Technical Memorandum

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To: Mike Peebles, PE

From: Rose Horton, PE; Gary Wolff, PE

Copies: File

Date: May 21, 2015

Subject: South Cooper Mountain Existing Drainages

Project No.: 16985

REGISTERED PROFESSIONAL ENGINEER
83599PE
OREGON
Dec. 12, 2010
ROSE C. HORTON
EXPIRES: 6/30/2017

Introduction

The South Cooper Mountain Heights subdivision project is a proposed residential development in the City of Beaverton, with stormwater jurisdiction through Clean Water Services (CWS). Two existing drainages flow through the property.

The purpose of this memorandum is to document hydrologic and hydraulic analyses carried out to determine Base Flood Elevations (BFE's) and map the flood hazard area subject to inundation by the 1% annual chance flood (100-year flood) on the property as required by the development application.

Hydrology

Study Area

The study area in the City of Beaverton, in Washington County, Oregon. The drainage basins were delineated in ArcMap 10.2.2 using LiDAR contours from Dogami as seen in Figure 1.

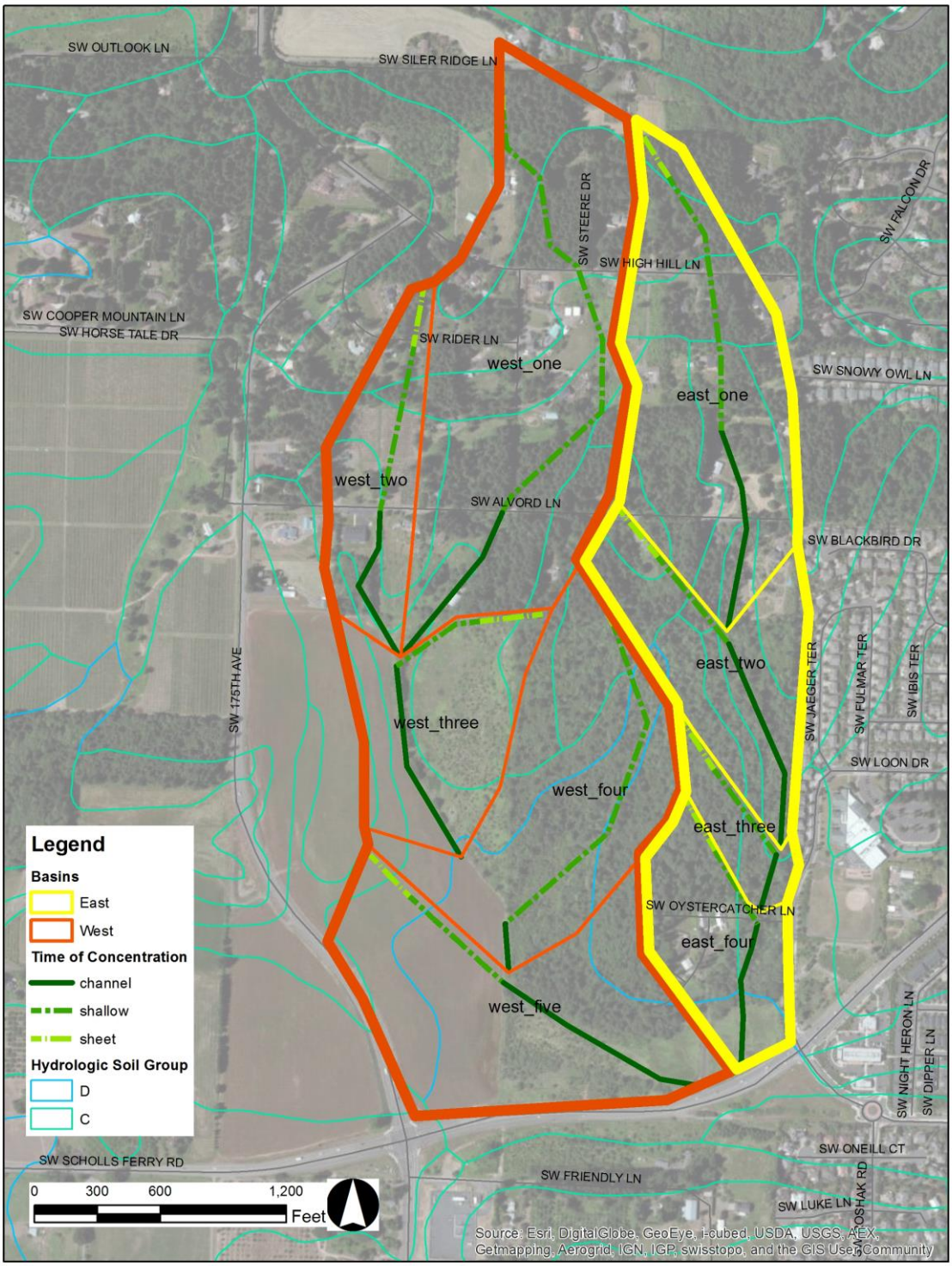


Figure 1. Drainage Basins

An unnamed drainage ditch intersects the property in the northeast corner and flows south to a wetland area before discharging through a culvert under SW Scholls Ferry Road. The eastern drainage ditch drains approximately 67 acres of relatively steep, mostly undeveloped grass and wooded areas with one housing development before it crosses SW Scholls Ferry Road.

A second unnamed drainage ditch runs from north to south across the property with significant wetland area located in the southern portion of the project site. The western drainage ditch drains approximately 141 acres before it crosses SW Scholls Ferry Road. The drainage basin has a few homes and wooded areas in the steep northern portion of the basin while the less steep southern portion of the basin is currently being used for agriculture. See Figure 1 for the drainage basins.

Soils are categorized by the National Resource Conservation Service (NRCS) as hydrologic soil group types C and D, which consist of silt loams (See Appendix A). These soils generally exhibit moderate to low infiltration rates and relatively high runoff rates. The subbasins were further divided by soil group and an impervious percentage was assigned to each based on existing land use as summarized in table 1.

