STORMWATER MANAGEMENT, DRAINAGE, EROSION AND SEDIMENT CONTROL CALCULATIONS

FOR

BLAIR PROPERTY

Chatham County, North Carolina

Prepared For:

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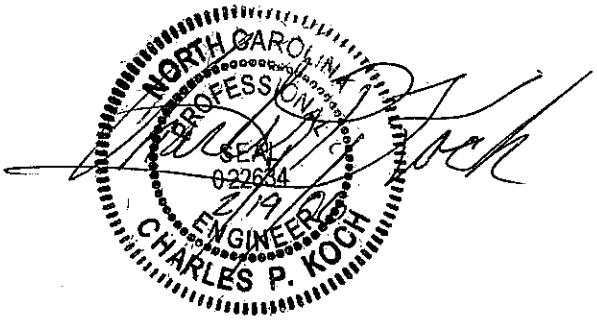
Date: December 18, 2005
Rev. February 19, 2006

Project Number: 05-050



STORM DRAINAGE AND EROSION CONTROL CALCULATIONS

Project Name:	**BLAIR PROPERTY**
Project Number:	05-050
Report Date:	December 18, 2005 **Revised: February 19, 2006**
Purpose:	To provide adequate storm drainage, erosion and sediment control measures for the subject property.

SITE DESCRIPTION:

Project Location:	Southeast Corner of Mt. Gilead Church Road and Hadley Road Chatham County, NC
Site Size:	10 Acres
Site Characteristics:	The site has gently sloping topography with slopes generally 5 to 15% draining southward to a stream located to the southern end of the site. The property is wooded with significant ground litter (pine needles). A small creek is located to the south of the site draining westward to a culvert under Mt. Gilead Church Road. A small, secondary stream is located on the eastern edge of the site which directs runoff from the northern offsite area through the site to the creek. Land use in the vicinity is similar: residential development and rural farms with mixed pasture and wooded areas. Offsite drainage is directed via two drainage ditches located below culverts at Hadley Road to the previously noted stream.
Drainage Characteristics:	As noted above, all drainage is directed to the stream located in the southern portion of the site and exits via the culverts under Mt. Gilead Road.

PROPOSED DEVELOPMENT:

Proposed Usage:	The proposed development consists of a boat and RV storage facility with gravel drives.
Detention Requirements:	Based on discussions with Keith Megginson, Chatham County requires detention for peak discharge increases due to development. Control is recommended for increases in the 2 year storm discharge. Based on an analysis of this site, the proposed development does not result in an increase in runoff in the 2, 10, 25, or 100 year events.
Proposed Drainage Structures:	All onsite drainage is handled via perimeter ditches and driveway culverts. The large volume of offsite runoff entering the site from the two northern culverts and the pond to the east is directed to the stream via the existing creek along the eastern edge of the site. Runoff from the western side of the site is directed to the southern creek via a perimeter ditch and culvert. In order to reduce the peak discharge, runoff entering the site via the northwestern culvert is directed around site via a wide shallow swale to the existing stream. This swale acts to increase the time of concentration, similar to a detention facility.

Proposed Erosion and Sediment Control Measures:	Sediment and erosion control is managed through traditional measures. Temporary measures: • Perimeter diversions and silt fence which direct runoff to sediment traps located below the area of disturbance. • Temporary construction entrances at access points • Straw and net liners in ditchlines Permanent measures: • Rip rap aprons at culverts • Grass lined swales at shallow slopes

ANALYSIS:

Detention Analysis:	Detention was analyzed using Hydraflow Hydrographs. Area measurements were performed using ACAD and time of concentration was calculated using the TR-55 calculator in Hydraflow. Curve numbers were applied based on the following recommended values from the US Soil Conservation Service and type B soils: Gravel parking = 85 Clear lawn with some trees = 65 Woods, fair ground coverage = 60 Based on the analysis performed, development did not result in an increase in runoff during the 2, 10, 25 or 100 year storm events. This is due to the increased time of concentration for offsite runoff entering from the northwest in the post-development condition. Based on this analysis, no detention is required for this site.
Pipe Capacity Requirements:	Calculations for the pipe structures were performed using Haestad's CulvertMaster and the peak flows calculated during the detailed detention analysis using the SCS method from Hydraflow. Capacity was calculated based on a 10yr storm and HW/D or 1.2 or less. Additionally, culverts were checked for overtopping in the 25 yr storm event.
Apron Requirements:	NCDENR guidelines use the 10 year Velocity for apron design. The NY method was used for apron design.
Ditch Calculations:	Temporary ditchline calculations were performed using Haestad's FlowMaster. Ditchlines were checked in accordance with NCDENR guidelines for temporary liner requirements.
Sediment Trap Calculations:	Sediment trap calculations were performed in accordance with NCDENR guidelines. The traps presented exceed the requirements or both surface area and storage.

CONCLUSION:

Based on the attached calculations, the proposed devices adequately meet the requirements of the NCDOT for drainage structures and the NCDENR for erosion and sediment control.

ATTACHMENTS:

Detention Calculations

ACAD Exhibits	Pre and Post development exhibits
Hydraflow Analysis	Overview and Details

Pipe Calculations

Pipe Calculations	Q10 and Q25 Culvert Master Calculations

Apron Calculations

Velocity Zones	Figure 8.06.b.1 from NCDENR Manual (NY method)
Apron Chart	NCDENR Chart

Ditch Calculations

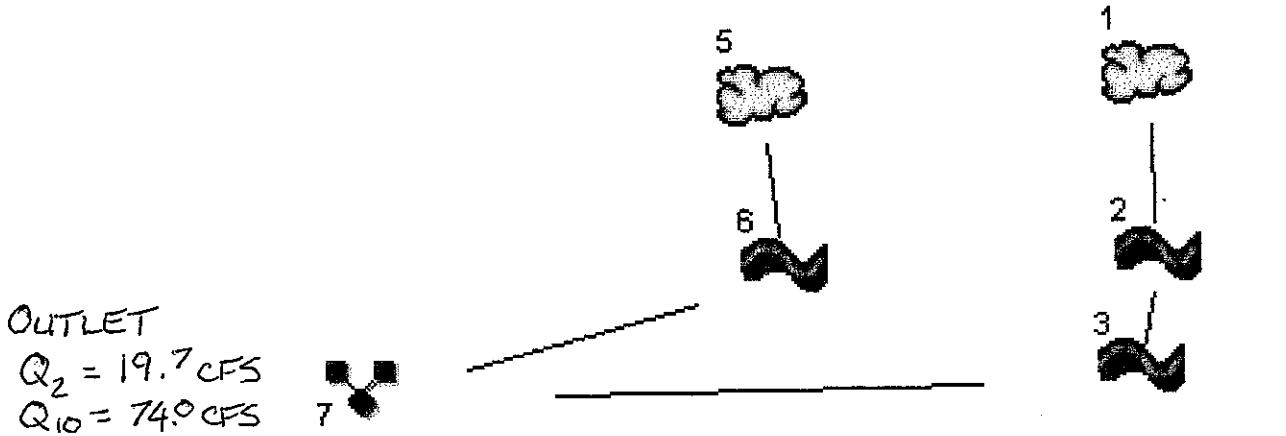
Ditch Calculations	FlowMaster Worksheets
Liner Info	NCDENR Liner Information

Sediment Trap Calculations

Sediment Trap Analysis	EXCEL Worksheet of Sediment Trap Calculations

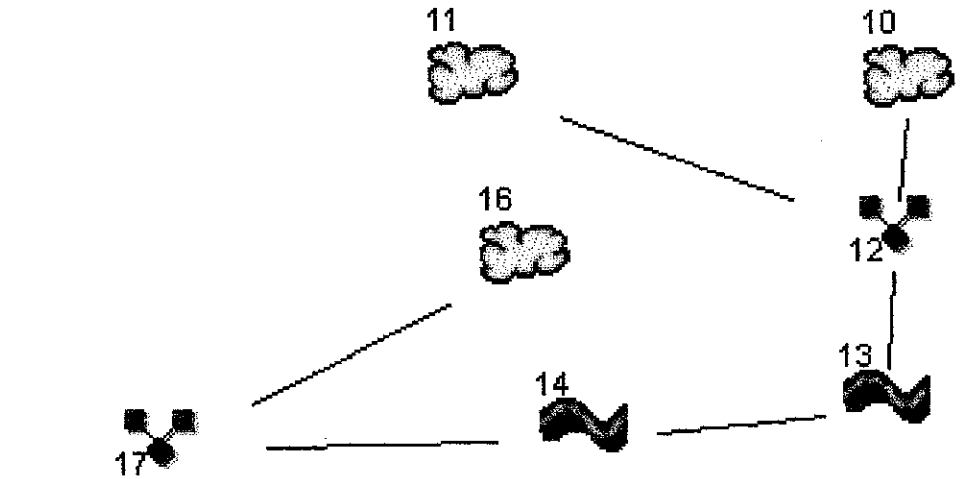
DETENTION DOCUMENTS

PRE-DEVELOPMENT



OUTLET
$Q_2 = 19.7$ CFS
$Q_{10} = 74.0$ CFS
$Q_{25} = 98.9$ CFS

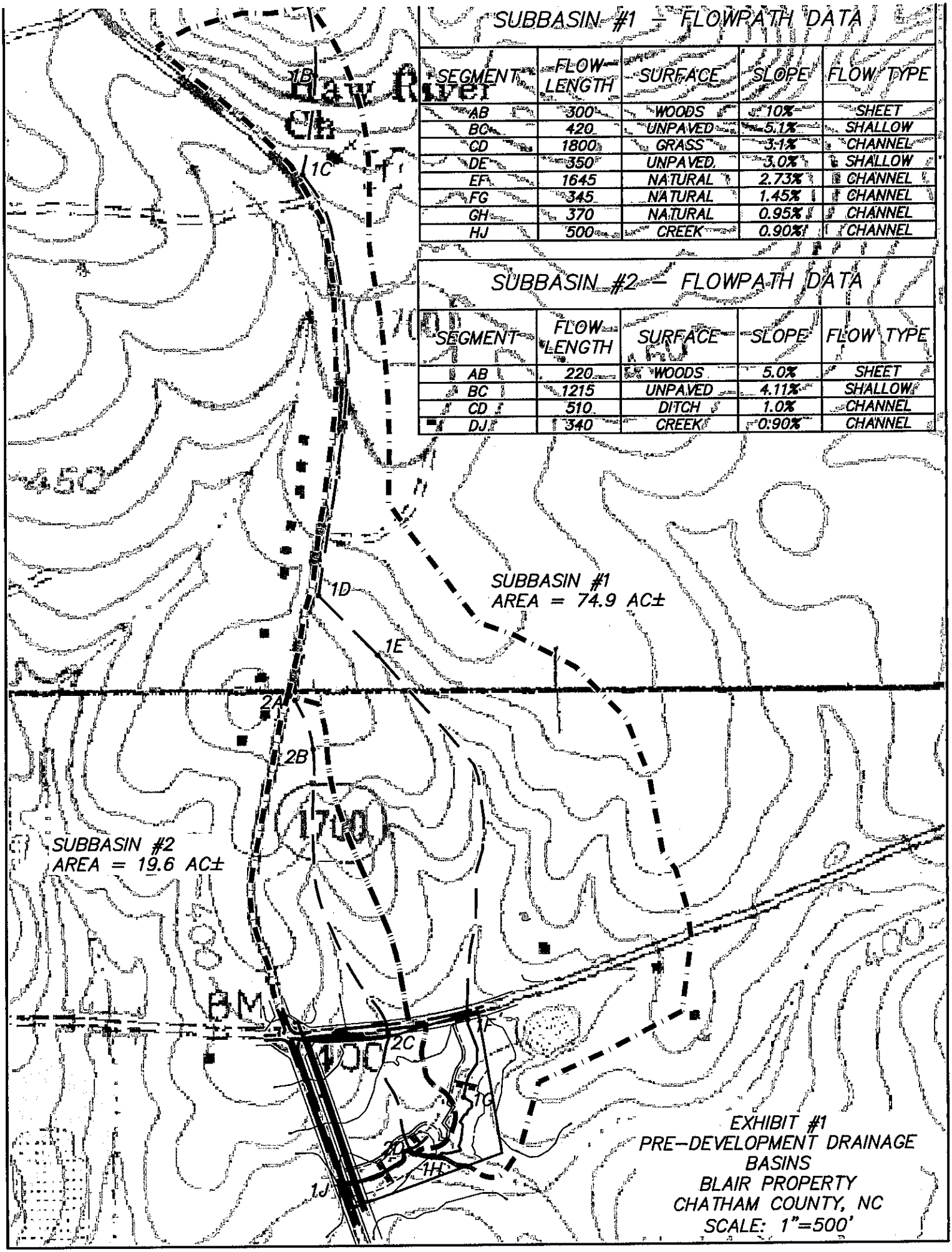
POST-DEVELOPMENT



OUTLET
$Q_2 = 19.7$ CFS
$Q_{10} = 72.2$ CFS
$Q_{25} = 96.2$ CFS

Legend

Hyd.	Origin	Description
1	SCS Runoff	Pre, Basin #1
2	Reach	Point G to H
3	Reach	Creek, Point H to J
5	SCS Runoff	Pre, Basin #2
6	Reach	Bend to Outlet
7	Combine	POI, Outlet
10	SCS Runoff	Post, Basin #1
11	SCS Runoff	Post, Basin #2a
12	Combine	Combine Flow at Point G
13	Reach	Point G to H
14	Reach	Creek, Point H to J
16	SCS Runoff	Post, Subbasin #2B
17	Combine	POI, Outlet



