Preliminary Stormwater Technical Information Report

Columbia Precast Products
Woodland Site Expansion
Woodland, WA

Submitted to:
City of Woodland

Prepared By:

GIBBS & OLSON
CIVIL ENGINEERS • LAND SURVEYORS

June 2021
Gibbs & Olson Project No. 0788.0231

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Table of Contents

Section A – Project Overview

Introduction

Columbia Precast Products (CPP) is proposing to develop Lot 1 (City of Woodland Parcel Number 5083301010) of the Centennial Industrial Park Binding Site Plan (City of Woodland BSP 2018-001). The property is owned by Garr/Hatt Woodland LLC and is located at the northwest corner of the intersection between Howard Way and Orchard Way Private Road, in Woodland, Washington. See the attached Vicinity Map in Appendix A. The Woodland Site Expansion project involves expanding the existing gravel laydown yard from CPP's property, City of Woodland Parcel Number 508750100, directly north of Lot 1. The improvements will include the expansion of CPP's existing facility with a gravel surface for storage area and storm drainage improvements. No buildings or structures are associated with the proposed improvements and water connections, sewer connections, or fire suppression supply will not be extended through the site. The site will be fully fenced and take access from CPP's existing property to the north. A driveway connection to Orchard Way Private Road will be constructed for emergency services only.

Existing Conditions

The overall property totals approximately 6.7 acres of light industrial zoned land. The proposed property is undeveloped, and the existing ground is predominately covered with grass. Web Soil Survey developed by the US Department of Agriculture - Natural Resources Conservation Service classifies soils in the southern quarter of the site as Hydrologic Soil Group (HSG) B and soils in the northern three quarters as HSG C/D, see the Soil Map in Appendix A. The topography of the site is such that it gently slopes from south to north, see the Pre-Developed Basin Map in Appendix A. The existing runoff from the site is primarily overland flow with most of the rainfall retained and infiltrated on-site. What does not infiltrate flows overland to the north.

Proposed Conditions

Site improvements include expanding the gravel storage area and drive aisles from CPP's existing site located directly north of Lot 1 totaling approximately 5.4 acres of new gravel surface. A combination stormwater wetpond and detention pond will provide for treatment and flow control of the runoff from the new gravel surface. A series of catch basins will collect stormwater runoff and convey it into the stormwater pond. See the Post-Developed Basin Map in Appendix A for post-developed areas.

After flow control, treated stormwater will be discharged across Guild Road into a ditch owned by Consolidated Diking Improvement District 2 which eventually connects to Goerig Slough. See Construction Drawing C1 for the layout of the proposed storm drain conveyance system.

This project will add more than 5,000 square feet of new impervious surface with the expansion of the gravel laydown yard; therefore, all minimum requirements apply to this project.

Section B – Approval Conditions Summary

Preliminary approval conditions associated with this project are included in the Type II Site Plan review comments and will be addressed as a part of this submittal. The proposed project follows the City of Woodland Stormwater Code requirements and the Department of Ecology's Stormwater Management Manual for the Puget Sound Basin, February 1992 Edition (The Puget Sound Manual).

Section C – Downstream Analysis

The stormwater runoff from the proposed site improvements is detained onsite such that the peak release rates for the developed site for the 2-, 10-, 25- and 100-year 24-hour storm events do not exceed the respective predeveloped rates. Therefore, an offsite analysis is not applicable to this project.

Section D – Quantity Control Analysis and Design

Hydrologic Analysis

Criteria

WMC Chapter 15.12 Stormwater Management states for surface runoff leaving a developed site "The peak release rate for the 2-, 10-, 25-, and 100-year, 24-hour design storms after development shall not exceed the respective predevelopment rates." To ensure these standards are met "the volume available for storing runoff in a stormwater facility shall be reduced by an assumed starting condition equivalent to an immediately prior two-year event." This condition was applied to the sizing of the stormwater pond for the runoff from the new gravel surface.

Rainfall totals for 2-, 10-, 25- and 100-year, 24-hour design storm events for the Woodland area were determined from the isopluvial maps for design storms in Cowlitz County listed in the NOAA Atlas 2, "Precipitation Frequency Atlas for the Western United States, Volume IX – Washington". The rainfall totals are 2.40 inches per hour (in/hr), 3.41 in/hr, 3.79 in/hr, and 4.55 in/hr for the 2-, 10-, 25- and 100-year, 24-hour design storm events, respectively.

The existing conditions for the site are described in Section A, Existing Conditions. The existing land use is modeled as pasture/grassland/range in fair condition with the HSG's shown in the Pre-Developed Basin Map. The proposed improvements for the site are described in Section A, Proposed Conditions. The proposed land use is modeled as a combination of gravel roads, grass cover in good condition, and pond water surface area with the HSG's shown in the Pos-Developed Basin Map. The developed site for the proposed site improvements is comprised of a single basin. See the modeling results in Appendix B for land use values.

Results

The proposed detention pond is designed to detain the runoff from the proposed improvements. Detention volume (live storage) is designed to be constructed above required water quality volume (dead storage), see Section F. Based on the single event hydrograph modeling using HydroCAD, the required storage volume was sized such that the combined peak release rates from the pond in the developed condition shall not exceed the peak runoff rate from the pre-developed 2-year, 10-year, 25-year, and 100-year 24-hour storm. A starting condition equivalent to an immediately prior two-year event was assumed for the stormwater pond which resulted in a water surface elevation 0.44 feet above the dead storage and an increase in pond water surface area of 0.022 acres. Modeling results for the ponds, with the surface area shown on the Pre-Developed Basin Map, indicates a total depth required of 1-feet is needed to provide the required storage volume with 1 foot of freeboard.

Quantity Control System Design

The proposed stormwater quantity control design meets or exceeds the City of Woodland Stormwater Code requirements and the 1992 Puget Sound Manual. Flow control for stream bank protection is accomplished through detention of the stormwater runoff from the proposed site improvements to achieve the required pre-developed release rates.

Per the geotechnical site investigation, see Section G, groundwater was encountered at 7 to 8 feet below ground surface near the location of the pond. During excavation of the nearby stormwater pond on Lot B of City of Woodland BSP 2018-001 (see Construction Drawing G4 - Existing Conditions Plan) groundwater was encountered at elevation 14.5 feet (6 to 8.5 feet below ground surface) in the Spring and was not present in the pond with maximum depths of 10 feet below ground surface in the month of June. Detention volume will be 1.5 to 3 feet below ground surface on average which provides adequate separation between live storage and the measured groundwater elevation.

Quantity Control System Plan

Design details for the pond and outlet structure are included on Construction Drawing C4 and C6.

Section E – Conveyance System Analysis and Design

Per City of Woodland Stormwater Code, the conveyance system was sized to pass the 24-hour, 100-year design storm in open flow conditions. For this project, the conveyance system is analyzed at critical points where critical points are defined as the furthest downstream pipe of a single pipe diameter. This method of analyzing critical points verifies all pipes in the conveyance system meet conveyance criteria. See Appendix C for conveyance modeling and Construction Drawing C1 for design of the stormwater conveyance system. The analysis is performed downstream to upstream, and Manning's equation is used to calculate pipe capacity.

The stormwater conveyance system is designed with 12-inch, 15-inch, and 18-inch concrete pipe at minimum slopes of 0.003 ft/ft, 0.0023 ft/ft, and 0.0018 ft/ft respectively. The most downstream critical point of the conveyance system is the 15-inch diameter stormwater pipe (number P0 in Appendix C) conveying stormwater from the pond across Guild Road and to the outfall in the ditch. 15-inch diameter concrete pipe at the minimum slope has a capacity of 3.35 cfs. Peak discharge from the pond during the 100-year storm is modeled as 2.90 cfs; therefore, Pipe P0 meets the conveyance criteria.

The gravel laydown yard was split into nine areas (S6 to S14 in Appendix C) each draining to catch basins placed at the low point. The conveyance system connects the catch basins and conveys water from east to west. Stormwater conveyance pipes start at 12-inch diameter and upsize as the additional flow from each drainage area requires a higher capacity pipe. The conveyance system ends with an 18-inch diameter pipe (number P1 in Appendix C) which outfalls into the stormwater pond. As shown in the HydroCAD report, peak discharge through this pipe is 4.76 cfs and an 18-inch concrete pipe at the minimum slope has a capacity of 4.83 cfs; therefore, pipe P1 meets the conveyance criteria. The 18-inch diameter concrete pipe downsizes to 15-inch diameter concrete pipe at Catch Basin S6. The 15-inch diameter concrete pipe is numbered P3 in the HydroCAD report. Peak discharge through this pipe is modeled as 3.24 cfs and 15-inch concrete pipe at the minimum slope has a capacity of 3.35 cfs; therefore, Pipe P3 meets the conveyance criteria.

The conveyance system downsizes from 15-inch diameter concrete pipe to 12-inch diameter concrete pipe at Catch Basin S10. The 12-inch diameter concrete pipe is numbered P7 in the HydroCAD report. Peak discharge through this pipe is modeled as 1.39 cfs and 12-inch diameter concrete pipe at the minimum slope has a capacity of 2.11 cfs; therefore, Pipe P7 meets the conveyance criteria.

Section F – Water Quality Design

This project will add more than 5,000 square feet of new pollution-generating impervious surface (PGIS) with the construction of the proposed road improvements; therefore, basic treatment is required prior to detention. The treatment of the new impervious surface for this project will be addressed through the use of a wet pond. Stormwater runoff from the gravel laydown area will be collected via a series of catch basins and conveyed to the wetpond. The wetpond is designed by utilizing a storage area underneath required detention storage for treatment, thus the pond has both live storage for detention and dead storage for treatment. The treatment BMP's are designed using the 6-month, 24-hour water quality design storm runoff volume defined as 64% of the 2-year, 24-hour design storm, or 1.54 inches. This volume is modeled in HydroCAD; see Appendix B for modeling results.

The proposed wetpond is designed per BMP RD.05 of the Puget Sound Manual to meet or exceed the water quality design storm runoff volume, with the layout consisting of two cells, a minimum 3-foot depth and an approximate length to width ratio of 6.5:1. The pond inlet and outlet are located on opposite sides of the pond to promote water residence time. Specific wetpond construction details are included on Construction Drawing C4. Columbia Precast Products will retain ownership and privately maintain the stormwater pond.

Section G – Soils Evaluation

Using the USDA Natural Resources Conservation Service (NRCS) the soils for this property have been identified as Clato silt loam with 0 to 3 percent slopes and Caples silty clay loam with 0 to 3 percent slopes. The Clato soil is classified as a soils hydrologic group B and the Caples soil is classified as a soils hydrologic group C/D. A soils map and descriptions are provided in Appendix A. A geotechnical evaluation was performed by Columbia West Engineering, Inc. on August 12, 2019, for the Centennial Industrial Park Site

Development project which includes Lot 1. The geotechnical evaluation includes infiltration testing results showing infiltration rates of 1.3 inches per hour closest to the proposed stormwater pond and other rates of 0.4 inches per hour and 2.5 inches per hour onsite. The Geotechnical Site Investigation is included in Appendix D.

Section H – Special Reports and Studies

The previous reports conducted as a part of Centennial Industrial Park, which were submitted to City of Woodland with the Binding Site Plan, are used for this project and include a Cultural Resources Risk Assessment report prepared in August 2018 by Historical Research Associates and an ESA Compliance report prepared in August 2018 by Ecological Land Services.

There are no known wetlands on this site. The proposed site is protected by a dike and therefore is not considered to be in a floodplain. The site is not located within the shoreline management area.

Section I – Other Permits

The proposed construction for this project will disturb over an acre of land. Therefore, a Construction Stormwater Permit and a Stormwater Pollution Prevention Plan is required for this project. A Temporary Sediment and Erosion Control (TESC) plan has been included with the Construction Drawings, see Drawing SP1.

A Type II Site Plan has been submitted to City of Woodland for concurrent review with Clark County Fire and Rescue. This TIR and the Construction Drawings address all comments from the Type II Site Plan Review. Other permits or forms which shall be obtained or completed prior to construction include:

- Fill and Grade Permit
- Critical Areas Checklist
- Land Use Application Form

Section J – Ground Water Monitoring Program

Infiltration was not incorporated into the design of the proposed stormwater facility; therefore, a ground water monitoring program is not required for this project at this time.

Section K – Operations and Maintenance Manual

The proposed stormwater facility will be privately owned and maintained by Columbia Precast Products. An Operations and Maintenance Manual is included in Appendix E.

Section L – Technical Appendix

Appendix A

Maps

Appendix B

Stormwater Pond Modeling Results

Appendix C

Conveyance Modeling Results

Appendix D

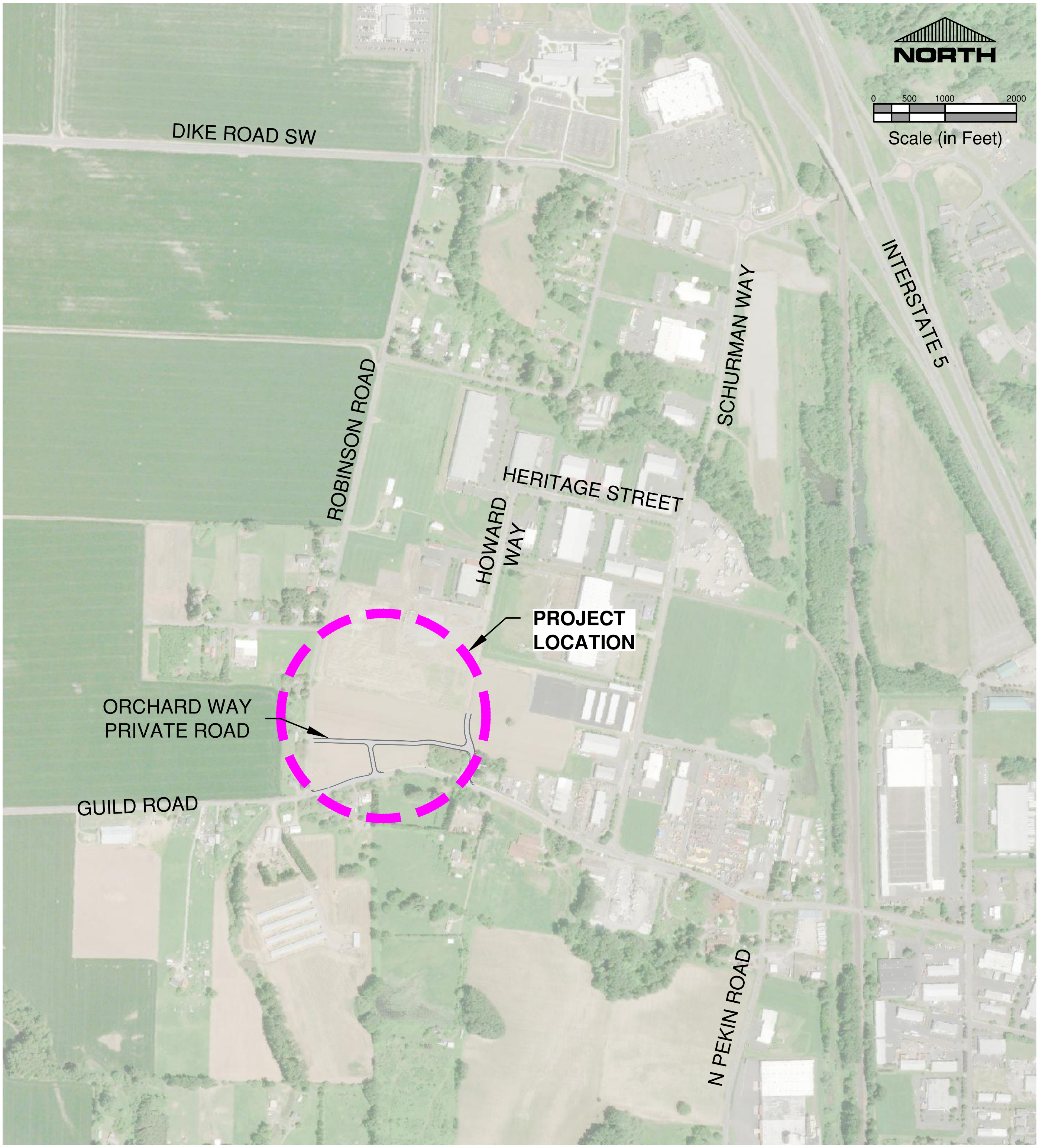
Geotechnical Site Investigation

Appendix E

Operations and Maintenance Manual

Appendix A

Maps



Vicinity Map

Scale: 1" = 1000'

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Columbia Precast Products
Woodland Site Expansion
Vicinity Map

Hydrologic Soil Group—Cowlitz County, Washington
(Columbia Precast Products | Woodland Site Expansion)

Map Scale: 1:1,770 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0, 25, 50, 100, 150

Feet: 0, 50, 100, 200, 300

Map projection: Web Mercator   Corner coordinates: WGS84

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 1:24,000.

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:
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: Cowlitz County, Washington
Survey Area Data: Version 21, Jun 4, 2020

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

Date(s) aerial images were photographed: Apr 26, 2019—Jun 11, 2019

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

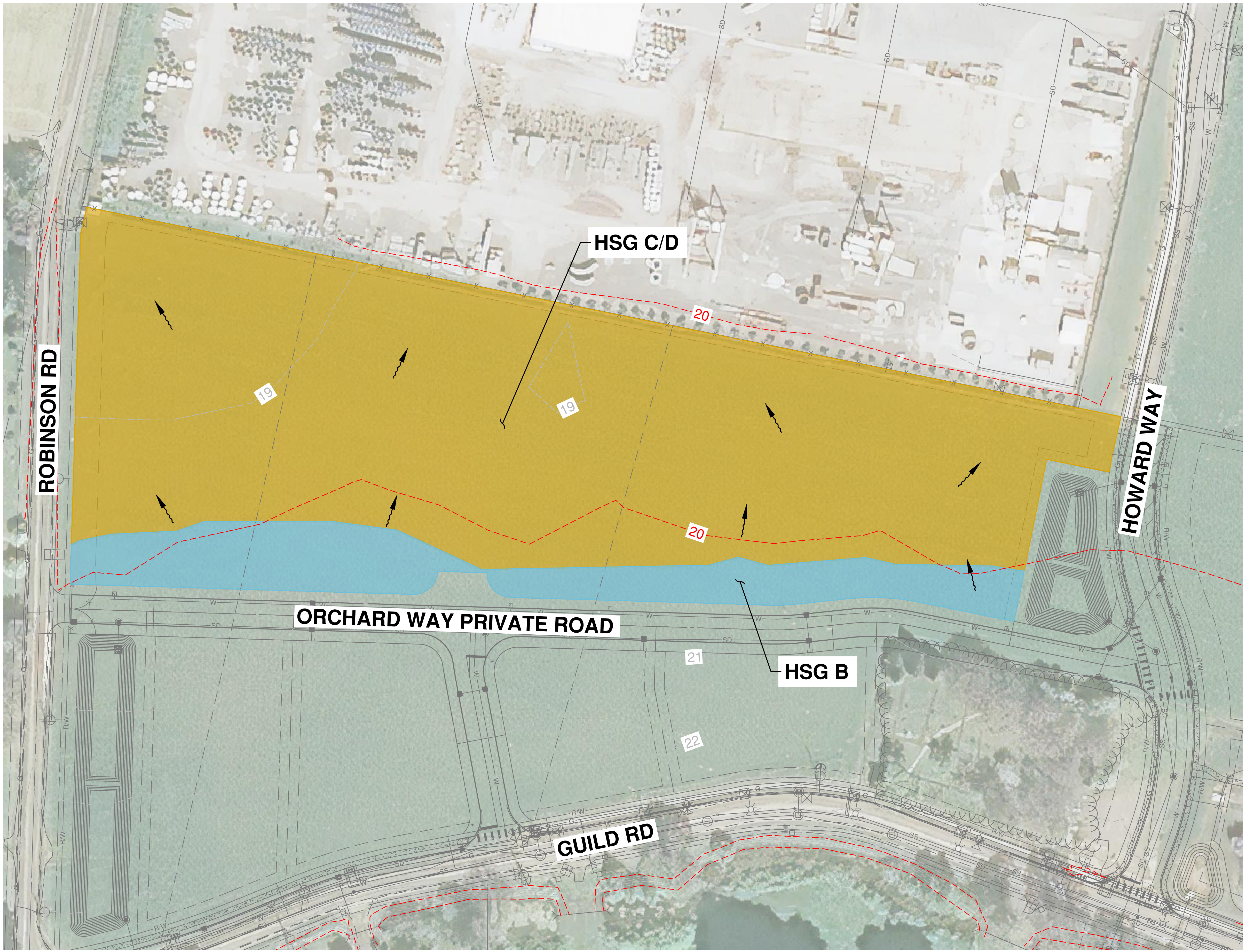
Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
17	Caples silty clay loam, 0 to 3 percent slopes	C/D	8.4	76.0%
32	Clato silt loam, 0 to 3 percent slopes	B	2.7	24.0%
Totals for Area of Interest			**11.1**	**100.0%**

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher



NORTH

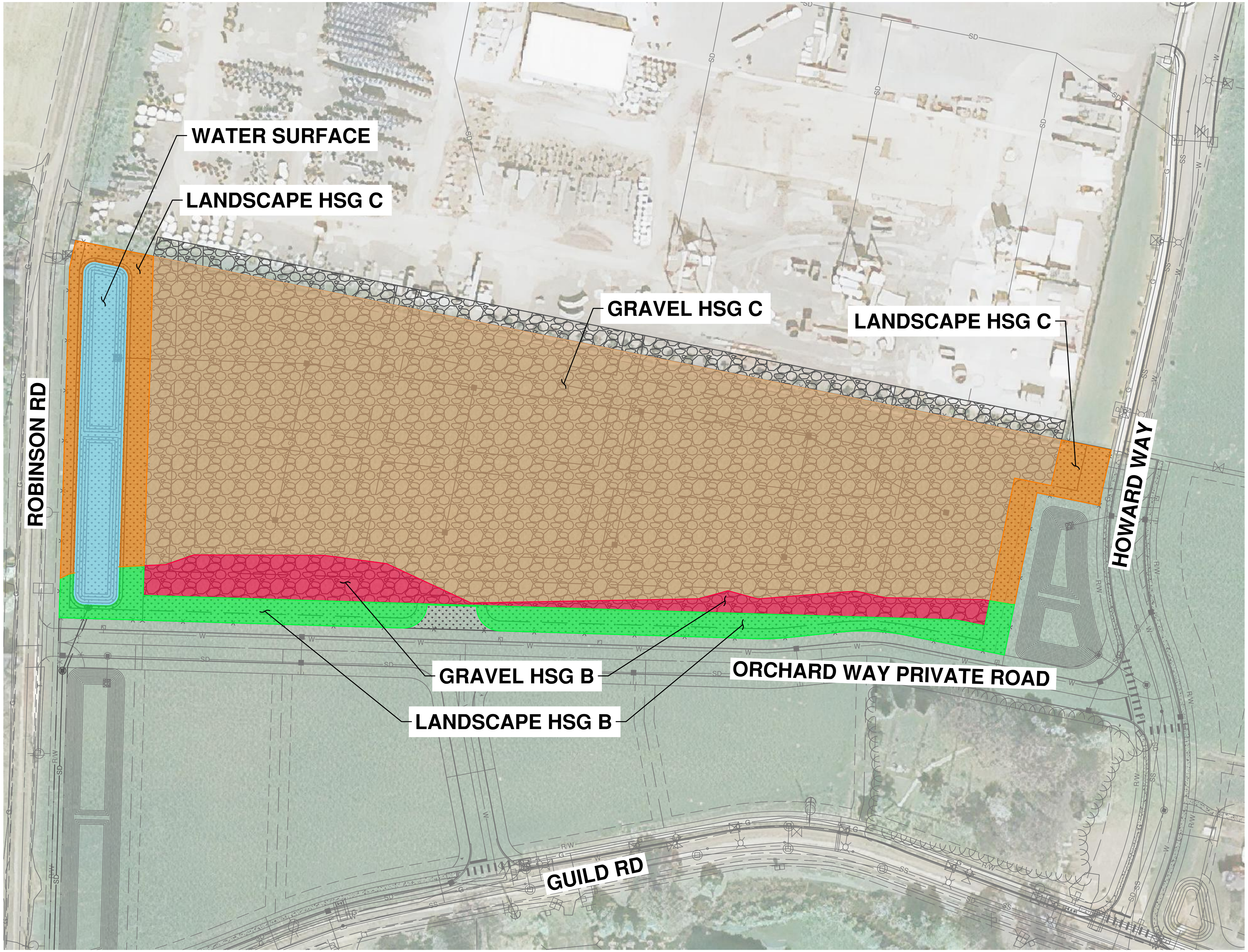
0 50 100 200

Scale (in Feet)

PRE-DEVELOPED BASIN INFORMATION

TOTAL:	6.679 ACRES
HSG B:	1.006 ACRES
HSG C/D:	5.673 ACRES

Columbia Precast Products
Woodland Site Expansion
Pre-Developed Basin Map



NORTH

0 50 100 200

Scale (in Feet)

DEVELOPED BASIN INFORMATION

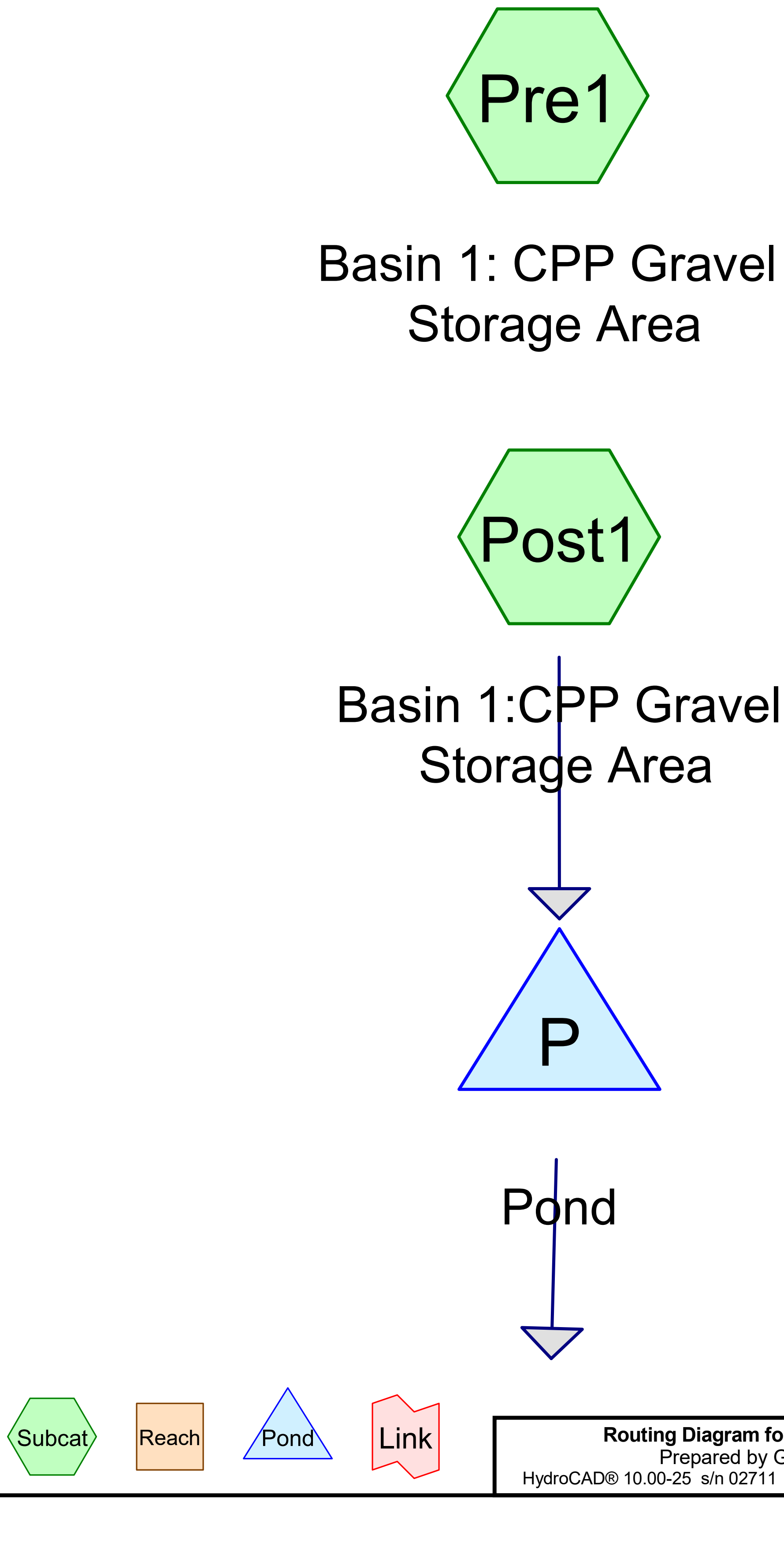
TOTAL:	6.679 ACRES
WATER SURFACE:	0.318 ACRES
GRAVEL HSG C:	4.908 ACRES
GRAVEL HSG B:	0.454 ACRES
LANDSCAPE HSG C:	0.479 ACRES
LANDSCAPE HSG B:	0.520 ACRES

Columbia Precast Products
Woodland Site Expansion
Post-Developed Basin Map

Appendix B

Stormwater Pond Modeling Results

Quantity Control System Design



Routing Diagram for Columbia Wetpond Sizing
Prepared by GNS, Printed 6/7/2021
HydroCAD® 10.00-25 s/n 02711 © 2019 HydroCAD Software Solutions LLC

Summary for Subcatchment Post1: Basin 1:CPP Gravel Storage Area

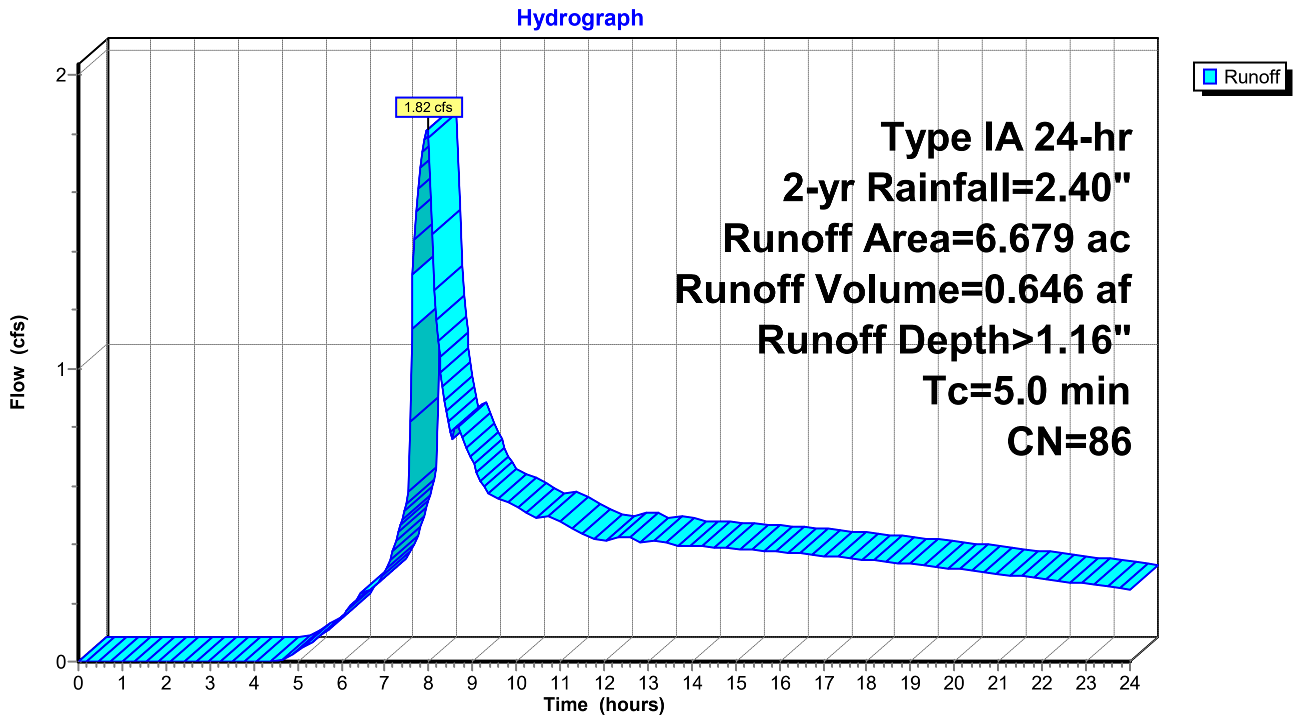
Runoff = 1.82 cfs @ 7.97 hrs, Volume= 0.646 af, Depth> 1.16"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.04 hrs
Type IA 24-hr 2-yr Rainfall=2.40"

Area (ac)	CN	Description
0.341	98	Water Surface, HSG C
4.908	89	Gravel roads, HSG C
0.454	85	Gravel roads, HSG B
0.458	74	>75% Grass cover, Good, HSG C
0.518	61	>75% Grass cover, Good, HSG B
6.679	86	Weighted Average
6.338		94.89% Pervious Area
0.341		5.11% Impervious Area

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

Subcatchment Post1: Basin 1:CPP Gravel Storage Area



Summary for Subcatchment Pre1: Basin 1: CPP Gravel Storage Area

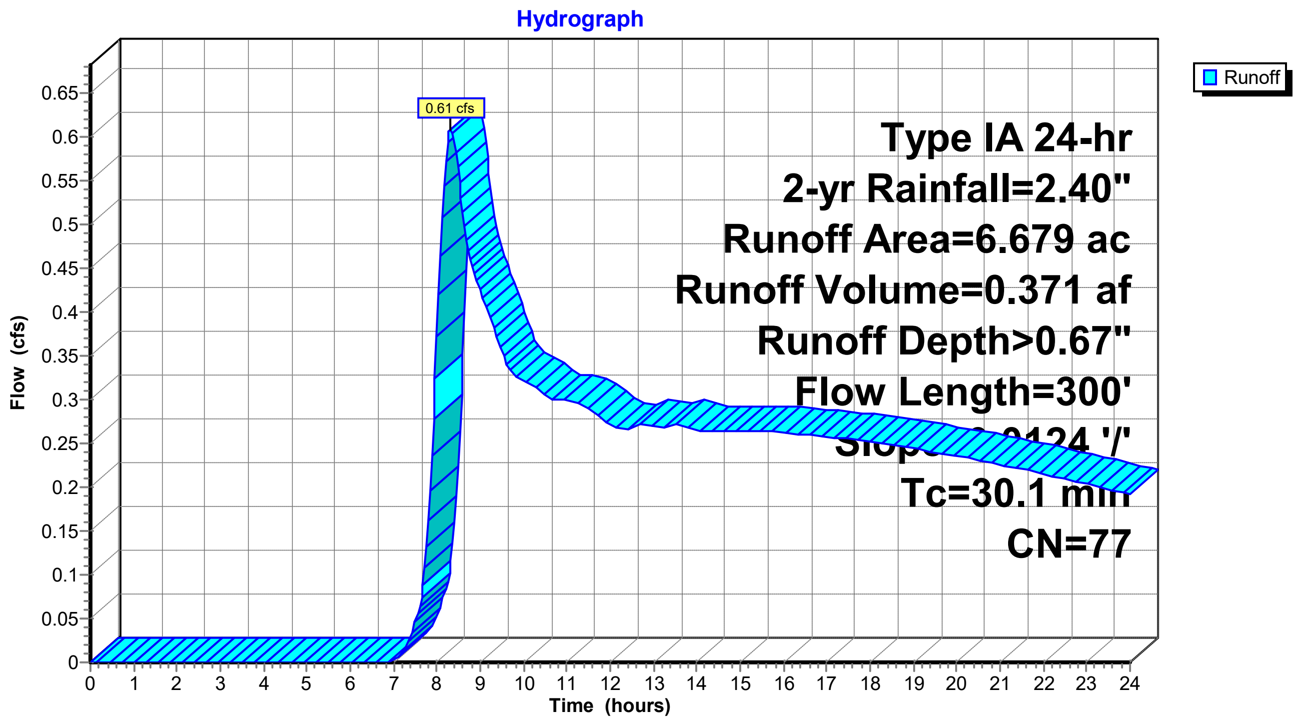
Runoff = 0.61 cfs @ 8.32 hrs, Volume= 0.371 af, Depth> 0.67"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.04 hrs
Type IA 24-hr 2-yr Rainfall=2.40"

Area (ac)	CN	Description
5.673	79	Pasture/grassland/range, Fair, HSG C
1.006	69	Pasture/grassland/range, Fair, HSG B
6.679	77	Weighted Average
6.679		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
27.6	150	0.0124	0.09		**Sheet Flow,** Grass: Dense n= 0.240 P2= 2.40"
2.5	150	0.0124	1.00		**Shallow Concentrated Flow, High Grass** Kv= 9.0 fps
30.1	300	Total			

Subcatchment Pre1: Basin 1: CPP Gravel Storage Area



Summary for Pond P: Pond

Inflow Area = 6.679 ac, 5.11% Impervious, Inflow Depth > 1.16" for 2-yr event
Inflow = 1.82 cfs @ 7.97 hrs, Volume= 0.646 af
Outflow = 0.61 cfs @ 9.20 hrs, Volume= 0.690 af, Atten= 66%, Lag= 73.7 min
Primary = 0.61 cfs @ 9.20 hrs, Volume= 0.690 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.04 hrs
Starting Elev= 0.44' Surf.Area= 14,844 sf Storage= 6,312 cf
Peak Elev= 0.48' @ 9.20 hrs Surf.Area= 14,924 sf Storage= 6,838 cf (526 cf above start)

Plug-Flow detention time= 205.5 min calculated for 0.544 af (84% of inflow)
Center-of-Mass det. time= (not calculated: outflow precedes inflow)

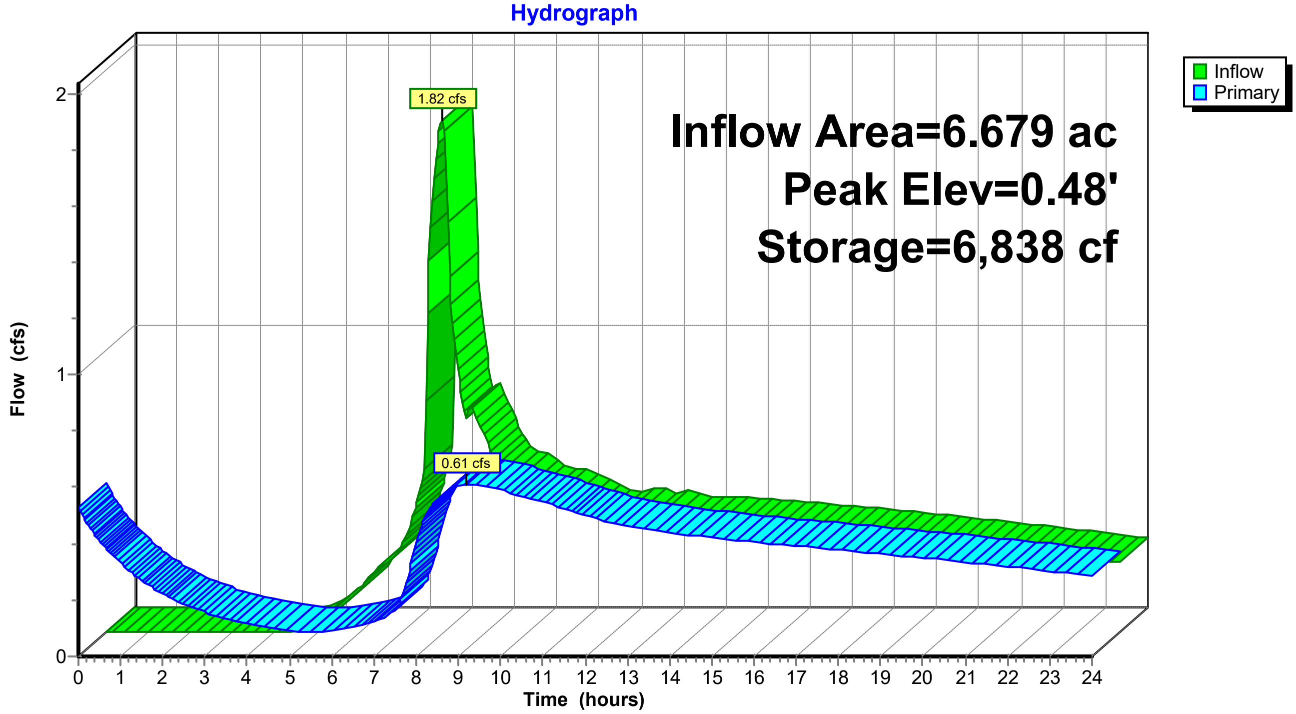
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	32,253 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
0.00	13,847	0	0
1.00	16,112	14,980	14,980
2.00	18,434	17,273	32,253