Table 1: Basin Areas

Subbasin Name	Hydrologic Soil Group	Percent Impervious	Impervious Area (ac)	Pervious Area (ac)
east_one	C	0	0.00	1.51
east_one	C	5	0.06	1.10
east_one	C	10	1.11	9.95
east_one	C	15	1.33	7.54
east_one	C	20	1.70	6.79
east_one	C	30	0.10	0.24
east_two	C	0	0	7.726
east_two	C	5	0.25	4.77
east_two	C	10	0.34	3.04
east_two	C	20	0.26	1.05
east_two	D	0	0	0.273
east_three	C	0	0.00	2.62
east_three	C	5	0.01	0.27
east_three	C	30	0.57	1.32
east_four	C	40	1.02	1.54
east_four	C	50	3.81	3.81
east_four	D	5	0.13	2.41
East			**10.69**	**55.95**

Table 1: Basin Areas				
Subbasin Name	Hydrologic Soil Group	Percent Impervious	Impervious Area (ac)	Pervious Area (ac)
west_one	C	0	0.00	2.72
west_one	C	10	0.37	3.30
west_one	C	15	1.19	6.74
west_one	C	20	5.32	21.26
west_one	C	25	2.06	6.17
west_two	C	0	0.00	1.51
west_two	C	15	0.66	3.72
west_two	C	20	0.46	1.82
west_two	C	35	1.73	3.22
west_three	C	0	0.00	17.24
west_three	D	0	0.00	0.11
west_four	C	0	0.00	17.06
west_four	D	0	0.00	12.50
west_five	C	0	0.00	1.40
west_five	C	5	0.30	5.77
west_five	C	30	1.04	2.42
west_five	D	5	1.07	20.26
West			**14.18**	**127.21**

Peak runoff rates generated from the basins were calculated using the Santa Barbara Urban Hydrograph (SBUH) method in HydroCAD v10.0. Precipitation depths for this project site, listed in Table 2, were obtained from the COB *Engineering Design Manual* and used to calculate site rainfall and runoff rates based on the NRCS Type 1A rainfall distribution.

Table 2: City of Beaverton Precipitation Depths	
Recurrence Interval	Precipitation Depth (in)
2-Year	2.50
10-Year	3.50
25-Year	4.00
100-Year	4.50

Based on the existing land use and hydrologic soil groups, curve numbers (CN) were applied to the subbasins. A higher CN indicated more potential for rainfall runoff. Table 3 provides a summary of the runoff curve numbers.

Table 3: Runoff Curve Numbers		
Cover Type	Hydrologic Soil Group	Curve Number
Paved roads w/curbs & sewers, HSG C	D	98
Paved roads w/curbs & sewers, HSG C	C	98
Pasture/grassland/range, Fair	D	84
Pasture/grassland/range, Fair	C	79
Woods/grass comb., Good	D	79
Woods/grass comb., Good	C	72

A time of concentration, which is the time for runoff to travel from the hydraulically most distant point to the point of interest, was calculated for the basin. The time of concentration includes overland flow, sheet flow, and shallow concentrated flow and is influenced by surface roughness, flow patterns and slope estimated from aerial imagery and LiDAR contours. The time of concentration was calculated directly using the HydroCAD v10.0 software. See appendix B for HydroCAD results and the flow rates summarized in Table 5.

Hydraulics

Modeling Approach

The hydraulic analysis for the eastern drainage ditch extends from the property boundary in the north to the road crossing just south for the property line. The analysis for the western drainage ditch extends from the property line in the north to the channel downstream of the culvert under SW Scholls Ferry Road.

The hydraulic analysis was only carried out for the one-percent-annual chance flood peak (100-yr event) with no floodway analysis. The U.S. Army Corps of Engineers HEC-RAS software was utilized to model the mapped floodplain through the study area. HEC-RAS was utilized to model this reach because it is the most common one-dimensional (1-D) model utilized for the National Flood Insurance Program.

The basis of the geometric data for the hydraulic modeling is the detailed topographic survey data collected specifically for this study. Available drawings of the culvert crossing under SW Scholls Ferry Road were used to supplement the survey data. Survey elevations are NGVD29 based on Washington County benchmark #107.

Manning's n values were based on field observations and engineering judgment. Main channel Manning's n values for the project reach ranged from 0.07 to 0.10 and overbank n values varied from 0.040 to 0.10. Table 4 summarizes the selected values.

Table 4. Manning's n values	
Description	Selected n Value
Main Channel	
Swale with tall grass	0.07
Swale through dense vegetation	0.10
Overbanks	
Open field	0.04
Tall grass	0.07
Dense vegetation	0.10

Contraction and expansion coefficients in the HEC-RAS model were set to 0.1/0.3 for all cross sections outside of the contraction/expansion zone in the vicinity of the culverts and bridge. The values were increased to 0.3/0.5 to account for contraction and expansion of flow into and downstream of the culverts and bridge on the western drainage ditch.

Ineffective flow areas were used in the HEC-RAS model to properly model the conveyance (distribution of flow) for the cross sections along the modeled reach. This includes constraining the flow for the contraction and expansion zones upstream and downstream of the culverts and bridge and to model low areas in the field west of the western drainage ditch.

Interpolated cross sections were added to the HEC-RAS model to improve the solution of the standard-step backwater calculations. Without the interpolated cross sections there were multiple locations in this reach with computed critical depth. The interpolated cross sections reduced the number of critical depth locations.

Input discharges to the HEC-RAS model were derived from the computed peak flows from the HydroCAD model and are summarized in Table 5.

Table 5. Flow Data				
Drainage	Reach	Cross-Section	Contributing Basins	Flow Rate (cfs)
East	East	1586	East_1	8.1
East	East	479	East_1, East_2	10.8
East	East	125	East_1, East_2, East_3	11.9
West	Trib	214	West_2	3.8
West	West	3167	West_1	11.7
West	WestMain	3065	West_1, West_2, West_3	15.4
West	WestMain	2032	West_1, West_2, West_3, West_4	22.1
West	WestMain	1416	West_1, West_2, West_3, West_4, West_5	28.0

The downstream boundary condition was based on normal depth for the downstream slope.

Model Results and Mapping

Results of the hydraulic analysis were used to develop BFE's along the study reach and to map the 100-year floodplain (SFHA) per FEMA standards. The computed 100-year water surface profile along the east and west drainage ditches are shown in Figures 2 and 3, respectively. The distances on the x-axis correspond to the stationing on the attached floodplain maps. The analysis shows the 100-year floodplain is constrained to a path along the channel in the eastern drainage ditch.

