APPENDIX K.2

FINAL COVER SYSTEM SURFACE WATER MANAGEMENT SYSTEM DESIGN

Geosyntec
consultants

COMPUTATION COVER SHEET

Client: Honeywell **Project:** Onondaga Lake SCA Design **Project #:** GJ4299 **Task #:** 18

TITLE OF COMPUTATIONS **FINAL COVER SYSTEM SURFACE WATER MANAGEMENT SYSTEM DESIGN**

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Written by:	**Jesus Sanchez**	Date:	**1/12/10**	Reviewed by:	**Joseph Sura / Ganesh Krishnan**	Date:	**1/12/10**	
Client:	**Honeywell**	Project:	**Onondaga Lake SCA Final Design**	Project No.:	**GJ4299**	Task No.:	**18**	

FINAL COVER SYSTEM
SURFACE WATER MANAGEMENT SYSTEM DESIGN

BACKGROUND & PURPOSE

This package was prepared in support of the design of the Sediment Consolidation Area (SCA) for the Onondaga Lake Bottom Site, which will be constructed on Wastebed 13 (WB-13). Specifically, the package is intended to present the design and analysis of the surface water management system for the proposed final cover system of the SCA.

The package addresses the surface water management system for the SCA final cover system. For purposes of the calculations conducted in this package, the SCA has a footprint corresponding to a capacity of up to 2.65 million cubic yards of dredge material within geotextile tubes (geo-tubes) surrounded by a perimeter dike (SCA perimeter dike).

KEY CONSIDERATIONS AND LIMITATIONS

This package addresses surface water management within the limits of the SCA perimeter dike. Surface water management outside the limits of the SCA perimeter dike will be addressed separately.

The anticipated duration for placement of dredged material in geo-tubes is 4 years, at which time it is expected that the final cover system will be constructed. Settlement is expected to occur during the four-year operational period, and continue to occur, after the final cover system is constructed. The calculations performed herein were based on a "calculated four-year post-settlement grade" of the SCA (i.e., at the time when the final cover system will be constructed) based on calculations presented in the package titled "Settlement Analyses for SCA" (Appendix H of the SCA Final Design). It is recognized that settlement of the SCA will continue to occur after the construction of the final cover system; however, the magnitude of the differential settlement is expected to be relatively small, based on calculations. Therefore, the design of the surface water management system presented herein does not consider the "calculated 30-year post-settlement grade". Periodic visual inspections, maintenance activities, and repair of the components of the surface water management system will be specified in the Post-Closure Care Plan (Appendix O of the SCA Final Design) for the final cover system to address any deficiencies that might be identified during the design life of the SCA final cover system.

The vegetation type for the final cover system had not been selected at the time this package was prepared. Since vegetation may consist of either grass or willows, the design parameters have been conservatively selected to work for either case.

REGULATORY & DESIGN CRITERIA

The surface water management system is designed to manage the calculated runoff from a 25-year, 24-hour design storm event as required by New York State Department of Environmental Conservation (NYSDEC) Regulations Section 360-2.7(b)(8)(ii). Specifically, the open-channel components of the surface water management system are designed to handle peak velocities of 5 ft/s from the design storm and convey the calculated discharges from the design storm event with a minimum freeboard of 6 inches.

SURFACE WATER MANAGEMENT SYSTEM COMPONENTS

The surface water management system of the SCA final cover system will include the components listed below and shown in Figure 1.

- **Riprap Chutes** – Runoff from the top-deck will be collected by trapezoidal riprap chutes, which will be constructed along the side slopes. The riprap chutes will direct the runoff to the two culvert locations.

- **Interception Benches (i.e., tack-on berms)** – Runoff from the upper portion of the side slopes will be intercepted by interception benches, which will be constructed along the side slopes. The interception benches will direct the runoff to the two culvert locations.

- **Toe Drainage Channels** – Runoff from the lower portion of the side slopes will be collected by toe drainage channels, which will be excavated into the SCA perimeter dike. The toe drainage channels will direct the runoff to the two culvert locations.

- **Perimeter Culverts** – Perimeter culverts will be located at the two low-points of the toe drainage channels. These two locations will be the main confluence areas for all runoff from the top deck and side slopes as the riprap chutes, toe drainage channels, and interception benches discharge. The culverts will convey all the runoff through the dike to a location outside the limits of the final cover system.

ANALYSIS METHODOLOGY

Hydraulic and hydrologic analyses are conducted using methods presented in TR-20 (SCS, 1983) and TR-55 (SCS, 1986). Analyses are conducted using the computer program *HydroCAD*™ (HydroCAD, 2005). Computer program analyses are supplemented with other design calculation methods wherever applicable.

MAJOR ASSUMPTIONS

- **Subcatchment Properties –** For purposes of the analyses conducted herein, the extent of the final cover system is divided into 12 subcatchments – four top-deck subcatchments (i.e., above the side slopes, S1A through S4A), four upper side-slope subcatchments (i.e., above the interception benches, S1B through S4B), and four lower side-slope subcatchments (i.e., below the interception benches, S1C through S4C). Tables 1, 2, and 3 summarize the important topographic features of the top-deck, upper side-slope, and lower side-slope subcatchments, respectively, including: area, longest travel path, and elevation maxima and minima.

Table 1 – Summary of Top-Deck Subcatchments

	S1A	S2A	S3A	S4A
Area (acres)	4.8	15.4	16.8	11.9
Longest Path (ft)	805	1290	1350	1040
Max. Elev. (ft)	461.0	462.0	462.0	461.0
Min. Elev. (ft)	452.4	452.4	450.4	450.4

Table 2 – Summary of Upper Side-Slope Subcatchments

	S1B	S2B	S3B	S4B
Area (acres)	2.1	3.5	4.4	2.7
Longest Path (ft)	117	117	143	143
Max Elev. (ft)	452.4	452.4	450.4	450.4
Min. Elev. (ft)	435.0	435.0	439.2	439.2

Table 3 – Summary of Lower Side-Slope Subcatchments

	S1C	S2C	S3C	S4C
Area (acres)	1.5	1.4	2.0	1.5
Longest Path (ft)	93	80	80	93
Max Elev. (ft)	457.0	459.0	459.0	457.0
Min. Elev. (ft)	440.7	443.5	443.5	440.7

- **Manning Coefficients** – For purposes of the calculations conducted herein, Manning Coefficients were adopted from the built-in database in *HydroCAD*^{TM}. The complete table is shown in Attachment 1 (HydroCAD, 2005).

- **Hydrologic Soil Group (HSG) for Cover System** – For purposes of this calculation, it is assumed that the final cover system soils are of HSG Type D (i.e., clay loam, silty clay loam, sandy clay, silty clay, or clay). This assumption will result in the most conservative estimate of the final cover runoff volumes as soils of HSG Type D result in the highest runoff quantity. For an extended description of HSG see Attachment 2 (TR-55, SCS, 1986).

- **Runoff Curve Number (CN)** – The final cover system is expected to be well vegetated. CN = 80 is selected based on Open Space, Good Condition, HSG Type D from Attachment 2 (TR-55, SCS, 1986).

- **Rainfall Distribution for Design Storm -** As shown in Attachment 3 (TR-55, SCS, 1986), the site is located in a region designated under a SCS Type II Rainfall Distribution.

- **Rainfall Depth for Design Storm -** Rainfall depths for 25-year and 2-year 24-hour design storm events were obtained from Attachment 4 (TR-55, SCS, 1986) and summarized below.

Table 4 – Rainfall Depths for Design Storm Events

Return Period (years)	Rainfall Depth (inches)
2	2.55
25	4.4

HYDROLOGIC MODELING

- **Nodal Network Diagram –** Attachment 5 presents a nodal network diagram showing the connectivity of the subcatchments and the surface water management system components listed below.
  - S1A through S4A – Top-Deck Subcatchments
  - S1B through S4B – Upper Side-Slope Subcatchments
  - S1C through S4C – Lower Side-Slope Subcatchments
  - R1A through R2C – Riprap Chutes
  - B1 through B4 – Interception Benches
  - T1 through T4 – Toe Drainage Channels
  - C1 and C2 – Perimeter Culverts
- **Computer Modeling –** A hydrologic analysis was conducted using the above described assumptions and the *HydroCAD*™ (HydroCAD, 2005) computer program. The results of the modeling are presented in Attachment 6.

DESIGN OF FINAL COVER SURFACE WATER MANAGEMENT SYSTEM COMPONENTS

- **Riprap Chutes –** The riprap chutes are shown as R1A-R1B and R2A-R2B-R2C in the *HydroCAD*™ nodal diagram and as R1X and R2X in Figure 1. R1X and R2X are segmented in multiple reaches in the *HydroCAD*™ model because the slope of the riprap chutes changes at multiple locations. The riprap chutes are designed as trapezoidal channels that will convey discharges from the top deck to the perimeter culverts. The design of the riprap chutes involved the selection of a riprap size that can withstand the calculated tractive stresses from the calculated peak inflow conditions from the western and eastern halves of the top-deck. Riprap was selected based on permissible tractive stress using an established method by Robinson et al. (1998). In using this method, the Manning's n value is a function of flow rate, channel width, slope, and riprap size, thus Manning's n is computed multiple times because both R1X and R2X have slope breaks. Attachment 7 provides the calculation for required riprap size for the steepest slope and the resulting Manning's n value for each of the segmented sections of the riprap chutes. Based on this calculation, a riprap size with D_{50} = 6 inches is selected for design. Design summary is as follows:

- Peak Design Inflow Q = 44 cfs (greater of R1A and R2A)
- Available Channel Depth = 1.5 foot
- Bottom Width of Chutes = 10 feet
- Left Side Slope = 3H:1V
- Right Side Slope = 3H:1V
- Manning's n (Riprap size with D_{50} = 6 inches)
  - R1X: R1A, n = 0.031; R1B, n = 0.049
  - R2X: R2A, n = 0.031; R2B, n = 0.050; R2C, n = 0.044
- Calculated Maximum Depth of Flow = 0.90 ft @ R2A (available freeboard = 7 inches based on an available depth of 1.5 foot)

- **Interception Benches** – The interception benches are shown as B1, B2, B3, and B4 in the *HydroCAD*™ nodal diagram and Figure 1. Interception benches are designed to collect and convey the runoff from Upper Side-Slope subcatchments S1B, S2B, S3B, and S4B to the culverts. The benches are designed with the following properties.

  - Available Channel Depth = 2 foot
  - Bottom Width of Chutes = 0 feet (V-Channel)
  - Left Side Slope = 2H:1V
  - Right Side Slope = Varies based on grading of top-deck areas
    - B1 and B2 = 4.7H:1V
    - B3 and B4 = 3.9H:1V
  - Manning's n = 0.030; Channel Lining = Grass

The proposed dimensions and hydraulic properties of the interception benches are modeled within *HydroCAD*™ (HydroCAD, 2005) (i.e., B1 through B4), and the peak flow depth and the peak velocities for the 25-year, 24-hour design storm for each interception bench is calculated within the model. The table below summarizes the performance of the interception benches. As shown below, each bench has at least 6 inches of freeboard during peak flow and is below the 5 ft/s allowable peak velocity.

Table 5 – Summary of Interception Benches

	B1	B2	B3	B4
Peak Inflow (cfs)	7.6	13	15	9.2
Minimum Freeboard (in)	14	12	11	13
Peak Velocity (ft/s)	2.6	3.0	3.1	2.9

- **Toe Drainage Channel –** The toe drainage channels are shown as T1, T2, T3, and T4 in the *HydroCAD*™ nodal diagram and Figure 1. Toe drainage channels will collect and convey the runoff from the side slopes to the two culvert locations. The channels are designed with the following properties:

  - Available Channel Depth = 2 feet
  - Bottom Width of Chutes = 4 feet
  - Left Side Slope = 2H:1V
  - Right Side Slope = 2H:1V
  - Manning's n = 0.030; Channel Lining = Grass

  Toe drainage channels are modeled in *HydroCAD*™ (HydroCAD, 2005) as T1, T2, T3, and T4. The proposed dimensions and hydraulic properties of the toe drainage channels are modeled within HydroCAD (i.e., T1 through T4), and the peak flow depth and the peak velocities for the 25-year, 24-hour design storm for each toe drainage channel is calculated within the model. The table below summarizes the performance of the toe drainage channels. As shown below, each channel has at least 6" of freeboard during peak flow and is below the 5 ft/s allowable peak velocity.

Table 6 – Summary of Toe Drainage Channels

	T1	T2	T3	T4
Peak Inflow (cfs)	6.7	5.6	8.1	6.6
Minimum Freeboard (in)	18	19	19	19
Peak Velocity (ft/s)	1.9	1.6	1.8	1.8

- **Perimeter Culverts** – The perimeter culverts are shown as C1 and C2 in the *HydroCAD*^{TM} nodal diagram and Figure 1. Perimeter culverts will be located at two locations across the SCA perimeter dike at the low-points of the toe drainage channel. It is assumed that the discharge conveyed by these culverts to outside the limits of the SCA dike will be managed as part of the Wastebeds 9 through 15 Closure. Therefore, at this time, nodes C1 and C2 are modeled as "dummy nodes" in *HydroCAD*^{TM} (HydroCAD, 2005). However, for planning purposes, calculations were performed to identify the number and diameter of the pipes required to convey the peak discharge. The following assumptions were required for these calculations:

  - Design Q = 55 cfs (greater of C1 and C2)
  - Manning's n = 0.013; Concrete Pipe, straight & clean
  - Longitudinal Slope = 0.01 ft/ft (Assumed Minimum Slope)

  Given these assumptions, six 18-inch diameter pipes are required.

CONCLUSION

The components of the proposed final cover surface water management system for the SCA were designed to convey the calculated discharges from a 25-year, 24-hour design storm. This package addresses surface water management within the limits of the SCA perimeter dike, and does not address how surface water management will be implemented outside the limits of the SCA perimeter dike, which will be addressed separately.

REFERENCES

HydroCAD, “HydroCAD^{TM} Storm Water Modeling System, Version 7.1”, HydroCAD Software Solutions LLC., Chocorua, New Hampshire, 2005.

NYSDEC (New York State Department of Environmental Conservation), 1998. Solid Waste Management Facilities. Part 360 of Title 6 of the Official Compilation of Codes, Rules, and Regulations.

Robinson, K. M., Rice, C. E., Kadavy, K. C., “Design of Rock Chutes”, American Society of Agricultural Engineers, Volume 41, No. 3, 1998, pp. 621-626.

SCS, “Computer Program for Project Formulation-Hydrology, Technical Release 20 (TR-20)”, United States Department of Agriculture, Soil Conservation Service, Washington, D.C., 1983.

SCS, “Hydrology for Small Watersheds, Technical Release 55 (TR-55)”, United States Department of Agriculture, Soil Conservation Service, Washington, D.C., 1986.

Figures

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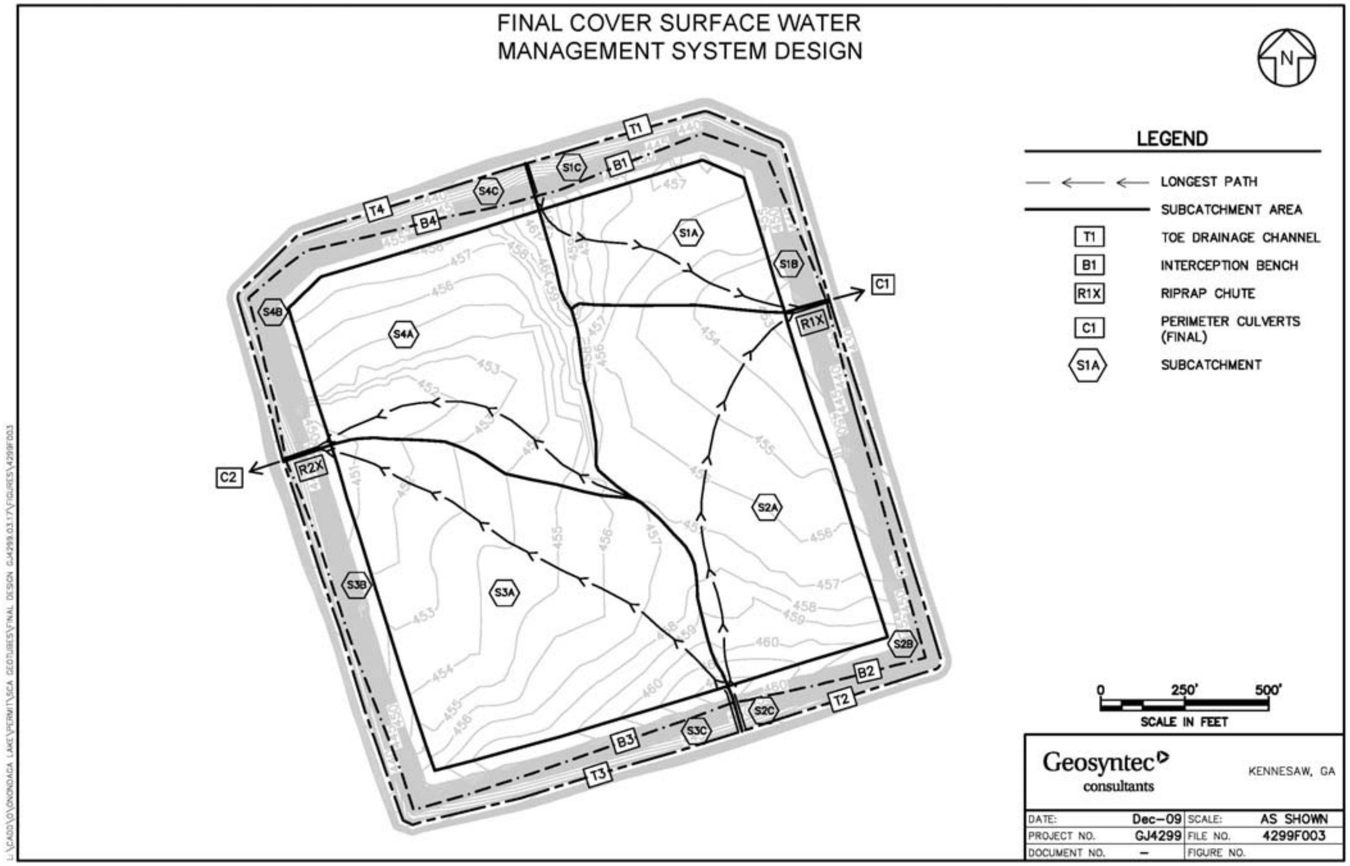

Figure 1: Final Cover Surface Water Management System Design

Attachment 1 – Manning Coefficients

(HydroCAD, 2005)

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Appendix C: Manning's Number Tables

VALUES OF THE ROUGHNESS COEFFICIENT n
(Boldface figures are values generally recommended in design)

Type of channel and description	Minimum	Normal	Maximum
A. CLOSED CONDUITS FLOWING PARTLY FULL			
A-1. Metal			
a. Brass, smooth	0.009	**0.010**	0.013
b. Steel			
1. Lockbar and welded	0.010	0.012	0.014
2. Riveted and spiral	0.013	0.016	0.017
c. Cast iron			
1. Coated	0.010	0.013	0.014
2. Uncoated	0.011	0.014	0.016
d. Wrought iron			
1. Black	0.012	0.014	0.015
2. Galvanized	0.013	0.016	0.017
e. Corrugated metal			
1. Subdrain	0.017	0.019	0.021
2. Storm drain	0.021	**0.024**	0.030
A-2. Nonmetal			
a. Lucite	0.008	0.009	0.010
b. Glass	0.009	**0.010**	0.013
c. Cement			
1. Neat, surface	0.010	0.011	0.013
2. Mortar	0.011	0.013	0.015
d. Concrete			
1. Culvert, straight and free of debris	0.010	0.011	0.013
2. Culvert with bends, connections, and some debris	0.011	**0.013**	0.014
3. Finished	0.011	0.012	0.014
4. Sewer with manholes, inlet, etc., straight	0.013	0.015	0.017
5. Unfinished, steel form	0.012	0.013	0.014
6. Unfinished, smooth wood form	0.012	**0.014**	0.016
7. Unfinished, rough wood form	0.015	0.017	0.020
e. Wood			
1. Stave	0.010	0.012	0.014
2. Laminated, treated	0.015	0.017	0.020
f. Clay			
1. Common drainage tile	0.011	**0.013**	0.017
2. Vitrified sewer	0.011	0.014	0.017
3. Vitrified sewer with manholes, inlet, etc.	0.013	0.015	0.017
4. Vitrified subdrain with open joint	0.014	**0.016**	0.018
g. Brickwork			
1. Glazed	0.011	0.013	0.015
2. Lined with cement mortar	0.012	0.015	0.017
h. Sanitary sewers coated with sewage slimes, with bends and connections	0.012	0.013	0.016
i. Paved invert, sewer, smooth bottom	0.016	0.019	0.020
j. Rubble masonry, cemented	0.018	0.025	0.030

VALUES OF THE ROUGHNESS COEFFICIENT n (*continued*)