Device	Routing	Invert	Outlet Devices
#1	Primary	0.00'	**7.4" Vert. Orifice/Grate** C= 0.600
#2	Primary	0.85'	**18.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#3	Primary	0.40'	**6.0" W x 4.8" H Vert. Orifice/Grate** C= 0.600

Primary OutFlow Max=0.61 cfs @ 9.20 hrs HW=0.48' (Free Discharge)
├─**1=Orifice/Grate** (Orifice Controls 0.58 cfs @ 2.35 fps)
├─**2=Orifice/Grate** (Controls 0.00 cfs)
└─**3=Orifice/Grate** (Orifice Controls 0.03 cfs @ 0.88 fps)

Pond P: Pond


Hydrograph
Inflow
Primary
1.82 cfs
0.61 cfs
Inflow Area=6.679 ac
Peak Elev=0.48'
Storage=6,838 cf
Flow (cfs)
Time (hours)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24

Summary for Subcatchment Post1: Basin 1:CPP Gravel Storage Area

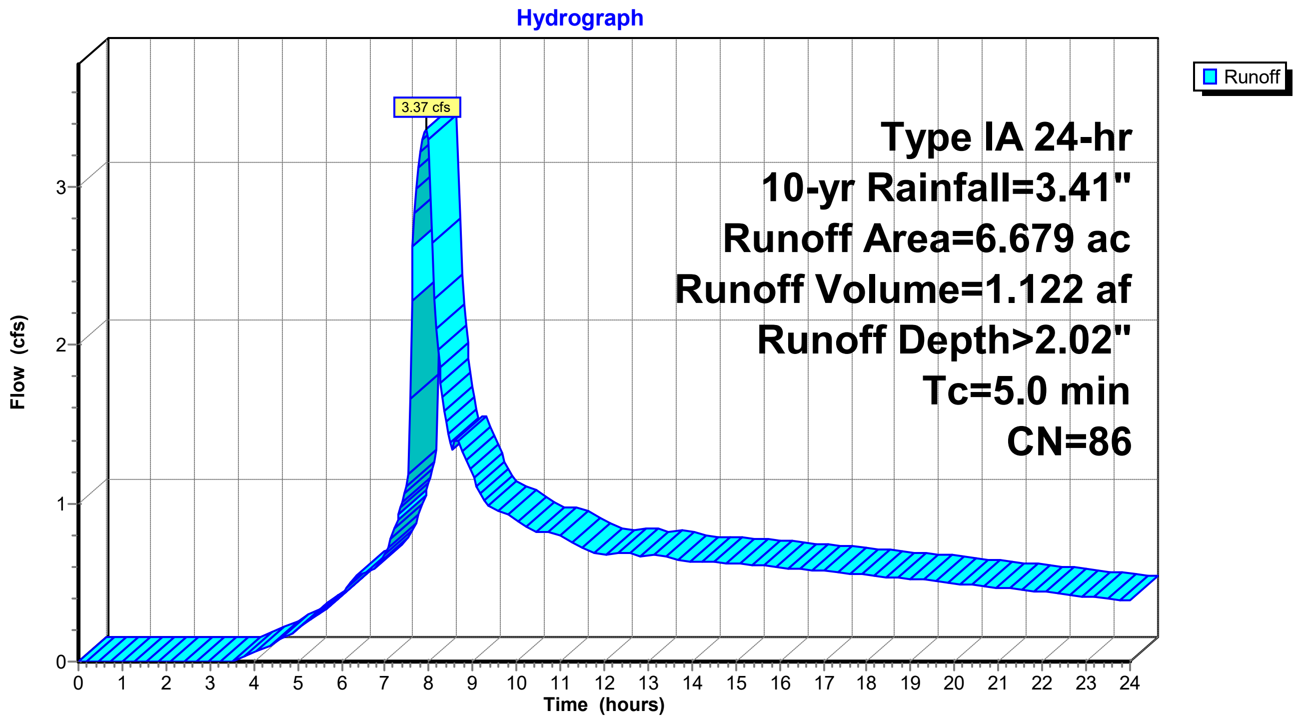
Runoff = 3.37 cfs @ 7.93 hrs, Volume= 1.122 af, Depth> 2.02"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.04 hrs
Type IA 24-hr 10-yr Rainfall=3.41"

Area (ac)	CN	Description
0.341	98	Water Surface, HSG C
4.908	89	Gravel roads, HSG C
0.454	85	Gravel roads, HSG B
0.458	74	>75% Grass cover, Good, HSG C
0.518	61	>75% Grass cover, Good, HSG B
6.679	86	Weighted Average
6.338		94.89% Pervious Area
0.341		5.11% Impervious Area

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

Subcatchment Post1: Basin 1:CPP Gravel Storage Area



Summary for Subcatchment Pre1: Basin 1: CPP Gravel Storage Area

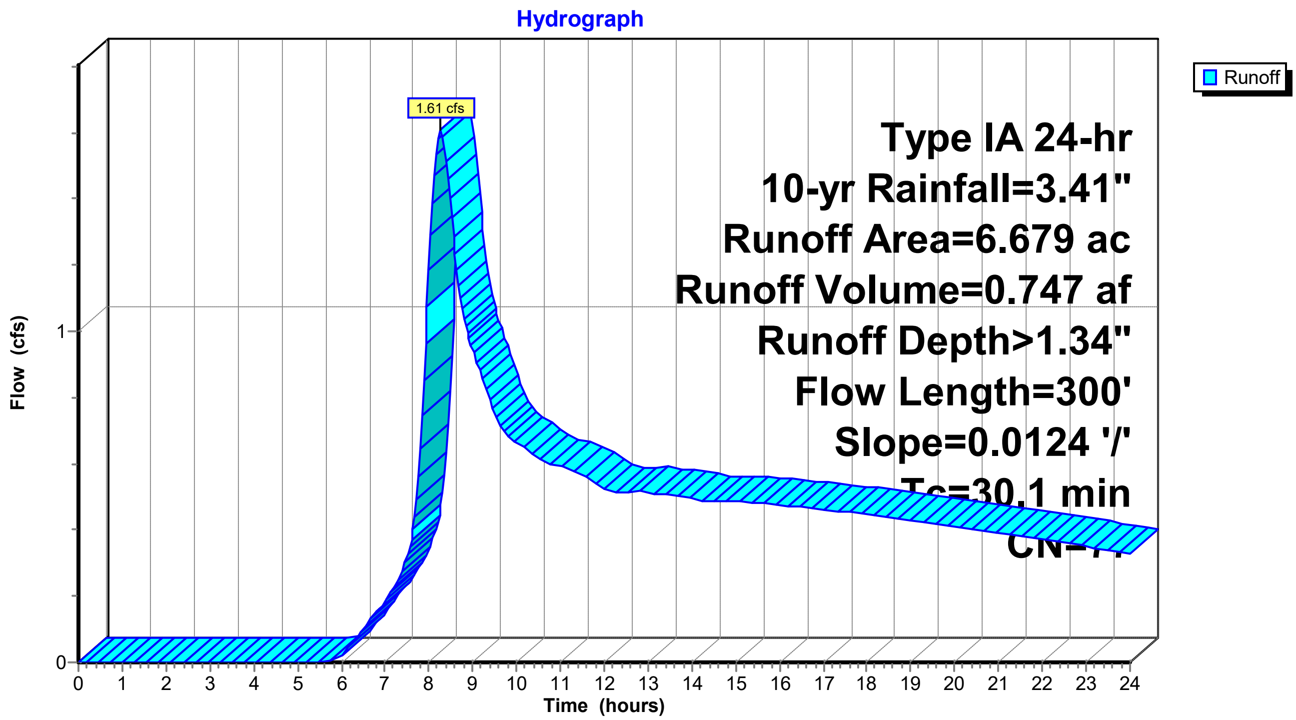
Runoff = 1.61 cfs @ 8.26 hrs, Volume= 0.747 af, Depth> 1.34"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.04 hrs
Type IA 24-hr 10-yr Rainfall=3.41"

Area (ac)	CN	Description
5.673	79	Pasture/grassland/range, Fair, HSG C
1.006	69	Pasture/grassland/range, Fair, HSG B
6.679	77	Weighted Average
6.679		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
27.6	150	0.0124	0.09		**Sheet Flow,** Grass: Dense n= 0.240 P2= 2.40"
2.5	150	0.0124	1.00		**Shallow Concentrated Flow, High Grass** Kv= 9.0 fps
30.1	300	Total			

Subcatchment Pre1: Basin 1: CPP Gravel Storage Area



Summary for Pond P: Pond

Inflow Area = 6.679 ac, 5.11% Impervious, Inflow Depth > 2.02" for 10-yr event
Inflow = 3.37 cfs @ 7.93 hrs, Volume= 1.122 af
Outflow = 1.27 cfs @ 8.86 hrs, Volume= 1.137 af, Atten= 62%, Lag= 55.8 min
Primary = 1.27 cfs @ 8.86 hrs, Volume= 1.137 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.04 hrs
Starting Elev= 0.44' Surf.Area= 14,844 sf Storage= 6,312 cf
Peak Elev= 0.74' @ 8.86 hrs Surf.Area= 15,528 sf Storage= 10,901 cf (4,589 cf above start)

Plug-Flow detention time= 165.9 min calculated for 0.991 af (88% of inflow)
Center-of-Mass det. time= 9.5 min (780.3 - 770.8)

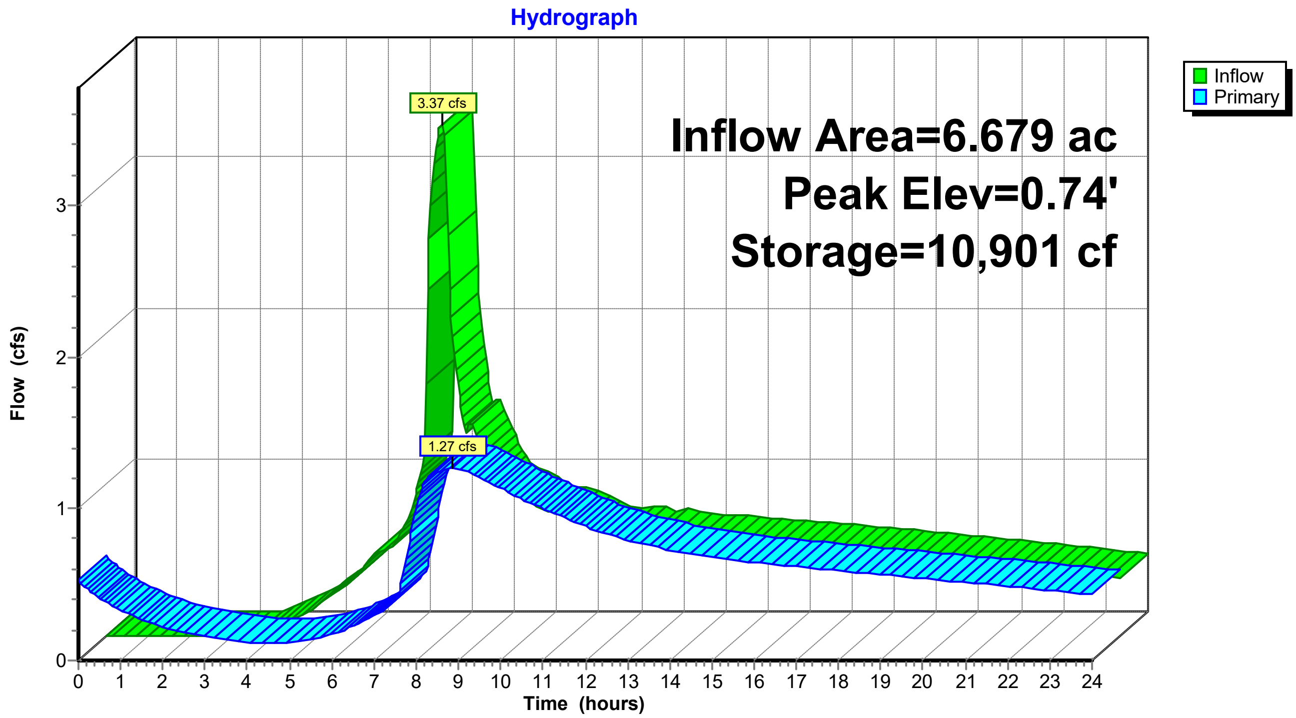
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	32,253 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
0.00	13,847	0	0
1.00	16,112	14,980	14,980
2.00	18,434	17,273	32,253

Device	Routing	Invert	Outlet Devices
#1	Primary	0.00'	**7.4" Vert. Orifice/Grate** C= 0.600
#2	Primary	0.85'	**18.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#3	Primary	0.40'	**6.0" W x 4.8" H Vert. Orifice/Grate** C= 0.600

Primary OutFlow Max=1.27 cfs @ 8.86 hrs HW=0.74' (Free Discharge)
├─**1=Orifice/Grate** (Orifice Controls 0.95 cfs @ 3.17 fps)
├─**2=Orifice/Grate** (Controls 0.00 cfs)
└─**3=Orifice/Grate** (Orifice Controls 0.32 cfs @ 1.88 fps)

Pond P: Pond


Hydrograph
Inflow
Primary
3.37 cfs
1.27 cfs
Inflow Area=6.679 ac
Peak Elev=0.74'
Storage=10,901 cf
Flow (cfs)
0
1
2
3
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time (hours)

Summary for Subcatchment Post1: Basin 1:CPP Gravel Storage Area

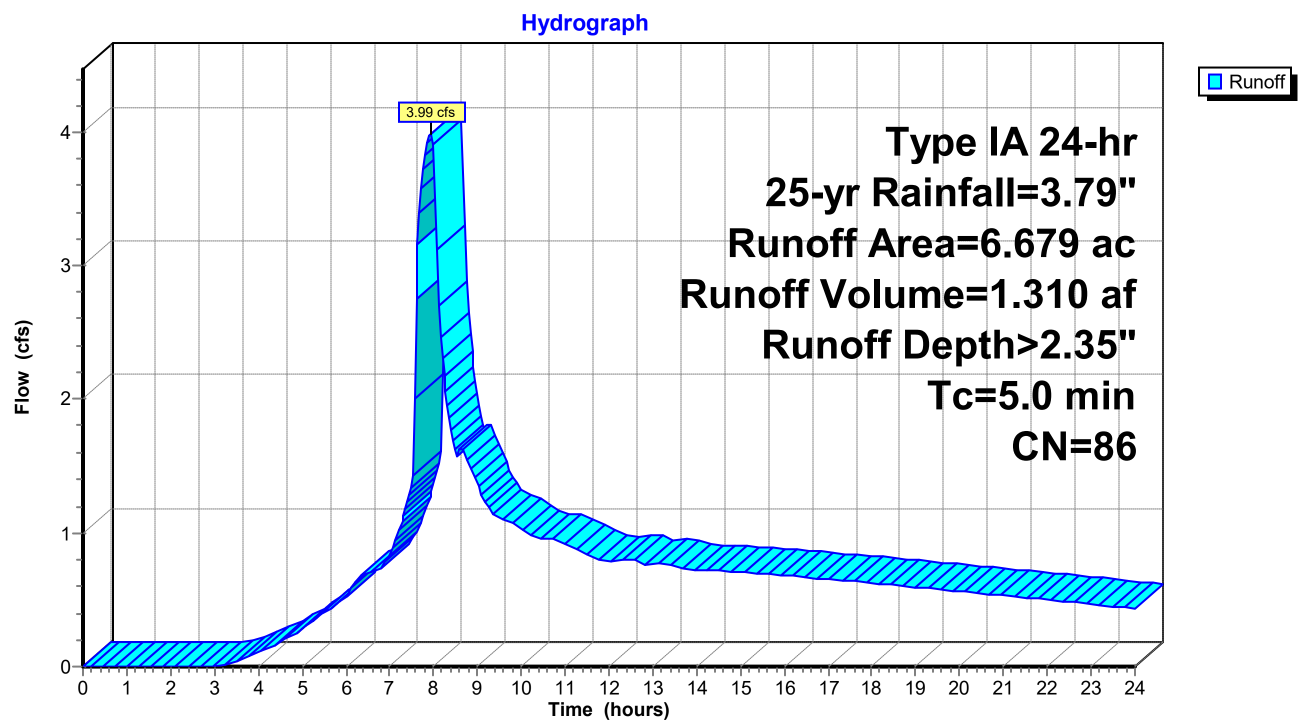
Runoff = 3.99 cfs @ 7.93 hrs, Volume= 1.310 af, Depth> 2.35"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.04 hrs
Type IA 24-hr 25-yr Rainfall=3.79"

Area (ac)	CN	Description
0.341	98	Water Surface, HSG C
4.908	89	Gravel roads, HSG C
0.454	85	Gravel roads, HSG B
0.458	74	>75% Grass cover, Good, HSG C
0.518	61	>75% Grass cover, Good, HSG B
6.679	86	Weighted Average
6.338		94.89% Pervious Area
0.341		5.11% Impervious Area

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

Subcatchment Post1: Basin 1:CPP Gravel Storage Area



Summary for Subcatchment Pre1: Basin 1: CPP Gravel Storage Area

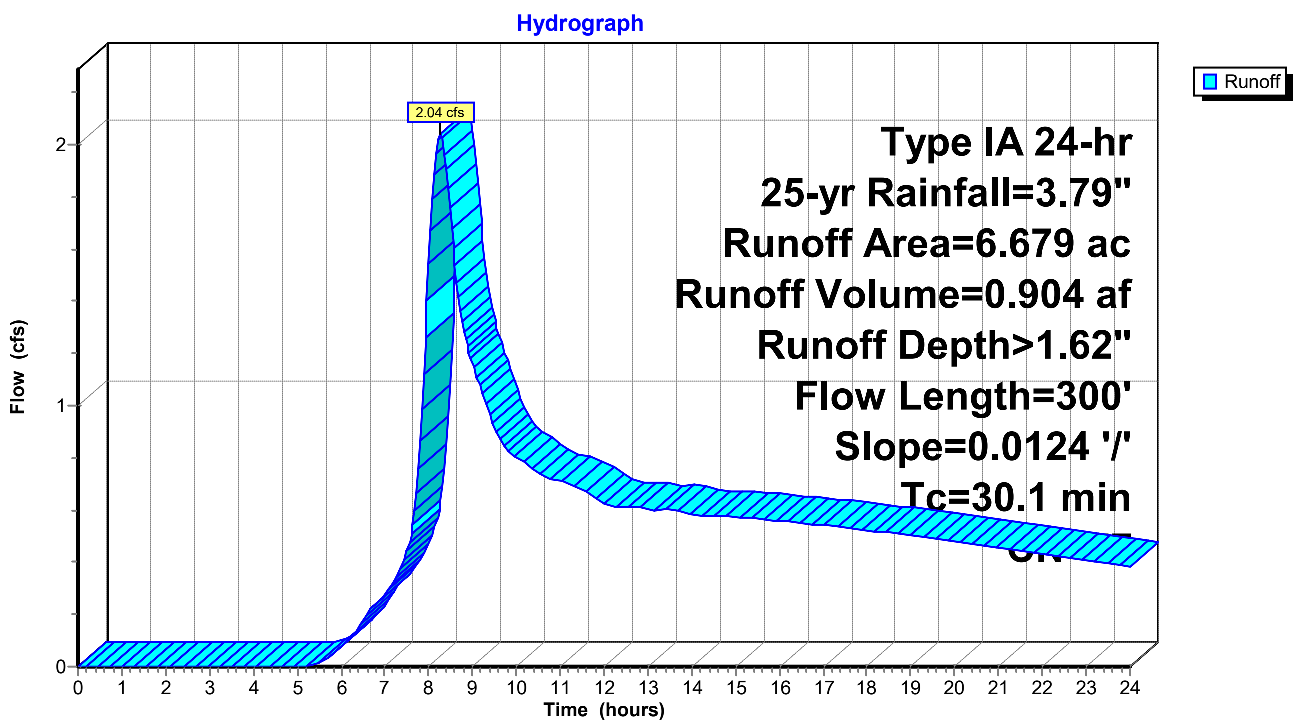
Runoff = 2.04 cfs @ 8.26 hrs, Volume= 0.904 af, Depth> 1.62"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.04 hrs
Type IA 24-hr 25-yr Rainfall=3.79"

Area (ac)	CN	Description
5.673	79	Pasture/grassland/range, Fair, HSG C
1.006	69	Pasture/grassland/range, Fair, HSG B
6.679	77	Weighted Average
6.679		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
27.6	150	0.0124	0.09		**Sheet Flow,** Grass: Dense n= 0.240 P2= 2.40"
2.5	150	0.0124	1.00		**Shallow Concentrated Flow, High Grass** Kv= 9.0 fps
30.1	300	Total			

Subcatchment Pre1: Basin 1: CPP Gravel Storage Area



Summary for Pond P: Pond

Inflow Area = 6.679 ac, 5.11% Impervious, Inflow Depth > 2.35" for 25-yr event
Inflow = 3.99 cfs @ 7.93 hrs, Volume= 1.310 af
Outflow = 1.52 cfs @ 8.81 hrs, Volume= 1.316 af, Atten= 62%, Lag= 53.2 min
Primary = 1.52 cfs @ 8.81 hrs, Volume= 1.316 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.04 hrs
Starting Elev= 0.44' Surf.Area= 14,844 sf Storage= 6,312 cf
Peak Elev= 0.85' @ 8.81 hrs Surf.Area= 15,766 sf Storage= 12,544 cf (6,233 cf above start)

Plug-Flow detention time= 157.8 min calculated for 1.171 af (89% of inflow)
Center-of-Mass det. time= 18.5 min (780.4 - 761.9)

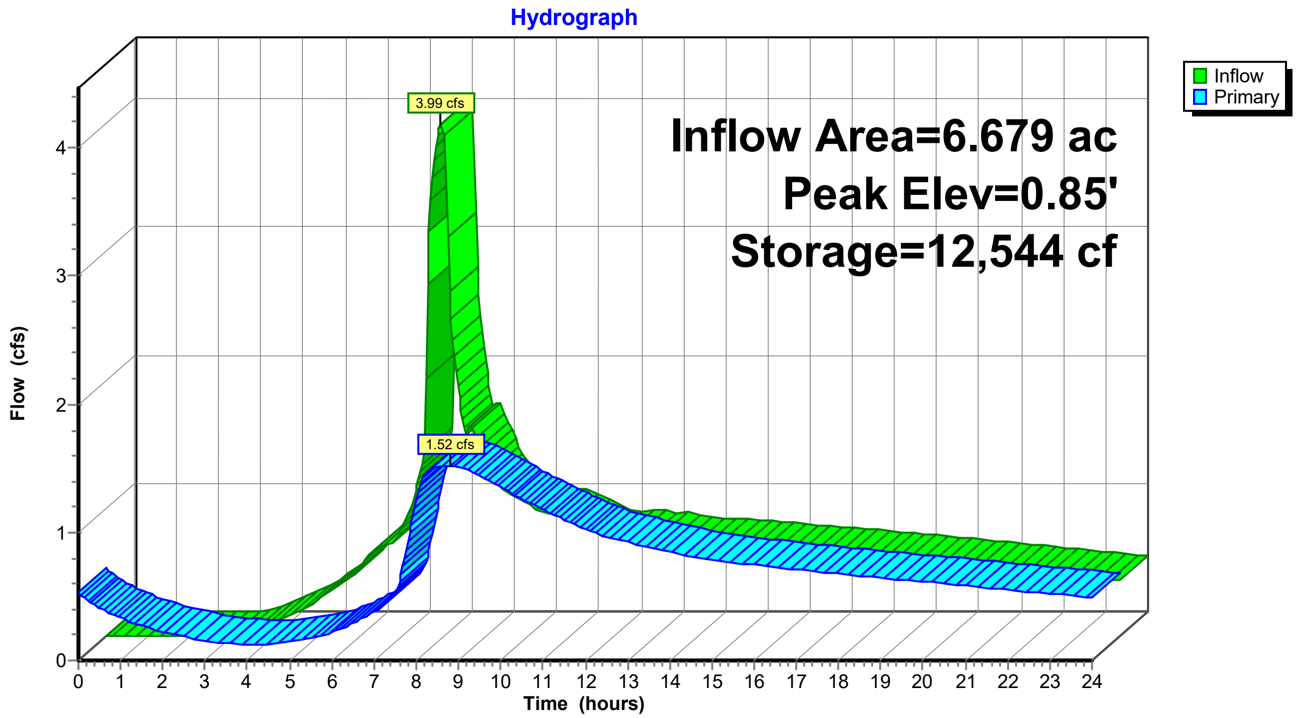
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	32,253 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
0.00	13,847	0	0
1.00	16,112	14,980	14,980
2.00	18,434	17,273	32,253

Device	Routing	Invert	Outlet Devices
#1	Primary	0.00'	**7.4" Vert. Orifice/Grate** C= 0.600
#2	Primary	0.85'	**18.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#3	Primary	0.40'	**6.0" W x 4.8" H Vert. Orifice/Grate** C= 0.600

Primary OutFlow Max=1.52 cfs @ 8.81 hrs HW=0.85' (Free Discharge)
├─**1=Orifice/Grate** (Orifice Controls 1.06 cfs @ 3.53 fps)
├─**2=Orifice/Grate** (Controls 0.00 cfs)
└─**3=Orifice/Grate** (Orifice Controls 0.46 cfs @ 2.32 fps)

Pond P: Pond


Hydrograph
Inflow
Primary
3.99 cfs
1.52 cfs
Inflow Area=6.679 ac
Peak Elev=0.85'
Storage=12,544 cf
Flow (cfs)
0
1
2
3
4
Time (hours)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

Summary for Subcatchment Post1: Basin 1:CPP Gravel Storage Area

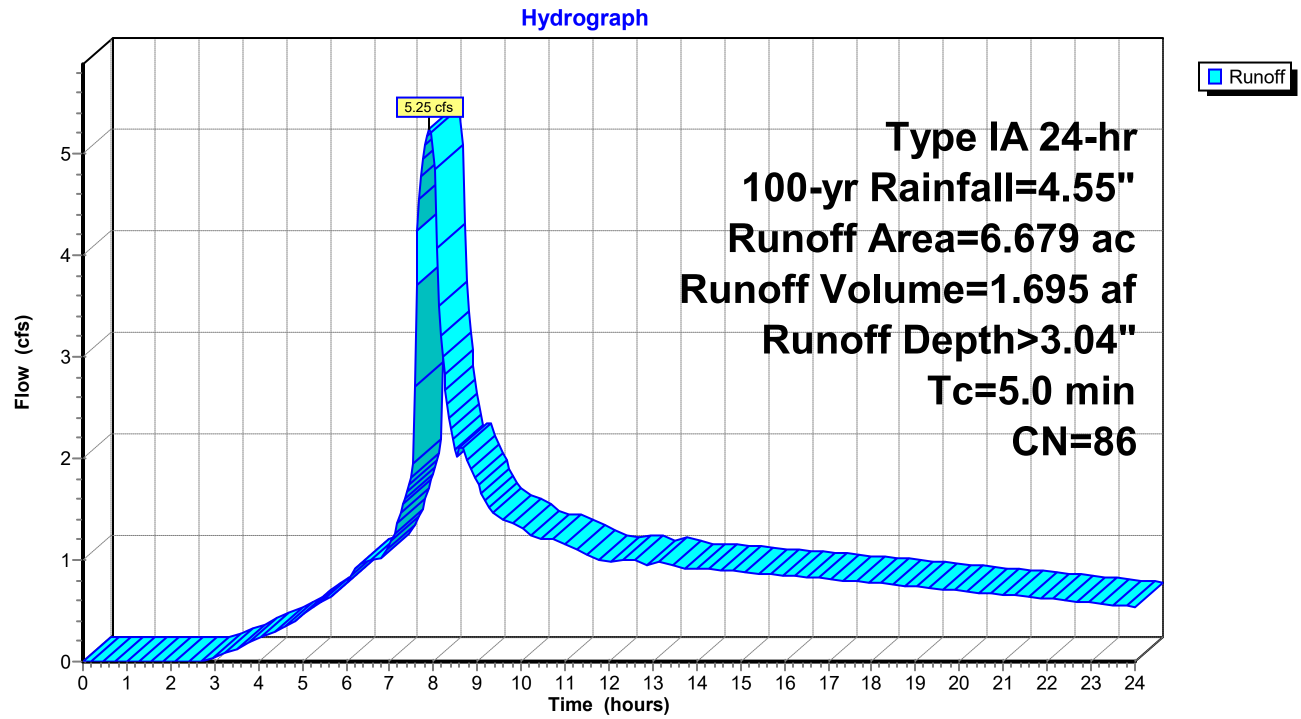
Runoff = 5.25 cfs @ 7.91 hrs, Volume= 1.695 af, Depth> 3.04"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.04 hrs
Type IA 24-hr 100-yr Rainfall=4.55"

Area (ac)	CN	Description
0.341	98	Water Surface, HSG C
4.908	89	Gravel roads, HSG C
0.454	85	Gravel roads, HSG B
0.458	74	>75% Grass cover, Good, HSG C
0.518	61	>75% Grass cover, Good, HSG B
6.679	86	Weighted Average
6.338		94.89% Pervious Area
0.341		5.11% Impervious Area

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

Subcatchment Post1: Basin 1:CPP Gravel Storage Area



Summary for Subcatchment Pre1: Basin 1: CPP Gravel Storage Area

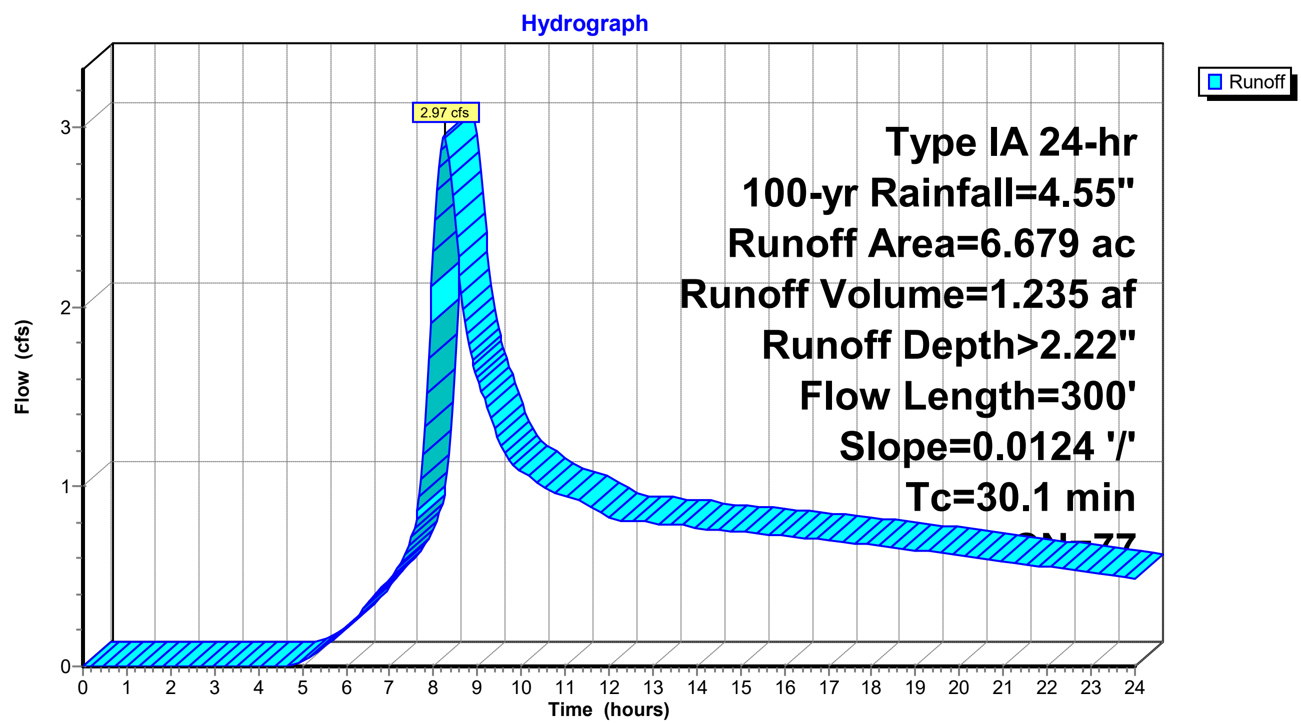
Runoff = 2.97 cfs @ 8.24 hrs, Volume= 1.235 af, Depth> 2.22"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.04 hrs
Type IA 24-hr 100-yr Rainfall=4.55"

Area (ac)	CN	Description
5.673	79	Pasture/grassland/range, Fair, HSG C
1.006	69	Pasture/grassland/range, Fair, HSG B
6.679	77	Weighted Average
6.679		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
27.6	150	0.0124	0.09		**Sheet Flow,** Grass: Dense n= 0.240 P2= 2.40"
2.5	150	0.0124	1.00		**Shallow Concentrated Flow, High Grass** Kv= 9.0 fps
30.1	300	Total			

Subcatchment Pre1: Basin 1: CPP Gravel Storage Area



Summary for Pond P: Pond

Inflow Area = 6.679 ac, 5.11% Impervious, Inflow Depth > 3.04" for 100-yr event
Inflow = 5.25 cfs @ 7.91 hrs, Volume= 1.695 af
Outflow = 2.68 cfs @ 8.28 hrs, Volume= 1.685 af, Atten= 49%, Lag= 21.9 min
Primary = 2.68 cfs @ 8.28 hrs, Volume= 1.685 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.04 hrs
Starting Elev= 0.44' Surf.Area= 14,844 sf Storage= 6,312 cf
Peak Elev= 1.00' @ 8.28 hrs Surf.Area= 16,110 sf Storage= 14,963 cf (8,651 cf above start)

Plug-Flow detention time= 142.2 min calculated for 1.540 af (91% of inflow)
Center-of-Mass det. time= 27.3 min (774.9 - 747.6)

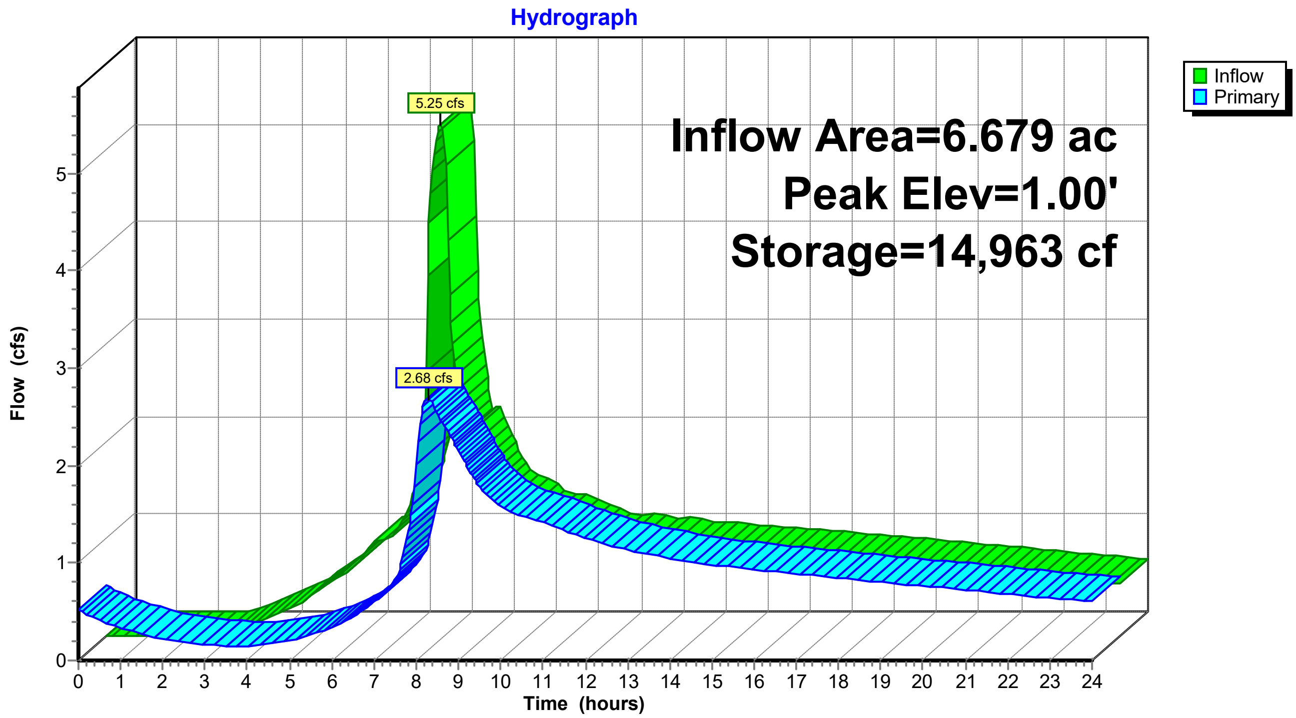
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	32,253 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
0.00	13,847	0	0
1.00	16,112	14,980	14,980
2.00	18,434	17,273	32,253