In the western drainage, the 100-year floodplain is constrained to the channel in the upper reach. Currently, there is a plugged culvert at approximately station 17+00 that causes the water to back up and overtop the ditch. Water flows through a low area in the field to the west until it reenters the ditch downstream. Stream restoration is planned for this section of channel under a United States Army Corps of Engineers Nationwide Permit. The culverts will be removed and the channel regraded with a slope to match the existing channel. As part of the restoration, the low area to the west of the channel will be filled to prevent evulsion. Under this proposed condition, 100-yr floodplain should be constrained to the channel in this section and the revised computed 100-year water surface profile along the west drainage ditch is shown in Figure 4. The floodplain widens in the downstream wetland area as the ditch flow more parallel to SW Scholls Ferry Road before crossing under the road. See the floodplain boundary in the attached maps.

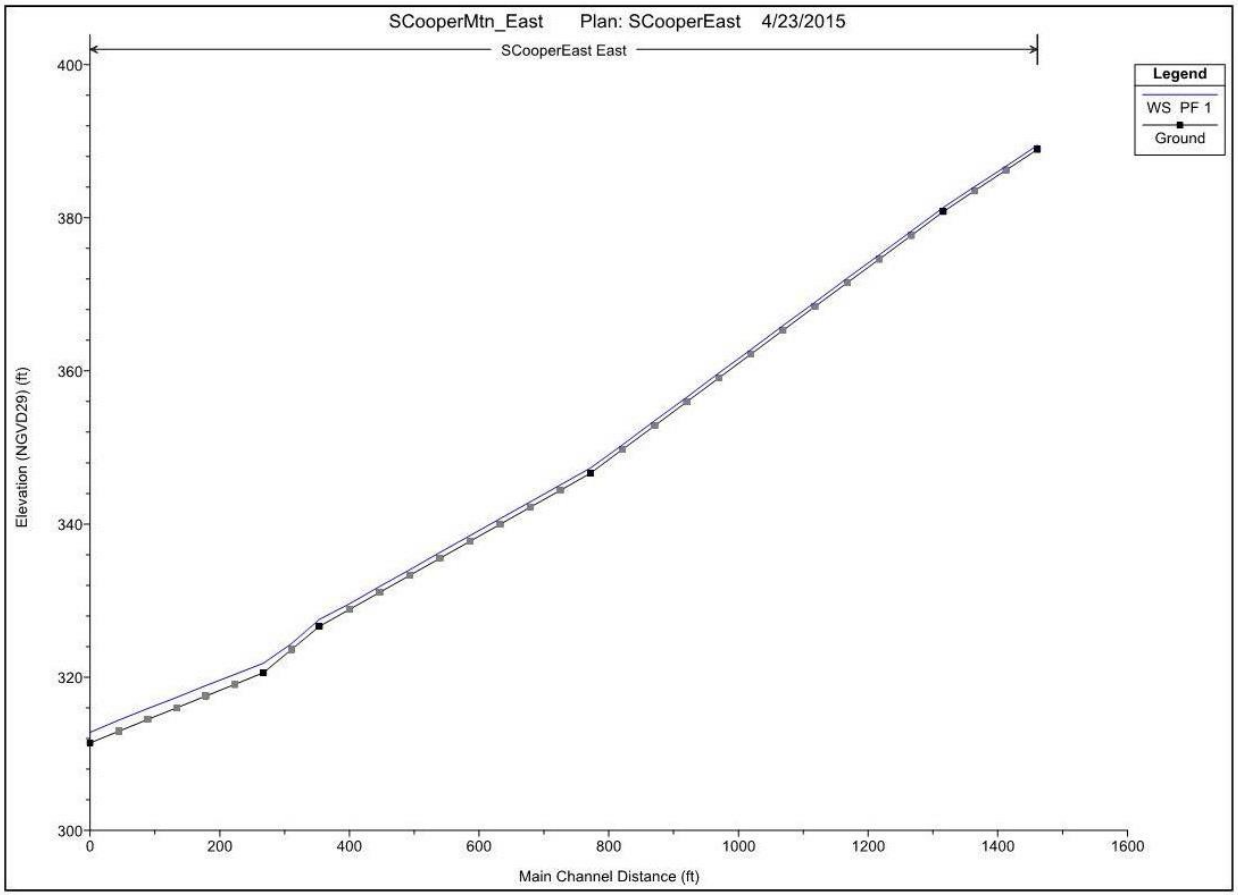


Figure 2 East Drainage channel bed and computed 100-yr water surface profile

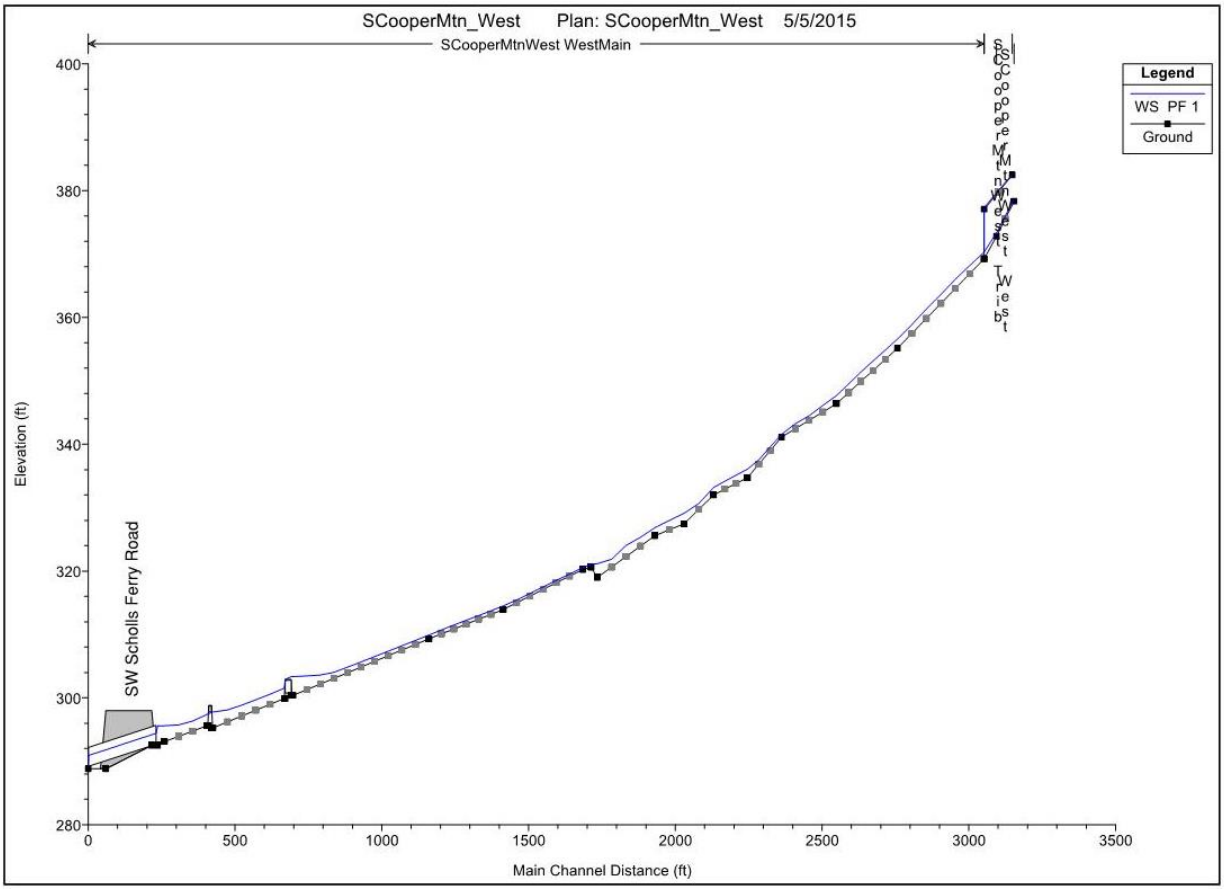


Figure 3 West Drainage channel bed and computed 100-year water surface profile

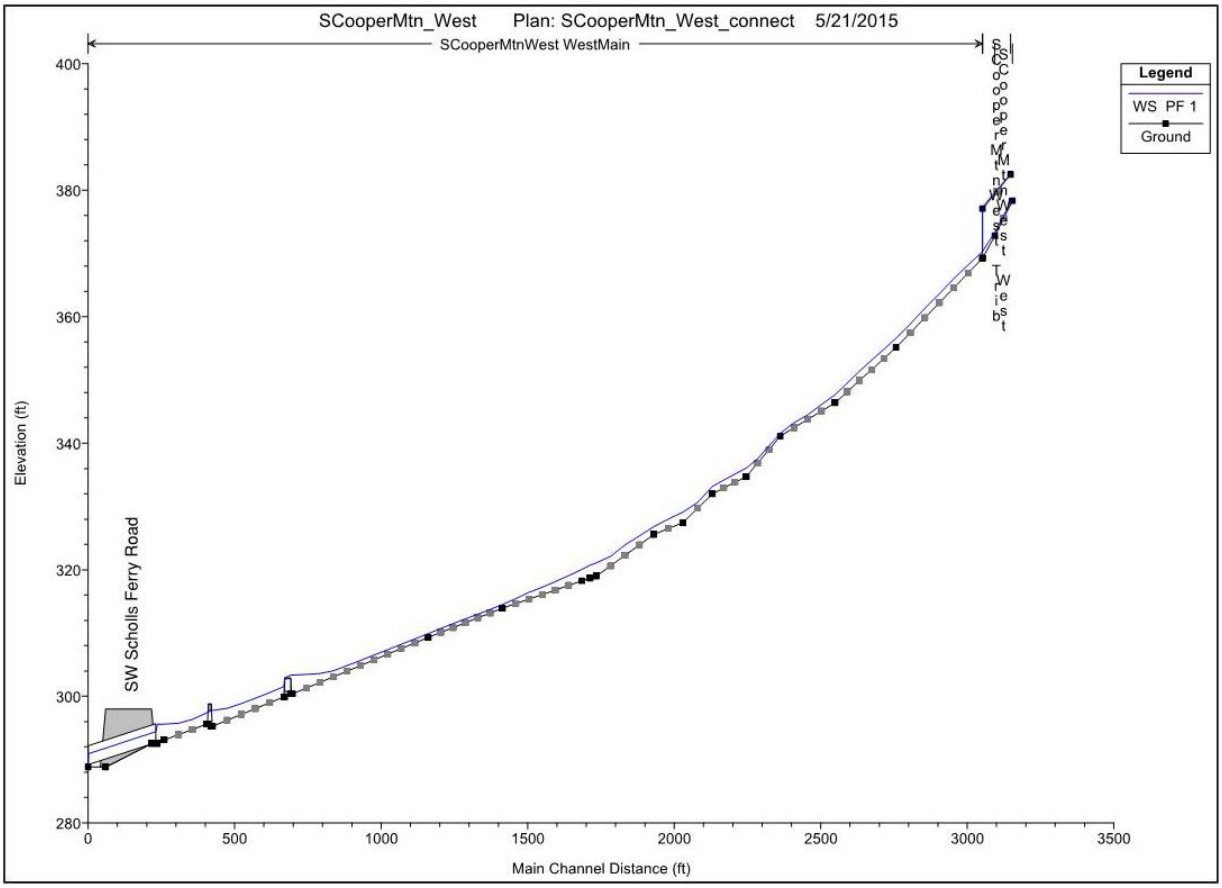
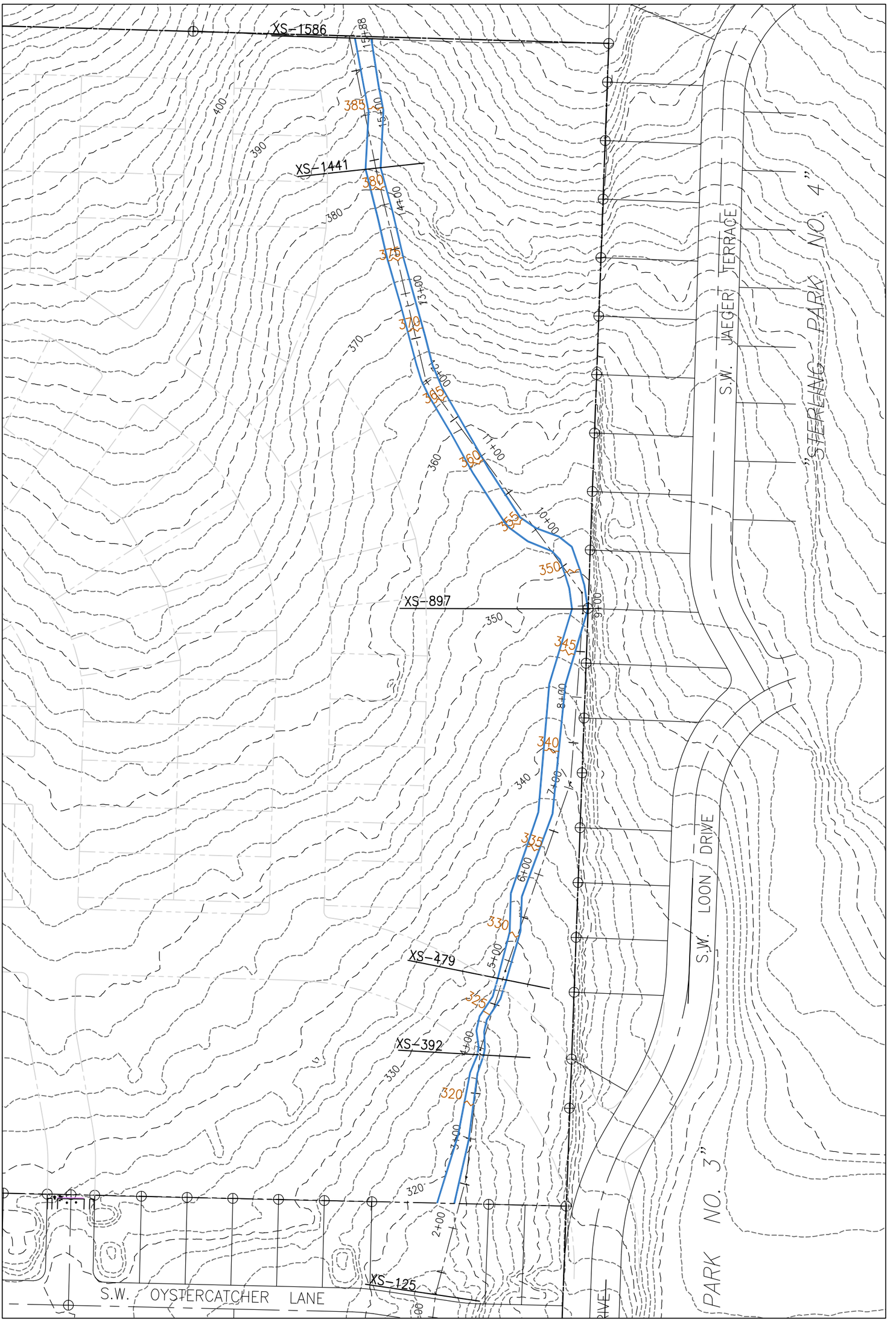


