Deep Pine Overlook

Concept Drainage Study

Prepared for:
JRP Land, LLC
(Section 31, T25N, R43E W.M.)

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Sign-off Sheet

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Prepared by _____
(signature)

Zak Sargent, P.E.

Reviewed by _____
(signature)

Alan Gay, P.E.

"The design improvements shown in this set of plans and calculations conform to the Spokane Regional Stormwater Manual adopted by the City of Spokane Public Works Department dated April 2008. All design deviations (if any) have been approved by the City of Spokane. This is a conceptual drainage study, not to be used for construction. These documents have been prepared under my direction as a licensed professional engineer in the State of Washington."

Stantec

Table of Contents

LIST OF TABLES

LIST OF APPENDICES

1.0 INTRODUCTION

The intent of this concept drainage study is to determine the general drainage characteristics of the site in both the existing and proposed conditions to determine whether the proposed development will reasonably comply with the Spokane Regional Stormwater Manual (SRSM). Prior to development and permitting, a full drainage analysis and design study report will be required that fully complies with the SRSM.

Located on an approximately 47.7 acre site, the project entails the creation of a 94 lot planned unit development utilizing only 12.5-acres of the overall site. The project site is located within the City of Spokane directly east of SR 195 and Latah Creek on South Inland Empire Way. (Section 31, T25N, R43E). A Vicinity Map is included in Appendix A for reference.

Is it anticipated that runoff generated by the proposed planned unit development will be collected and channeled to release off-site at or below pre-developed flow rates and volumes. It is expected that swales and pond areas will collect and channel stormwater, performing the required treatment and flow-rate mitigation.

2.0 EXISTING CONDITIONS

Soil types are shown on the Natural Resources Conservation Service (NRCS) soils map for the City of Spokane, Washington, see Appendix C. The soils are primarily in the pre-developed condition; the site is generally composed of open space and is covered with wild grasses and weeds.

The majority of soils within the project boundary are Hardesty silt loam. These soils primary consist of very deep, well-drained soils with moderate to rapid permeability. Based on SRSM (Appendix C), these soils are mostly characterized as Type B soils; curve numbers were chosen accordingly.

Adjacent to the project boundary is a steep slope rising approximately 480-feet from the flat plain area of the site. This slope is mainly composed of Springdale gravelly loamy sand. This soil type consists primarily of very deep, excessively drained soils with moderately rapid permeability. Based on SRSM (Appendix C), these soils are mostly characterized as Type A soils; curve numbers were chosen accordingly. The slope has moderate ground cover of trees, small bushes, and weeds.

Final design will incorporate field-gathered geotechnical data, and swale sizing will be altered as necessary to accommodate measured infiltration rates.

3.0 PRE-DEVELOPMENT DRAINAGE

In the pre-developed condition, most of the project area is covered with grasses and weeds. There are several small existing residential type structures on the site, which will be removed. Runoff from the site currently flows overland to the west/northwest to Latah Creek. Offsite runoff from the adjacent hillside flows across the site, also to Latah Creek. The existing site has one drainage basin, plus an offsite hillside component which can be seen in the basin map found in Appendix B, Figure PRE.

4.0 POST-DEVELOPMENT DRAINAGE

The proposed site conditions will create two (2) new drainage basins, which can be seen in the proposed basin map found in Appendix B, as figure POST. The impervious area will include asphalt paved roadways, pathways, residential structures, and driveways. Pervious areas will consist mainly of lawns and landscaped areas.

Runoff generated by the project will be routed via grading to drainage swales located adjacent to the roadways. All runoff will be channeled via these swales, with culverts at roadway crossings, and released to the west-northwest into Latah Creek. Release to Latah Creek will occur at or below existing rates and volumes, necessitating the use of grassy lined swale areas for storage and treatment prior to release.

Offsite flow will be channeled around structures on the eastern lots via grading along the property lines. This runoff will be collected in the conveyance swale system and routed to Latah Creek and allowed to release.

The following is a summary description of the Proposed Drainage Basin Area:

4.1 DRAINAGE AREA 1 (DA-1)

DA-1 is roughly the northern 5.3 acres of the developed site. The basin will contain approximately 37 lots, 950-feet of roadway, 1,100-feet of pathway and a cul-de-sac with additional parking. The easternmost lots will be located along the large hillside with housing units positional outside the 15' toe of slope setback limits. These lots will be graded to channel off-site stormwater to the property lines. This will then be channeled into the proposed conveyance system toward Swale 1 positioned behind Lots 14 and 15. The outflow will be dissipated using a rip-rap channel which will both slow and spread flow.

4.2 DRAINAGE AREA 2 (DA-2)

DA-2 is roughly the southern 7.2 acres of the site. The basin will contain approximately 57 lots, 1,800-feet of roadway, 2,800-feet of pathways, and a turn-around on the southeast end of the site. The easternmost lots will be located along the large hillside with housing units positioned outside the 15' setback. These lots will also be graded to channel off-site stormwater to the property lines. This will then be channeled into the proposed conveyance swales. The swales will route stormwater to the west then north to a discharge point approximately between lots 11 and 12 and collected in Swale 2. The outflow will be dissipated using a rip-rap channel which will both slow and spread flow.

5.0 SUMMARY OF STORMWATER CALCULATIONS

5.1 RUNOFF CONTROL

Runoff was analyzed using the SCS Curve Number Method as described in Spokane County Regional Stormwater Manual, Section 5.3 Curve Number Method. The drainage area was modeled using Hydraflow Hydrograph software by Autodesk to determine site runoff and storage requirements, based on a 25-year return frequency. The software has the capability to model conditions using the SCS Method. Concept calculation reports of pre and post-developed conditions are included Appendix D.

To determine basin runoff using the Curve Number Method, event rainfall data was taken from the manual's corresponding Isopluvial maps. A weighted curve number (CN) was calculated for each of the pre and post-developed basins using the various surface types within the drainage areas (DA). Off-site runoff was calculated for the pre-developed case and routed through both the pre and post-developed basins.

Table 1 is a tabular summary of these calculations.

Table 1: Drainage Area Summary Calculations

Drainage Area Number	Time of Concentration, T_c (min)	25-year Rainfall (in)	Weighted Curve Number (CN)	Contributing Area (ac)	Peak Runoff, Q_{25YR} (cfs)	Peak Runoff Volume, V_{25YR} (cf)
Hillside	15.8	2.0	70	21.6	3.61	17,686
PRE	65.4	2.0	77	12.5	2.27	20,695
Hillside to DA-1	15.8*	2.0	70	11.5	1.80	8,802
DA-1	61.6	2.0	78	5.3	1.07	9,486

Hillside to DA-2	15.8*	2.0	70	10.0	1.80	8,802
DA-2	49.0	2.0	77	7.2	1.68	11,418

*To simplify the calculations, offsite flow and volume was split between the two proposed basins using Hydraflow.

Based on the calculations, flow rates of 5.88 cfs and 6.35 cfs are generated in pre and post-developed conditions, respectively. This will be due to the addition of lawn and landscaped areas and swale routing leading to increased Tc values. Flow for the offsite hillside area will remain the same, but will be routed through the two proposed basins and allowed to release to the creek. There is additional volume generated based on increased impervious areas. This difference in volume will be retained and infiltrated and Swales 1 and 2 were sized to adequately handle runoff volumes up to a 25-year storm event. The required storage volumes for all drainage swales are laid out in Table 2 below.

Table 2: Storage Summary

ID	Contributing Drainage Areas	25-yr Retention Storage Volume (cf)	Runoff Storage Volume Provided (cf)	Flow Released, Q_{25YR} (cfs)	Allowed Release (combined), Q_{25YR} (cfs)	Meets Criteria?
Swale 1	DA-1	4,161	4,959	1.416	5.88	Yes
Swale 2	DA-2	6,516	6,549	1.419		Yes

5.2 RUNOFF TREATMENT

Treatment is required for runoff generated by pavement area. Biofiltration swales are designed to remove low concentrations of total suspended solids (TSS), heavy metals, petroleum hydrocarbons, and various nutrients from stormwater runoff. The runoff requiring treatment for the roadway and driveways will be routed via the conveyance swales to treatment facilities prior to discharge.

Preliminary sizing of the treatment swales was done in accordance with SRSM *Chapter 6, Water Quality Treatment Design*. This chapter provides two equations for calculating the required treatment volume. The majority of site soils are Type B Hardesty silt loam and as described in SRSM (Appendix C) have moderate rates of water transmission (0.15 – 0.30 in/hr). Based on the assumed infiltration rates, the following equation must be used to determine the amount of treatment required for impervious area.

$V = 1815A$ (Equation 6-1d)

V = Required volume of biofiltration swale (cubic feet)

A = Area of impervious area requiring treatment (acres)

Based on this equation, Table 3 shows the required treatment volumes for the roadways, driveways, and cul-de-sacs.

Table 3: Swale Treatment

ID	Contributing Drainage Areas	Total Impervious Area (ac)	Required Treatment Volume (cf)	Volume Provided (cf)	Meets Criteria?
Swale 1	DA-1	1.21	2,196	4,959	Yes
Swale 2	DA-2	1.79	3,249	6,549	Yes

6.0 EROSION CONTROL CONSIDERATIONS

The Contractor is responsible for insuring the use of proper erosion control and shall maintain such measures throughout construction, until all pertinent landscaping and permanent erosion control measures (i.e. grassed areas, paved surfaces) have been established. Maintenance shall include daily inspections and repair of the silt fencing, hay bales, or other. The Contractor will also inspect all erosion control measures following each storm water event during construction or until the permanent measures are established.

The Contractor shall include an erosion/sedimentation control plan providing suitable measures to prevent sediment laden runoff from leaving the site or impacting roadway or drainage systems. It shall be the responsibility of the owner/developer to implement and maintain suitable and effective erosion/sedimentation control systems. A construction entrance will be required in order to clean the tires of trucks and vehicles exiting the construction area.

Periodically, the temporary erosion control measures must be cleaned of debris and siltation. The contractor shall dispose of the materials so as not to damage any reclaimed areas or create other erosion problem areas. Upon direction by the City of Spokane, Owner or Engineer, the Contractor may also be required to clean roadways of siltation or other debris, which may occur along construction entrances.

7.0 MAINTENANCE

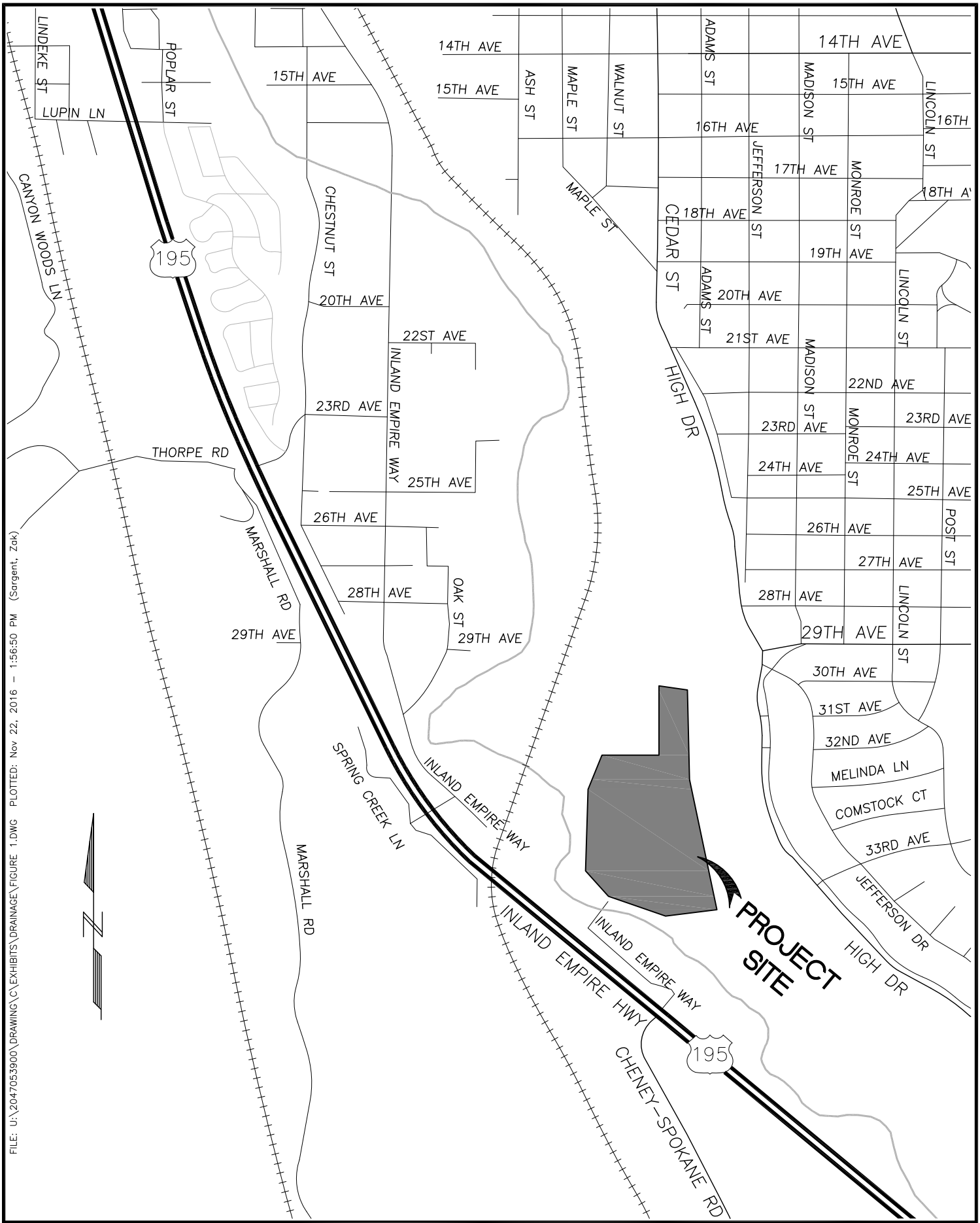
The maintenance and operation of the drainage facilities is the responsibility of the property owner(s). Periodic maintenance is important and is anticipated in order to ensure drainage facilities remain silt and dirt-free.