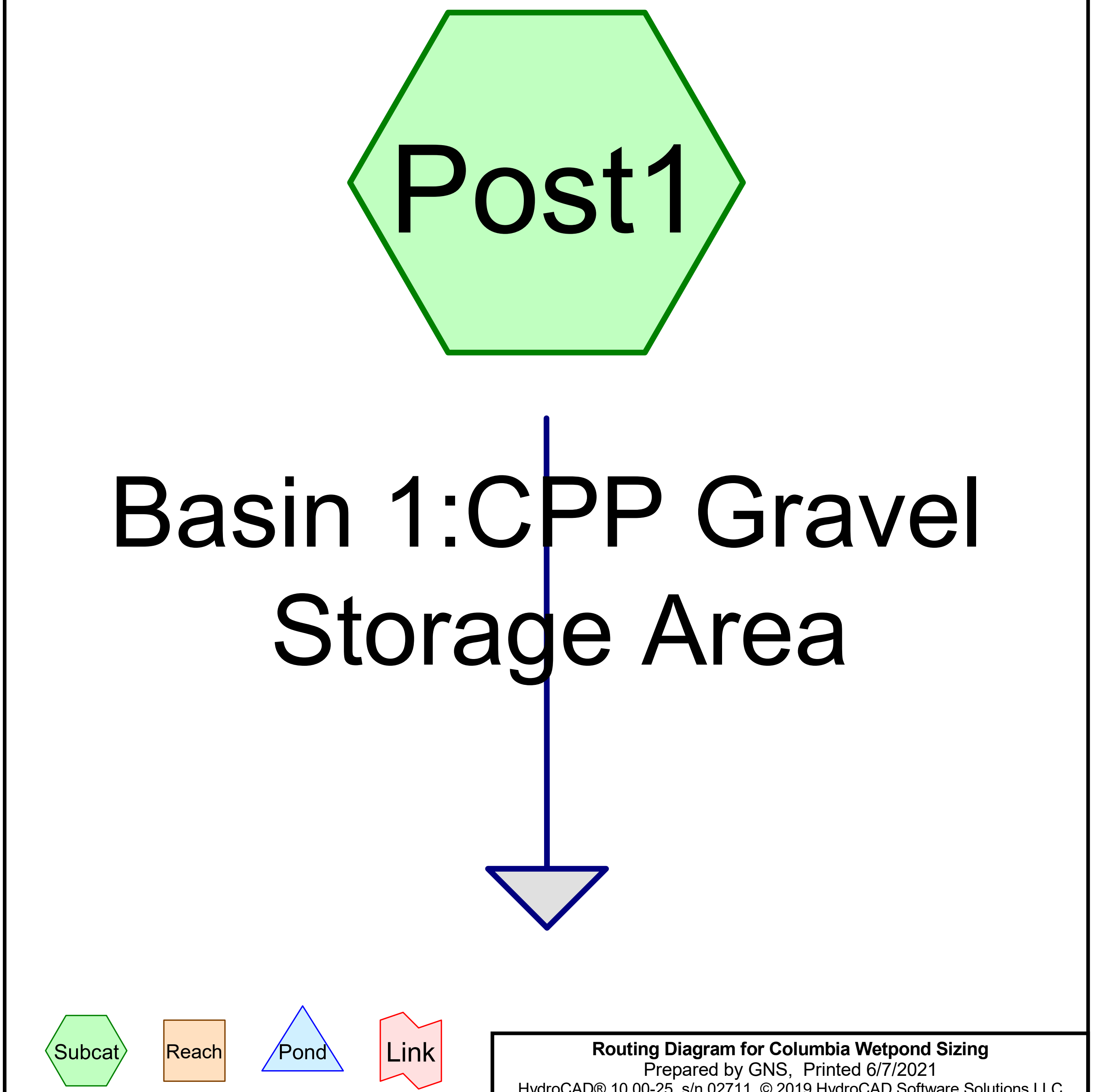
Device	Routing	Invert	Outlet Devices
#1	Primary	0.00'	**7.4" Vert. Orifice/Grate** C= 0.600
#2	Primary	0.85'	**18.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#3	Primary	0.40'	**6.0" W x 4.8" H Vert. Orifice/Grate** C= 0.600

Primary OutFlow Max=2.68 cfs @ 8.28 hrs HW=1.00' (Free Discharge)
├─**1=Orifice/Grate** (Orifice Controls 1.20 cfs @ 4.00 fps)
├─**2=Orifice/Grate** (Weir Controls 0.89 cfs @ 1.26 fps)
└─**3=Orifice/Grate** (Orifice Controls 0.60 cfs @ 3.01 fps)

Pond P: Pond


Hydrograph
Inflow
Primary
5.25 cfs
2.68 cfs
Inflow Area=6.679 ac
Peak Elev=1.00'
Storage=14,963 cf
Flow (cfs)
0
1
2
3
4
5
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time (hours)

Water Quality Design



Routing Diagram for Columbia Wetpond Sizing
Prepared by GNS, Printed 6/7/2021
HydroCAD® 10.00-25 s/n 02711 © 2019 HydroCAD Software Solutions LLC

Summary for Subcatchment Post1: Basin 1:CPP Gravel Storage Area

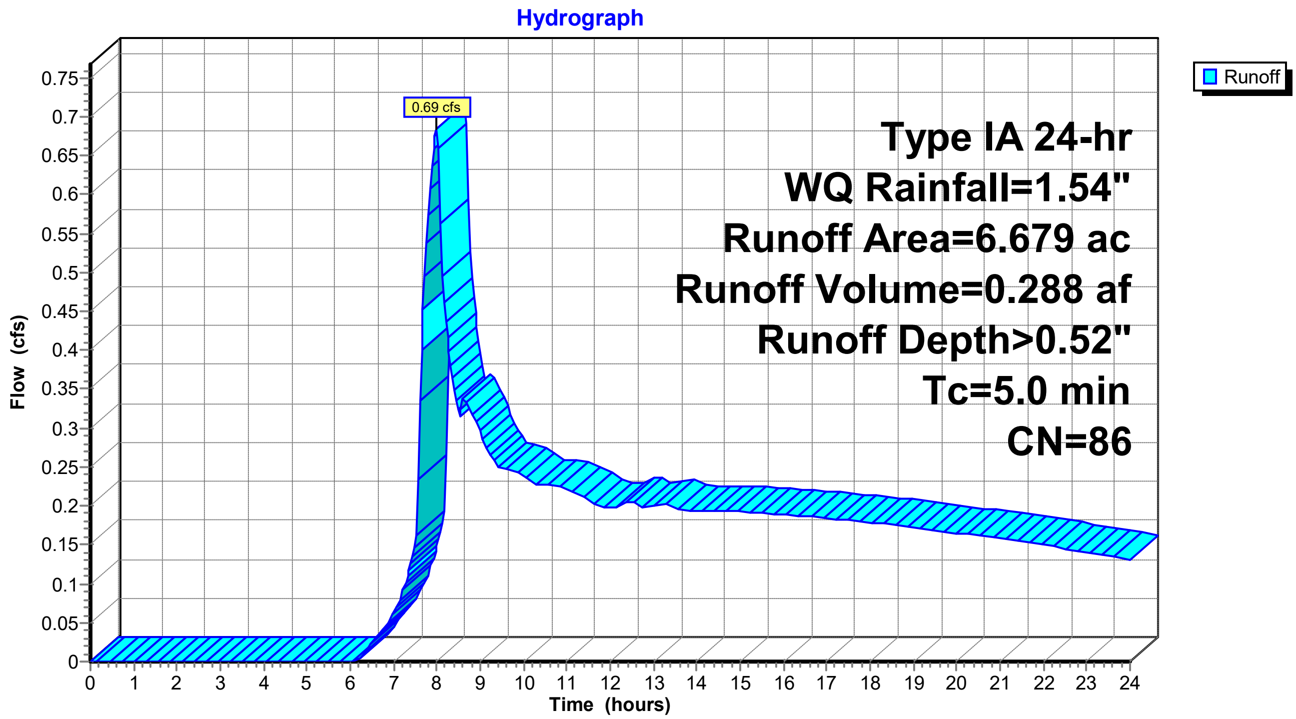
Runoff = 0.69 cfs @ 7.99 hrs, Volume= 0.288 af, Depth> 0.52"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.04 hrs
Type IA 24-hr WQ Rainfall=1.54"

Area (ac)	CN	Description
0.341	98	Water Surface, HSG C
4.908	89	Gravel roads, HSG C
0.454	85	Gravel roads, HSG B
0.458	74	>75% Grass cover, Good, HSG C
0.518	61	>75% Grass cover, Good, HSG B
6.679	86	Weighted Average
6.338		94.89% Pervious Area
0.341		5.11% Impervious Area

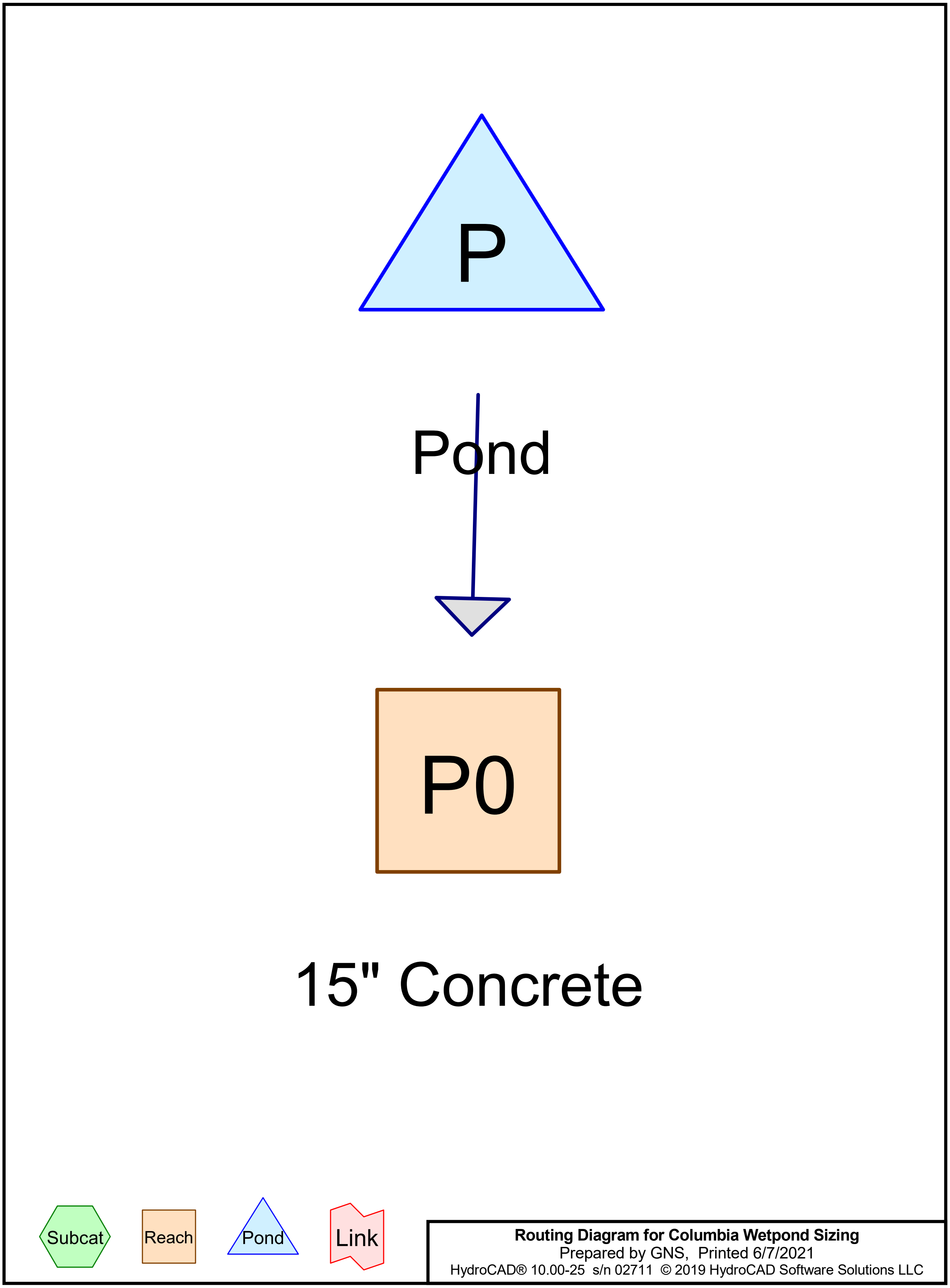
Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment Post1: Basin 1:CPP Gravel Storage Area



Appendix C

Conveyance Modeling Results


P
Pond
P0
15" Concrete
Subcat
Reach
Pond
Link
Routing Diagram for Columbia Wetpond Sizing
Prepared by GNS, Printed 6/7/2021
HydroCAD® 10.00-25 s/n 02711 © 2019 HydroCAD Software Solutions LLC

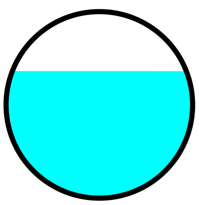
Summary for Reach P0: 15" Concrete

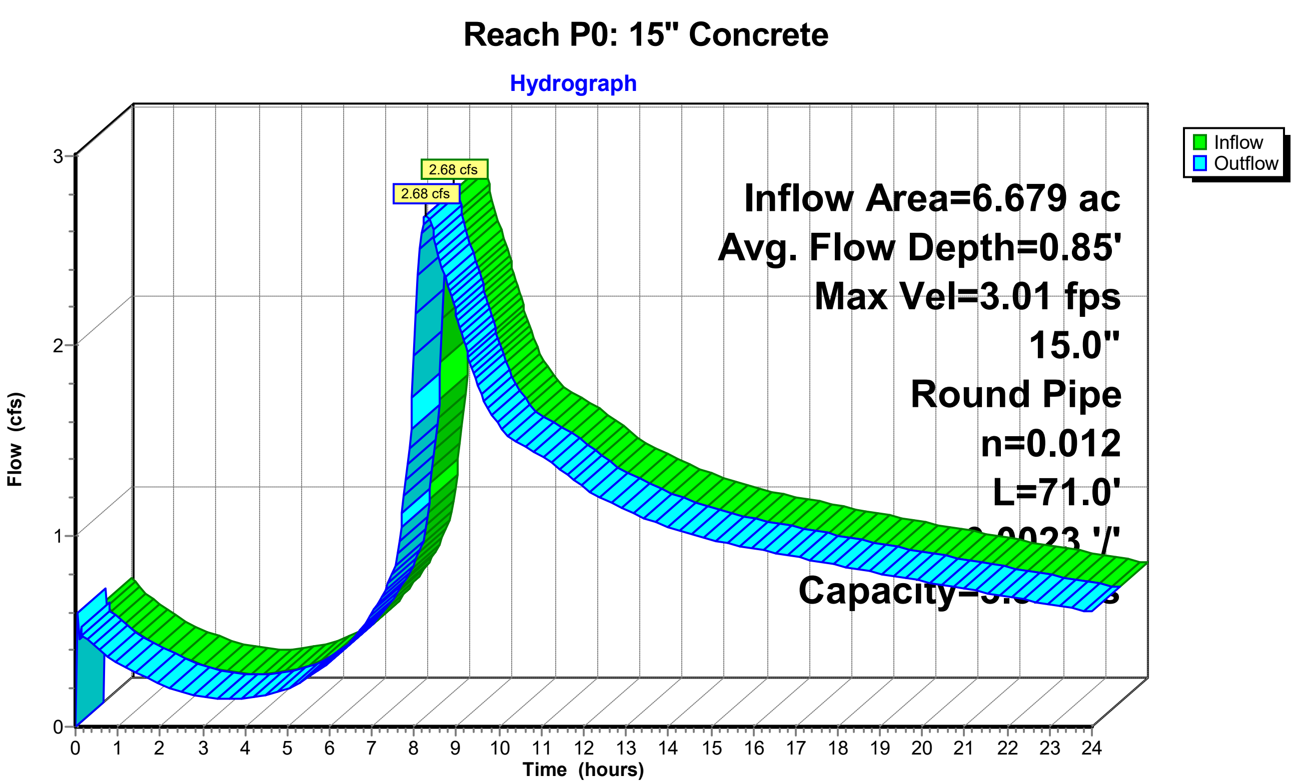
Inflow Area = 6.679 ac, 5.11% Impervious, Inflow Depth > 3.03" for 100-yr event
Inflow = 2.68 cfs @ 8.28 hrs, Volume= 1.685 af
Outflow = 2.68 cfs @ 8.29 hrs, Volume= 1.683 af, Atten= 0%, Lag= 0.7 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.04 hrs
Max. Velocity= 3.01 fps, Min. Travel Time= 0.4 min
Avg. Velocity = 2.15 fps, Avg. Travel Time= 0.5 min

Peak Storage= 63 cf @ 8.28 hrs
Average Depth at Peak Storage= 0.85'
Bank-Full Depth= 1.25' Flow Area= 1.2 sf, Capacity= 3.32 cfs

15.0" Round Pipe
n= 0.012 Concrete pipe, finished
Length= 71.0' Slope= 0.0023 '/'
Inlet Invert= 15.39', Outlet Invert= 15.23'





Summary for Pond P: Pond

Inflow Area = 6.679 ac, 5.11% Impervious, Inflow Depth > 3.04" for 100-yr event
Inflow = 5.25 cfs @ 7.91 hrs, Volume= 1.695 af
Outflow = 2.68 cfs @ 8.28 hrs, Volume= 1.685 af, Atten= 49%, Lag= 21.9 min
Primary = 2.68 cfs @ 8.28 hrs, Volume= 1.685 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.04 hrs
Starting Elev= 0.44' Surf.Area= 14,844 sf Storage= 6,312 cf
Peak Elev= 1.00' @ 8.28 hrs Surf.Area= 16,110 sf Storage= 14,963 cf (8,651 cf above start)

Plug-Flow detention time= 142.2 min calculated for 1.540 af (91% of inflow)
Center-of-Mass det. time= 27.3 min (774.9 - 747.6)

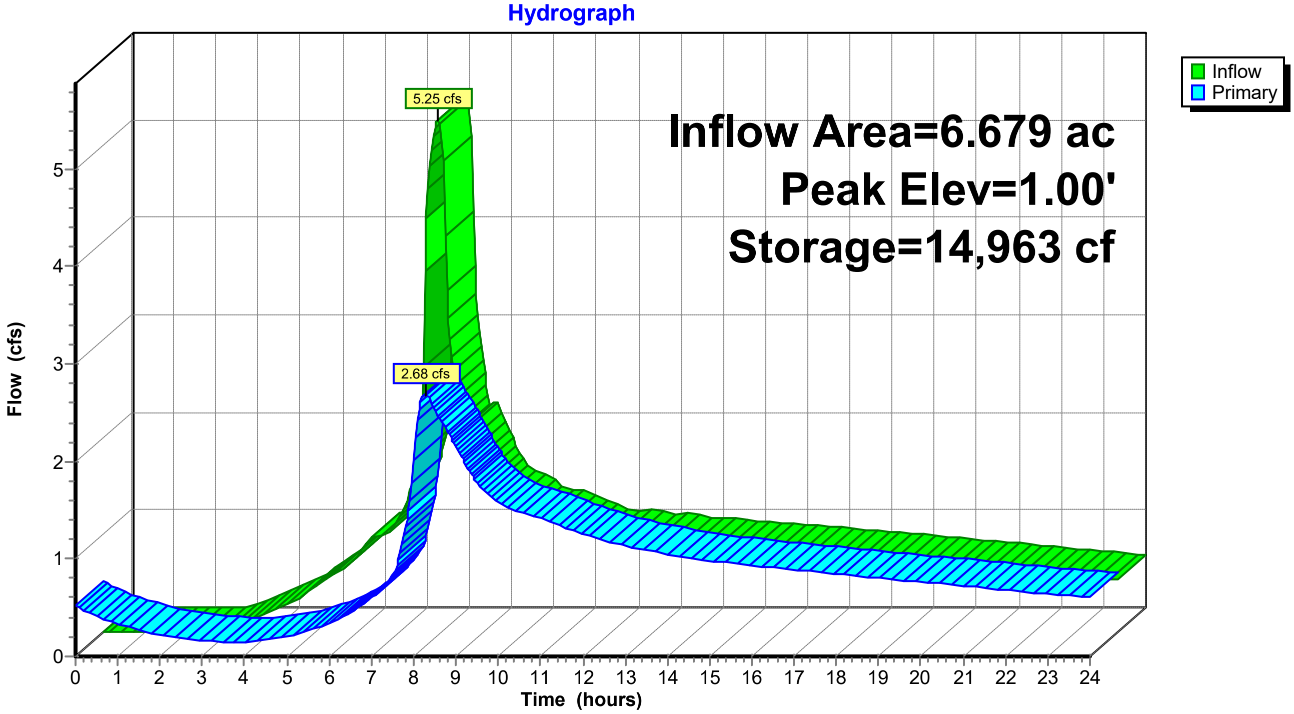
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	32,253 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
0.00	13,847	0	0
1.00	16,112	14,980	14,980
2.00	18,434	17,273	32,253

Device	Routing	Invert	Outlet Devices
#1	Primary	0.00'	**7.4" Vert. Orifice/Grate** C= 0.600
#2	Primary	0.85'	**18.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#3	Primary	0.40'	**6.0" W x 4.8" H Vert. Orifice/Grate** C= 0.600

Primary OutFlow Max=2.68 cfs @ 8.28 hrs HW=1.00' (Free Discharge)
├─**1=Orifice/Grate** (Orifice Controls 1.20 cfs @ 4.00 fps)
├─**2=Orifice/Grate** (Weir Controls 0.89 cfs @ 1.26 fps)
└─**3=Orifice/Grate** (Orifice Controls 0.60 cfs @ 3.01 fps)

Pond P: Pond


Hydrograph
5.25 cfs
2.68 cfs
Inflow Area=6.679 ac
Peak Elev=1.00'
Storage=14,963 cf
Inflow
Primary
Flow (cfs)
Time (hours)
0
1
2
3
4
5
6
7
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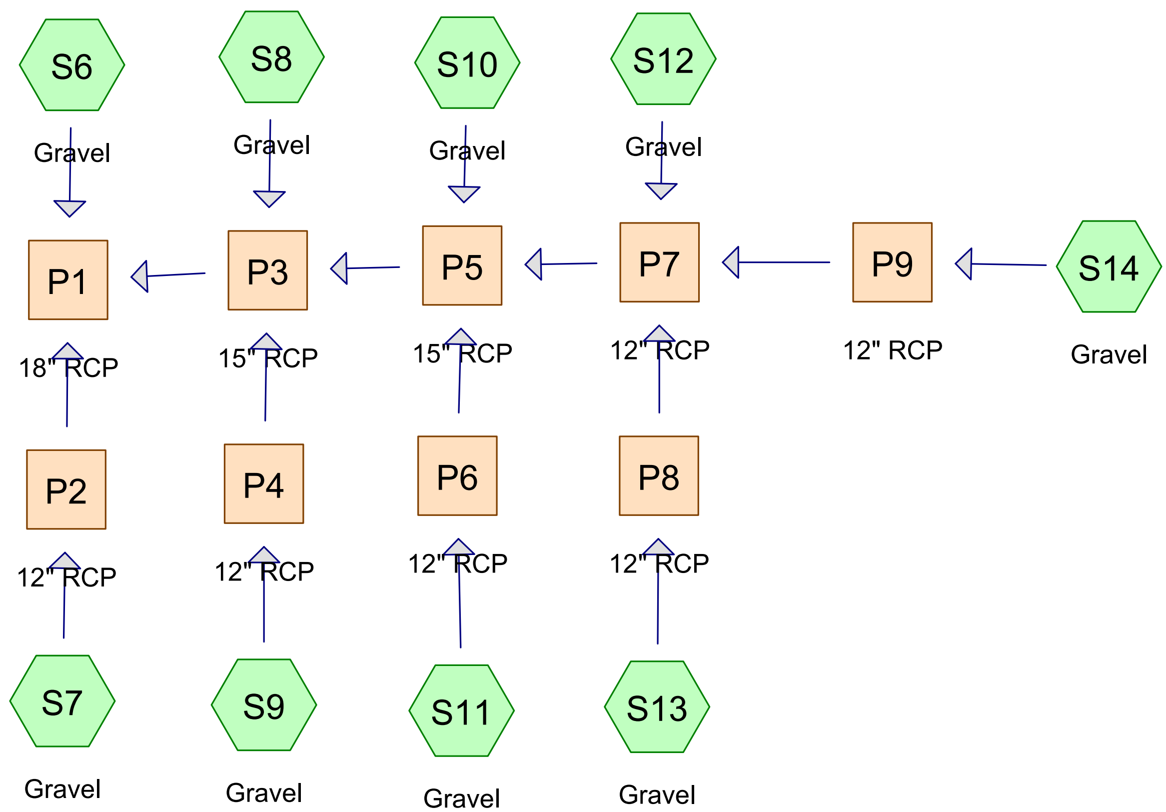
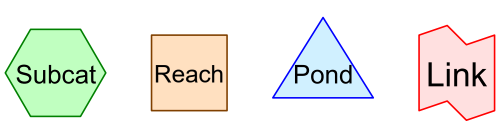
24





Routing Diagram for CPP Conveyance
Prepared by GNS, Printed 6/7/2021

Summary for Subcatchment S10: Gravel

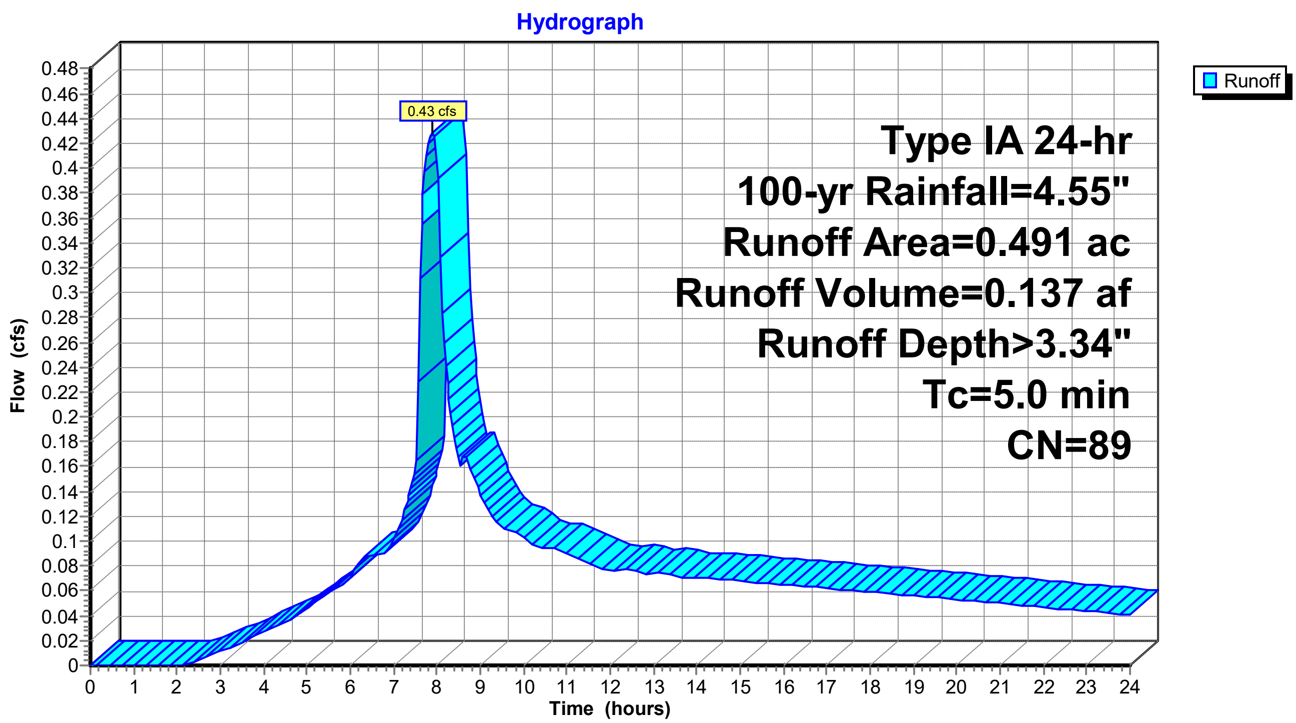
Runoff = 0.43 cfs @ 7.90 hrs, Volume= 0.137 af, Depth> 3.34"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.04 hrs
Type IA 24-hr 100-yr Rainfall=4.55"

Area (ac)	CN	Description
0.491	89	Gravel roads, HSG C
0.491		100.00% Pervious Area

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

Subcatchment S10: Gravel



Summary for Subcatchment S11: Gravel

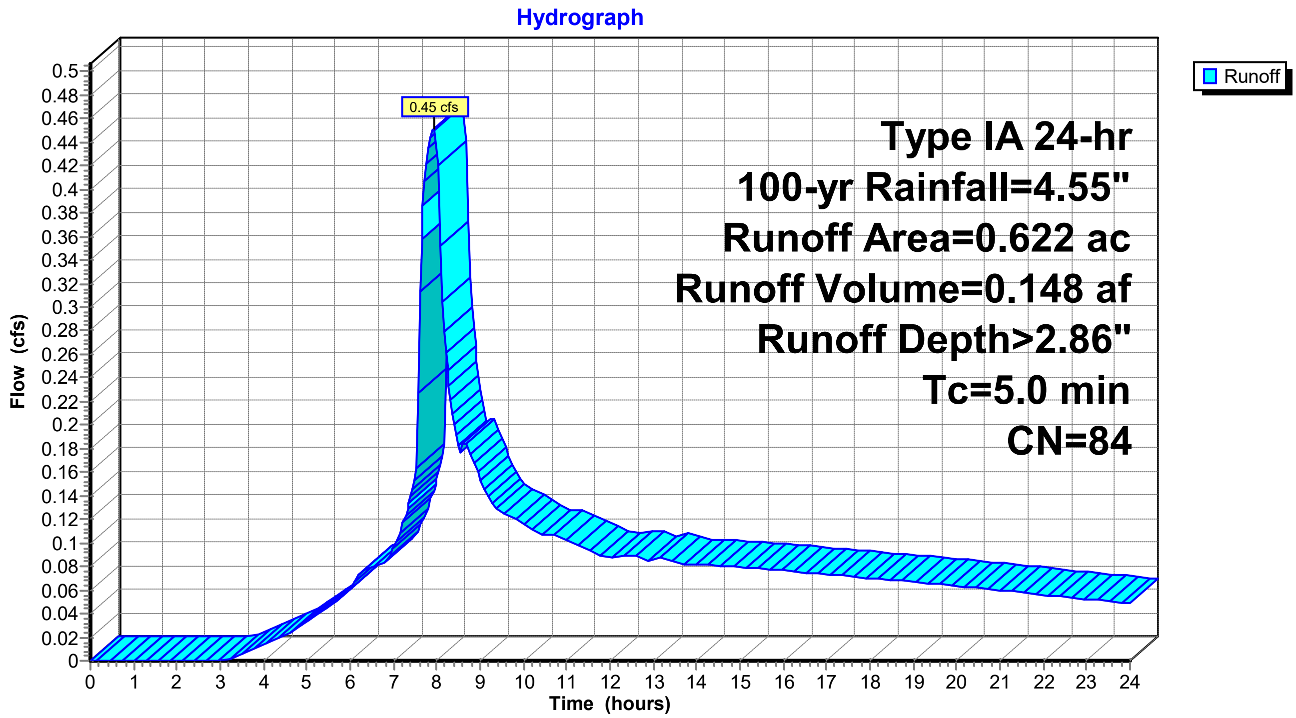
Runoff = 0.45 cfs @ 7.92 hrs, Volume= 0.148 af, Depth> 2.86"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.04 hrs
Type IA 24-hr 100-yr Rainfall=4.55"

Area (ac)	CN	Description
0.036	85	Gravel roads, HSG B
0.488	89	Gravel roads, HSG C
0.098	61	>75% Grass cover, Good, HSG B
0.622	84	Weighted Average
0.622		100.00% Pervious Area

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

Subcatchment S11: Gravel



Summary for Subcatchment S12: Gravel

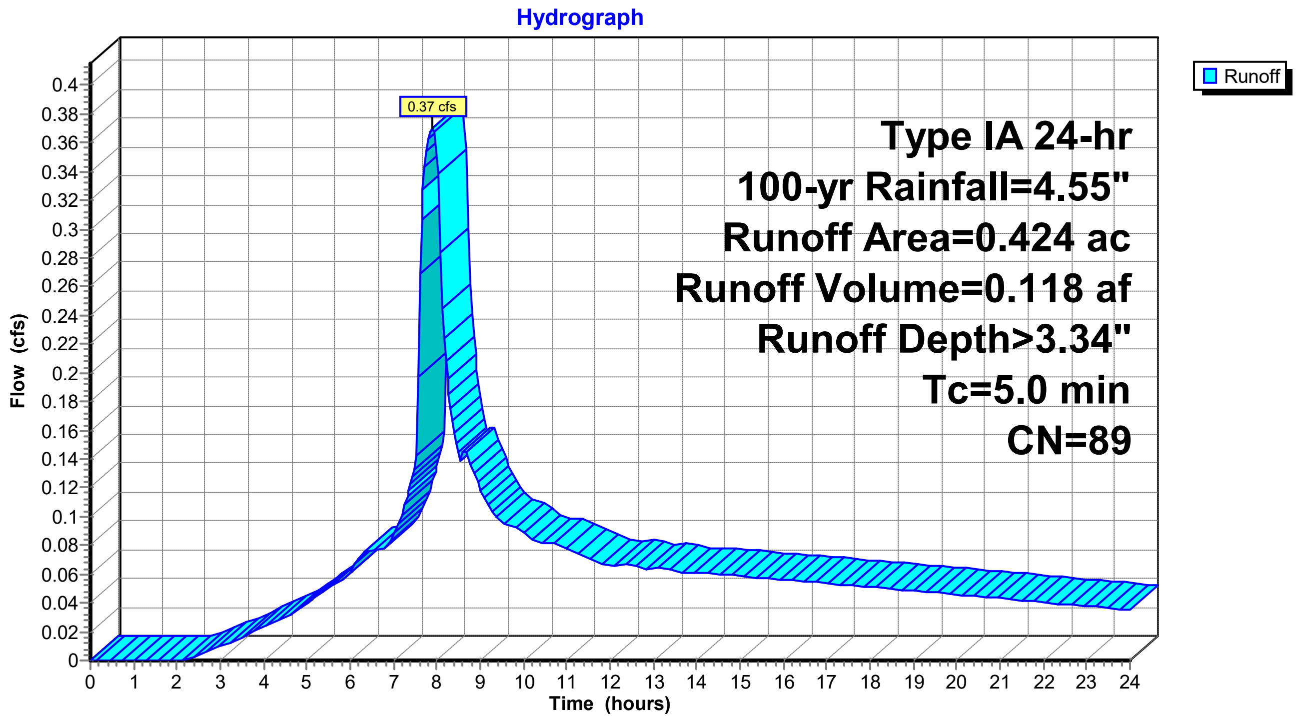
Runoff = 0.37 cfs @ 7.90 hrs, Volume= 0.118 af, Depth> 3.34"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.04 hrs
Type IA 24-hr 100-yr Rainfall=4.55"

Area (ac)	CN	Description
0.424	89	Gravel roads, HSG C
0.424		100.00% Pervious Area

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

Subcatchment S12: Gravel



Summary for Subcatchment S13: Gravel

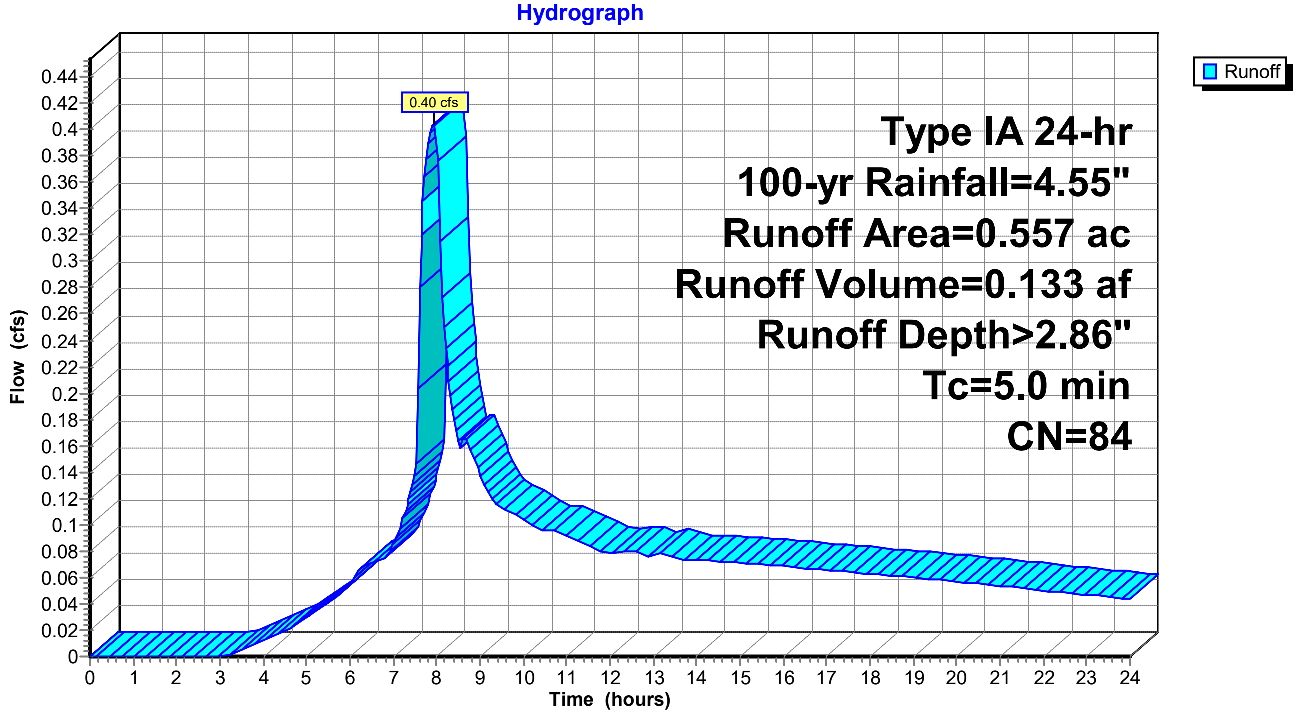
Runoff = 0.40 cfs @ 7.92 hrs, Volume= 0.133 af, Depth> 2.86"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.04 hrs
Type IA 24-hr 100-yr Rainfall=4.55"

Area (ac)	CN	Description
0.079	85	Gravel roads, HSG B
0.393	89	Gravel roads, HSG C
0.085	61	>75% Grass cover, Good, HSG B
0.557	84	Weighted Average
0.557		100.00% Pervious Area

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

Subcatchment S13: Gravel



Summary for Subcatchment S14: Gravel

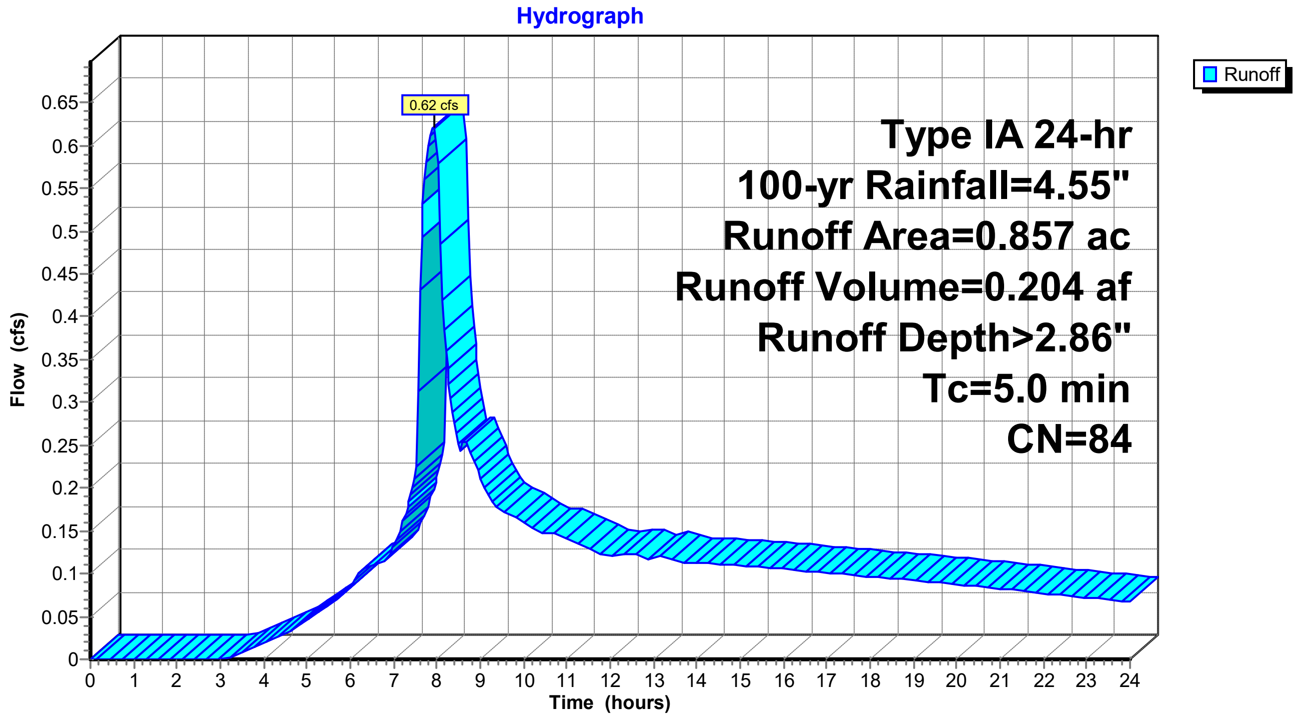
Runoff = 0.62 cfs @ 7.92 hrs, Volume= 0.204 af, Depth> 2.86"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.04 hrs
Type IA 24-hr 100-yr Rainfall=4.55"