Figure 4 West Drainage channel bed connected and computed 100-year water surface profile

Attachments—Drainage Floodplain Maps



South Cooper Mountain East Drainage Floodplain

100' 0' 100' 200'

SCALE IN FEET

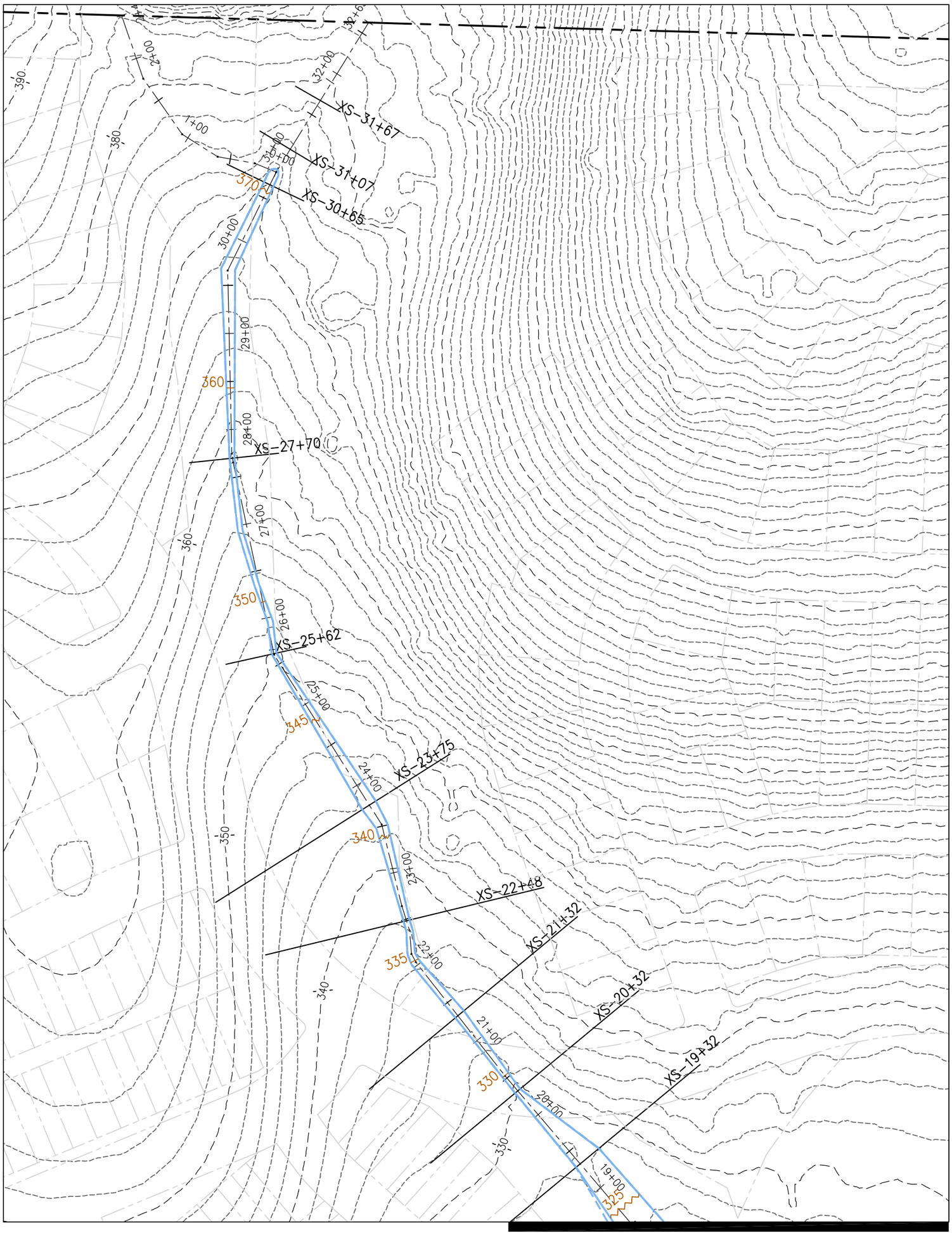
LEGEND

Cross Section — XS-7+00

Floodplain Limits

Base Flood Elevation — 330

Proposed Lots/ROW



MATCHLINE

South Cooper Mountain West Drainage Floodplain

LEGEND

Cross Section — XS-7+00

Floodplain Limits Existing

Floodplain Limits Proposed

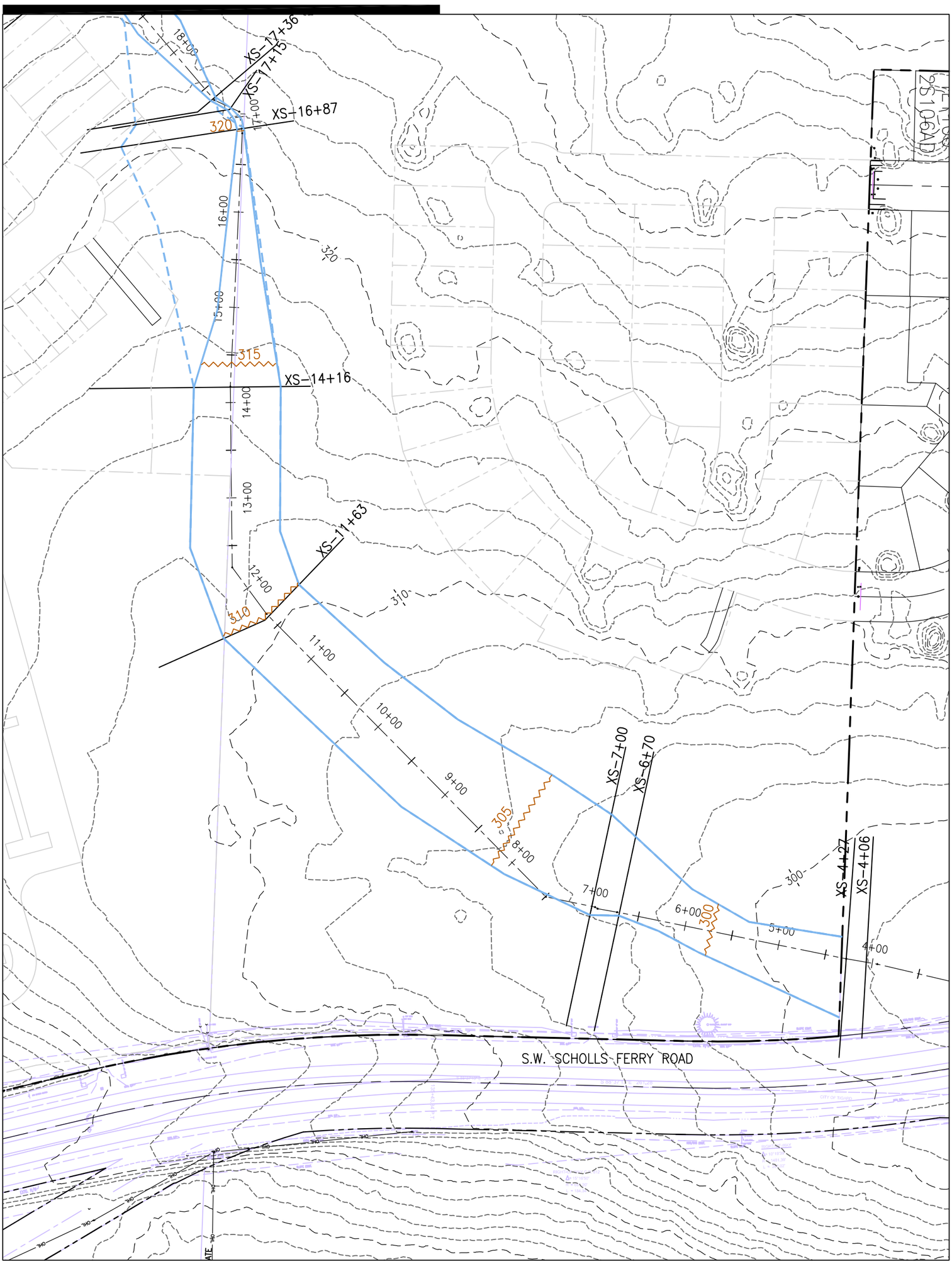
Base Flood Elevation — 330

Proposed Lots/ROW

100' 0' 100' 200'

SCALE IN FEET

MATCHLINE



South Cooper Mountain West Drainage Floodplain

100' 0' 100' 200'