Type of channel and description	Minimum	Normal	Maximum
B. LINED OR BUILT-UP CHANNELS			
B-1. Metal			
a. Smooth steel surface			
1. Unpainted	0.011	**0.012**	0.014
2. Painted	0.012	0.013	0.017
b. Corrugated	0.021	**0.025**	0.030
B-2. Nonmetal			
a. Cement			
1. Neat, surface	0.010	0.011	0.013
2. Mortar	0.011	0.013	0.015
b. Wood			
1. Planed, untreated	0.010	0.012	0.014
2. Planed, creosoted	0.011	0.012	0.015
3. Unplaned	0.011	0.013	0.015
4. Plank with battens	0.012	0.015	0.018
5. Lined with roofing paper	0.010	0.014	0.017
c. Concrete			
1. Trowel finish	0.011	**0.013**	0.015
2. Float finish	0.013	0.015	0.016
3. Finished, with gravel on bottom	0.015	0.017	0.020
4. Unfinished	0.014	0.017	0.020
5. Gunite, good section	0.016	0.019	0.023
6. Gunite, wavy section	0.018	0.022	0.025
7. On good excavated rock	0.017	0.020	
8. On irregular excavated rock	0.022	0.027	
d. Concrete bottom float finished with sides of			
1. Dressed stone in mortar	0.015	0.017	0.020
2. Random stone in mortar	0.017	0.020	0.024
3. Cement rubble masonry, plastered	0.016	0.020	0.024
4. Cement rubble masonry	0.020	0.025	0.030
5. Dry rubble or riprap	0.020	0.030	0.035
e. Gravel bottom with sides of			
1. Formed concrete	0.017	0.020	0.025
2. Random stone in mortar	0.020	0.023	0.026
3. Dry rubble or riprap	0.023	0.033	0.036
f. Brick			
1. Glazed	0.011	**0.013**	0.015
2. In cement mortar	0.012	**0.015**	0.018
g. Masonry			
1. Cemented rubble	0.017	**0.025**	0.030
2. Dry rubble	0.023	**0.032**	0.035
h. Dressed ashlar	0.013	0.015	0.017
i. Asphalt			
1. Smooth	0.013	0.013	
2. Rough	0.016	0.016	
j. Vegetal lining	0.030	.....	0.500

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Appendix C: Manning's Number Tables (continued)

VALUES OF THE ROUGHNESS COEFFICIENT n (continued)

Type of channel and description	Minimum	Normal	Maximum
C. EXCAVATED OR DREDGED			
a. Earth, straight and uniform			
1. Clean, recently completed	0.016	0.018	0.020
2. Clean, after weathering	0.018	0.022	0.025
3. Gravel, uniform section, clean	0.022	0.025	0.030
4. With short grass, few weeds	0.022	0.027	0.033
b. Earth, winding and sluggish			
1. No vegetation	0.023	0.025	0.030
2. Grass, some weeds	0.025	0.030	0.033
3. Dense weeds or aquatic plants in deep channels	0.030	0.035	0.040
4. Earth bottom and rubble sides	0.028	0.030	0.035
5. Stony bottom and weedy banks	0.025	0.035	0.040
6. Cobble bottom and clean sides	0.030	0.040	0.050
c. Dragline-excavated or dredged			
1. No vegetation	0.025	0.028	0.033
2. Light brush on banks	0.035	0.050	0.060
d. Rock cuts			
1. Smooth and uniform	0.025	0.035	0.040
2. Jagged and irregular	0.035	0.040	0.050
e. Channels not maintained, weeds and brush uncut			
1. Dense weeds, high as flow depth	0.050	0.080	0.120
2. Clean bottom, brush on sides	0.040	0.050	0.080
3. Same, highest stage of flow	0.045	0.070	0.110
4. Dense brush, high stage	0.080	0.100	0.140
D. NATURAL STREAMS			
D-1. Minor streams (top width at flood stage <100 ft)			
a. Streams on plain			
1. Clean, straight, full stage, no rifts or deep pools	0.025	0.030	0.033
2. Same as above, but more stones and weeds	0.030	0.035	0.040
3. Clean, winding, some pools and shoals	0.033	0.040	0.045
4. Same as above, but some weeds and stones	0.035	0.045	0.050
5. Same as above, lower stages, more ineffective slopes and sections	0.040	0.048	0.055
6. Same as 4, but more stones	0.045	0.050	0.060
7. Sluggish reaches, weedy, deep pools	0.050	0.070	0.080
8. Very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush	0.075	0.100	0.150

VALUES OF THE ROUGHNESS COEFFICIENT n (continued)

Type of channel and description	Minimum	Normal	Maximum
b. Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stages			
1. Bottom: gravels, cobbles, and few boulders	0.030	0.040	0.050
2. Bottom: cobbles with large boulders	0.040	0.050	0.070
D-2. Flood plains			
a. Pasture, no brush			
1. Short grass	0.025	0.030	0.035
2. High grass	0.030	0.035	0.050
b. Cultivated areas			
1. No crop	0.020	0.030	0.040
2. Mature row crops	0.025	0.035	0.045
3. Mature field crops	0.030	0.040	0.050
c. Brush			
1. Scattered brush, heavy weeds	0.035	0.050	0.070
2. Light brush and trees, in winter	0.035	0.050	0.060
3. Light brush and trees, in summer	0.040	0.060	0.080
4. Medium to dense brush, in winter	0.045	0.070	0.110
5. Medium to dense brush, in summer	0.070	0.100	0.160
d. Trees			
1. Dense willows, summer, straight	0.110	0.150	0.200
2. Cleared land with tree stumps, no sprouts	0.030	0.040	0.050
3. Same as above, but with heavy growth of sprouts	0.050	0.060	0.080
4. Heavy stand of timber, a few down trees, little undergrowth, flood stage below branches	0.080	0.100	0.120
5. Same as above, but with flood stage reaching branches	0.100	0.120	0.160
D-3. Major streams (top width at flood stage >100 ft). The n value is less than that for minor streams of similar description, because banks offer less effective resistance.			
a. Regular section with no boulders or brush	0.025	.....	0.060
b. Irregular and rough section	0.035	.....	0.100

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Attachment 2 – Hydrologic Soil Groups and Runoff Curve Numbers

(TR-55, SCS, 1986)

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Client:	Honeywell	Project:	Onondaga Lake SCA Final Design	Project No.:	GJ4299	Task No.:	18

Soils are classified into hydrologic soil groups (HSG's) to indicate the minimum rate of infiltration obtained for bare soil after prolonged wetting. The HSG's, which are A, B, C, and D, are one element used in determining runoff curve numbers (see chapter 2). For the convenience of TR-55 users, exhibit A-1 lists the HSG classification of United States soils.

The infiltration rate is the rate at which water enters the soil at the soil surface. It is controlled by surface conditions. HSG also indicates the transmission rate—the rate at which the water moves within the soil. This rate is controlled by the soil profile. Approximate numerical ranges for transmission rates shown in the HSG definitions were first published by Musgrave (USDA 1955). The four groups are defined by SCS soil scientists as follows:

Group Asoils have low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sand or gravel and have a high rate of water transmission (greater than 0.30 in/hr).

Group Bsoils have moderate infiltration rates when thoroughly wetted and consist chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission (0.15-0.30 in/hr).

Group Csoils have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine texture. These soils have a low rate of water transmission (0.05-0.15 in/hr).

Group Dsoils have high runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very low rate of water transmission (0-0.05 in/hr).

In exhibit A-1, some of the listed soils have an added modifier; for example, "Abrazo, gravelly." This refers to a gravelly phase of the Abrazo series that is found in SCS soil map legends.

Disturbed soil profiles

As a result of urbanization, the soil profile may be considerably altered and the listed group classification may no longer apply. In these circumstances, use the following to determine HSG according to the texture of the new surface soil, provided that significant compaction has not occurred (Brakensiek and Rawls 1983).

HSG	*Soil textures*
A	Sand, loamy sand, or sandy loam
B	Silt loam or loam
C	Sandy clay loam
D	Clay loam, silty clay loam, sandy clay, silty clay, or clay

Drainage and group D soils

Some soils in the list are in group D because of a high water table that creates a drainage problem. Once these soils are effectively drained, they are placed in a different group. For example, Ackerman soil is classified as A/D. This indicates that the drained Ackerman soil is in group A and the undrained soil is in group D.

Written by:	**Jesus Sanchez**	Date:	**1/12/10**	Reviewed by:	**Joseph Sura / Ganesh Krishnan**	Date:	**1/12/10**
Client:	**Honeywell**	Project:	**Onondaga Lake SCA Final Design**	Project No.:	**GJ4299**	Task No.:	**18**

Table 2-2a Runoff curve numbers for urban areas 1/

Cover type and hydrologic condition	Average percent impervious area 2/	A	B	C	D
		Curve numbers for hydrologic soil group			
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.) 3/:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only) 4/		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation) 5/		77	86	91	94
Idle lands (CN's are determined using cover types similar to those in table 2-2c).					

1 Average runoff condition, and $I_a = 0.2S$.
2 The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. CN's for other combinations of conditions may be computed using figure 2-3 or 2-4.
3 CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.
4 Composite CN's for natural desert landscaping should be computed using figures 2-3 or 2-4 based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert shrub in poor hydrologic condition.
5 Composite CN's to use for the design of temporary measures during grading and construction should be computed using figure 2-3 or 2-4 based on the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

Attachment 3 – Rainfall Distributions

(TR-55, SCS, 1986)

Written by:	**Jesus Sanchez**	Date:	**1/12/10**	Reviewed by:	**Joseph Sura / Ganesh Krishnan**	Date:	**1/12/10**
Client:	**Honeywell**	Project:	**Onondaga Lake SCA Final Design**	Project No.:	**GJ4299**	Task No.:	**18**

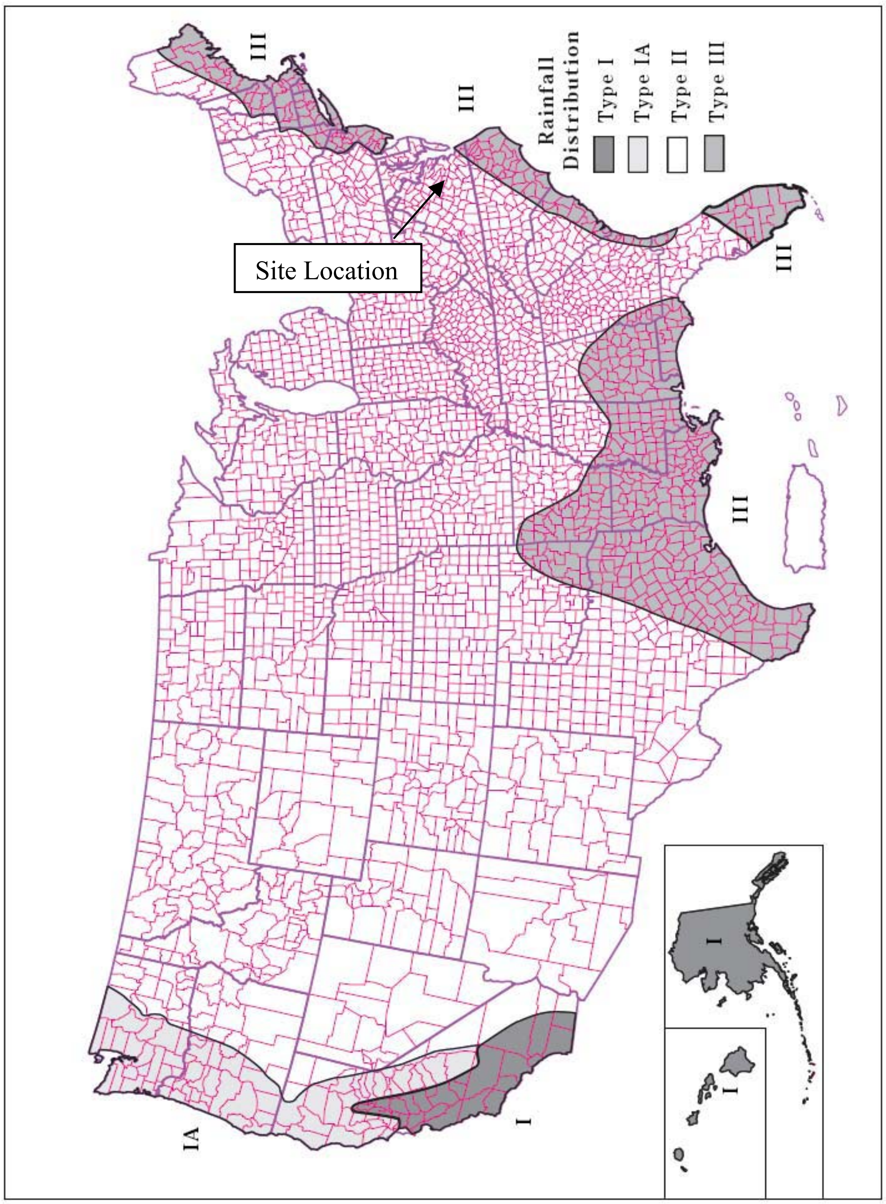
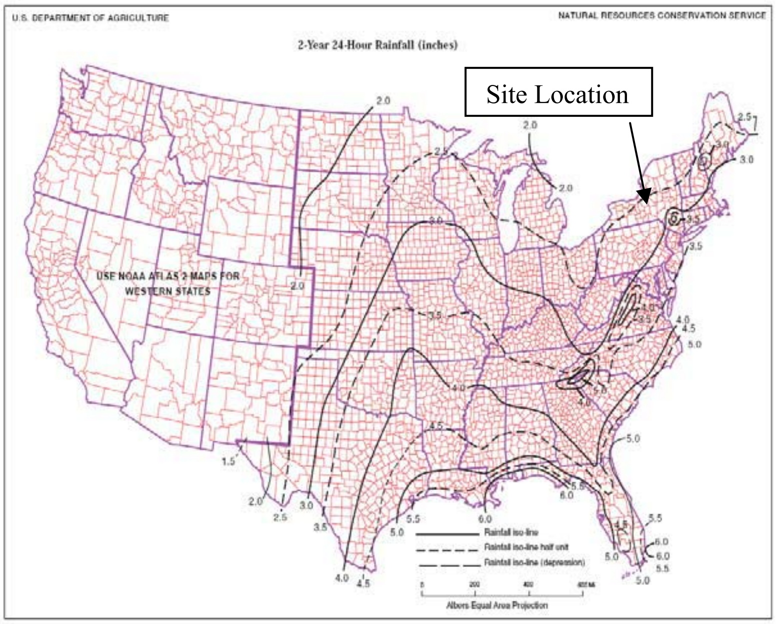


Figure B-2 Approximate geographic boundaries for NRCS (SCS) rainfall distributions

Attachment 4 – Rainfall Depths

(TR-55, SCS, 1986)

Figure B-3 2-year, 24-hr rainfall



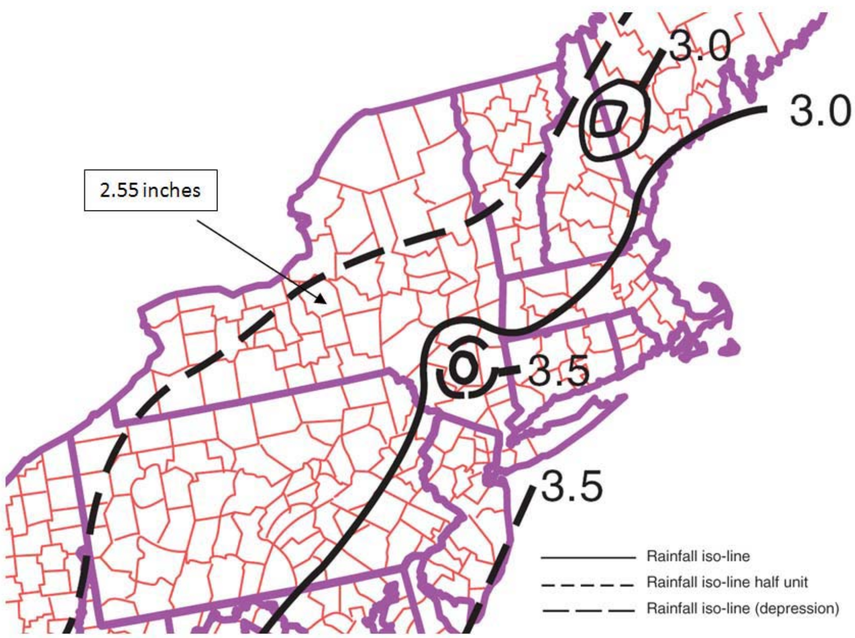
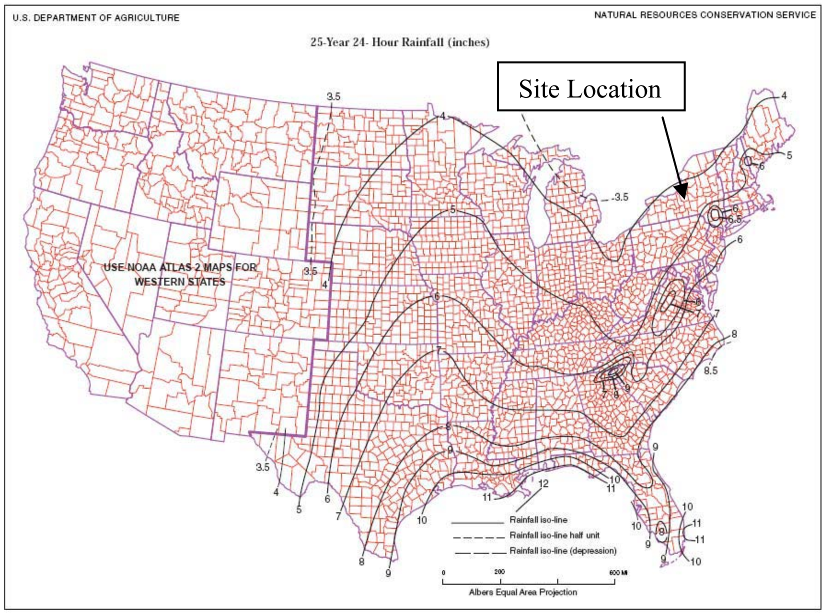
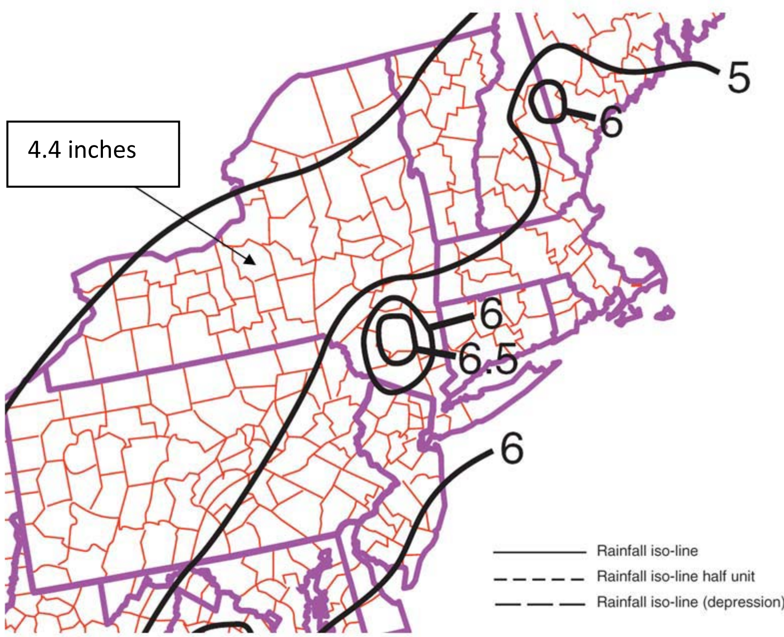


