 ac 83.86% Impervious = 35.060 ac

Summary for Subcatchment 11S: EX-1

[49] Hint: Tc<2dt may require smaller dt

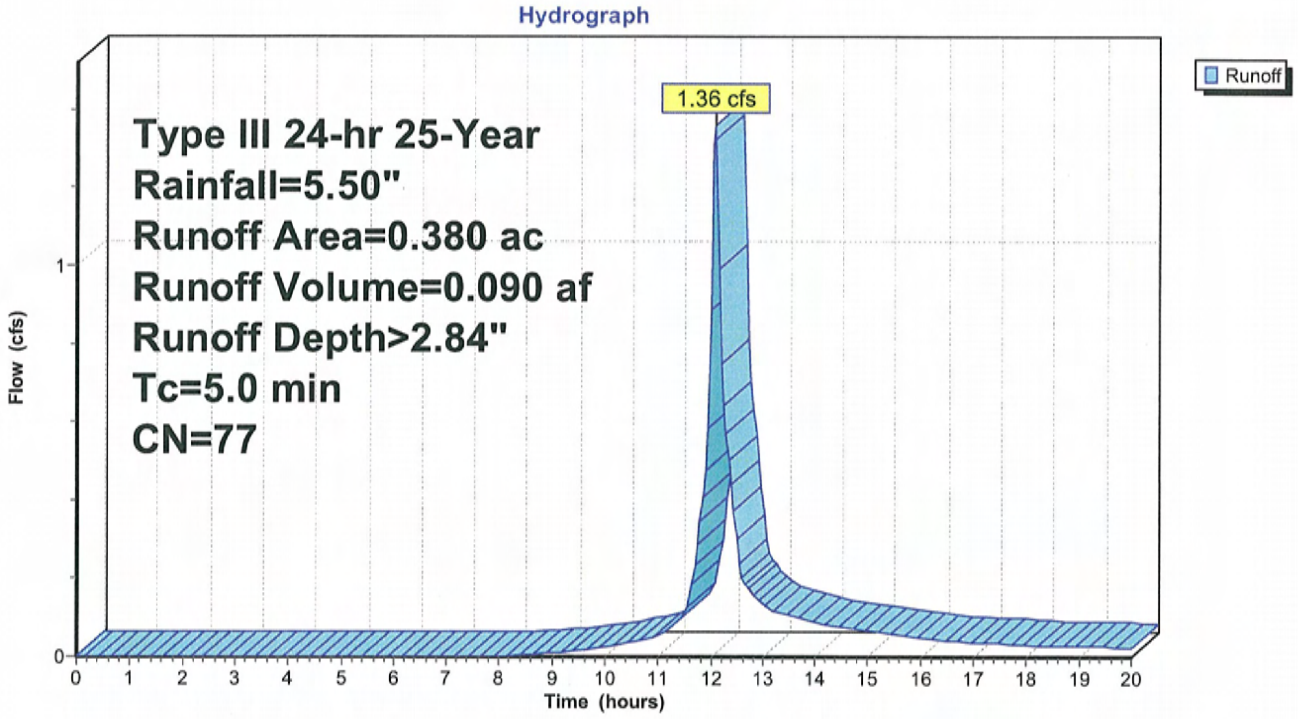
Runoff = 1.36 cfs @ 12.08 hrs, Volume= 0.090 af, Depth> 2.84"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=5.50"

	Area (ac)	CN	Description
*	0.380	77	Existing Landfill
	0.380		100.00% Pervious Area

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

Subcatchment 11S: EX-1



Summary for Subcatchment 12S: EX-2

[49] Hint: Tc<2dt may require smaller dt

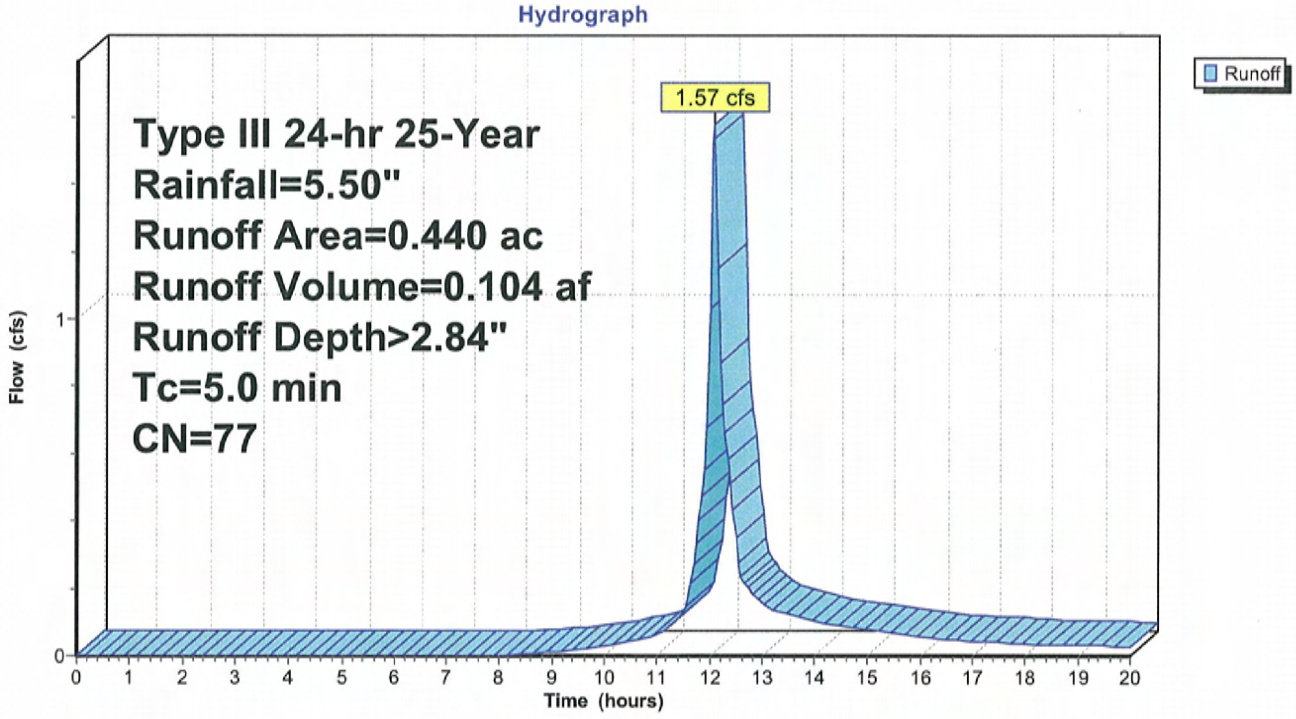
Runoff = 1.57 cfs @ 12.08 hrs, Volume= 0.104 af, Depth> 2.84"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=5.50"

	Area (ac)	CN	Description
*	0.440	77	Existing Landfill
	0.440		100.00% Pervious Area

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

Subcatchment 12S: EX-2



Summary for Subcatchment 18S: F-2

[49] Hint: Tc<2dt may require smaller dt

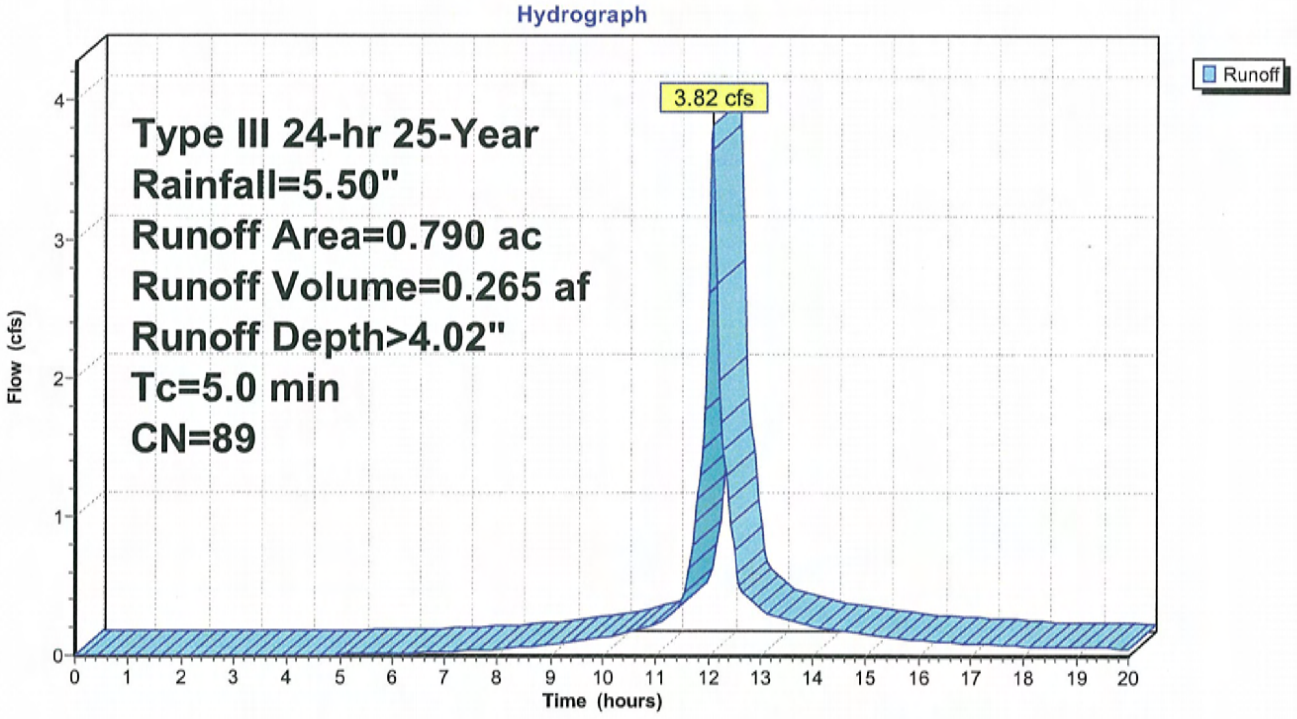
Runoff = 3.82 cfs @ 12.07 hrs, Volume= 0.265 af, Depth> 4.02"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=5.50"

Area (ac)	CN	Description
0.790	89	Gravel roads, HSG C
0.790		100.00% Pervious Area