The Contractor(s) will be responsible for the proper installation and maintenance of all temporary erosion control measures necessary to protect down-gradient areas from siltation during construction. The Contractor shall also protect against siltation of any storm drainage structures down gradient from the site throughout construction. It is the property-owner(s)' responsibility to maintain drainage areas and parking facilities once construction has been completed.

8.0 SUMMARY AND CONCLUSIONS

The stormwater runoff generated in the proposed condition will be collected and routed in roadside swales and conveyed to detention basins for treatment prior to release. Release will occur at or below pre-developed flow rates and volumes, based on the submitted calculations. Grading provisions will be made to route the offsite basin through the site for release. Based on the findings provided in this concept drainage study, the proposed development will reasonably comply with the Spokane Regional Stormwater Manual (SRSM).

Appendix A VICINITY MAP



FILE: U:\2047053900\DRAWING\C\EXHIBITS\DRAINAGE\FIGURE 1.DWG PLOTTED: Nov 22, 2016 – 1:56:50 PM (Sargent, Zak)

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LATAH CREEK PRE-PLAT

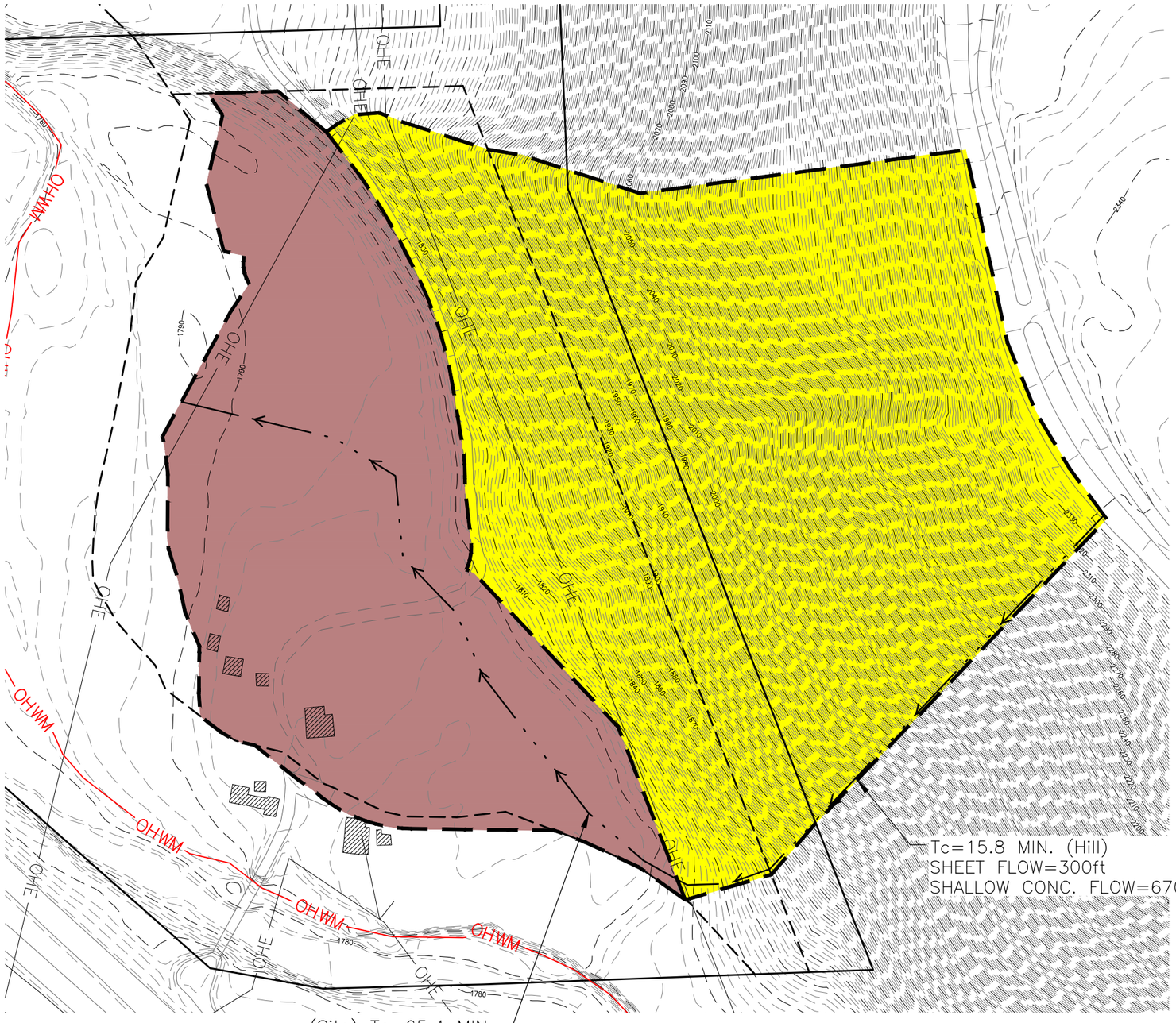
City of Spokane, Washington

JRP LAND, LLC

Date	10/30/16
Drawn	ZCS
Checked	AEG
W.O.	2047053900

Sheet
Fig1

Appendix B DRAINAGE BASIN MAPS



Tc=15.8 MIN. (Hill)
SHEET FLOW=300ft
SHALLOW CONC. FLOW=670ft

(Site) Tc=65.4 MIN.
SHEET FLOW=300ft
SHALLOW CONC. FLOW=930ft
CHANNEL FLOW=N/A

LEGEND

EXISTING SITE AREA
544,412 SF
(12.5 AC)

OFFSITE HILLSIDE AREA
939,640 SF
(21.6 AC)

TIME OF CONCENTRATION

N

0 200' 400'

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LATAH CREEK PRE-PLAT
Pre-Development Basin Map
Spokane, Washington

John Pilcher

Date 9/22/16
Drawn ZCS
Checked AEG
W.O. 2047053900

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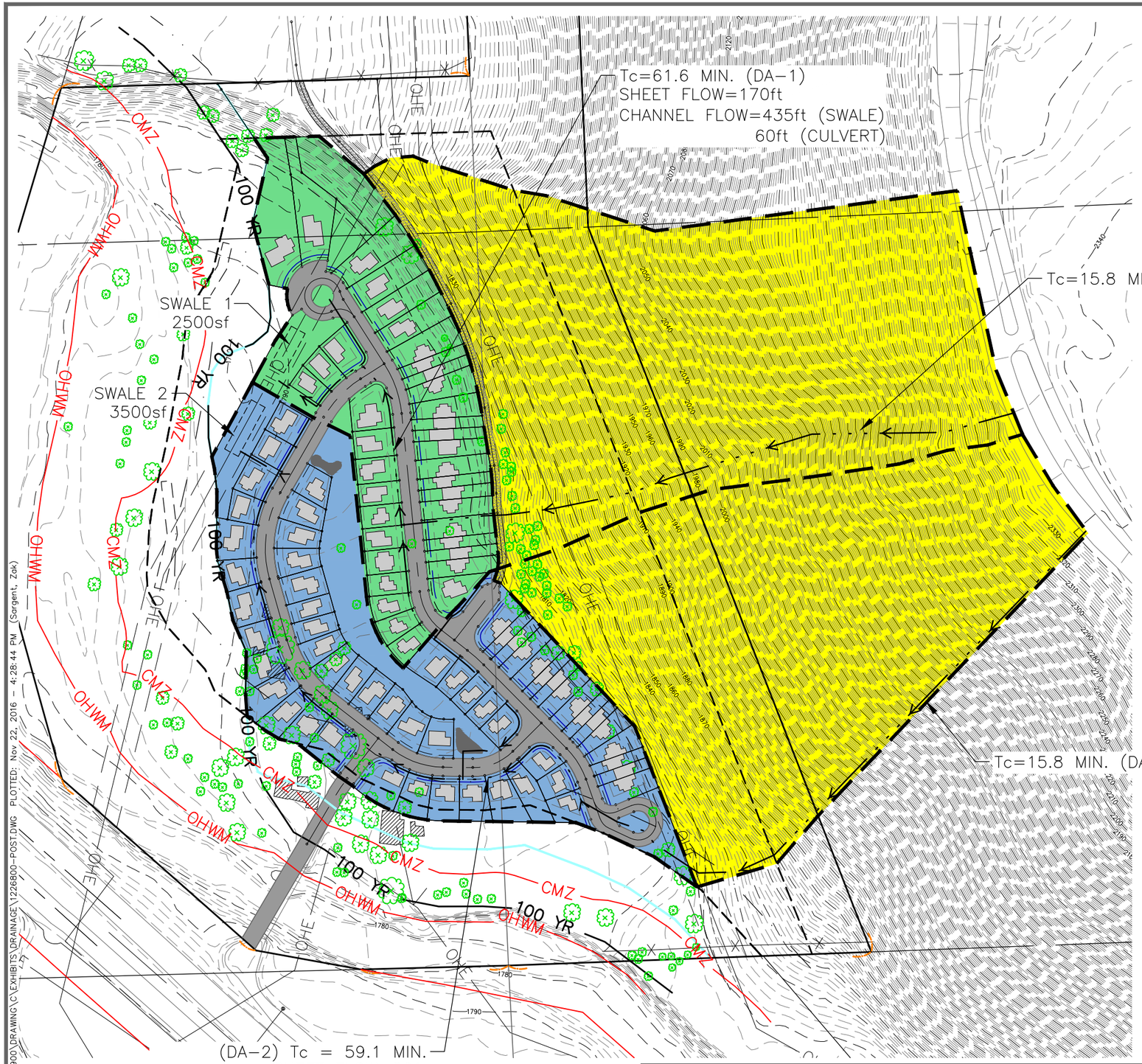
PRE



LEGEND

- DA-1 (A=5.3 AC)
- DA-1 HILLSIDE (A=11.5 AC)
- DA-2 (A=7.2 AC)
- DA-2 HILLSIDE (A=10.0 AC)
- TIME OF CONCENTRATION (PROBABLE FLOW PATH)

N

0 200' 400'

FILE: U:\2047053900\DRAWING\C\EXHIBITS\DRAINAGE\226800-POST.DWG PLOTTED: Nov 22, 2016 - 4:28:44 PM (Sargent, Zak)

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LATAH CREEK PRE-PLAT
Post Development Basin Map
Spokane, Washington

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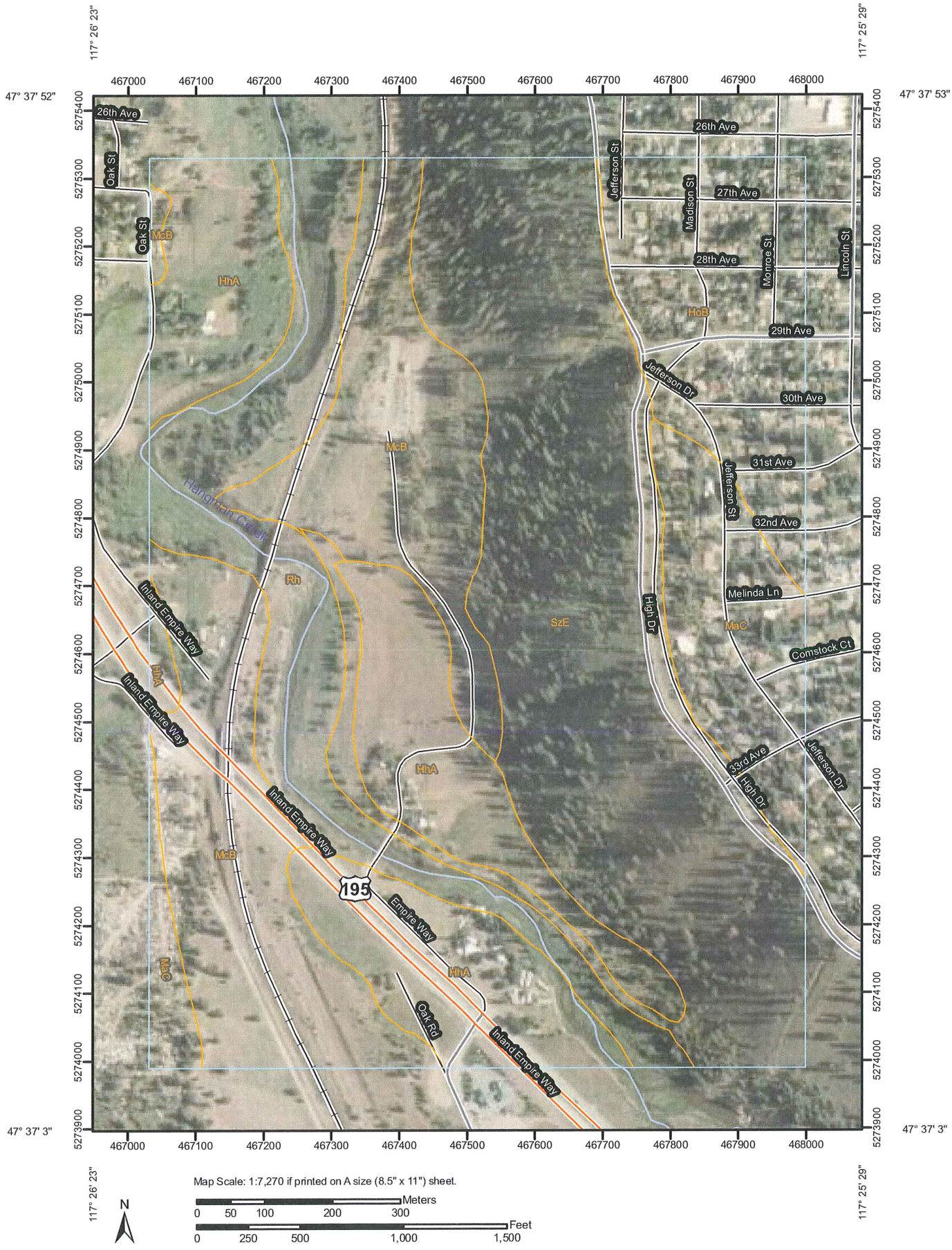
POST

Appendix C SCS AND OTHER SOILS INFORMATION

APPLICABLE SPOKANE REGIONAL STORMWATER MANUAL DOCUMENTS


117° 26' 23"
117° 25' 29"
47° 37' 52"
47° 37' 53"
47° 37' 3"
467000
467100
467200
467300
467400
467500
467600
467700
467800
467900
468000
5275400
5275300
5275200
5275100
5275000
5274900
5274800
5274700
5274600
5274500
5274400
5274300
5274200
5274100
5274000
5273900
26th Ave
Oak St
McB
HhA
Hangman Creek
Rh
Inland Empire Way
SzE
High Dr
MaC
Comstock Ct
Melinda Ln
33rd Ave
Jefferson Dr
Empire Way
195
Oak Rd
27th Ave
Madison St
28th Ave
Monroe St
Lincoln St
HoB
29th Ave
30th Ave
31st Ave
Jefferson St
32nd Ave
Map Scale: 1:7,270 if printed on A size (8.5" x 11") sheet.
N
Meters
0 50 100 200 300
Feet
0 250 500 1,000 1,500

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Units

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other

Special Line Features
- Gully
- Short Steep Slope
- Other

Political Features
- Cities

Water Features
- Oceans
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

MAP INFORMATION

Map Scale: 1:7,270 if printed on A size (8.5" × 11") sheet.