Area (ac)	CN	Description
0.060	85	Gravel roads, HSG B
0.572	89	Gravel roads, HSG C
0.142	74	>75% Grass cover, Good, HSG C
0.083	61	>75% Grass cover, Good, HSG B
0.857	84	Weighted Average
0.857		100.00% Pervious Area

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

Subcatchment S14: Gravel



Summary for Subcatchment S6: Gravel

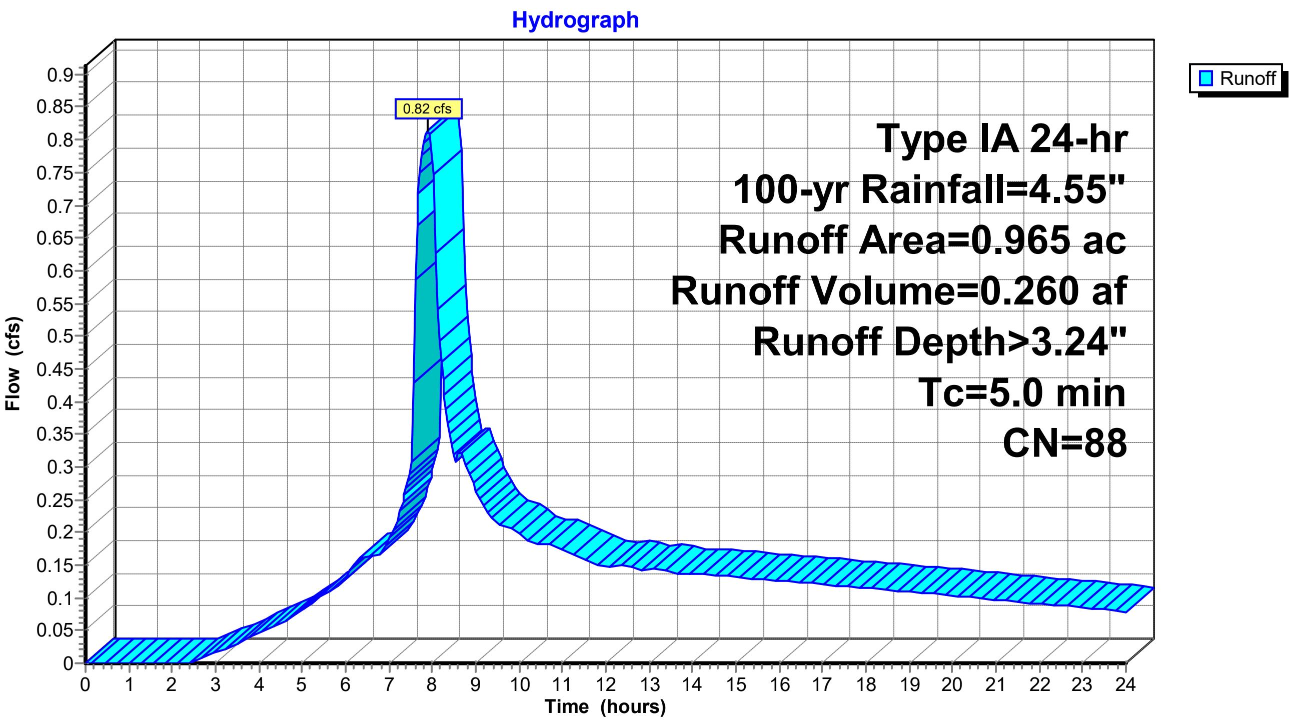
Runoff = 0.82 cfs @ 7.90 hrs, Volume= 0.260 af, Depth> 3.24"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.04 hrs
Type IA 24-hr 100-yr Rainfall=4.55"

Area (ac)	CN	Description
0.882	89	Gravel roads, HSG C
0.083	74	>75% Grass cover, Good, HSG C
0.965	88	Weighted Average
0.965		100.00% Pervious Area

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

Subcatchment S6: Gravel



Summary for Subcatchment S7: Gravel

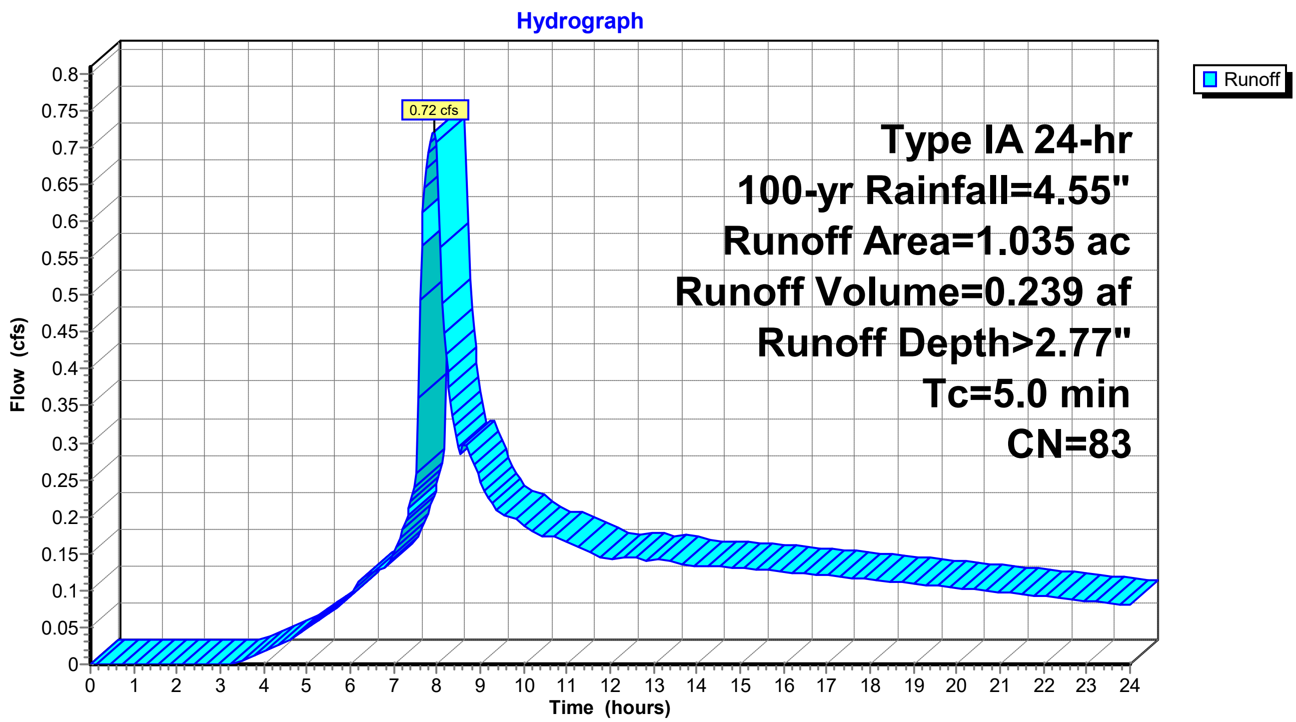
Runoff = 0.72 cfs @ 7.93 hrs, Volume= 0.239 af, Depth> 2.77"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.04 hrs
Type IA 24-hr 100-yr Rainfall=4.55"

Area (ac)	CN	Description
0.207	85	Gravel roads, HSG B
0.610	89	Gravel roads, HSG C
0.150	61	>75% Grass cover, Good, HSG B
0.068	74	>75% Grass cover, Good, HSG C
1.035	83	Weighted Average
1.035		100.00% Pervious Area

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

Subcatchment S7: Gravel



Summary for Subcatchment S8: Gravel

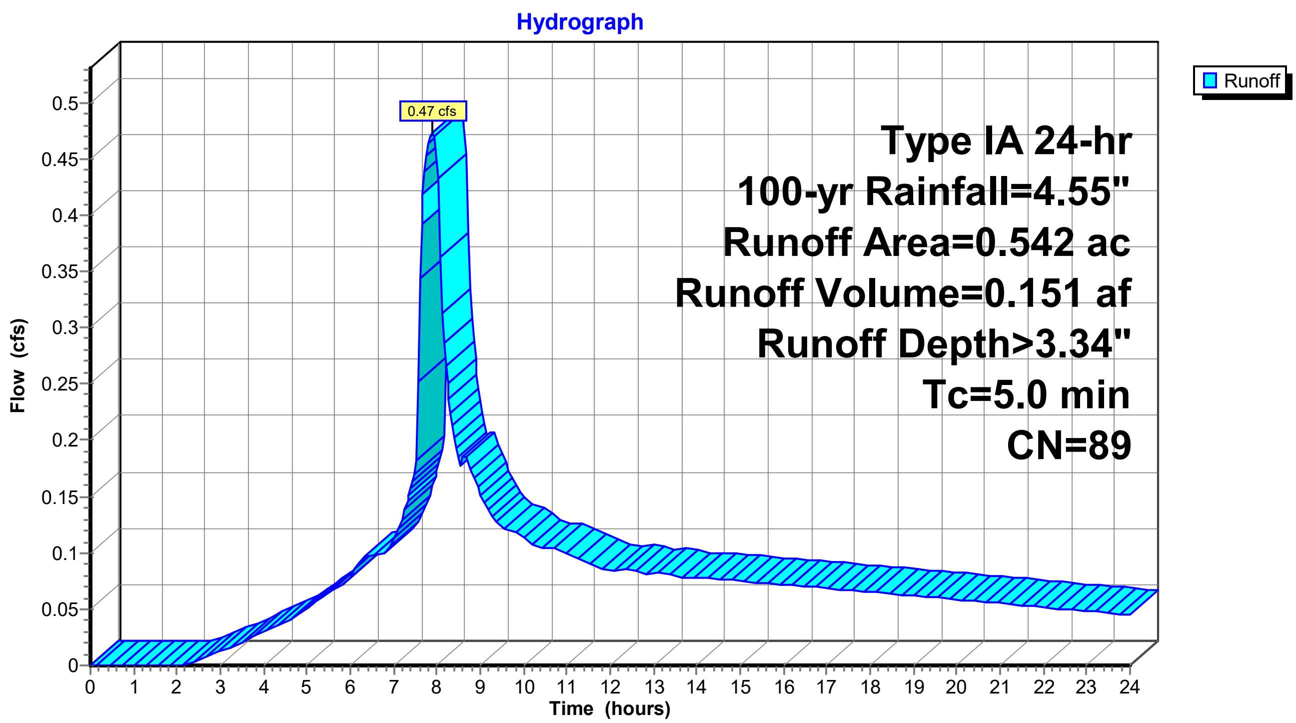
Runoff = 0.47 cfs @ 7.90 hrs, Volume= 0.151 af, Depth> 3.34"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.04 hrs
Type IA 24-hr 100-yr Rainfall=4.55"

Area (ac)	CN	Description
0.542	89	Gravel roads, HSG C
0.542		100.00% Pervious Area

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

Subcatchment S8: Gravel



Summary for Subcatchment S9: Gravel

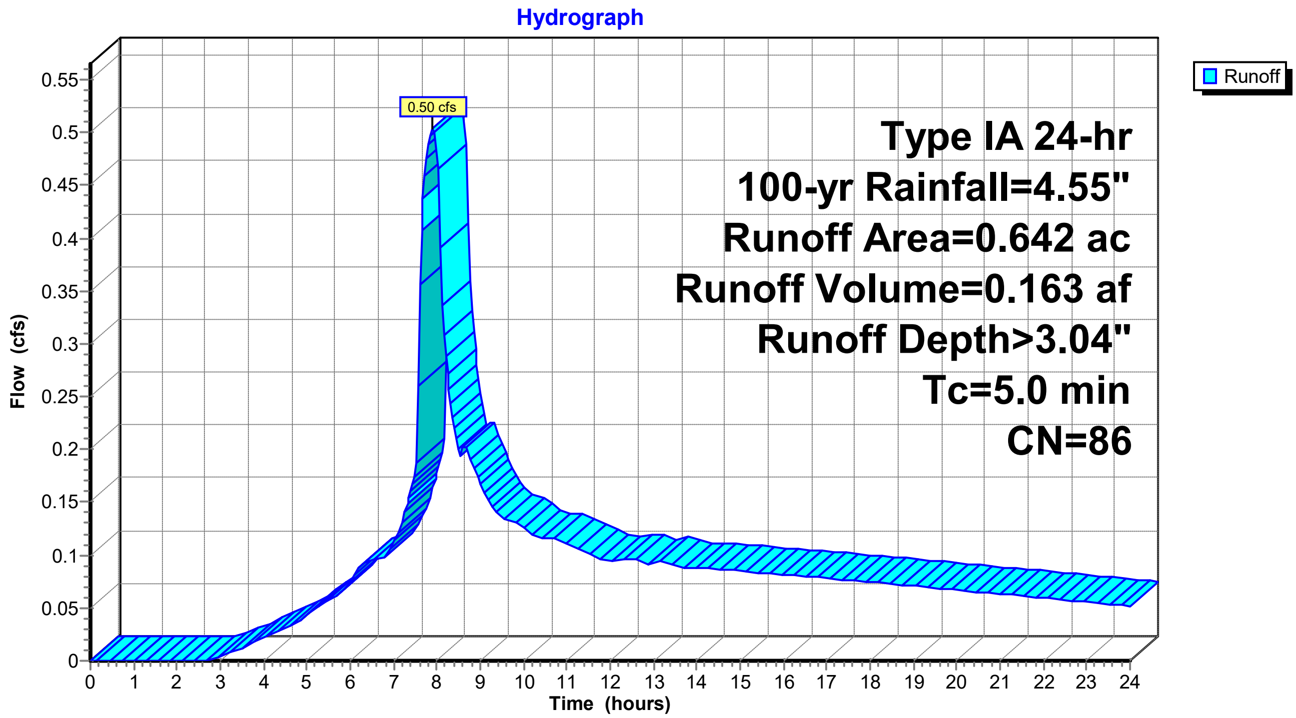
Runoff = 0.50 cfs @ 7.91 hrs, Volume= 0.163 af, Depth> 3.04"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.04 hrs
Type IA 24-hr 100-yr Rainfall=4.55"

Area (ac)	CN	Description
0.072	85	Gravel roads, HSG B
0.505	89	Gravel roads, HSG C
0.065	61	>75% Grass cover, Good, HSG B
0.642	86	Weighted Average
0.642		100.00% Pervious Area

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

Subcatchment S9: Gravel



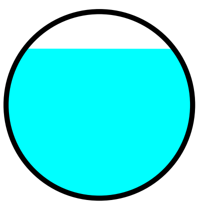
Summary for Reach P1: 18" RCP

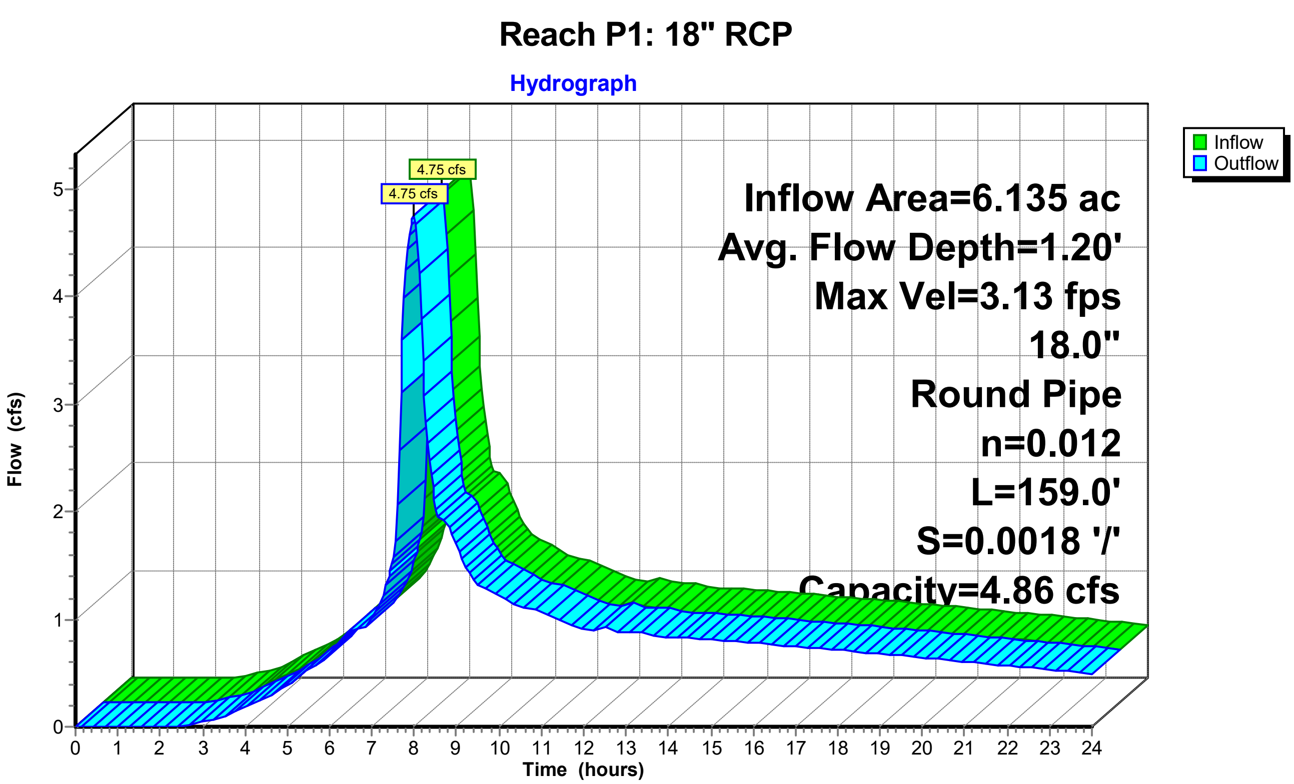
Inflow Area = 6.135 ac, 0.00% Impervious, Inflow Depth > 3.03" for 100-yr event
Inflow = 4.75 cfs @ 7.97 hrs, Volume= 1.548 af
Outflow = 4.75 cfs @ 7.99 hrs, Volume= 1.546 af, Atten= 0%, Lag= 1.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.04 hrs
Max. Velocity= 3.13 fps, Min. Travel Time= 0.8 min
Avg. Velocity = 1.95 fps, Avg. Travel Time= 1.4 min

Peak Storage= 241 cf @ 7.98 hrs
Average Depth at Peak Storage= 1.20'
Bank-Full Depth= 1.50' Flow Area= 1.8 sf, Capacity= 4.86 cfs

18.0" Round Pipe
n= 0.012 Concrete pipe, finished
Length= 159.0' Slope= 0.0018 '/'
Inlet Invert= 16.56', Outlet Invert= 16.27'





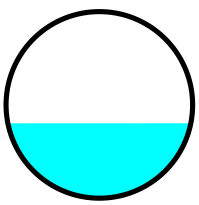
Summary for Reach P2: 12" RCP

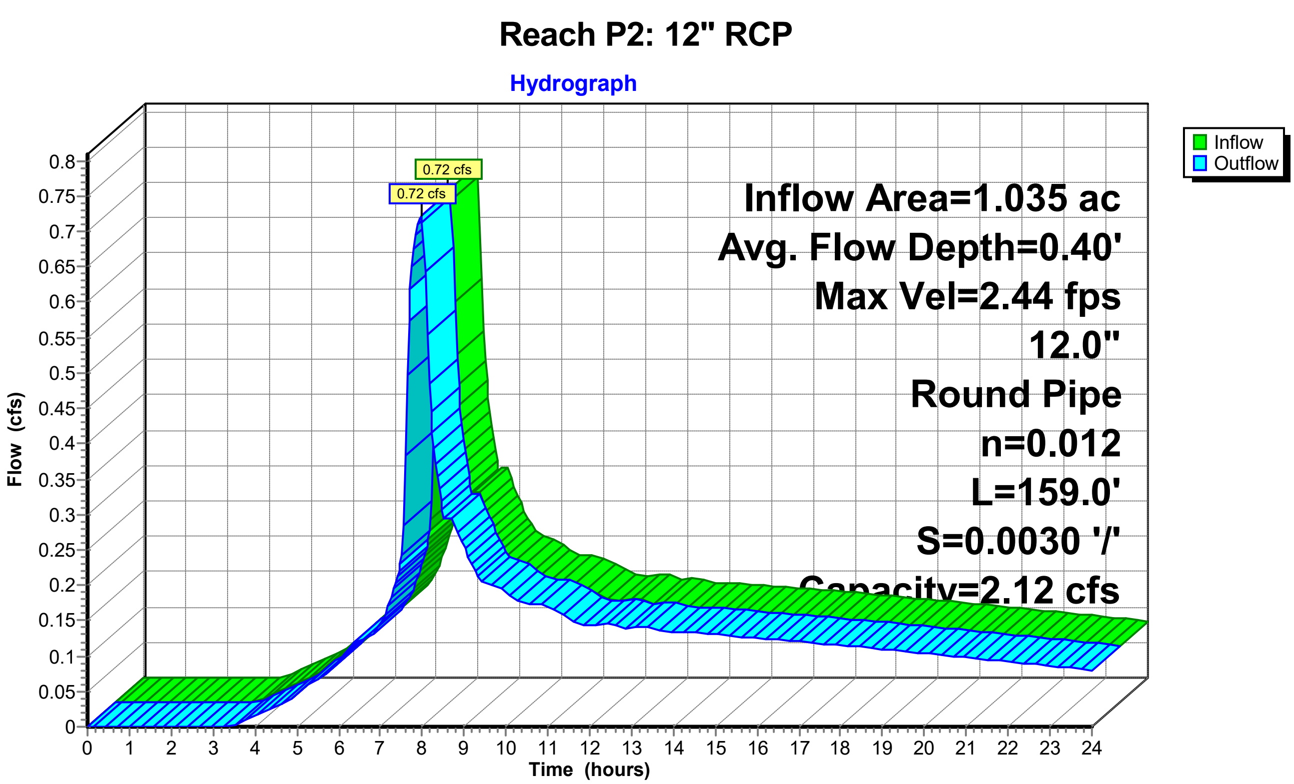
Inflow Area = 1.035 ac, 0.00% Impervious, Inflow Depth > 2.77" for 100-yr event
Inflow = 0.72 cfs @ 7.93 hrs, Volume= 0.239 af
Outflow = 0.72 cfs @ 7.96 hrs, Volume= 0.238 af, Atten= 0%, Lag= 1.9 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.04 hrs
Max. Velocity= 2.44 fps, Min. Travel Time= 1.1 min
Avg. Velocity = 1.46 fps, Avg. Travel Time= 1.8 min

Peak Storage= 47 cf @ 7.94 hrs
Average Depth at Peak Storage= 0.40'
Bank-Full Depth= 1.00' Flow Area= 0.8 sf, Capacity= 2.12 cfs

12.0" Round Pipe
n= 0.012 Concrete pipe, finished
Length= 159.0' Slope= 0.0030 '/'
Inlet Invert= 16.56', Outlet Invert= 16.08'





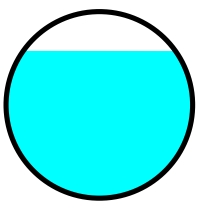
Summary for Reach P3: 15" RCP

Inflow Area = 4.135 ac, 0.00% Impervious, Inflow Depth > 3.05" for 100-yr event
Inflow = 3.24 cfs @ 7.96 hrs, Volume= 1.051 af
Outflow = 3.23 cfs @ 7.99 hrs, Volume= 1.049 af, Atten= 0%, Lag= 1.5 min

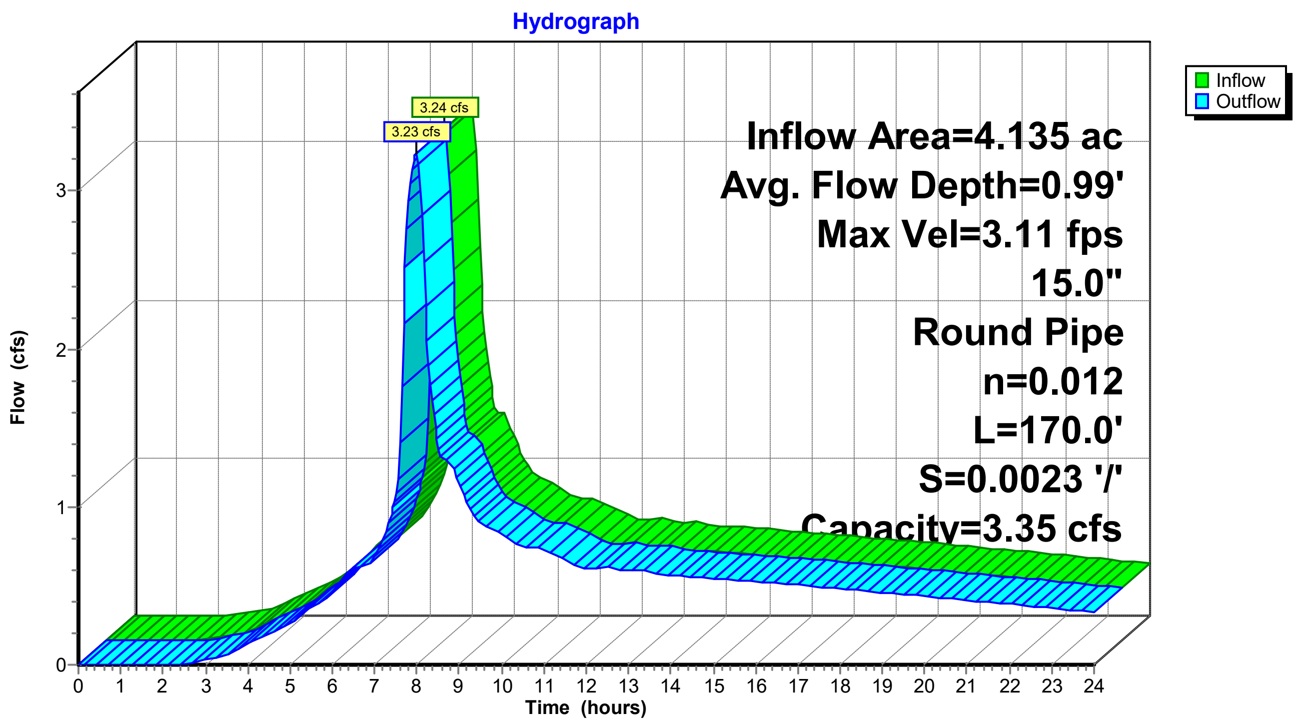
Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.04 hrs
Max. Velocity= 3.11 fps, Min. Travel Time= 0.9 min
Avg. Velocity = 1.93 fps, Avg. Travel Time= 1.5 min

Peak Storage= 177 cf @ 7.98 hrs
Average Depth at Peak Storage= 0.99'
Bank-Full Depth= 1.25' Flow Area= 1.2 sf, Capacity= 3.35 cfs

15.0" Round Pipe
n= 0.012 Concrete pipe, finished
Length= 170.0' Slope= 0.0023 '/'
Inlet Invert= 16.56', Outlet Invert= 16.17'



Reach P3: 15" RCP



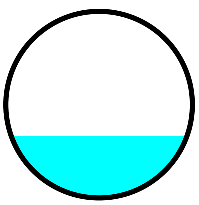
Summary for Reach P4: 12" RCP

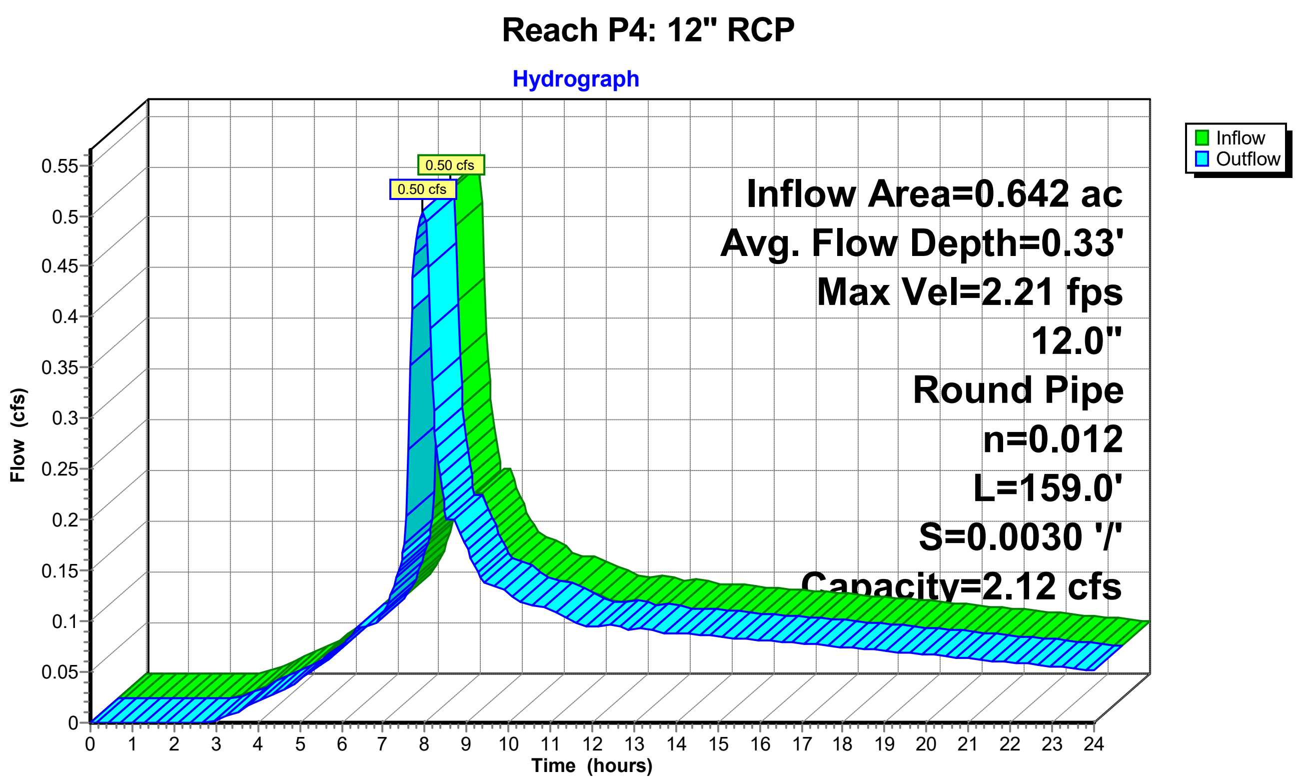
Inflow Area = 0.642 ac, 0.00% Impervious, Inflow Depth > 3.04" for 100-yr event
Inflow = 0.50 cfs @ 7.91 hrs, Volume= 0.163 af
Outflow = 0.50 cfs @ 7.95 hrs, Volume= 0.163 af, Atten= 0%, Lag= 2.1 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.04 hrs
Max. Velocity= 2.21 fps, Min. Travel Time= 1.2 min
Avg. Velocity = 1.29 fps, Avg. Travel Time= 2.1 min

Peak Storage= 36 cf @ 7.93 hrs
Average Depth at Peak Storage= 0.33'
Bank-Full Depth= 1.00' Flow Area= 0.8 sf, Capacity= 2.12 cfs

12.0" Round Pipe
n= 0.012 Concrete pipe, finished
Length= 159.0' Slope= 0.0030 '/'
Inlet Invert= 16.56', Outlet Invert= 16.08'





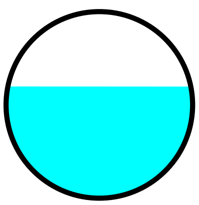
Summary for Reach P5: 15" RCP

Inflow Area = 2.951 ac, 0.00% Impervious, Inflow Depth > 3.00" for 100-yr event
Inflow = 2.27 cfs @ 7.95 hrs, Volume= 0.738 af
Outflow = 2.27 cfs @ 7.98 hrs, Volume= 0.737 af, Atten= 0%, Lag= 1.6 min

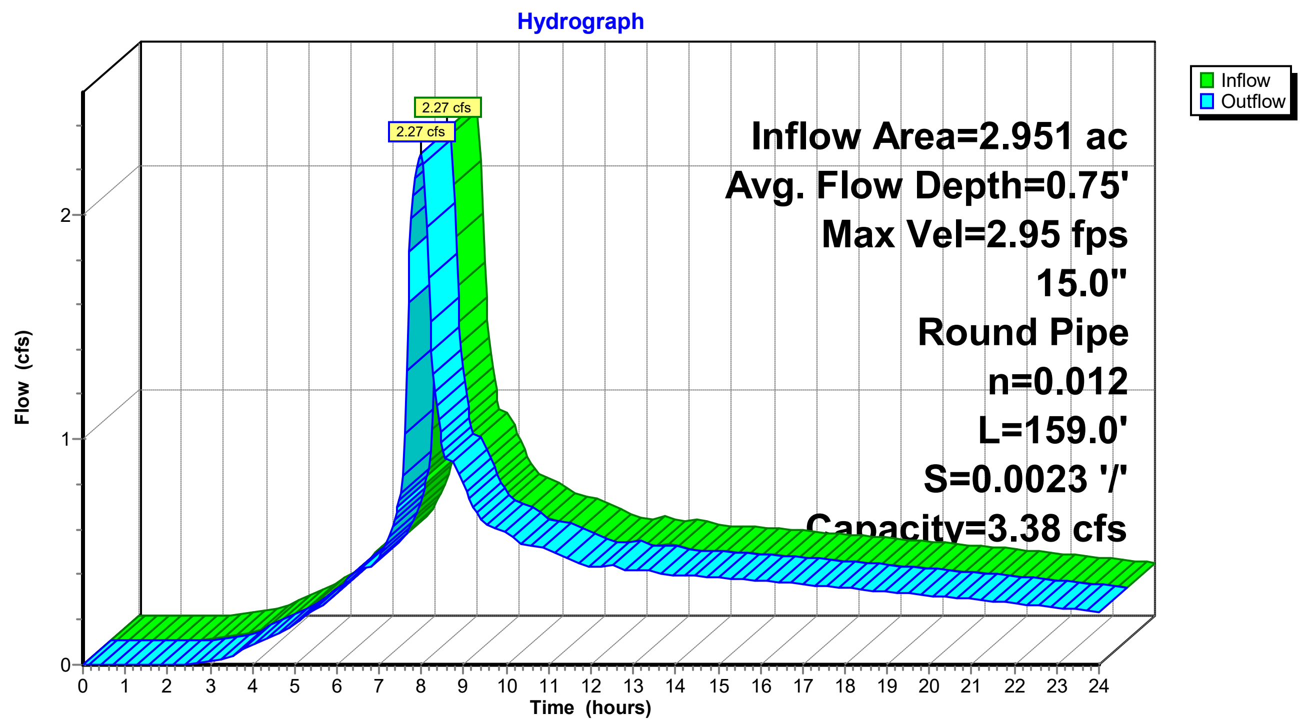
Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.04 hrs
Max. Velocity= 2.95 fps, Min. Travel Time= 0.9 min
Avg. Velocity = 1.75 fps, Avg. Travel Time= 1.5 min

Peak Storage= 122 cf @ 7.97 hrs
Average Depth at Peak Storage= 0.75'
Bank-Full Depth= 1.25' Flow Area= 1.2 sf, Capacity= 3.38 cfs

15.0" Round Pipe
n= 0.012 Concrete pipe, finished
Length= 159.0' Slope= 0.0023 '/'
Inlet Invert= 16.56', Outlet Invert= 16.19'



Reach P5: 15" RCP



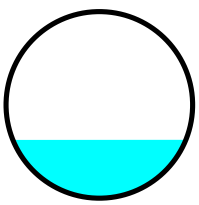
Summary for Reach P6: 12" RCP

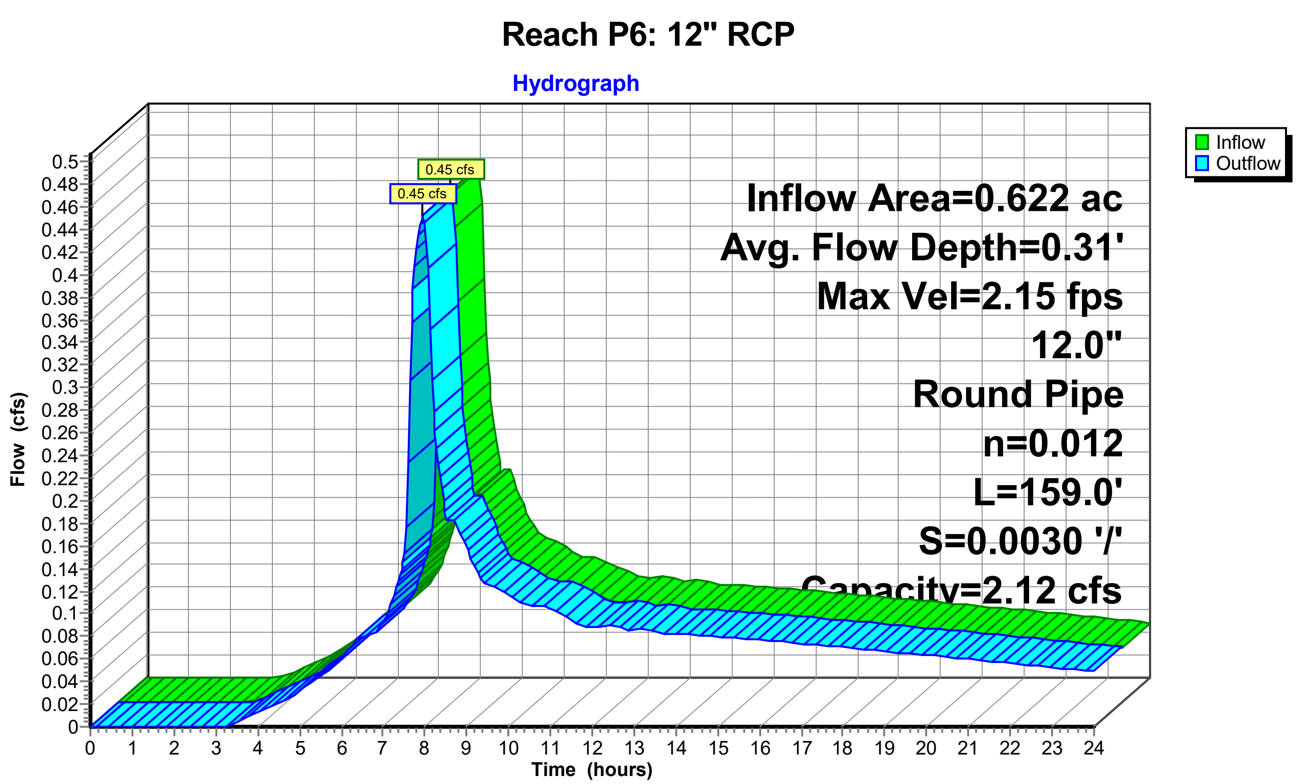
Inflow Area = 0.622 ac, 0.00% Impervious, Inflow Depth > 2.86" for 100-yr event
Inflow = 0.45 cfs @ 7.92 hrs, Volume= 0.148 af
Outflow = 0.45 cfs @ 7.96 hrs, Volume= 0.148 af, Atten= 0%, Lag= 2.1 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.04 hrs
Max. Velocity= 2.15 fps, Min. Travel Time= 1.2 min
Avg. Velocity = 1.26 fps, Avg. Travel Time= 2.1 min