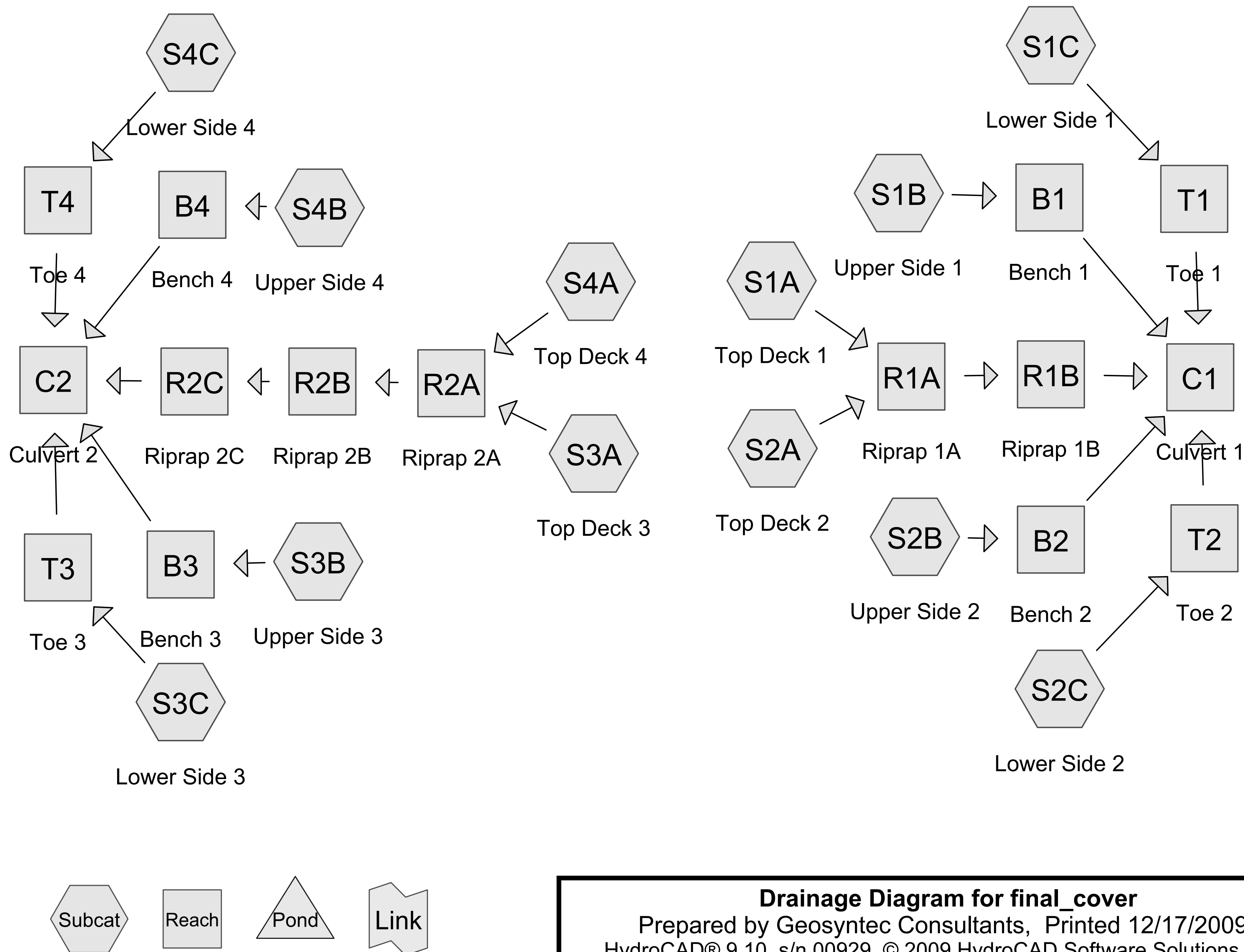
Figure B-6 25-year, 24-hour rainfall





Written by:	**Jesus Sanchez**	Date:	**1/12/10**	Reviewed by:	**Joseph Sura / Ganesh Krishnan**	Date:	**1/12/10**
Client:	**Honeywell**	Project:	**Onondaga Lake SCA Final Design**	Project No.:	**GJ4299**	Task No.:	**18**

Attachment 5 – Nodal Network Diagram



Drainage Diagram for final_cover
Prepared by Geosyntec Consultants, Printed 12/17/2009
HydroCAD® 9.10 s/n 00929 © 2009 HydroCAD Software Solutions LLC

Attachment 6 – HydroCAD Analysis

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
67.994	80	(S1A, S1B, S1C, S2A, S2B, S2C, S3A, S3B, S3C, S4A, S4B, S4C)
67.994		**TOTAL AREA**

Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
0.000	HSG A	
0.000	HSG B	
0.000	HSG C	
0.000	HSG D	
67.994	Other	S1A, S1B, S1C, S2A, S2B, S2C, S3A, S3B, S3C, S4A, S4B, S4C
67.994		**TOTAL AREA**

Pipe Listing (all nodes)

Line#	Node Number	In-Invert (feet)	Out-Invert (feet)	Length (feet)	Slope (ft/ft)	n	Diam/Width (inches)	Height (inches)	Fill (inches)
1	C1	432.24	431.24	100.0	0.0100	0.013	18.0	0.0	0.0
2	C2	431.07	430.07	100.0	0.0100	0.013	18.0	0.0	0.0

Time span=0.00-36.00 hrs, dt=0.01 hrs, 3601 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment S1A: Top Deck 1 Runoff Area=4.838 ac 0.00% Impervious Runoff Depth=2.38"
Flow Length=805' Tc=36.3 min CN=80 Runoff=8.76 cfs 0.958 af

Subcatchment S1B: Upper Side 1 Runoff Area=2.071 ac 0.00% Impervious Runoff Depth=2.38"
Flow Length=117' Tc=10.1 min CN=80 Runoff=7.55 cfs 0.410 af

Subcatchment S1C: Lower Side 1 Runoff Area=1.537 ac 0.00% Impervious Runoff Depth=2.38"
Flow Length=93' Tc=5.2 min CN=80 Runoff=6.68 cfs 0.304 af

Subcatchment S2A: Top Deck 2 Runoff Area=15.428 ac 0.00% Impervious Runoff Depth=2.38"
Flow Length=1,290' Tc=47.2 min CN=80 Runoff=23.22 cfs 3.055 af

Subcatchment S2B: Upper Side 2 Runoff Area=3.531 ac 0.00% Impervious Runoff Depth=2.38"
Flow Length=117' Tc=10.1 min CN=80 Runoff=12.88 cfs 0.699 af

Subcatchment S2C: Lower Side 2 Runoff Area=1.352 ac 0.00% Impervious Runoff Depth=2.38"
Flow Length=80' Tc=6.5 min CN=80 Runoff=5.61 cfs 0.268 af

Subcatchment S3A: Top Deck 3 Runoff Area=16.752 ac 0.00% Impervious Runoff Depth=2.38"
Flow Length=1,350' Tc=43.1 min CN=80 Runoff=27.01 cfs 3.318 af

Subcatchment S3B: Upper Side 3 Runoff Area=4.406 ac 0.00% Impervious Runoff Depth=2.38"
Flow Length=143' Tc=12.0 min CN=80 Runoff=15.03 cfs 0.873 af

Subcatchment S3C: Lower Side 3 Runoff Area=1.952 ac 0.00% Impervious Runoff Depth=2.38"
Flow Length=80' Tc=6.5 min CN=80 Runoff=8.10 cfs 0.387 af

Subcatchment S4A: Top Deck 4 Runoff Area=11.904 ac 0.00% Impervious Runoff Depth=2.38"
Flow Length=1,040' Tc=49.4 min CN=80 Runoff=17.37 cfs 2.358 af

Subcatchment S4B: Upper Side 4 Runoff Area=2.699 ac 0.00% Impervious Runoff Depth=2.38"
Flow Length=143' Tc=12.0 min CN=80 Runoff=9.21 cfs 0.535 af

Subcatchment S4C: Lower Side 4 Runoff Area=1.524 ac 0.00% Impervious Runoff Depth=2.38"
Flow Length=93' Tc=5.2 min CN=80 Runoff=6.63 cfs 0.302 af

Reach B1: Bench 1 Avg. Flow Depth=0.82' Max Vel=2.64 fps Inflow=7.55 cfs 0.410 af
n=0.030 L=1,190.0' S=0.0100 '/' Capacity=64.21 cfs Outflow=5.95 cfs 0.410 af

Reach B2: Bench 2 Avg. Flow Depth=0.97' Max Vel=2.96 fps Inflow=12.88 cfs 0.699 af
n=0.030 L=1,690.0' S=0.0100 '/' Capacity=64.21 cfs Outflow=9.40 cfs 0.699 af

Reach B3: Bench 3 Avg. Flow Depth=1.07' Max Vel=3.14 fps Inflow=15.03 cfs 0.873 af
n=0.030 L=2,070.0' S=0.0100 '/' Capacity=56.17 cfs Outflow=10.66 cfs 0.873 af

Reach B4: Bench 4 Avg. Flow Depth=0.93' Max Vel=2.85 fps Inflow=9.21 cfs 0.535 af
n=0.030 L=1,410.0' S=0.0100 '/' Capacity=56.17 cfs Outflow=7.20 cfs 0.535 af

Reach C1: Culvert 1 Avg. Flow Depth=0.86' Max Vel=6.28 fps Inflow=39.69 cfs 5.695 af
18.0" Round Pipe x 6.00 n=0.013 L=100.0' S=0.0100 '/' Capacity=63.03 cfs Outflow=39.69 cfs 5.695 af

Reach C2: Culvert 2 Avg. Flow Depth=1.09' Max Vel=6.70 fps Inflow=55.08 cfs 7.771 af
18.0" Round Pipe x 6.00 n=0.013 L=100.0' S=0.0100 '/' Capacity=63.03 cfs Outflow=55.07 cfs 7.771 af

Reach R1A: Riprap 1A Avg. Flow Depth=0.74' Max Vel=3.47 fps Inflow=31.28 cfs 4.014 af
n=0.031 L=37.0' S=0.0100 '/' Capacity=112.18 cfs Outflow=31.28 cfs 4.014 af

Reach R1B: Riprap 1B Avg. Flow Depth=0.40' Max Vel=7.02 fps Inflow=31.28 cfs 4.014 af
n=0.049 L=80.0' S=0.2125 '/' Capacity=327.17 cfs Outflow=31.27 cfs 4.014 af

Reach R2A: Riprap 2A Avg. Flow Depth=0.89' Max Vel=3.87 fps Inflow=43.90 cfs 5.675 af
n=0.031 L=35.0' S=0.0100 '/' Capacity=112.18 cfs Outflow=43.90 cfs 5.675 af

Reach R2B: Riprap 2B Avg. Flow Depth=0.47' Max Vel=8.27 fps Inflow=43.90 cfs 5.675 af
n=0.050 L=65.0' S=0.2538 '/' Capacity=350.43 cfs Outflow=43.90 cfs 5.675 af

Reach R2C: Riprap 2C Avg. Flow Depth=0.57' Max Vel=6.62 fps Inflow=43.90 cfs 5.675 af
n=0.044 L=43.0' S=0.1000 '/' Capacity=249.94 cfs Outflow=43.90 cfs 5.675 af

Reach T1: Toe 1 Avg. Flow Depth=0.48' Max Vel=1.85 fps Inflow=6.68 cfs 0.304 af
n=0.030 L=1,260.0' S=0.0050 '/' Capacity=64.55 cfs Outflow=4.36 cfs 0.304 af

Reach T2: Toe 2 Avg. Flow Depth=0.38' Max Vel=1.64 fps Inflow=5.61 cfs 0.268 af
n=0.030 L=1,750.0' S=0.0050 '/' Capacity=64.55 cfs Outflow=3.01 cfs 0.268 af

Reach T3: Toe 3 Avg. Flow Depth=0.46' Max Vel=1.82 fps Inflow=8.10 cfs 0.387 af
n=0.030 L=2,120.0' S=0.0050 '/' Capacity=64.55 cfs Outflow=4.12 cfs 0.387 af

Reach T4: Toe 4 Avg. Flow Depth=0.45' Max Vel=1.80 fps Inflow=6.63 cfs 0.302 af
n=0.030 L=1,450.0' S=0.0050 '/' Capacity=64.55 cfs Outflow=4.01 cfs 0.302 af

Total Runoff Area = 67.994 ac Runoff Volume = 13.466 af Average Runoff Depth = 2.38"
100.00% Pervious = 67.994 ac 0.00% Impervious = 0.000 ac

Summary for Subcatchment S1A: Top Deck 1

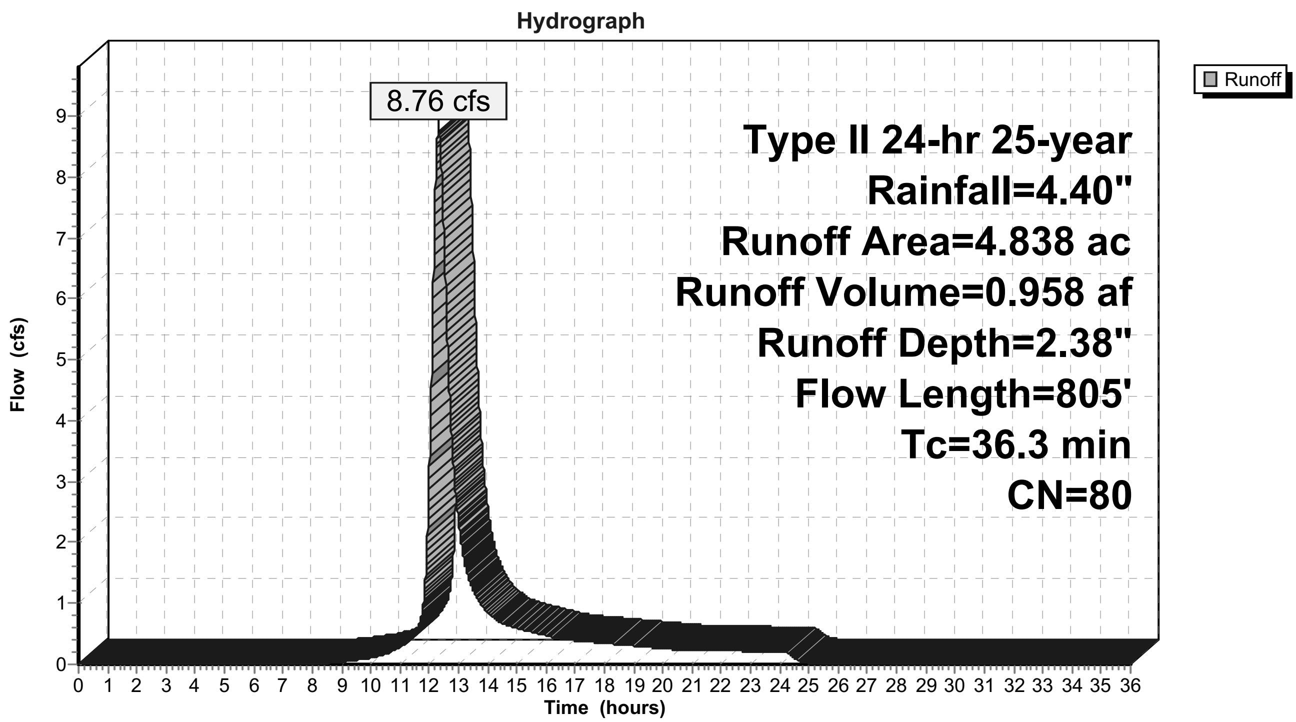
Runoff = 8.76 cfs @ 12.31 hrs, Volume= 0.958 af, Depth= 2.38"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs
Type II 24-hr 25-year Rainfall=4.40"

	Area (ac)	CN	Description
*	4.838	80	
	4.838		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
30.2	300	0.0143	0.17		**Sheet Flow, Sheet Flow** Grass: Short n= 0.150 P2= 2.55"
6.1	505	0.0086	1.39		**Shallow Concentrated Flow, Shallow Concentrated** Grassed Waterway Kv= 15.0 fps
36.3	805	Total			

Subcatchment S1A: Top Deck 1



Summary for Subcatchment S1B: Upper Side 1

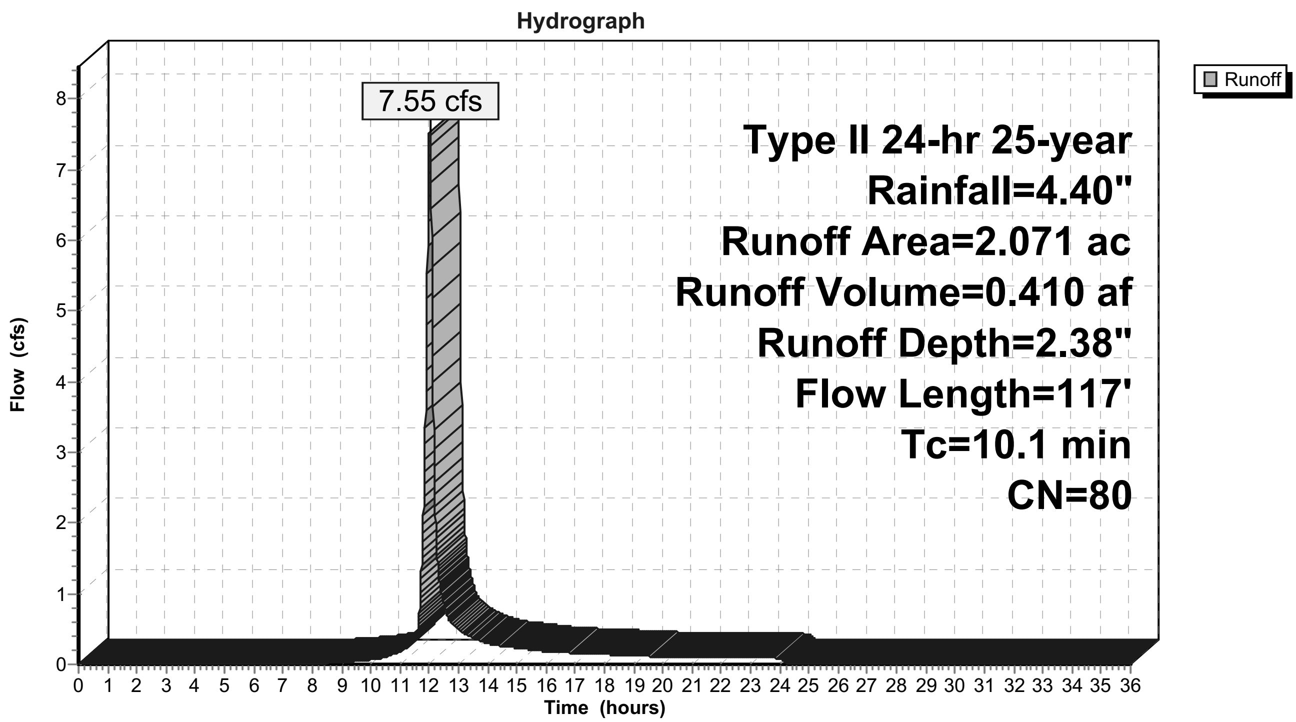
Runoff = 7.55 cfs @ 12.02 hrs, Volume= 0.410 af, Depth= 2.38"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs
Type II 24-hr 25-year Rainfall=4.40"

	Area (ac)	CN	Description
*	2.071	80	
	2.071		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.5	37	0.0100	0.09		**Sheet Flow, Sheet 1** Grass: Short n= 0.150 P2= 2.55"
3.6	80	0.2125	0.37		**Sheet Flow, Sheet 2** Grass: Short n= 0.150 P2= 2.55"
10.1	117	Total			

Subcatchment S1B: Upper Side 1



Summary for Subcatchment S1C: Lower Side 1

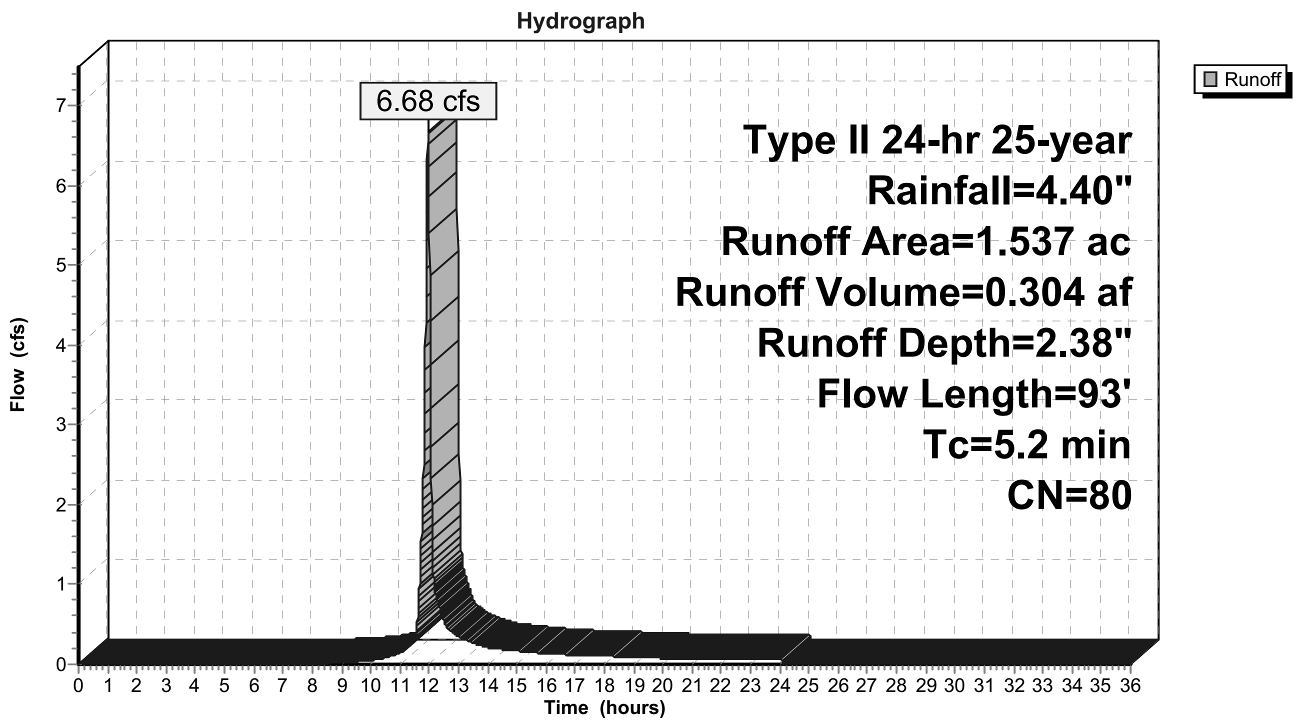
Runoff = 6.68 cfs @ 11.96 hrs, Volume= 0.304 af, Depth= 2.38"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs
Type II 24-hr 25-year Rainfall=4.40"