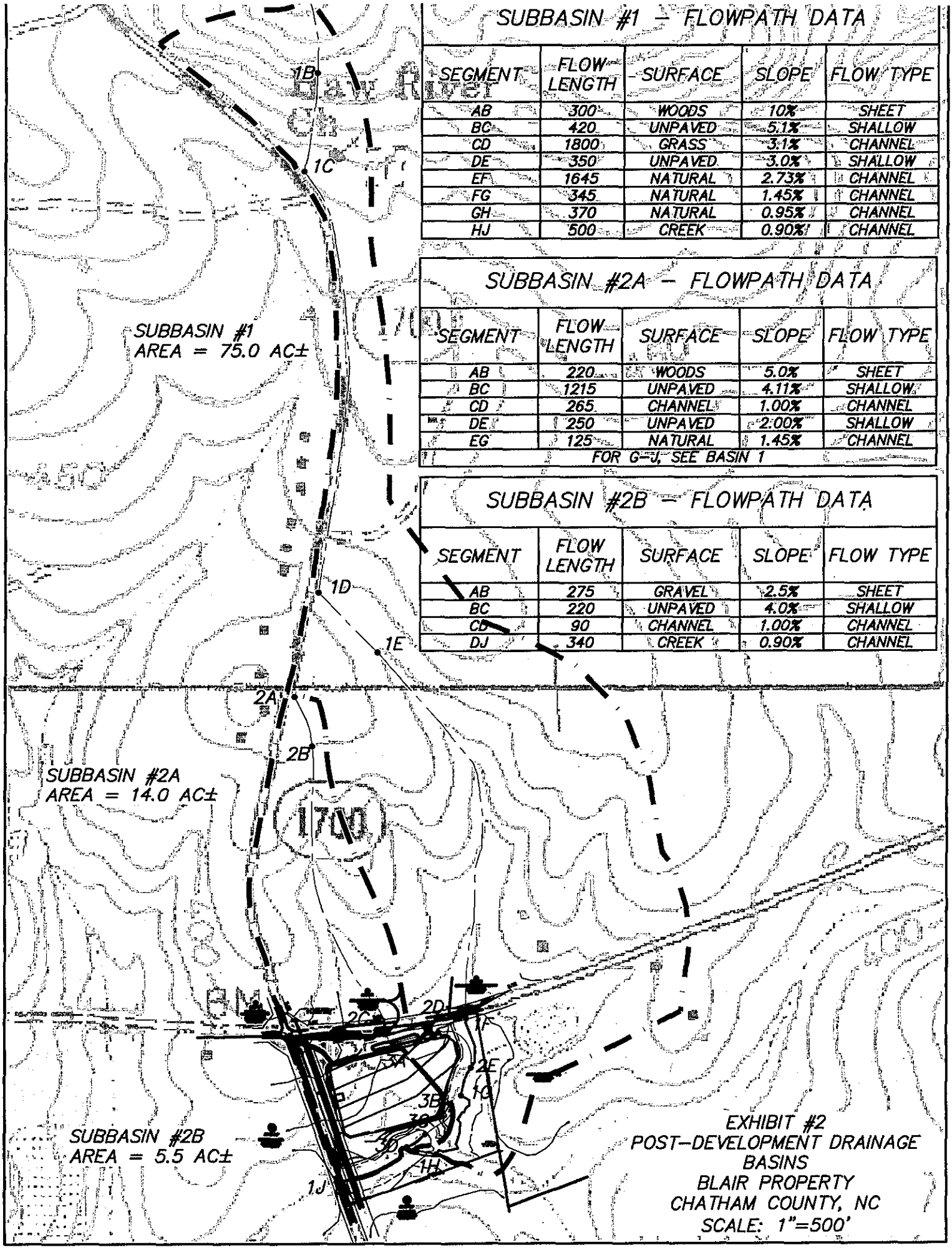
SUBBASIN #1 – FLOWPATH DATA

SEGMENT	FLOW LENGTH	SURFACE	SLOPE	FLOW TYPE
AB	300	WOODS	10%	SHEET
BC	420	UNPAVED	5.1%	SHALLOW
CD	1800	GRASS	3.1%	CHANNEL
DE	350	UNPAVED	3.0%	SHALLOW
EF	1645	NATURAL	2.73%	CHANNEL
FG	345	NATURAL	1.45%	CHANNEL
GH	370	NATURAL	0.95%	CHANNEL
HJ	500	CREEK	0.90%	CHANNEL

SUBBASIN #2 – FLOWPATH DATA

SEGMENT	FLOW LENGTH	SURFACE	SLOPE	FLOW TYPE
AB	220	WOODS	5.0%	SHEET
BC	1215	UNPAVED	4.11%	SHALLOW
CD	510	DITCH	1.0%	CHANNEL
DJ	340	CREEK	0.90%	CHANNEL

EXHIBIT #1
PRE-DEVELOPMENT DRAINAGE BASINS
BLAIR PROPERTY
CHATHAM COUNTY, NC
SCALE: 1"=500'



SUBBASIN #1 – FLOWPATH DATA

SEGMENT	FLOW LENGTH	SURFACE	SLOPE	FLOW TYPE
AB	300'	WOODS	10%	SHEET
BC	420	UNPAVED	5.1%	SHALLOW
CD	1800	GRASS	3.1%	CHANNEL
DE	350	UNPAVED	3.0%	SHALLOW
EF	1645	NATURAL	2.73%	CHANNEL
FG	345	NATURAL	1.45%	CHANNEL
GH	370	NATURAL	0.95%	CHANNEL
HJ	500	CREEK	0.90%	CHANNEL

SUBBASIN #2A – FLOWPATH DATA

SEGMENT	FLOW LENGTH	SURFACE	SLOPE	FLOW TYPE
AB	220	WOODS	5.0%	SHEET
BC	1215	UNPAVED	4.11%	SHALLOW
CD	265	CHANNEL	1.00%	CHANNEL
DE	250	UNPAVED	2.00%	SHALLOW
EG	125	NATURAL	1.45%	CHANNEL
FOR G–J, SEE BASIN 1				

SUBBASIN #2B – FLOWPATH DATA

SEGMENT	FLOW LENGTH	SURFACE	SLOPE	FLOW TYPE
AB	275	GRAVEL	2.5%	SHEET
BC	220	UNPAVED	4.0%	SHALLOW
CD	90	CHANNEL	1.00%	CHANNEL
DJ	340	CREEK	0.90%	CHANNEL

EXHIBIT #2
POST–DEVELOPMENT DRAINAGE BASINS
BLAIR PROPERTY
CHATHAM COUNTY, NC
SCALE: 1"=500'

Hydrograph Return Period Recap

Hyd. No.	Hydrograph type (origin)	Inflow Hyd(s)	Peak Outflow (cfs)								Hydrograph description
			1-Yr	2-Yr	3-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	
1	SCS Runoff	———	———	16.69	———	———	61.01	81.11	———	———	Pre, Basin #1 PRE
2	Reach	1	———	16.28	———	———	60.01	79.99	———	———	Point G to H
3	Reach	2	———	15.67	———	———	58.47	78.17	———	———	Creek, Point H to J
5	SCS Runoff	———	———	4.75	———	———	17.43	23.15	———	———	Pre, Basin #2
6	Reach	5	———	4.73	———	———	17.40	23.11	———	———	Bend to Outlet
7	Combine	3, 6	———	19.73	———	———	73.96	98.91	———	———	POI, Outlet
10	SCS Runoff	———	———	16.71	———	———	61.09	81.22	———	———	Post, Basin #1 POST
11	SCS Runoff	———	———	3.32	———	———	12.17	16.18	———	———	Post, Basin #2a
12	Combine	10, 11	———	20.02	———	———	73.13	97.20	———	———	Combine Flow at Point G
13	Reach	12	———	19.55	———	———	72.06	95.99	———	———	Point G to H
14	Reach	13	———	18.87	———	———	70.35	94.01	———	———	Creek, Point H to J
16	SCS Runoff	———	———	12.67	———	———	27.39	33.14	———	———	Post, Subbasin #2B
17	Combine	14, 16	———	19.71	———	———	72.19	96.22	———	———	POI, Outlet

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Hydrograph Summary Report

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to peak (min)	Volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Maximum storage (cuft)	Hydrograph description
1	SCS Runoff	16.69	1	754	155,727	—	—	—	Pre, Basin #1
2	Reach	16.28	1	764	155,724	1	—	—	Point G to H
3	Reach	15.67	1	774	155,719	2	—	—	Creek, Point H to J
5	SCS Runoff	4.75	1	750	40,592	—	—	—	Pre, Basin #2
6	Reach	4.73	1	753	40,589	5	—	—	*Bend to Outlet*
7	Combine	19.73	1	771	196,308	3, 6	—	—	POI, Outlet
10	SCS Runoff	16.71	1	754	155,935	—	—	—	Post, Basin #1
11	SCS Runoff	3.32	1	751	29,108	—	—	—	Post, Basin #2a
12	Combine	20.02	1	754	185,043	10, 11	—	—	Combine Flow at Point G
13	*Reach*	19.55	1	763	185,040	12	—	—	Point G to H
14	Reach	18.87	1	773	185,035	13	—	—	Creek, Point H to J
16	SCS Runoff	12.67	1	718	25,528	—	—	—	Post, Subbasin #2B
17	Combine	19.71	1	772	210,564	14, 16	—	—	POI, Outlet

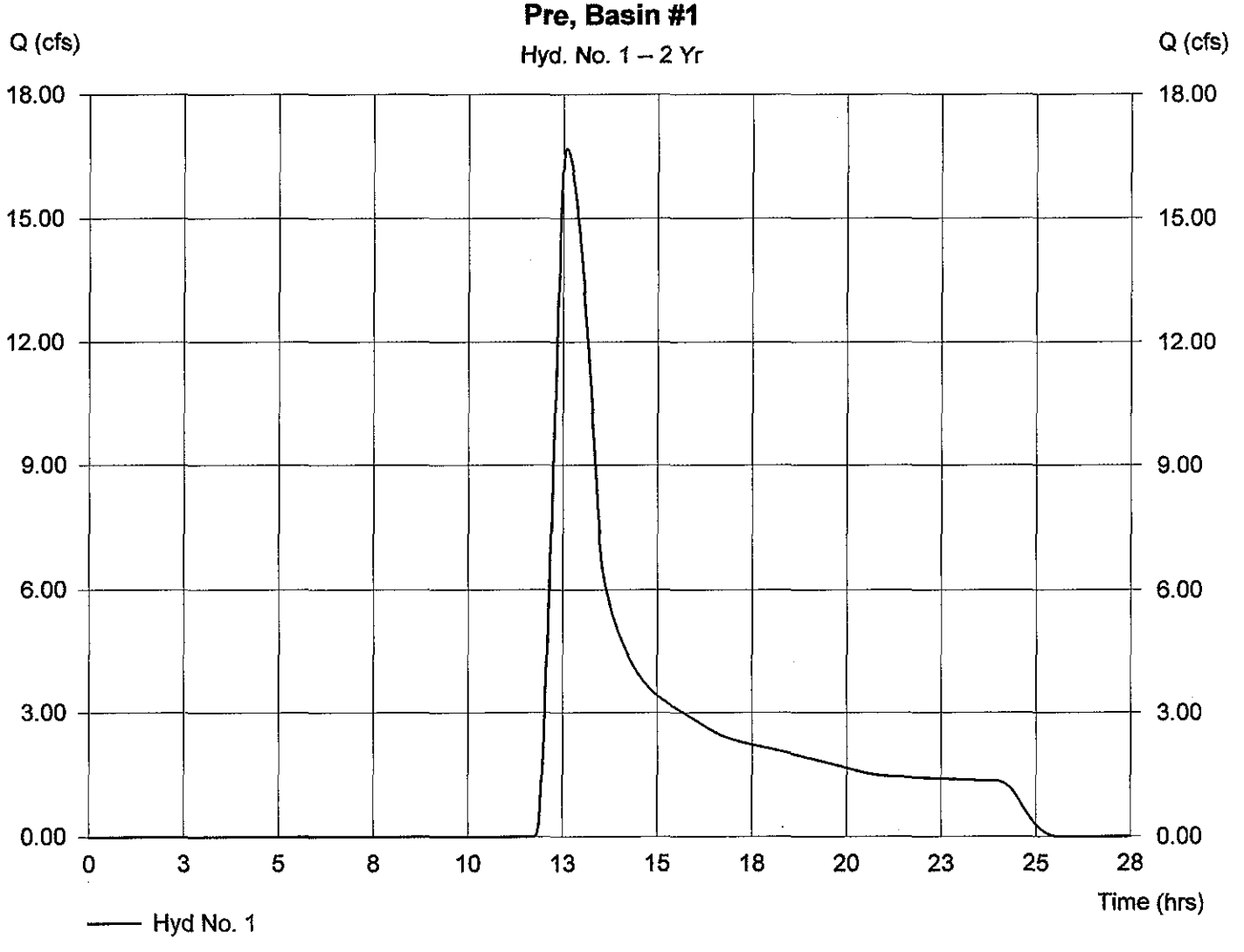
Hydrograph Plot

Hyd. No. 1

Pre, Basin #1

Hydrograph type	= SCS Runoff	Peak discharge	= 16.69 cfs
Storm frequency	= 2 yrs	Time interval	= 1 min
Drainage area	= 74.900 ac	Curve number	= 61
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 59.70 min
Total precip.	= 3.50 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