Peak Storage= 33 cf @ 7.94 hrs
Average Depth at Peak Storage= 0.31'
Bank-Full Depth= 1.00' Flow Area= 0.8 sf, Capacity= 2.12 cfs

12.0" Round Pipe
n= 0.012 Concrete pipe, finished
Length= 159.0' Slope= 0.0030 '/'
Inlet Invert= 16.56', Outlet Invert= 16.08'





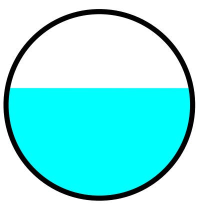
Summary for Reach P7: 12" RCP

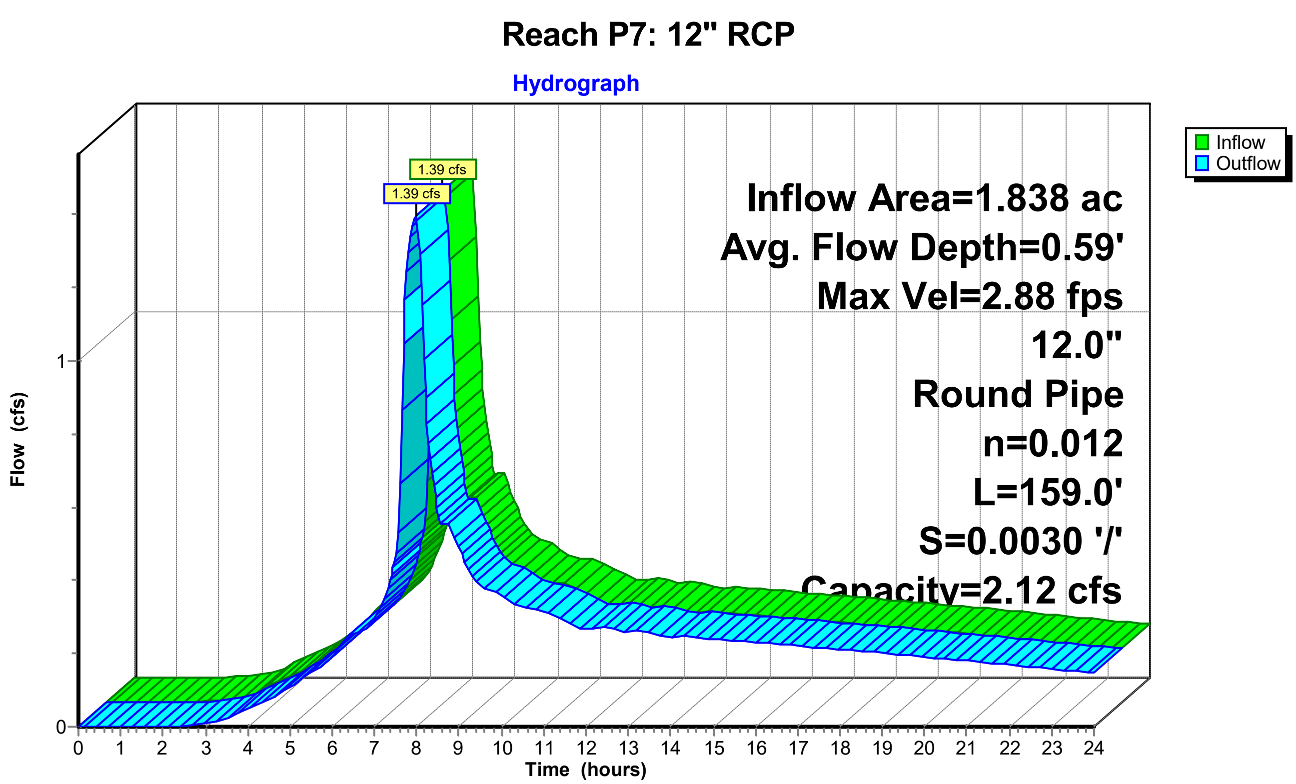
Inflow Area = 1.838 ac, 0.00% Impervious, Inflow Depth > 2.96" for 100-yr event
Inflow = 1.39 cfs @ 7.94 hrs, Volume= 0.454 af
Outflow = 1.39 cfs @ 7.97 hrs, Volume= 0.454 af, Atten= 0%, Lag= 1.6 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.04 hrs
Max. Velocity= 2.88 fps, Min. Travel Time= 0.9 min
Avg. Velocity = 1.71 fps, Avg. Travel Time= 1.6 min

Peak Storage= 77 cf @ 7.95 hrs
Average Depth at Peak Storage= 0.59'
Bank-Full Depth= 1.00' Flow Area= 0.8 sf, Capacity= 2.12 cfs

12.0" Round Pipe
n= 0.012 Concrete pipe, finished
Length= 159.0' Slope= 0.0030 '/'
Inlet Invert= 16.56', Outlet Invert= 16.08'





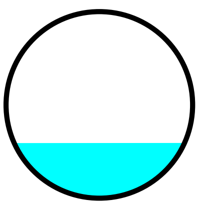
Summary for Reach P8: 12" RCP

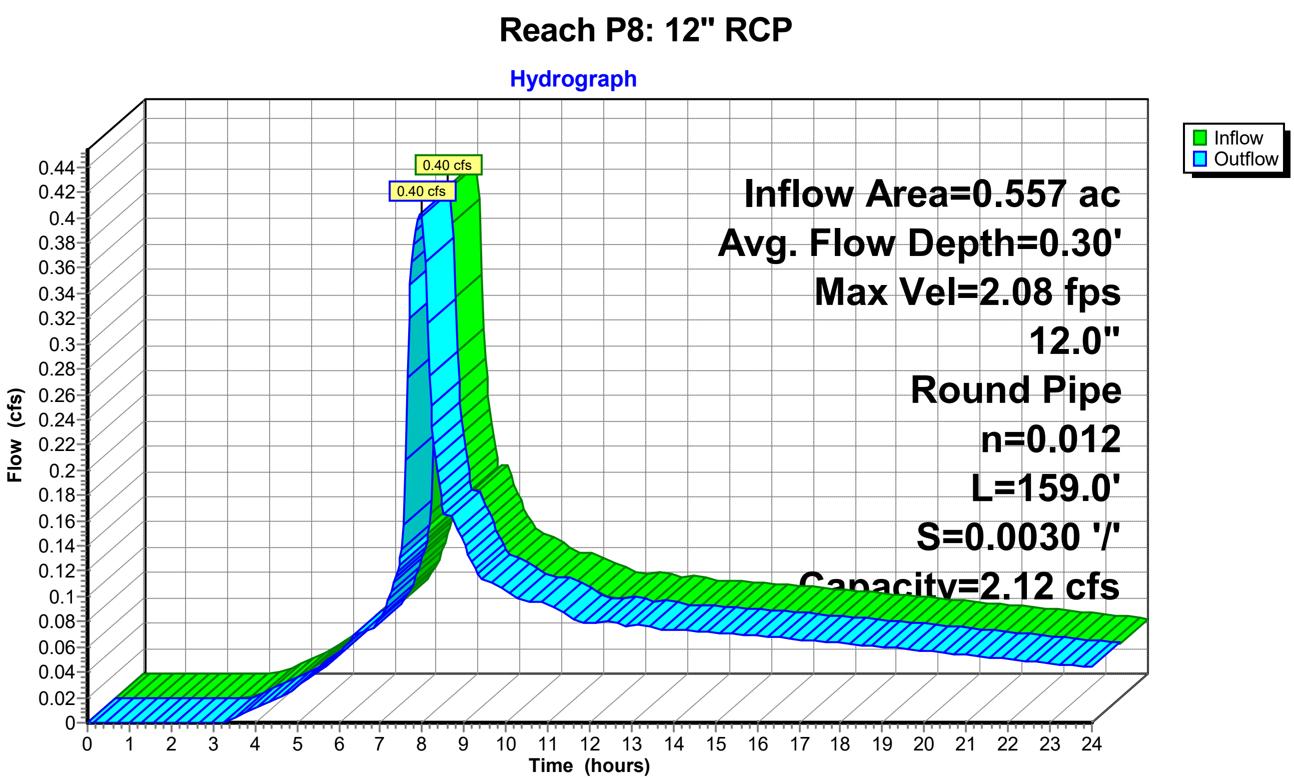
Inflow Area = 0.557 ac, 0.00% Impervious, Inflow Depth > 2.86" for 100-yr event
Inflow = 0.40 cfs @ 7.92 hrs, Volume= 0.133 af
Outflow = 0.40 cfs @ 7.96 hrs, Volume= 0.132 af, Atten= 0%, Lag= 2.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.04 hrs
Max. Velocity= 2.08 fps, Min. Travel Time= 1.3 min
Avg. Velocity = 1.22 fps, Avg. Travel Time= 2.2 min

Peak Storage= 31 cf @ 7.94 hrs
Average Depth at Peak Storage= 0.30'
Bank-Full Depth= 1.00' Flow Area= 0.8 sf, Capacity= 2.12 cfs

12.0" Round Pipe
n= 0.012 Concrete pipe, finished
Length= 159.0' Slope= 0.0030 '/'
Inlet Invert= 16.56', Outlet Invert= 16.08'





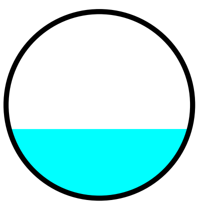
Summary for Reach P9: 12" RCP

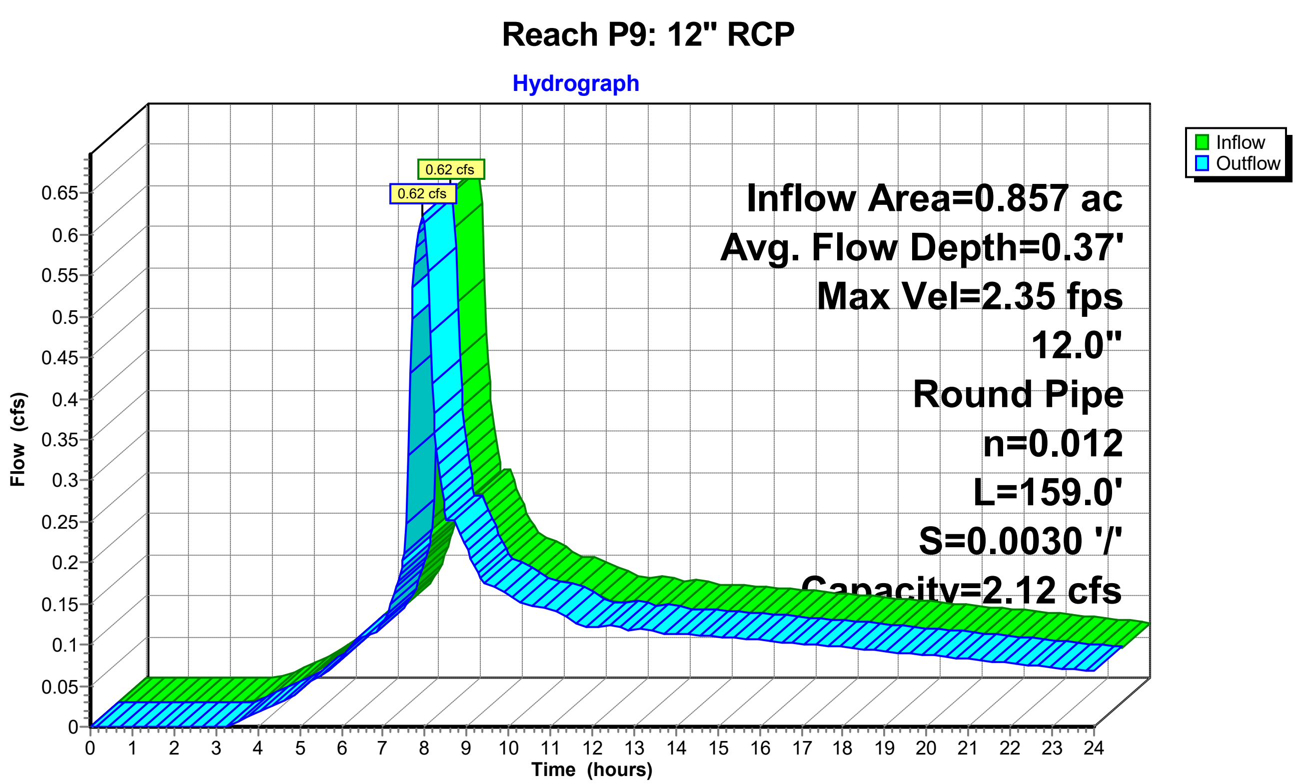
Inflow Area = 0.857 ac, 0.00% Impervious, Inflow Depth > 2.86" for 100-yr event
Inflow = 0.62 cfs @ 7.92 hrs, Volume= 0.204 af
Outflow = 0.62 cfs @ 7.96 hrs, Volume= 0.204 af, Atten= 0%, Lag= 1.9 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.04 hrs
Max. Velocity= 2.35 fps, Min. Travel Time= 1.1 min
Avg. Velocity = 1.39 fps, Avg. Travel Time= 1.9 min

Peak Storage= 42 cf @ 7.94 hrs
Average Depth at Peak Storage= 0.37'
Bank-Full Depth= 1.00' Flow Area= 0.8 sf, Capacity= 2.12 cfs

12.0" Round Pipe
n= 0.012 Concrete pipe, finished
Length= 159.0' Slope= 0.0030 '/'
Inlet Invert= 16.56', Outlet Invert= 16.08'





Appendix D

Geotechnical Site Investigation

Geotechnical Site Investigation

Howard Way Extension

Woodland, Washington

August 12, 2019

Geotechnical ■ Environmental ■ Special Inspections

Columbia West

Engineering, Inc

11917 NE 95th Street
Vancouver, Washington
98682
Phone: 360-823-2900
Fax: 360-823-2901




Geotechnical ■ Environmental ■ Special Inspections
Columbia West Engineering, Inc

GEOTECHNICAL SITE INVESTIGATION
HOWARD WAY EXTENSION
WOODLAND, WASHINGTON

Prepared For:	**Mr. Rich Gushman, PE** **Gibbs & Olson** **PO Box 400** **Longview, Washington 98632**
Site Location:	**1620 Guild Road and Portion of Guild Road** **South of Parcels 508730100 and 508740100** **Woodland, Washington**
Prepared By:	**Columbia West Engineering, Inc.** **11917 NE 95th Street** **Vancouver, Washington 98682** **Phone: 360-823-2900** **Fax: 360-823-2901**
Date Prepared:	**August 12, 2019**

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GEOTECHNICAL SITE INVESTIGATION
HOWARD WAY EXTENSION
WOODLAND, WASHINGTON

1.0 INTRODUCTION

Columbia West Engineering, Inc. (Columbia West) was retained by Gibbs & Olson to conduct a geotechnical site investigation for the proposed Howard Way Extension project located in Woodland, Washington. The purpose of the investigation was to observe and assess subsurface soil conditions at specific locations and provide geotechnical engineering analyses, planning, and design recommendations for proposed development. The specific scope of services was outlined in a letter contract agreement for subconsultant services executed June 5, 2019. This report summarizes the investigation and provides field assessment documentation and laboratory analytical test reports. This report is subject to the limitations expressed in Section 6.0, *Conclusion and Limitations*, and Appendix E.

1.1 General Site Information

As indicated on Figures 1 and 2, the proposed Howard Way extension area is located within tax parcel 508330100 between Guild Road and the current southern terminus of Howard Way in Woodland, Washington. The Guild Road widening portion of the project is located south of tax parcels 508730100 and 508740100. The regulatory jurisdictional agency is the City of Woodland, Washington. The approximate latitude and longitude of the proposed improvements areas are N 45° 54' 60" and W 122° 46' 01" for the Howard Way extension and N 45° 54' 57" and W 122° 46' 13" for the Guild Road widening.

1.2 Proposed Development

Correspondence with the design team indicates the Port of Woodland desires to extend Howard Way from its current termination at the north end of the subject site south to connect to Guild Road and widen Guild Road along the southwest portion of the property to Robinson Road. Proposed roadway improvements are indicated on Figure 2. Water and sanitary sewer utilities will be extended to Guild Road within the extension of Howard Way. Columbia West has not reviewed a preliminary grading plan but understands that cut and fill will likely be proposed. This report is based upon proposed development as described above and may not be applicable if modified.

2.0 REGIONAL GEOLOGY AND SOIL CONDITIONS

The subject site lies within the Willamette Valley/Puget Sound Lowland, a wide physiographic depression flanked by the mountainous Coast Range on the west and the Cascade Range on the east. Inclined or uplifted structural zones within the Willamette Valley/Puget Sound Lowland constitute highland areas and depressed structural zones form sediment-filled basins. The site is located in the northern portion of the Portland/Vancouver Basin, an open, somewhat elliptical, northwest-trending syncline approximately 60 miles wide.

According to the *Geological Map of the Deer Island Quadrangle, Columbia County, Oregon and Cowlitz County, Washington* (Miscellaneous Field Studies Map MF-2392, U.S. Geological Survey, 2002), near-surface soils are expected to consist of Holocene and Pleistocene, unconsolidated, poorly to well-sorted sand, silt, and minor gravel alluvial deposits (Qa).

The *Web Soil Survey* (United States Department of Agriculture, Natural Resource Conservation Service [USDA NRCS], 2019 Website) identifies surface soils as Caples silty clay loam and Clato silt loam. Although soil conditions may vary from the broad USDA descriptions, Caples soils are generally fine-textured silts and clays with low permeability, low water capacity, and low shear strength. They are generally moisture sensitive, somewhat compressible, and described as having high shrink swell potential. They exhibit a slight erosion hazard based primarily on slope grade.

Clato soils are generally fine-textured silts and sands with moderate permeability, high water capacity, and low shear strength. They are generally moisture sensitive, somewhat compressible, and described as having low shrink swell potential. They exhibit a slight erosion hazard based primarily on slope grade.

3.0 REGIONAL SEISMOLOGY

Recent research and subsurface mapping investigations within the Pacific Northwest appear to suggest the historic potential risk for a large earthquake event with strong localized ground movement may be underestimated. Past earthquakes in the Pacific Northwest appear to have caused landslides and ground subsidence, in addition to severe flooding near coastal areas. Earthquakes may also induce soil liquefaction, which occurs when elevated horizontal ground acceleration and velocity cause soil particles to interact as a fluid as opposed to a solid. Liquefaction of soil can result in lateral spreading and temporary loss of bearing capacity and shear strength.

There are at least four major known fault zones in the vicinity of the site that may be capable of generating potentially destructive horizontal accelerations. These fault zones are described briefly in the following text.

<u>Portland Hills Fault Zone</u>

The Portland Hills Fault Zone consists of several northwest-trending faults located along the northeastern margin of the Tualatin Mountains, also known as the Portland Hills, and the southwest margin of the Portland Basin. The fault zone is approximately 25 to 30 miles in length and is located approximately 15 ½ miles southwest of the site. According to *Seismic Design Mapping, State of Oregon* (Geomatrix Consultants, 1995), there is no definitive consensus among geologists as to the zone fault type. Several alternate interpretations have been suggested.

According to the *USGS Earthquake Hazards Program*, the fault was originally mapped as a down-to-the-northeast normal fault but has also been mapped as part of a regional-scale zone of right-lateral, oblique slip faults, and as a steep escarpment caused by asymmetrical folding above a south-west dipping, blind thrust fault. The Portland Hills fault offsets Miocene Columbia River Basalts, and Miocene to Pliocene sedimentary rocks of the Troutdale Formation. No fault scarps on surficial Quaternary deposits have been described along the fault trace, and the fault is mapped as buried by the Pleistocene-aged Missoula flood deposits.

However, evidence suggests that fault movement has impacted shallow Holocene deposits and deeper Pleistocene sediments. Seismologists recorded a M3.2 earthquake thought to be associated with the fault zone near Kelly Point Park in November 2012, a M3.9 earthquake thought to be associated with the fault zone near Kelly Point Park in April 2003, and a M3.5 earthquake possibly associated with the fault zone approximately 1.3 miles east of the fault in 1991. Therefore, the Portland Hills Fault Zone is generally thought to be potentially active and capable of producing possible damaging earthquakes.

Gales Creek-Newberg-Mt. Angel Fault Zone

Located approximately 30 miles southwest of the site, the northwest-striking, approximately 50-mile long Gales Creek-Newberg-Mt. Angel Structural Zone forms the northwestern boundary between the Oregon Coast Range and the Willamette Valley, and consists of a series of discontinuous northwest-trending faults. The southern end of the fault zone forms the southwest margin of the Tualatin basin. Possible late-Quaternary geomorphic surface deformation may exist along the structural zone (Geomatrix Consultants, 1995).

According to the *USGS Earthquake Hazards Program*, the Mount Angel fault is mapped as a high-angle, reverse-oblique fault, which offsets Miocene rocks of the Columbia River Basalts, and Miocene and Pliocene sedimentary rocks. The fault appears to have controlled emplacement of the Frenchman Spring Member of the Wanapum Basalts, and thus must have a history that predates the Miocene age of these rocks. No unequivocal evidence of deformation of Quaternary deposits has been described, but a thick sequence of sediments deposited by the Missoula floods covers much of the southern part of the fault trace.

Although no definitive evidence of impacts to Holocene sediments have clearly been identified, the Mount Angel fault appears to have been the location of minor earthquake swarms in 1990 near Woodburn, Oregon, and a M5.6 earthquake in March 1993 near Scotts Mills, approximately four miles south of the mapped extent of the Mt. Angel fault. It is unclear if the earthquake occurred along the fault zone or a parallel structure. Therefore, the Gales Creek-Newberg-Mt. Angel Structural Zone is considered potentially active.

Lacamas Lake-Sandy River Fault Zone

The northwest-trending Lacamas Lake Fault and northeast-trending Sandy River Fault intersect north of Camas, Washington approximately 28 miles southeast of the site, and form part of the northeastern margin of the Portland basin. According to *Geology and Groundwater Conditions of Clark County Washington* (USGS Water Supply Paper 1600, Mundorff, 1964) and the *Geologic Map of the Lake Oswego Quadrangle* (Oregon DOGAMI Series GMS-59, 1989), the Lacamas Lake fault zone consists of shear contact between the Troutdale Formation and underlying Oligocene andesite-basalt bedrock. Secondary shear contact associated with the fault zone may have produced a series of prominent northwest-southeast geomorphic lineaments in proximity to the site.

According to the *USGS Earthquake Hazards Program* the fault has been mapped as a normal fault with down-to-the-southwest displacement and has also been described as a steeply northeast or southwest-dipping, oblique, right-lateral, slip-fault. The trace of the Lacamas Lake fault is marked by the very linear lower reach of Lacamas Creek. No fault scarps on Quaternary surficial deposits have been described. The Lacamas Lake fault offsets Pliocene-aged sedimentary conglomerates generally identified as the Troutdale formation, and Pliocene- to Pleistocene-aged basalts generally identified as the Boring Lava formation.

Recent seismic reflection data across the probable trace of the fault under the Columbia River yielded no unequivocal evidence of displacement underlying the Missoula flood deposits, however, recorded mild seismic activity during the recent past indicates this area may be potentially seismogenic.

Cascadia Subduction Zone

The Cascadia Subduction Zone has recently been recognized as a potential source of strong earthquake activity in the Portland/Vancouver Basin. This phenomenon is the result of the earth's large tectonic plate movement. Geologic evidence indicates that volcanic ocean floor activity along the Juan de Fuca ridge in the Pacific Ocean causes the Juan de Fuca Plate to perpetually move east and subduct under the North American Continental Plate. The subduction zone results in historic volcanic and potential earthquake activity in proximity to the plate interface, believed to lie approximately 20 to 50 miles west of the general location of the Oregon and Washington coast (Geomatrix Consultants, 1995).

4.0 GEOTECHNICAL AND GEOLOGIC FIELD INVESTIGATION

A geotechnical field investigation consisting of visual reconnaissance, three test pit explorations (TP-1 through TP-3), three infiltration tests (IT-1 through IT-3), and two piezometers (P-1 and P-2) was conducted at the site on June 13, 2019. Test pit exploration was performed with a track-mounted excavator. Subsurface soil profiles were logged in accordance with Unified Soil Classification System (USCS) specifications. Disturbed soil samples were collected from relevant soil horizons and submitted for laboratory analysis. Analytical laboratory test results are presented in Appendix A. Exploration locations and measured infiltration rates are indicated on Figure 2. Subsurface exploration logs are presented in Appendix B. Soil descriptions and classification information are provided in Appendix C. A photo log is presented in Appendix D.

4.1 Surface Investigation and Site Description

Field reconnaissance and review of aerial photography indicates the site is generally flat with slope grades of less than 5 percent and elevations ranging from 19 to 24 feet amsl within proposed development areas. The site is bounded by open acreage to the east, Guild Road to the south, Robinson Road to the west, and industrial development to the north. Current development within the project area consists of a small park and a Port of Woodland facility adjacent to the proposed intersection of Howard Way and Guild Road. Site vegetation consists of open grassy areas throughout with the exception of manicured landscapes and trees associated with the previously mentioned current development.

4.2 Subsurface Exploration and Investigation

Test pit explorations were advanced to a maximum depth of 14 feet below ground surface (bgs). The piezometers were installed to a depth of approximately 9 ½ feet bgs. Exploration locations were selected to observe subsurface soil characteristics in proximity to proposed improvement areas and are indicated on Figure 2.

4.2.1 Soil Type Description

Exploration in observed locations indicated the presence of approximately 6 to 8 inches of grass and topsoil with a disturbed till zone extending to approximately 12 inches bgs. Underlying topsoil and till layers, subsurface soils resembling USDA Caples and Clato soil series descriptions were encountered. Subsurface lithology may generally be described by soil types identified in the following text.

Soil Type 1 – SILT / Sandy SILT

Soil Type 1 was observed to primarily consist of brown, gray, tan, and blueish-gray, moist to wet, medium stiff SILT and sandy SILT. Soil Type 1 was observed below the topsoil layer in all explorations. Within test pits TP-1 and TP-3, Soil Type 1 extended to depths of 7 and 11 feet bgs, respectively, where it was underlain by Soil Type 2. Within test pit TP-2, Soil Type 1 extended to the terminal depth of exploration at 12 feet bgs.

Analytical laboratory testing conducted on representative soil samples obtained from test pits TP-1 and TP-2 indicated approximately 64 to 99 percent by weight passing the No. 200 sieve and in situ moisture contents ranging from 30 to 40 percent. Atterberg Limits analysis indicated tested samples of Soil Type 1 have liquid limits between approximately 29 and 38 percent and a plasticity index between approximately 3 and 11 percent. Laboratory tested samples of Soil Type 1 are classified ML according to USCS specifications and A-4(3) and A-6(6) according to AASHTO specifications.

Soil Type 2 – Silty SAND

Soil Type 2 was observed to consist of blueish-gray, wet, medium dense silty SAND. Soil Type 2 was observed below Soil Type 1 in test pits TP-1 and TP-3 where it extended to the terminal depths of exploration at 10 and 14 feet bgs, respectively.

Analytical laboratory testing conducted on a representative soil sample obtained from test pit TP-3 indicated approximately 18 percent by weight passing the No. 200 sieve and an in situ moisture content of 43 percent. Atterberg Limits analysis indicated the tested sample of Soil Type 2 is nonplastic. The laboratory tested sample of Soil Type 2 is classified SM according to USCS specifications and A-2-4(0) according to AASHTO specifications.

4.2.2 Groundwater

Groundwater was encountered in all test pit explorations between approximately 7 and 8 feet below ground surface. Groundwater levels are often subject to seasonal variance and may rise during extended periods of increased precipitation. Perched groundwater may also be present in localized areas. Seeps and springs may become evident during site grading, primarily along slopes or in areas cut below existing grade. Drainage design should be planned accordingly.

To further study site groundwater conditions, Columbia West installed two piezometers at the site, designated as P-1 and P-2, adjacent to test pits TP-1 and TP-2, respectively. The locations of the piezometers are indicated on Figure 2. The piezometers consisted of one-inch PVC casing with a three-foot screened interval backfilled with gravel and capped with bentonite. Columbia West understands the piezometers will be monitored by Gibbs & Olson.

5.0 DESIGN RECOMMENDATIONS

The geotechnical site investigation suggests the proposed improvements are generally compatible with surface and subsurface soils, provided the recommendations presented in this report are utilized and incorporated into the design and construction processes. The primary geotechnical concerns associated with the site are near-surface fine-textured soils, shallow groundwater, dynamic settlement, and dewatering considerations. Design recommendations are presented in the following text sections.

5.1 Site Preparation and Grading

Vegetation, organic material, deleterious material, and existing fill that may be encountered should be cleared from areas identified for site grading. Stripped topsoil should also be removed or used only as landscape fill in nonstructural areas with slopes less than 25 percent. The stripping depth for sod, highly organic topsoil, and disturbed soil is anticipated to be approximately 12 inches. The required stripping depth may increase in areas of existing fill, heavy organics, or previously existing structures. Actual stripping depths should be determined based upon visual observations made during construction when soil conditions are exposed. The post-construction maximum depth of landscape fill placed or spread at any location onsite should not exceed one foot.

Previously disturbed soil, debris, pavement, or unconsolidated fill encountered during grading or construction activities should be removed completely and thoroughly from structural areas. Demolition work prior to site improvements construction may generate unsuitable fill and disturbed soils in areas of old foundations, basement walls, utilities, and debris. Construction debris and unsuitable fill soils associated with demolition of these structures should be thoroughly removed from structural areas and backfilled with engineered structural fill. The potential for reusing soils disturbed during demolition should be evaluated by Columbia West at the time of construction.

Test pits excavated during site exploration were backfilled loosely with onsite soils. These test pits should be located and properly backfilled with structural fill during site improvements construction. Trees, stumps, and associated roots should also be removed from structural areas, individually and carefully. Resulting cavities and excavation areas should be backfilled with engineered structural fill.

Site grading activities should be performed in accordance with requirements specified in Chapter 18 and Appendix J of the *2015 International Building Code* (IBC) with exceptions noted in the text herein. Site preparation, soil stripping, and grading activities should be observed and documented by Columbia West.

5.2 Engineered Structural Fill

Areas proposed for fill placement should be appropriately prepared as described in the preceding text. Unless dispersed infiltration is proposed, surface soils should then be scarified and compacted prior to additional fill placement. Engineered structural fill should be placed in loose lifts not exceeding 12 inches in depth and compacted using standard conventional compaction equipment. The soil moisture content should be within two percentage points of optimum conditions. A field density at least equal to 95 percent of the maximum dry density, obtained from the modified Proctor moisture-density relationship test (AASHTO T180), is recommended for structural fill placement. For engineered structural fill placed on sloped grades, the area should be benched to provide a horizontal surface for compaction.

Compaction of engineered structural fill should be verified by nuclear gauge field compaction testing performed in accordance with ASTM D6938. Field compaction testing should be performed for each vertical foot of engineered fill placed. Engineered fill placement should be observed by Columbia West.

Engineered structural fill placement activities should be performed during dry summer months if possible. Clean native soils may be suitable for use as structural fill if adequately dried or moisture-conditioned to achieve recommended compaction specifications. Native soils may require addition of moisture during periods of dry weather. Compacted fill soils should be covered shortly after placement.

Because they are moisture-sensitive, fine-textured soils are often difficult to excavate and compact during wet weather conditions. If adequate compaction is not achievable with clean native soils, import structural fill consisting of granular fill meeting WSDOT specifications for *Gravel Borrow 9-03.14(1)* is recommended.

Representative samples of proposed engineered structural fill should be submitted for laboratory analysis and approval by Columbia West prior to placement. Laboratory analyses should include particle-size gradation and modified Proctor moisture-density analysis.

5.3 Cut and Fill Slopes

Fill placed on existing grades steeper than 5H:1V should be horizontally benched at least 10 feet into the slope. Fill slopes greater than six feet in height should be vertically keyed into existing subsurface soil. A typical fill slope cross-section is shown in Figure 3. Drainage implementations, including subdrains or perforated drain pipe trenches, may also be necessary in proximity to cut and fill slopes if seeps or springs are encountered. Drainage design may be performed on a case-by-case basis. Extent, depth, and location of drainage may be determined in the field by Columbia West during construction when soil conditions are exposed. Failure to provide adequate drainage may result in soil sloughing, settlement, or erosion.

Final cut or fill slopes at the site should not exceed 2H:1V or 10 feet in height without individual slope stability analysis. The values above assume a minimum horizontal setback for loads of 10 feet from top of cut or fill slope face or overall slope height divided by three (H/3), whichever is greater. A minimum slope setback detail for structures is presented in Figure 4.

Concentrated drainage or water flow over the face of slopes should be prohibited, and adequate protection against erosion is required. Fill slopes should be constructed by placing fill material in maximum 12-inch level lifts, compacting as described in Section 5.2, *Engineered Structural Fill* and horizontally benching where appropriate. Fill slopes should be overbuilt, compacted, and trimmed at least two feet horizontally to provide adequate compaction of the outer slope face. Proper cut and fill slope construction is critical to overall project stability and should be observed and documented by Columbia West.

5.4 Excavation

Soils at the site were explored to a maximum depth of 14 feet. Bedrock was not observed within subsurface explorations and blasting or specialized rock-excavation techniques are not anticipated. As stated previously, groundwater was encountered at 7 to 8 feet bgs in all test pit explorations. Perched groundwater layers may exist at shallower depths depending on seasonal fluctuations in the water table. Recommendations as presented in Section 5.5, *Dewatering* should be considered where below-grade construction intersects the shallow groundwater table.

Based on laboratory analysis and field testing, near-surface soils may be Washington State Industrial Safety and Health Administration (WISHA) Type C. For temporary open-cut excavations deeper than four feet, but less than 20 feet in soils of these types, the maximum allowable slope is 1.5H:1V. WISHA soil type should be confirmed during field construction activities by the contractor. Soil is often anisotropic and heterogeneous, and it is possible that WISHA soil types determined in the field may differ from those described above.

Site-specific shoring design may be required if open-cut excavations are infeasible or if excavations are proposed adjacent to existing infrastructure. Typical methods for stabilizing excavations consist of soldier piles and timber lagging, sheet pile walls, tiebacks and shotcrete, or pre-fabricated hydraulic shoring. Because lateral earth pressure distributions acting on below-grade structures are dependent on the type of shoring system used, Columbia West should be contacted to conduct additional analysis when shoring type, excavation depths, and locations are known.

The contractor should be held responsible for site safety, sloping, and shoring. Columbia West is not responsible for contractor activities and in no case should excavation be conducted in excess of all applicable local, state, and federal laws.

5.5 Dewatering

Groundwater elevation and hydrostatic pressure should be carefully considered during design of utilities, retaining walls, or other structures that require below-grade excavation. As described previously, shallow groundwater may be encountered in areas proposed for development. Utility trenches in shallow groundwater areas or excavations and cuts that remain open for even short periods of time may undermine or collapse due to groundwater effects. Placement of layers of riprap or quarry spalls in localized areas on shallow excavation side slopes may be required to limit instability. Over-excavation and stabilization of pipe trenches or other excavations with imported crushed aggregate or gabion rock may also be necessary to provide adequate subgrade support.

Significant pumping and dewatering may be required to temporarily reduce the groundwater elevation to allow construction of proposed below-grade structures, installation of utilities, or placement of structural fills. Dewatering via a sump within excavation zones may be insufficient to control groundwater and provide excavation side slope stability. Dewatering may be more feasibly conducted by installing a system of temporary well points and pumps around proposed excavation areas or utility trenches. Depending on proposed utility depths, a site-specific dewatering plan may be necessary. Well pumps should remain functioning at all times during the excavation and construction period. Suitable back-up pumps and power supplies should be available to prevent unanticipated shut-down of dewatering equipment. Failure to operate pumps full-time may result in flooding of the excavation zones, resulting in damage to forms, slopes, or equipment.

Columbia West recommends that the contractor be required to prepare and present a detailed dewatering plan. The contractor should consult with a dewatering professional, as necessary, to provide an adequate dewatering plan for site conditions. If additional subsurface information not provided in the site-specific geotechnical report is necessary to complete the dewatering plan, the contractor shall be responsible for securing all the required information necessary for the design of the system.

The contractor should be required to acknowledge the existence of challenging surface and subsurface soil conditions including, but not limited to, shallow groundwater, low-strength soils, running sands, and collapsing trench conditions.

The dewatering plan should be submitted and reviewed by the owner prior to commencement of construction activities requiring dewatering. The dewatering plan should include, at a minimum, well construction details, pumping rates, radius of influence of pumping wells, effluent flow rates, water disposal locations, outfall scour considerations, and all applicable environmental considerations.

5.6 Soil Liquefaction and Dynamic Settlement

According to the *Liquefaction Susceptibility Map of Cowlitz County Washington* (Washington State Department of Natural Resources, 2004), the site is mapped as moderate to high susceptibility for liquefaction.

Liquefaction, defined as the transformation of the behavior of a granular material from a solid to a liquid due to increased pore-water pressure and reduced effective stress, may occur when granular materials quickly compact under cyclic stresses caused by a seismic event. The effects of liquefaction may include immediate ground settlement and lateral spreading.

Soils most susceptible to liquefaction are generally saturated, cohesionless, loose to medium-dense sands within 50 feet of the ground surface. Recent research has also indicated that low plasticity silts and clays may also be subject to sand-like liquefaction behavior if the plasticity index determined by the Atterberg Limits analysis is less than 8. Potentially liquefiable soils located above the existing, historic, or expected ground water levels do not generally pose a liquefaction hazard. It is important to note that changes in perched ground water elevation may occur due to project development or other factors not observed at the time of the investigation.

Based upon results of laboratory analysis and site-specific testing, observed site soils may meet the criteria described above for liquefiable soils. Evaluation of liquefaction potential was beyond the scope of this investigation. Columbia West should be contacted if analysis of liquefaction and dynamic settlement is required for future structures.

5.7 Infiltration Testing Results

To investigate the feasibility of subsurface disposal of stormwater, Columbia West conducted in situ infiltration testing at three locations on June 13, 2019. Results of in situ infiltration testing are presented in Table 1. The soil classifications presented in Table 1 are based on laboratory analysis when available.

As indicated in Table 1, tests were conducted in all test pits at the indicated depths. Soils in the tested locations were observed and sampled where appropriate to adequately characterize the subsurface profile. Tested native soils are classified SILT (ML) and sandy SILT (ML). Soil laboratory analytical test reports are provided in Appendix A.