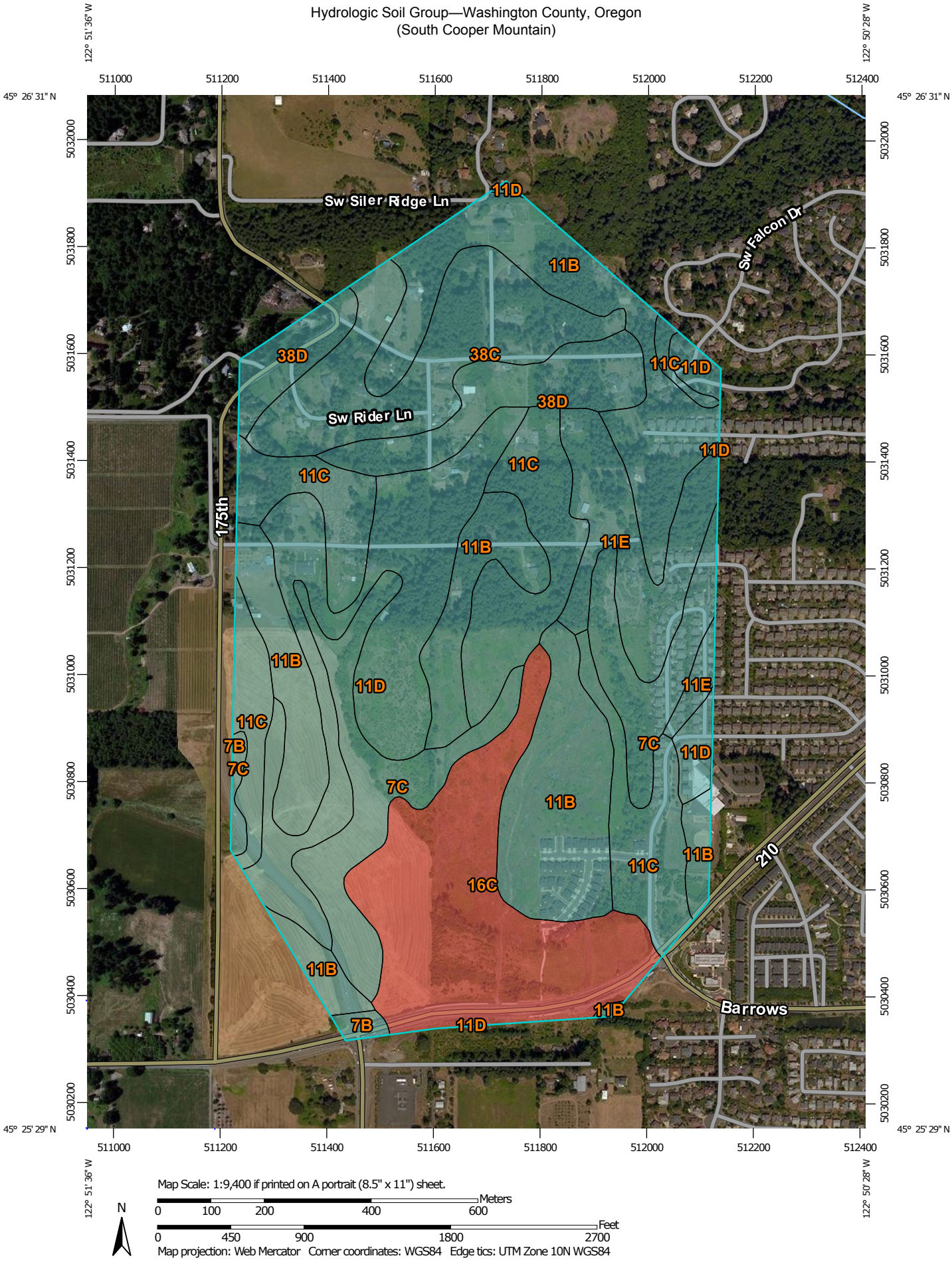
SCALE IN FEET

LEGEND

Cross Section	XS-7+00
Floodplain Limits Existing	
Floodplain Limits Proposed	
Base Flood Elevation	330
Proposed Lots/ROW	

Appendix A—NCRS Soils Report

Hydrologic Soil Group—Washington County, Oregon
(South Cooper Mountain)



MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Lines

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Points

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Water Features

Streams and Canals

Transportation

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

Background

Aerial Photography

MAP INFORMATION

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

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

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

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

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

Soil Survey Area: Washington County, Oregon
Survey Area Data: Version 12, Sep 19, 2014