Hydrograph Volume = 155,727 cuft



TR55 Tc Worksheet

Hyd. No. 1

Pre, Basin #1

Description	A	B	C	Totals
Sheet Flow				
Manning's n-value	= 0.800	0.011	0.011	
Flow length (ft)	= 300.0	0.0	0.0	
Two-year 24-hr precip. (in)	= 3.70	0.00	0.00	
Land slope (%)	= 10.00	0.00	0.00	
Travel Time (min)	**= 43.99**	**+ 0.00**	**+ 0.00**	**= 43.99**
Shallow Concentrated Flow				
Flow length (ft)	= 420.00	350.00	0.00	
Watercourse slope (%)	= 5.10	3.00	0.00	
Surface description	= Unpaved	Unpaved	Paved	
Average velocity (ft/s)	= 3.64	2.79	0.00	
Travel Time (min)	**= 1.92**	**+ 2.09**	**+ 0.00**	**= 4.01**
Channel Flow				
X sectional flow area (sqft)	= 6.75	4.00	4.00	
Wetted perimeter (ft)	= 9.00	6.00	6.00	
Channel slope (%)	= 3.10	2.73	1.00	
Manning's n-value	= 0.035	0.035	0.035	
Velocity (ft/s)	= 6.18	5.36	3.24	
Flow length (ft)	= 1800.0	1645.0	345.0	
Travel Time (min)	**= 4.85**	**+ 5.11**	**+ 1.77**	**= 11.74**

Total Travel Time, Tc ..... 59.70 min

Hydrograph Plot

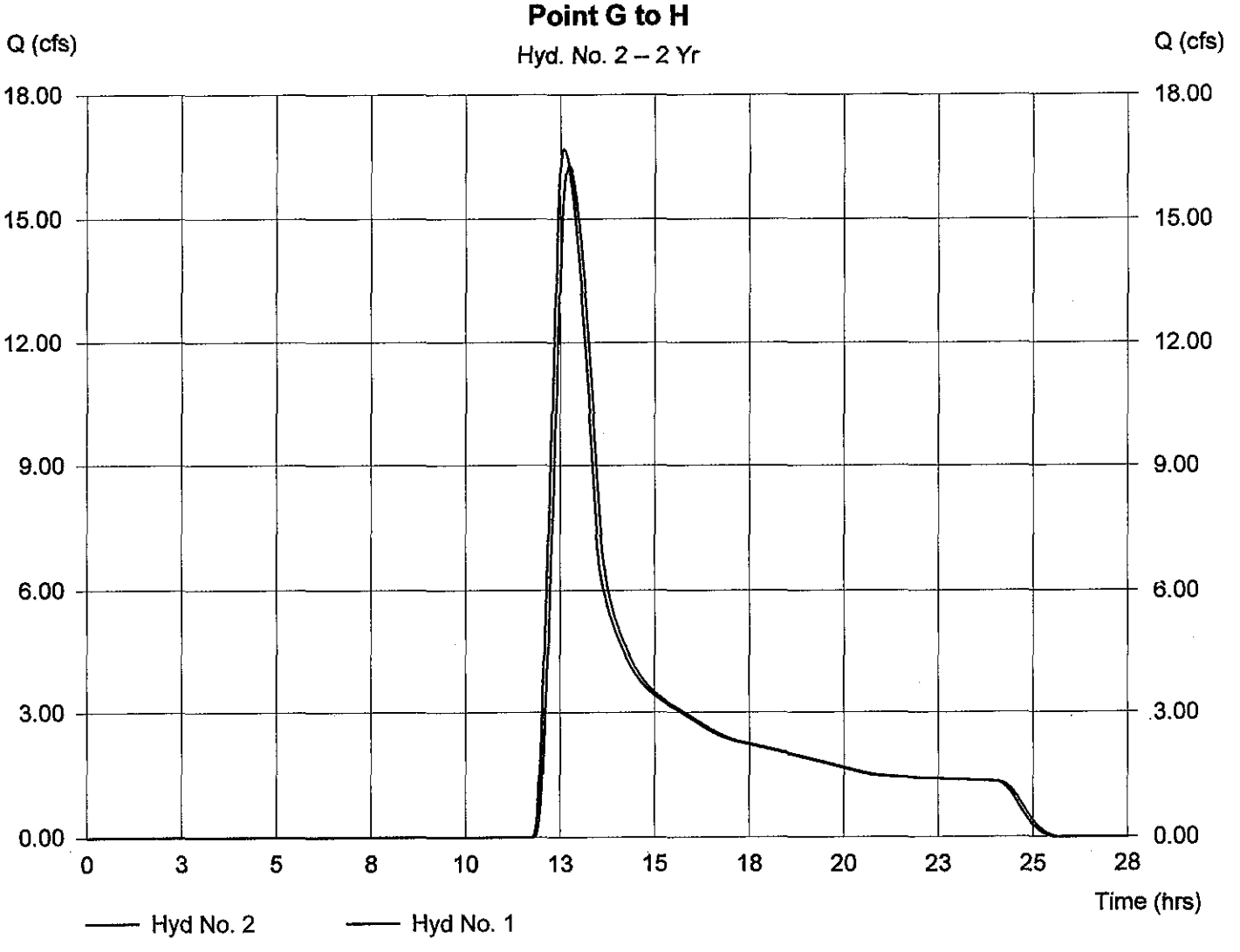
Hydraflow Hydrographs by Intelisolve | Sunday, Feb 19 2006, 12:44 PM

Hyd. No. 2

Point G to H

Hydrograph type	= Reach	Peak discharge	= 16.28 cfs
Storm frequency	= 2 yrs	Time interval	= 1 min
Inflow hyd. No.	= 1	Section type	= Rectangular
Reach length	= 370.0 ft	Channel slope	= 1.0 %
Manning's n	= 0.350	Bottom width	= 5.0 ft
Side slope	= 0.0:1	Max. depth	= 1.0 ft
Rating curve x	= 0.142	Rating curve m	= 1.528
Ave. velocity	= 0.74 ft/s	Routing coeff.	= 0.1671

Modified Att-Kin routing method used. | Hydrograph Volume = 155,724 cuft



Hydrograph Plot

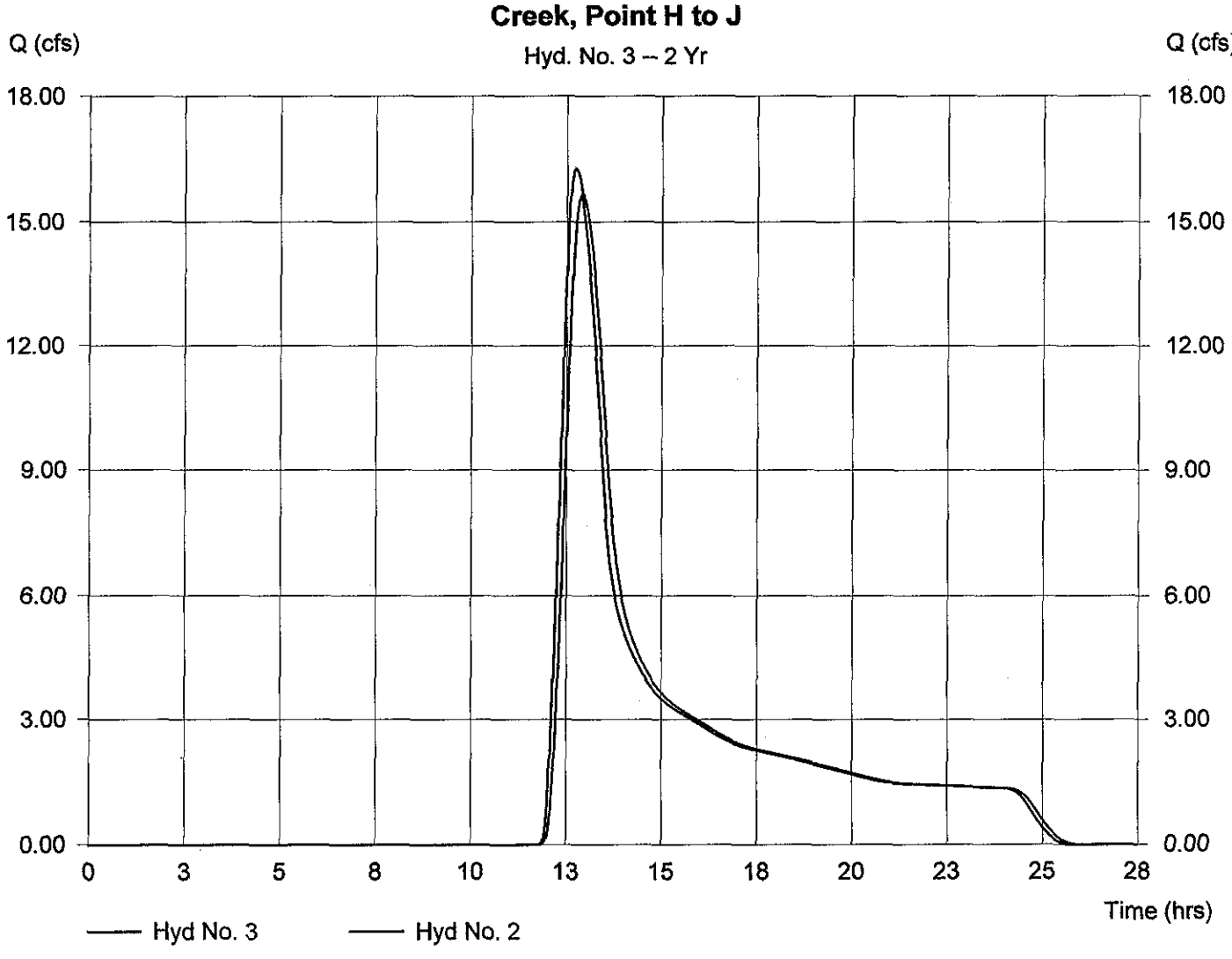
Hydraflow Hydrographs by Intelisolve | Sunday, Feb 19 2006, 12:44 PM

Hyd. No. 3

Creek, Point H to J

Hydrograph type	= Reach	Peak discharge	= 15.67 cfs
Storm frequency	= 2 yrs	Time interval	= 1 min
Inflow hyd. No.	= 2	Section type	= Rectangular
Reach length	= 500.0 ft	Channel slope	= 0.9 %
Manning's n	= 0.350	Bottom width	= 5.0 ft
Side slope	= 0.0:1	Max. depth	= 1.5 ft
Rating curve x	= 0.138	Rating curve m	= 1.511
Ave. velocity	= 0.69 ft/s	Routing coeff.	= 0.1183