Single-ring, falling head infiltration testing was performed by inserting three-inch diameter tubes into the soil at the noted depths. The tests were conducted by filling the tubes with water and measuring changes in hydraulic head relative to time at regular intervals. Using Darcy's Law for saturated flow in homogeneous media, the coefficient of permeability (k) was then calculated.

The reported infiltration rates, as defined by the soil coefficient of permeability, reflect approximate raw observed data, without application of a factor of safety. An appropriate soil correction factor should be applied to the observed infiltration rates prior to use in design calculations. The soil correction factor should be applied in addition to other factors of safety associated with civil design considerations.

Infiltration facilities should maintain code-specified structural setback distances and be protected from erosion, especially during construction. Improperly designed or constructed systems may become fouled or plugged with mud or micaceous sediment. Excavation and preparation of stormwater disposal facilities should be closely monitored by Columbia West. An emergency overflow discharge point should be provided.

It is important to note that site soil conditions and localized infiltration capability may be variable. Therefore, infiltration rates should be verified by additional testing during construction when subgrade soils are exposed. Subgrade soils should also be observed by Columbia West to verify soil index properties pertaining to infiltration are similar to those at the tested locations.

The recommended infiltration rates provided in Table 1 are based upon an assumed adequate separation distance between the infiltrating surface and the groundwater table or other confining layers and Columbia West's observations during limited subsurface exploration. Therefore, they may not be an accurate indicator of post-developed long-term system performance. It should be understood that systems may require additional infiltration capacity if submerged or mounded conditions are present, or construction verification testing or future performance indicate the system is not functioning according to original tested and designed parameters.

Table 1. Infiltration Test Data

Test Number	Location (See Figure 2)	Approximate Test Depth (feet bgs)	Groundwater Depth (feet bgs) On 06-13-19	Soil Type (*Indicates Visual Classification)	Passing No. 200 Sieve (%)	Infiltration Rate (**Coefficient of Permeability, k) (inches/hour)
IT-1	TP-1	3	7	ML, SILT	98.5	2.5
IT-2	TP-2	2.5	8	ML, Sandy SILT	64.7	0.4
IT-3	TP-3	2	7	ML, Sandy SILT*	-	1.3

*Indicates visual soil classification
**Infiltration rate as defined by soil's approximate vertical coefficient of permeability (k).

5.8 Drainage

At a minimum, site drainage should include surface water collection and conveyance to properly designed stormwater management structures and facilities. Drainage design in general should conform to City of Woodland regulations. Subdrains should be considered if portions of the site are cut below surrounding grades. Shallow groundwater, springs, or seeps should be conveyed via drainage channel or perforated pipe into an approved discharge location. Recommendations for design and installation of perforated drainage pipe may be performed on a case-by-case basis by Columbia West during construction. Failure to provide adequate surface and subsurface drainage may result in soil slumping or unanticipated settlement of pavements exceeding tolerable limits. A typical perforated drain pipe trench detail is presented in Figure 5.

Site improvements construction in some areas may occur at or near the shallow groundwater table, particularly if work is conducted during wet-weather conditions. Dewatering may be necessary, and a drainage mat may be required to achieve sufficient elevation for fill placement. A typical drainage mat is shown on Figure 6. Columbia West should determine drainage mat location, extent, and thickness when subsurface conditions are exposed. Drainage mats may need to be constructed in conjunction with subdrains to convey captured water to an approved discharge location.

Drains should be closely monitored after construction to assess their effectiveness. If additional surface or shallow subsurface seeps become evident, the drainage provisions may require modification or additional drains. Columbia West should be consulted to provide appropriate recommendations.

5.9 Bituminous Asphalt and Portland Cement Concrete Pavement

Design of pavement sections for the Guild Road widening portion of the project was outside the scope of this investigation. The below pavement recommendations are applicable only for the Howard Way extension portion of the project. Proposed improvements for the Howard Way extension are anticipated to include construction of new pavement sections over in situ soils or embankment fill. Columbia West conducted engineering analysis for flexible pavement design using the 1993 *AASHTO Guide for Design of Pavement Structures* in general accordance with WSDOT structural design policy. Two pavement sections were analyzed for the proposed roadway considering subgrade support, structural layer proportions, and pavement materials. Twenty-year design life criteria for the roadway was selected based upon client correspondence and City of Woodland standards. Design criteria are presented in Table 2.

5.9.1 Design Traffic Loading

Traffic loading for the proposed roadway is primarily based upon traffic estimates provided by Gibbs & Olson and from *Guild Road II Industrial Park, Traffic Impact Analysis Report, Port of Woodland, WA* produced by SCJ Alliance (November, 2017). Design Equivalent Single Axle Loads (ESALs) are based upon current and 20-year projected traffic loading, estimated traffic composition, and assumed Load Equivalency Factors (LEFs). Table 2 presents pavement design traffic loading used in the flexible and rigid pavement design analysis. Serviceability and reliability parameters used in the analysis are based upon suggested values from WSDOT.

Table 2. *Pavement Design Traffic Loading*

Location	Design Life	*Design Life ESALs	Assumed Annual Traffic Growth (%)	Equivalent Traffic Index (TI)
Proposed Howard Way Extension As Indicated On Figure 2	20 years	200,000	4.0	7.5

*If actual traffic substantially exceeds design traffic, reduced pavement serviceability and design life should be expected.

5.9.2 Soil Subgrade Properties

Soil subgrade properties for pavement design are based upon laboratory analysis of samples collected during the field investigation. Laboratory tested subgrade soils within the proposed alignment are classified as SILT(ML) and sandy SILT (ML) according to USCS specifications and A-4(3) and A-6(6) according to AASHTO specifications.

In-situ testing during field exploration revealed subgrade soils to be medium stiff and generally consistent in composition in the observed locations. Based upon field testing, observations, and laboratory analysis, the CBR value was estimated to be approximately 3.0, corresponding to a resilient modulus of 4,500 psi. An effective resilient modulus for the subgrade, reflecting the reduction in stiffness due to seasonal wetting or saturation of the subgrade, was calculated to be 4,100 psi using suggested WSDOT values.

As previously discussed, site grades may need to be altered to meet proposed finished grades for the roadway and associated improvements. For areas where structural fill meeting WSDOT Gravel Borrow 9-03.14(1) may be used to elevate site grades, a separate pavement design analysis was conducted to consider the included subbase section. Results of these analyses are presented below.

5.9.3 Recommended Flexible (Asphalt) Pavement Sections

Based upon design parameters presented in the previous sections, flexible pavement sections were developed to achieve serviceable conditions over the 20-year design life. Recommended flexible pavement sections for the proposed roadway are presented in Table 3.

Table 3. ***Flexible Pavement Section Recommendations***

Pavement Section Layer	Recommended Section Thickness (inches)		Specifications
	Conventional HMA Section over firm native soils	*Conventional HMA Section over engineered fill subbase meeting WSDOT Gravel Borrow 9-03.14(1)	
Asphalt concrete HMA Class ½" 70-22	4.0	4.0	91 percent of maximum Rice density (AASHTO T209)
$1^1/_4$"-0 Crushed aggregate base course WSDOT 9-03.0(3)	12.0	8.0	95% of maximum modified Proctor density (AASHTO T180)
Well-graded, granular subbase meeting WSDOT Gravel Borrow 9-03.14(1)	-	12.0	95% of maximum modified Proctor density (AASHTO T180)
Geotextile Fabric	yes	no	Mirafi 500X or approved equivalent placed directly over exposed native soils
Scarified and compacted subgrade soils	12	12	95% of maximum modified Proctor density (AASHTO T180)

*Structural section applicable when placed upon a minimum of 12 inches of gravel borrow fill as described.

5.9.4 Construction Recommendations

In general, road construction methods and materials should follow WSDOT *Standard Specifications for Road, Bridge, and Municipal Construction* and City of Woodland standards. For dry weather construction, pavement surface sections should bear upon competent subgrade consisting of scarified and compacted native soil or engineered structural fill. Wet weather pavement construction is discussed later in Section 5.9, *Wet Weather Construction Methods and Techniques*. Flexible pavement sections should not bear upon undocumented fill soils or uncompacted native soils. Subgrade conditions should be evaluated and tested by Columbia West prior to placement of crushed aggregate base. Subgrade evaluation should include nuclear gauge density testing and wheel proof-roll observations conducted with a 12-cubic yard, double-axle dump truck or equivalent.

Nuclear gauge density testing should be conducted at 250-foot intervals or as determined by the onsite geotechnical engineer. Subgrade soil should be compacted to at least 95 percent of the modified Proctor moisture-density relationship test, as determined by AASHTO T180. Areas of observed deflection or rutting during proof-roll evaluation should be excavated to a firm surface and replaced with compacted crushed aggregate. Geotextile fabric consisting of Mirafi 500X or approved equal should be installed directly over compacted native soils where applicable.

Crushed surfacing base course meeting WSDOT 9-03.9(3) should be compacted and tested in accordance with the specifications outlined above. Asphalt concrete pavement should consist of HMA Class ½" 70-22 and should be compacted to at least 91 percent of maximum Rice density. Nuclear gauge density testing should be conducted to verify adherence to recommended specifications. Testing frequency should be in accordance with WSDOT and City of Woodland specifications.

Portland cement concrete curbs and sidewalks should be installed in accordance with City of Woodland specifications. Aggregate base should be observed and proof-rolled by Columbia West. Soft areas that deflect or rut should be stabilized prior to pouring concrete. Concrete should be tested during installation in accordance with ASTM C171, C138, C231, C143, C1064, and C31.

Recommended field concrete testing includes slump, air entrainment, temperature, and unit weight, as well as casting of cylinder specimens for compressive strength tests.

5.10 Wet Weather Construction Methods and Techniques

Wet weather construction often results in significant shear strength reduction and soft areas that may rut or deflect. Installation of granular working layers may be necessary to provide a firm support base and sustain construction equipment. Granular layers should consist of all-weather gravel, 2x4-inch gabion, or other similar material (six-inch maximum size with less than five percent passing the No. 200 sieve).

Construction equipment traffic across exposed soil should be minimized. Equipment traffic induces dynamic loading, which may result in weak areas and significant reduction in shear strength for wet soils. Wet weather construction may also result in generation of significant excess quantities of soft wet soil. This material should be removed from the site or stockpiled in a designated area.

Construction during wet weather conditions may require increased base thickness. Over-excavation of subgrade soils or subgrade amendment with lime and/or cement may be necessary to provide a firm base upon which to place crushed aggregate. Geotextile filter fabric is also recommended. If soil amendment with lime or cement is considered, Columbia West should be contacted to provide appropriate recommendations based upon observed field conditions and desired performance criteria.

Crushed aggregate base should be installed in a single lift with trucks end-dumping from an advancing pad of granular fill. During extended wet periods, stripping activities may also need to be conducted from an advancing pad of granular fill. Once installed, the crushed aggregate base should be compacted with several passes from a static drum roller. A vibratory compactor is not recommended because it may further disturb the subgrade. Subdrains may also be necessary to provide subgrade drainage and maintain structural integrity.

Crushed aggregate base should be compacted to at least 95 percent of maximum dry density according to the modified Proctor density test (ASTM D1557). Compaction should be verified by nuclear gauge density testing. Observation of a proof-roll with a loaded dump truck is also recommended as an indication of the compacted aggregate's performance.

It should be understood that wet weather construction is risky and costly. Columbia West should observe and document wet weather construction activities. Proper construction methods and techniques are critical to overall project integrity.

5.11 Erosion Control Measures

Based upon field observations and laboratory testing, the erosion hazard for site soils in flat to shallow-gradient portions of the property is likely to be low. The potential for erosion generally increases in sloped areas. Therefore, disturbance to vegetation in sloped areas should be minimized during construction activities. Soil is also prone to erosion if unprotected and unvegetated during periods of increased precipitation. Erosion can be minimized by performing construction activities during dry summer months.

Site-specific erosion control measures should be implemented to address the maintenance of exposed areas. This may include silt fence, biofilter bags, straw wattles, or other suitable methods. During construction activities, exposed areas should be well-compacted and protected from erosion with visqueen, surface tackifier, or other means, as appropriate. Temporary slopes or exposed areas may be covered with straw, crushed aggregate, or riprap in localized areas to minimize erosion. Erosion and water runoff during wet weather conditions may be controlled by application of strategically placed channels and small detention depressions with overflow pipes.

After grading, exposed surfaces should be vegetated as soon as possible with erosion-resistant native vegetation. Jute mesh or straw may be applied to enhance vegetation. Once established, vegetation should be properly maintained. Disturbance to existing native vegetation and surrounding organic soil should also be minimized during construction activities.

5.12 Utility Installation

Utility installation may require subsurface excavation and trenching. Excavation, trenching and shoring should conform to federal (Occupational Safety and Health Administration) (OSHA) (29 CFR, Part 1926) and *WISHA* (WAC, Chapter 296-155) regulations. Site soils may slough when cut vertically and sudden precipitation events or perched groundwater may result in accumulation of water within excavation zones and trenches.

Utilities should be installed in general accordance with manufacturer's recommendations. Utility trench backfill should consist of *WSDOT 9-03.19 Bank Run Gravel for Trench Backfill* or *WSDOT 9-03.14(2) Select Borrow* with a maximum particle size of 2 ½-inches. Trench backfill material within 18 inches of the top of utility pipes should be hand compacted (i.e., no heavy compaction equipment). The remaining backfill should be compacted to at least 95 percent of maximum dry density as determined by the modified Proctor moisture-density test (AASHTO T180). Clean, free-draining, fine bedding sand is recommended for use in the pipe zone. With exception of the pipe zone, backfill should be placed in loose lifts not exceeding 12 inches in thickness.

Compaction of utility trench backfill material should be verified by nuclear gauge field compaction testing performed in accordance with ASTM D6938. It is recommended that field compaction testing be performed at 200-foot intervals along the utility trench centerline at the surface and midpoint depth of the trench. Compaction frequency and specifications may be modified for non-structural areas in accordance with recommendations of the site geotechnical engineer.

6.0 CONCLUSION AND LIMITATIONS

This geotechnical site investigation report was prepared in accordance with accepted standard conventional principles and practices of geotechnical engineering. This investigation pertains only to material tested and observed as of the date of this report and is based on proposed site development as described in the text herein. This report is a professional opinion containing recommendations established by engineering interpretations of subsurface soils based on conditions observed during site exploration. Soil conditions may differ between tested locations or over time. Slight variations may produce impacts to the performance of structural facilities if not adequately addressed. This underscores the importance of diligent QA/QC construction observation and testing to verify soil conditions are as anticipated in this report.

Therefore, this report contains several recommendations for field observation and testing by Columbia West personnel during construction activities. Columbia West cannot accept responsibility for deviations from recommendations described in this report. Future performance of structural facilities is often related to the degree of construction observation by qualified personnel. These services should be performed to the full extent recommended.

This report is not an environmental assessment and should not be construed as a representative warranty of site subsurface conditions. The discovery of adverse environmental conditions, or subsurface soils that deviate from those described in this report, should immediately prompt further investigation. The above statements are in lieu of all other statements expressed or implied.

This report was prepared solely for the client and is not to be reproduced without prior authorization from Columbia West. Final engineering plans and specifications for the project should be reviewed and approved by Columbia West as they relate to geotechnical and grading issues prior to final design approval. Columbia West is not responsible for independent conclusions or recommendations made by other parties based on information presented in this report. Unless a particular service was expressly included in the scope, it was not performed and there should be no assumptions based on services not provided. Additional report limitations and important information about this document are presented in Appendix E. This information should be carefully read and understood by the client and other parties reviewing this document.

Sincerely,

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REFERENCES

American Society for Testing and Materials (ASTM), *Annual Book of ASTM Standards, Soil and Rock (I): D420 – D5876, Volume 04.08, Soil and Rock (II): D5878 – Latest*, *Volume 04.09*, 2018.

AASHTO Guide for Design of Pavement Structures 1993, by the American Association of State Highway and Transportation Officials, 1993.

Evarts, Russell, *Geological Map of the Deer Island Quadrangle, Columbia County, Oregon and Cowlitz County, Washington,* Miscellaneous Field Studies Map MF-2392, U.S. Geological Survey, 2002

Geomatrix Consultants, Oregon Department of Transportation (ODOT), *Seismic Design Mapping, State of Oregon*, 1995.

International Code Council, *2015 International Building Code (IBC),* 2015.

Occupational Safety and Health Administration (OSHA), *29 CFR Part 1926 – Safety and Health Regulations for Construction*, 2001.

Palmer, Stephen P., Magsino, Sammantha L., Poilstra, James L., and Niggeman, Rebecca A., *Site Class Map of Cowlitz County, Washington;* Washington State Department of Natural Resources, September 2004.

Palmer, Stephen P., et al, *Liquefaction Susceptibility Map of Cowlitz County, Washington;* Washington State Department of Natural Resources; Division of Geology and Earth Resources, September 2004.

SCJ Alliance Consulting Services, *Guild Road II Industrial Park, Traffic Impact Analysis Report, Port of Woodland, WA,* November, 2017.

United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS), *Web Soil Survey,* http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm, accessed June 2019.

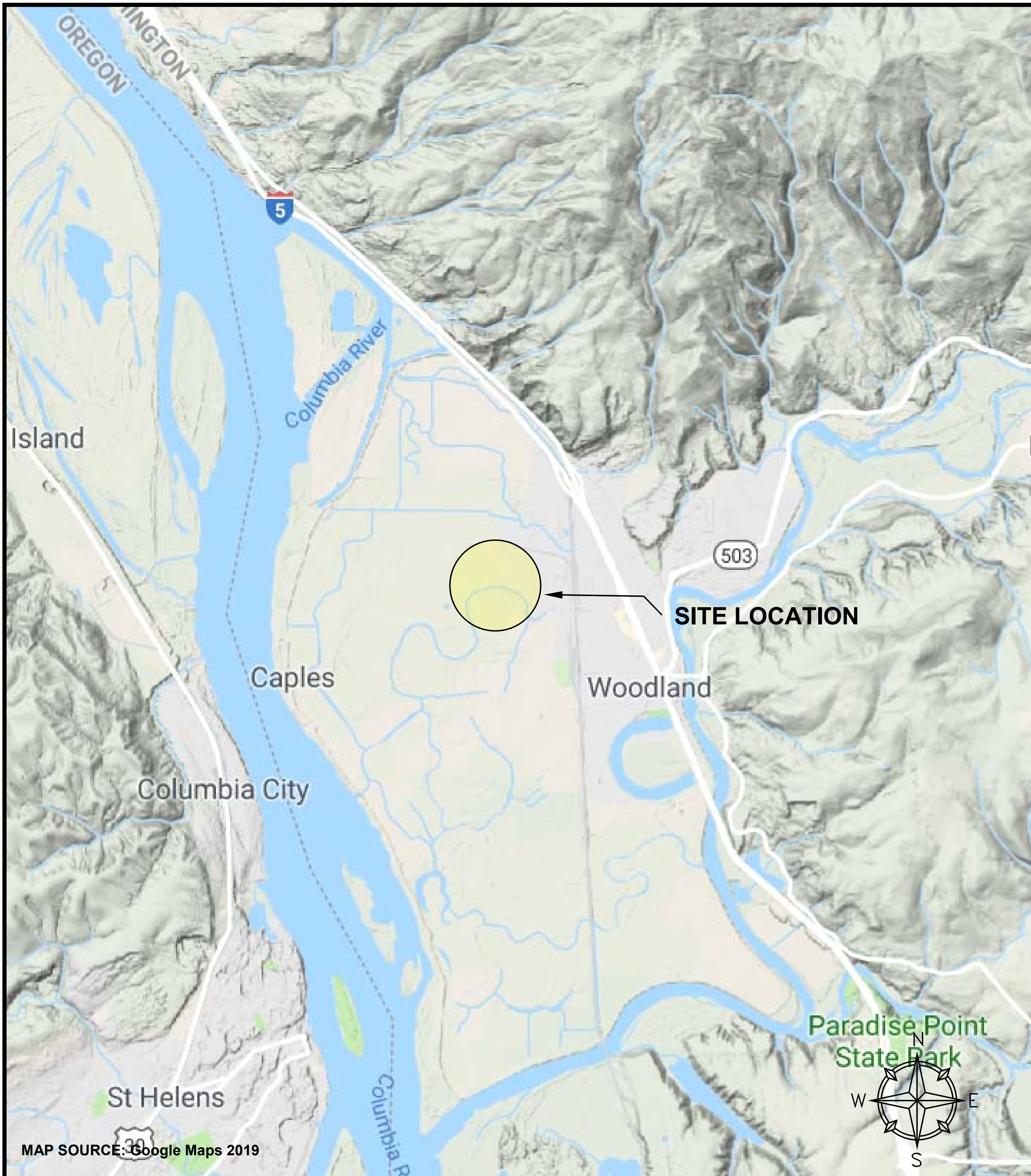
Washington Administrative Code, Chapter 296-155, Division of Industrial Safety and Health, Washington Department of Labor and Industries, *Safety Standards for Construction Work, Part N, Excavation, Trenching and Shoring,* 1993.

WSDOT *Geotechnical Design Manual, Version M 46-03.10,* Washington State Department of Transportation, August, 2014.

WSDOT Pavement Policy, June 2011, Washington State Department of Transportation.

WSDOT Standard Specifications for Road, Bridge, and Municipal Construction, 2014, Washington State Department of Transportation

FIGURES



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Design	Drawn: JFM			SITE LOCATION MAP	FIGURE 1
Checked: LVL	Date: 08/12/2019				
Client : GIBBS&OLSON	Rev	By	Date	HOWARD WAY EXTENSION WOODLAND, WASHINGTON	
Job No.: 19152					
CAD File: FIGURE 1					
Scale: NTS					

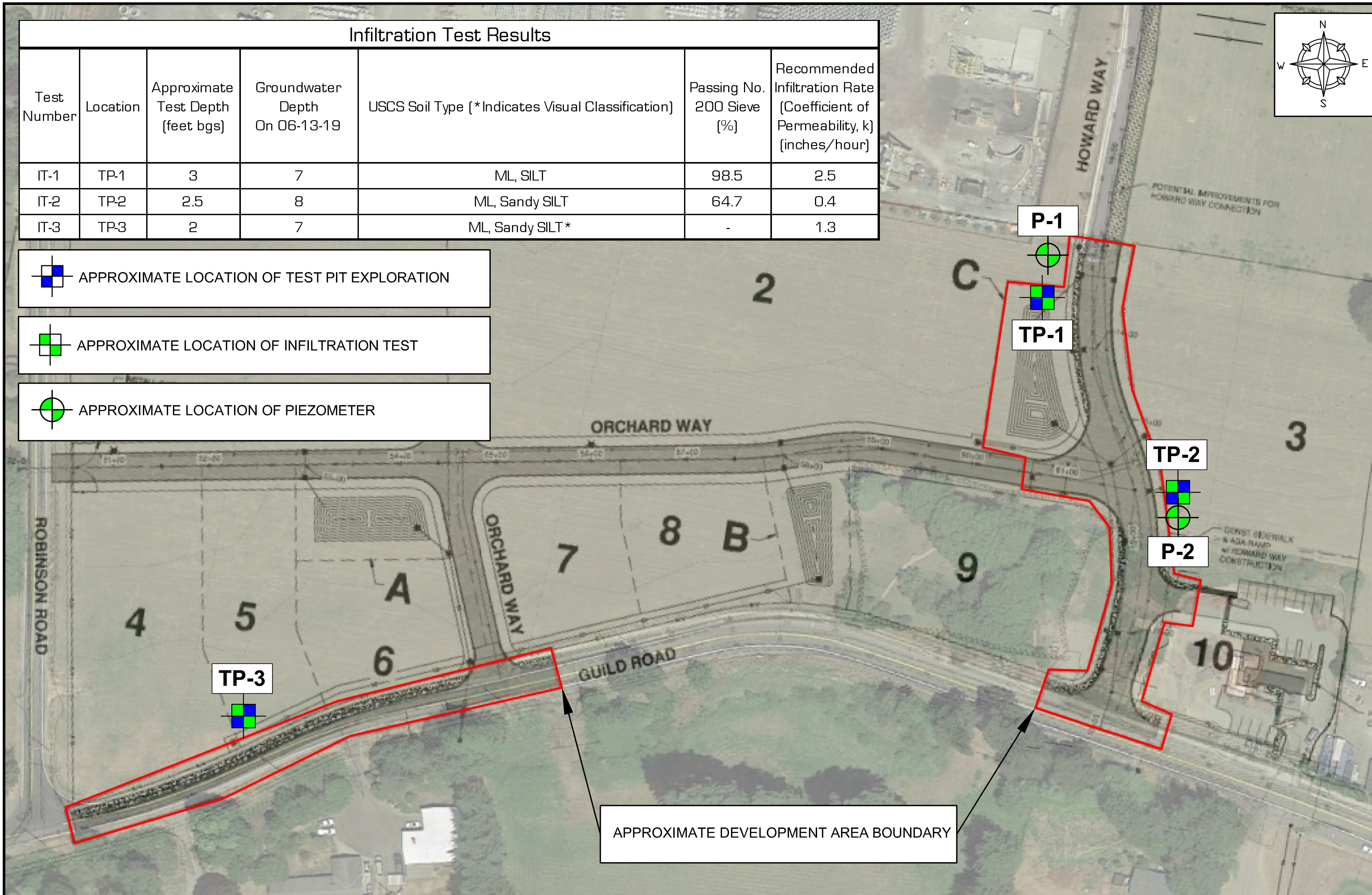
Infiltration Test Results

Test Number	Location	Approximate Test Depth (feet bgs)	Groundwater Depth On 06-13-19	USCS Soil Type (*Indicates Visual Classification)	Passing No. 200 Sieve (%)	Recommended Infiltration Rate (Coefficient of Permeability, k) (inches/hour)
IT-1	TP-1	3	7	ML, SILT	98.5	2.5
IT-2	TP-2	2.5	8	ML, Sandy SILT	64.7	0.4
IT-3	TP-3	2	7	ML, Sandy SILT*	-	1.3

APPROXIMATE LOCATION OF TEST PIT EXPLORATION

APPROXIMATE LOCATION OF INFILTRATION TEST

APPROXIMATE LOCATION OF PIEZOMETER



NOTES:
1. SITE LOCATION: 1620 GUILD ROAD AND SECTION OF GUILD ROAD SOUTH OF TAX PARCELS 508730100 AND 508740100 IN WOODLAND, WASHINGTON.
2. DEVELOPMENT AREA CONSISTS OF A PORTION OF TAX PARCEL 508330100 TOTALING APPROXIMATELY 1.3 ACRES AND A GUILD ROAD ALIGNMENT LENGTH OF APPROXIMATELY 540 LINEAR FEET.
3. DRAWING IS NOT TO SCALE.
4. AREAL IMAGE SOURCED FROM GOOGLE EARTH.
5. PRELIMINARY SITE PLAN OBTAINED FROM GIBBS & OLSON.
6. EXPLORATION LOCATIONS ARE APPROXIMATE AND NOT SURVEYED.
7. TEST PITS BACKFILLED LOOSELY WITH ONSITE SOIL AND PIEZOMETERS BACKFILLED WITH GRAVEL AND BENTONITE ON JUNE 13, 2019.
8. INFILTRATION RATES ARE APPROXIMATE COEFFICIENTS OF PERMEABILITY AND DO NOT INCLUDE A FACTOR OF SAFETY.

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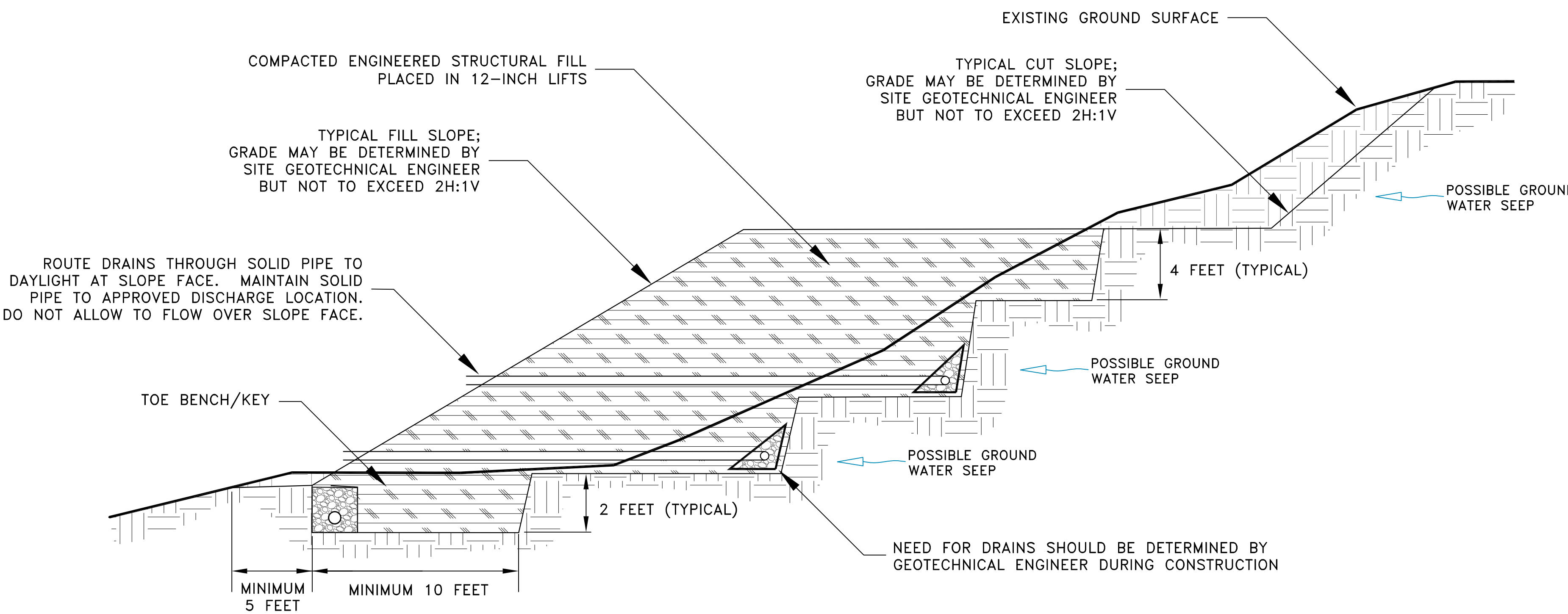
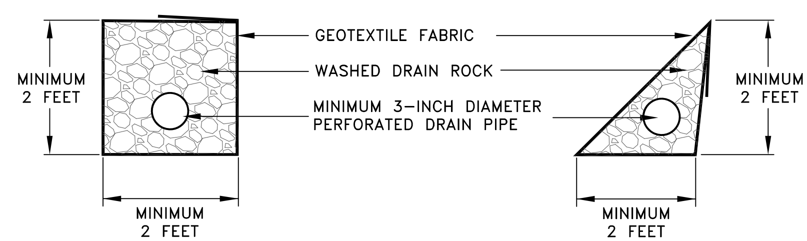
Design:	Drawn: JFM			EXPLORATION LOCATION MAP
Checked: LVL	Date: 06/14/19			
Client: GIBBS&OLSON	Rev	By	Date	HOWARD WAY EXTENSION WOODLAND, WASHINGTON
Job No: 19152				
CAD File: FIGURE 2				
Scale: NONE				

FIGURE 2

TYPICAL CUT AND FILL SLOPE CROSS-SECTION



TYPICAL DRAIN SECTION DETAIL



DRAIN SPECIFICATIONS

GEOTEXTILE FABRIC SHALL CONSIST OF MIRAFI 140N OR APPROVED EQUIVALENT WITH AOS BETWEEN No. 70 AND No. 100 SIEVE.

WASHED DRAIN ROCK SHALL BE OPEN-GRADED ANGULAR DRAIN ROCK WITH LESS THAN 2 PERCENT PASSING THE No. 200 SIEVE AND A MAXIMUM PARTICLE SIZE OF 3 INCHES.

NOTES:
1. DRAWING IS NOT TO SCALE.
2. SLOPES AND PROFILES SHOWN ARE APPROXIMATE.
3. DRAWING REPRESENTS TYPICAL FILL AND CUT SLOPE SECTION, AND MAY NOT BE SITE-SPECIFIC.

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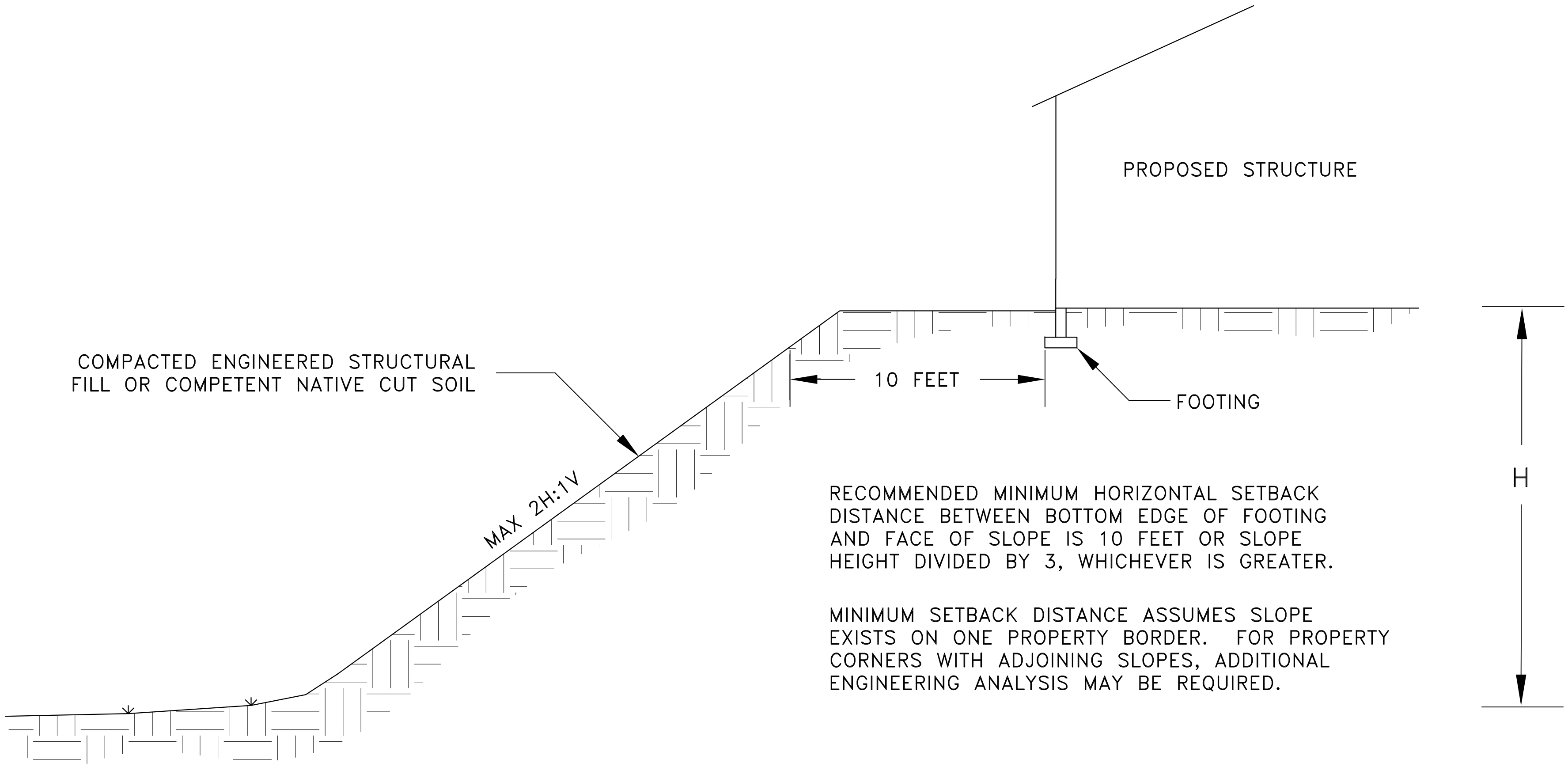
Design:	Drawn: JFM			TYPICAL CUT AND FILL SLOPE CROSS-SECTION	FIGURE 3
Checked: LVL	Date: 06/21/19				
Client: GIBBS & OLSON	Rev	By	Date		
Job No: 19152				HOWARD WAY EXTENSION WOODLAND, WASHINGTON	
CAD File: FIGURE 3					
Scale: NONE					

MINIMUM FOUNDATION SLOPE SETBACK DETAIL



RECOMMENDED MINIMUM HORIZONTAL SETBACK DISTANCE BETWEEN BOTTOM EDGE OF FOOTING AND FACE OF SLOPE IS 10 FEET OR SLOPE HEIGHT DIVIDED BY 3, WHICHEVER IS GREATER.

MINIMUM SETBACK DISTANCE ASSUMES SLOPE EXISTS ON ONE PROPERTY BORDER. FOR PROPERTY CORNERS WITH ADJOINING SLOPES, ADDITIONAL ENGINEERING ANALYSIS MAY BE REQUIRED.

NOTES:
1. DRAWING IS NOT TO SCALE.
2. SLOPES AND PROFILES SHOWN ARE APPROXIMATE.
3. DRAWING REPRESENTS TYPICAL FOUNDATION SETBACK DETAIL, AND MAY NOT BE SITE-SPECIFIC.