The soil surveys that comprise your AOI were mapped at 1:20,000.

Please rely on the bar scale on each map sheet for accurate map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 11N NAD83

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Spokane County, Washington
Survey Area Data: Version 2, Jun 9, 2009

Date(s) aerial images were photographed: 6/27/2006

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Spokane County, Washington (WA063)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
HhA	Hardesty silt loam, 0 to 5 percent slopes	58.2	18.1%
HoB	Hesseltine silt loam, moderatley deep, 0 to 8 percent slopes	32.0	10.0%
MaC	Marble loamy sand, 0 to 30 percent slopes	25.6	8.0%
McB	Marble variant sandy loam, 0 to 8 percent slopes	68.6	21.4%
Rh	Riverwash	39.2	12.2%
SzE	Springdale gravelly loamy sand, 30 to 70 percent slopes	97.0	30.3%
Totals for Area of Interest		**320.5**	**100.0%**

APPENDIX 5E - HYDROLOGIC SOIL SERIES FOR WASHINGTON STATE

Soil Type	Hydrologic Soil Group	Soil Type	Hydrologic Soil Group
Agnew	C	Dimal	D
Ahl	B	Dragoon	C
Aits	C	Dupont	D
Alderwood	C	Earlmont	C
Arents, Alderwood	B	Edgewick	C
Arents, Everett	B	Eld	B
Ashoe	B	Eloika	B
Athena	B	Elwell	B
Baldhill	B	Emdent	D
Barneston	C	Esquatzel	B
Baumgard	B	Everett	A
Beausite	B	Everson	D
Belfast	C	Freeman	C
Bellingham	D	Galvin	D
Bellingham variant	C	Garfield	C
Bernhill	B	Garrison	B
Boistfort	B	Getchell	A
Bong	A	Giles	B
Bonner	B	Glenrose	B
Bow	D	Godfrey	D
Brickel	C	Green Bluff	B
Bridgeson	D	Greenwater	A
Briscot	D	Grove	C
Buckley	C	Hagen	B
Bunker	B	Hardesty	B
Cagey	C	Harstine	C
Caldwell	C	Hartnit	C
Carlsborg	A	Hesseltine	B
Casey	D	Hoh	B
Cassolary	C	Hoko	C
Cathcart	B	Hoodsport	C
Cedonia	B	Hoogdal	C
Centralia	B	Hoypus	A
Chehalis	B	Huel	A
Cheney	B	Indianola	A
Chesaw	A	Jonas	B
Cinebar	B	Jumpe	B
Clallam	C	Kalaloch	C
Clayton	B	Kapowsin	C/D
Coastal beaches	variable	Katula	C
Cocolalla	D	Kilchis	C
Colter	C	Kitsap	C
Custer	D	Klaus	C
Custer, Drained	C	Klone	B
Dabob	C	Konner	D

Soil Type	Hydrologic Soil Group	Soil Type	Hydrologic Soil Group
Dearyton	C	Lakesol	B
Delphi	D	Laketon	C
Dick	A	Lance	B
Larkin	B	Poulsbo	C
Latah	D	Prather	C
Lates	C	Puget	D
Lebam	B	Puyallup	B
Lummi	D	Queets	B
Lynnwood	A	Quilcene	C
Lystair	B	Ragnar	B
Mal	C	Rainier	C
Manley	B	Raught	B
Marble	A	Reardan	C
Mashel	B	Reed	D
Maytown	C	Reed, Drained or Protected	C
McKenna	D	Renton	D
McMurray	D	Republic	B
Melbourne	B	Riverwash	variable
Menzel	B	Rober	C
Mixed Alluvial	variable	Salal	C
Molson	B	Salkum	B
Mondovi	B	Sammamish	D
Moscow	C	San Juan	A
Mukilteo	C/D	Scamman	D
Naff	B	Schneider	B
Narcisse	C	Schumacher	B
Nargar	A	Seattle	D
National	B	Sekiu	D
Neilton	A	Semiahmoo	D
Newberg	B	Shalcar	D
Nez Perce	C	Shano	B
Nisqually	B	Shelton	C
Nooksack	C	Si	C
Norma	C/D	Sinclair	C
Ogarty	C	Skipopa	D
Olete	C	Skykomish	B
Olomount	C	Snahopish	B
Olympic	B	Snohomish	D
Orcas	D	Snow	B
Oridia	D	Solduc	B
Orting	D	Solleks	C
Oso	C	Spana	D
Ovall	C	Spanaway	A/B
Palouse	B	Speigle	B
Pastik	C	Spokane	C
Peone	D	Springdale	A
Pheeney	C	Sulsavar	B
Phelan	D	Sultan	C
Phoebe	B	Sultan variant	B
Pilchuck	C	Sumas	C
Potchub	C	Swantown	D
Tacoma	D	Vailton	B

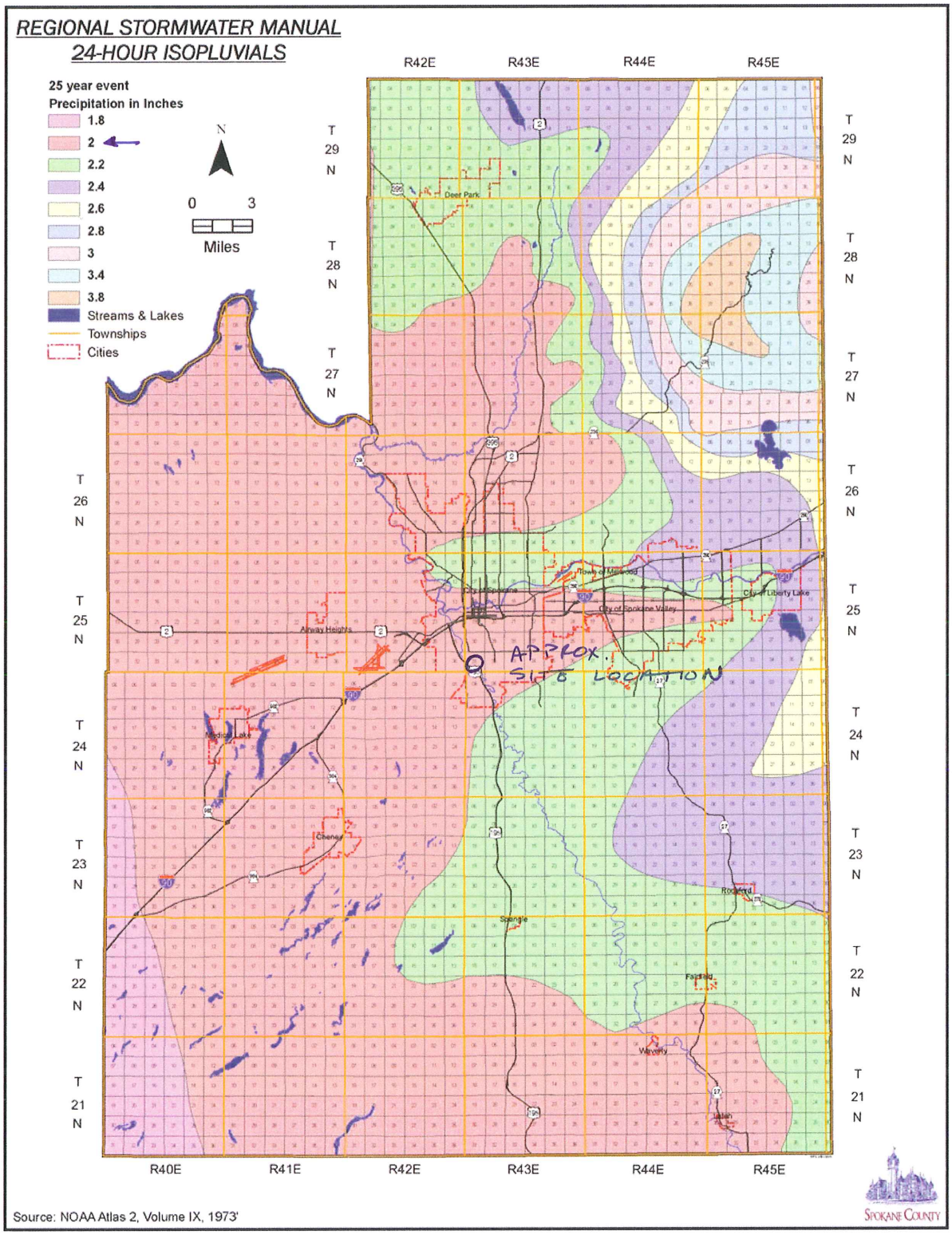


Figure 5-3 – 25-Year, 24-Hour Isopluvial Map

TABLE 5-4
SUGGESTED VALUES OF MANNING'S ROUGHNESS COEFFICIENT "*n*" FOR CHANNEL FLOW

Type of Channel and Description	"*n*"[1]	Type of Channel and Description	"*n*"[1]
A. CONSTRUCTED CHANNELS		7. Very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush	0.100
a. Earth, straight and uniform			
1. Clean, recently completed	0.018		
2. Gravel, uniform selection, clean	0.025	*b. Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stages*	
3. With short grass, few weeds	0.027		
b. Earth, winding and sluggish			
1. No vegetation	0.025	1. Bottom: gravel, cobbles and few boulders	0.040
2. Grass, some weeds	0.030		
3. Dense weeds or aquatic plants in deep channels	0.035	2. Bottom: cobbles with large boulders	0.050
4. Earth bottom and rubble sides	0.030	**B-2 Floodplains**	
5. Stony bottom and weedy banks	0.035	*a. Pasture, no brush*	
6. Cobble bottom and clean sides	0.040	1. Short grass	0.030
c. Rock lined		2. High grass	0.035
1. Smooth and uniform	0.035	*b. Cultivated areas*	
2. Jagged and irregular	0.040	1. No crop	0.030
d. Channels not maintained, weeds and brush uncut		2. Mature row crops	0.035
1. Dense weeds, high as flow depth	0.080	3. Mature field crops	0.040
2. Clean bottom, brush on sides	0.050	*c. Brush*	
3. Same, highest stage of flow	0.070	1. Scattered brush, heavy weeds	0.050
4. Dense brush, high stage	0.100	2. Light brush and trees	0.060
B. NATURAL STREAMS		3. Medium to dense brush	0.070
B-1 Minor streams (top width at flood stage < 100		4. Heavy, dense brush	0.100
a. Streams on plain		*d. Trees*	
1. Clean, straight, full stage, no rifts or deep pools	0.030	1. Dense willows, straight	0.150
2. Same as No. 1, but more stones and weeds	0.035	2. Cleared land with tree stumps, no sprouts	0.040
3. Clean, winding, some pools and shoals	0.040	3. Same as No. 2, but with heavy growth of sprouts	0.060
4. Same as No. 3, but some weeds	0.045	4. Heavy stand of timber, a few down trees, little undergrowth, flood stage below branches	0.100
5. Same as No. 4, but more stones	0.050		
6. Sluggish reaches, weedy deep pools	0.070	5. Same as above, but with flood stage reaching branches	0.120

[1] The "n" values presented in this table are the "Normal" values as presented in Chow (1959). For an extensive range and for additional values refer to Chow (1959)

Source: WSDOT Hyway Runoff Manual (2004) Table 4B-6; Engman (1983) and the Florida Department of Transportation Drainage Manual (1986).