Modified Att-Kin routing method used. | Hydrograph Volume = 155,719 cuft



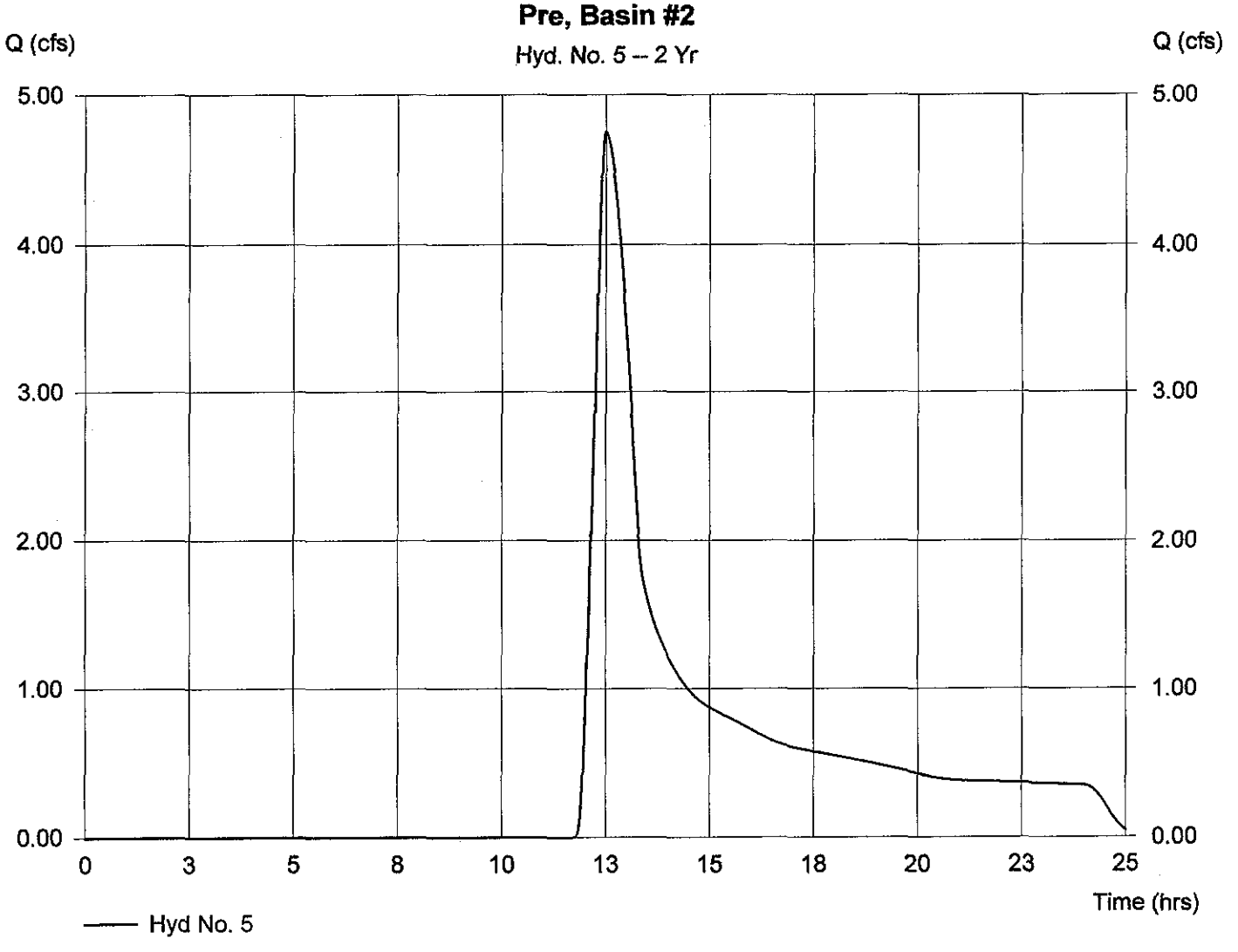
Hydrograph Plot

Hyd. No. 5

Pre, Basin #2

Hydrograph type	= SCS Runoff	Peak discharge	= 4.75 cfs
Storm frequency	= 2 yrs	Time interval	= 1 min
Drainage area	= 19.600 ac	Curve number	= 61
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 54.10 min
Total precip.	= 3.50 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

Hydrograph Volume = 40,592 cuft



TR55 Tc Worksheet

Hyd. No. 5

Pre, Basin #2

Description	A	B	C	Totals
Sheet Flow				
Manning's n-value	= 0.800	0.011	0.011	
Flow length (ft)	= 220.0	0.0	0.0	
Two-year 24-hr precip. (in)	= 3.70	0.00	0.00	
Land slope (%)	= 5.00	0.00	0.00	
Travel Time (min)	**= 45.29**	**+ 0.00**	**+ 0.00**	**= 45.29**
Shallow Concentrated Flow				
Flow length (ft)	= 1215.00	0.00	0.00	
Watercourse slope (%)	= 4.11	0.00	0.00	
Surface description	= Unpaved	Unpaved	Unpaved	
Average velocity (ft/s)	= 3.27	0.00	0.00	
Travel Time (min)	**= 6.19**	**+ 0.00**	**+ 0.00**	**= 6.19**
Channel Flow				
X sectional flow area (sqft)	= 4.00	0.00	0.00	
Wetted perimeter (ft)	= 6.00	0.00	0.00	
Channel slope (%)	= 1.00	0.00	0.00	
Manning's n-value	= 0.035	0.035	0.035	
Velocity (ft/s)	= 3.24	0.00	0.00	
Flow length (ft)	= 510.0	0.0	0.0	
Travel Time (min)	**= 2.62**	**+ 0.00**	**+ 0.00**	**= 2.62**

Total Travel Time, Tc ..... 54.10 min

Hydrograph Plot

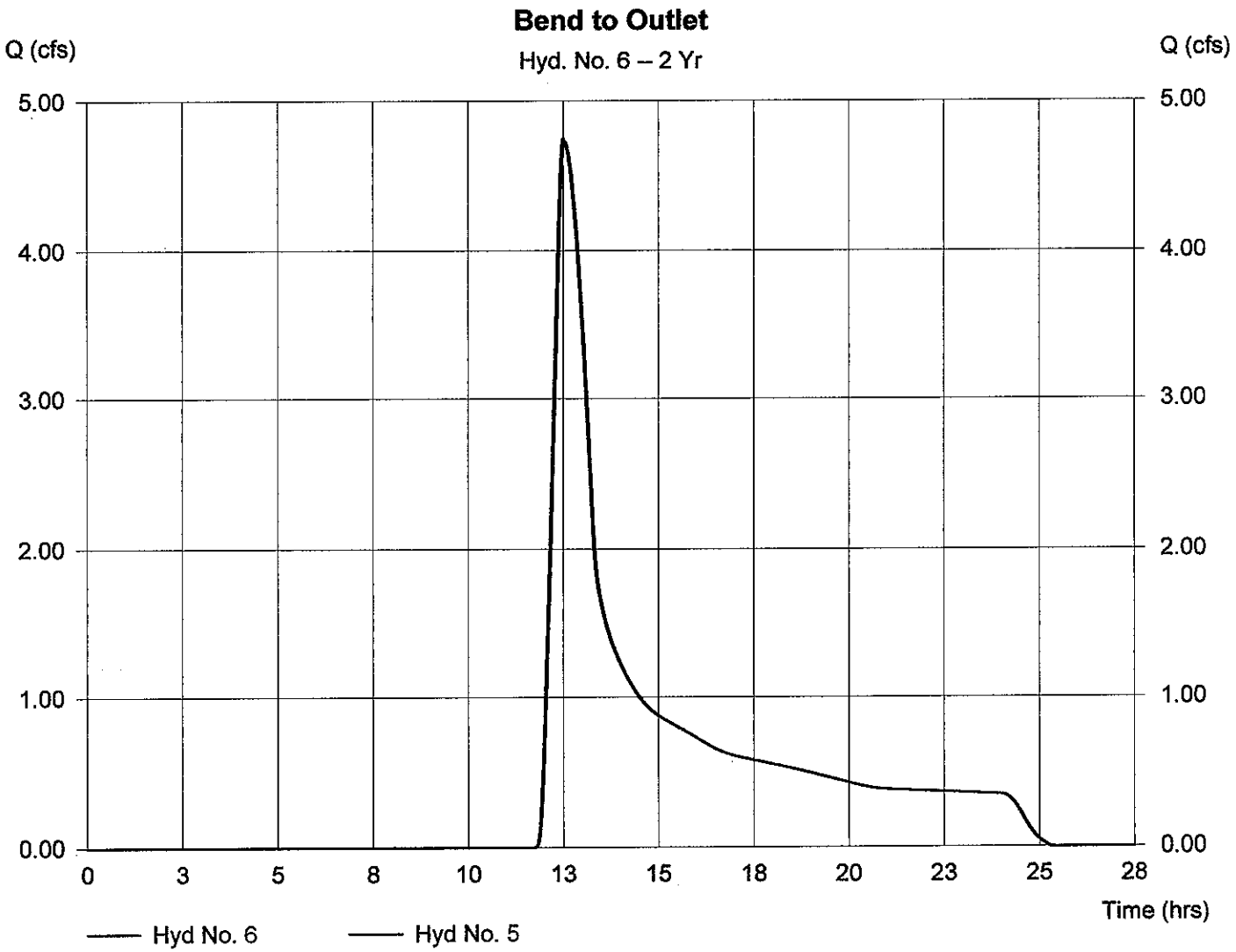
Hydraflow Hydrographs by Intelisolve | Sunday, Feb 19 2006, 12:44 PM

Hyd. No. 6

Bend to Outlet

Hydrograph type	= Reach	Peak discharge	= 4.73 cfs
Storm frequency	= 2 yrs	Time interval	= 1 min
Inflow hyd. No.	= 5	Section type	= Rectangular
Reach length	= 340.0 ft	Channel slope	= 0.9 %
Manning's n	= 0.035	Bottom width	= 5.0 ft
Side slope	= 0.0:1	Max. depth	= 1.5 ft
Rating curve x	= 1.380	Rating curve m	= 1.511
Ave. velocity	= 2.10 ft/s	Routing coeff.	= 0.4372

Modified Att-Kin routing method used. | Hydrograph Volume = 40,589 cuft



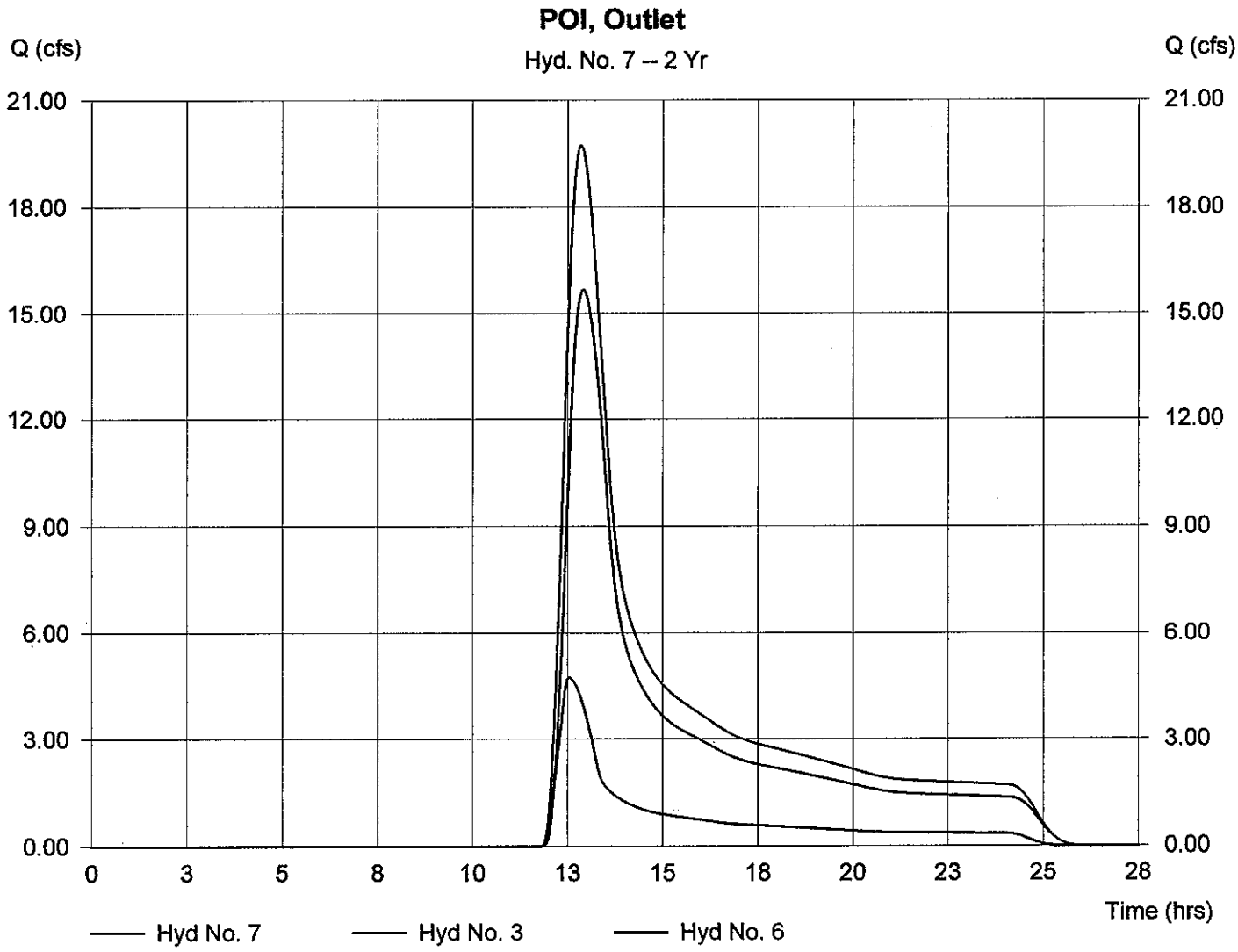
Hydrograph Plot

Hyd. No. 7

POI, Outlet

Hydrograph type	= Combine	Peak discharge	= 19.73 cfs
Storm frequency	= 2 yrs	Time interval	= 1 min
Inflow hyds.	= 3, 6		