	Area (ac)	CN	Description
*	1.537	80	
	1.537		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.3	50	0.2400	0.36		**Sheet Flow, Sheet 1** Grass: Short n= 0.150 P2= 2.55"
2.9	43	0.1000	0.24		**Sheet Flow, Sheet 2** Grass: Short n= 0.150 P2= 2.55"
5.2	93	Total			

Subcatchment S1C: Lower Side 1



Summary for Subcatchment S2A: Top Deck 2

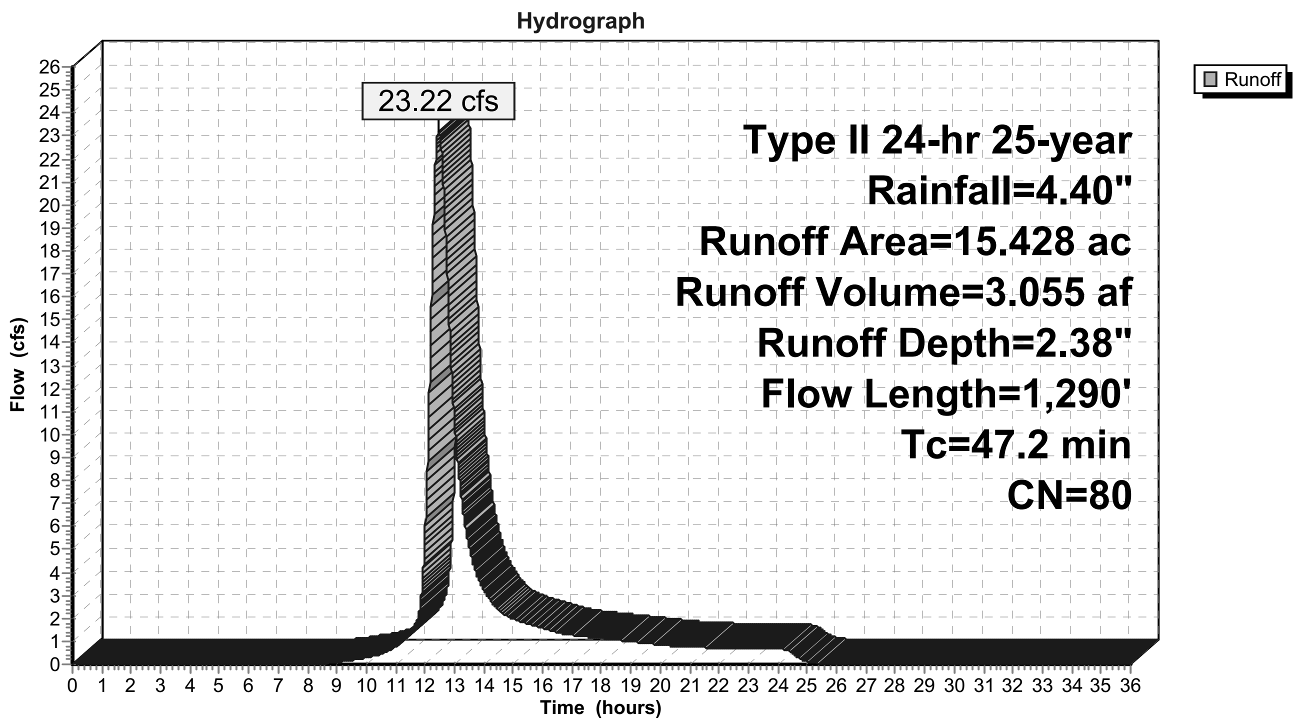
Runoff = 23.22 cfs @ 12.44 hrs, Volume= 3.055 af, Depth= 2.38"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs
Type II 24-hr 25-year Rainfall=4.40"

	Area (ac)	CN	Description
*	15.428	80	
	15.428		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
33.3	300	0.0112	0.15		**Sheet Flow, Sheet Flow** Grass: Short n= 0.150 P2= 2.55"
13.9	990	0.0063	1.19		**Shallow Concentrated Flow, Shallow Concentrated** Grassed Waterway Kv= 15.0 fps
47.2	1,290	Total			

Subcatchment S2A: Top Deck 2



Summary for Subcatchment S2B: Upper Side 2

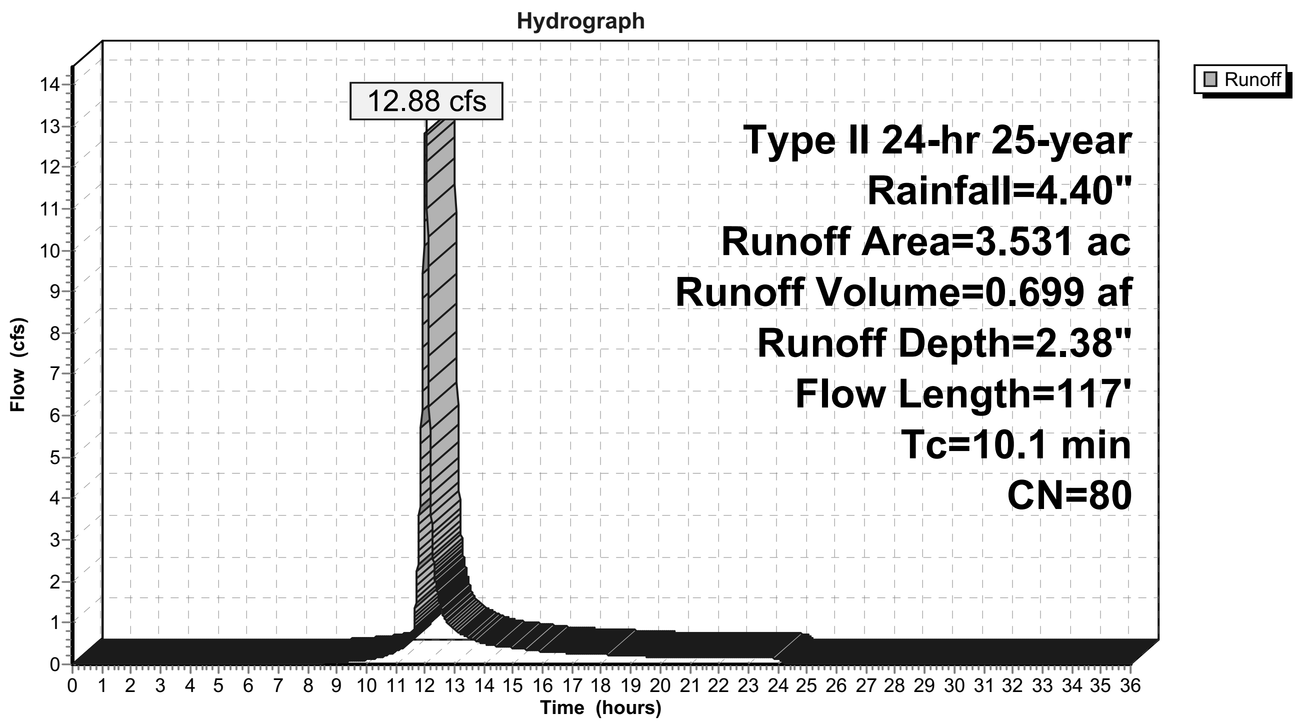
Runoff = 12.88 cfs @ 12.02 hrs, Volume= 0.699 af, Depth= 2.38"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs
Type II 24-hr 25-year Rainfall=4.40"

	Area (ac)	CN	Description
*	3.531	80	
	3.531		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.5	37	0.0100	0.09		**Sheet Flow, Sheet 1** Grass: Short n= 0.150 P2= 2.55"
3.6	80	0.2125	0.37		**Sheet Flow, Sheet 2** Grass: Short n= 0.150 P2= 2.55"
10.1	117	Total			

Subcatchment S2B: Upper Side 2



Summary for Subcatchment S2C: Lower Side 2

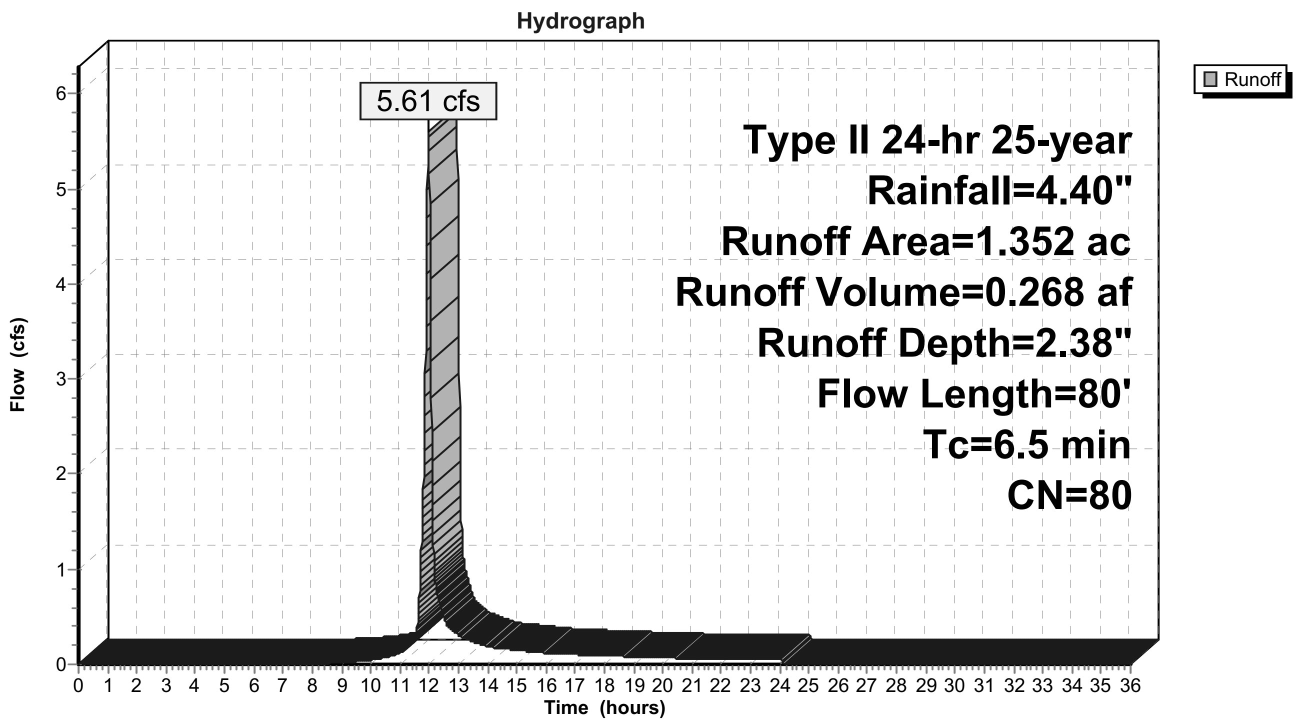
Runoff = 5.61 cfs @ 11.98 hrs, Volume= 0.268 af, Depth= 2.38"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs
Type II 24-hr 25-year Rainfall=4.40"

	Area (ac)	CN	Description
*	1.352	80	
	1.352		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.6	55	0.0545	0.20		**Sheet Flow, Sheet 1** Grass: Short n= 0.150 P2= 2.55"
1.9	25	0.1000	0.22		**Sheet Flow, Sheet 2** Grass: Short n= 0.150 P2= 2.55"
6.5	80	Total			

Subcatchment S2C: Lower Side 2



Summary for Subcatchment S3A: Top Deck 3

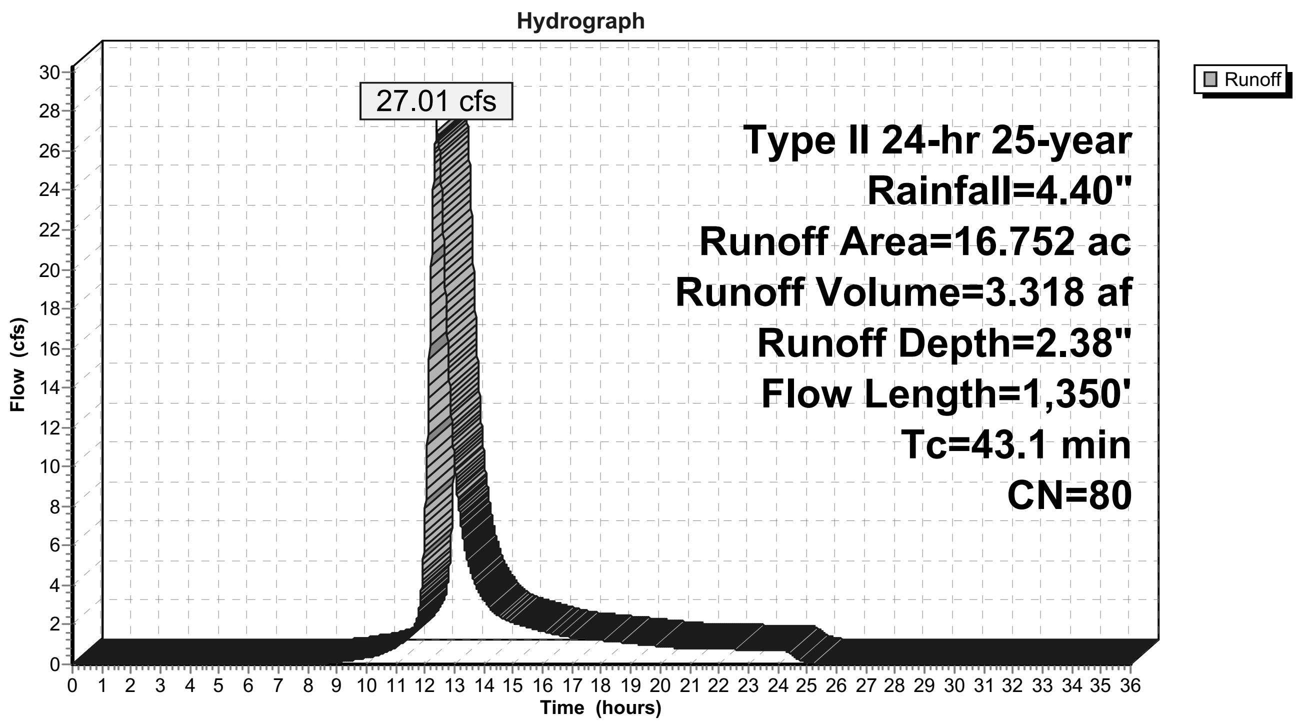
Runoff = 27.01 cfs @ 12.40 hrs, Volume= 3.318 af, Depth= 2.38"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs
Type II 24-hr 25-year Rainfall=4.40"

	Area (ac)	CN	Description
*	16.752	80	
	16.752		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
28.4	300	0.0167	0.18		**Sheet Flow, Sheet** Grass: Short n= 0.150 P2= 2.55"
14.7	1,050	0.0063	1.19		**Shallow Concentrated Flow, Shallow Concentrated** Grassed Waterway Kv= 15.0 fps
43.1	1,350	Total			

Subcatchment S3A: Top Deck 3



Summary for Subcatchment S3B: Upper Side 3

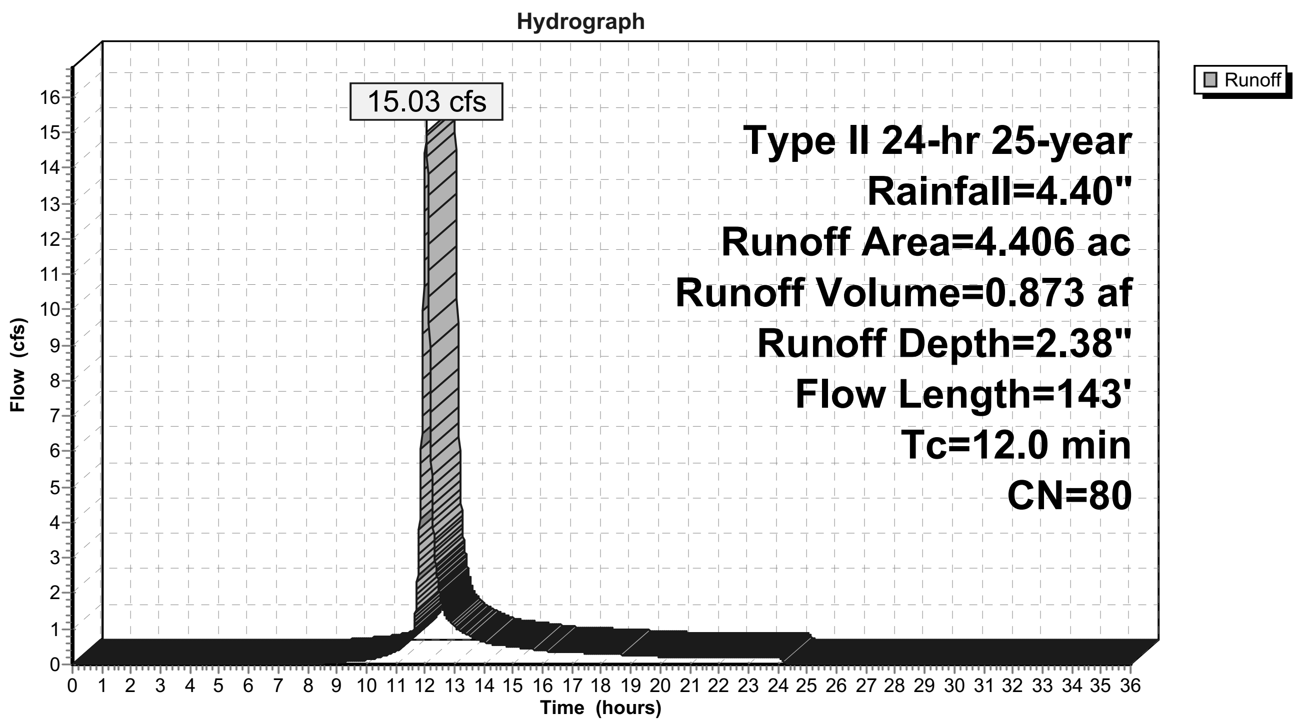
Runoff = 15.03 cfs @ 12.04 hrs, Volume= 0.873 af, Depth= 2.38"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs
Type II 24-hr 25-year Rainfall=4.40"

	Area (ac)	CN	Description
*	4.406	80	
	4.406		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.3	35	0.0100	0.09		**Sheet Flow, Sheet 1** Grass: Short n= 0.150 P2= 2.55"
2.8	65	0.2538	0.38		**Sheet Flow, Sheet 2** Grass: Short n= 0.150 P2= 2.55"
2.9	43	0.1000	0.24		**Sheet Flow, Sheet 3** Grass: Short n= 0.150 P2= 2.55"
12.0	143	Total			

Subcatchment S3B: Upper Side 3



Summary for Subcatchment S3C: Lower Side 3

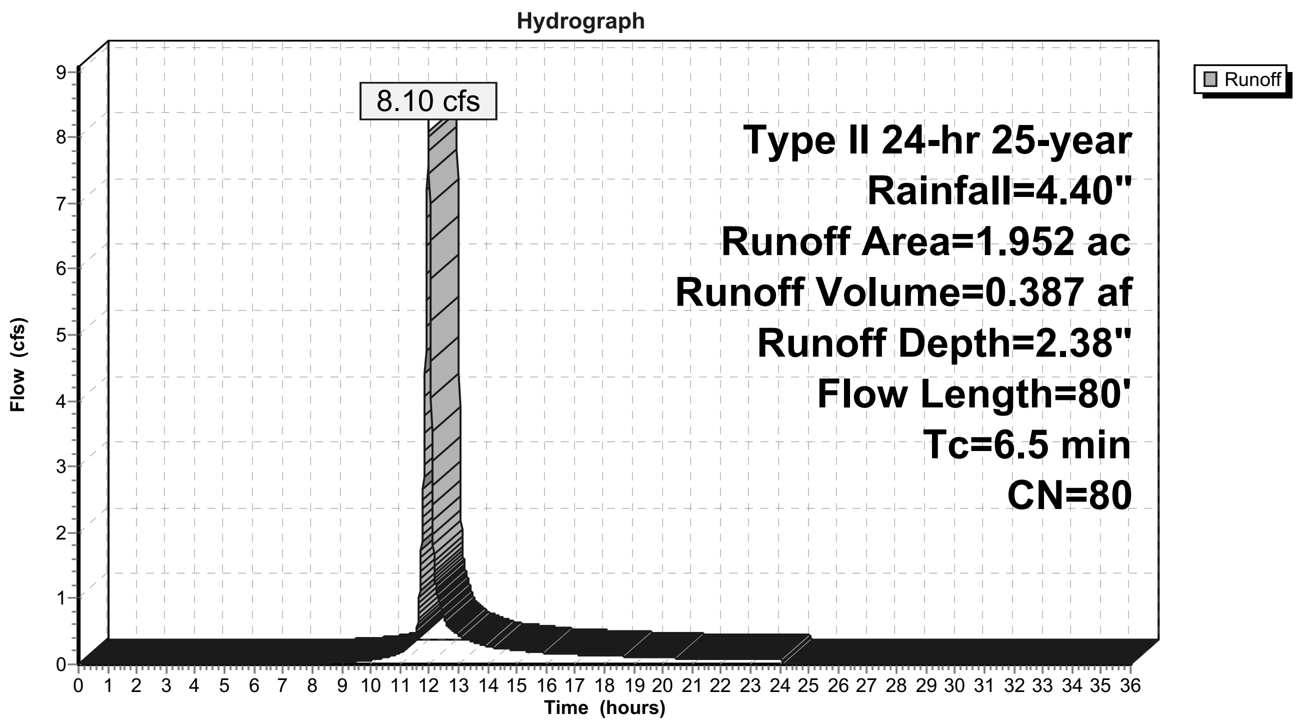
Runoff = 8.10 cfs @ 11.98 hrs, Volume= 0.387 af, Depth= 2.38"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs
Type II 24-hr 25-year Rainfall=4.40"