TABLE 5-1
RUNOFF CURVE NUMBERS
ANTECEDENT RUNOFF CONDITION (ARC) II

Cover type and hydrologic condition	Group A Soils	Group B Soils	Group C Soils	Group D Soils
Open Space (lawns, parks, golf courses, cemeteries, landscaping, etc.): [1]				
Poor condition (grass cover <50% of the area)	68	79	86	89
Fair condition (grass cover on 50% to 75% of the area)	49	69	79	84
Good condition (grass cover on >75% of the area)	39	61	74	80
Impervious Areas:				
Open water bodies: lakes, wetlands, ponds etc.	100	100	100	100
Paved parking lots, roofs, driveways, etc. (excluding right of way)	98	98	98	98
Porous pavers and permeable interlocking concrete (assumed as 85% impervious and 15% lawn):				
Fair lawn condition (weighted average CNs)	91	94	96	97
Gravel	76	85	89	91
Dirt	72	82	87	89
Pasture, Grassland, or Range-Continuous Forage for Grazing:				
Poor condition (ground cover <50% or heavily grazed with no mulch).	68	79	86	89
Fair condition (ground cover 50% to 75% and not heavily grazed)	49	69	79	84
Good condition (ground cover >75% and lightly or only occasionally grazed)	39	61	74	80
Cultivated Agricultural Lands:				
Row Crops (good) e.g. corn, sugar beets, soy beans	64	75	82	85
Small Grain (good) e.g. wheat, barley, flax	60	72	80	84
Meadow (continuous grass, protected from grazing and generally mowed for hay)	30	58	71	78
Brush (brush-weed-grass mixture with brush the major element):				
Poor (<50% ground cover)	48	67	77	83
Fair (50% to 75% ground cover)	35	56	70	77
Good (>75% ground cover)[2]	30	48	65	73
Woods - grass combination (orchard or tree farm)[3]:				
Poor	57	73	82	86
Fair	43	65	76	82
Good	32	58	72	79
Woods:				
Poor (Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning)	45	66	77	83
Fair (Woods are grazed but not burned, and some forest litter covers the soil)	36	60	73	79
Good (Woods are protected from grazing, and litter and brush adequately cover the soil)	30	55	70	77
Herbaceous (mixture of grass, weeds, and low-growing brush, with brush the minor element)[4]:				
Poor (<30% ground cover)		80	87	93
Fair (30% to 70% ground cover)		71	81	89
Good (>70% ground cover)		62	74	85
Sagebrush with Grass Understory[4]:				
Poor (<30% ground cover)		67	80	85
Fair (30% to 70% ground cover)		51	63	70
Good (>70% ground cover)		35	47	55

[1] Composite CNs may be computed for other combinations of open space cover type.
[2] Actual curve number is less than 30; use CN = 30 for runoff computations.
[3] CNs shown were computed for areas with 50% woods and 50% grass (pasture) cover. Other combinations of conditions may be computed from the CNs for woods and pasture.
[4] Curve numbers have not been developed for group A soils.

For a more detailed and complete description of land use curve numbers refer to Chapter 2 of the Soil Conservation Service's Technical Release No. 55 (Publication 210-VI-TR-55, Second Ed., June 1986).

flow control design storm event (refer to Section 2.2.4). If a bio-infiltration facility will also be used as a detention facility, refer to Section 7.3.2 for additional information.

Bio-Infiltration Swale Design

Bio-infiltration swales shall be sized using either Equation 6-1a or 6-1b. These equations estimate the volume required to treat stormwater runoff and were developed using the Alternate Hydrograph Method found in the *Stormwater Management Manual for Eastern Washington.*

$$V = 1133AP^{1.53} \quad (6\text{-}1a)$$

$$V = 1815AP^{1.53} \quad (6\text{-}1b)$$

Where: V = volume of bio-infiltration swale (cubic feet);

A = hydraulically connected impervious area to be treated (acres); and,

P = precipitation amount for the 6-month NRCS Type II 24 hour water quality design storm.

P shall be 1 inch for the all of the Spokane region, therefore the above equations can be simplified as follows:

$$V = 1133A \quad (6\text{-}1c)$$

$$V = 1815A \quad (6\text{-}1d)$$

Equations 6-1a and 6-1c can only be used when the following requirements are met, otherwise, Equations 6-1b and 6-1d shall be used:

- The subgrade soils have less than 12% fines; and,
- The subgrade soils have an infiltration rate greater than 0.15 in/hr.

Appendix 6A provides an example calculation for bioinfiltration swales.

Bio-Infiltration Swale Minimum Requirements

Bio-infiltration facilities shall meet the minimum requirements for limiting layers, setbacks, slopes, embankments, planting, and general requirements specified in Sections 7.5.2 and 7.8. In addition, the design of bio-infiltration swales shall conform to the requirements described below.

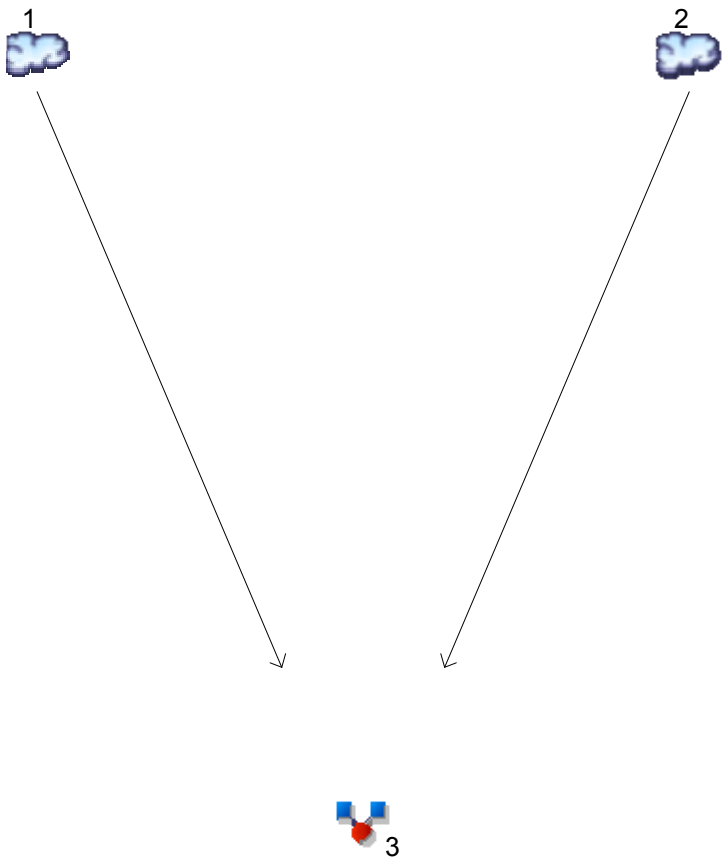
Treatment Design Depth and Soil Criteria: Bio-infiltration swales shall fully contain the design treatment volume with a maximum treatment design depth (from the swale

Appendix D HYDRAFLOW HYDROGRAPH REPORTS

Hydraflow Table of Contents

Watershed Model Schematic

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2014 by Autodesk, Inc. v10.3



Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2014 by Autodesk, Inc. v10.3

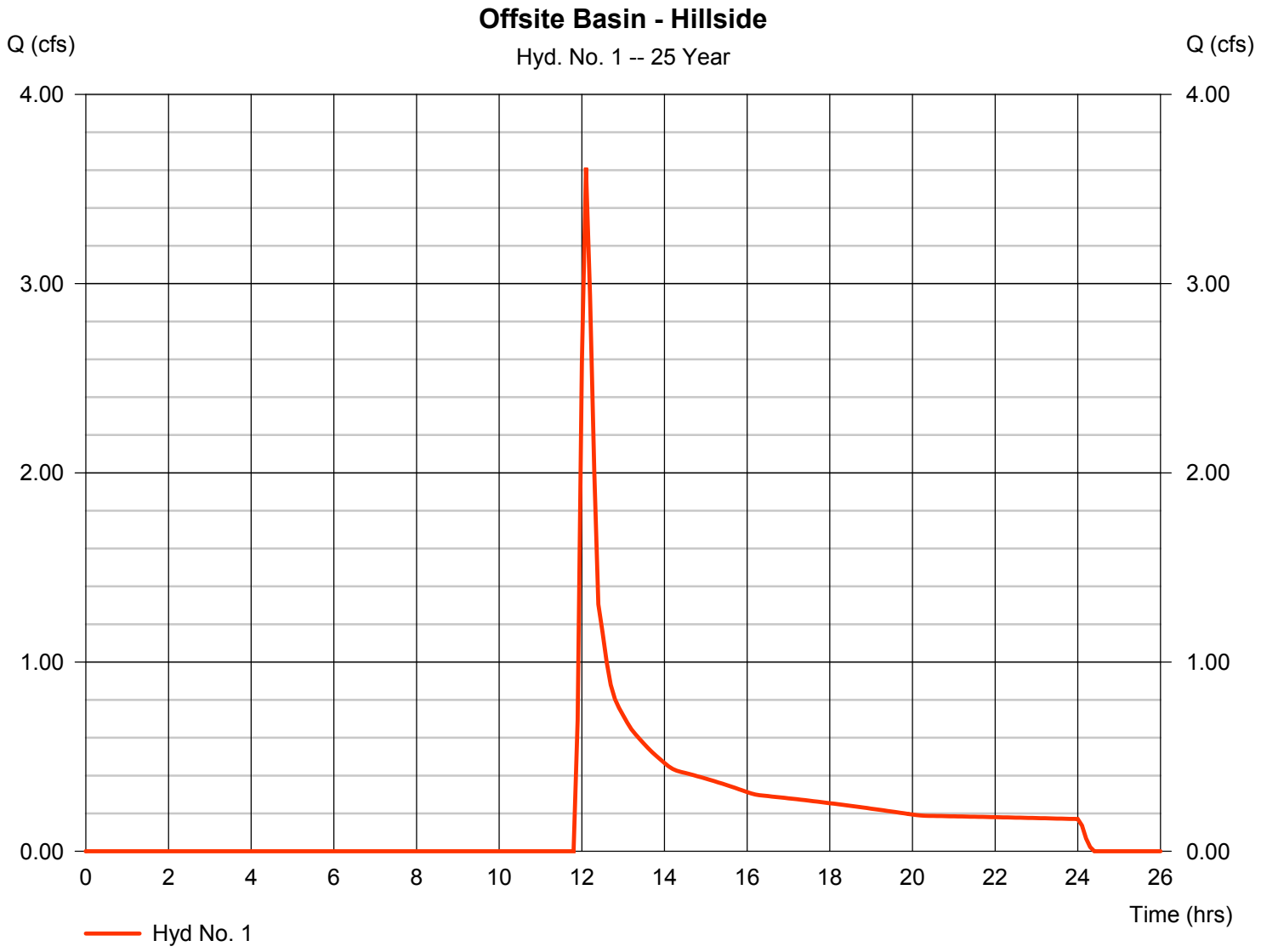
Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph Description
1	SCS Runoff	3.612	6	726	17,686	------	------	------	Offsite Basin - Hillside
2	SCS Runoff	2.268	6	756	20,695	------	------	------	Existing Site
3	Combine	4.396	6	726	38,380	1, 2	------	------	Combined Release to Creek

Hydrograph Report

Hyd. No. 1

Offsite Basin - Hillside

Hydrograph type	= SCS Runoff	Peak discharge	= 3.612 cfs
Storm frequency	= 25 yrs	Time to peak	= 12.10 hrs
Time interval	= 6 min	Hyd. volume	= 17,686 cuft
Drainage area	= 21.600 ac	Curve number	= 70
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 15.80 min
Total precip.	= 2.00 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

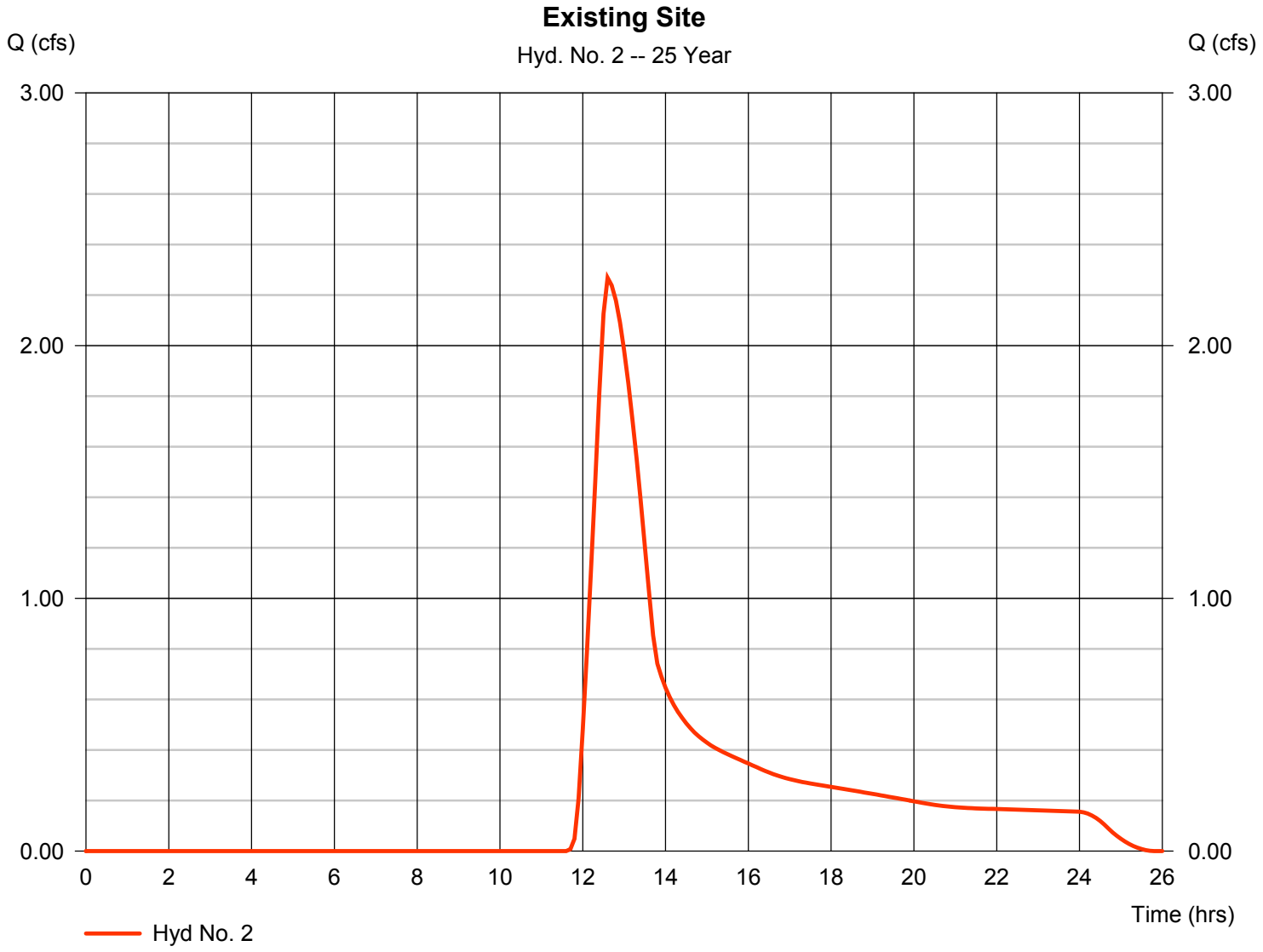


Hydrograph Report

Hyd. No. 2

Existing Site

Hydrograph type	= SCS Runoff	Peak discharge	= 2.268 cfs
Storm frequency	= 25 yrs	Time to peak	= 12.60 hrs
Time interval	= 6 min	Hyd. volume	= 20,695 cuft
Drainage area	= 12.500 ac	Curve number	= 77
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 65.40 min
Total precip.	= 2.00 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