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

Subcatchment 18S: F-2



Summary for Subcatchment 20S: F-4

[49] Hint: Tc<2dt may require smaller dt

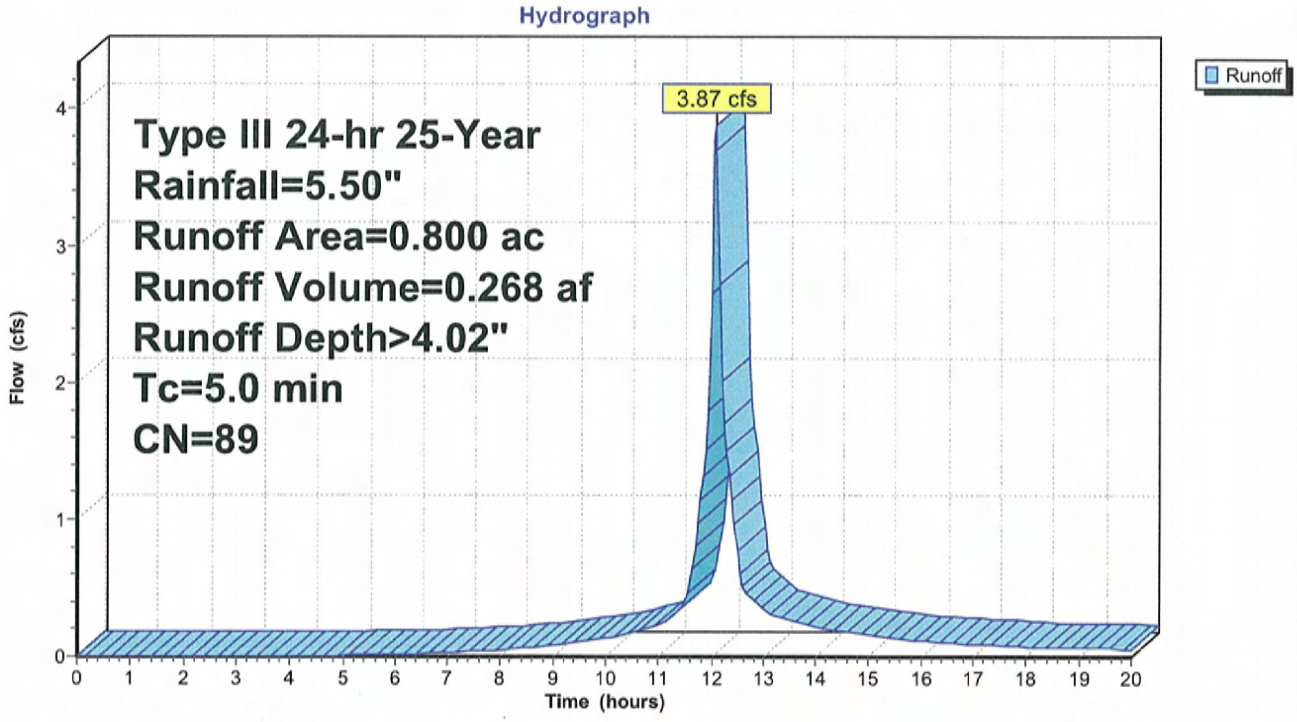
Runoff = 3.87 cfs @ 12.07 hrs, Volume= 0.268 af, Depth> 4.02"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=5.50"

Area (ac)	CN	Description
0.800	89	Gravel roads, HSG C
0.800		100.00% Pervious Area

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

Subcatchment 20S: F-4



Summary for Subcatchment 24S: F-6

[49] Hint: Tc<2dt may require smaller dt

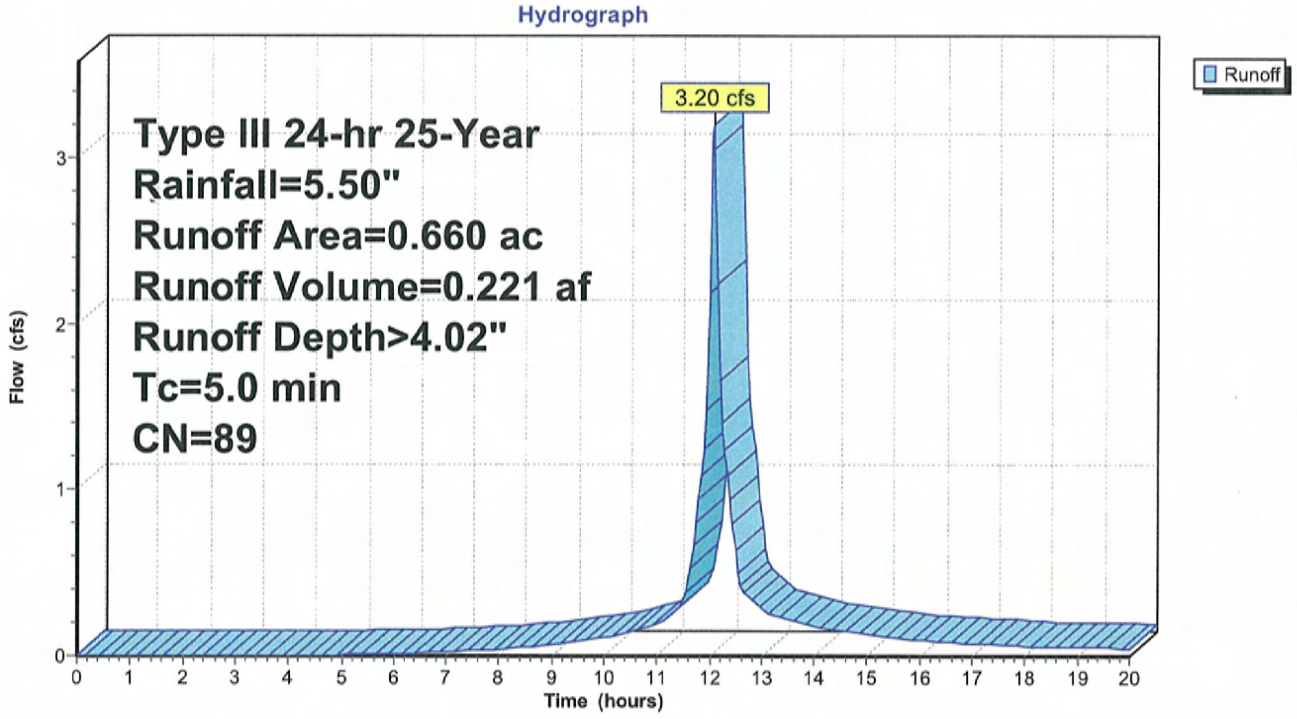
Runoff = 3.20 cfs @ 12.07 hrs, Volume= 0.221 af, Depth> 4.02"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=5.50"

Area (ac)	CN	Description
0.660	89	Gravel roads, HSG C
0.660		100.00% Pervious Area

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

Subcatchment 24S: F-6



Summary for Subcatchment 26S: F-8

[49] Hint: Tc<2dt may require smaller dt

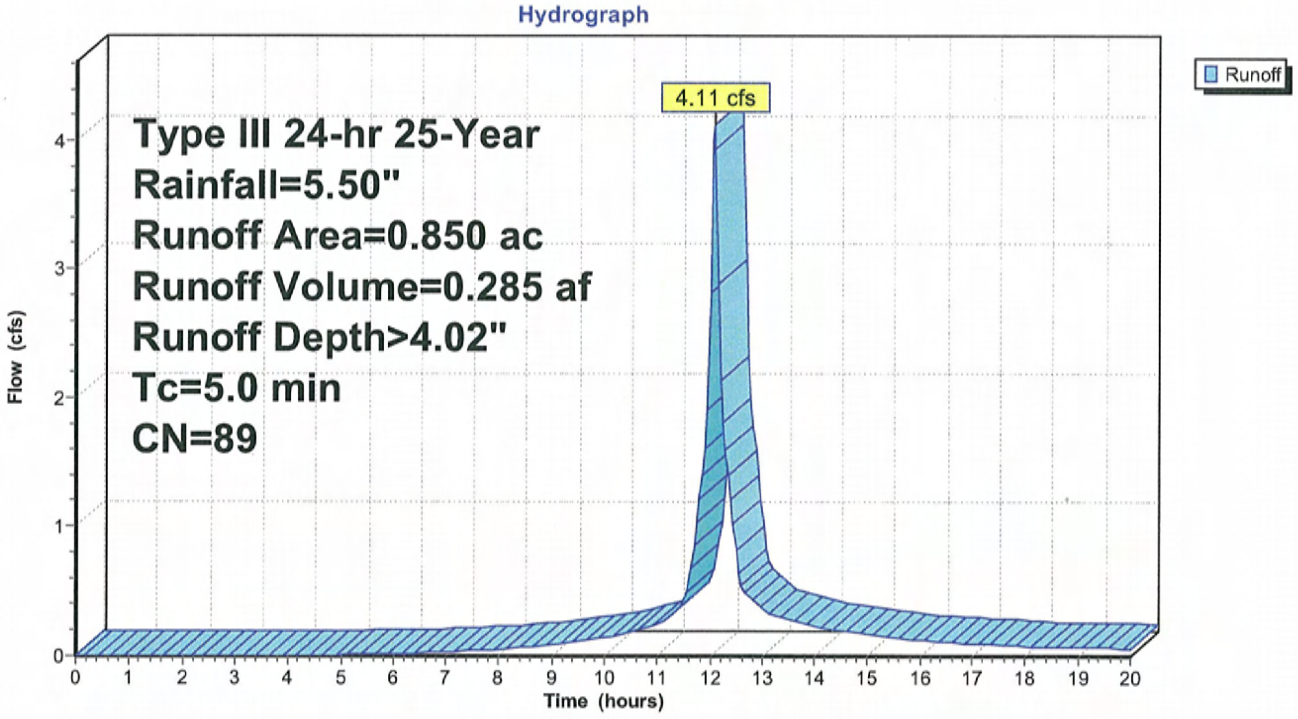
Runoff = 4.11 cfs @ 12.07 hrs, Volume= 0.285 af, Depth> 4.02"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=5.50"

Area (ac)	CN	Description
0.850	89	Gravel roads, HSG C
0.850		100.00% Pervious Area