	Area (ac)	CN	Description
*	1.952	80	
	1.952		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.6	55	0.0545	0.20		**Sheet Flow, Sheet 1** Grass: Short n= 0.150 P2= 2.55"
1.9	25	0.1000	0.22		**Sheet Flow, Sheet 2** Grass: Short n= 0.150 P2= 2.55"
6.5	80	Total			

Subcatchment S3C: Lower Side 3



Summary for Subcatchment S4A: Top Deck 4

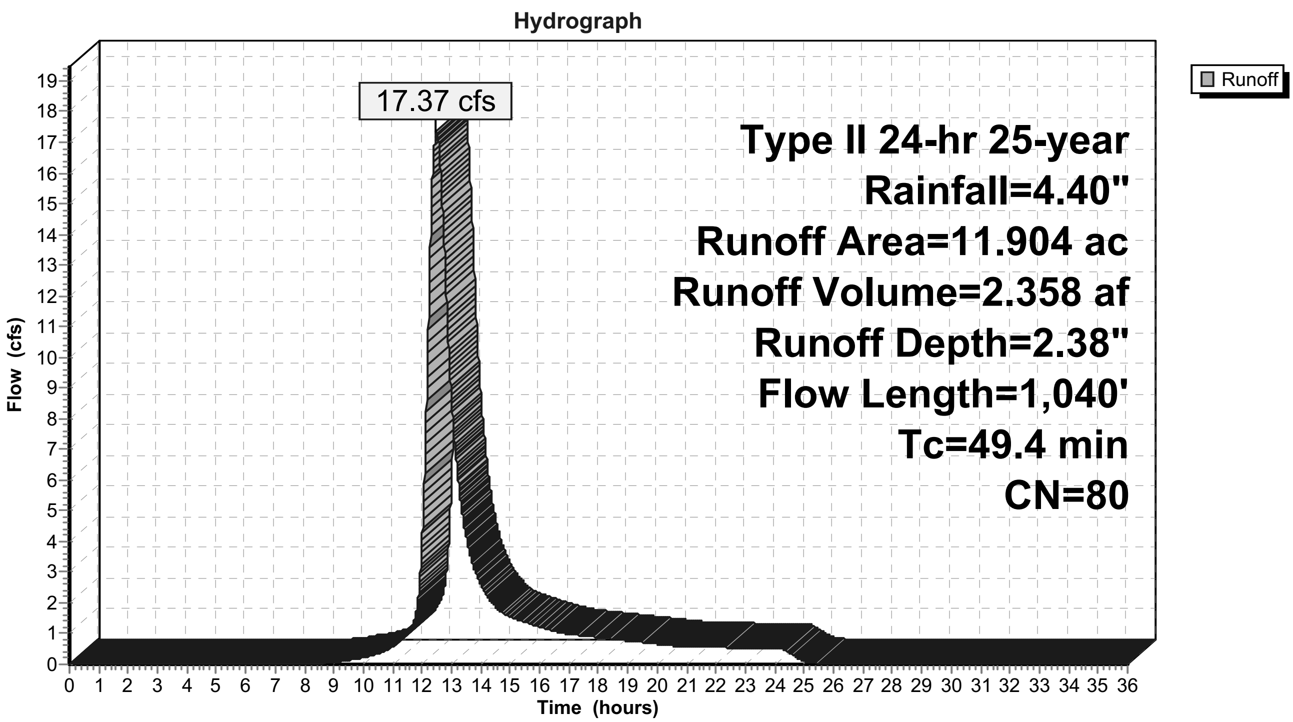
Runoff = 17.37 cfs @ 12.46 hrs, Volume= 2.358 af, Depth= 2.38"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs
Type II 24-hr 25-year Rainfall=4.40"

	Area (ac)	CN	Description
*	11.904	80	
	11.904		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
38.7	300	0.0077	0.13		**Sheet Flow, Sheet** Grass: Short n= 0.150 P2= 2.55"
10.7	740	0.0059	1.15		**Shallow Concentrated Flow, Shallow Concentrated** Grassed Waterway Kv= 15.0 fps
49.4	1,040	Total			

Subcatchment S4A: Top Deck 4



Summary for Subcatchment S4B: Upper Side 4

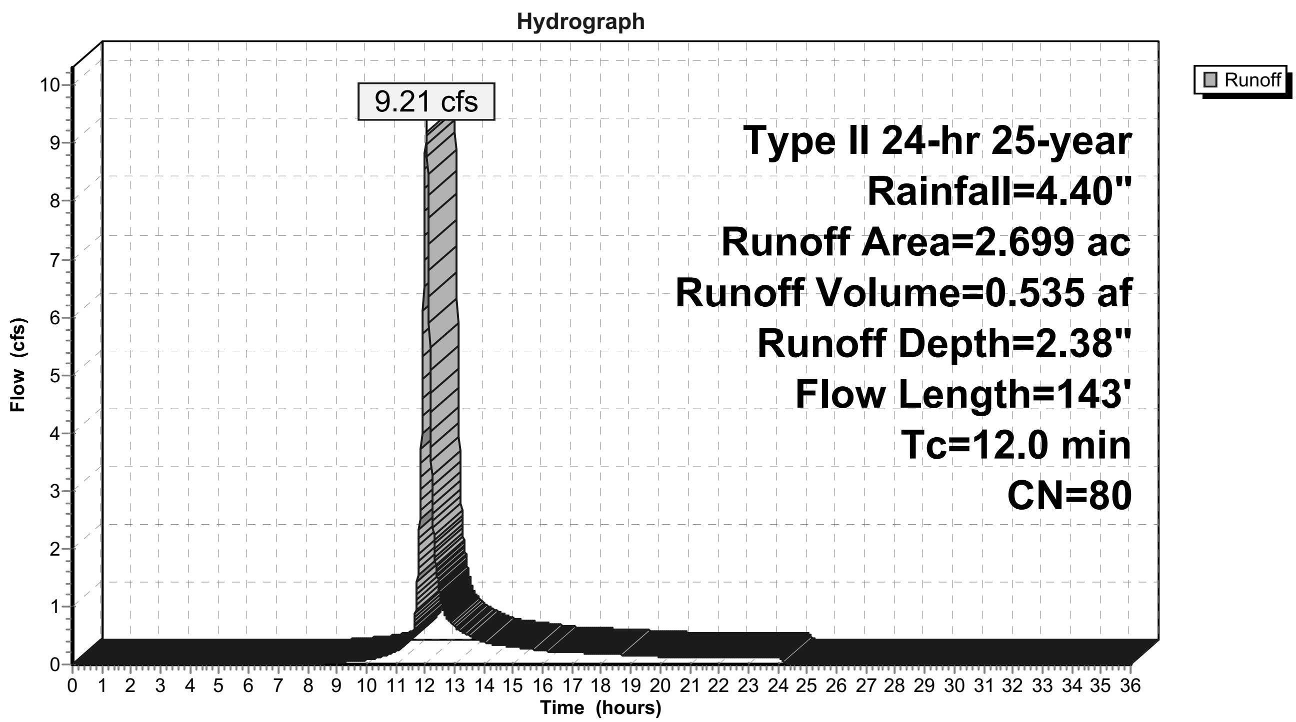
Runoff = 9.21 cfs @ 12.04 hrs, Volume= 0.535 af, Depth= 2.38"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs
Type II 24-hr 25-year Rainfall=4.40"

	Area (ac)	CN	Description
*	2.699	80	
	2.699		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.3	35	0.0100	0.09		**Sheet Flow, Sheet 1** Grass: Short n= 0.150 P2= 2.55"
2.8	65	0.2538	0.38		**Sheet Flow, Sheet 2** Grass: Short n= 0.150 P2= 2.55"
2.9	43	0.1000	0.24		**Sheet Flow, Sheet 3** Grass: Short n= 0.150 P2= 2.55"
12.0	143	Total			

Subcatchment S4B: Upper Side 4



Summary for Subcatchment S4C: Lower Side 4

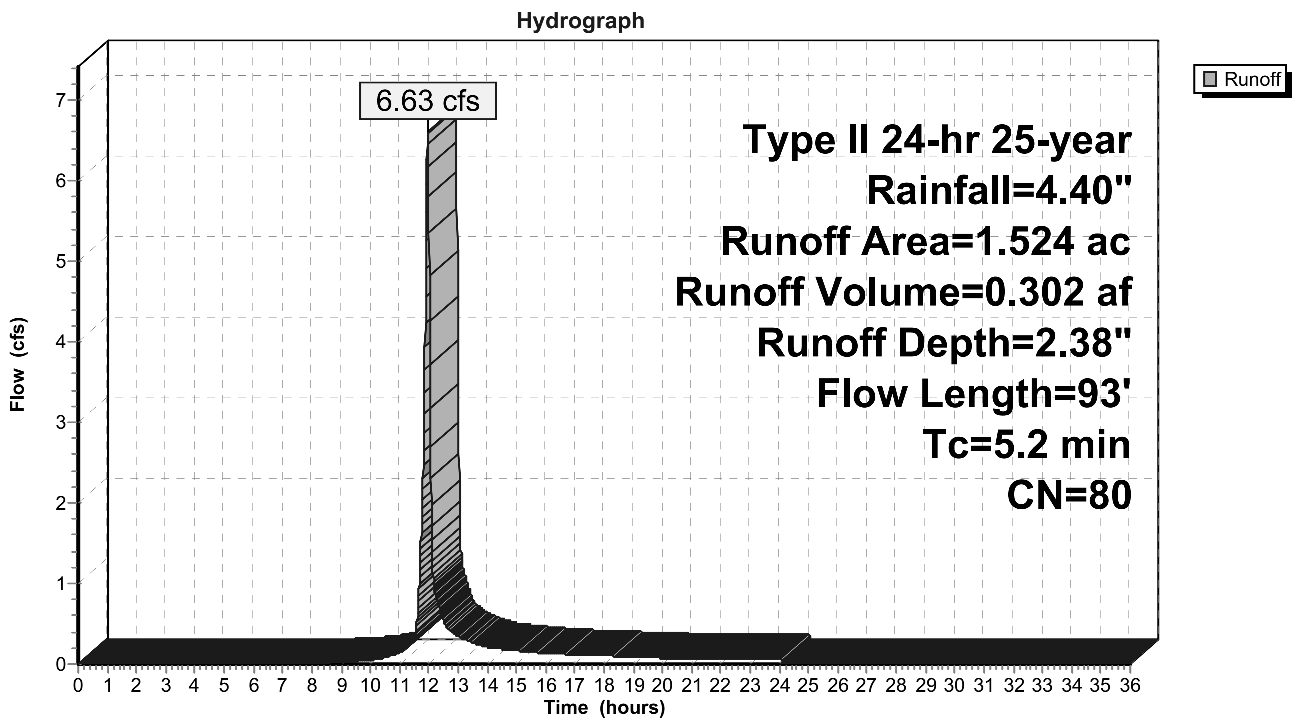
Runoff = 6.63 cfs @ 11.96 hrs, Volume= 0.302 af, Depth= 2.38"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs
Type II 24-hr 25-year Rainfall=4.40"

	Area (ac)	CN	Description
*	1.524	80	
	1.524		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.3	50	0.2400	0.36		**Sheet Flow, Sheet 4** Grass: Short n= 0.150 P2= 2.55"
2.9	43	0.1000	0.24		**Sheet Flow, Sheet 2** Grass: Short n= 0.150 P2= 2.55"
5.2	93	Total			

Subcatchment S4C: Lower Side 4



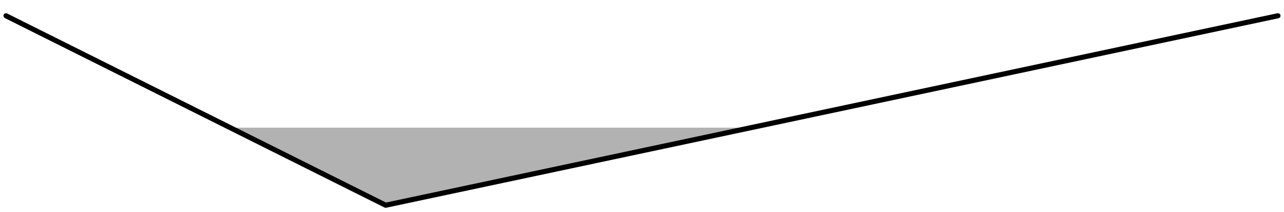
Summary for Reach B1: Bench 1

Inflow Area = 2.071 ac, 0.00% Impervious, Inflow Depth = 2.38" for 25-year event
Inflow = 7.55 cfs @ 12.02 hrs, Volume= 0.410 af
Outflow = 5.95 cfs @ 12.08 hrs, Volume= 0.410 af, Atten= 21%, Lag= 3.8 min

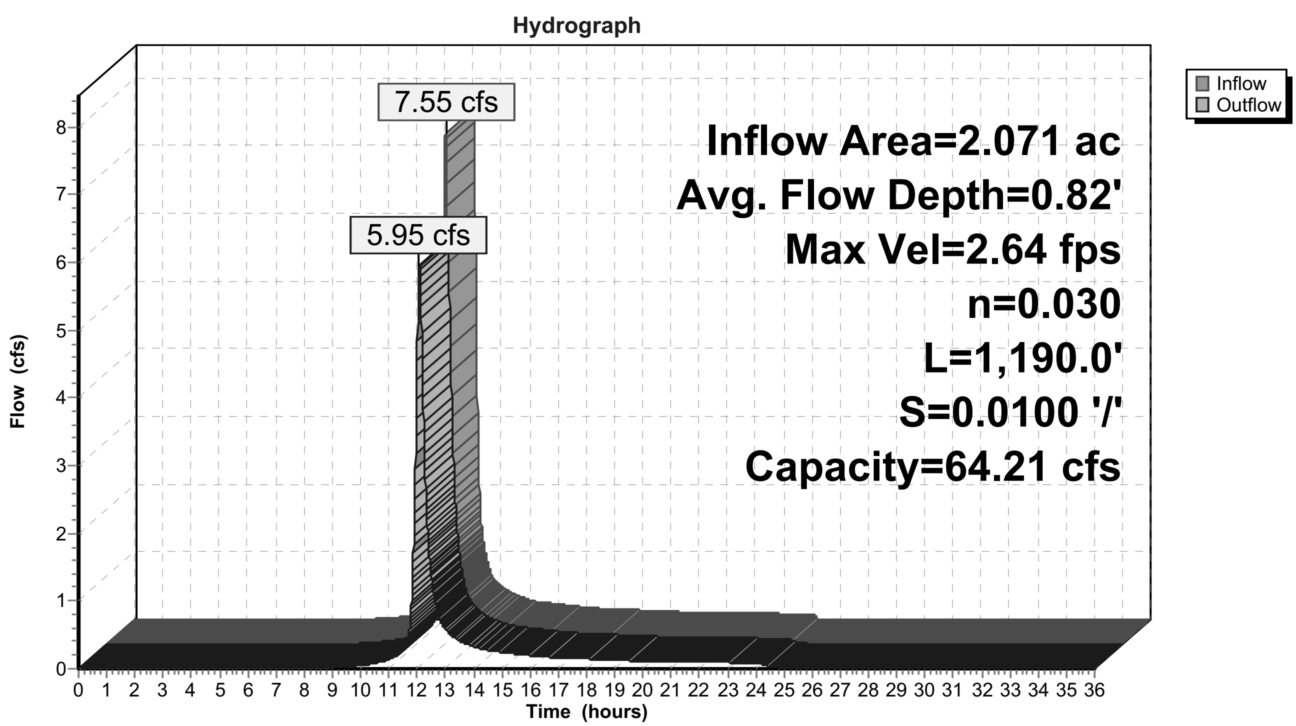
Routing by Dyn-Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs
Max. Velocity= 2.64 fps, Min. Travel Time= 7.5 min
Avg. Velocity = 0.83 fps, Avg. Travel Time= 23.8 min

Peak Storage= 2,678 cf @ 12.08 hrs
Average Depth at Peak Storage= 0.82'
Bank-Full Depth= 2.00', Capacity at Bank-Full= 64.21 cfs

0.00' x 2.00' deep channel, n= 0.030
Side Slope Z-value= 2.0 4.7 '/' Top Width= 13.40'
Length= 1,190.0' Slope= 0.0100 '/'
Inlet Invert= 461.00', Outlet Invert= 449.10'



Reach B1: Bench 1



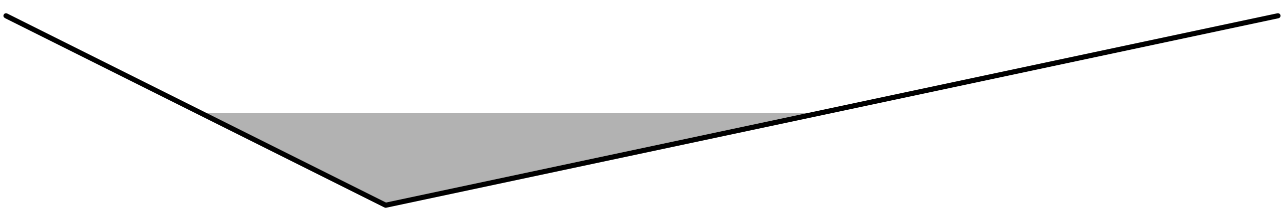
Summary for Reach B2: Bench 2

Inflow Area = 3.531 ac, 0.00% Impervious, Inflow Depth = 2.38" for 25-year event
Inflow = 12.88 cfs @ 12.02 hrs, Volume= 0.699 af
Outflow = 9.40 cfs @ 12.09 hrs, Volume= 0.699 af, Atten= 27%, Lag= 4.5 min

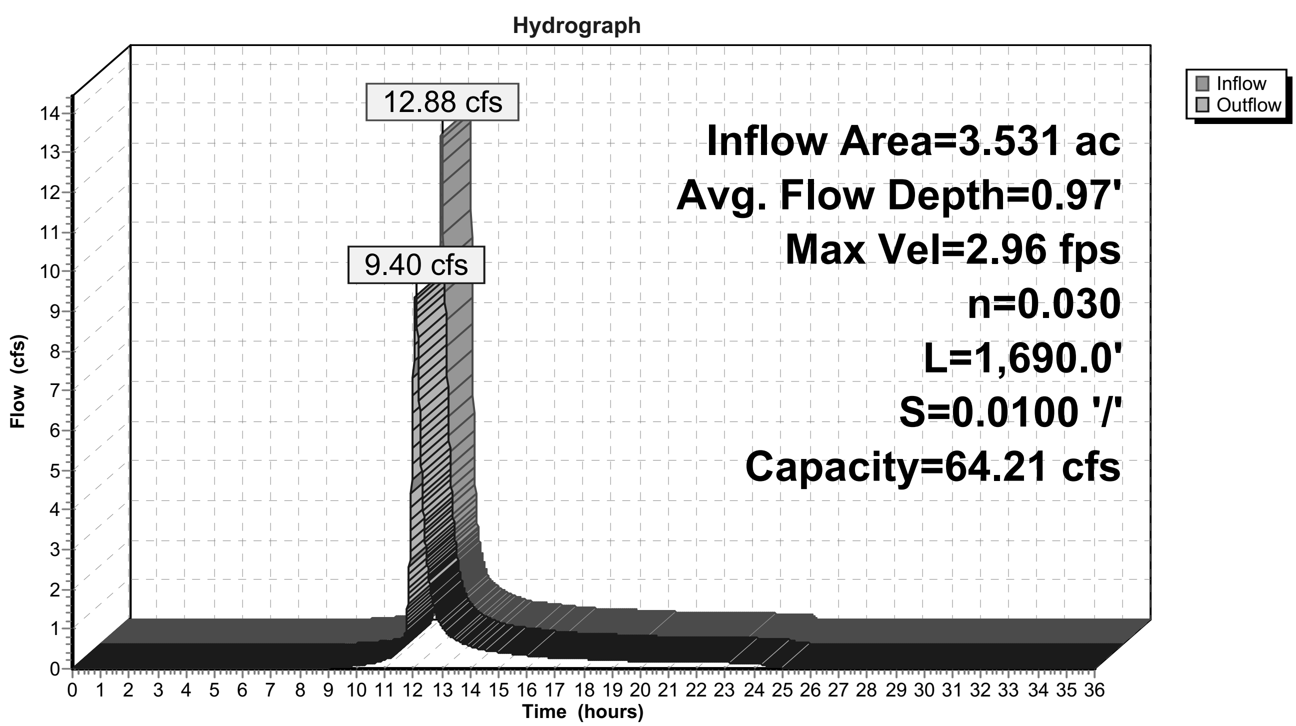
Routing by Dyn-Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs
Max. Velocity= 2.96 fps, Min. Travel Time= 9.5 min
Avg. Velocity = 0.87 fps, Avg. Travel Time= 32.5 min