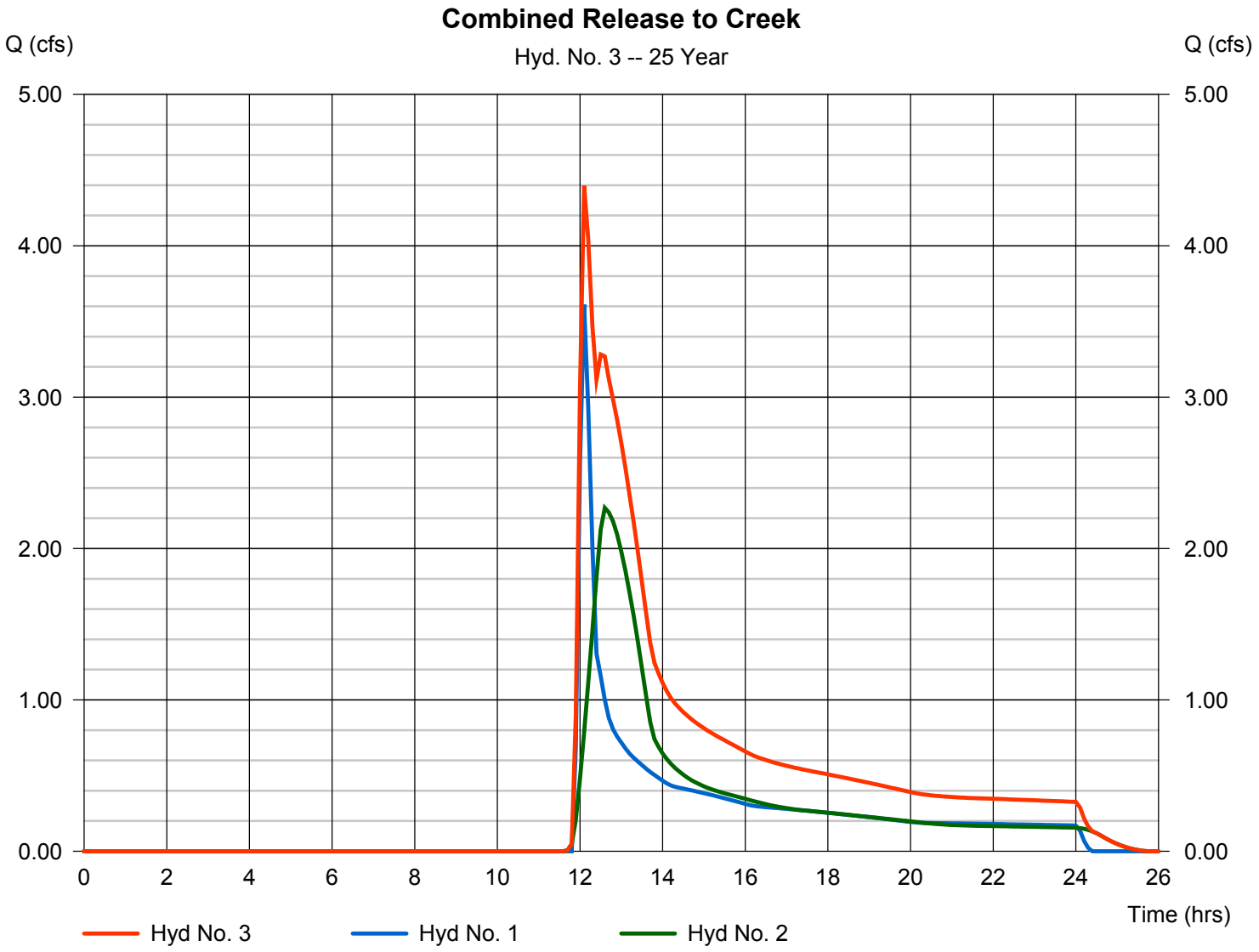


Hydrograph Report

Hyd. No. 3

Combined Release to Creek

Hydrograph type	= Combine	Peak discharge	= 4.396 cfs
Storm frequency	= 25 yrs	Time to peak	= 12.10 hrs
Time interval	= 6 min	Hyd. volume	= 38,380 cuft
Inflow hyds.	= 1, 2	Contrib. drain. area	= 34.100 ac

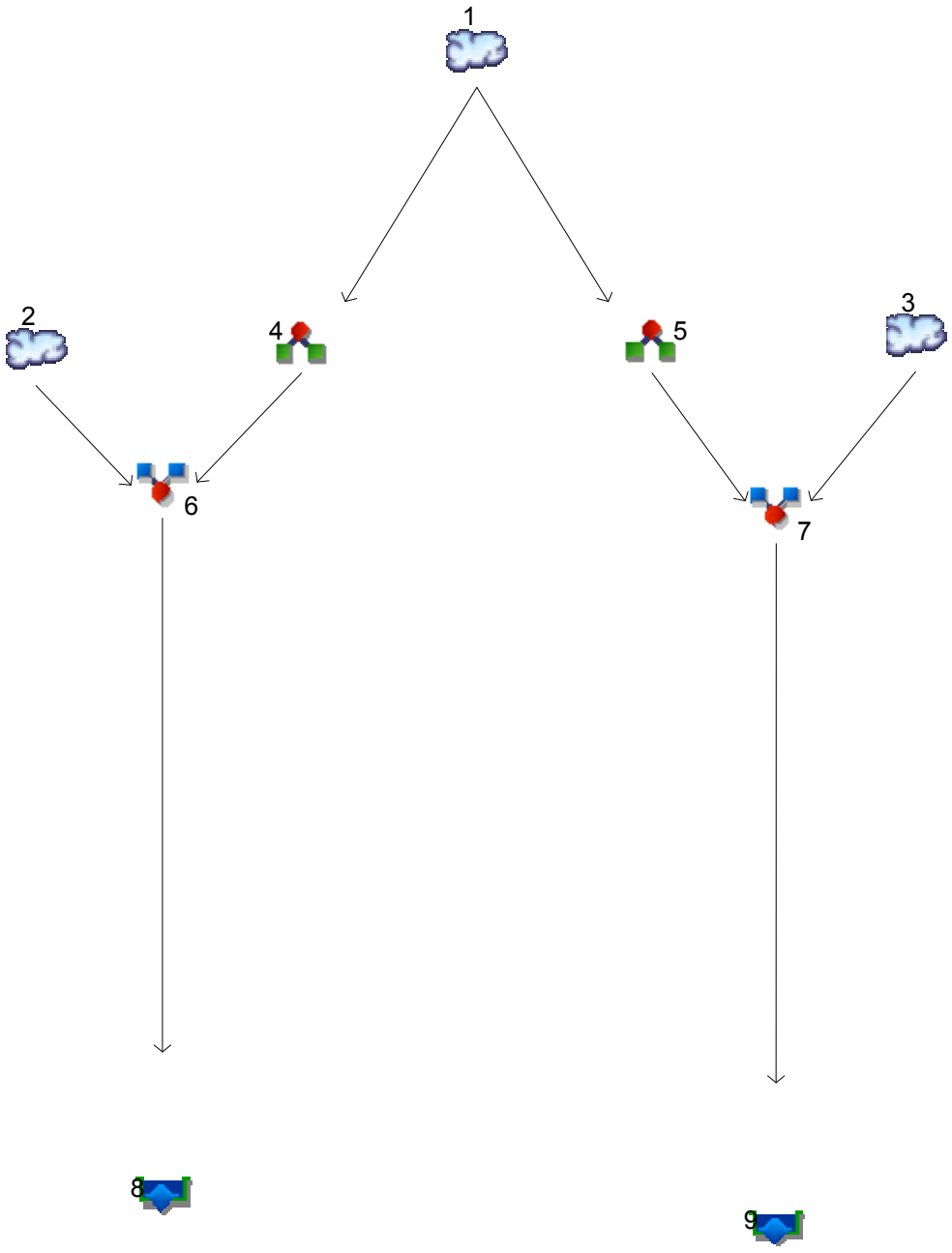


Hydraflow Table of Contents

Concept Prop_new(09-30).gpw

Watershed Model Schematic

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2014 by Autodesk, Inc. v10.3



Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2014 by Autodesk, Inc. v10.3

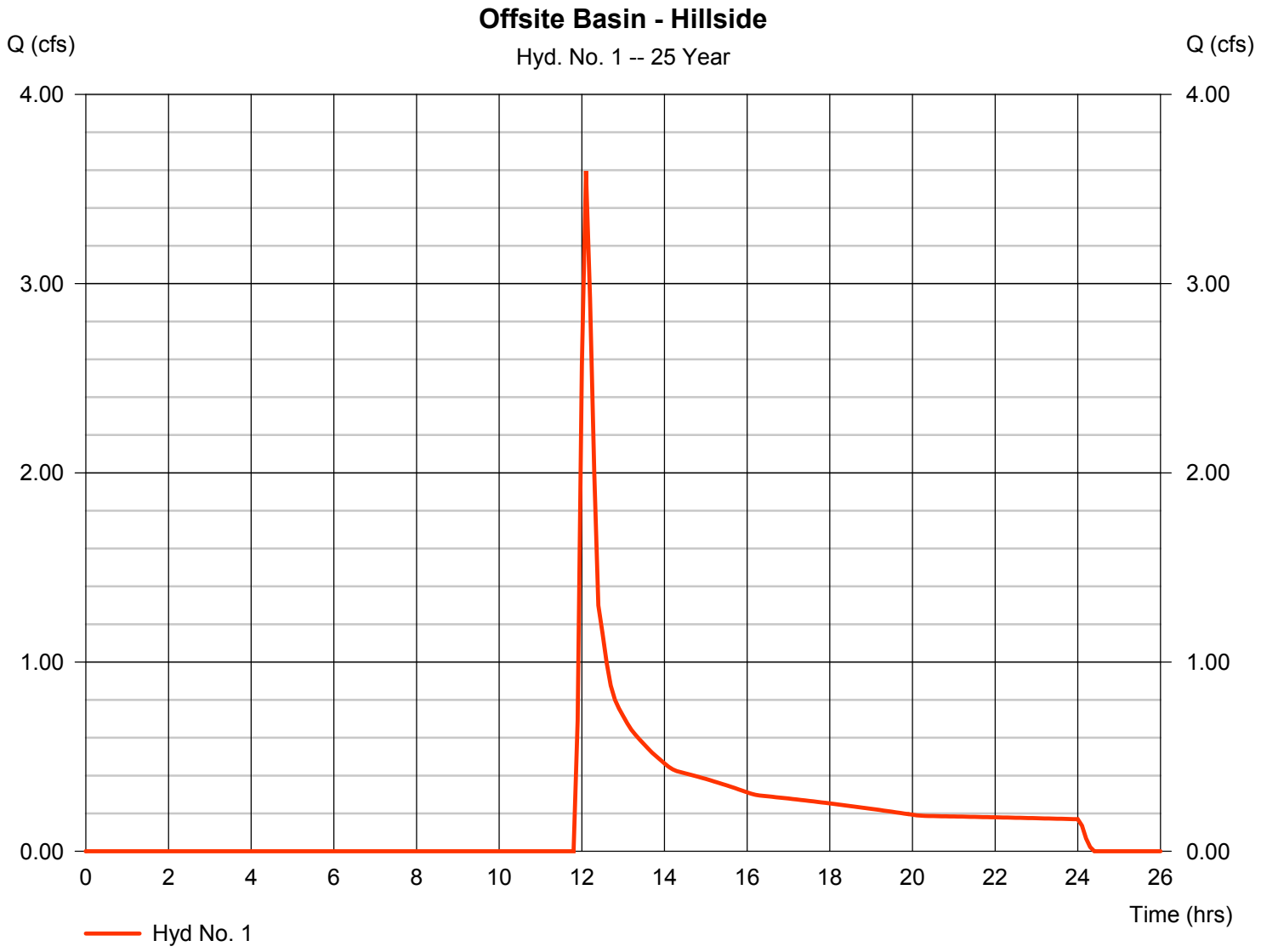
Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph Description
1	SCS Runoff	3.595	6	726	17,604	------	------	------	Offsite Basin - Hillside
2	SCS Runoff	1.074	6	756	9,486	------	------	------	DA-1
3	SCS Runoff	1.677	6	744	11,418	------	------	------	DA-2
4	Diversion1	1.798	6	726	8,802	1	------	------	Hillside to DA-1
5	Diversion2	1.798	6	726	8,802	1	------	------	Hillside to DA-2
6	Combine	2.183	6	726	18,288	2, 4,	------	------	DA-1 with Hillside
7	Combine	2.737	6	732	20,437	3, 5,	------	------	DA-2 with Hillside
8	Reservoir	1.416	6	768	14,869	6	1.29	4,161	Swale 1
9	Reservoir	1.419	6	774	14,877	7	1.49	6,516	Swale 2