Hydrograph Volume = 196,308 cuft



Hydrograph Plot

Hydraflow Hydrographs by Intelisolve

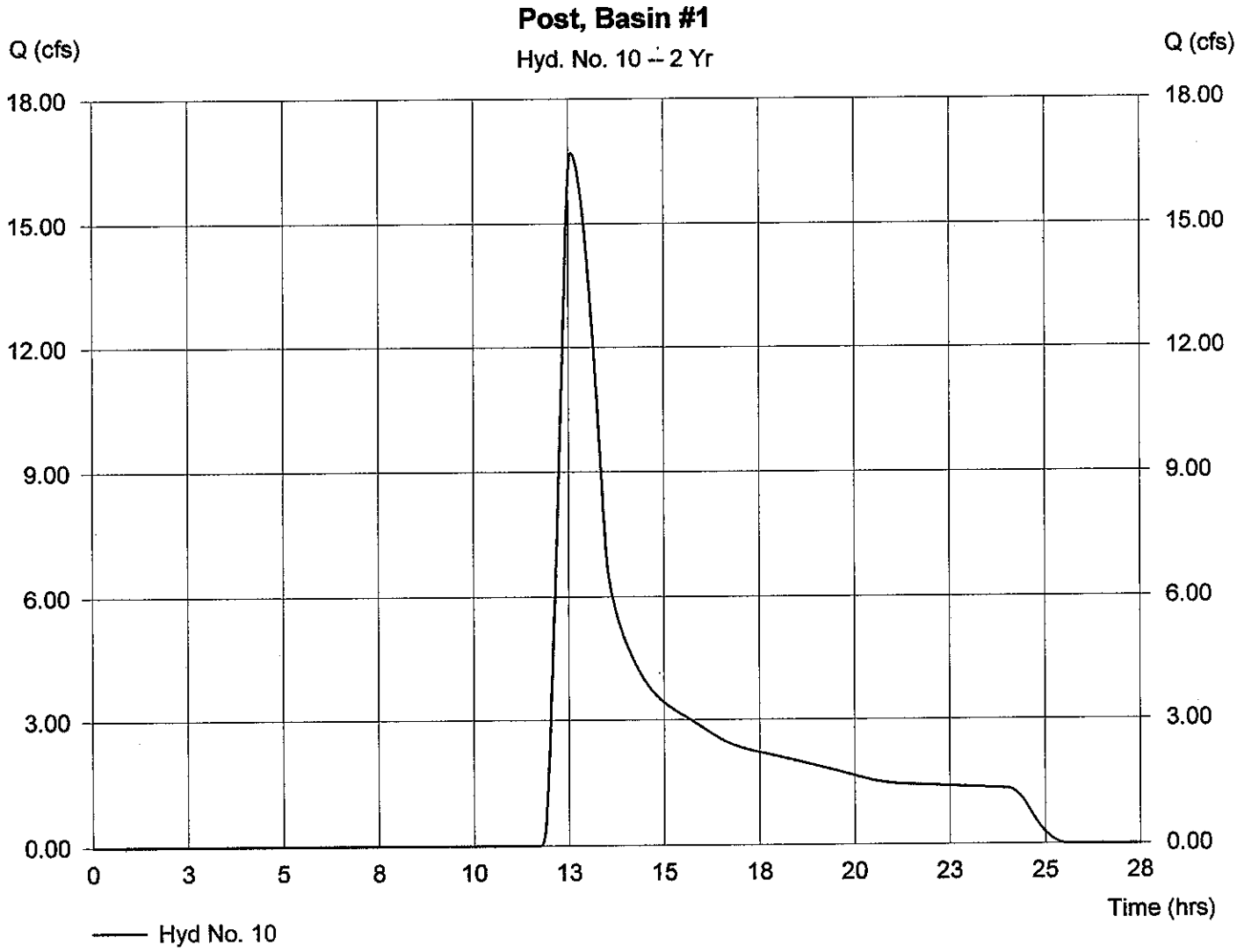
Sunday, Feb 19 2006, 12:44 PM

Hyd. No. 10

Post, Basin #1

Hydrograph type	= SCS Runoff	Peak discharge	= 16.71 cfs
Storm frequency	= 2 yrs	Time interval	= 1 min
Drainage area	= 75.000 ac	Curve number	= 61
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 59.70 min
Total precip.	= 3.50 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

Hydrograph Volume = 155,935 cuft



TR55 Tc Worksheet

Hydraflow Hydrographs by Intelisolve

Hyd. No. 10

Post, Basin #1

Description	A	B	C	Totals
Sheet Flow				
Manning's n-value	= 0.800	0.011	0.011	
Flow length (ft)	= 300.0	0.0	0.0	
Two-year 24-hr precip. (in)	= 3.70	0.00	0.00	
Land slope (%)	= 10.00	0.00	0.00	
Travel Time (min)	**= 43.99 +**	**0.00 +**	**0.00 =**	**43.99**
Shallow Concentrated Flow				
Flow length (ft)	= 420.00	350.00	0.00	
Watercourse slope (%)	= 5.10	3.00	0.00	
Surface description	= Unpaved	Unpaved	Paved	
Average velocity (ft/s)	= 3.64	2.79	0.00	
Travel Time (min)	**= 1.92 +**	**2.09 +**	**0.00 =**	**4.01**
Channel Flow				
X sectional flow area (sqft)	= 6.75	4.00	4.00	
Wetted perimeter (ft)	= 9.00	6.00	6.00	
Channel slope (%)	= 3.10	2.73	1.00	
Manning's n-value	= 0.035	0.035	0.035	
Velocity (ft/s)	= 6.18	5.36	3.24	
Flow length (ft)	= 1800.0	1645.0	345.0	
Travel Time (min)	**= 4.85 +**	**5.11 +**	**1.77 =**	**11.74**

Total Travel Time, Tc ..... **59.70 min**

Hydrograph Plot

Hydraflow Hydrographs by Intelisolve

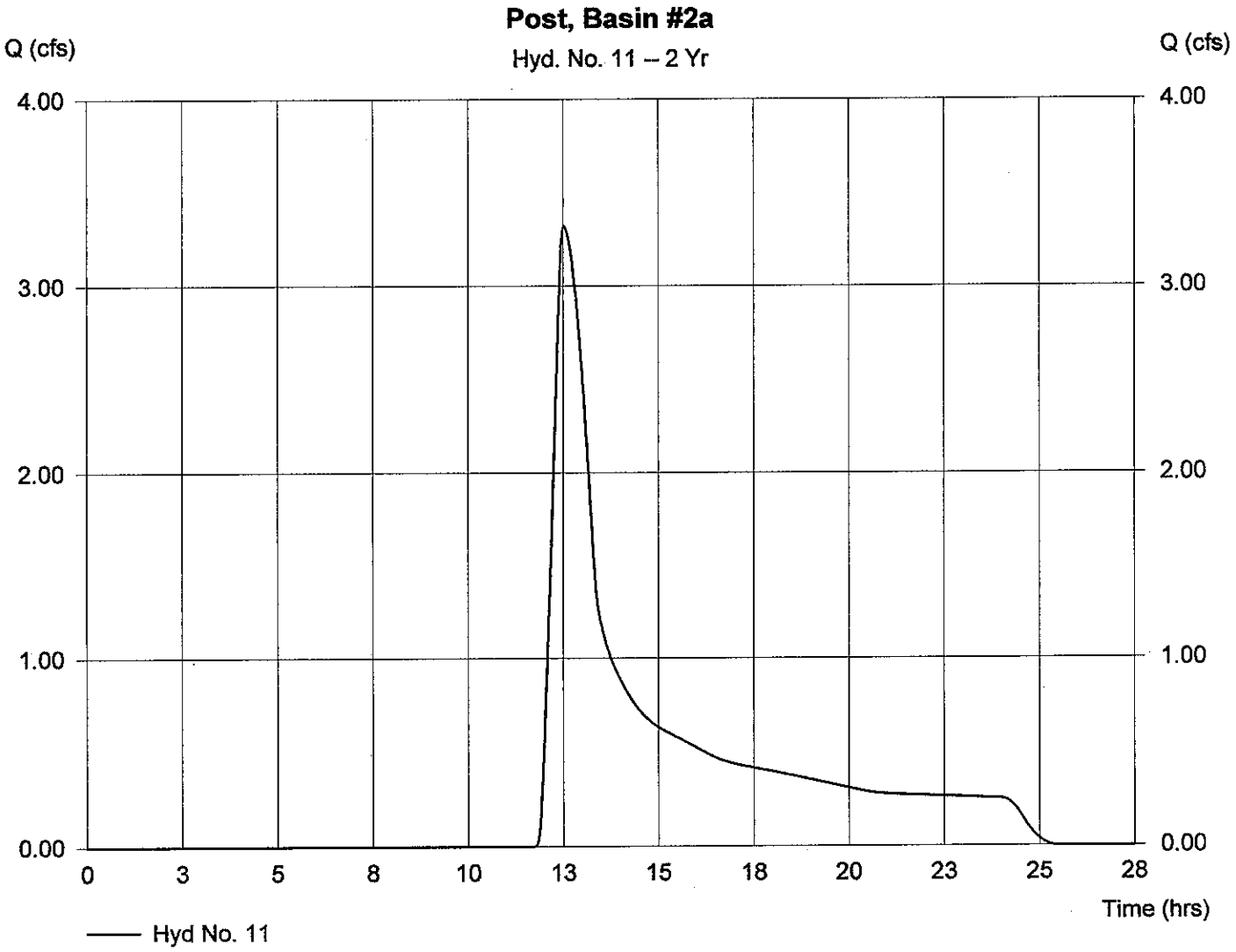
Sunday, Feb 19 2006, 12:44 PM

Hyd. No. 11

Post, Basin #2a

Hydrograph type	= SCS Runoff	Peak discharge	= 3.32 cfs
Storm frequency	= 2 yrs	Time interval	= 1 min
Drainage area	= 14.000 ac	Curve number	= 61
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 54.80 min
Total precip.	= 3.50 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

Hydrograph Volume = 29,108 cuft



TR55 Tc Worksheet

Hydraflow Hydrographs by Intelisolve

Hyd. No. 11

Post, Basin #2a

Description	A	B	C	Totals
Sheet Flow				
Manning's n-value	= 0.800	0.011	0.011	
Flow length (ft)	= 220.0	0.0	0.0	
Two-year 24-hr precip. (in)	= 3.70	0.00	0.00	
Land slope (%)	= 5.00	0.00	0.00	
Travel Time (min)	**= 45.29**	**+ 0.00**	**+ 0.00**	**= 45.29**
Shallow Concentrated Flow				
Flow length (ft)	= 1215.00	250.00	0.00	
Watercourse slope (%)	= 4.11	2.00	0.00	
Surface description	= Unpaved	Unpaved	Paved	
Average velocity (ft/s)	= 3.27	2.28	0.00	
Travel Time (min)	**= 6.19**	**+ 1.83**	**+ 0.00**	**= 8.02**
Channel Flow				
X sectional flow area (sqft)	= 60.00	4.00	0.00	
Wetted perimeter (ft)	= 34.00	6.00	0.00	
Channel slope (%)	= 0.50	1.45	0.00	
Manning's n-value	= 0.035	0.035	0.015	
Velocity (ft/s)	= 4.40	3.91	0.00	
Flow length (ft)	= 265.0	125.0	0.0	
Travel Time (min)	**= 1.00**	**+ 0.53**	**+ 0.00**	**= 1.54**

Total Travel Time, Tc ..... 54.80 min

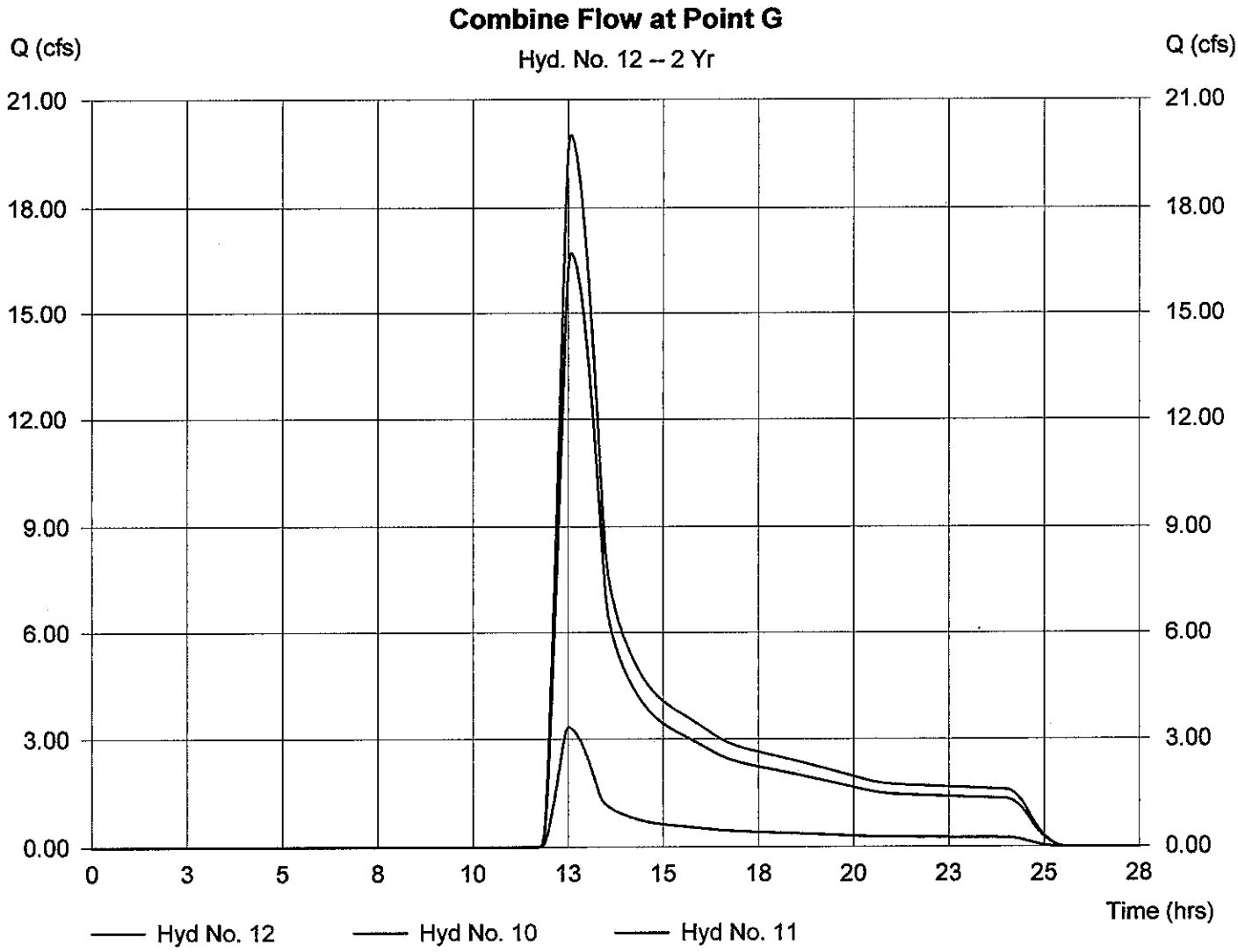
Hydrograph Plot

Hyd. No. 12

Combine Flow at Point G

Hydrograph type	= Combine	Peak discharge	= 20.02 cfs
Storm frequency	= 2 yrs	Time interval	= 1 min
Inflow hyds.	= 10, 11		