Peak Storage= 5,357 cf @ 12.09 hrs
Average Depth at Peak Storage= 0.97'
Bank-Full Depth= 2.00', Capacity at Bank-Full= 64.21 cfs

0.00' x 2.00' deep channel, n= 0.030
Side Slope Z-value= 2.0 4.7 '/' Top Width= 13.40'
Length= 1,690.0' Slope= 0.0100 '/'
Inlet Invert= 462.00', Outlet Invert= 445.10'



Reach B2: Bench 2



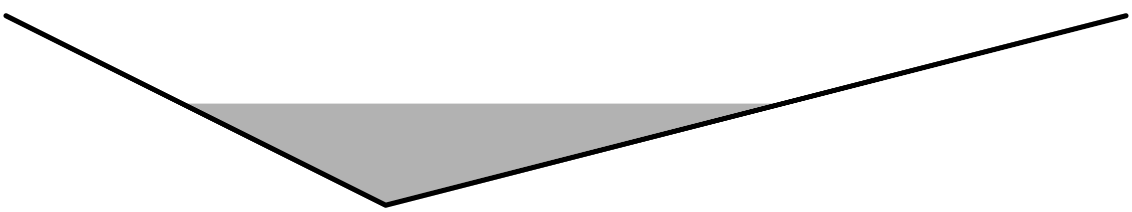
Summary for Reach B3: Bench 3

Inflow Area = 4.406 ac, 0.00% Impervious, Inflow Depth = 2.38" for 25-year event
Inflow = 15.03 cfs @ 12.04 hrs, Volume= 0.873 af
Outflow = 10.66 cfs @ 12.13 hrs, Volume= 0.873 af, Atten= 29%, Lag= 5.2 min

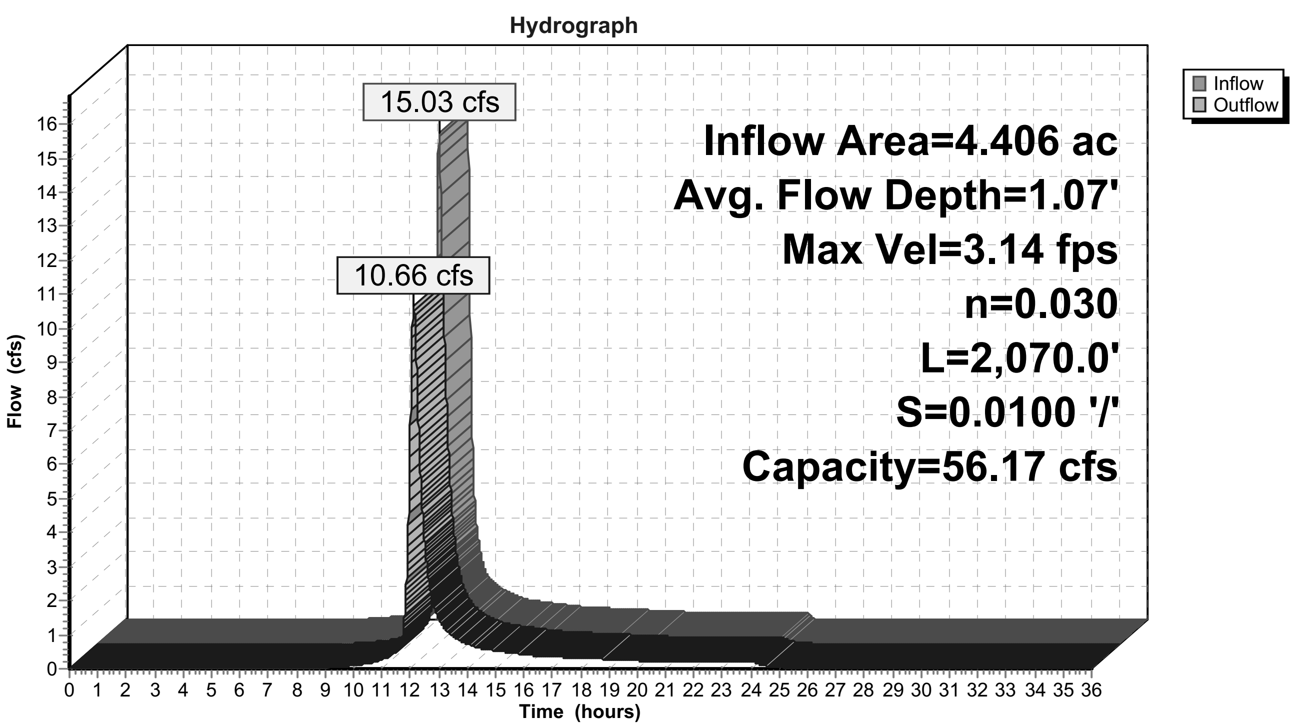
Routing by Dyn-Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs
Max. Velocity= 3.14 fps, Min. Travel Time= 11.0 min
Avg. Velocity = 0.90 fps, Avg. Travel Time= 38.1 min

Peak Storage= 7,024 cf @ 12.13 hrs
Average Depth at Peak Storage= 1.07'
Bank-Full Depth= 2.00', Capacity at Bank-Full= 56.17 cfs

0.00' x 2.00' deep channel, n= 0.030
Side Slope Z-value= 2.0 3.9 '/' Top Width= 11.80'
Length= 2,070.0' Slope= 0.0100 '/'
Inlet Invert= 462.00', Outlet Invert= 441.30'



Reach B3: Bench 3



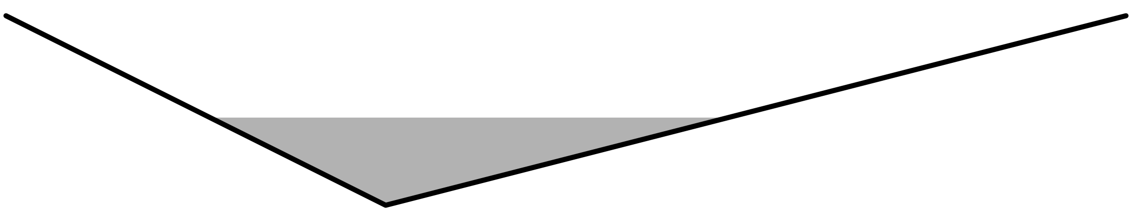
Summary for Reach B4: Bench 4

Inflow Area = 2.699 ac, 0.00% Impervious, Inflow Depth = 2.38" for 25-year event
Inflow = 9.21 cfs @ 12.04 hrs, Volume= 0.535 af
Outflow = 7.20 cfs @ 12.11 hrs, Volume= 0.535 af, Atten= 22%, Lag= 4.4 min

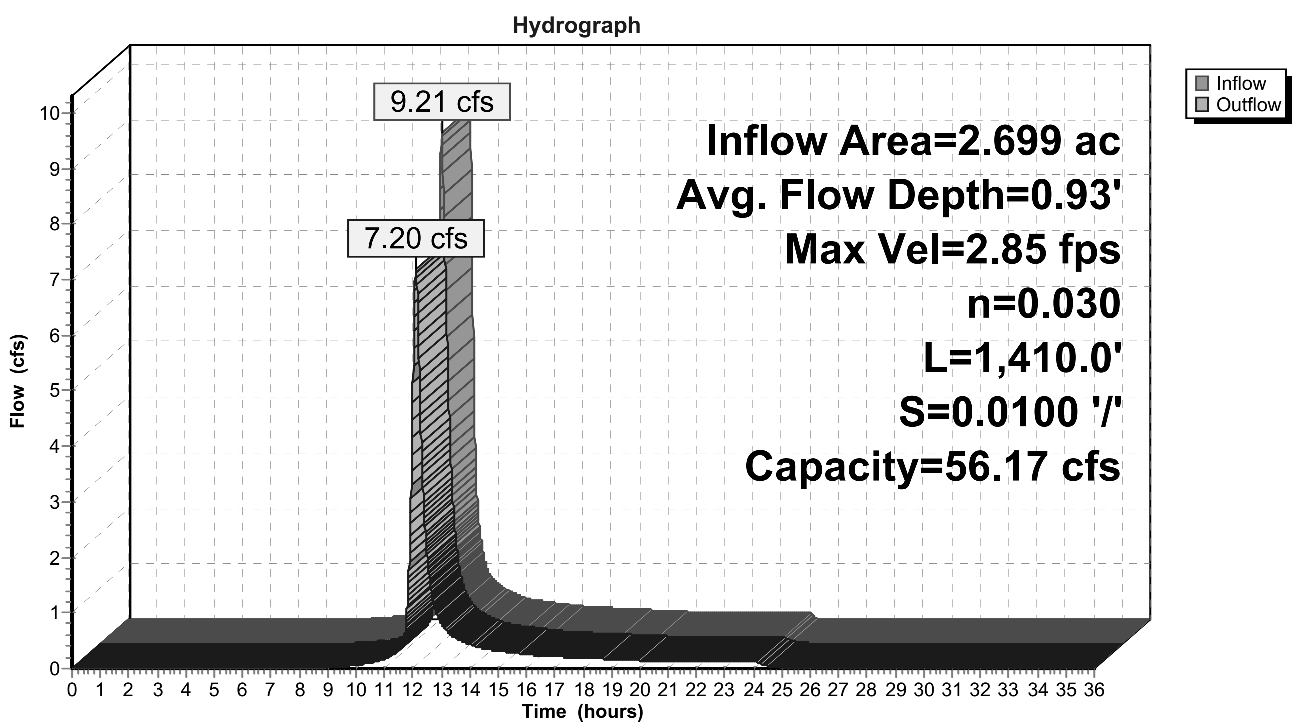
Routing by Dyn-Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs
Max. Velocity= 2.85 fps, Min. Travel Time= 8.3 min
Avg. Velocity = 0.88 fps, Avg. Travel Time= 26.8 min

Peak Storage= 3,563 cf @ 12.11 hrs
Average Depth at Peak Storage= 0.93'
Bank-Full Depth= 2.00', Capacity at Bank-Full= 56.17 cfs

0.00' x 2.00' deep channel, n= 0.030
Side Slope Z-value= 2.0 3.9 '/' Top Width= 11.80'
Length= 1,410.0' Slope= 0.0100 '/'
Inlet Invert= 461.00', Outlet Invert= 446.90'



Reach B4: Bench 4



Summary for Reach C1: Culvert 1

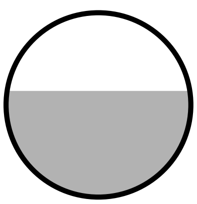
[52] Hint: Inlet/Outlet conditions not evaluated
[62] Hint: Exceeded Reach T1 OUTLET depth by 0.63' @ 12.43 hrs
[61] Hint: Exceeded Reach T2 outlet invert by 0.18' @ 12.33 hrs

Inflow Area = 28.757 ac, 0.00% Impervious, Inflow Depth = 2.38" for 25-year event
Inflow = 39.69 cfs @ 12.33 hrs, Volume= 5.695 af
Outflow = 39.69 cfs @ 12.33 hrs, Volume= 5.695 af, Atten= 0%, Lag= 0.2 min

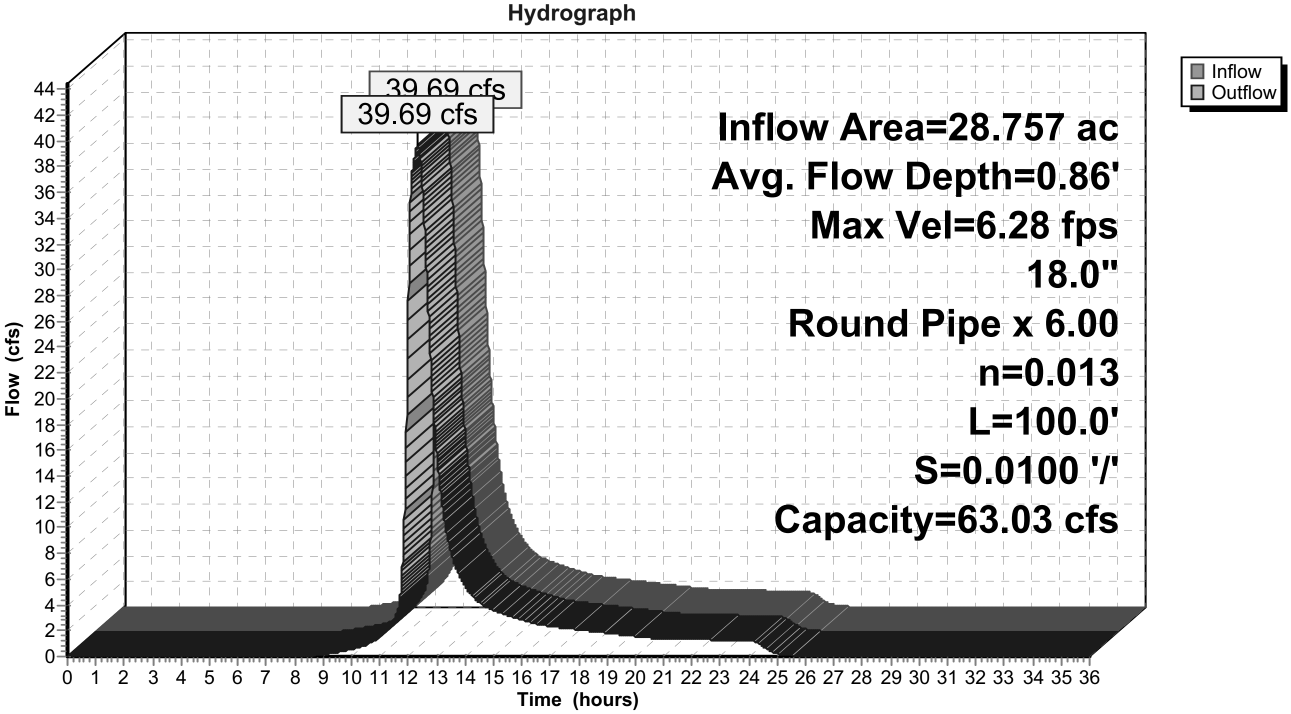
Routing by Dyn-Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs
Max. Velocity= 6.28 fps, Min. Travel Time= 0.3 min
Avg. Velocity = 1.90 fps, Avg. Travel Time= 0.9 min

Peak Storage= 632 cf @ 12.33 hrs
Average Depth at Peak Storage= 0.86'
Bank-Full Depth= 1.50', Capacity at Bank-Full= 63.03 cfs

A factor of 6.00 has been applied to the storage and discharge capacity
18.0" Round Pipe
n= 0.013
Length= 100.0' Slope= 0.0100 '/'
Inlet Invert= 432.24', Outlet Invert= 431.24'



Reach C1: Culvert 1



Summary for Reach C2: Culvert 2

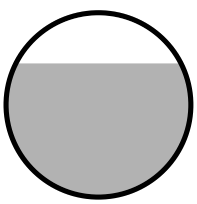
[52] Hint: Inlet/Outlet conditions not evaluated
[62] Hint: Exceeded Reach T3 OUTLET depth by 0.78' @ 12.42 hrs
[62] Hint: Exceeded Reach T4 OUTLET depth by 0.63' @ 12.42 hrs

Inflow Area = 39.237 ac, 0.00% Impervious, Inflow Depth = 2.38" for 25-year event
Inflow = 55.08 cfs @ 12.36 hrs, Volume= 7.771 af
Outflow = 55.07 cfs @ 12.36 hrs, Volume= 7.771 af, Atten= 0%, Lag= 0.2 min

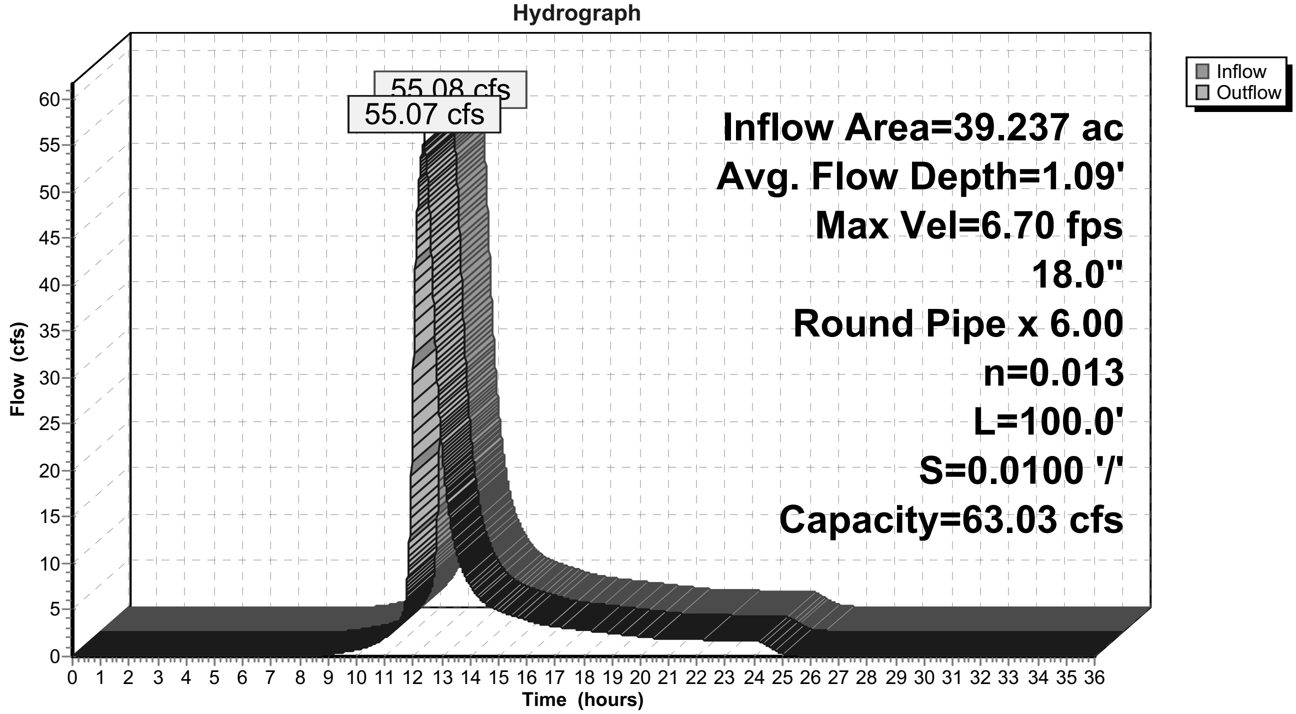
Routing by Dyn-Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs
Max. Velocity= 6.70 fps, Min. Travel Time= 0.2 min
Avg. Velocity = 2.07 fps, Avg. Travel Time= 0.8 min

Peak Storage= 822 cf @ 12.36 hrs
Average Depth at Peak Storage= 1.09'
Bank-Full Depth= 1.50', Capacity at Bank-Full= 63.03 cfs

A factor of 6.00 has been applied to the storage and discharge capacity
18.0" Round Pipe
n= 0.013
Length= 100.0' Slope= 0.0100 '/'
Inlet Invert= 431.07', Outlet Invert= 430.07'



Reach C2: Culvert 2



Summary for Reach R1A: Riprap 1A

Inflow Area = 20.266 ac, 0.00% Impervious, Inflow Depth = 2.38" for 25-year event
Inflow = 31.28 cfs @ 12.43 hrs, Volume= 4.014 af
Outflow = 31.28 cfs @ 12.43 hrs, Volume= 4.014 af, Atten= 0%, Lag= 0.1 min