Hydrograph Report

Hyd. No. 1

Offsite Basin - Hillside

Hydrograph type	=	SCS Runoff	Peak discharge	=	3.595 cfs
Storm frequency	=	25 yrs	Time to peak	=	12.10 hrs
Time interval	=	6 min	Hyd. volume	=	17,604 cuft
Drainage area	=	21.500 ac	Curve number	=	70
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	15.80 min
Total precip.	=	2.00 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484



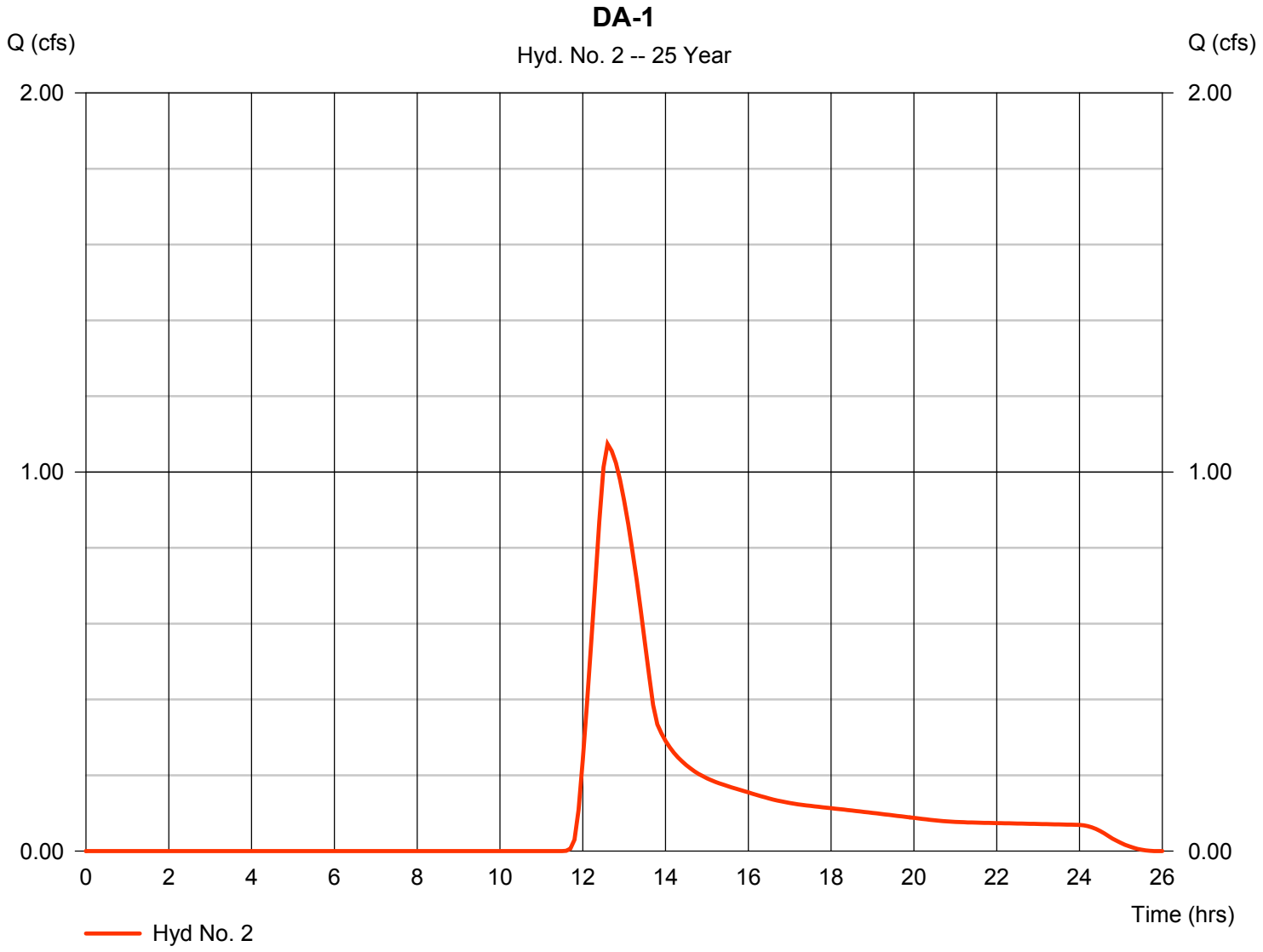
Hydrograph Report

Hyd. No. 2

DA-1

Hydrograph type	=	SCS Runoff	Peak discharge	=	1.074 cfs
Storm frequency	=	25 yrs	Time to peak	=	12.60 hrs
Time interval	=	6 min	Hyd. volume	=	9,486 cuft
Drainage area	=	5.300 ac	Curve number	=	78*
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	61.60 min
Total precip.	=	2.00 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

* Composite (Area/CN) = [(2.630 x 98) + (1.300 x 77) + (4.980 x 68)] / 5.300



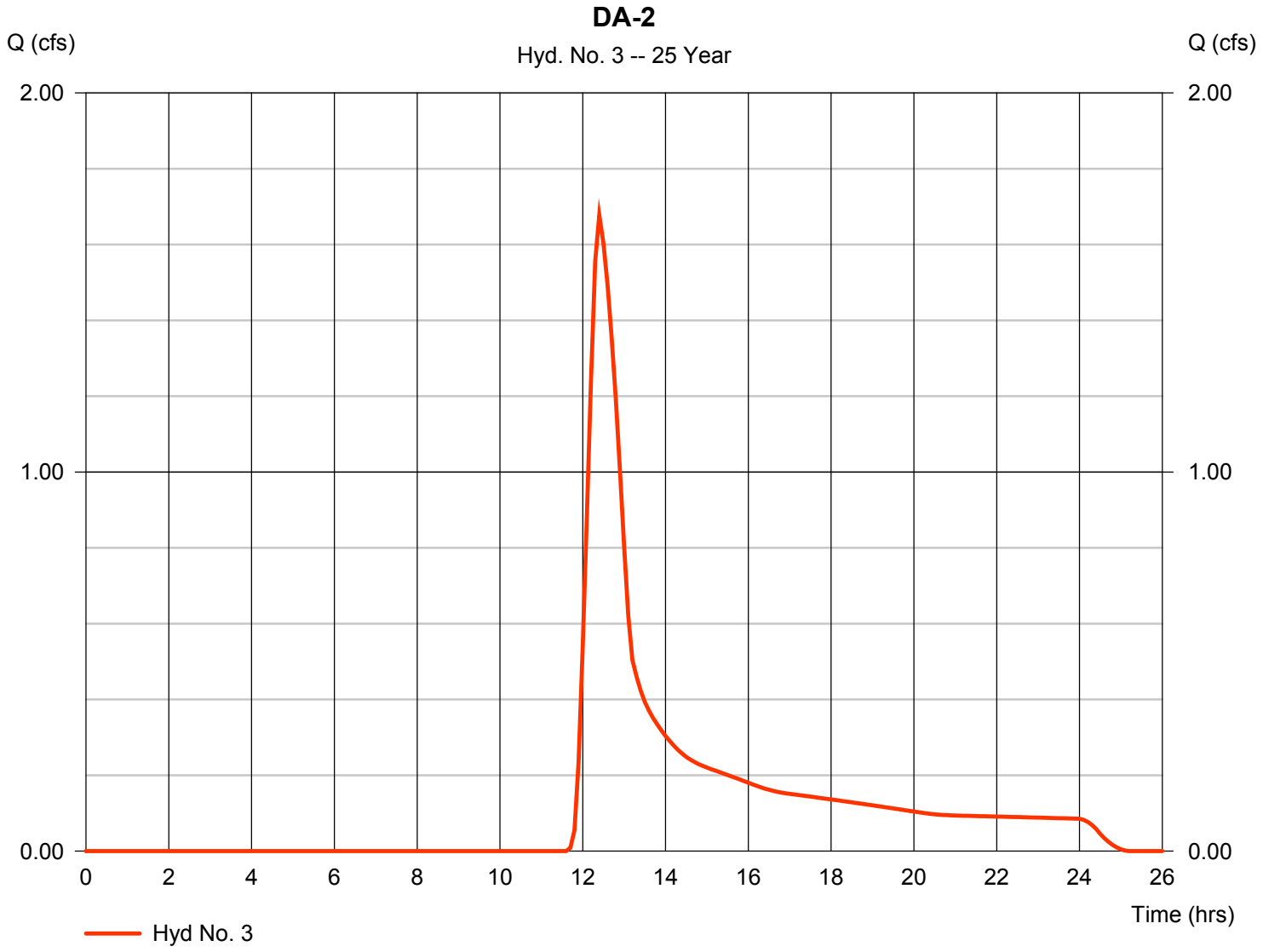
Hydrograph Report

Hyd. No. 3

DA-2

Hydrograph type	=	SCS Runoff	Peak discharge	=	1.677 cfs
Storm frequency	=	25 yrs	Time to peak	=	12.40 hrs
Time interval	=	6 min	Hyd. volume	=	11,418 cuft
Drainage area	=	7.200 ac	Curve number	=	77*
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	49.00 min
Total precip.	=	2.00 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

* Composite (Area/CN) = [(1.810 x 77) + (4.040 x 98) + (9.190 x 68)] / 7.200

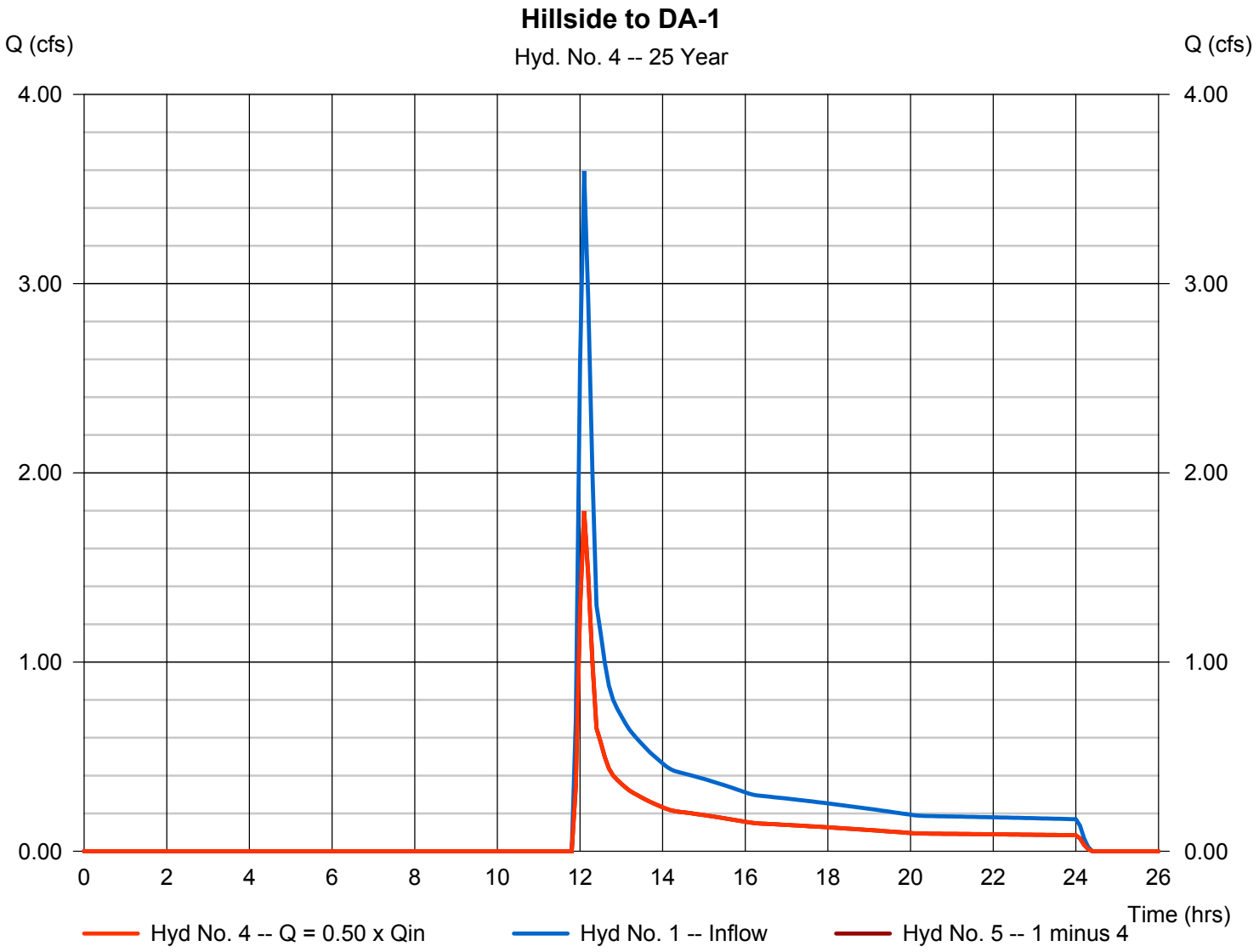


Hydrograph Report

Hyd. No. 4

Hillside to DA-1

Hydrograph type	= Diversion1	Peak discharge	= 1.798 cfs
Storm frequency	= 25 yrs	Time to peak	= 12.10 hrs
Time interval	= 6 min	Hyd. volume	= 8,802 cuft
Inflow hydrograph	= 1 - Offsite Basin - Hillside	2nd diverted hyd.	= 5
Diversion method	= Flow Ratio	Flow ratio	= 0.50