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jul 8, 2010—Aug 23, 2014

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.

Hydrologic Soil Group

Hydrologic Soil Group— Summary by Map Unit — Washington County, Oregon (OR067)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
7B	Cascade silt loam, 3 to 7 percent slopes	C	1.1	0.4%
7C	Cascade silt loam, 7 to 12 percent slopes	C	31.0	10.3%
11B	Cornelius and Kinton silt loams, 2 to 7 percent slopes	C	73.4	24.4%
11C	Cornelius and Kinton silt loams, 7 to 12 percent slopes	C	44.5	14.8%
11D	Cornelius and Kinton silt loams, 12 to 20 percent slopes	C	41.6	13.8%
11E	Cornelius and Kinton silt loams, 20 to 30 percent slopes	C	18.9	6.3%
16C	Delena silt loam, 3 to 12 percent slopes	D	42.6	14.2%
38C	Saum silt loam, 7 to 12 percent slopes	C	27.9	9.3%
38D	Saum silt loam, 12 to 20 percent slopes	C	19.9	6.6%
Totals for Area of Interest			**301.0**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

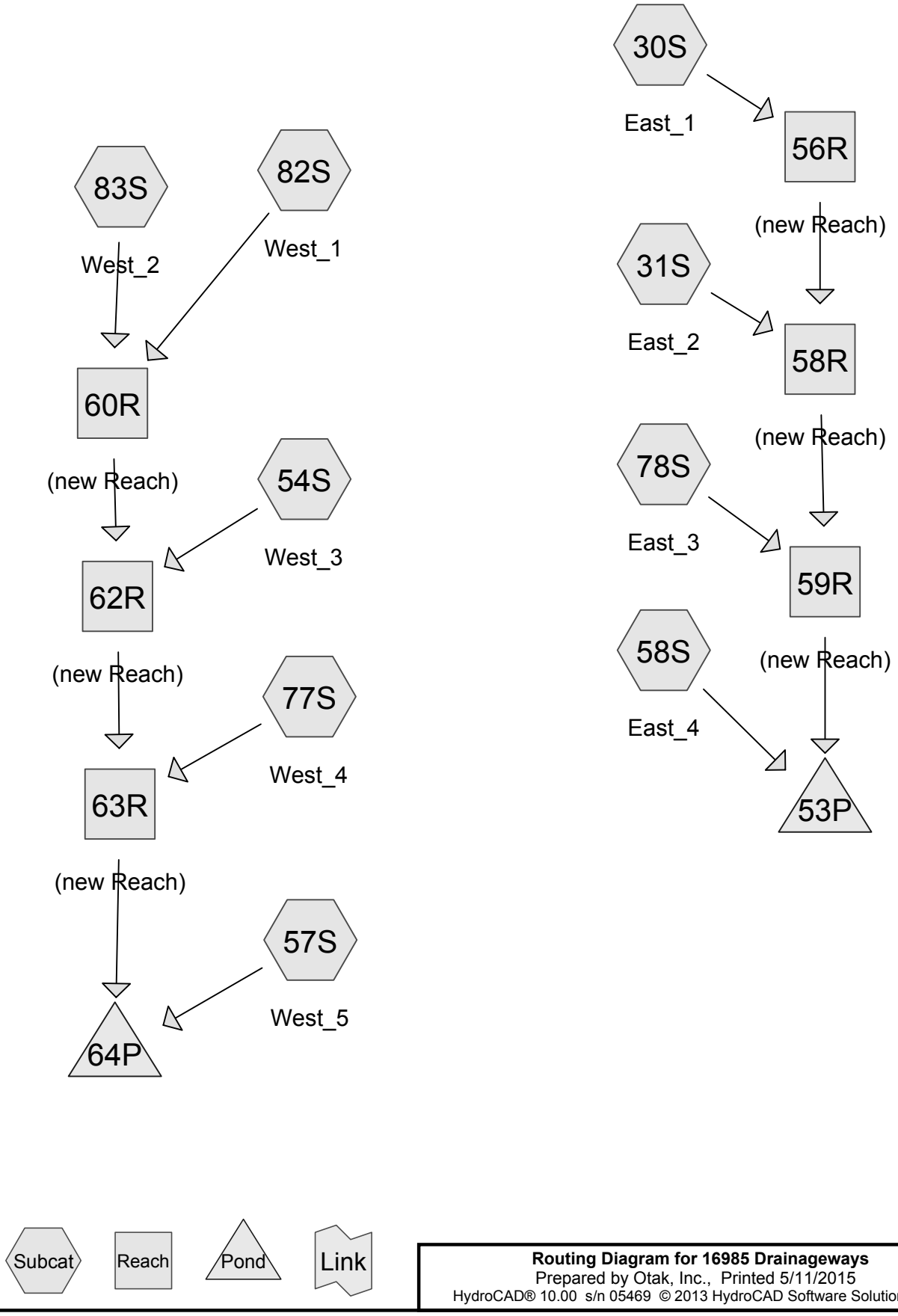
Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Higher