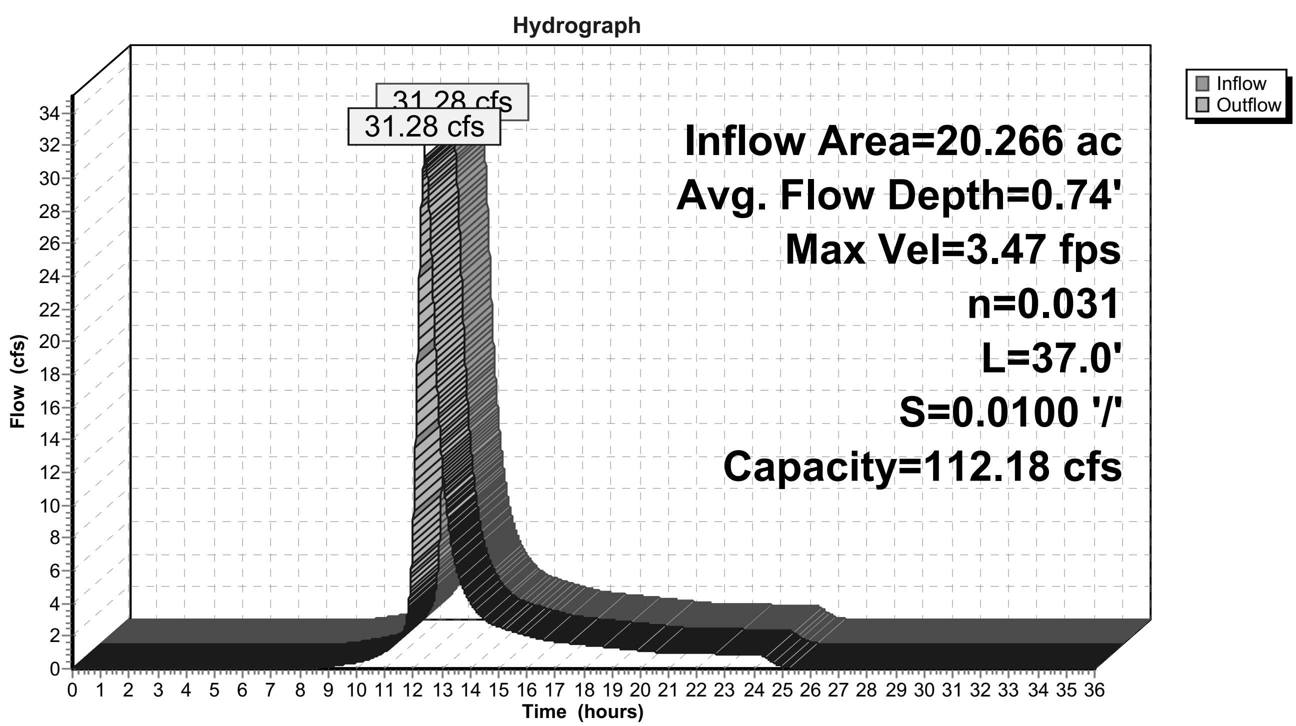
Routing by Dyn-Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs
Max. Velocity= 3.47 fps, Min. Travel Time= 0.2 min
Avg. Velocity = 1.11 fps, Avg. Travel Time= 0.6 min

Peak Storage= 334 cf @ 12.43 hrs
Average Depth at Peak Storage= 0.74'
Bank-Full Depth= 1.50', Capacity at Bank-Full= 112.18 cfs

10.00' x 1.50' deep channel, n= 0.031
Side Slope Z-value= 3.0 '/' Top Width= 19.00'
Length= 37.0' Slope= 0.0100 '/'
Inlet Invert= 452.37', Outlet Invert= 452.00'

‡

Reach R1A: Riprap 1A



Summary for Reach R1B: Riprap 1B

[61] Hint: Exceeded Reach R1A outlet invert by 0.40' @ 12.43 hrs

Inflow Area = 20.266 ac, 0.00% Impervious, Inflow Depth = 2.38" for 25-year event
Inflow = 31.28 cfs @ 12.43 hrs, Volume= 4.014 af
Outflow = 31.27 cfs @ 12.43 hrs, Volume= 4.014 af, Atten= 0%, Lag= 0.1 min

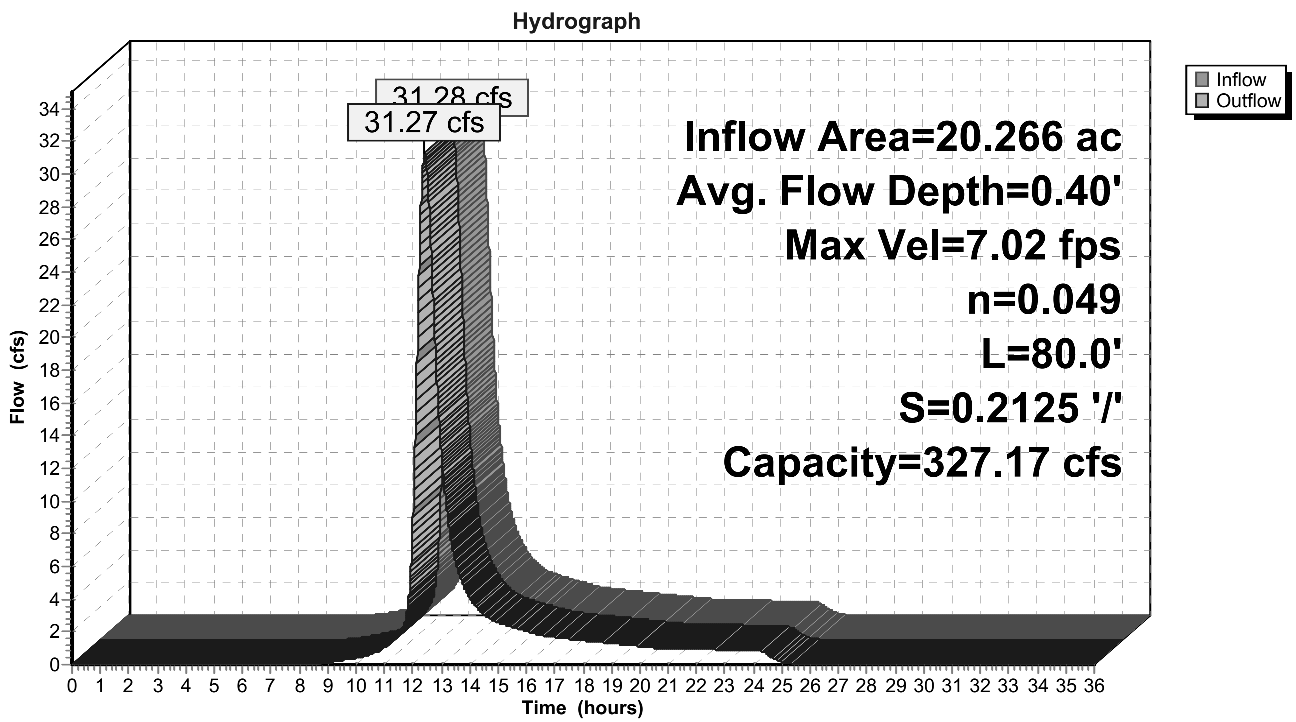
Routing by Dyn-Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs
Max. Velocity= 7.02 fps, Min. Travel Time= 0.2 min
Avg. Velocity = 2.21 fps, Avg. Travel Time= 0.6 min

Peak Storage= 356 cf @ 12.43 hrs
Average Depth at Peak Storage= 0.40'
Bank-Full Depth= 1.50', Capacity at Bank-Full= 327.17 cfs

10.00' x 1.50' deep channel, n= 0.049
Side Slope Z-value= 3.0 '/' Top Width= 19.00'
Length= 80.0' Slope= 0.2125 '/'
Inlet Invert= 452.00', Outlet Invert= 435.00'

‡

Reach R1B: Riprap 1B



Summary for Reach R2A: Riprap 2A

Inflow Area = 28.656 ac, 0.00% Impervious, Inflow Depth = 2.38" for 25-year event
Inflow = 43.90 cfs @ 12.45 hrs, Volume= 5.675 af
Outflow = 43.90 cfs @ 12.45 hrs, Volume= 5.675 af, Atten= 0%, Lag= 0.0 min

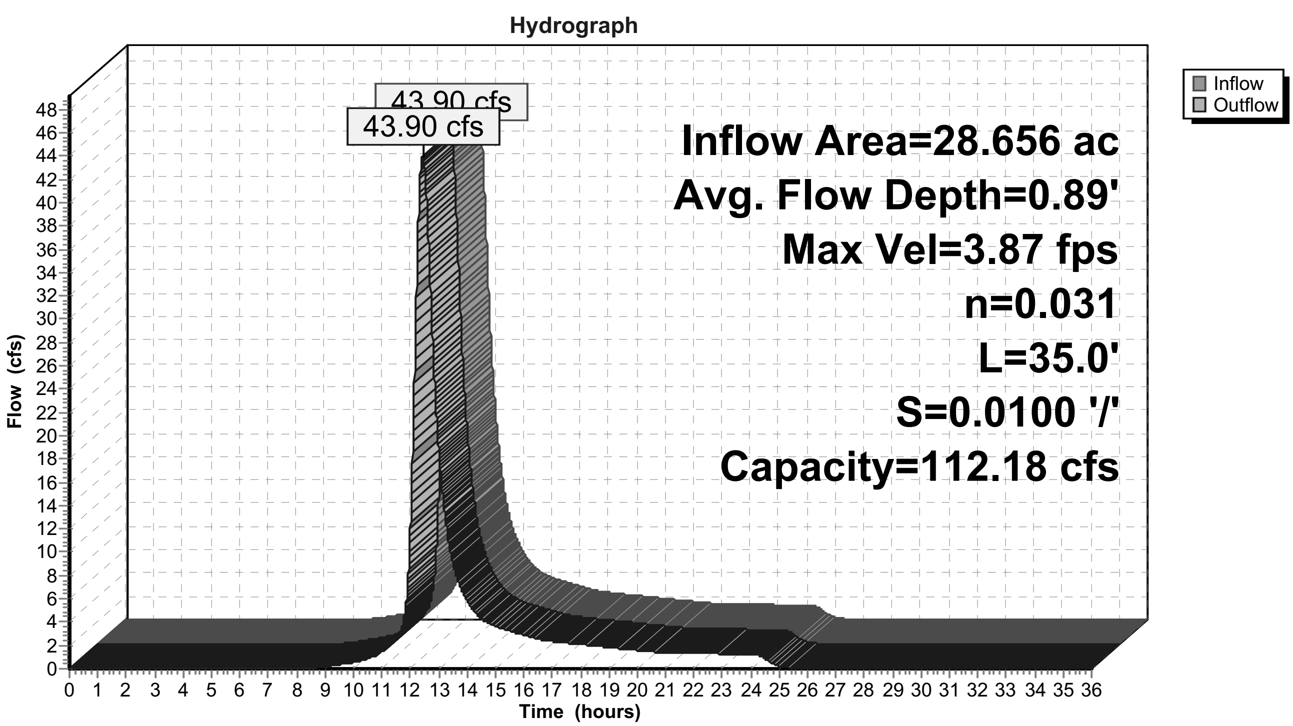
Routing by Dyn-Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs
Max. Velocity= 3.87 fps, Min. Travel Time= 0.2 min
Avg. Velocity = 1.26 fps, Avg. Travel Time= 0.5 min

Peak Storage= 397 cf @ 12.45 hrs
Average Depth at Peak Storage= 0.89'
Bank-Full Depth= 1.50', Capacity at Bank-Full= 112.18 cfs

10.00' x 1.50' deep channel, n= 0.031
Side Slope Z-value= 3.0 '/' Top Width= 19.00'
Length= 35.0' Slope= 0.0100 '/'
Inlet Invert= 450.35', Outlet Invert= 450.00'

‡

Reach R2A: Riprap 2A



Summary for Reach R2B: Riprap 2B

[61] Hint: Exceeded Reach R2A outlet invert by 0.47' @ 12.45 hrs

Inflow Area = 28.656 ac, 0.00% Impervious, Inflow Depth = 2.38" for 25-year event
Inflow = 43.90 cfs @ 12.45 hrs, Volume= 5.675 af
Outflow = 43.90 cfs @ 12.45 hrs, Volume= 5.675 af, Atten= 0%, Lag= 0.0 min

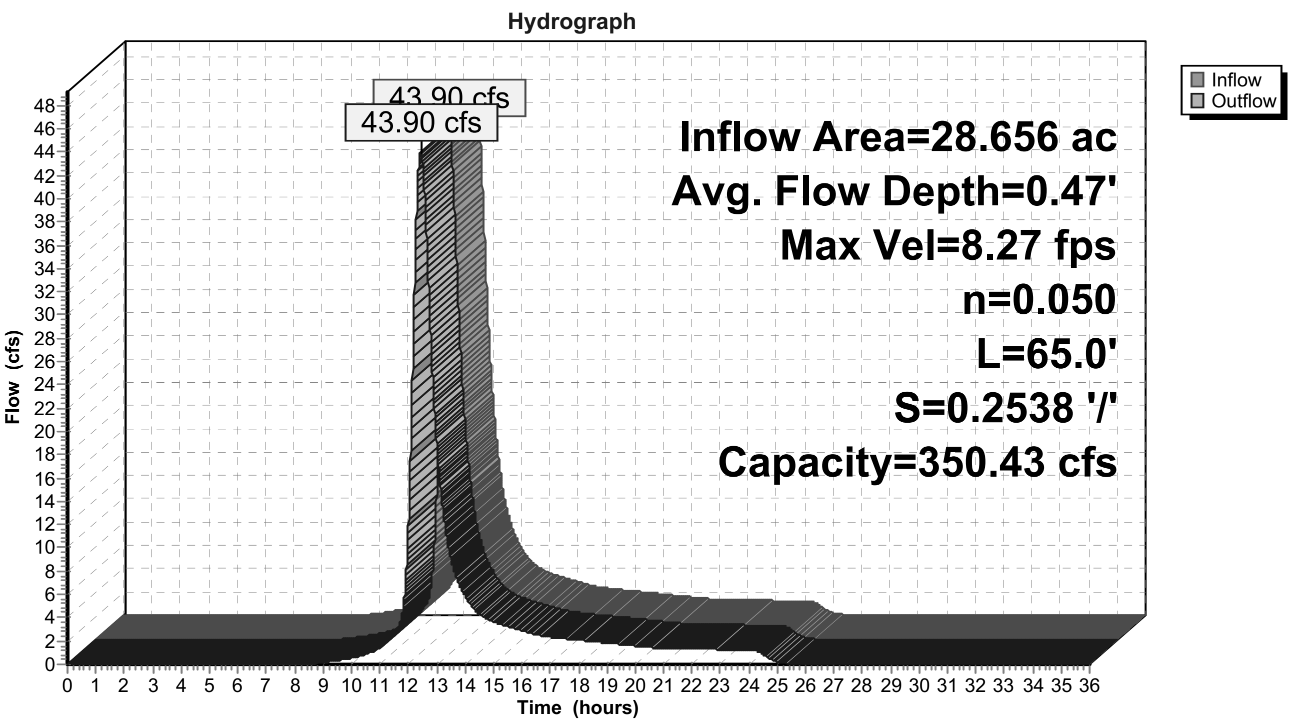
Routing by Dyn-Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs
Max. Velocity= 8.27 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 2.61 fps, Avg. Travel Time= 0.4 min

Peak Storage= 345 cf @ 12.45 hrs
Average Depth at Peak Storage= 0.47'
Bank-Full Depth= 1.50', Capacity at Bank-Full= 350.43 cfs

10.00' x 1.50' deep channel, n= 0.050
Side Slope Z-value= 3.0 '/' Top Width= 19.00'
Length= 65.0' Slope= 0.2538 '/'
Inlet Invert= 450.00', Outlet Invert= 433.50'

‡

Reach R2B: Riprap 2B



Summary for Reach R2C: Riprap 2C

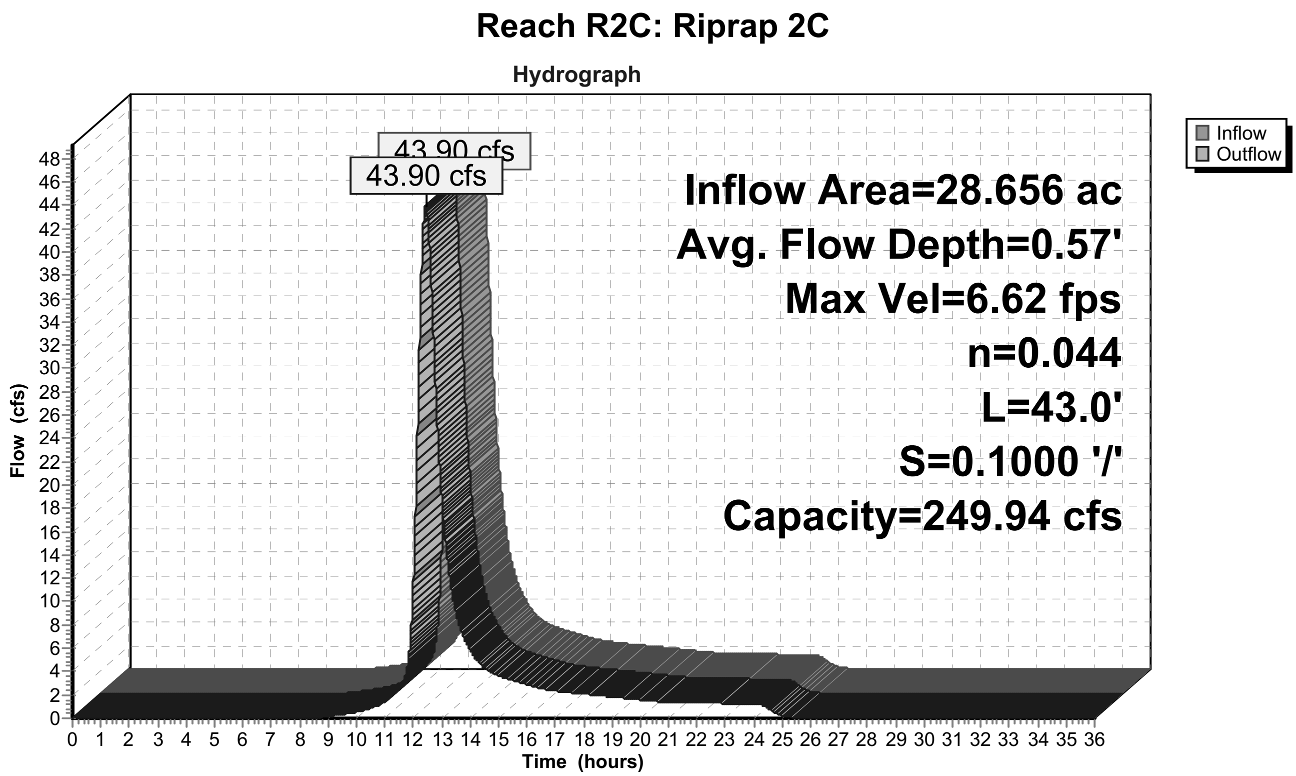
[62] Hint: Exceeded Reach R2B OUTLET depth by 10.10' @ 12.46 hrs

Inflow Area = 28.656 ac, 0.00% Impervious, Inflow Depth = 2.38" for 25-year event
Inflow = 43.90 cfs @ 12.45 hrs, Volume= 5.675 af
Outflow = 43.90 cfs @ 12.45 hrs, Volume= 5.675 af, Atten= 0%, Lag= 0.0 min

Routing by Dyn-Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs
Max. Velocity= 6.62 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 2.10 fps, Avg. Travel Time= 0.3 min

Peak Storage= 285 cf @ 12.45 hrs
Average Depth at Peak Storage= 0.57'
Bank-Full Depth= 1.50', Capacity at Bank-Full= 249.94 cfs

10.00' x 1.50' deep channel, n= 0.044
Side Slope Z-value= 3.0 '/' Top Width= 19.00'
Length= 43.0' Slope= 0.1000 '/'
Inlet Invert= 443.50', Outlet Invert= 439.20'