Hydrograph Volume = 185,043 cuft



Hydrograph Plot

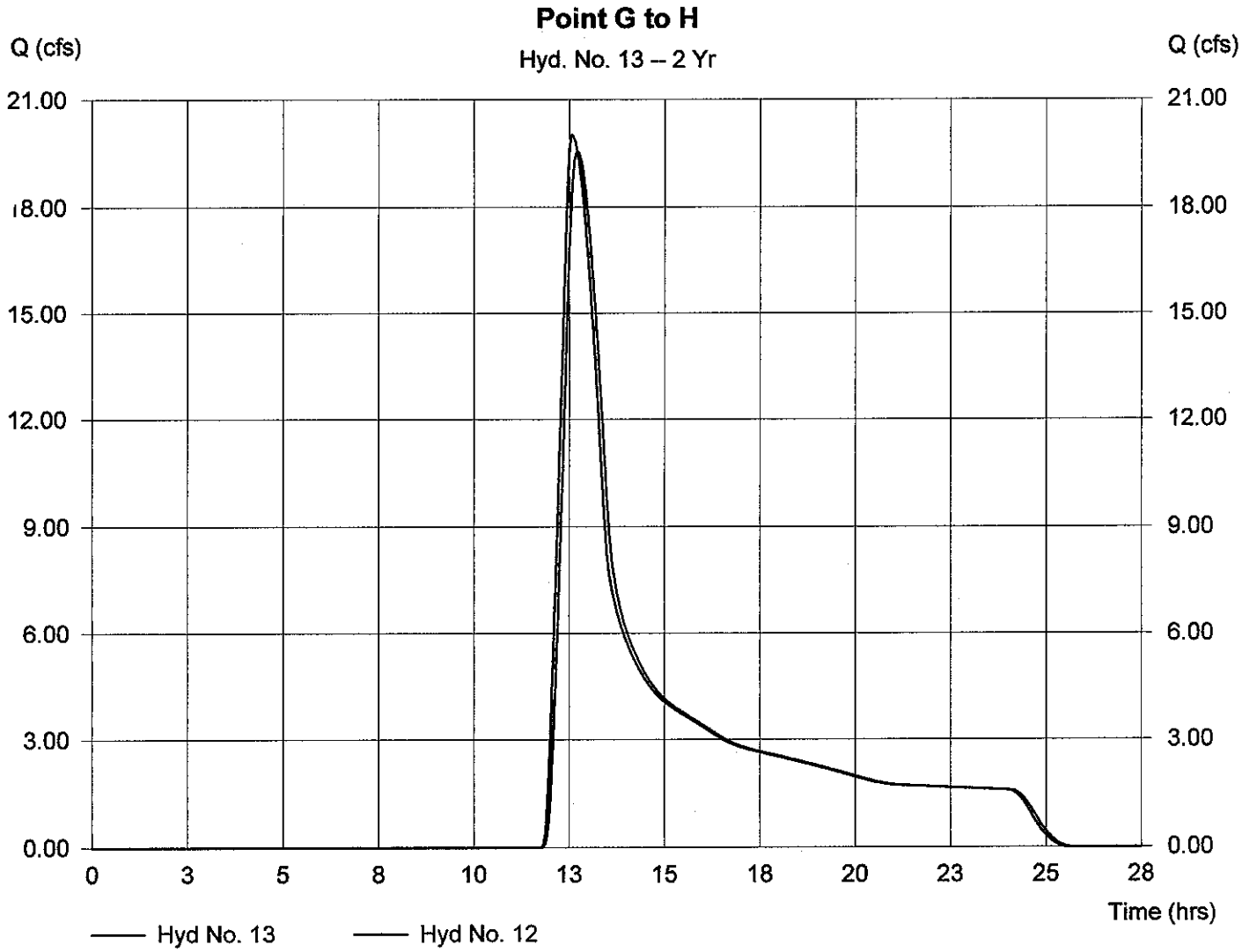
Hydraflow Hydrographs by Intelisolve | Sunday, Feb 19 2006, 12:44 PM

Hyd. No. 13

Point G to H

Hydrograph type	= Reach	Peak discharge	= 19.55 cfs
Storm frequency	= 2 yrs	Time interval	= 1 min
Inflow hyd. No.	= 12	Section type	= Rectangular
Reach length	= 370.0 ft	Channel slope	= 1.0 %
Manning's n	= 0.350	Bottom width	= 5.0 ft
Side slope	= 0.0:1	Max. depth	= 1.0 ft
Rating curve x	= 0.142	Rating curve m	= 1.528
Ave. velocity	= 0.78 ft/s	Routing coeff.	= 0.1770

Modified Att-Kin routing method used. | Hydrograph Volume = 185,040 cuft



Hydrograph Plot

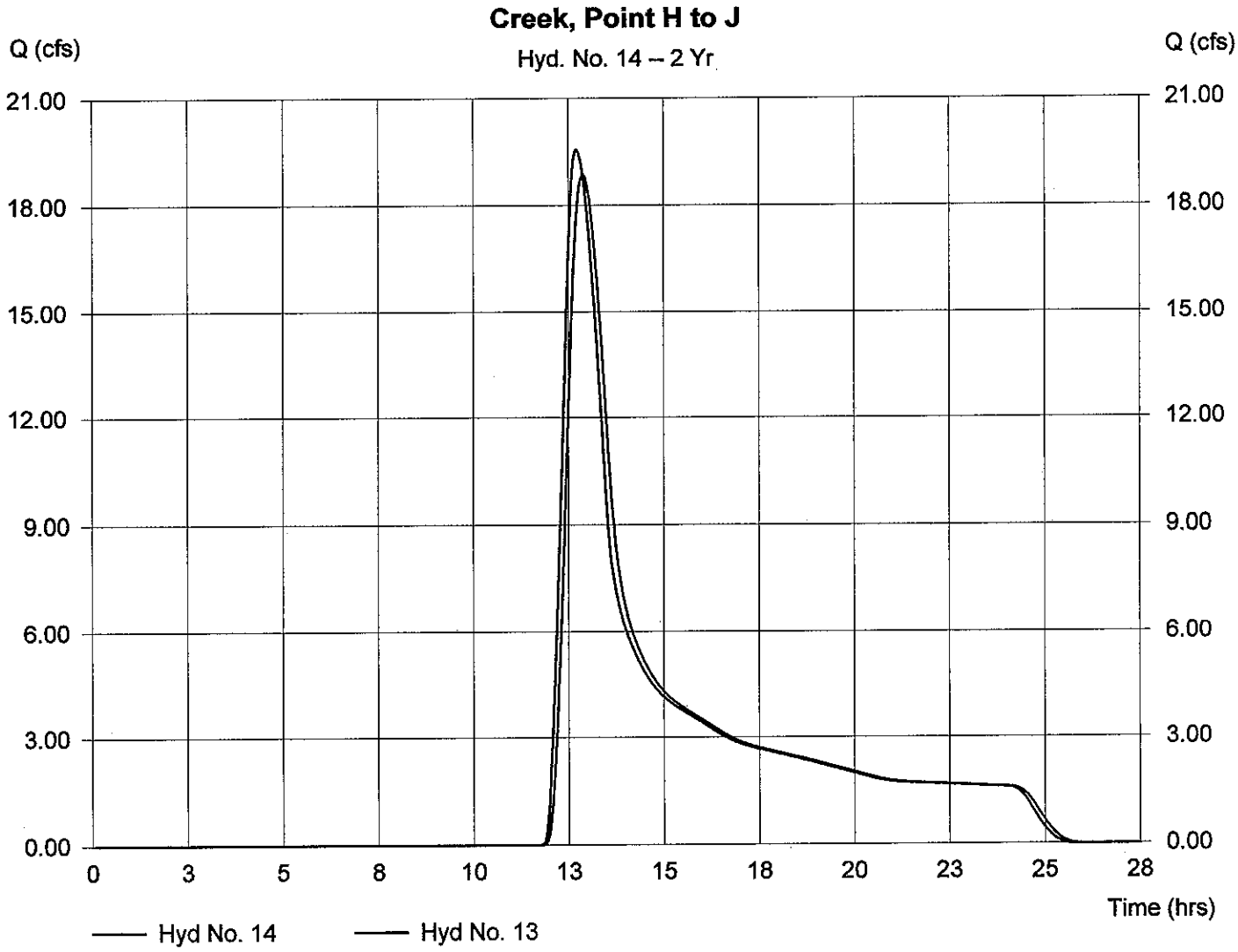
Hydraflow Hydrographs by Intelisolve — Sunday, Feb 19 2006, 12:44 PM

Hyd. No. 14

Creek, Point H to J

Hydrograph type	= Reach	Peak discharge	= 18.87 cfs
Storm frequency	= 2 yrs	Time interval	= 1 min
Inflow hyd. No.	= 13	Section type	= Rectangular
Reach length	= 500.0 ft	Channel slope	= 0.9 %
Manning's n	= 0.350	Bottom width	= 5.0 ft
Side slope	= 0.0:1	Max. depth	= 1.5 ft
Rating curve x	= 0.138	Rating curve m	= 1.511
Ave. velocity	= 0.74 ft/s	Routing coeff.	= 0.1254

Modified Att-Kin routing method used. — Hydrograph Volume = 185,035 cuft



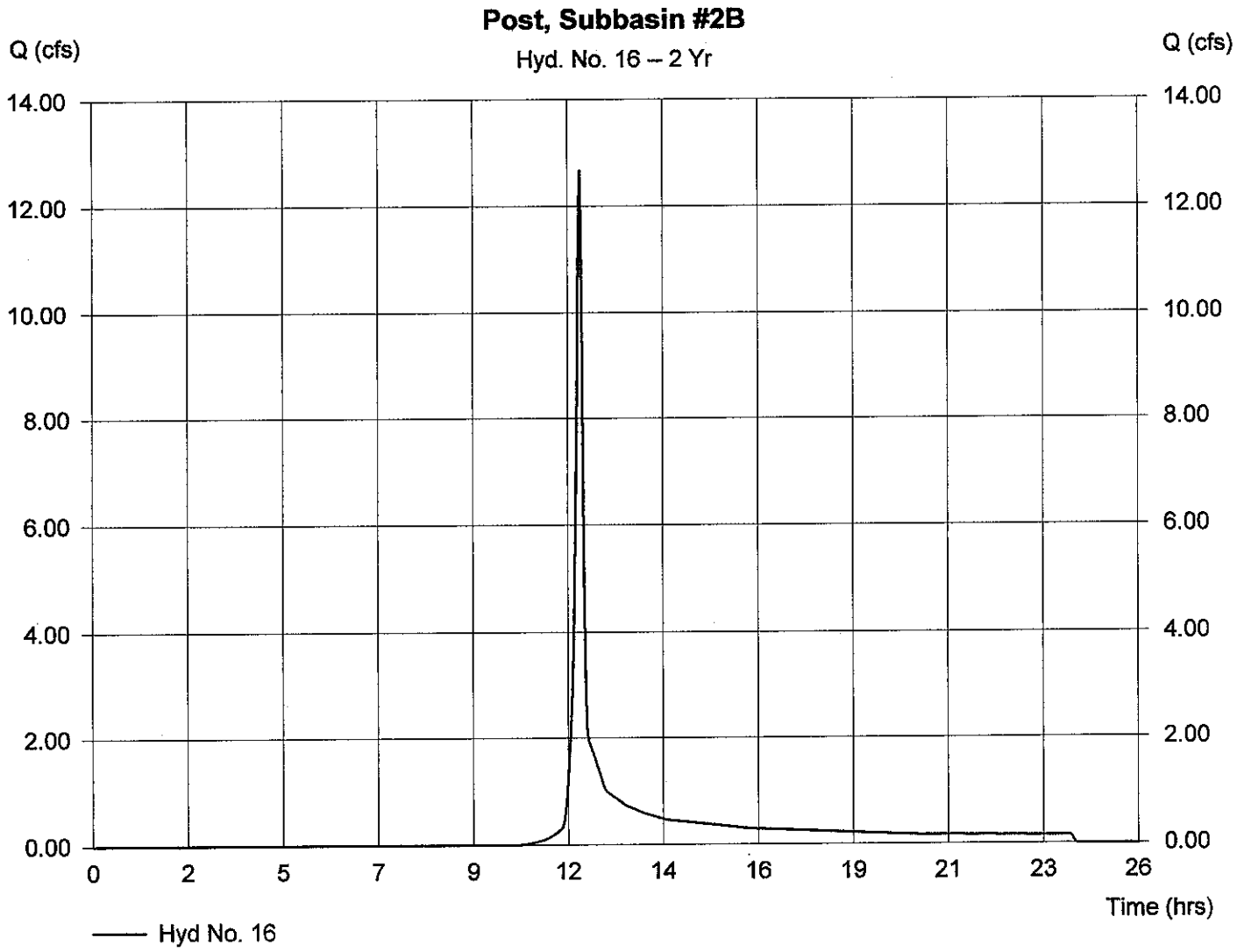
Hydrograph Plot

Hyd. No. 16

Post, Subbasin #2B

Hydrograph type	= SCS Runoff	Peak discharge	= 12.67 cfs
Storm frequency	= 2 yrs	Time interval	= 1 min
Drainage area	= 5.500 ac	Curve number	= 74
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 6.20 min
Total precip.	= 3.50 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