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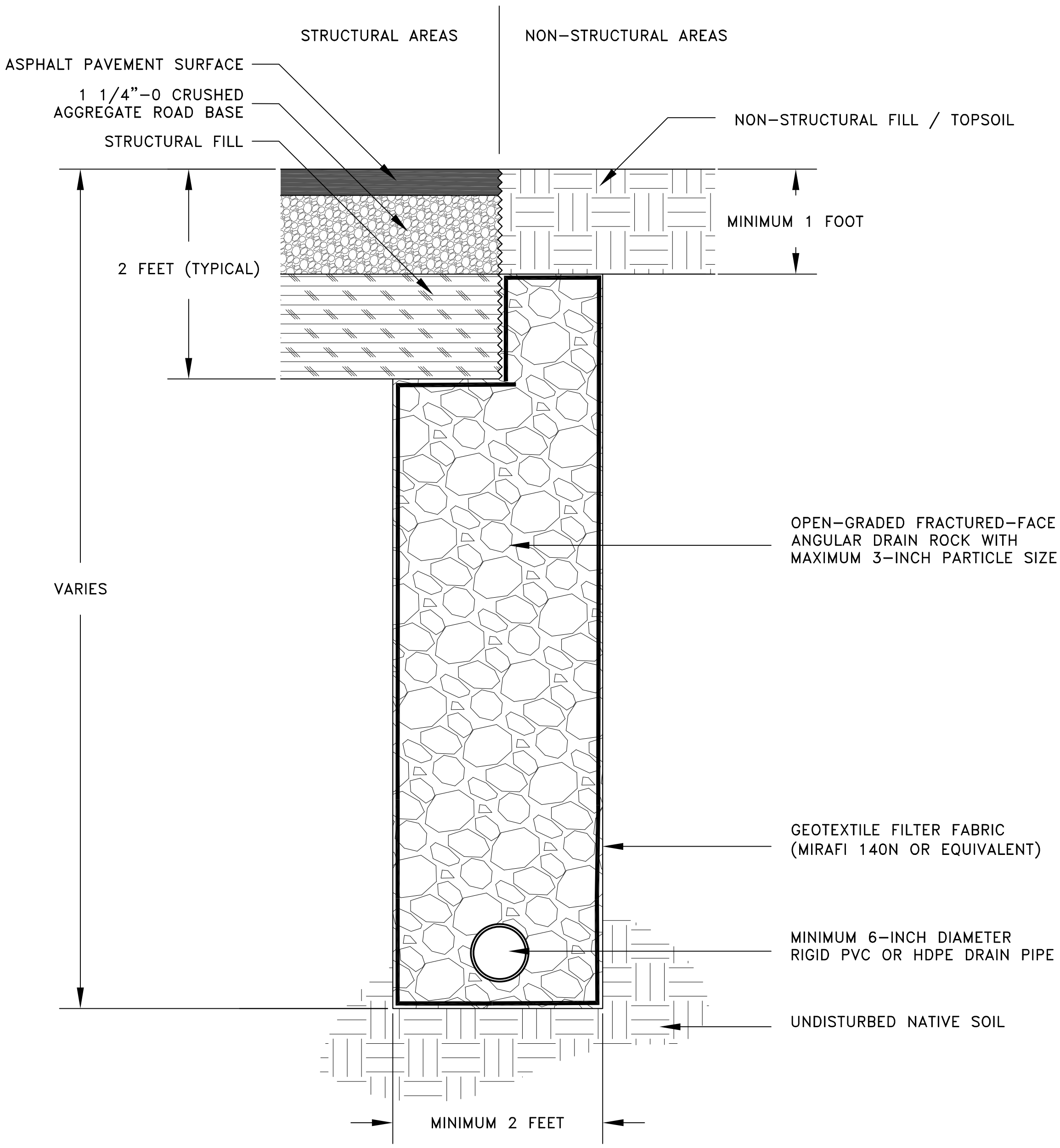
Design:	Drawn: JFM		
Checked: LVL	Date: 06/21/19		
Client: GIBBS & OLSON	Rev	By	Date
Job No: 19152			
CAD File: FIGURE 4			
Scale: NONE			

TYPICAL MINIMUM SLOPE SETBACK DETAIL

HOWARD WAY EXTENSION
WOODLAND, WASHINGTON

FIGURE 4

TYPICAL PERFORATED DRAIN PIPE TRENCH DETAIL



NOTE: LOCATION, INVERT ELEVATION, DEPTH OF TRENCH, AND EXTENT OF PERFORATED PIPE REQUIRED MAY BE MODIFIED BY THE GEOTECHNICAL ENGINEER DURING CONSTRUCTION BASED UPON FIELD OBSERVATION AND SITE-SPECIFIC SOIL CONDITIONS.

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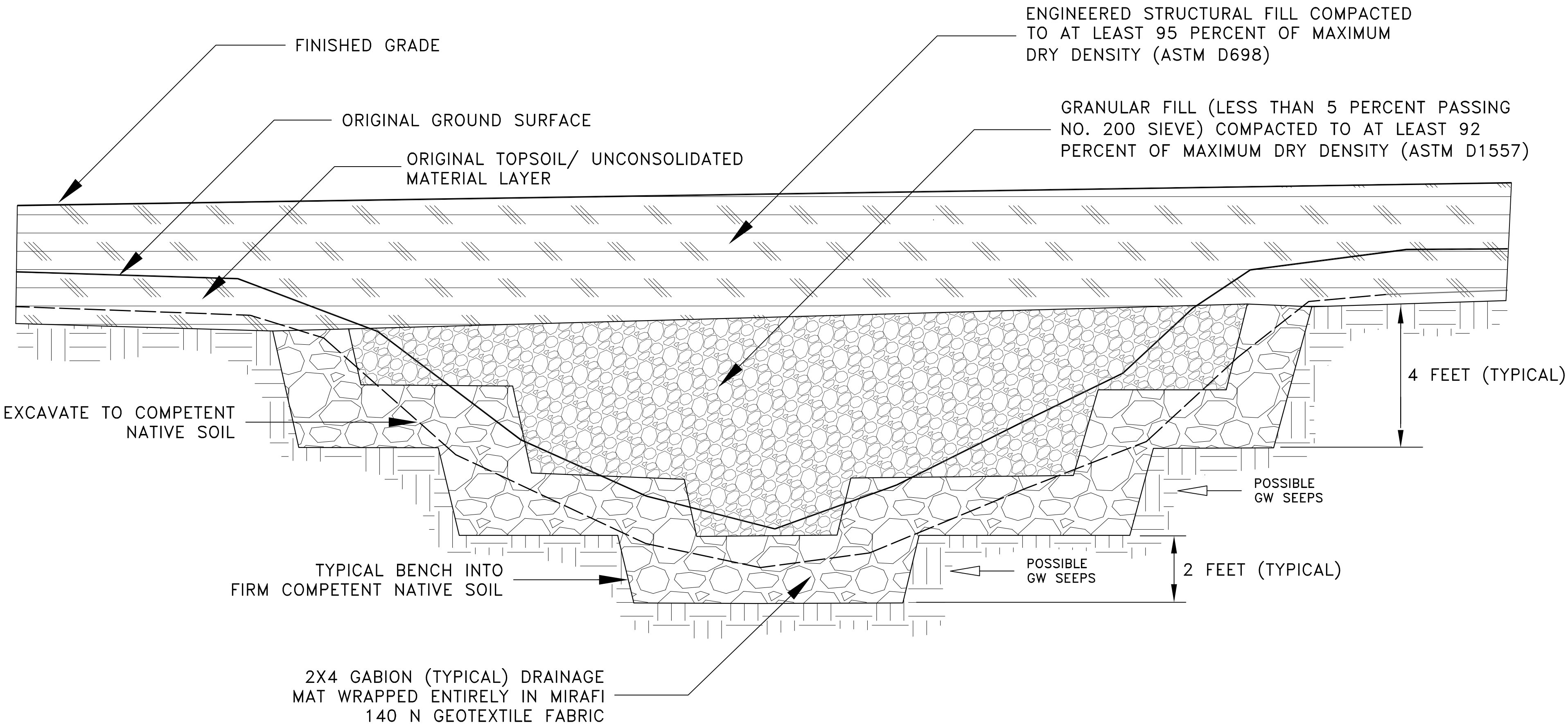
Design:	Drawn: JFM			TYPICAL PERFORATED DRAIN PIPE TRENCH DETAIL	FIGURE 5
Checked: LVL	Date: 06/21/19				
Client: GIBBS & OLSON	Rev	By	Date	HOWARD WAY EXTENSION WOODLAND, WASHINGTON	
Job No: 19152					
CAD File: FIGURE 5					
Scale: NONE					

TYPICAL DRAINAGE MAT CROSS-SECTION



NOTES:
1. DRAWING IS NOT TO SCALE.
2. SLOPES AND PROFILES SHOWN ARE APPROXIMATE.
3. DRAWING REPRESENTS TYPICAL DRAINAGE MAT SECTION AND MAY NOT BE SITE-SPECIFIC.
4. DEPTH, LOCATION, EXTENT, AND THICKNESS OF GABION MAT AND GRANULAR FILL LAYER SHOULD BE DETERMINED IN THE FIELD BY COLUMBIA WEST.
5. DRAIN PIPE MAY BE NEEDED AT LOWEST GRADIENT POINT OF DRAINAGE MAT TO CONTROL AND DIRECT FLOW.

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Design:	Drawn: JFM		TYPICAL DRAINAGE MAT SECTION	FIGURE 6
Checked: LVL	Date: 06/21/19			
Client: GIBBS & OLSON	Rev	By	Date	HOWARD WAY EXTENSION WOODLAND, WASHINGTON
Job No: 19152				
CAD File: FIGURE 6				
Scale: NONE				

APPENDIX A
LABORATORY TEST RESULTS

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CALIFORNIA BEARING RATIO (CBR) REPORT

PROJECT	CLIENT	PROJECT NO.	LAB ID
Howard Way Extension and Guild Road Widening Project Port of Woodland Woodland, Washington	Gibbs & Olson 1157 3rd Avenue, Suite 219 Longview, Washington 98632	19152	S19-492
		REPORT DATE: 06/26/19	FIELD ID: TP1.2
		DATE SAMPLED: 06/13/19	SAMPLED BY: MCK

MATERIAL DATA

MATERIAL SAMPLED	MATERIAL SOURCE	USCS SOIL TYPE
SILT	Test Pit TP-01 depth = 3.5 feet	ML, Silt

LABORATORY TEST DATA

LABORATORY EQUIPMENT	TEST PROCEDURE
ELE International Versa Loader 25-3525/02	ASTM D1883

SAMPLE AND TEST DATA

	PARAMETER	10 blows/lift	25 blows/lift	56 blows/lift
sample	preparation method	ASTM D698	ASTM D698	ASTM D698
	condition at testing	soaked 4 days	soaked 4 days	soaked 4 days
dry density, pcf	before soaking	77.0	85.1	91.3
	after soaking	77.0	85.1	91.3
moisture content, %	before compaction	24.8%	24.8%	24.5%
	after compaction	24.4%	24.6%	24.3%
	after soaking	36.9%	31.4%	28.0%
height, in	before soaking	4.585	4.581	4.583
	after soaking	4.639	4.644	4.666
	swell, %	1.18%	1.38%	1.81%
	surcharge amount, lbs	10	10	10
	bearing ratio (CBR value)	0.8	3.3	5.3

ADDITIONAL DATA

PROCTOR

maximum dry density = 89.7 pcf
optimum moisture = 24.2%

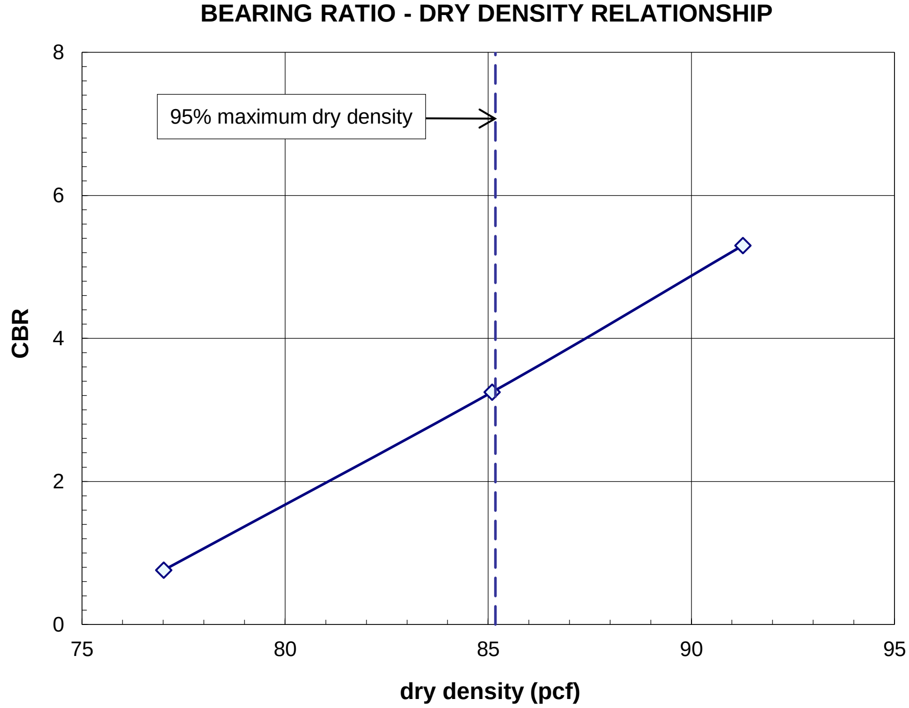
ATTERBERG LIMITS

liquid limit = 29
plastic limit = 26
plasticity index = 3

SIEVE ANALYSIS SUMMARY

% gravel = 0.0%
% sand = 1.5%
% silt and clay = 98.5%

BEARING RATIO - DRY DENSITY RELATIONSHIP



ADDITIONAL NOTES

CBR is approximately equal to **3.3** at 95% maximum dry density (ASTM D698)

Bearing ratio reported at the 0.100 inch penetration.

DATE TESTED	TESTED BY
06/24/19	JJC/MJR

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MOISTURE-DENSITY RELATIONSHIP

PROJECT	CLIENT	PROJECT NO.	LAB ID
Howard Way Extension and Guild Road Widening Project Port of Woodland Woodland, Washington	Gibbs & Olson 1157 3rd Avenue, Suite 219 Longview, Washington 98632	19152	S19-492
		REPORT DATE: 06/26/19	FIELD ID: TP1.2
		DATE SAMPLED: 06/13/19	SAMPLED BY: MCK

MATERIAL DATA

MATERIAL SAMPLED	MATERIAL SOURCE	USCS SOIL TYPE
SILT	Test Pit TP-01 depth = 3.5 feet	ML, Silt

SPECIFICATIONS	AASHTO SOIL TYPE
none	A-4(3)

LABORATORY TEST DATA

TEST STANDARD AND SAMPLE PREPARATION
ASTM D698 Method A, prepared moist, manual compaction, circular face rammer

MAX DRY DENSITY AND OPTIMUM MOISTURE

maximum dry density = 89.7 pcf
optimum moisture content = 24.2%

DATA POINTS

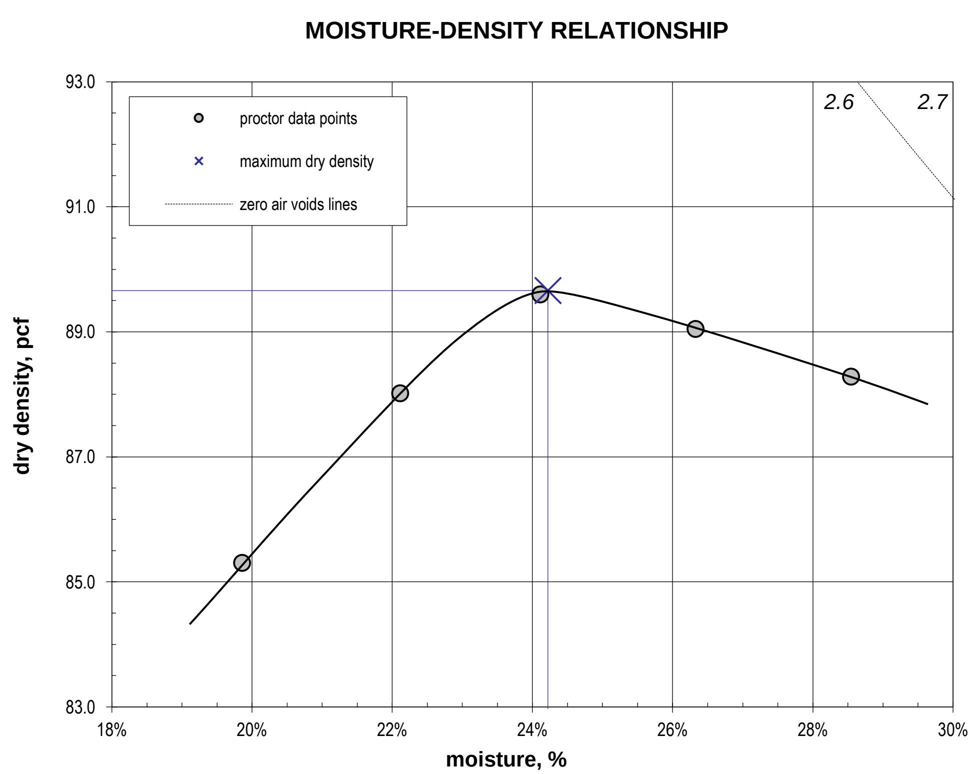
	❶	❷	❸	❹	❺
% m =	19.9%	22.1%	24.1%	26.3%	28.5%
DD =	85.3	88.0	89.6	89.0	88.3

OVERSIZE CORRECTION

sieve	%retained*	
3-inch	0%	removed
3/4-inch	0.0%	removed/replaced
#4	0.0%	

* values are individual

Note: Per ASTM D1883, material retained on 3-inch sieve removed from sample. Material passing 3-inch sieve and retained on 3/4-inch sieve replaced with equivalent weight of material passing 3/4-inch sieve and retained on #4 sieve.



SIEVE DATA

	SIEVE SIZE US	SIEVE SIZE mm	PERCENT PASSING SIEVE actual	SPECS max	SPECS min
GRAVEL	6.00"	150.0			
	4.00"	100.0			
	3.00"	75.0			
	2.50"	63.0			
	2.00"	50.0			
	1.75"	45.0			
	1.50"	37.5			
	1.25"	31.5			
	1.00"	25.0			
	7/8"	22.4			
	3/4"	19.0			
	5/8"	16.0			
	1/2"	12.5			
	3/8"	9.50			
	1/4"	6.30			
	#4	4.75	100%		
SAND	#8	2.36			
	#10	2.00	100%		
	#16	1.18			
	#20	0.850	100%		
	#30	0.600			
	#40	0.425	100%		
	#50	0.300			
	#60	0.250	99%		
	#80	0.180			
	#100	0.150	99%		
	#140	0.106			
	#170	0.090			
	#200	0.075	99%		

DATE TESTED	TESTED BY
06/18/19	BTT/MJR

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PARTICLE-SIZE ANALYSIS REPORT

PROJECT	CLIENT	PROJECT NO.	LAB ID
Howard Way Extension and Guild Road Widening Project Port of Woodland Woodland, Washington	Gibbs & Olson 1157 3rd Avenue, Suite 219 Longview, Washington 98632	19152	S19-492
		REPORT DATE: 06/26/19	FIELD ID: TP1.2
		DATE SAMPLED: 06/13/19	SAMPLED BY: MCK

MATERIAL DATA

MATERIAL SAMPLED	MATERIAL SOURCE	USCS SOIL TYPE
SILT	Test Pit TP-01 depth = 3.5 feet	ML, Silt

SPECIFICATIONS	AASHTO SOIL TYPE
none	A-4(3)

LABORATORY TEST DATA

LABORATORY EQUIPMENT	TEST PROCEDURE
Rainhart "Mary Ann" Sifter 637	ASTM D6913

ADDITIONAL DATA

initial dry mass (g) =	168.77		
as-received moisture content =	40.0%	coefficient of curvature, C_C =	n/a
liquid limit =	29	coefficient of uniformity, C_U =	n/a
plastic limit =	26	effective size, $D_{(10)}$ =	n/a
plasticity index =	3	$D_{(30)}$ =	n/a
fineness modulus =	n/a	$D_{(60)}$ =	n/a

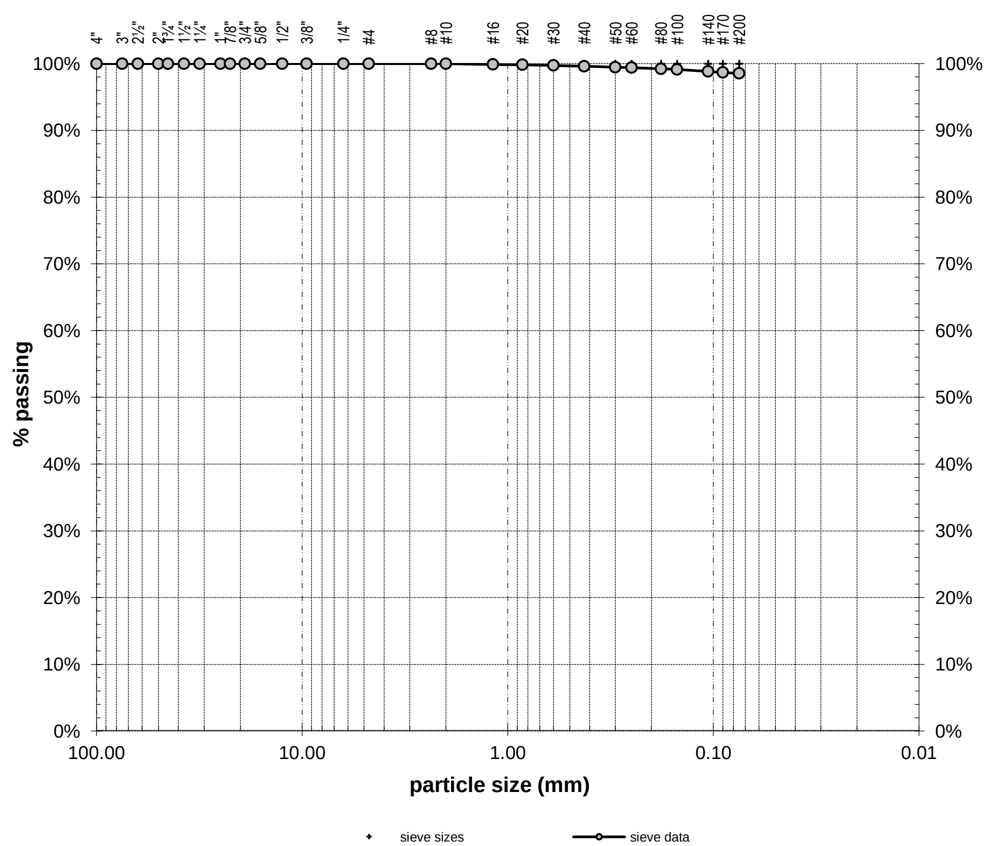
SIEVE DATA

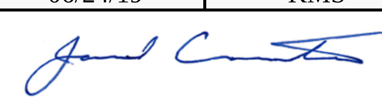
% gravel = 0.0%
% sand = 1.5%
% silt and clay = 98.5%

	SIEVE SIZE US	mm	PERCENT PASSING SIEVE act.	interp.	SPECS max	min
GRAVEL	6.00"	150.0		100%		
	4.00"	100.0		100%		
	3.00"	75.0		100%		
	2.50"	63.0		100%		
	2.00"	50.0		100%		
	1.75"	45.0		100%		
	1.50"	37.5		100%		
	1.25"	31.5		100%		
	1.00"	25.0		100%		
	7/8"	22.4		100%		
	3/4"	19.0		100%		
	5/8"	16.0		100%		
	1/2"	12.5		100%		
	3/8"	9.50		100%		
	1/4"	6.30		100%		
	#4	4.75	100%			
SAND	#8	2.36		100%		
	#10	2.00	100%			
	#16	1.18		100%		
	#20	0.850	100%			
	#30	0.600		100%		
	#40	0.425	100%			
	#50	0.300		99%		
	#60	0.250	99%			
	#80	0.180		99%		
	#100	0.150	99%			
	#140	0.106		99%		
	#170	0.090		99%		
	#200	0.075	99%			

DATE TESTED	TESTED BY
06/24/19	KMS

GRAIN SIZE DISTRIBUTION





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ATTERBERG LIMITS REPORT

PROJECT	CLIENT	PROJECT NO.	LAB ID
Howard Way Extension and Guild Road Widening Project Port of Woodland Woodland, Washington	Gibbs & Olson 1157 3rd Avenue, Suite 219 Longview, Washington 98632	19152	S19-492
		REPORT DATE: 06/26/19	FIELD ID: TP1.2
		DATE SAMPLED: 06/13/19	SAMPLED BY: MCK

MATERIAL DATA

MATERIAL SAMPLED	MATERIAL SOURCE	USCS SOIL TYPE
SILT	Test Pit TP-01 depth = 3.5 feet	ML, Silt

LABORATORY TEST DATA

LABORATORY EQUIPMENT	TEST PROCEDURE
Liquid Limit Machine, Hand Rolled	ASTM D4318

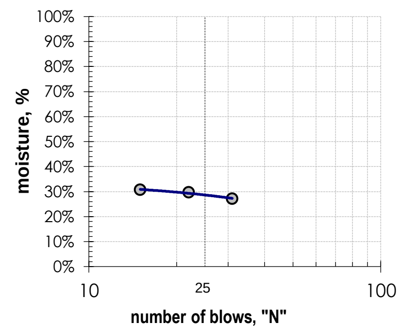
ATTERBERG LIMITS

liquid limit = 29
plastic limit = 26
plasticity index = 3

LIQUID LIMIT DETERMINATION

	❶	❷	❸	❹
wet soil + pan weight, g =	30.41	34.25	31.95	
dry soil + pan weight, g =	28.36	31.18	29.34	
pan weight, g =	20.80	20.84	20.83	
N (blows) =	31	22	15	
moisture, % =	27.1 %	29.7 %	30.7 %	

LIQUID LIMIT



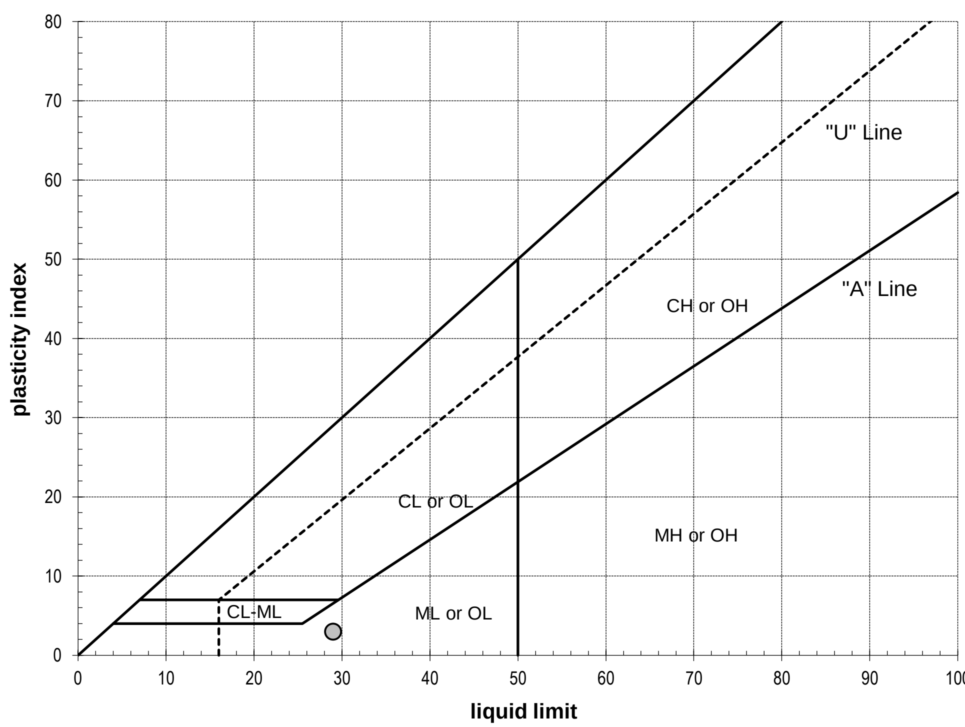
SHRINKAGE

shrinkage limit = n/a
shrinkage ratio = n/a

PLASTIC LIMIT DETERMINATION

	❶	❷	❸	❹
wet soil + pan weight, g =	27.38	27.32		
dry soil + pan weight, g =	26.03	25.95		
pan weight, g =	20.87	20.67		
moisture, % =	26.2 %	26.0 %		

PLASTICITY CHART



ADDITIONAL DATA

% gravel =	0.0%
% sand =	1.5%
% silt and clay =	98.5%
% silt =	n/a
% clay =	n/a
moisture content =	40.0%

DATE TESTED	TESTED BY
06/25/19	RTT

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PARTICLE-SIZE ANALYSIS REPORT

PROJECT	CLIENT	PROJECT NO.	LAB ID
Howard Way Extension and Guild Road Widening Project Port of Woodland Woodland, Washington	Gibbs & Olson 1157 3rd Avenue, Suite 219 Longview, Washington 98632	19152	S19-493
		REPORT DATE: 06/26/19	FIELD ID: TP2.1
		DATE SAMPLED: 06/15/19	SAMPLED BY: MCK

MATERIAL DATA

MATERIAL SAMPLED	MATERIAL SOURCE	USCS SOIL TYPE
Sandy SILT	Test Pit TP-02 depth = 2.5 feet	ML, Sandy Silt

SPECIFICATIONS	AASHTO SOIL TYPE
none	A-6(6)

LABORATORY TEST DATA

LABORATORY EQUIPMENT	TEST PROCEDURE
Rainhart "Mary Ann" Sifter 637	ASTM D6913

ADDITIONAL DATA

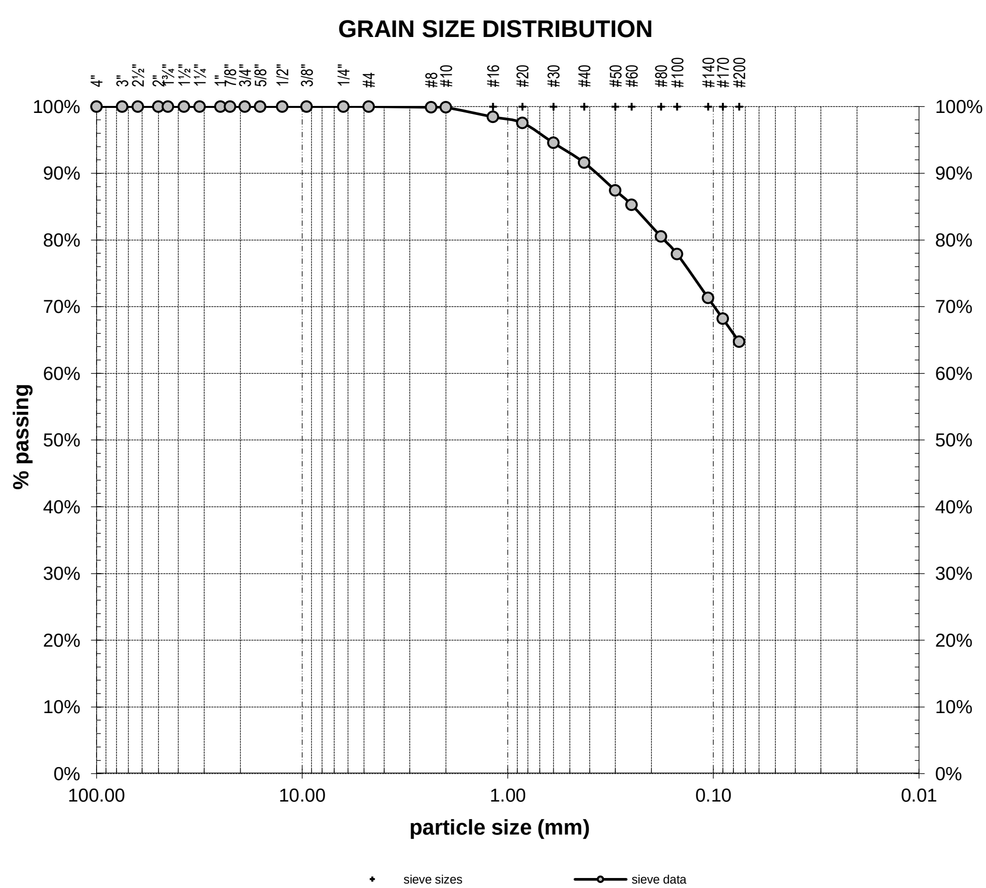
initial dry mass (g) =	197.40		
as-received moisture content =	30.2%	coefficient of curvature, C_C =	n/a
liquid limit =	38	coefficient of uniformity, C_U =	n/a
plastic limit =	27	effective size, $D_{(10)}$ =	n/a
plasticity index =	11	$D_{(30)}$ =	n/a
fineness modulus =	n/a	$D_{(60)}$ =	n/a

SIEVE DATA

% gravel = 0.0%
% sand = 35.3%
% silt and clay = 64.7%

	SIEVE SIZE US	SIEVE SIZE mm	PERCENT PASSING SIEVE act.	PERCENT PASSING SIEVE interp.	SPECS max	SPECS min
GRAVEL	6.00"	150.0		100%		
	4.00"	100.0		100%		
	3.00"	75.0		100%		
	2.50"	63.0		100%		
	2.00"	50.0		100%		
	1.75"	45.0		100%		
	1.50"	37.5		100%		
	1.25"	31.5		100%		
	1.00"	25.0		100%		
	7/8"	22.4		100%		
	3/4"	19.0		100%		
	5/8"	16.0		100%		
	1/2"	12.5		100%		
	3/8"	9.50		100%		
	1/4"	6.30		100%		
	#4	4.75	100%			
SAND	#8	2.36		100%		
	#10	2.00	100%			
	#16	1.18		98%		
	#20	0.850	98%			
	#30	0.600		95%		
	#40	0.425	92%			
	#50	0.300		87%		
	#60	0.250	85%			
	#80	0.180		81%		
	#100	0.150	78%			
	#140	0.106		71%		
	#170	0.090		68%		
	#200	0.075	65%			

DATE TESTED	TESTED BY
06/24/19	KMS



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ATTERBERG LIMITS REPORT

PROJECT	CLIENT	PROJECT NO.	LAB ID
Howard Way Extension and Guild Road Widening Project Port of Woodland Woodland, Washington	Gibbs & Olson 1157 3rd Avenue, Suite 219 Longview, Washington 98632	19152	S19-493
		REPORT DATE: 06/26/19	FIELD ID: TP2.1
		DATE SAMPLED: 06/15/19	SAMPLED BY: MCK

MATERIAL DATA

MATERIAL SAMPLED	MATERIAL SOURCE	USCS SOIL TYPE
Sandy SILT	Test Pit TP-02 depth = 2.5 feet	ML, Sandy Silt

LABORATORY TEST DATA

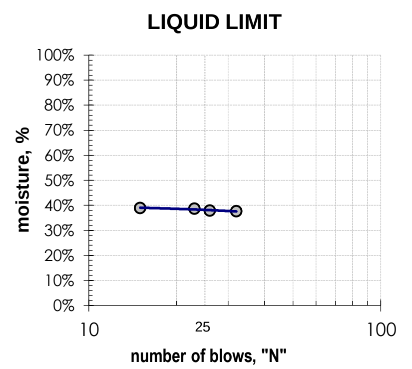
LABORATORY EQUIPMENT	TEST PROCEDURE
Liquid Limit Machine, Hand Rolled	ASTM D4318

ATTERBERG LIMITS

liquid limit = 38
plastic limit = 27
plasticity index = 11

LIQUID LIMIT DETERMINATION

	❶	❷	❸	❹
wet soil + pan weight, g =	32.23	32.55	31.37	33.38
dry soil + pan weight, g =	29.14	29.28	28.41	29.89
pan weight, g =	20.91	20.64	20.76	20.93
N (blows) =	32	26	23	15
moisture, % =	37.6 %	37.9 %	38.7 %	39.0 %

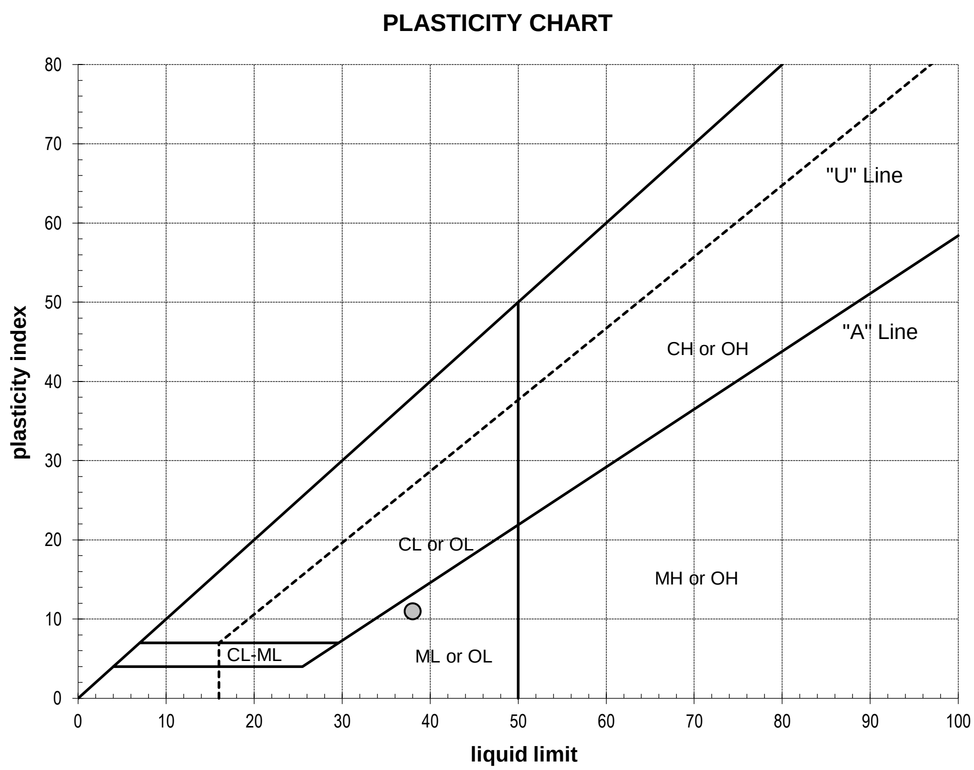


SHRINKAGE

shrinkage limit = n/a
shrinkage ratio = n/a

PLASTIC LIMIT DETERMINATION

	❶	❷	❸	❹
wet soil + pan weight, g =	27.98	28.77		
dry soil + pan weight, g =	26.45	27.11		
pan weight, g =	20.74	20.87		
moisture, % =	26.8 %	26.6 %		



ADDITIONAL DATA

% gravel = 0.0%
% sand = 35.3%
% silt and clay = 64.7%
% silt = n/a
% clay = n/a
moisture content = 30.2%

DATE TESTED	TESTED BY
06/25/19	RTT

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PARTICLE-SIZE ANALYSIS REPORT

PROJECT	CLIENT	PROJECT NO.	LAB ID
Howard Way Extension and Guild Road Widening Project, Port of Woodland, Woodland, Washington	Gibbs & Olson, 1157 3rd Avenue, Suite 219, Longview, Washington 98632	19152	S19-494
		REPORT DATE: 06/26/19	FIELD ID: TP3.2
		DATE SAMPLED: 06/13/19	SAMPLED BY: MCK

MATERIAL DATA

MATERIAL SAMPLED	MATERIAL SOURCE	USCS SOIL TYPE
Silty SAND	Test Pit TP-03, depth = 14 feet	SM, Silty Sand

SPECIFICATIONS	AASHTO SOIL TYPE
none	A-2-4(0)

LABORATORY TEST DATA

LABORATORY EQUIPMENT	TEST PROCEDURE
Rainhart "Mary Ann" Sifter 637	ASTM D6913

ADDITIONAL DATA

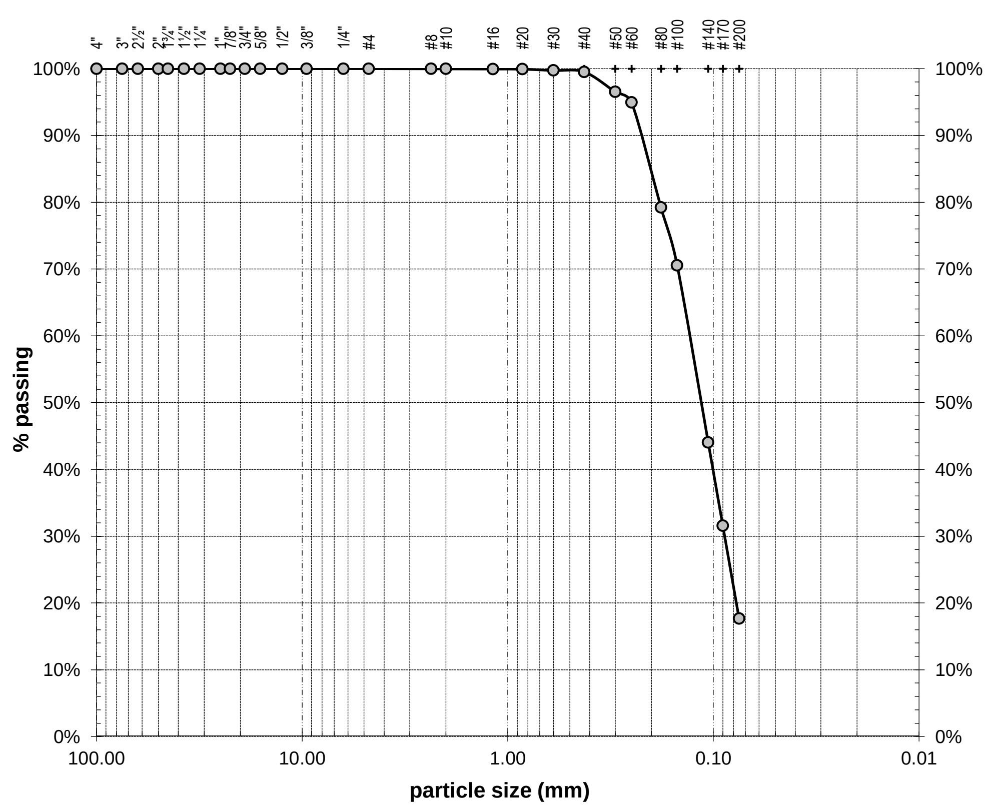
initial dry mass (g) =	126.20		
as-received moisture content =	43.0%	coefficient of curvature, C_C =	n/a
liquid limit =	-	coefficient of uniformity, C_U =	n/a
plastic limit =	-	effective size, $D_{(10)}$ =	n/a
plasticity index =	NP	$D_{(30)}$ =	0.088 mm
fineness modulus =	n/a	$D_{(60)}$ =	0.131 mm