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

Subcatchment 26S: F-8



Summary for Subcatchment 29S: A-2

[49] Hint: Tc<2dt may require smaller dt

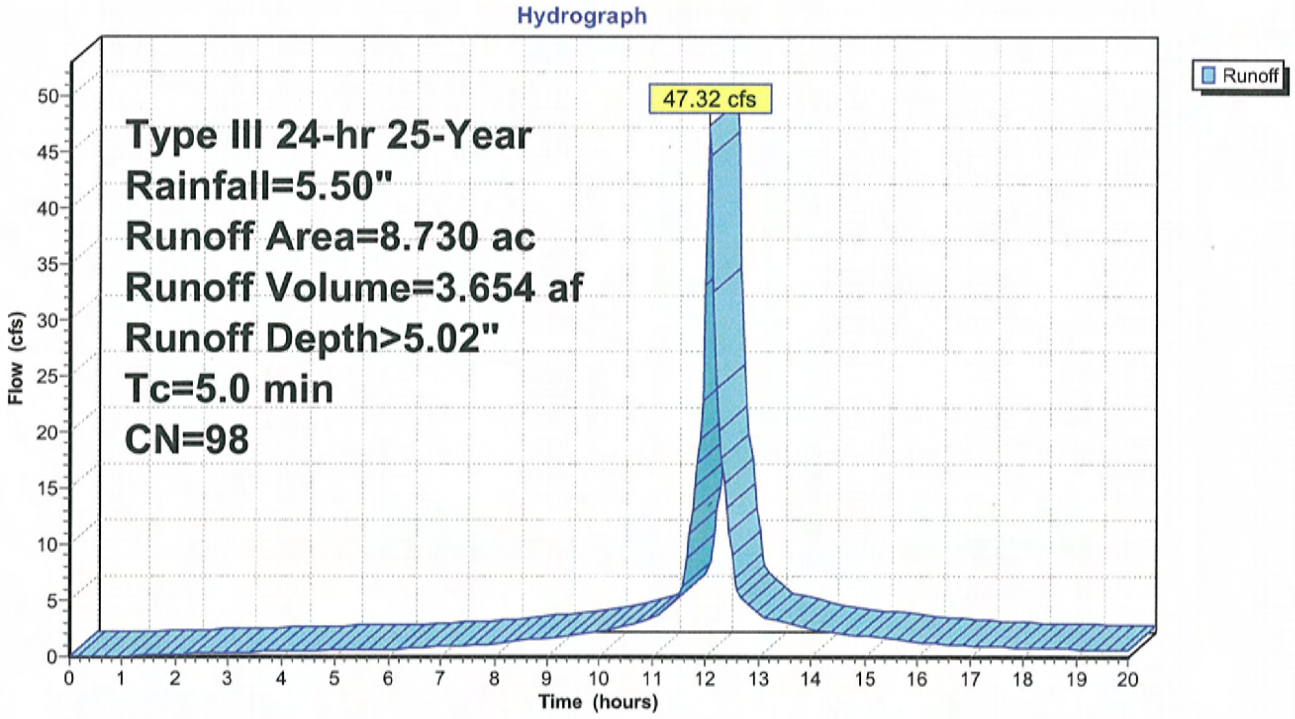
Runoff = 47.32 cfs @ 12.07 hrs, Volume= 3.654 af, Depth> 5.02"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=5.50"

	Area (ac)	CN	Description
*	8.730	98	
	8.730		100.00% Impervious Area

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

Subcatchment 29S: A-2



Summary for Subcatchment 30S: A-1

[49] Hint: Tc<2dt may require smaller dt

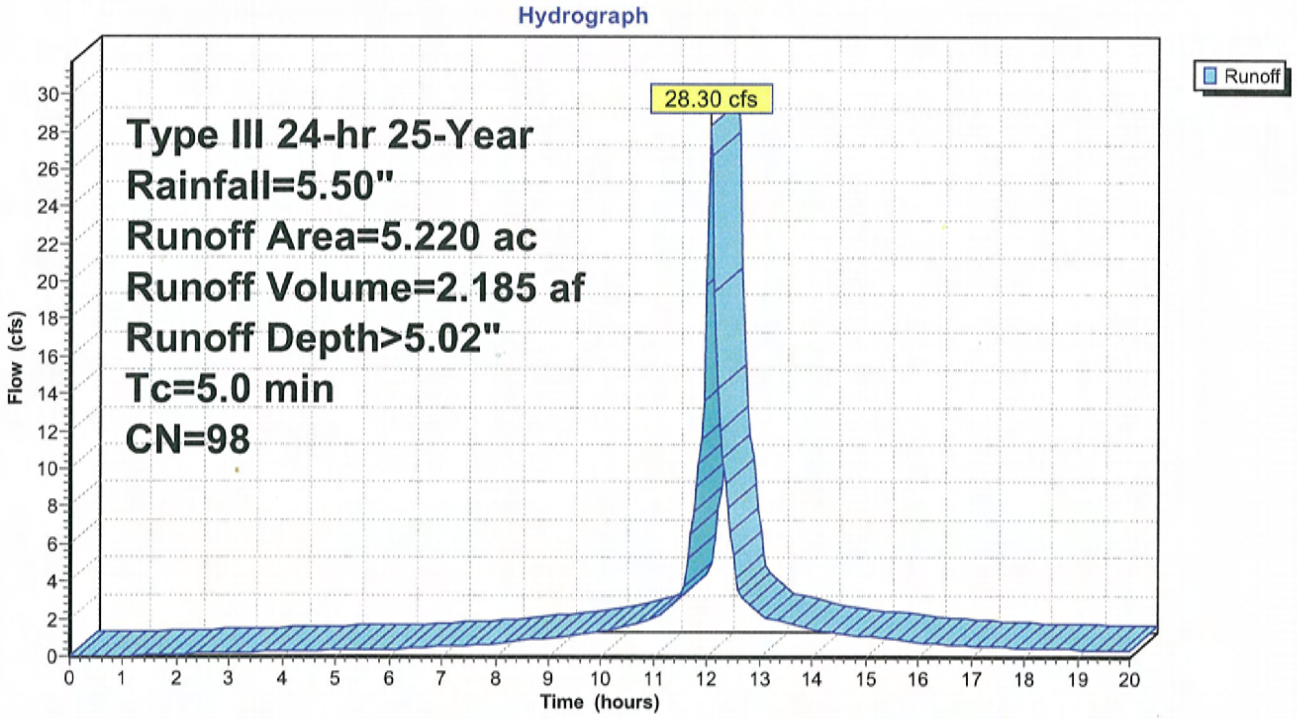
Runoff = 28.30 cfs @ 12.07 hrs, Volume= 2.185 af, Depth> 5.02"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=5.50"

	Area (ac)	CN	Description
*	5.220	98	
	5.220		100.00% Impervious Area

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

Subcatchment 30S: A-1



Summary for Subcatchment 31S: A-3

[49] Hint: Tc<2dt may require smaller dt

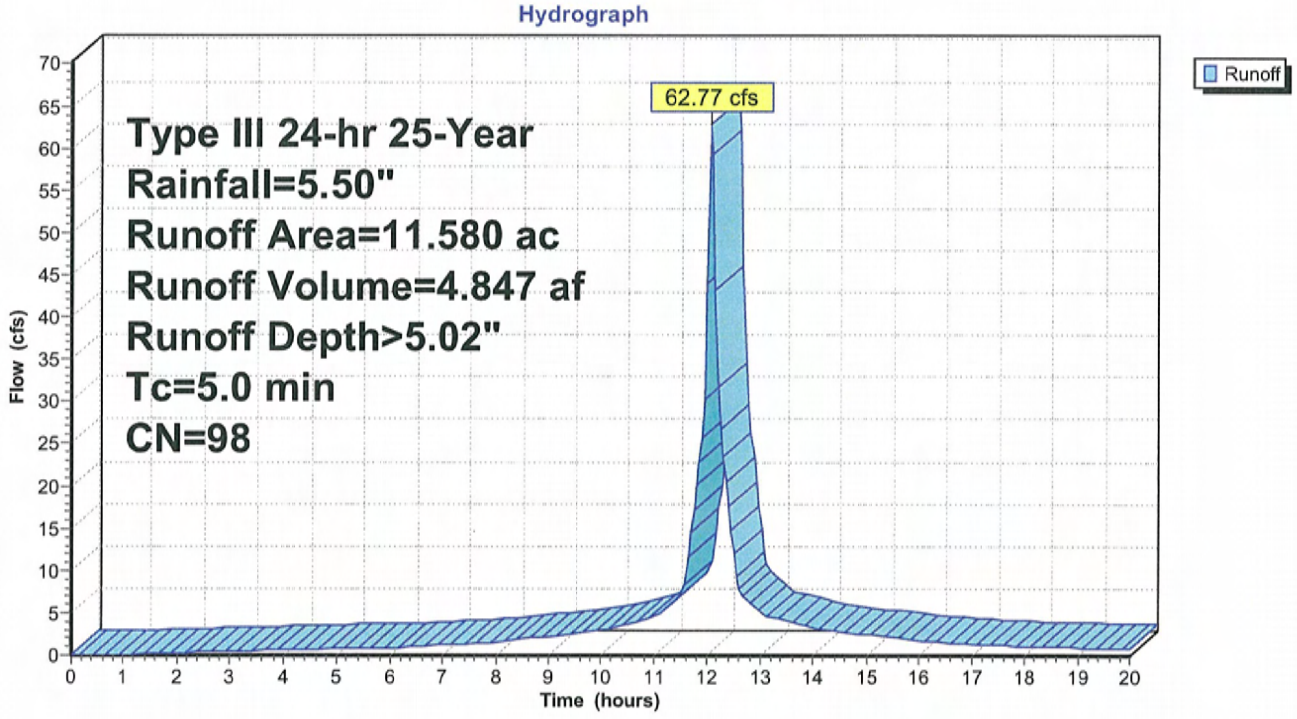
Runoff = 62.77 cfs @ 12.07 hrs, Volume= 4.847 af, Depth> 5.02"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=5.50"

	Area (ac)	CN	Description
*	11.580	98	
	11.580		100.00% Impervious Area

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

Subcatchment 31S: A-3



Summary for Subcatchment 32S: A-4

[49] Hint: Tc<2dt may require smaller dt

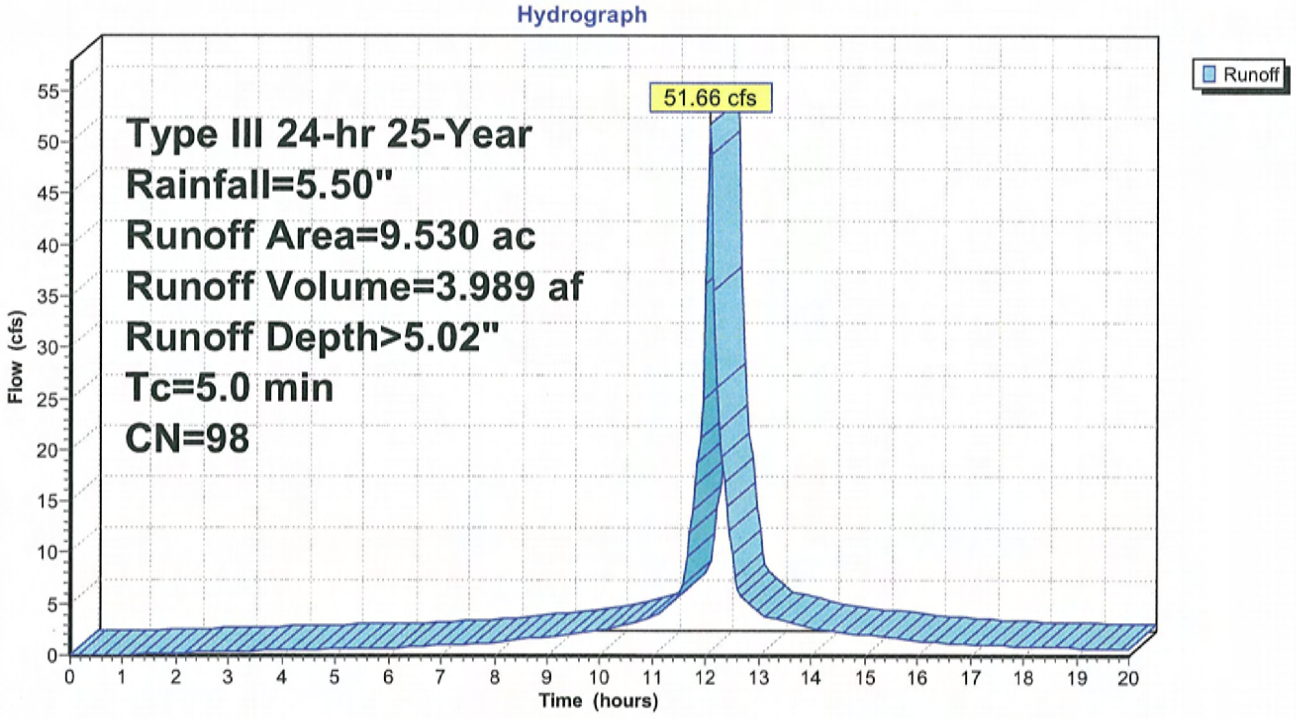
Runoff = 51.66 cfs @ 12.07 hrs, Volume= 3.989 af, Depth> 5.02"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=5.50"