Appendix B—Hydrocad Results



Routing Diagram for 16985 Drainageways
Prepared by Otak, Inc., Printed 5/11/2015
HydroCAD® 10.00 s/n 05469 © 2013 HydroCAD Software Solutions LLC

Time span=0.00-72.00 hrs, dt=0.05 hrs, 1441 points x 3
Runoff by SBUH method, Split Pervious/Imperv.
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment30S: East_1 Runoff Area=31.422 ac 16.97% Impervious Runoff Depth=2.24"
Flow Length=2,517' Tc=58.0 min CN=72/98 Runoff=8.09 cfs 5.852 af

Subcatchment31S: East_2 Runoff Area=16.935 ac 0.50% Impervious Runoff Depth=1.83"
Flow Length=1,842' Tc=82.2 min CN=72/98 Runoff=2.79 cfs 2.586 af

Subcatchment54S: West_3 Runoff Area=17.354 ac 0.00% Impervious Runoff Depth=2.38"
Flow Length=1,743' Tc=23.8 min CN=79/0 Runoff=7.38 cfs 3.437 af

Subcatchment57S: West_5 Runoff Area=32.250 ac 7.46% Impervious Runoff Depth=2.36"
Flow Length=1,979' Tc=35.0 min CN=77/98 Runoff=11.49 cfs 6.353 af

Subcatchment58S: East_4 Runoff Area=12.731 ac 44.99% Impervious Runoff Depth=3.00"
Flow Length=1,385' Tc=44.6 min CN=74/98 Runoff=5.51 cfs 3.186 af

Subcatchment77S: West_4 Runoff Area=29.553 ac 0.00% Impervious Runoff Depth=2.05"
Flow Length=2,210' Tc=71.8 min CN=75/0 Runoff=6.14 cfs 5.050 af

Subcatchment78S: East_3 Runoff Area=4.786 ac 16.07% Impervious Runoff Depth=2.21"
Flow Length=1,066' Tc=70.4 min CN=72/98 Runoff=1.11 cfs 0.883 af

Subcatchment82S: West_1 Runoff Area=49.121 ac 23.04% Impervious Runoff Depth=2.38"
Flow Length=3,395' Tc=82.4 min CN=72/98 Runoff=11.74 cfs 9.756 af

Subcatchment83S: West_2 Runoff Area=13.109 ac 21.69% Impervious Runoff Depth=2.35"
Flow Length=1,848' Tc=53.5 min CN=72/98 Runoff=3.76 cfs 2.568 af

Reach 56R: (new Reach) Avg. Flow Depth=0.52' Max Vel=4.37 fps Inflow=8.09 cfs 5.852 af
n=0.040 L=1,070.0' S=0.0561 '/' Capacity=31.31 cfs Outflow=8.08 cfs 5.852 af

Reach 58R: (new Reach) Avg. Flow Depth=0.58' Max Vel=4.91 fps Inflow=10.76 cfs 8.439 af
n=0.040 L=320.0' S=0.0625 '/' Capacity=33.06 cfs Outflow=10.75 cfs 8.439 af

Reach 59R: (new Reach) Avg. Flow Depth=0.71' Max Vel=4.03 fps Inflow=11.86 cfs 9.321 af
n=0.040 L=740.0' S=0.0338 '/' Capacity=24.30 cfs Outflow=11.85 cfs 9.321 af

Reach 60R: (new Reach) Avg. Flow Depth=0.85' Max Vel=4.90 fps Inflow=15.45 cfs 12.323 af
n=0.040 L=1,020.0' S=0.0392 '/' Capacity=49.95 cfs Outflow=15.44 cfs 12.323 af

Reach 62R: (new Reach) Avg. Flow Depth=1.07' Max Vel=4.98 fps Inflow=22.12 cfs 15.760 af
n=0.040 L=630.0' S=0.0317 '/' Capacity=44.94 cfs Outflow=22.11 cfs 15.760 af

Reach 63R: (new Reach) Avg. Flow Depth=1.41' Max Vel=4.13 fps Inflow=28.15 cfs 20.810 af
n=0.040 L=1,240.0' S=0.0161 '/' Capacity=32.03 cfs Outflow=28.04 cfs 20.810 af

Pond 53P: Inflow=17.11 cfs 12.508 af
Primary=17.11 cfs 12.508 af

Pond 64P: Inflow=39.11 cfs 27.162 af
Primary=39.11 cfs 27.162 af

Total Runoff Area = 207.261 ac Runoff Volume = 39.670 af Average Runoff Depth = 2.30"
86.26% Pervious = 178.782 ac 13.74% Impervious = 28.479 ac