Hydrograph Volume = 25,528 cuft



TR55 Tc Worksheet

Hyd. No. 16

Post, Subbasin #2B

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.016		0.011		0.011		
Flow length (ft)	= 275.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		0.00		0.00		
Land slope (%)	= 2.50		0.00		0.00		
Travel Time (min)	**= 3.12**	**+**	**0.00**	**+**	**0.00**	**=**	**3.12**
Shallow Concentrated Flow							
Flow length (ft)	= 220.00		0.00		0.00		
Watercourse slope (%)	= 4.00		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	= 3.23		0.00		0.00		
Travel Time (min)	**= 1.14**	**+**	**0.00**	**+**	**0.00**	**=**	**1.14**
Channel Flow							
X sectional flow area (sqft)	= 4.00		7.50		0.00		
Wetted perimeter (ft)	= 6.00		8.00		0.00		
Channel slope (%)	= 1.00		0.90		0.00		
Manning's n-value	= 0.035		0.035		0.015		
Velocity (ft/s)	= 3.24		3.87		0.00		
Flow length (ft)	= 90.0		340.0		0.0		
Travel Time (min)	**= 0.46**	**+**	**1.47**	**+**	**0.00**	**=**	**1.93**

Total Travel Time, Tc ..... 6.20 min

Hydrograph Plot

Hydraflow Hydrographs by Intelisolve

Sunday, Feb 19 2006, 12:44 PM

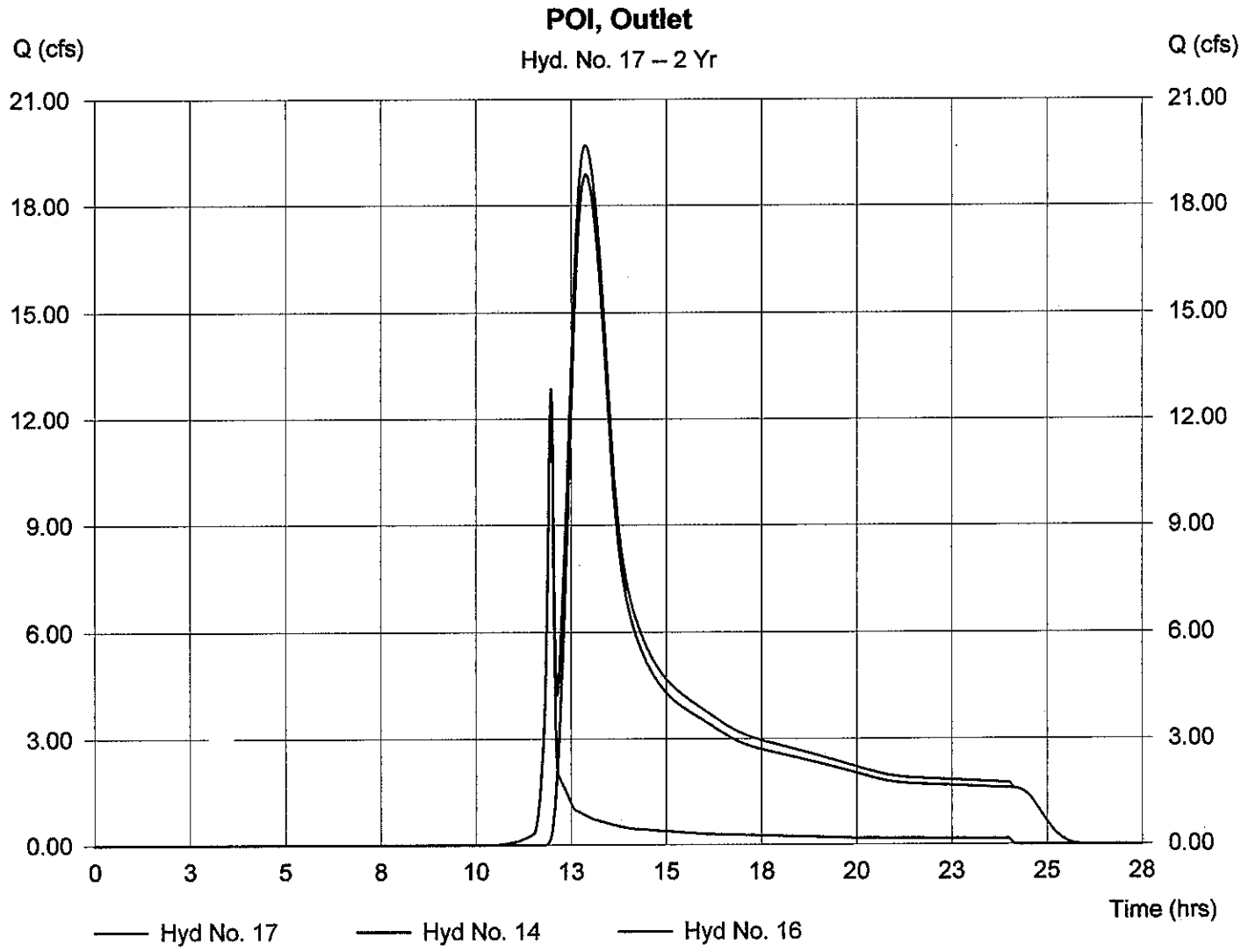
Hyd. No. 17

POI, Outlet

Hydrograph type = Combine
Storm frequency = 2 yrs
Inflow hyds. = 14, 16

Peak discharge = 19.71 cfs
Time interval = 1 min

Hydrograph Volume = 210,564 cuft



PIPE CALCULATIONS
(Detailed Pipe Calculations using CulvertMaster)

Culvert Designer/Analyzer Report
Culvert #1

Peak Discharge Method: User-Specified			
Design Discharge	12.17 cfs	Check Discharge	16.18 cfs
Grades Model: Inverts			
Invert Upstream	379.42 ft	Invert Downstream	379.00 ft
Length	84.00 ft	Slope	0.005000 ft/ft
Drop	0.42 ft		
Headwater Model: Allowable HW/Height			
Headwater Depth/ Height	1.20		
Tailwater Conditions: Constant Tailwater			
Tailwater Elevation	N/A ft		

	Name	Desc	Discharge	HW Elev	Velocity
x	Trial-1	1-24 inch Circular	12.17 cfs	381.46 ft	5.87 ft/s
	Trial-2	1-24 inch Circular	16.18 cfs	381.86 ft	6.63 ft/s

Q_{10} / Q_{25} TAKEN FROM DETENTION ANALYSIS

Culvert Designer/Analyzer Report
Culvert #1

Design:Trial-1

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	381.82	ft	Storm Event	Design	
Computed Headwater Elevation	381.46	ft	Discharge	12.17	cfs
Headwater Depth/ Height	1.02		Tailwater Elevation	N/A	ft
Inlet Control HW Elev	381.35	ft	Control Type	Outlet Control	
Outlet Control HW Elev	381.46	ft			

Grades					
Upstream Invert	379.42	ft	Downstream Invert	379.00	ft
Length	84.00	ft	Constructed Slope	0.005000	ft/ft

Hydraulic Profile					
Profile	M2		Depth, Downstream	1.25	ft
Slope Type	Mild		Normal Depth	1.31	ft
Flow Regime	Subcritical		Critical Depth	1.25	ft
Velocity Downstream	5.87	ft/s	Critical Slope	0.005621	ft/ft

Section					
Section Shape	Circular		Mannings Coefficient	0.013	
Section Material	Concrete		Span	2.00	ft
Section Size	24 inch		Rise	2.00	ft
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev	381.46	ft	Upstream Velocity Head	0.49	ft
Ke	0.50		Entrance Loss	0.24	ft

Inlet Control Properties					
Inlet Control HW Elev	381.35	ft	Flow Control	Unsubmerged	
Inlet Type	End-Section Conforming to fill slope		Area Full	3.1	ft²
K	0.00980		HDS 5 Chart	1	
M	2.00000		HDS 5 Scale	1	
C	0.03980		Equation Form	1	
Y	0.67000				

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Culvert Designer/Analyzer Report
Culvert #1

Design:Trial-2

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	381.82	ft	Storm Event	Check	
Computed Headwater Elevation	381.86	ft	Discharge	16.18	cfs
Headwater Depth/ Height	1.22		Tailwater Elevation	N/A	ft
Inlet Control HW Elev	381.82	ft	Control Type	Outlet Control	
Outlet Control HW Elev	381.86	ft			

Grades					
Upstream Invert	379.42	ft	Downstream Invert	379.00	ft
Length	84.00	ft	Constructed Slope	0.005000	ft/ft

Hydraulic Profile					
Profile	M2		Depth, Downstream	1.45	ft
Slope Type	Mild		Normal Depth	1.66	ft
Flow Regime	Subcritical		Critical Depth	1.45	ft
Velocity Downstream	6.63	ft/s	Critical Slope	0.006672	ft/ft

Section					
Section Shape	Circular		Mannings Coefficient	0.013	
Section Material	Concrete		Span	2.00	ft
Section Size	24 inch		Rise	2.00	ft
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev	381.86	ft	Upstream Velocity Head	0.54	ft
Ke	0.50		Entrance Loss	0.27	ft

Inlet Control Properties					
Inlet Control HW Elev	381.82	ft	Flow Control	Transition	
Inlet Type	End-Section Conforming to fill slope		Area Full	3.1	ft²
K	0.00980		HDS 5 Chart	1	
M	2.00000		HDS 5 Scale	1	
C	0.03980		Equation Form	1	
Y	0.67000				

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Culvert Designer/Analyzer Report
Culvert #2

Peak Discharge Method: User-Specified			
Design Discharge	5.35 cfs	Check Discharge	5.93 cfs
Grades Model: Inverts			
Invert Upstream	369.00 ft	Invert Downstream	368.00 ft
Length	66.00 ft	Slope	0.015152 ft/ft
Drop	1.00 ft		
Headwater Model: Allowable HW/Height			
Headwater Depth/ Height	1.20		
Tailwater Conditions: Constant Tailwater			
Tailwater Elevation	N/A ft		

	Name	Desc	Discharge	HW Elev	Velocity
x	Trial-1	1-18 inch Circular	5.35 cfs	370.45 ft	6.97 ft/s
	Trial-2	1-18 inch Circular	5.93 cfs	370.54 ft	7.14 ft/s

$T_c = 5 MIN$

$I_{10} = 7.22$ IN/HR $\qquad I_{25} = 8.0$ IN/HR

$Q_{10} = C I_{10} A$

$= .65 \times 7.22 \times 1.14$

$= 5.35$

$Q_{25} = C I_{10} A$

$= .65 \times 8 \times 1.14$

$= 5.93$

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Culvert Designer/Analyzer Report
Culvert #2

Design:Trial-1

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	370.80	ft	Storm Event	Design	
Computed Headwater Elevation	370.45	ft	Discharge	5.35	cfs
Headwater Depth/ Height	0.97		Tailwater Elevation	N/A	ft
Inlet Control HW Elev	370.34	ft	Control Type	Outlet Control	
Outlet Control HW Elev	370.45	ft			

Grades					
Upstream Invert	369.00	ft	Downstream Invert	368.00	ft
Length	66.00	ft	Constructed Slope	0.015152	ft/ft

Hydraulic Profile					
Profile	S2		Depth, Downstream	0.67	ft
Slope Type	Steep		Normal Depth	0.67	ft
Flow Regime	Supercritical		Critical Depth	0.89	ft
Velocity Downstream	6.97	ft/s	Critical Slope	0.005926	ft/ft