	Area (ac)	CN	Description
*	9.530	98	
	9.530		100.00% Impervious Area

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

Subcatchment 32S: A-4



Summary for Subcatchment 33S: EX-3

[49] Hint: Tc<2dt may require smaller dt

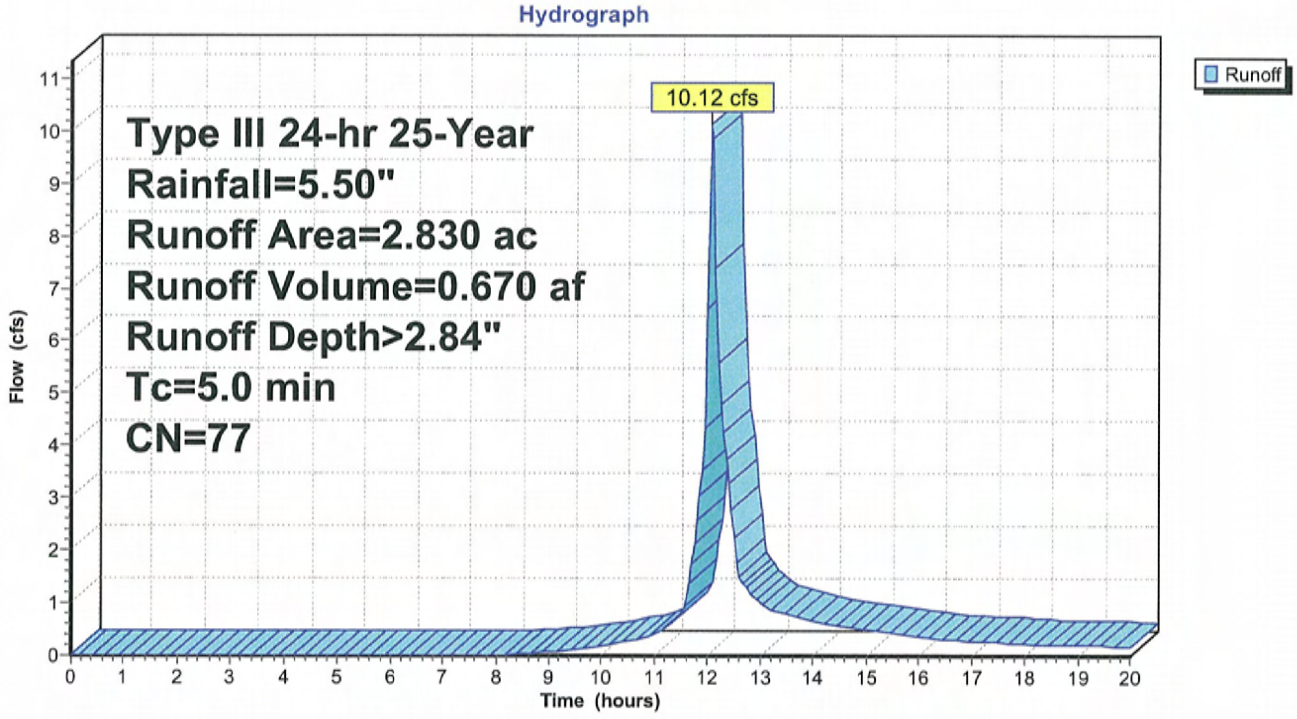
Runoff = 10.12 cfs @ 12.08 hrs, Volume= 0.670 af, Depth> 2.84"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=5.50"

	Area (ac)	CN	Description
*	2.830	77	Existing Landfill
	2.830		100.00% Pervious Area

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

Subcatchment 33S: EX-3



Summary for Reach 1R: Concrete Swale

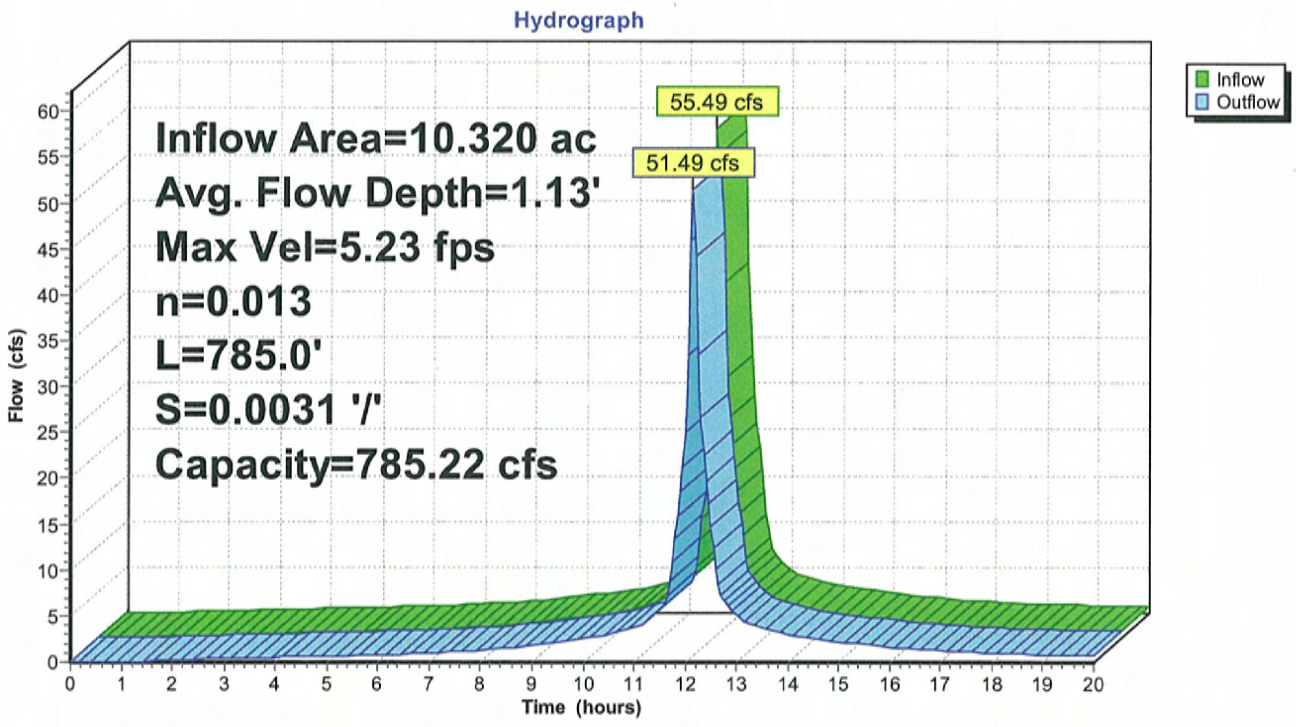
Inflow Area = 10.320 ac, 92.34% Impervious, Inflow Depth > 4.95" for 25-Year event
Inflow = 55.49 cfs @ 12.07 hrs, Volume= 4.253 af
Outflow = 51.49 cfs @ 12.15 hrs, Volume= 4.241 af, Atten= 7%, Lag= 4.6 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs
Max. Velocity= 5.23 fps, Min. Travel Time= 2.5 min
Avg. Velocity = 1.77 fps, Avg. Travel Time= 7.4 min

Peak Storage= 7,889 cf @ 12.10 hrs
Average Depth at Peak Storage= 1.13'
Bank-Full Depth= 4.00', Capacity at Bank-Full= 785.22 cfs

25.00' x 4.00' deep Parabolic Channel, n= 0.013 Concrete, trowel finish
Length= 785.0' Slope= 0.0031 '/'
Inlet Invert= 46.80', Outlet Invert= 44.35'

Reach 1R: Concrete Swale



Summary for Reach 2R: Concrete Swale

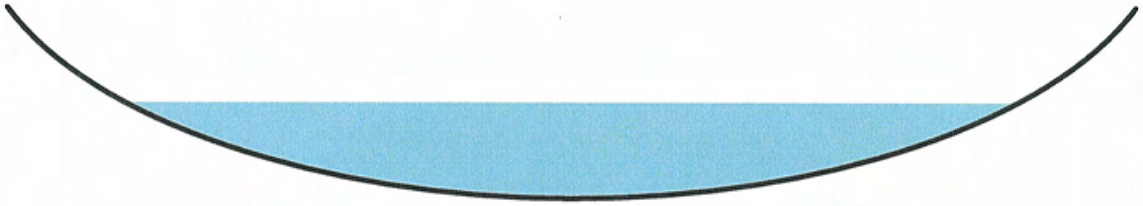
[62] Hint: Exceeded Reach 1R OUTLET depth by 0.94' @ 12.20 hrs