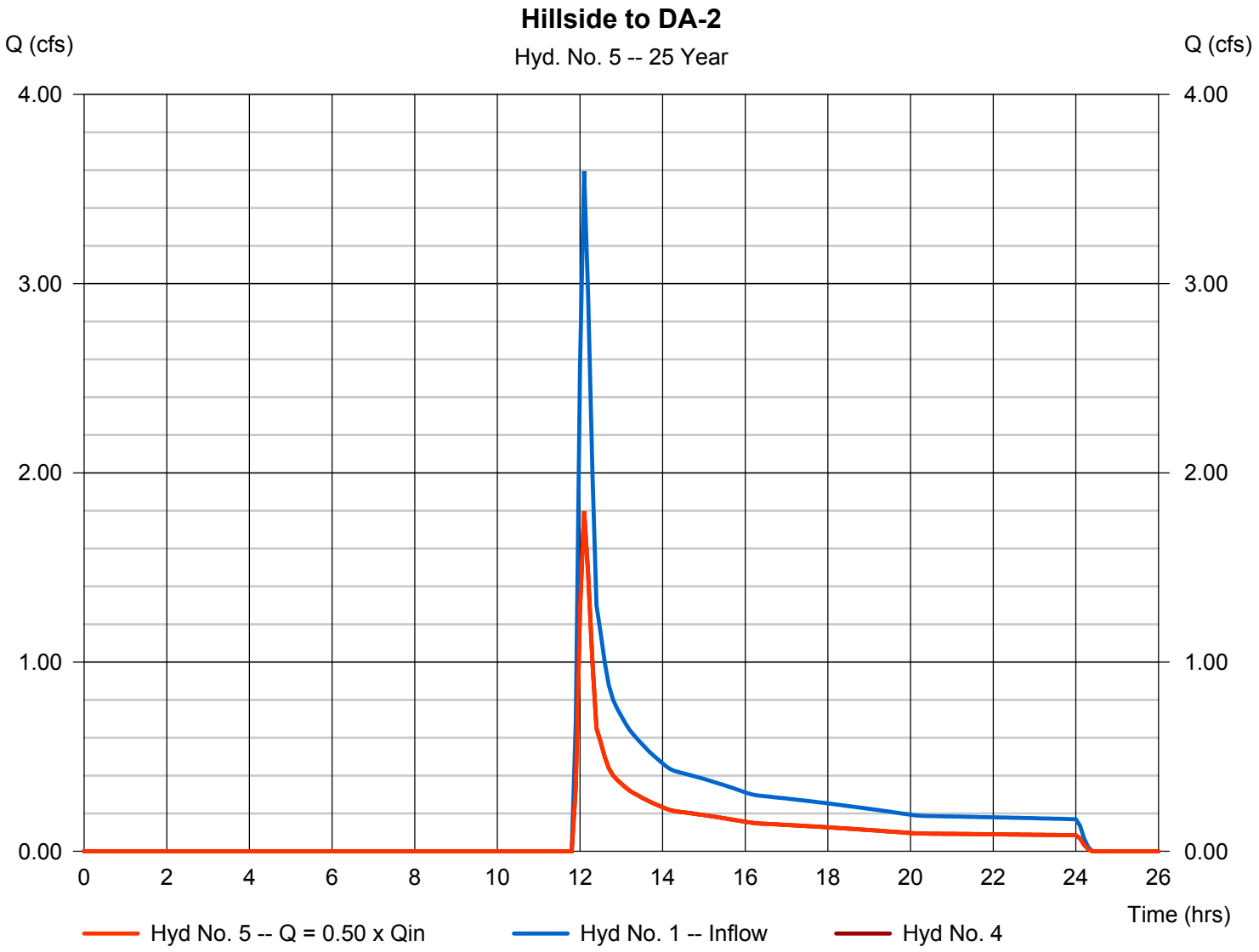


Hydrograph Report

Hyd. No. 5

Hillside to DA-2

Hydrograph type	= Diversion2	Peak discharge	= 1.798 cfs
Storm frequency	= 25 yrs	Time to peak	= 12.10 hrs
Time interval	= 6 min	Hyd. volume	= 8,802 cuft
Inflow hydrograph	= 1 - Offsite Basin - Hillside	2nd diverted hyd.	= 4
Diversion method	= Flow Ratio	Flow ratio	= 0.50

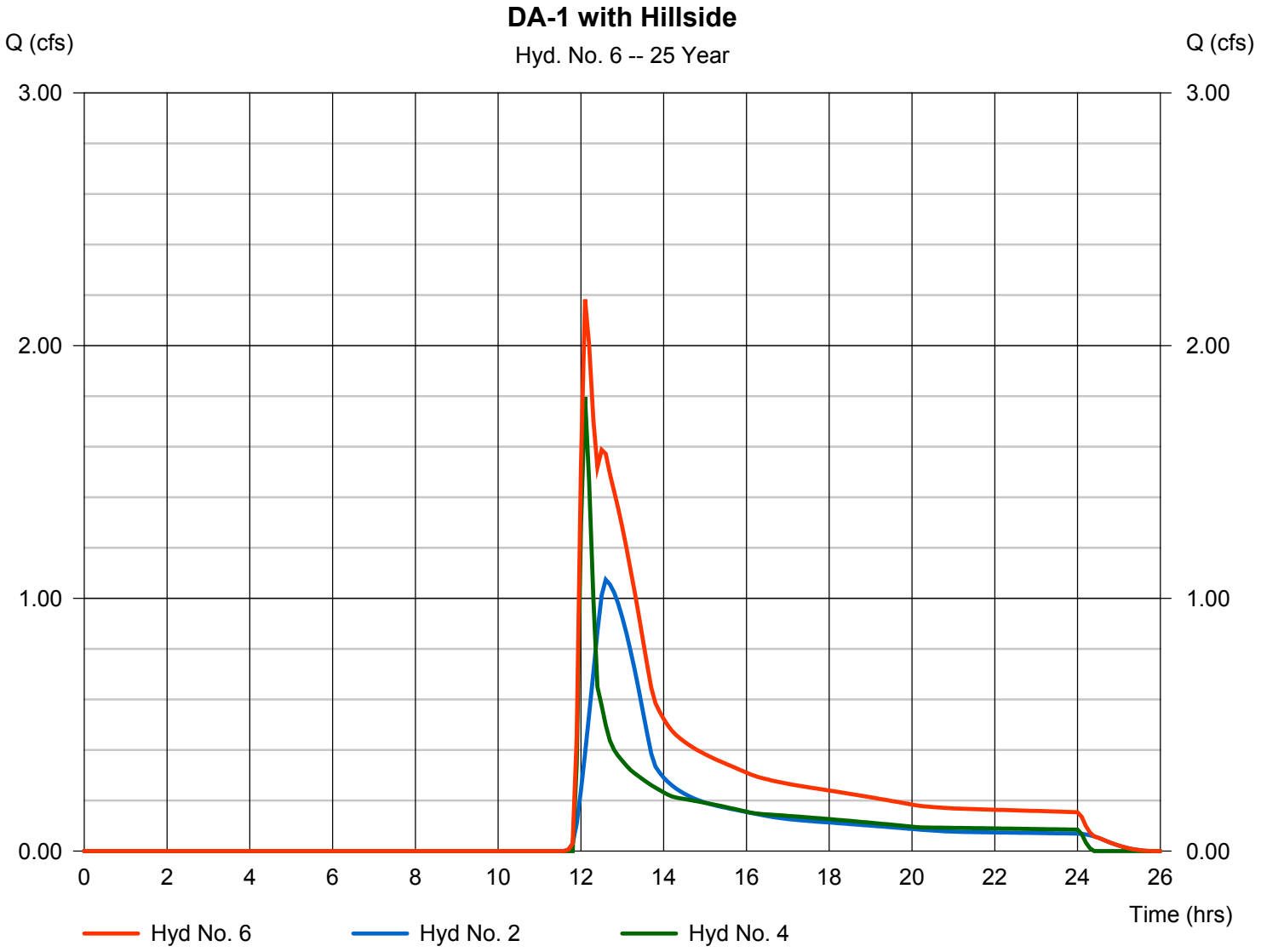


Hydrograph Report

Hyd. No. 6

DA-1 with Hillside

Hydrograph type	= Combine	Peak discharge	= 2.183 cfs
Storm frequency	= 25 yrs	Time to peak	= 12.10 hrs
Time interval	= 6 min	Hyd. volume	= 18,288 cuft
Inflow hyds.	= 2, 4	Contrib. drain. area	= 5.300 ac

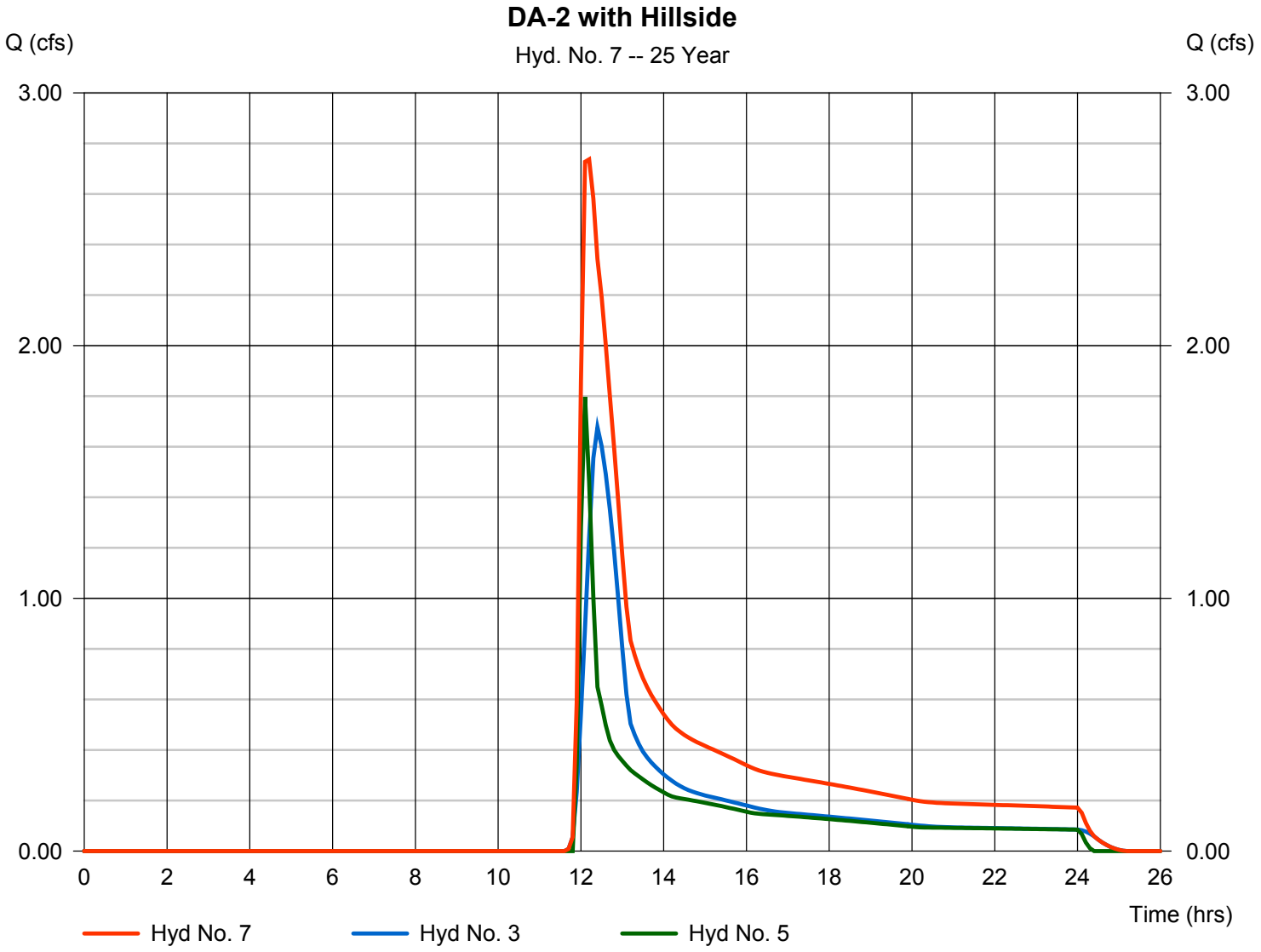


Hydrograph Report

Hyd. No. 7

DA-2 with Hillside

Hydrograph type	=	Combine	Peak discharge	=	2.737 cfs
Storm frequency	=	25 yrs	Time to peak	=	12.20 hrs
Time interval	=	6 min	Hyd. volume	=	20,437 cuft
Inflow hyds.	=	3, 5	Contrib. drain. area	=	7.200 ac