Section					
Section Shape	Circular		Mannings Coefficient	0.013	
Section Material	Concrete		Span	1.50	ft
Section Size	18 inch		Rise	1.50	ft
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev	370.45	ft	Upstream Velocity Head	0.37	ft
Ke	0.50		Entrance Loss	0.19	ft

Inlet Control Properties					
Inlet Control HW Elev	370.34	ft	Flow Control	Unsubmerged	
Inlet Type	Square edge w/headwall		Area Full	1.8	ft²
K	0.00980		HDS 5 Chart	1	
M	2.00000		HDS 5 Scale	1	
C	0.03980		Equation Form	1	
Y	0.67000				

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Culvert Designer/Analyzer Report
Culvert #2

Design:Trial-2

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	370.80	ft	Storm Event	Check	
Computed Headwater Elevation	370.54	ft	Discharge	5.93	cfs
Headwater Depth/ Height	1.03		Tailwater Elevation	N/A	ft
Inlet Control HW Elev	370.44	ft	Control Type	Outlet Control	
Outlet Control HW Elev	370.54	ft			

Grades					
Upstream Invert	369.00	ft	Downstream Invert	368.00	ft
Length	66.00	ft	Constructed Slope	0.015152	ft/ft

Hydraulic Profile					
Profile	S2		Depth, Downstream	0.71	ft
Slope Type	Steep		Normal Depth	0.71	ft
Flow Regime	Supercritical		Critical Depth	0.94	ft
Velocity Downstream	7.14	ft/s	Critical Slope	0.006183	ft/ft

Section					
Section Shape	Circular		Mannings Coefficient	0.013	
Section Material	Concrete		Span	1.50	ft
Section Size	18 inch		Rise	1.50	ft
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev	370.54	ft	Upstream Velocity Head	0.40	ft
Ke	0.50		Entrance Loss	0.20	ft

Inlet Control Properties					
Inlet Control HW Elev	370.44	ft	Flow Control	Unsubmerged	
Inlet Type	Square edge w/headwall		Area Full	1.8	ft²
K	0.00980		HDS 5 Chart	1	
M	2.00000		HDS 5 Scale	1	
C	0.03980		Equation Form	1	
Y	0.67000				

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APRON CALCULATIONS
(Aprons based on 10-year Storm)

NEW YORK DOT DISSIPATOR METHOD FOR USE IN DEFINED CHANNELS

(Source: "Bank and channel lining procedures", New York Department of Transportation, Division of Design and Construction, 1971.)

Note: To use the following chart you must know:

(1) Q full capacity
(2) Q_{10}
(3) V full
(4) V_{10}

where Q = discharge in cfs and V = Velocity in FPS.

ESTIMATION OF STONE SIZE AND DIMENSIONS FOR CULVERT APRONS

Step 1) Compute flow velocity V_o at culvert or paved channel outlet.

Step 2) For pipe culverts D_o is diameter.
For pipe arch, arch and box culverts, and paved channel outlets, $D_o=A_o$, where A.= cross-sectional area of flow at outlet.

For multiple culverts, use $D_o=1.25xD_o$ of single culvert.

Step 3) For apron grades of 10% or steeper, use recommendations For next higher zone. (Zones 1 through 6).

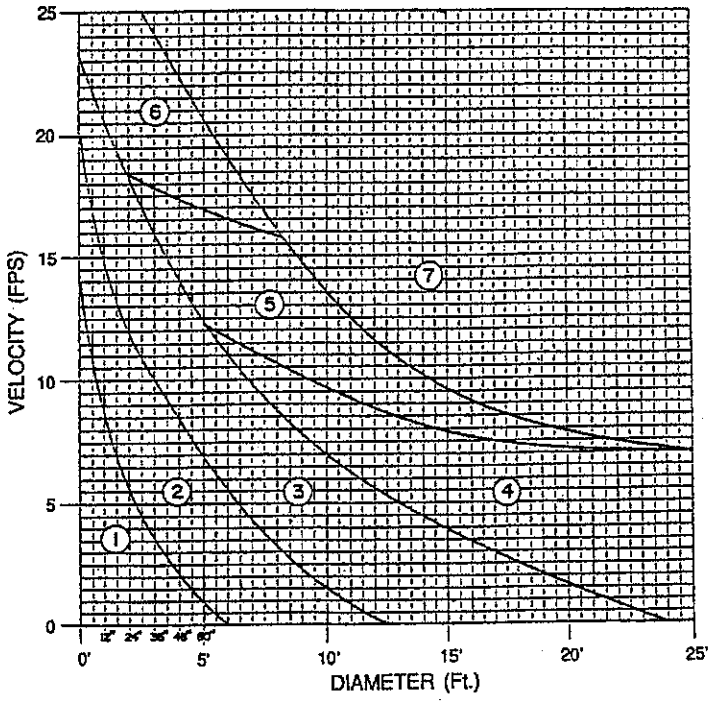

Figure 8.06.b.1

CULVERT #1
24" @ 5.87 CFS
ZONE 2

CULVERT #2
18" @ 6.97 CFS
ZONE 2

ZONE	APRON MATERIAL		LENGTH OF APRON TO PROTECT CULVERT L1	LENGTH OF APRON TO PREVENT SCOUR HOLE USE L2 ALWAYS L2
1	STONE FILLING (FINE)	CL. A	3 x D_o	4 x D_o
2	STONE FILLING (LIGHT)	CL. B	3 x D_o	6 x D_o
3	STONE FILLING (MEDIUM)	CL. 1	4 x D_o	8 x D_o
4	STONE FILLING (HEAVY)	CL. 1	4 x D_o	8 x D_o
5	STONE FILLING (HEAVY)	CL. 2	5 x D_o	10 x D_o
6	STONE FILLING (HEAVY)	CL. 2	6 x D_o	10 x D_o
7	SPECIAL STUDY REQUIRED (ENERGY DISSIPATORS, STILLING BASIN OR LARGER SIZE STONE).			

Fig. 8.06.b.2

Width = 3 times pipe dia. (min.)

DETERMINATION OF STONE SIXES FOR DUMPED STONE CHANNEL LININGS AND REVETMENTS

Step 1) Use figure 8.06.b.3 to determine maximum stone size (e.g. for 12 Fps=20" or 550 lbs.

Step 2) Use figure 8.06.b.4 to determine acceptable size range for stone (for 12 FPS it is 125-500 lbs. for 75% of stone, and the maximum and minimum range in weight should be 25-500 lbs.)

Note: In determining channel velocities for stone linings and revetment, use the following coefficients of roughness:

	Diameter (inches)	Mannin's "n"	Min. thickness of lining	(inches)
Fine	3	0.031	9	12
Light	6	0.035	12	18
Medium	13	0.040	18	24
Heavy	23	0.044	30 (Channels)	36 (Dissapators)

DITCHLINE CALCULATIONS
(Calculations perfomed with Flowmaster)

(continued) Sample Problem 8.05a Design of a grass-lined channel.

Channel summary:
Trapezoidal shape, Z=3, b=3 ft, d=1.5 ft, grade = 2%

Note: In Sample Problem 8.05a the "n-value" is first choosen based on a permissible velocity and not a design velocity criteria. Therefore the use of table 8.05c may not be as accurate as individual retardance class charts when a design velocity is the determining factor.

Tractive Force Procedure

The design of riprap-lined channels and temporary channel linings is based on analysis of tractive force.

NOTE: This procedure is for uniform flow in channels and is *not* to be used for design of deenergizing devices and may not be valid for larger channels

To calculate the required size of an open channel, assume the design flow is uniform and does not vary with time. Since actual flow conditions change through the length of a channel, subdivide the channel into design reaches as appropriate.

PERMISSIBLE SHEAR STRESS

The permissible shear stress, T_d, is the force required to initiate movement of the lining material. Permissible shear stress for the liner is not related to the erodibility of the underlying soil. However, if the lining is eroded or broken, the bed material will be exposed to the erosive force of the flow.

COMPUTING NORMAL DEPTH

The first step in selecting an appropriate lining is to compute the design flow depth (the normal depth) and determine the shear stress.

Normal depths can be calculated by Manning's equation as shown for trapezoidal channels in Figure 8.05d. Values of the Manning's roughness coefficient for different ranges of depth are provided in Table 8.05e for temporary linings and Table 8.05f for riprap. The coefficient of roughness generally decreases with increasing flow depth.

Table 8.05e Manning's Roughness Coefficients for Temporary Lining Materials

	n value for Depth Ranges*		
	0-0.5 ft	0.5-2.0 ft	>2.0 ft
Lining Type			
Woven Paper Net	0.016	0.015	0.015
Jute Net	0.028	0.022	0.019
Fiberglass Roving	0.028	0.021	0.019
Straw with Net	0.065	0.033	0.025
Curled Wood Mat	0.066	0.035	0.028
Synthetic Mat	0.036	0.025	0.021

* Adapted from: FHWA-HEC 15, Pg. 37 - April 1988

USE OF 0.065 INCREASE D > 0.5 FT, USE 0.033

Northern Ditch - Liner
Worksheet for Trapezoidal Channel

Project Description	
Project File	c:\projects\05-050\05-050 calcs\05-050 d.fm2
Worksheet	Northern Ditch - revised
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.033	
Channel Slope	0.005000	ft/ft
Left Side Slope	3.000000	H : V
Right Side Slope	3.000000	H : V
Bottom Width	15.00	ft
Discharge	12.17	cfs

Results		
Depth	0.43	ft
Flow Area	7.06	ft²
Wetted Perimeter	17.74	ft
Top Width	17.60	ft
Critical Depth	0.27	ft
Critical Slope	0.025181	ft/ft
Velocity	1.72	ft/s
Velocity Head	0.05	ft
Specific Energy	0.48	ft
Froude Number	0.48	
Flow is subcritical.		

Notes:

T=yds
T=62.4x0.43x0.005
T=0.13

Use Straw with Net Liner, T=1.45 max.

T calculated using 10 year storm to provide greater protection.

Table 8.05g
Permissible Shear Stresses for Riprap and Temporary Liners

Lining Category	Permissible Unit Shear Stress, T_d Lining Type	(lb/ft^2)
Temporary	Woven Paper Net	0.15
	Jute Net	0.45
	Fiberglass Roving:	
	Single	*0.60*
	Double	0.85
	Straw with Net	1.45
	Curled Wood mat	1.55
	Synthetic Mat	2.00
	d_{50} **Stone Size** (Inches)	
Gravel Riprap	1	0.33
	2	0.67
Rock Riprap	6	2.00
	9	3.00
	12	4.00
	15	5.00
	18	6.00
	21	7.80
	24	8.00

Adapted From: FHWA, HEC-15, April 1983, pgs. 17 & 37.

Design Procedure-Temporary Liners

The following is a step-by-step procedure for designing a temporary liner for a channel. Because temporary liners have a short period of service, the design Q may be reduced. For liners that are needed for six months or less, the 2-yr frequency storm is recommended.

Step 1. Select a liner material suitable for site conditions and application. Determine roughness coefficient from manufacturer's specifications or Table 8.05e, pg. 8.05.10.

Step 2. Calculate the normal flow depth using Manning's equation (Figure 8.05d). Check to see that depth is consistent with that assumed for selection of Manning's *n* in Figure 8.05d, pg. 8.05.11. For smaller runoffs Figure 8.05d is not as clearly defined. Recommended solutions can be determined by using the Manning equation.

Step 3. Calculate shear stress at normal depth.

Step 4. Compare computed shear stress with the permissible shear stress for the liner.

Step 5. If computed shear is greater than permissible shear, adjust channel dimensions to reduce shear or select a more resistant lining and repeat steps 1 through 4.

Design of a channel with temporary lining is illustrated in Sample Problem 8.05b, pg. 8.05.14.

SEDIMENT TRAP CALCULATIONS
(Sizing per NCDENR Manual)

SEDIMENT TRAP ANALYSIS

Project Data

Name:	Blair Project	Description:	RV/Boat Storage Facility	Manager:	CPK	Date:	12/18/2005
Number:	05-050	Location:	Mt. Gilead Road, Chatham Co., NC	Engineer:	CPK	Revision:	2/19/2006

Calculation Data:

				Rainfall Data			Surface Area Calculations					Storage Volume Calculations					Weir Data
Trap	Rational Coefficient	Drainage Area	Disturbed Area	Tc	I10	Q10	Surface Required	Length @ Weir	Width @ Weir	SA Provided	SA Prov. > SA Req'd	Storage Required	Minimum Depth	Design Depth	Storage Provided	Stor. Prov > Stor. Req'd	Weir Length
#		AC	AC	min	in/hr	cfs	sf	ft	ft	sf	y/n	cf	ft	ft	cf	y/n	ft
1	0.40	1.00	1.00	5.00	7.10	2.84	1237	45.00	30.00	1350	Y	1800	2.00	2.00	2132	Y	4.00
2	0.40	3.00	3.00	5.00	7.10	8.52	3711	150.00	25.00	3750	Y	5400	2.00	2.00	6132	Y	8.00
											N					N	
											N					N	
											N					N	
											N					N	
											N					N	
											N					N	
											N					N	
											N					N	

Notes:

1 All dimensions based on NCDENR design criteria presented in "Erosion and Sediment Control Design Manual"

2 All dimensions noted are measured at or from the crest of weir.