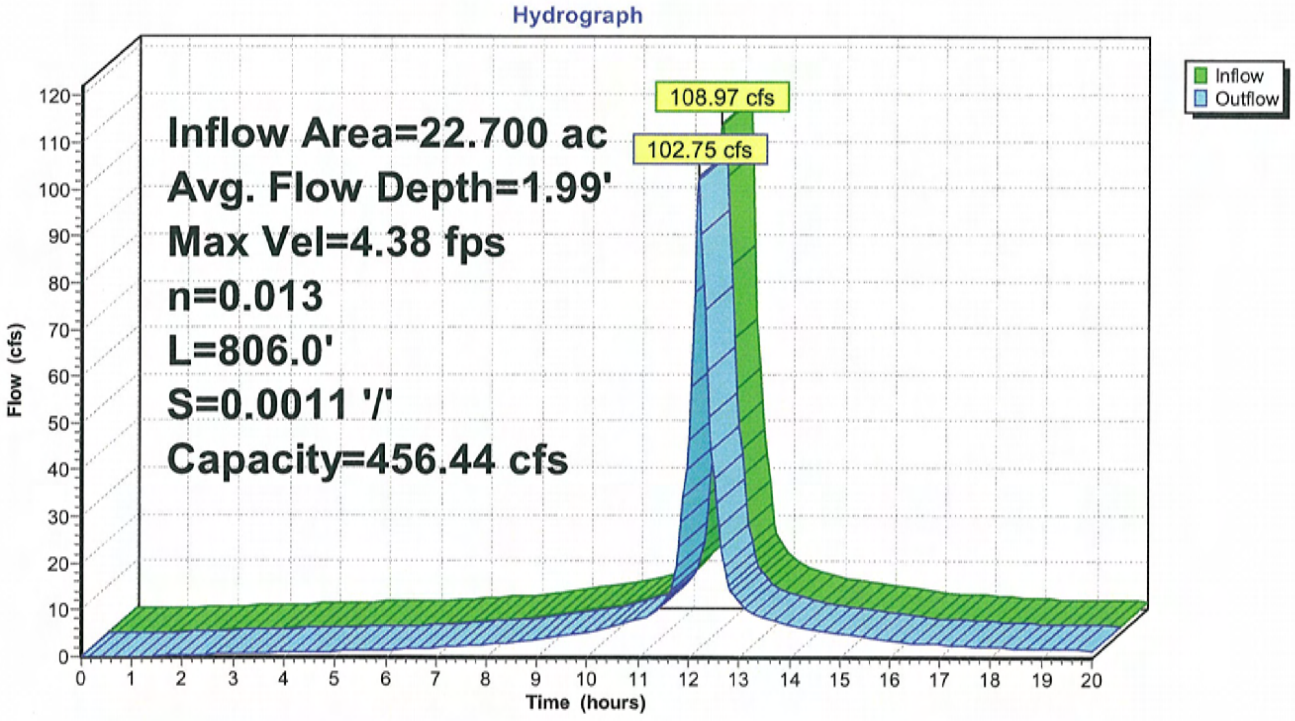
Inflow Area = 22.700 ac, 93.00% Impervious, Inflow Depth > 4.95" for 25-Year event
Inflow = 108.97 cfs @ 12.10 hrs, Volume= 9.356 af
Outflow = 102.75 cfs @ 12.19 hrs, Volume= 9.324 af, Atten= 6%, Lag= 5.3 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.38 fps, Min. Travel Time= 3.1 min
Avg. Velocity = 1.54 fps, Avg. Travel Time= 8.7 min

Peak Storage= 18,898 cf @ 12.14 hrs
Average Depth at Peak Storage= 1.99'
Bank-Full Depth= 4.00', Capacity at Bank-Full= 456.44 cfs

25.00' x 4.00' deep Parabolic Channel, n= 0.013 Concrete, trowel finish
Length= 806.0' Slope= 0.0011 '/'
Inlet Invert= 44.35', Outlet Invert= 43.50'





Summary for Reach 3R: Concrete Swale

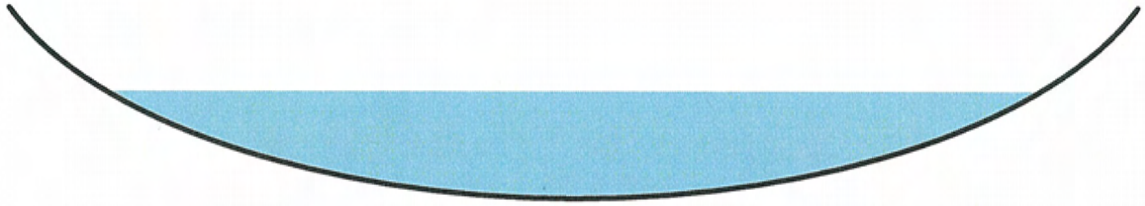
[62] Hint: Exceeded Reach 2R OUTLET depth by 0.45' @ 12.30 hrs

Inflow Area = 32.090 ac, 92.99% Impervious, Inflow Depth > 4.94" for 25-Year event
Inflow = 133.11 cfs @ 12.15 hrs, Volume= 13.199 af
Outflow = 130.22 cfs @ 12.22 hrs, Volume= 13.165 af, Atten= 2%, Lag= 4.1 min

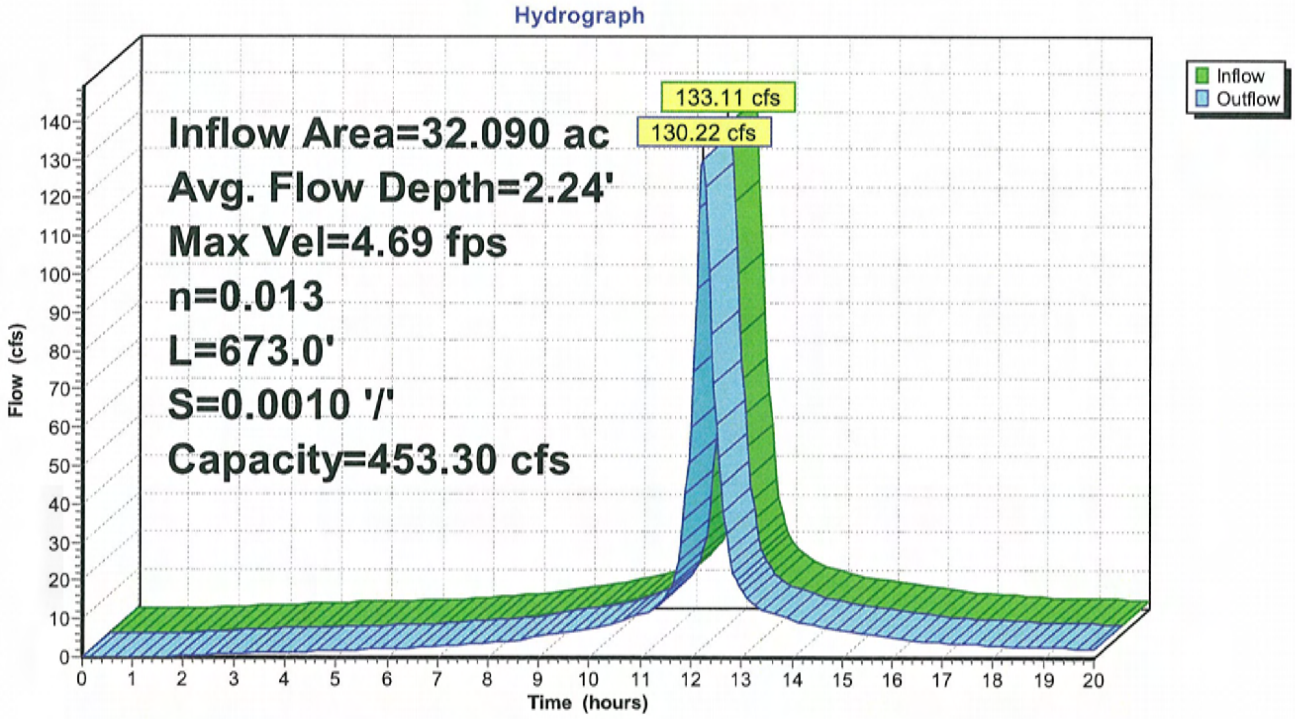
Routing by Stor-Ind+Trans method, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.69 fps, Min. Travel Time= 2.4 min
Avg. Velocity = 1.70 fps, Avg. Travel Time= 6.6 min

Peak Storage= 18,776 cf @ 12.18 hrs
Average Depth at Peak Storage= 2.24'
Bank-Full Depth= 4.00', Capacity at Bank-Full= 453.30 cfs

25.00' x 4.00' deep Parabolic Channel, n= 0.013 Concrete, trowel finish
Length= 673.0' Slope= 0.0010 '/'
Inlet Invert= 43.50', Outlet Invert= 42.80'



Reach 3R: Concrete Swale



Summary for Reach 4R: Concrete Swale

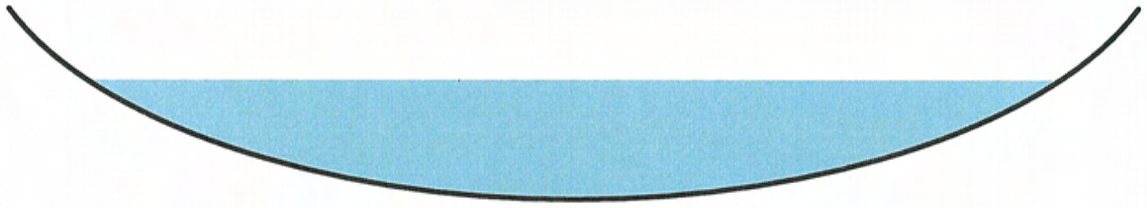
[62] Hint: Exceeded Reach 3R OUTLET depth by 0.45' @ 12.35 hrs

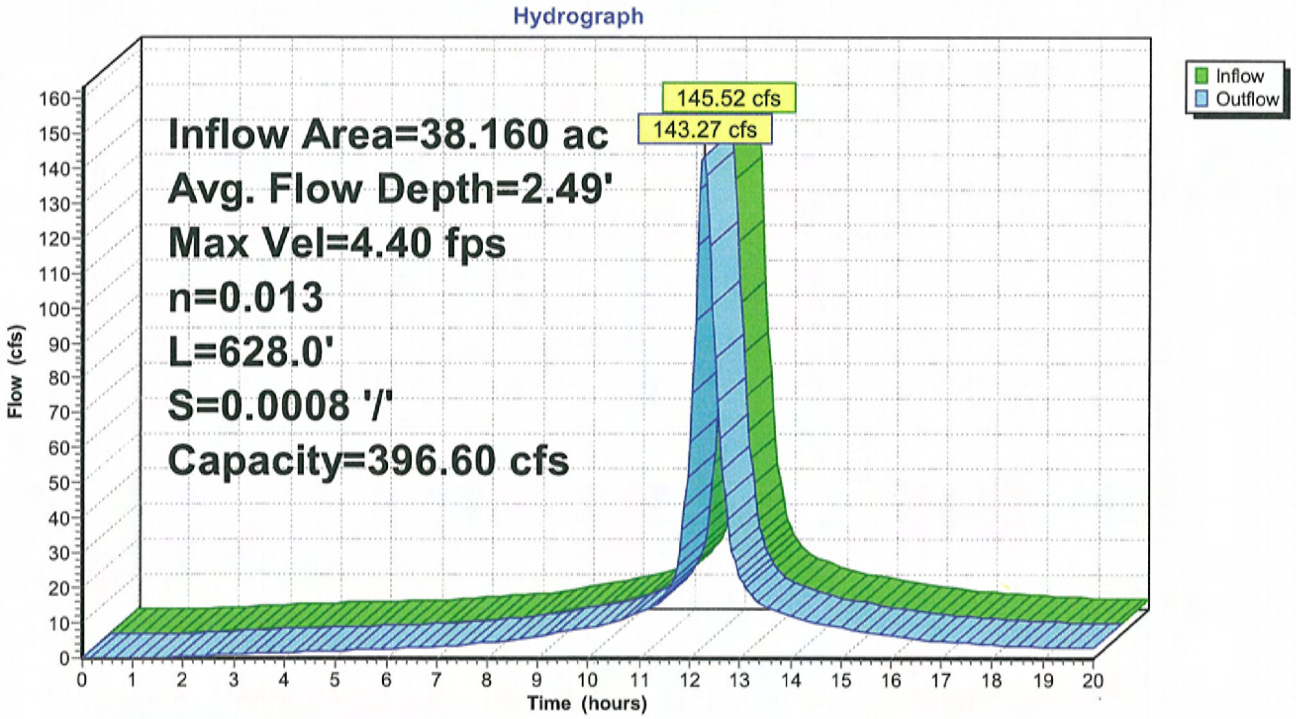
Inflow Area = 38.160 ac, 91.88% Impervious, Inflow Depth > 4.92" for 25-Year event
Inflow = 145.52 cfs @ 12.21 hrs, Volume= 15.635 af
Outflow = 143.27 cfs @ 12.27 hrs, Volume= 15.594 af, Atten= 2%, Lag= 4.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.40 fps, Min. Travel Time= 2.4 min
Avg. Velocity = 1.62 fps, Avg. Travel Time= 6.5 min