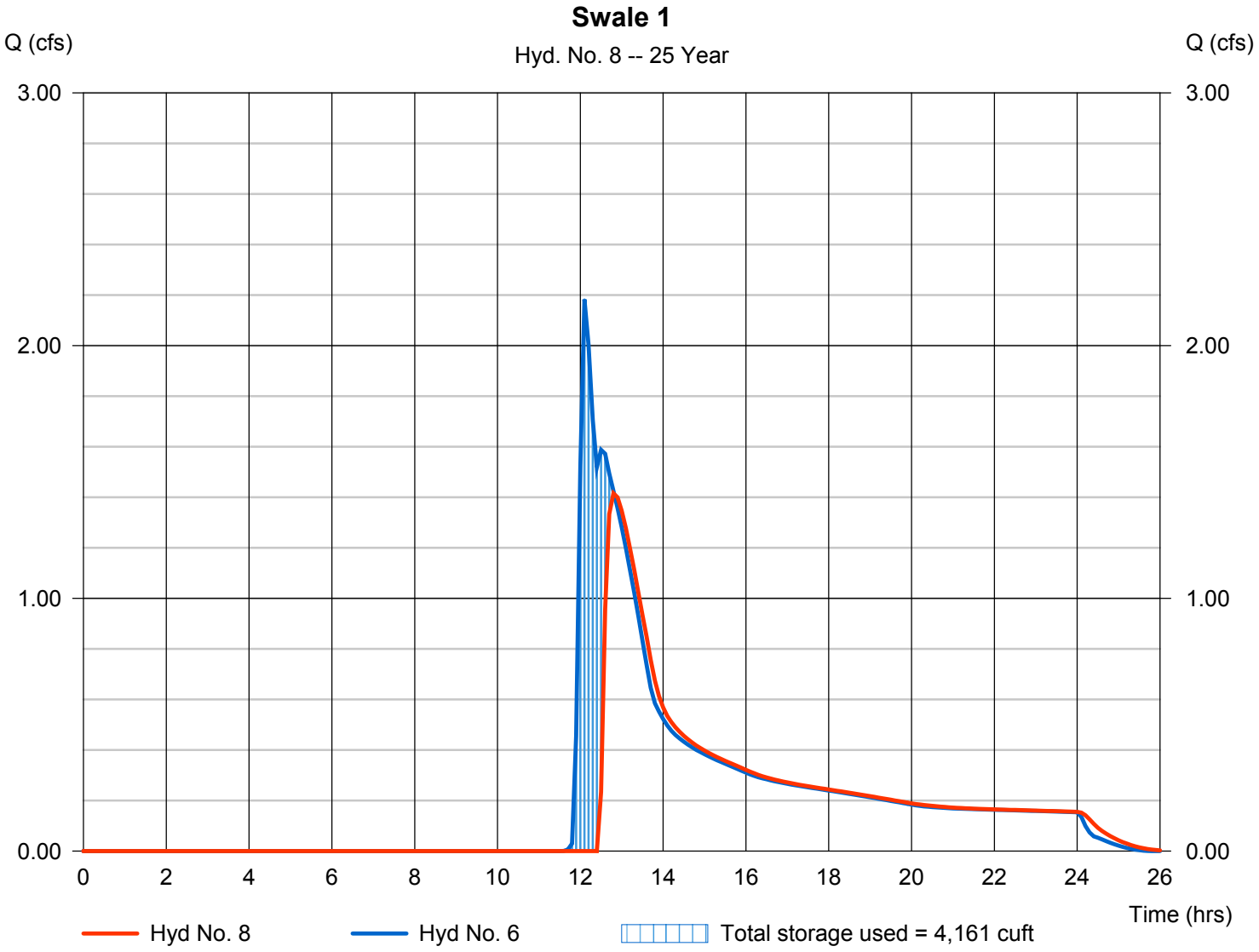
Hydrograph Report

Hyd. No. 8

Swale 1

Hydrograph type	=	Reservoir	Peak discharge	=	1.416 cfs
Storm frequency	=	25 yrs	Time to peak	=	12.80 hrs
Time interval	=	6 min	Hyd. volume	=	14,869 cuft
Inflow hyd. No.	=	6 - DA-1 with Hillside	Max. Elevation	=	1.29 ft
Reservoir name	=	Swale 1	Max. Storage	=	4,161 cuft

Storage Indication method used.



Pond Report

Pond No. 1 - Swale 1

Pond Data

Contours -User-defined contour areas. Average end area method used for volume calculation. Begining Elevation = 0.00 ft

Stage / Storage Table

Stage (ft)	Elevation (ft)	Contour area (sqft)	Incr. Storage (cuft)	Total storage (cuft)
0.00	0.00	2,500	0	0
1.00	1.00	3,564	3,032	3,032
1.50	1.50	4,144	1,927	4,959

Culvert / Orifice Structures

	[A]	[B]	[C]	[PrfRsr]
Rise (in)	= 0.00	0.00	0.00	0.00
Span (in)	= 0.00	0.00	0.00	0.00
No. Barrels	= 0	0	0	0
Invert El. (ft)	= 0.00	0.00	0.00	0.00
Length (ft)	= 0.00	0.00	0.00	0.00
Slope (%)	= 0.00	0.00	0.00	n/a
N-Value	= .000	.000	.000	n/a
Orifice Coeff.	= 0.00	0.00	0.00	0.00
Multi-Stage	= n/a	No	No	No

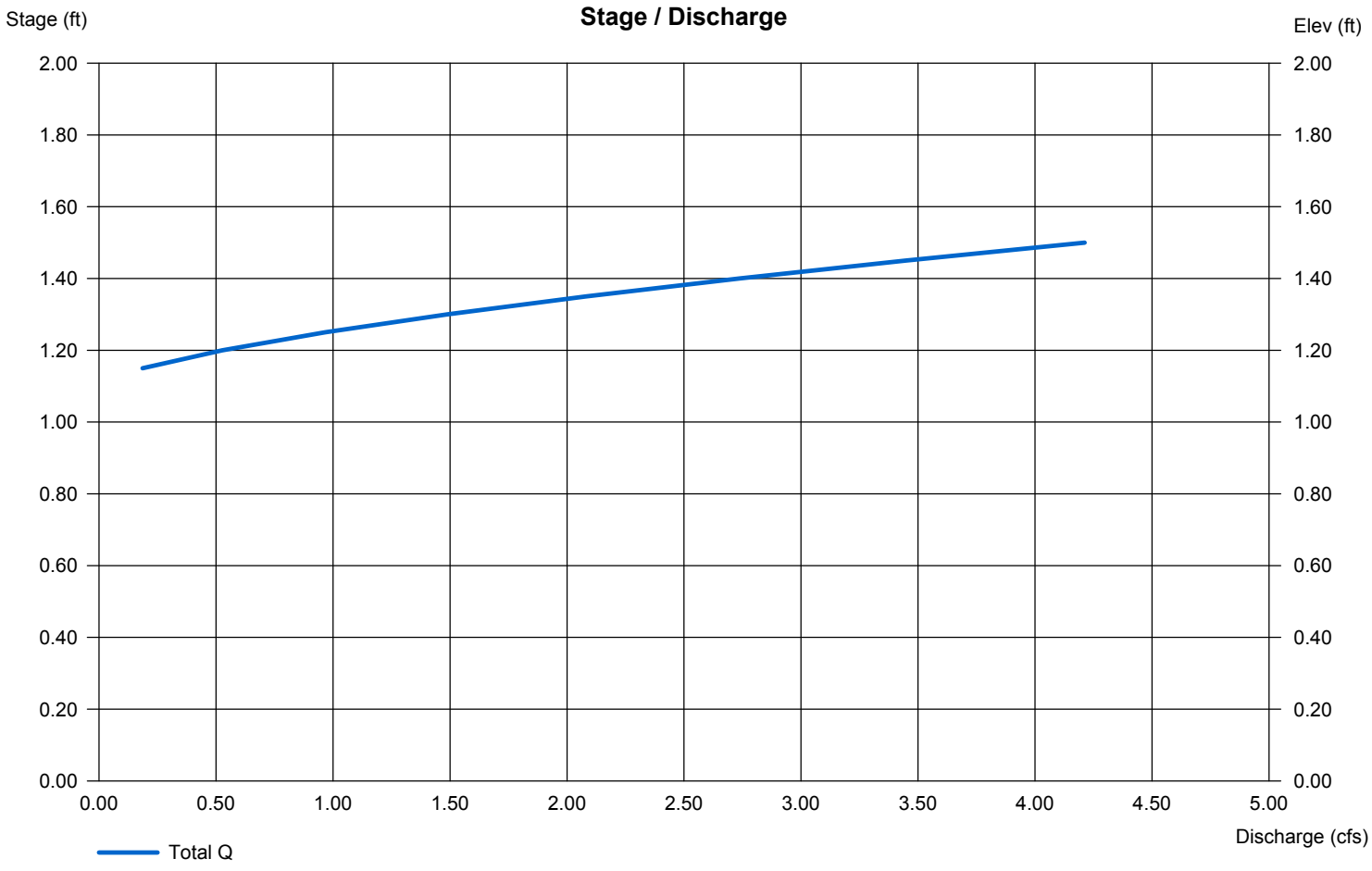
Weir Structures

	[A]	[B]	[C]	[D]
Crest Len (ft)	= 5.00	0.00	0.00	0.00
Crest El. (ft)	= 1.10	0.00	0.00	0.00
Weir Coeff.	= 3.33	0.00	0.00	0.00
Weir Type	= Rect	---	---	---
Multi-Stage	= No	No	No	No

Exfil.(in/hr) = 0.000 (by Contour)

TW Elev. (ft) = 0.00

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



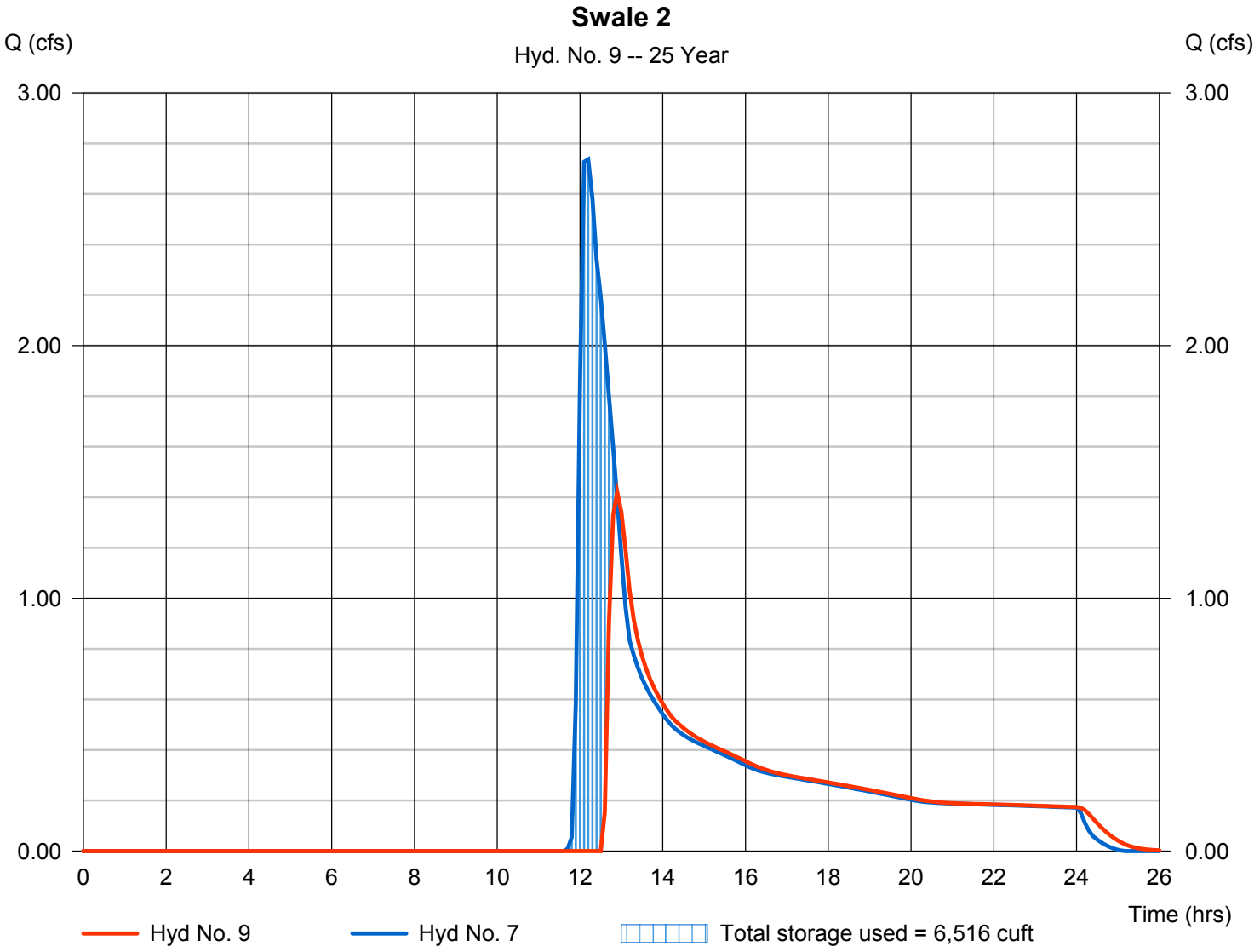
Hydrograph Report

Hyd. No. 9

Swale 2

Hydrograph type	=	Reservoir	Peak discharge	=	1.419 cfs
Storm frequency	=	25 yrs	Time to peak	=	12.90 hrs
Time interval	=	6 min	Hyd. volume	=	14,877 cuft
Inflow hyd. No.	=	7 - DA-2 with Hillside	Max. Elevation	=	1.49 ft
Reservoir name	=	Swale 2	Max. Storage	=	6,516 cuft

Storage Indication method used.



Pond Report

Pond No. 2 - Swale 2

Pond Data

Stage / Storage Table

Stage (ft)	Elevation (ft)	Contour area (sqft)	Incr. Storage (cuft)	Total storage (cuft)
0.00	0.00	3,500	0	0
1.00	1.00	4,644	4,072	4,072
1.50	1.50	5,264	2,477	6,549

Culvert / Orifice Structures

	[A]	[B]	[C]	[PrfRsr]
Rise (in)	= 0.00	0.00	0.00	0.00
Span (in)	= 0.00	0.00	0.00	0.00
No. Barrels	= 0	0	0	0
Invert El. (ft)	= 0.00	0.00	0.00	0.00
Length (ft)	= 0.00	0.00	0.00	0.00
Slope (%)	= 0.00	0.00	0.00	n/a
N-Value	= .000	.000	.000	n/a
Orifice Coeff.	= 0.00	0.00	0.00	0.00
Multi-Stage	= n/a	No	No	No

Weir Structures

	[A]	[B]	[C]	[D]
Crest Len (ft)	= 5.00	0.00	0.00	0.00
Crest El. (ft)	= 1.30	0.00	0.00	0.00
Weir Coeff.	= 3.33	0.00	0.00	0.00
Weir Type	= Rect	---	---	---
Multi-Stage	= No	No	No	No

Exfil.(in/hr) = 0.000 (by Contour)

TW Elev. (ft) = 0.00

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