Summary for Reach T1: Toe 1

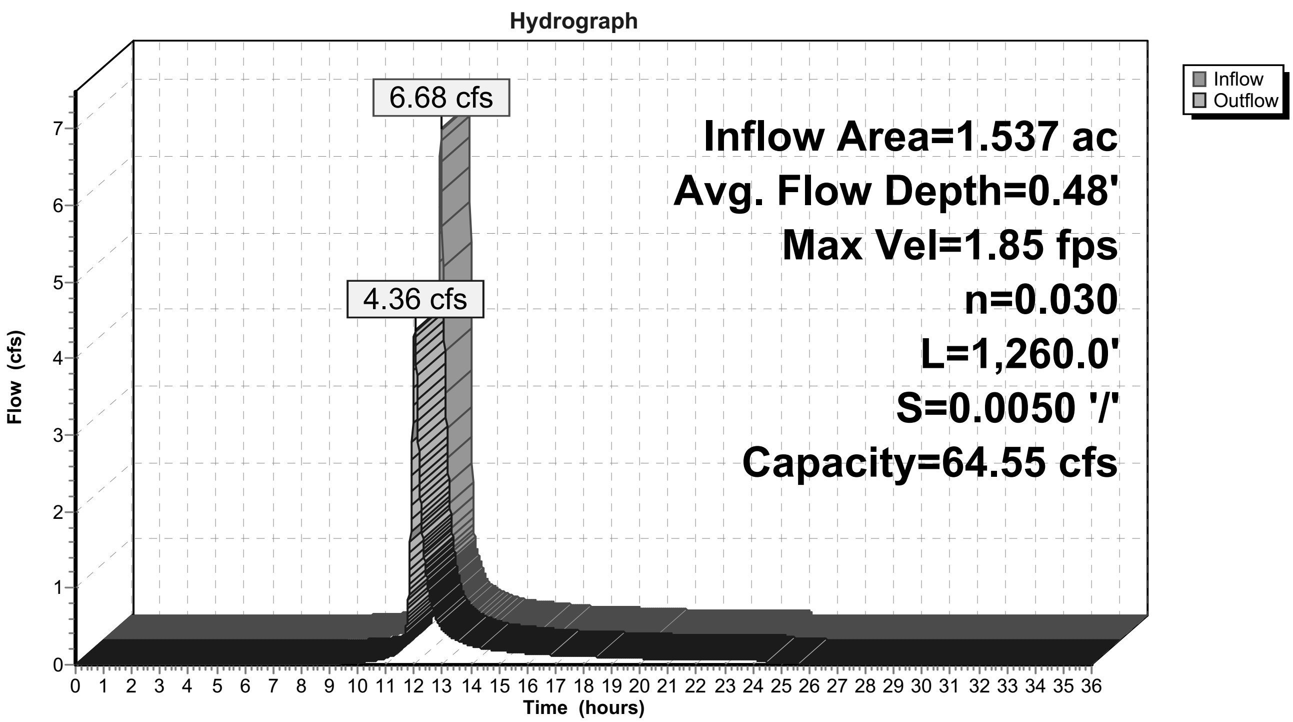
Inflow Area = 1.537 ac, 0.00% Impervious, Inflow Depth = 2.38" for 25-year event
Inflow = 6.68 cfs @ 11.96 hrs, Volume= 0.304 af
Outflow = 4.36 cfs @ 12.03 hrs, Volume= 0.304 af, Atten= 35%, Lag= 3.9 min

Routing by Dyn-Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs
Max. Velocity= 1.85 fps, Min. Travel Time= 11.3 min
Avg. Velocity = 0.43 fps, Avg. Travel Time= 49.2 min

Peak Storage= 2,968 cf @ 12.03 hrs
Average Depth at Peak Storage= 0.48'
Bank-Full Depth= 2.00', Capacity at Bank-Full= 64.55 cfs

4.00' x 2.00' deep channel, n= 0.030
Side Slope Z-value= 2.0 '/' Top Width= 12.00'
Length= 1,260.0' Slope= 0.0050 '/'
Inlet Invert= 438.54', Outlet Invert= 432.24'

Reach T1: Toe 1



Summary for Reach T2: Toe 2

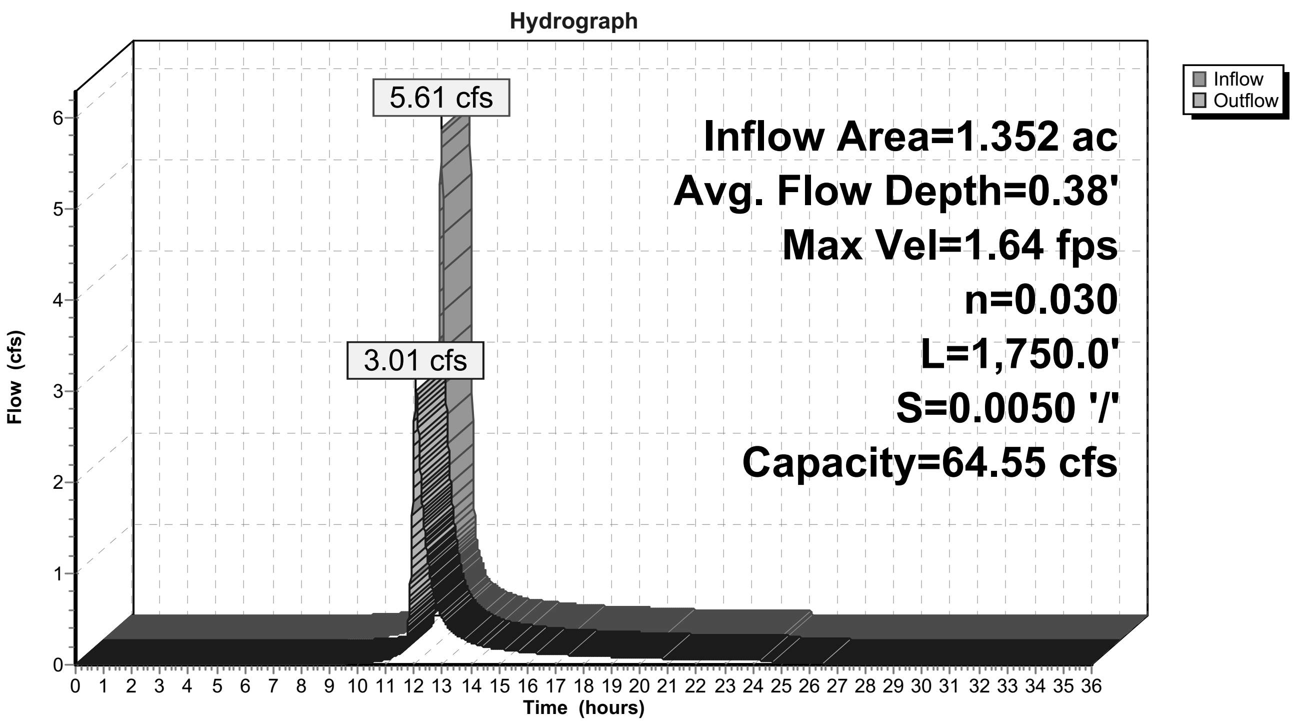
Inflow Area = 1.352 ac, 0.00% Impervious, Inflow Depth = 2.38" for 25-year event
Inflow = 5.61 cfs @ 11.98 hrs, Volume= 0.268 af
Outflow = 3.01 cfs @ 12.06 hrs, Volume= 0.268 af, Atten= 46%, Lag= 5.2 min

Routing by Dyn-Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs
Max. Velocity= 1.64 fps, Min. Travel Time= 17.8 min
Avg. Velocity = 0.40 fps, Avg. Travel Time= 72.4 min

Peak Storage= 3,207 cf @ 12.06 hrs
Average Depth at Peak Storage= 0.38'
Bank-Full Depth= 2.00', Capacity at Bank-Full= 64.55 cfs

4.00' x 2.00' deep channel, n= 0.030
Side Slope Z-value= 2.0 '/' Top Width= 12.00'
Length= 1,750.0' Slope= 0.0050 '/'
Inlet Invert= 441.67', Outlet Invert= 432.92'

Reach T2: Toe 2



Summary for Reach T3: Toe 3

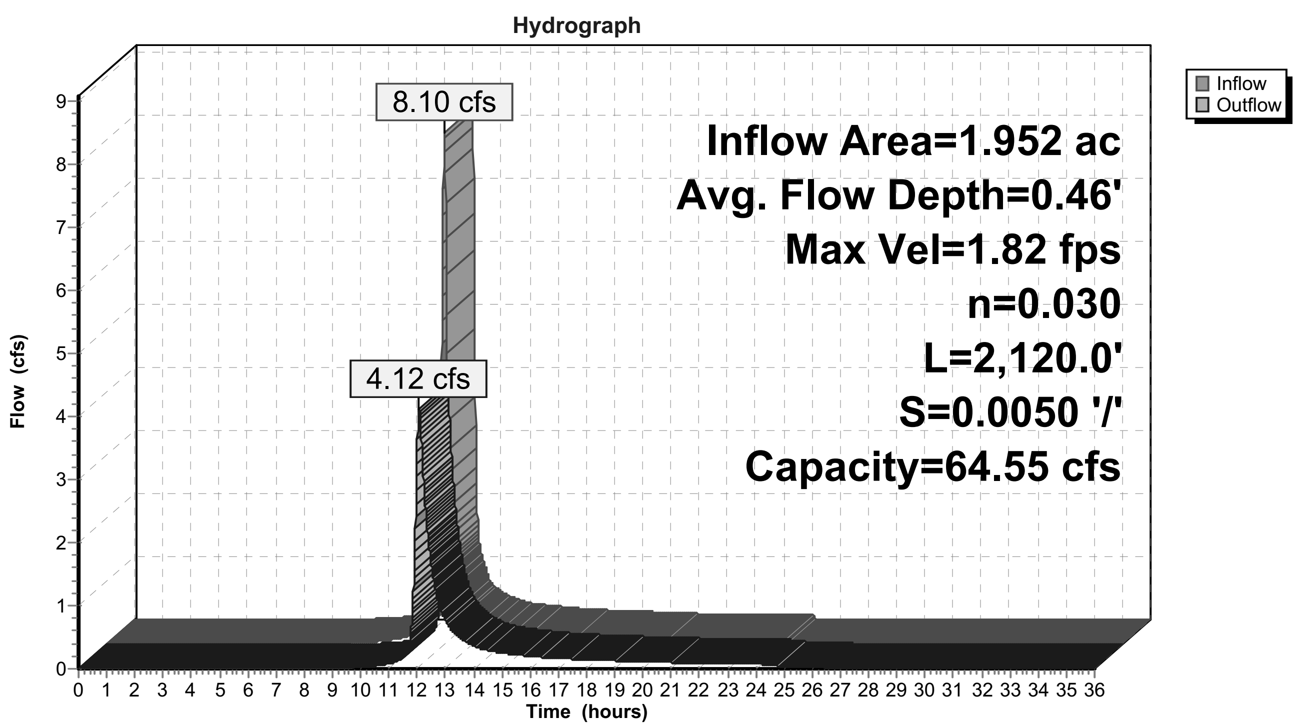
Inflow Area = 1.952 ac, 0.00% Impervious, Inflow Depth = 2.38" for 25-year event
Inflow = 8.10 cfs @ 11.98 hrs, Volume= 0.387 af
Outflow = 4.12 cfs @ 12.07 hrs, Volume= 0.387 af, Atten= 49%, Lag= 5.4 min

Routing by Dyn-Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs
Max. Velocity= 1.82 fps, Min. Travel Time= 19.4 min
Avg. Velocity = 0.45 fps, Avg. Travel Time= 79.3 min

Peak Storage= 4,804 cf @ 12.07 hrs
Average Depth at Peak Storage= 0.46'
Bank-Full Depth= 2.00', Capacity at Bank-Full= 64.55 cfs

4.00' x 2.00' deep channel, n= 0.030
Side Slope Z-value= 2.0 '/' Top Width= 12.00'
Length= 2,120.0' Slope= 0.0050 '/'
Inlet Invert= 441.67', Outlet Invert= 431.07'

Reach T3: Toe 3



Summary for Reach T4: Toe 4

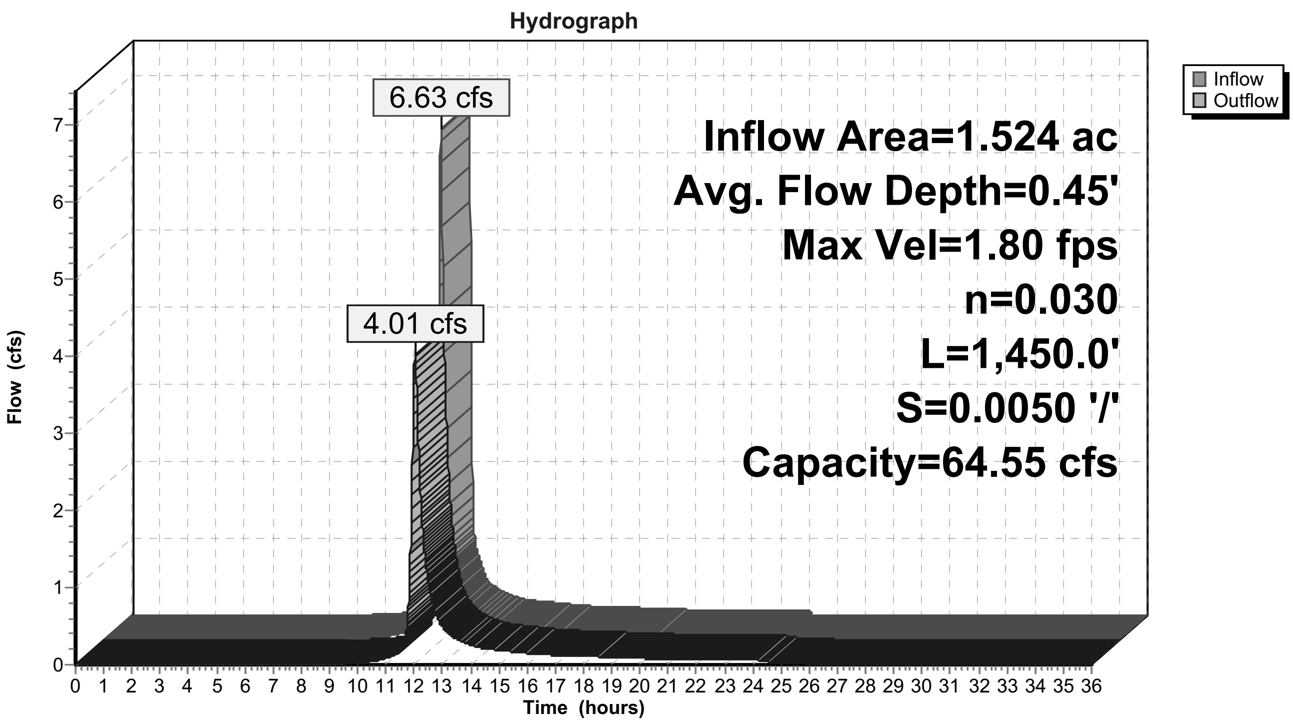
Inflow Area = 1.524 ac, 0.00% Impervious, Inflow Depth = 2.38" for 25-year event
Inflow = 6.63 cfs @ 11.96 hrs, Volume= 0.302 af
Outflow = 4.01 cfs @ 12.03 hrs, Volume= 0.302 af, Atten= 40%, Lag= 4.2 min

Routing by Dyn-Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs
Max. Velocity= 1.80 fps, Min. Travel Time= 13.4 min
Avg. Velocity = 0.42 fps, Avg. Travel Time= 57.9 min

Peak Storage= 3,224 cf @ 12.03 hrs
Average Depth at Peak Storage= 0.45'
Bank-Full Depth= 2.00', Capacity at Bank-Full= 64.55 cfs

4.00' x 2.00' deep channel, n= 0.030
Side Slope Z-value= 2.0 '/' Top Width= 12.00'
Length= 1,450.0' Slope= 0.0050 '/'
Inlet Invert= 438.54', Outlet Invert= 431.29'

Reach T4: Toe 4



Written by:	Jesus Sanchez	Date:	1/12/10	Reviewed by:	Joseph Sura / Ganesh Krishnan	Date:	1/12/10
Client:	Honeywell	Project:	Onondaga Lake SCA Final Design	Project No.:	GJ4299	Task No.:	18

Attachment 7 – Riprap Chute Analysis

Design - Trapezoidal Riprap Chute

Methodology: Robinson et.al 1998

Project: Onandaga Lake SCA

Chute ID: R1A

INPUT PARAMETERS

Peak Discharge, Q_{max} =	32.00	cfs
Bottom Width, B =	10.00	ft
Left Side Slope, Z_1 =	3.00	horizontal :1 vertical
Right Side Slope, Z_2 =	3.00	horizontal :1 vertical
Longitudinal Channel Slope, S_o =	0.0100	ft/ft

ROCK SIZING

Equivalent Unit Discharge, q_t =	3.20	cfs/ft
Median Rock Diameter, D_{50} =	6.00	inches

MANNING'S ROUGHNESS

Calculated Channel Roughness, n =	0.031

NORMAL DEPTH CALCULATIONS - Using Manning's Equation

Depth of Flow Y ft	Area of Flow A ft^2	Wetted Perimeter P ft	Hydraulic Radius R=A/P ft	Average Velocity V ft/s	Discharge (Flow Rate) Q=AV ft^3/s	Avg. Tractive Stress τ_o lb/ft^2	Comments
0.74	9.04	14.68	0.62	3.47	31.38	0.38	DESIGN Q

Design - Trapezoidal Riprap Chute

Methodology: Robinson et.al 1998

Project: Onandaga Lake SCA

Chute ID: R1B

INPUT PARAMETERS

Peak Discharge, Q_{max}=	32.00	cfs
Bottom Width, B =	10.00	ft
Left Side Slope, Z_1 =	3.00	horizontal :1 vertical
Right Side Slope, Z_2 =	3.00	horizontal :1 vertical
Longitudinal Channel Slope, S_o =	0.2125	ft/ft

ROCK SIZING

Equivalent Unit Discharge, q_t =	3.20	cfs/ft
Median Rock Diameter, D_{50} =	6.00	inches

MANNING'S ROUGHNESS

Calculated Channel Roughness, n =	0.049

NORMAL DEPTH CALCULATIONS - Using Manning's Equation

Depth of Flow Y ft	Area of Flow A ft^2	Wetted Perimeter P ft	Hydraulic Radius R=A/P ft	Average Velocity V ft/s	Discharge (Flow Rate) Q=AV ft^3/s	Avg. Tractive Stress τ_o lb/ft^2	Comments
0.40	4.48	12.53	0.36	7.10	31.81	4.74	DESIGN Q

Design - Trapezoidal Riprap Chute

Methodology: Robinson et.al 1998

Project: Onandaga Lake SCA

Chute ID: R2A

INPUT PARAMETERS

Peak Discharge, Q_{max}=	44.00	cfs
Bottom Width, B =	10.00	ft
Left Side Slope, Z_1 =	3.00	horizontal :1 vertical
Right Side Slope, Z_2 =	3.00	horizontal :1 vertical
Longitudinal Channel Slope, S_o =	0.0100	ft/ft

ROCK SIZING

Equivalent Unit Discharge, q_t =	4.40	cfs/ft
Median Rock Diameter, D_{50} =	6.00	inches

MANNING'S ROUGHNESS

Calculated Channel Roughness, n =	0.031

NORMAL DEPTH CALCULATIONS - Using Manning's Equation

Depth of Flow Y ft	Area of Flow A ft^2	Wetted Perimeter P ft	Hydraulic Radius R=A/P ft	Average Velocity V ft/s	Discharge (Flow Rate) Q=AV ft^3/s	Avg. Tractive Stress τ_o lb/ft^2	Comments
0.90	11.43	15.69	0.73	3.88	44.36	0.45	DESIGN Q

Design - Trapezoidal Riprap Chute

Methodology: Robinson et.al 1998

Project: Onandaga Lake SCA

Chute ID: R2B

INPUT PARAMETERS

Peak Discharge, Q_{max}=	44.00	cfs
Bottom Width, B =	10.00	ft
Left Side Slope, Z_1 =	3.00	horizontal :1 vertical
Right Side Slope, Z_2 =	3.00	horizontal :1 vertical
Longitudinal Channel Slope, S_o =	0.2538	ft/ft

ROCK SIZING

Equivalent Unit Discharge, q_t =	4.40	cfs/ft
Median Rock Diameter, D_{50} =	6.00	inches

MANNING'S ROUGHNESS

Calculated Channel Roughness, n =	0.050

NORMAL DEPTH CALCULATIONS - Using Manning's Equation

Depth of Flow Y ft	Area of Flow A ft^2	Wetted Perimeter P ft	Hydraulic Radius R=A/P ft	Average Velocity V ft/s	Discharge (Flow Rate) Q=AV ft^3/s	Avg. Tractive Stress τ_o lb/ft^2	Comments
0.46	5.23	12.91	0.41	8.22	43.04	6.42	DESIGN Q

Design - Trapezoidal Riprap Chute

Methodology: Robinson et.al 1998

Project: Onandaga Lake SCA

Chute ID: R2C

INPUT PARAMETERS

Peak Discharge, Q_{max}=	44.00	cfs
Bottom Width, B =	10.00	ft
Left Side Slope, Z_1 =	3.00	horizontal :1 vertical
Right Side Slope, Z_2 =	3.00	horizontal :1 vertical
Longitudinal Channel Slope, S_o =	0.1000	ft/ft

ROCK SIZING

Equivalent Unit Discharge, q_t =	4.40	cfs/ft
Median Rock Diameter, D_{50} =	6.00	inches

MANNING'S ROUGHNESS

Calculated Channel Roughness, n =	0.044

NORMAL DEPTH CALCULATIONS - Using Manning's Equation

Depth of Flow Y ft	Area of Flow A ft^2	Wetted Perimeter P ft	Hydraulic Radius R=A/P ft	Average Velocity V ft/s	Discharge (Flow Rate) Q=AV ft^3/s	Avg. Tractive Stress τ_o lb/ft^2	Comments
0.56	6.54	13.54	0.48	6.65	43.50	3.01	DESIGN Q