Peak Storage= 20,563 cf @ 12.24 hrs
Average Depth at Peak Storage= 2.49'
Bank-Full Depth= 4.00', Capacity at Bank-Full= 396.60 cfs

25.00' x 4.00' deep Parabolic Channel, n= 0.013 Concrete, trowel finish
Length= 628.0' Slope= 0.0008 '/'
Inlet Invert= 42.80', Outlet Invert= 42.30'





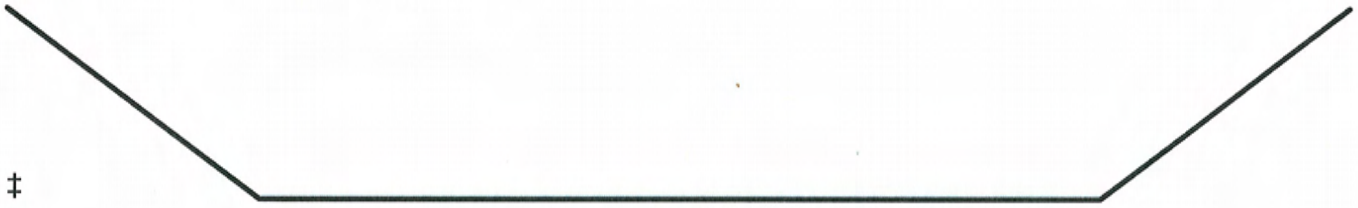
Summary for Reach A-R1: Downchute

Inflow Area = 0.380 ac, 0.00% Impervious, Inflow Depth > 2.84" for 25-Year event
Inflow = 1.36 cfs @ 12.08 hrs, Volume= 0.090 af
Outflow = 1.35 cfs @ 12.09 hrs, Volume= 0.090 af, Atten= 1%, Lag= 0.8 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.17 fps, Min. Travel Time= 0.4 min
Avg. Velocity = 2.51 fps, Avg. Travel Time= 0.7 min

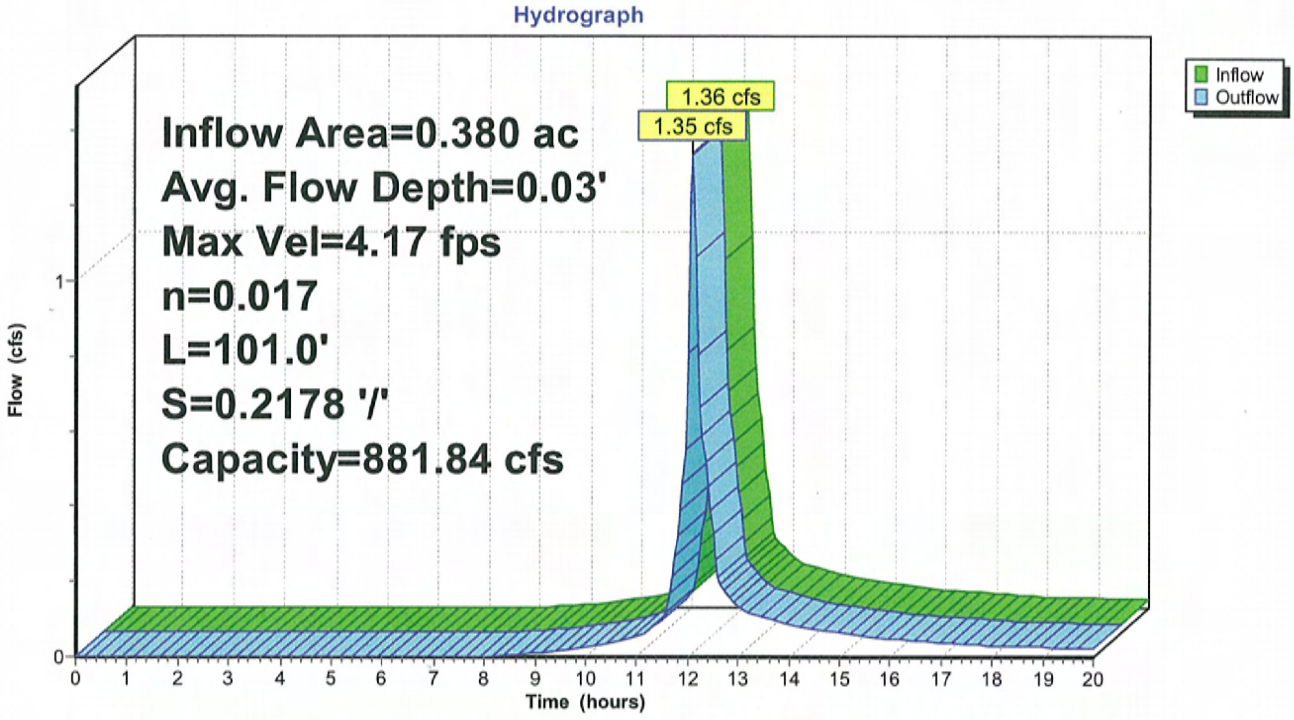
Peak Storage= 33 cf @ 12.08 hrs
Average Depth at Peak Storage= 0.03'
Bank-Full Depth= 1.50', Capacity at Bank-Full= 881.84 cfs

10.00' x 1.50' deep channel, n= 0.017 Concrete, unfinished
Side Slope Z-value= 2.0 '/' Top Width= 16.00'
Length= 101.0' Slope= 0.2178 '/'
Inlet Invert= 131.00', Outlet Invert= 109.00'



‡

Reach A-R1: Downchute



Summary for Reach A-R2: Downchute

[62] Hint: Exceeded Reach A-R1 OUTLET depth by 0.02' @ 12.10 hrs

Inflow Area = 0.820 ac, 0.00% Impervious, Inflow Depth > 2.84" for 25-Year event
Inflow = 2.91 cfs @ 12.08 hrs, Volume= 0.194 af
Outflow = 2.87 cfs @ 12.10 hrs, Volume= 0.194 af, Atten= 1%, Lag= 0.8 min

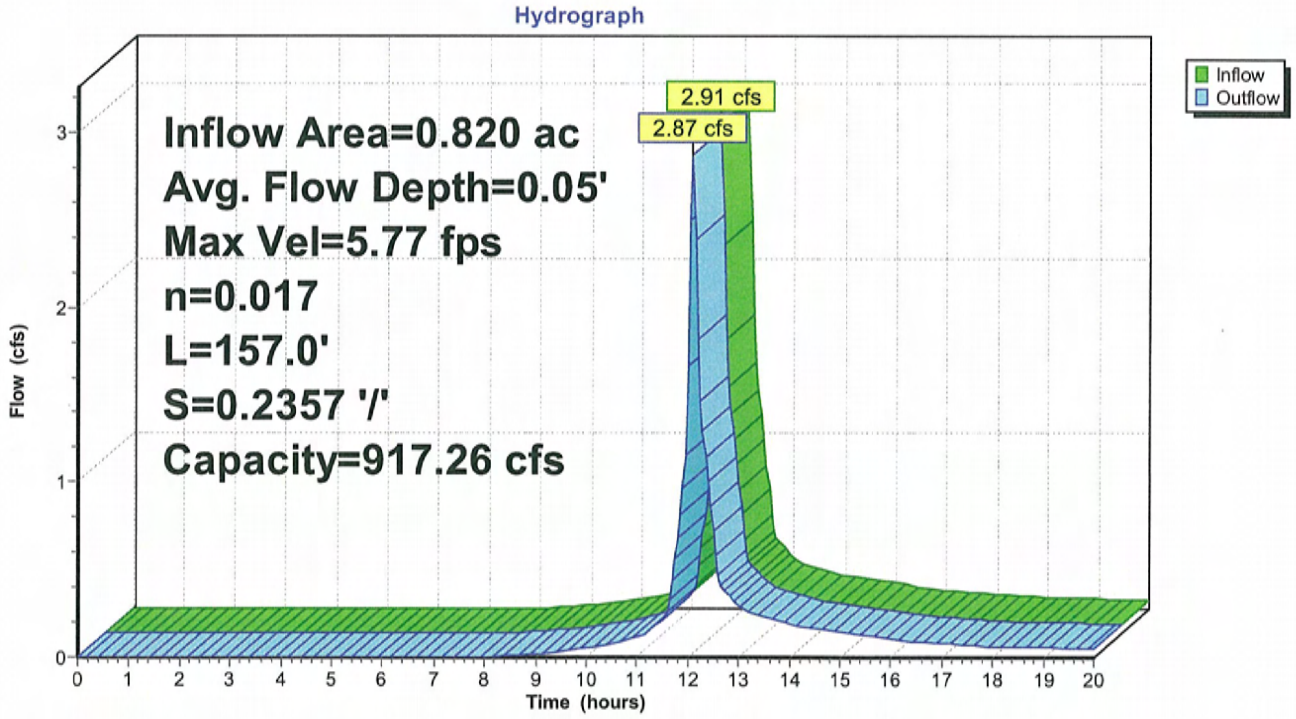
Routing by Stor-Ind+Trans method, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs
Max. Velocity= 5.77 fps, Min. Travel Time= 0.5 min
Avg. Velocity = 2.69 fps, Avg. Travel Time= 1.0 min

Peak Storage= 80 cf @ 12.09 hrs
Average Depth at Peak Storage= 0.05'
Bank-Full Depth= 1.50', Capacity at Bank-Full= 917.26 cfs

10.00' x 1.50' deep channel, n= 0.017 Concrete, unfinished
Side Slope Z-value= 2.0 '/' Top Width= 16.00'
Length= 157.0' Slope= 0.2357 '/'
Inlet Invert= 109.00', Outlet Invert= 72.00'

‡

Reach A-R2: Downchute



Summary for Reach A-R3: Downchute

[61] Hint: Exceeded Reach A-R2 outlet invert by 0.05' @ 12.10 hrs

Inflow Area = 0.820 ac, 0.00% Impervious, Inflow Depth > 2.84" for 25-Year event
Inflow = 2.87 cfs @ 12.10 hrs, Volume= 0.194 af
Outflow = 2.86 cfs @ 12.10 hrs, Volume= 0.194 af, Atten= 1%, Lag= 0.2 min

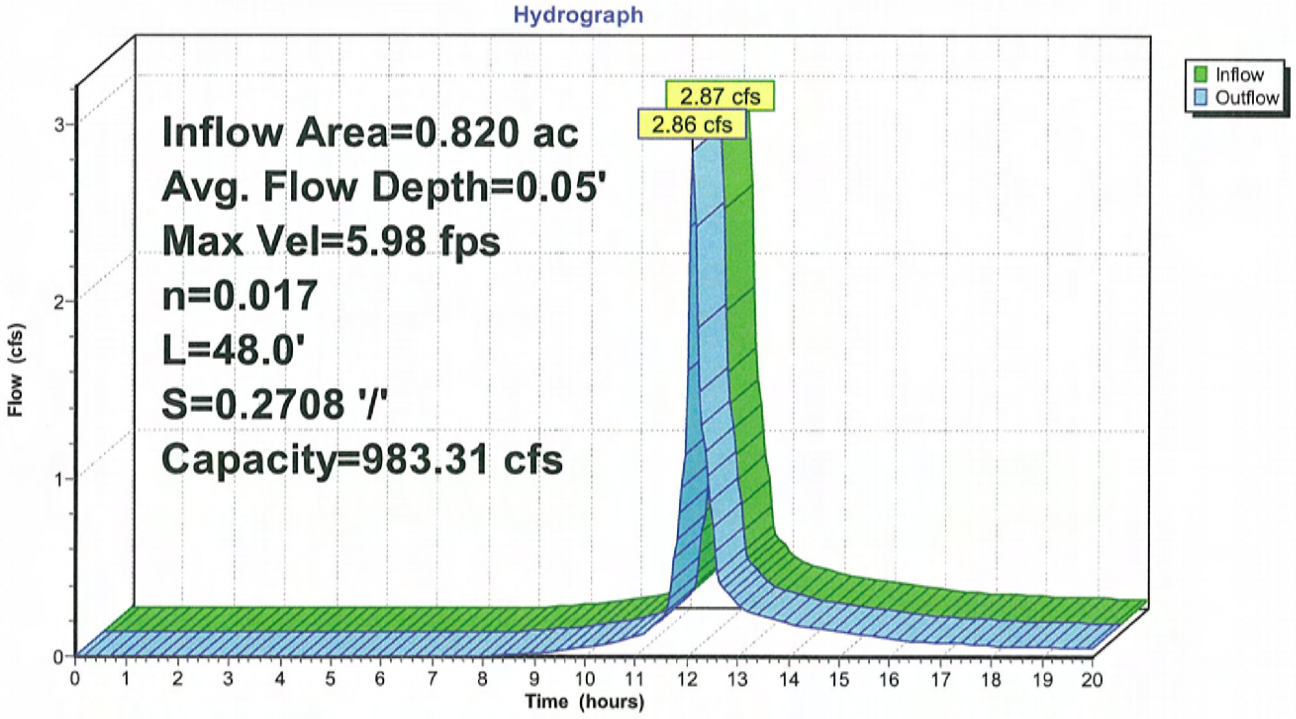
Routing by Stor-Ind+Trans method, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs
Max. Velocity= 5.98 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 2.87 fps, Avg. Travel Time= 0.3 min

Peak Storage= 23 cf @ 12.10 hrs
Average Depth at Peak Storage= 0.05'
Bank-Full Depth= 1.50', Capacity at Bank-Full= 983.31 cfs

10.00' x 1.50' deep channel, n= 0.017 Concrete, unfinished
Side Slope Z-value= 2.0 '/' Top Width= 16.00'
Length= 48.0' Slope= 0.2708 '/'
Inlet Invert= 72.00', Outlet Invert= 59.00'

‡

Reach A-R3: Downchute



Summary for Pond 29P: Swale Storage

[63] Warning: Exceeded Reach 4R INLET depth by 0.40' @ 12.50 hrs

Inflow Area = 38.160 ac, 91.88% Impervious, Inflow Depth > 4.90" for 25-Year event
Inflow = 143.27 cfs @ 12.27 hrs, Volume= 15.594 af
Outflow = 122.88 cfs @ 12.38 hrs, Volume= 15.581 af, Atten= 14%, Lag= 6.6 min
Primary = 122.88 cfs @ 12.38 hrs, Volume= 15.581 af
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs
Peak Elev= 45.23' @ 12.39 hrs Surf.Area= 0.805 ac Storage= 1.004 af

Plug-Flow detention time= 4.1 min calculated for 15.581 af (100% of inflow)
Center-of-Mass det. time= 3.7 min (741.4 - 737.8)

Volume	Invert	Avail.Storage	Storage Description
#1	42.30'	4.485 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

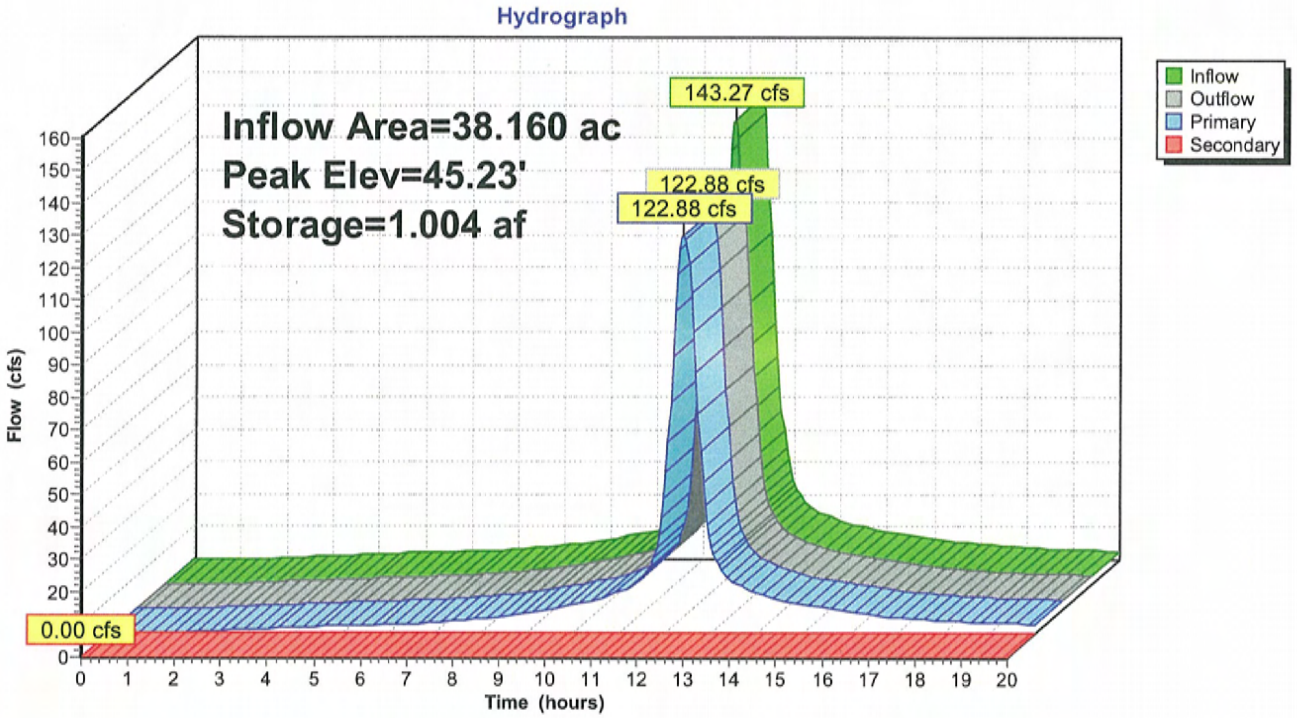
Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
42.30	0.001	0.000	0.000
44.00	0.346	0.295	0.295
46.00	1.092	1.438	1.733
48.00	1.660	2.752	4.485

Device	Routing	Invert	Outlet Devices
#1	Primary	42.30'	**36.0" Vert. Orifice/Grate X 3.00** C= 0.600
#2	Secondary	47.00'	**25.0' long x 12.0' breadth Broad-Crested Rectangular Weir**
			Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60
			Coef. (English) 2.57 2.62 2.70 2.67 2.66 2.67 2.66 2.64

Primary OutFlow Max=122.59 cfs @ 12.38 hrs HW=45.22' (Free Discharge)
↑—**1=Orifice/Grate** (Orifice Controls 122.59 cfs @ 5.82 fps)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=42.30' (Free Discharge)
↑—**2=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Pond 29P: Swale Storage

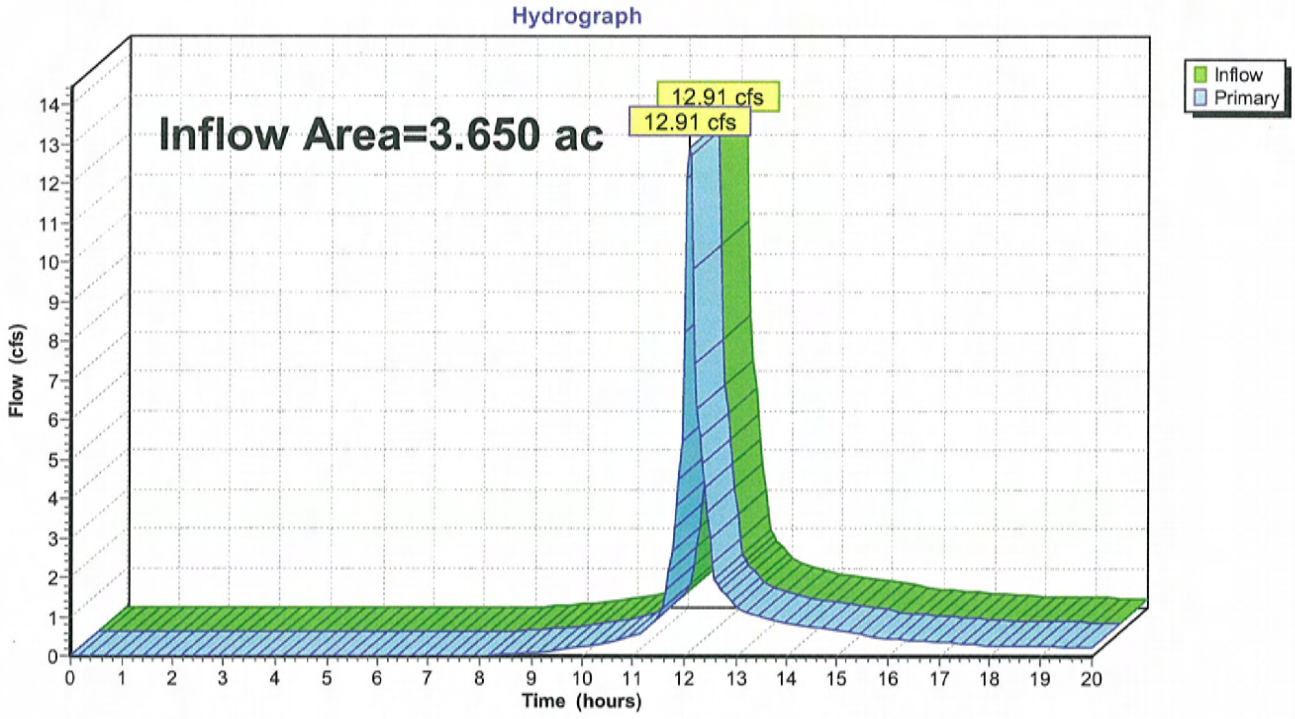


Summary for Link 27L: CL-CB

Inflow Area = 3.650 ac, 0.00% Impervious, Inflow Depth > 2.84" for 25-Year event
Inflow = 12.91 cfs @ 12.08 hrs, Volume= 0.864 af
Primary = 12.91 cfs @ 12.08 hrs, Volume= 0.864 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs

Link 27L: CL-CB

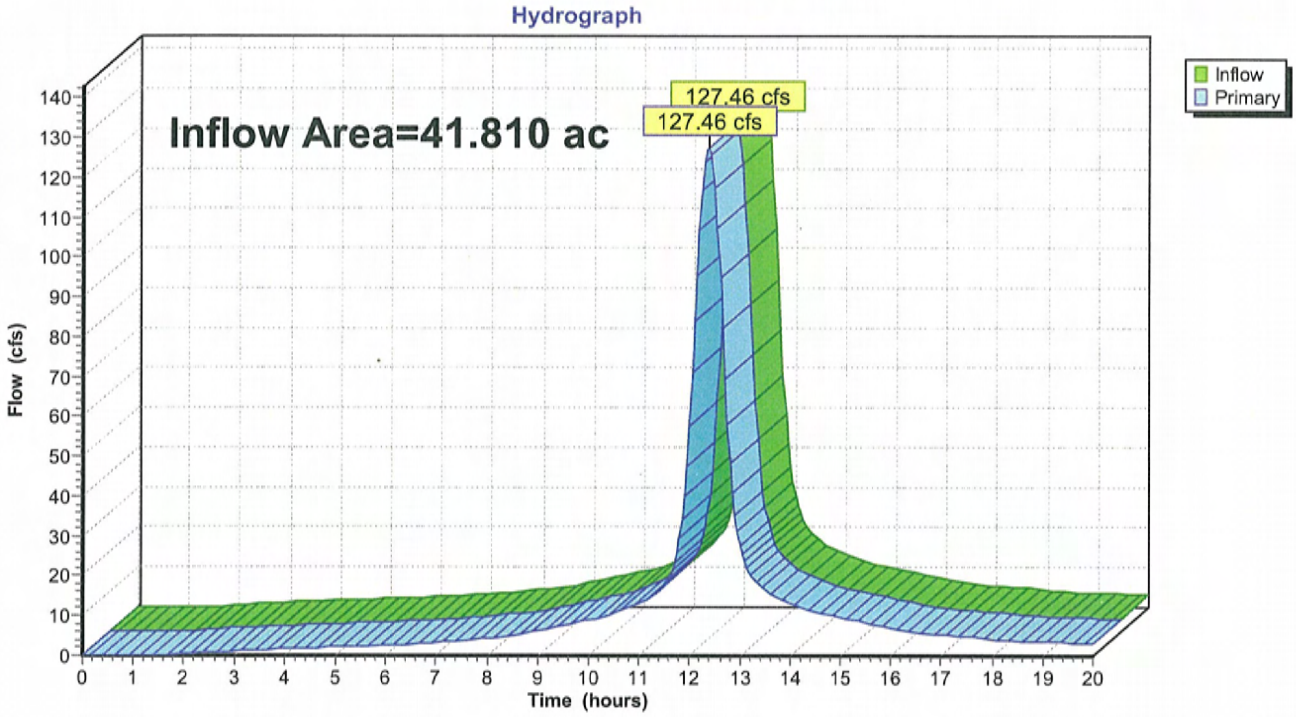


Summary for Link 28L: Dike Drainage Ditch

Inflow Area = 41.810 ac, 83.86% Impervious, Inflow Depth > 4.72" for 25-Year event
Inflow = 127.46 cfs @ 12.37 hrs, Volume= 16.445 af
Primary = 127.46 cfs @ 12.37 hrs, Volume= 16.445 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs

Link 28L: Dike Drainage Ditch



FUSS & O'NEILL

Appendix F

Exposed TPO Swale and Culvert Calculations

Worksheet for Alternative B - Eastern Dike Swale

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.016	
Channel Slope	0.00080	ft/ft
Constructed Depth	4.00	ft
Constructed Top Width	25.00	ft
Discharge	143.27	ft^3/s

Results

Normal Depth	2.73	ft
Flow Area	37.65	ft^2
Wetted Perimeter	21.59	ft
Hydraulic Radius	1.74	ft
Top Width	20.66	ft
Critical Depth	1.93	ft
Critical Slope	0.00324	ft/ft
Velocity	3.81	ft/s
Velocity Head	0.23	ft
Specific Energy	2.96	ft
Froude Number	0.50	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	2.73	ft
Critical Depth	1.93	ft
Channel Slope	0.00080	ft/ft
Critical Slope	0.00324	ft/ft

Worksheet for Alternative B - Eastern Dike Swale

Messages

Notes

Discharge taken from HydraCAD output.

Cross Section for Alternative B - Eastern Dike Swale

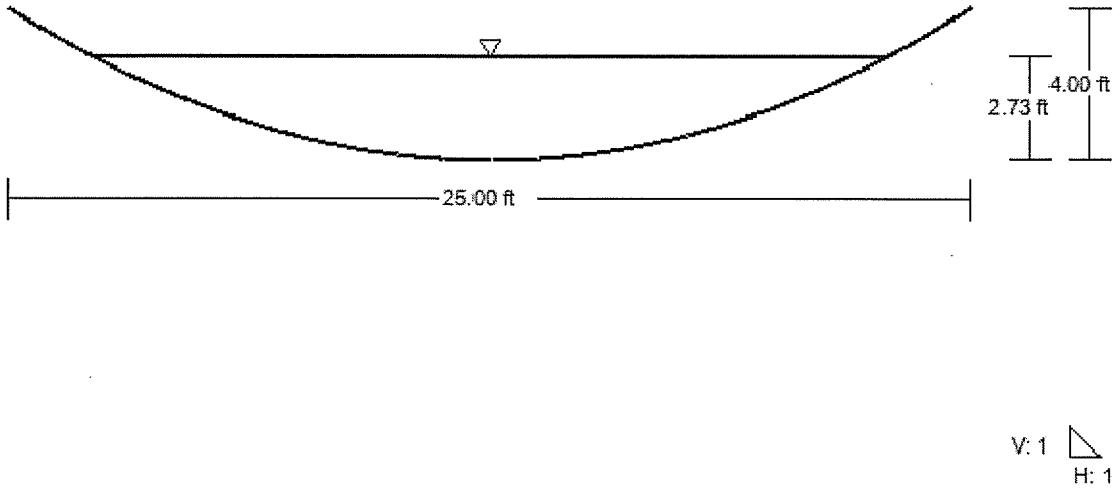
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.016	
Channel Slope	0.00080	ft/ft
Constructed Depth	4.00	ft
Normal Depth	2.73	ft
Constructed Top Width	25.00	ft
Discharge	143.27	ft³/s

Cross Section Image



Culvert Calculator Report
Alternative B - Eastern Dike Swale Culvert

Comments: Discharge taken from HydraCAD output.

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	47.00	ft	Headwater Depth/Height	1.19	
Computed Headwater Eleva	45.87	ft	Discharge	143.27	cfs
Inlet Control HW Elev.	45.82	ft	Tailwater Elevation	0.00	ft
Outlet Control HW Elev.	45.87	ft	Control Type	Entrance Control	

Grades					
Upstream Invert	42.30	ft	Downstream Invert	42.00	ft
Length	30.00	ft	Constructed Slope	0.010000	ft/ft

Hydraulic Profile					
Profile	S2		Depth, Downstream	2.00	ft
Slope Type	Steep		Normal Depth	1.88	ft
Flow Regime	Supercritical		Critical Depth	2.25	ft
Velocity Downstream	9.56	ft/s	Critical Slope	0.006161	ft/ft

Section					
Section Shape	Circular		Mannings Coefficient	0.013	
Section Material	Concrete		Span	3.00	ft
Section Size	36 inch		Rise	3.00	ft
Number Sections	3				

Outlet Control Properties					
Outlet Control HW Elev.	45.87	ft	Upstream Velocity Head	1.10	ft
Ke	0.20		Entrance Loss	0.22	ft

Inlet Control Properties					
Inlet Control HW Elev.	45.82	ft	Flow Control	Transition	
Inlet Type	Groove end w/headwall		Area Full	21.2	ft²
K	0.00180		HDS 5 Chart	1	
M	2.00000		HDS 5 Scale	2	
C	0.02920		Equation Form	1	
Y	0.74000				

Worksheet for Alternative B - Vegetated Drainage Ditch

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.045	
Channel Slope	0.06000	ft/ft
Left Side Slope	4.00	ft/ft (H:V)
Right Side Slope	4.00	ft/ft (H:V)
Bottom Width	4.00	ft
Discharge	127.46	ft^3/s

Results

Normal Depth	1.58	ft
Flow Area	16.24	ft^2
Wetted Perimeter	17.00	ft
Hydraulic Radius	0.96	ft
Top Width	16.61	ft
Critical Depth	1.86	ft
Critical Slope	0.02930	ft/ft
Velocity	7.85	ft/s
Velocity Head	0.96	ft
Specific Energy	2.53	ft
Froude Number	1.40	
Flow Type	Supercritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	1.58	ft
Critical Depth	1.86	ft
Channel Slope	0.06000	ft/ft

Worksheet for Alternative B - Vegetated Drainage Ditch

GVF Output Data

Critical Slope	0.02930	ft/ft

Messages

Notes

Roughness coefficient of 0.030 provided by manufacturer.
Discharge taken from HydraCAD output.

Cross Section for Alternative B - Vegetated Drainage Ditch

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.045	
Channel Slope	0.06000	ft/ft
Normal Depth	1.58	ft
Left Side Slope	4.00	ft/ft (H:V)
Right Side Slope	4.00	ft/ft (H:V)
Bottom Width	4.00	ft
Discharge	127.46	ft³/s

Cross Section Image