SIEVE DATA

% gravel = 0.0%
% sand = 82.4%
% silt and clay = 17.6%

	SIEVE SIZE US	SIEVE SIZE mm	PERCENT PASSING SIEVE act.	PERCENT PASSING SIEVE interp.	SPECS max	SPECS min
GRAVEL	6.00"	150.0		100%		
	4.00"	100.0		100%		
	3.00"	75.0		100%		
	2.50"	63.0		100%		
	2.00"	50.0		100%		
	1.75"	45.0		100%		
	1.50"	37.5		100%		
	1.25"	31.5		100%		
	1.00"	25.0		100%		
	7/8"	22.4		100%		
	3/4"	19.0		100%		
	5/8"	16.0		100%		
	1/2"	12.5		100%		
	3/8"	9.50		100%		
	1/4"	6.30		100%		
	#4	4.75	100%			
SAND	#8	2.36		100%		
	#10	2.00	100%			
	#16	1.18		100%		
	#20	0.850	100%			
	#30	0.600		100%		
	#40	0.425	100%			
	#50	0.300		97%		
	#60	0.250	95%			
	#80	0.180		79%		
	#100	0.150	71%			
	#140	0.106		44%		
	#170	0.090		32%		
	#200	0.075	18%			

GRAIN SIZE DISTRIBUTION



DATE TESTED	TESTED BY
06/24/19	KMS

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APPENDIX B
SUBSURFACE EXPLORATION LOGS

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TEST PIT LOG

PROJECT NAME Howard Way Extension	CLIENT Gibbs & Olson		PROJECT NO. 19152	TEST PIT NO. TP-1
PROJECT LOCATION Woodland, Washington	CONTRACTOR L&S Contractors	EQUIPMENT Excavator	ENGINEER JFM	DATE 06/13/19
TEST PIT LOCATION See Figure 2	APPROX. SURFACE ELEVATION 21 feet amsl	GROUNDWATER DEPTH ON 06-13-19 7 Feet bgs	START TIME 0820	FINISH TIME 1105

Depth (feet)	Sample Field ID	SCS Soil Survey Description	AASHTO Soil Type	USCS Soil Type	Graphic Log	LITHOLOGIC DESCRIPTION AND REMARKS	Moisture Content (%)	Passing No. 200 Sieve (%)	Liquid Limit	Plasticity Index	Infiltration Testing
0						Approximately 6 to 8 inches of topsoil and grass with a disturbed till zone extending to 12 inches.					
		Caples Silty Clay Loam		ML		Brown SILT, moist, medium stiff [Soil Type 1].					
	TP1.2		A-4(3)			Becomes gray and tan, mottled, and moist to wet at 3.5 feet.	40.0	98.5	29	3	IT-1 Depth = 3.0-ft k = 2.5 in/hr
5											
			A-2	SM		Blueish-gray silty SAND, wet, medium dense [Soil Type 2].					
10						Bottom of test pit at 10 feet bgs. Groundwater observed at 7 feet bgs.					
15											

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TEST PIT LOG

PROJECT NAME	CLIENT		PROJECT NO.	TEST PIT NO.
Howard Way Extension	Gibbs & Olson		19152	TP-2
PROJECT LOCATION	CONTRACTOR	EQUIPMENT	ENGINEER	DATE
Woodland, Washington	L&S Contractors	Excavator	JFM	06/13/19
TEST PIT LOCATION	APPROX. SURFACE ELEVATION	GROUNDWATER DEPTH ON 06-13-19	START TIME	FINISH TIME
See Figure 2	22 feet amsl	8 Feet bgs	0936	1145

Depth (feet)	Sample Field ID	SCS Soil Survey Description	AASHTO Soil Type	USCS Soil Type	Graphic Log	LITHOLOGIC DESCRIPTION AND REMARKS	Moisture Content (%)	Passing No. 200 Sieve (%)	Liquid Limit	Plasticity Index	Infiltration Testing
0						Approximately 6 to 8 inches of topsoil and grass with a disturbed till zone extending to 12 inches.					
		Clato Silt Loam		ML		Brown sandy SILT, moist, medium stiff [Soil Type 1].					
	TP2.1		A-6(6)				30.2	64.7	38	11	IT-2 Depth = 2.5-ft k = 0.4 in/hr
5						Becomes gray and tan, moist to wet, and more coarse-textured with interbedded lenses of silt at 4.5 feet.					
10											
						Bottom of test pit at 12 feet bgs. Groundwater observed at 8 feet bgs.					
15											

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TEST PIT LOG

PROJECT NAME	CLIENT		PROJECT NO.	TEST PIT NO.
Howard Way Extension	Gibbs & Olson		19152	TP-3
PROJECT LOCATION	CONTRACTOR	EQUIPMENT	ENGINEER	DATE
Woodland, Washington	L&S Contractors	Excavator	JFM	06/13/19
TEST PIT LOCATION	APPROX. SURFACE ELEVATION	GROUNDWATER DEPTH ON 06-13-19	START TIME	FINISH TIME
See Figure 2	23 feet amsl	7 Feet bgs	0856	1120

Depth (feet)	Sample Field ID	SCS Soil Survey Description	AASHTO Soil Type	USCS Soil Type	Graphic Log	LITHOLOGIC DESCRIPTION AND REMARKS	Moisture Content (%)	Passing No. 200 Sieve (%)	Liquid Limit	Plasticity Index	Infiltration Testing
0						Approximately 6 to 8 inches of topsoil and grass with a disturbed till zone extending to 12 inches.					
		Clato Silt Loam	A-6	ML		Brown sandy SILT, moist, medium stiff [Soil Type 1].					IT-3 Depth = 2.0-ft k = 1.3 in/hr
						Becomes gray with decrease in silt content at 2.5 feet.					
5						Becomes blueish-gray and moist to wet with increase in silt content at 5 feet.					
10											
				SM		Blueish-gray silty SAND, wet, medium dense [Soil Type 2].					
	TP3.2		A-2-4(0)				43.0	17.6	NP	NP	
15						Bottom of test pit at 14 feet bgs. Groundwater observed at 7 feet bgs.					

APPENDIX C
SOIL CLASSIFICATION INFORMATION

SOIL DESCRIPTION AND CLASSIFICATION GUIDELINES

Particle-Size Classification

COMPONENT	ASTM/USCS size range	ASTM/USCS sieve size range	AASHTO size range	AASHTO sieve size range
Cobbles	> 75 mm	greater than 3 inches	> 75 mm	greater than 3 inches
Gravel	75 mm – 4.75 mm	3 inches to No. 4 sieve	75 mm – 2.00 mm	3 inches to No. 10 sieve
Coarse	75 mm – 19.0 mm	3 inches to 3/4-inch sieve	-	-
Fine	19.0 mm – 4.75 mm	3/4-inch to No. 4 sieve	-	-
Sand	4.75 mm – 0.075 mm	No. 4 to No. 200 sieve	2.00 mm – 0.075 mm	No. 10 to No. 200 sieve
Coarse	4.75 mm – 2.00 mm	No. 4 to No. 10 sieve	2.00 mm – 0.425 mm	No. 10 to No. 40 sieve
Medium	2.00 mm – 0.425 mm	No. 10 to No. 40 sieve	-	-
Fine	0.425 mm – 0.075 mm	No. 40 to No. 200 sieve	0.425 mm – 0.075 mm	No. 40 to No. 200 sieve
Fines (Silt and Clay)	< 0.075 mm	Passing No. 200 sieve	< 0.075 mm	Passing No. 200 sieve

Consistency for Cohesive Soil

CONSISTENCY	SPT N-VALUE (BLOWS PER FOOT)	POCKET PENETROMETER (UNCONFINED COMPRESSIVE STRENGTH, tsf)
Very Soft	2	less than 0.25
Soft	2 to 4	0.25 to 0.50
Medium Stiff	4 to 8	0.50 to 1.0
Stiff	8 to 15	1.0 to 2.0
Very Stiff	15 to 30	2.0 to 4.0
Hard	30 to 60	greater than 4.0
Very Hard	greater than 60	-

Relative Density for Granular Soil

RELATIVE DENSITY	SPT N-VALUE (BLOWS PER FOOT)
Very Loose	0 to 4
Loose	4 to 10
Medium Dense	10 to 30
Dense	30 to 50
Very Dense	more than 50

Moisture Designations

TERM	FIELD IDENTIFICATION
Dry	No moisture. Dusty or dry.
Damp	Some moisture. Cohesive soils are usually below plastic limit and are moldable.
Moist	Grains appear darkened, but no visible water is present. Cohesive soils will clump. Sand will bulk. Soils are often at or near plastic limit.
Wet	Visible water on larger grains. Sand and silt exhibit dilatancy. Cohesive soil can be readily remolded. Soil leaves wetness on the hand when squeezed. Soil is much wetter than optimum moisture content and is above plastic limit.

AASHTO SOIL CLASSIFICATION SYSTEM

TABLE 1. Classification of Soils and Soil-Aggregate Mixtures

General Classification	Granular Materials (35 Percent or Less Passing .075 mm)			Silt-Clay Materials (More than 35 Percent Passing 0.075)			
Group Classification	A-1	A-3	A-2	A-4	A-5	A-6	A-7
Sieve analysis, percent passing:							
2.00 mm (No. 10)	-	-	-				
0.425 mm (No. 40)	50 max	51 min	-	-	-	-	-
0.075 mm (No. 200)	25 max	10 max	35 max	36 min	36 min	36 min	36 min
Characteristics of fraction passing 0.425 mm (No. 40)							
Liquid limit				40 max	41 min	40 max	41 min
Plasticity index	6 max	N.P.		10 max	10 max	11 min	11 min
General rating as subgrade	Excellent to good			Fair to poor			

Note: The placing of A-3 before A-2 is necessary in the "left to right elimination process" and does not indicate superiority of A-3 over A-2.

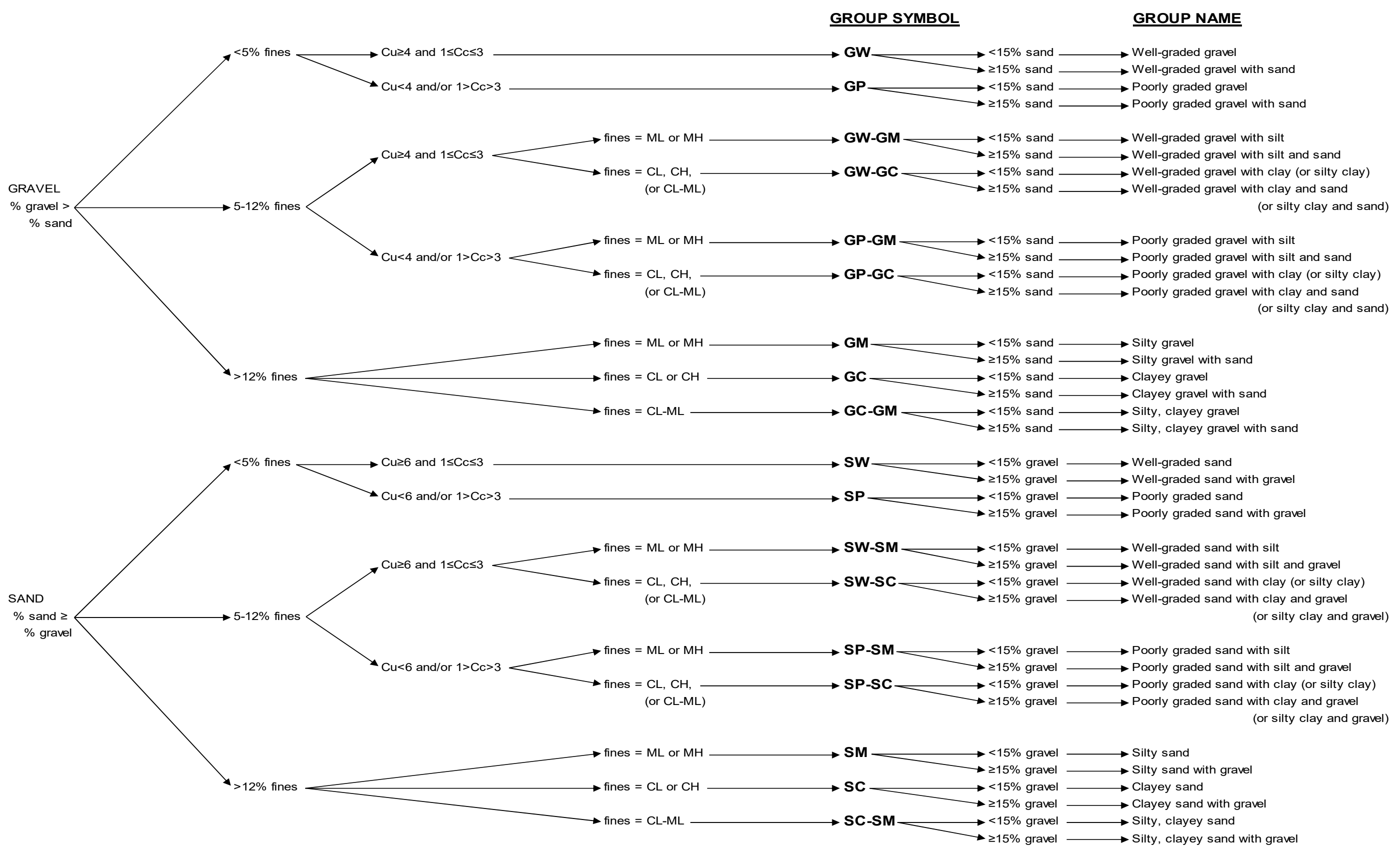
TABLE 2. Classification of Soils and Soil-Aggregate Mixtures

General Classification	Granular Materials (35 Percent or Less Passing 0.075 mm)							Silt-Clay Materials (More than 35 Percent Passing 0.075 mm)			
	A-1			A-2							A-7
Group Classification	A-1-a	A-1-b	A-3	A-2-4	A-2-5	A-2-6	A-2-7	A-4	A-5	A-6	A-7-5, A-7-6
Sieve analysis, percent passing:											
2.00 mm (No. 10)	50 max	-	-	-	-	-	-	-	-	-	-
0.425 mm (No. 40)	30 max	50 max	51 min	-	-	-	-	-	-	-	-
0.075 mm (No. 200)	15 max	25 max	10 max	35 max	35 max	35 max	35 max	36 min	36 min	36 min	36 min
Characteristics of fraction passing 0.425 mm (No. 40)											
Liquid limit				40 max	41 min	40 max	41 min	40 max	41 min	40 max	41 min
Plasticity index	6 max		N.P.	10 max	10 max	11 min	11 min	10 max	10 max	11 min	11min
Usual types of significant constituent materials	Stone fragments, gravel and sand		Fine sand	Silty or clayey gravel and sand				Silty soils		Clayey soils	
General ratings as subgrade	Excellent to Good							Fair to poor			

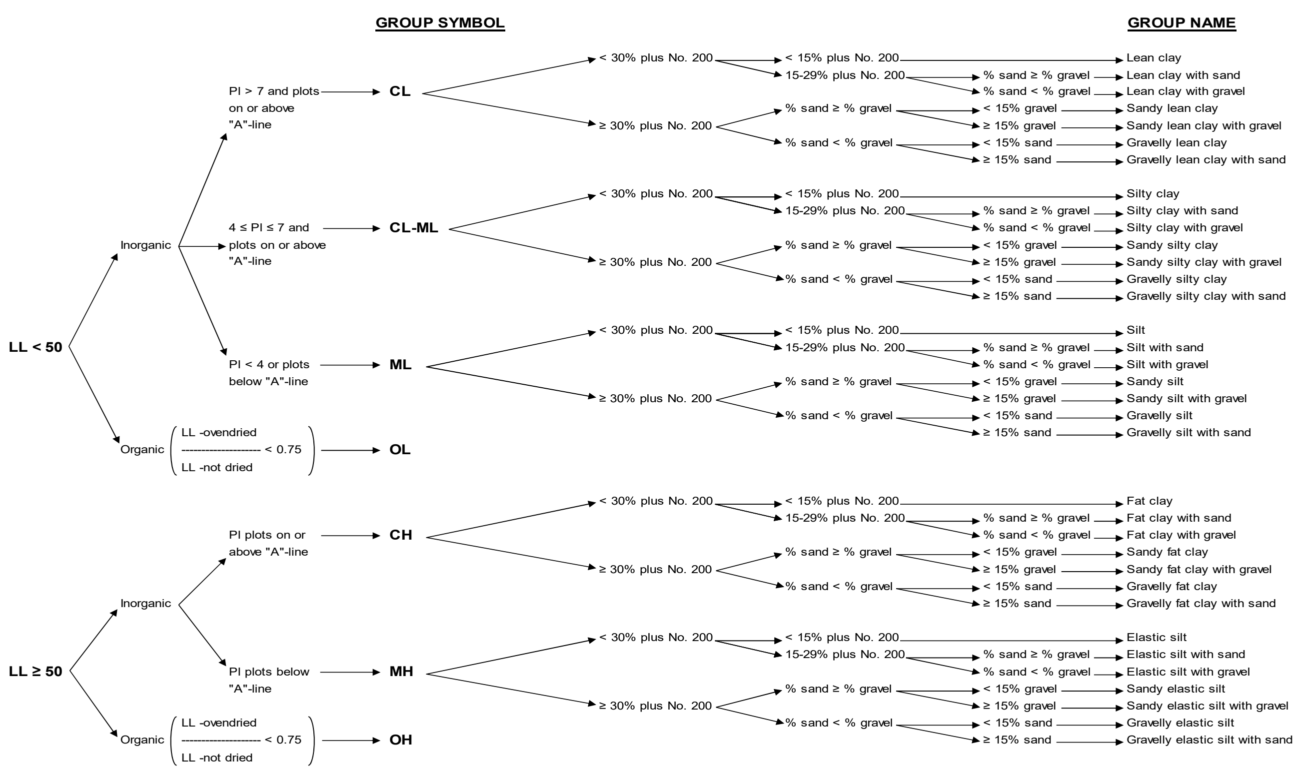
Note: Plasticity index of A-7-5 subgroup is equal to or less than LL minus 30. Plasticity index of A-7-6 subgroup is greater than LL minus 30 (see Figure 2).

AASHTO = American Association of State Highway and Transportation Officials

USCS SOIL CLASSIFICATION SYSTEM



Flow Chart for Classifying Coarse-Grained Soils (More Than 50% Retained on No. 200 Sieve)



Flow Chart for Classifying Fine-Grained Soil (50% or More Passes No. 200 Sieve)

APPENDIX D
PHOTO LOG

HOWARD WAY EXTENSION
WOODLAND, WASHINGTON
PHOTO LOG

Typical Test Pit Profile, TP-2

HOWARD WAY EXTENSION
WOODLAND, WASHINGTON
PHOTO LOG

View from TP-1, Facing Southeast Towards TP-2

View from TP-1, Facing West

APPENDIX E
REPORT LIMITATIONS AND IMPORTANT INFORMATION

Geotechnical ■ Environmental ■ Special Inspections
Columbia West
Engineering, Inc

Date: August 12, 2019
Project: Howard Way Extension
Woodland, Washington

Geotechnical and Environmental Report Limitations and Important Information

Report Purpose, Use, and Standard of Care

This report has been prepared in accordance with standard fundamental principles and practices of geotechnical engineering and/or environmental consulting, and in a manner consistent with the level of care and skill typical of currently practicing local engineers and consultants. This report has been prepared to meet the specific needs of specific individuals for the indicated site. It may not be adequate for use by other consultants, contractors, or engineers, or if change in project ownership has occurred. It should not be used for any other reason than its stated purpose without prior consultation with Columbia West Engineering, Inc. (Columbia West). It is a unique report and not applicable for any other site or project. If site conditions are altered, or if modifications to the project description or proposed plans are made after the date of this report, it may not be valid. Columbia West cannot accept responsibility for use of this report by other individuals for unauthorized purposes, or if problems occur resulting from changes in site conditions for which Columbia West was not aware or informed.

Report Conclusions and Preliminary Nature

This geotechnical or environmental report should be considered preliminary and summary in nature. The recommendations contained herein have been established by engineering interpretations of subsurface soils based upon conditions observed during site exploration. The exploration and associated laboratory analysis of collected representative samples identifies soil conditions at specific discreet locations. It is assumed that these conditions are indicative of actual conditions throughout the subject property. However, soil conditions may differ between tested locations at different seasonal times of the year, either by natural causes or human activity. Distinction between soil types may be more abrupt or gradual than indicated on the soil logs. This report is not intended to stand alone without understanding of concomitant instructions, correspondence, communication, or potential supplemental reports that may have been provided to the client.

Because this report is based upon observations obtained at the time of exploration, its adequacy may be compromised with time. This is particularly relevant in the case of natural disasters, earthquakes, floods, or other significant events. Report conclusions or interpretations may also be subject to revision if significant development or other manmade impacts occur within or in proximity to the subject property. Groundwater conditions, if presented in this report, reflect observed conditions at the time of investigation. These conditions may change annually, seasonally or as a result of adjacent development.

Additional Investigation and Construction QA/QC

Columbia West should be consulted prior to construction to assess whether additional investigation above and beyond that presented in this report is necessary. Even slight variations in soil or site conditions may produce impacts to the performance of structural facilities if not adequately addressed. This underscores the importance of diligent QA/QC construction observation and testing to verify soil conditions do not differ materially or significantly from the interpreted conditions utilized for preparation of this report.

Therefore, this report contains several recommendations for field observation and testing by Columbia West personnel during construction activities. Actual subsurface conditions are more readily observed and discerned during the earthwork phase of construction when soils are exposed. Columbia West cannot accept responsibility for deviations from recommendations described in this report or future performance of structural facilities if another consultant is retained during the construction phase or Columbia West is not engaged to provide construction observation to the full extent recommended.

Collected Samples

Uncontaminated samples of soil or rock collected in connection with this report will be retained for thirty days. Retention of such samples beyond thirty days will occur only at client's request and in return for payment of storage charges incurred. All contaminated or environmentally impacted materials or samples are the sole property of the client. Client maintains responsibility for proper disposal.

Report Contents

This geotechnical or environmental report should not be copied or duplicated unless in full, and even then only under prior written consent by Columbia West, as indicated in further detail in the following text section entitled *Report Ownership*. The recommendations, interpretations, and suggestions presented in this report are only understandable in context of reference to the whole report. Under no circumstances should the soil boring or test pit excavation logs, monitor well logs, or laboratory analytical reports be separated from the remainder of the report. The logs or reports should not be redrawn or summarized by other entities for inclusion in architectural or civil drawings, or other relevant applications.

Report Limitations for Contractors

Geotechnical or environmental reports, unless otherwise specifically noted, are not prepared for the purpose of developing cost estimates or bids by contractors. The extent of exploration or investigation conducted as part of this report is usually less than that necessary for contractor's needs. Contractors should be advised of these report limitations, particularly as they relate to development of cost estimates. Contractors may gain valuable information from this report, but should rely upon their own interpretations as to how subsurface conditions may affect cost, feasibility, accessibility and other components of the project work. If believed necessary or relevant, contractors should conduct additional exploratory investigation to obtain satisfactory data for the purposes of developing adequate cost estimates. Clients or developers cannot insulate themselves from attendant liability by disclaiming accuracy for subsurface ground conditions without advising contractors appropriately and providing the best information possible to limit potential for cost overruns, construction problems, or misunderstandings.

Report Ownership

Columbia West retains the ownership and copyright property rights to this entire report and its contents, which may include, but may not be limited to, figures, text, logs, electronic media, drawings, laboratory reports, and appendices. This report was prepared solely for the client, and other relevant approved users or parties, and its distribution must be contingent upon prior express written consent by Columbia West. Furthermore, client or approved users may not use, lend, sell, copy, or distribute this document without express written consent by Columbia West. Client does not own nor have rights to electronic media files that constitute this report, and under no circumstances should said electronic files be distributed or copied. Electronic media is susceptible to unauthorized manipulation or modification, and may not be reliable.

Consultant Responsibility

Geotechnical and environmental engineering and consulting is much less exact than other scientific or engineering disciplines, and relies heavily upon experience, judgment, interpretation, and opinion often based upon media (soils) that are variable, anisotropic, and non-homogenous. This often results in unrealistic expectations, unwarranted claims, and uninformed disputes against a geotechnical or environmental consultant. To reduce potential for these problems and assist relevant parties in better understanding of risk, liability, and responsibility, geotechnical and environmental reports often provide definitive statements or clauses defining and outlining consultant responsibility. The client is encouraged to read these statements carefully and request additional information from Columbia West if necessary.

Appendix E

Operations and Maintenance Manual

Operation and Maintenance

Inspection Frequency and Requirements

Stormwater for the site will be collected using catch basins then conveyed to a combination detention and wetpond. Runoff will be stored until it is released at the required pre-developed rates using a flow control manhole. The discharge system from the flow control manhole will release to an existing ditch along the south side of Guild Road. Inspection requirements for the storm system are listed in tables at the end of this document.

A complete and thorough system inspection using the inspection and maintenance forms provided in this plan will be conducted in April and September.

Safety Information

Inspections

The inspector should have the proper safety equipment (heavy duty gloves, steel-toed boots, first aid kits, etc.) and training before conducting any inspections. If the storm water system inspection reveals a safety problem, the site activities may need to be modified to reduce or eliminate the safety risk. The following is a list of safety precautions an inspector should be aware of when conducting storm water system inspections.

- Never enter a confined space unless the proper Occupational Health and Safety Administration (OSHA) training has been obtained. Do not enter any confined space until the atmosphere has been checked and proper safety equipment is worn or erected.
- Avoid entering pipes or conduits without another individual present. If the structural strength of a pipe or conduit is questionable, do not enter the pipe or conduit.
- Check the ventilation in the storm water system before using any ignitable materials. Some storm water systems may be sealed and have poor ventilation, posing a safety risk to the inspector if the vapor comes in contact with an open flame. Also, be sure to allow the storm water system to vent for a period of time if a peculiar odor is present.
- Wear gloves if any mechanical parts or structure components are going to be handled. Wearing gloves not only reduces the risk of getting cuts and abrasions, but also reduces the exposure of pollutants to the skin.
- Lift manhole cover or other structural covers carefully. These items can be very heavy and if wet, can be slippery. Also, learn the correct way to lift heavy items to avoid back injury.
- Check the water depth of the system before you take a step in the water. The water may be deeper than appears, or there may be steep slopes below the water surface.

- Be aware that nails, broken glass, or other sharp debris may be in the storm water system and can cause injury. Wearing the proper safety clothing will reduce the safety risk associated with these objects.

Maintenance

All maintenance work should be done in accordance with OSHA regulations. Maintenance personnel will have the proper safety equipment (heavy gloves, steel-toed boots, first aid kits, etc.) and training before performing any maintenance on a storm water system. The following is a list of safety precautions maintenance personnel should be aware of when they perform maintenance on storm water systems.

- Operate equipment safely and in accordance with manufacturer's specifications. Equipment operator should be aware of site personnel at all times to avoid causing injury to others.
- Contact utility companies before excavating a site. Underground utility wires may be present. Cover or clearly mark excavated areas that cannot be filled in at the end of the day to alert site employees of the potential risk. Also, be aware of overhead electrical wires that could come in contact with maintenance equipment.
- Identify where you will dispose of removed sediment or wastes prior to cleaning the storm water system. Use shovels, trowels or a high-suction vacuum to removes wastes. Do not clean out sediment or waste with bare hands. The sediment or waste may be hazardous. Place the sediment or waste in an area where it cannot be washed into a storm drain or water body.
- Wear gloves if any mechanical parts or structural components are going to be handled. Wearing gloves not only reduces the risk of getting cuts and abrasions, but also reduces the exposure of pollutants to the skin.

Best Management Practices

The following operational BMPs will keep pollutants out of the storm water runoff. These BMPS are also known as source controls and were selected from the Washington State Department of Ecology Stormwater Management Manual for Western Washington. These include the following

- One or more individuals should be assigned to be responsible for the stormwater pollution control. Hold regular meetings to review the overall operation of the BMPs. Establish responsibilities for inspections, operation, maintenance and inspections of BMPs and reporting procedures.
- Promptly contain and clean up solid and liquid pollutant leaks and spills including oils, solvents, and fuels on any exposed soil, vegetation or paved area.
- Impervious surfaces are to be kept clean and free of trash and debris.
- Do not hose down pollutants from any area to the ground, storm drains, conveyance ditches or receiving water unless necessary for dust control purposed to meet air quality regulations.

Convey pollutants before discharge to the treatment system. Employees should be notified that only storm water should go into the storm water system.

- Do not flush or otherwise direct absorbent materials or other spill cleanup materials to a storm drain. Collect the contaminated absorbent material as a solid and place in appropriate disposal containers.
- Promptly repair or replace all substantially cracked or otherwise damaged paved secondary containment, high-intensity parking, and any other drainage areas, subjected to pollutant material leaks or spills. Promptly repair or replace all leaking connections, pipes, hoses, valves, etc., which can contaminate stormwater.
- Drop clothes should be used when performing maintenance work, such as painting, scraping or sand blasting. The collected material should be disposed of properly, and on a daily basis.
- Filter fabric should be used to cover storm drain inlets if pollutants, such as dirt, grit or paint chips are blown outside the building maintenance area and near storm drains.
- Where feasible, store potential stormwater pollutant materials inside a building or under a cover and/or containment.
- Stop, contain and clean up all spills immediately upon discovery.

References

Washington State Department of Ecology, Olympia, WA; Stormwater Management Manual for Western Washington, 2012.

Washington State Department of Ecology, Olympia, WA; Stormwater Management Manual for the Puget Sound Basin (The Technical Manual), 1992.

City of Boise Public Works, Boise, ID; Storm Water Operation & Maintenance, A Resource Guide.

Washington Stormwater Center, Olympia, WA; Western Washington Low Impact Development (LID) Operation and Maintenance (O&M) Guidance Document, 2013

Inspection Forms

Inspection Cover sheet

Date:_________________

Facility Name: ____

Facility Address: ____

Facility Owner: ____

Inspector Name: ____

Inspector Phone Number: ____

Important Safety Information

- Never enter a confined space unless the proper Occupational Health and Safety Administration (OSHA) training has been obtained. Do not enter any confined space until the atmosphere has been checked and proper safety equipment is worn or erected.
- Check the ventilation in the storm water system before using any ignitable materials. Some storm water systems may be sealed and have poor ventilation, posing a safety risk to the inspector if the vapor comes in contact with an open flame.
- Always cover or clearly mark excavated areas as potential safety risks if the areas cannot be filled in by the end of a work day.

Inspection Comments:

Maintenance Report Form

Date:_________________

Facility Name: ____

Facility Address: ____

Name of Person Overseeing Maintenance: ______________________________

Type of System: ____

Date of Last Inspection: ____

Describe maintenance activities, including type of work, completion dates, contractors, time needed to complete task, and cost.

Inspection Checklist

Table III-2.10 Maintenance of Control Structures and Catchbasins

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
I. Control Structure/ Flow Restrictor - General	Trash & Debris (includes sediment)	Distance between debris buildup & bottom of orifice is < 1½ feet.	All trash & debris removed.
	Structural Damage	Structure is not securely attached to manhole wall & outlet pipe structure should support at least 1000# of up or down pressure.	Structure securely attached to wall & outlet pipe.
		Structure is not in upright position (up to 10% from plumb allowed).	Structure in correct position.
		Connections to outlet pipe are not watertight & show signs of rust.	Connections to outlet pipe are watertight; structure repaired or replaced and works as designed.
		Any holes - other than designed holes - in structure.	Structure has no holes other than designed holes.
Cleanout Gate	Damaged or missing	Cleanout gate is not watertight or is missing.	Gate is watertight and works as designed.
		Gate cannot be moved up & down by one maintenance person.	Gate moves up and down easily and is watertight.
		Chain leading to gate is missing or damaged.	Chain is in place & works as designed.
		Gate is rusted over 50% of its surface area.	Gate is repaired or replaced to meet design standards.
	Obstructions	Trash, debris, sediment or vegetation blocking the plate.	Plate is free of all obstructions & works as designed.
Overflow Pipe	Obstructions	Trash or debris is blocking or potentially blocking the overflow pipe.	Pipe is free of all obstructions & works as designed.
Manhole		See "Pipes/Tanks" standard, Section III-4.6.1.	See "Pipes/Tanks" standard, Section III-4.6.1.
II. Catchbasins - General	Trash & Debris (includes sediment)	Trash & debris ≥ ½ $ft.^3$ which is located immediately in front of the catchbasin opening of is blocking capacity by > 10%.	No trash or debris immediately in front of the catchbasin opening.
		Trash or debris in the basin that exceeds ⅓ the depth from the bottom of basin to the invert of the lowest pipe.	No trash or debris in the catchbasin.
		Trash or debris in any inlet or pipe blocking more than ⅓ of its height.	Inlet & outlet pipes free of trash or debris.
		Dead animals or vegetation that could generate odors or dangerous gases (e.g. methane).	No dead animals or vegetation present within the catchbasin.

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
Catchbasins - General, con't.		No condition present which would attract or support the breeding of insects or rodents.	
	Structural Damage to Frame and/or Top Slab	Frame is even with curb.	
		Top slab is free of holes & cracks.	
		Frame is sitting flush on top slab.	
	Cracks in Basin Walls or Bottom	Basin repaired or replaced to design standards.	
		No cracks more than ¼ in. wide at the joint of inlet/outlet pipe.	
	Settlement/misalignment	Basin replaced or repaired to design standards.	
	Fire Hazard	No flammable chemicals present.	
	Vegetation	No vegetation blocking opening to basin.	
		No vegetation or root growth present.	
	Pollution	No pollution present other than surface film	
	68^F^Cider than ½ in. & longer than 1 ft. at the joint of any inlet or outlet pipe or any evidence of soil particles entering the catchbasin through cracks.		
	Basin has settled > 1 in. or has rotated > 2 in. out of alignment.		
	Presence of chemicals such as natural gas, oil and gasoline.		
	Vegetation growing across & blocking >10% of the basin opening.		

Table III-4.7 Specific Maintenance Requirements for Detention Vaults/Tanks

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
I. Storage Area	Plugged air vents	One-half of the end area of a vent is blocked at any point with debris and sediment.	Vents free of debris and sediment.
	Debris and sediment	Accumulated sediment depth is ≥ 10% of the diameter of the storage area for ½ the length of the storage vault or any point exceeds 15% of the diameter. Example: 72-inch storage tank would require cleaning when sediment reaches a depth of 7 in. or more than ½ the length of the tank.	All sediment and debris removed from storage area.
	Joints between tank/pipe section	Any crack allowing material to be transported into the facility.	All joints between tank/pipe sections are sealed.
II. Manhole	Cover not in place	Cover is missing or only partially in place. Any open manhole requires maintenance.	Manhole is closed.
	Locking mechanism not working	Mechanism cannot be opened by one maintenance person with proper tools. Bolts into frame have < ½ inch of thread (may not apply to self-locking lids.	Mechanism opens with proper tools.
	Cover difficult to remove	One maintenance person cannot remove lid after applying 800 pounds of lift. Intent is to keep cover from sealing off access to maintenance.	Cover can be removed and reinstalled by one maintenance person.
	Ladder rungs unsafe	Local Government Safety Officer and/or maintenance person judge that ladder is unsafe due to missing rungs, misalignment, rust or cracks.	Ladder meets design standards and allows maintenance persons safe access.
III. Catchbasins	See "catchbasins" standard, Section III-4.8	See "catchbasins" standard, Section III-4.8.	See "catchbasins" standard, Section III-4.8.

III-4.6 REFERENCES

(1) Kulzer, Louise, Considerations for the Use of Wet Ponds for Water Quality Enhancement, Municipality of Metropolitan Seattle, 1989.

(2) Whipple, W., Jr. and J.V. Hunter, "Settleability of Urban Runoff Pollution", JWPCF, S3:1726-1731, 1981.

(3) Anderson, Gary, Washington Dept. of Ecology, Personal Communication via Office Memo dated Sept. 27, 1989.

(4) Schueler, T.R., Controlling Urban Runoff; A Practical Manual for Planning and Designing Urban BMPs, Washington Council of Governments, Washington, D.C., 1987.

(5) Horner, R.R., Highway Construction Site Erosion and Pollution Control: Recent Research Results, Proceedings from the 39th Annual Road Builders' Clinic, Washington State University, 1988.

(6) Minton, G.R., "Appendix D, Sizing of Ponds and Infiltration Basins" in: Lake Sammamish Water Quality Plan, Draft, Prepared by Entranco Engineers, Inc., for Metro, King County, and the Cities of Bellevue, Redmond, and Issaquah, October, 1988.

Table III-4.4 Specific Maintenance Requirements for Detention Ponds

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
I. Ponds - General	Trash and debris	Any trash or debris which exceeds 1 ft^3/1000 ft^2 (equal to the volume of a standard size office garbage can). In general, there should be no evidence of dumping.	Trash and debris cleared from site.
	Poisonous vegetation	Any poisonous vegetation which may constitute a hazard to maintenance personnel or the public, e.g. tansy, poison oak, stinging nettles, devils club.	No danger of poisonous vegetation where maintenance personnel or the public might normally be. Coordinate with the local county health dept.
	Pollution	1 gallon or more of oil, gas or other contaminants or any amount found that could: 1) cause damage to plant, animal or marine life, 2) constitute a fire hazard, 3) be flushed downstream during storms or 4) contaminate ground water.	No contaminants present other than a surface film. Coordinate with the local county health dept.
	Unmowed grass/ground cover	In residential areas, mowing is needed when the cover exceeds 18 inches in height. Otherwise, match facility cover with adjacent ground cover and terrain as long as there is no decrease in facility function.	When mowing is needed, grass or ground cover should be mowed down to 2 inches. A dense grass cover must be maintained on slopes, and in dry ponds on the bottom as well.
	Rodent holes	Any evidence of rodent holes if facility is acting as a dam or berm, or any evidence of water piping through dam or berm via rodent holes.	Rodents destroyed and dam or berm repaired. Coordinate with the local county health dept.
	Insects	When insects such as wasps or hornets interfere with maintenance activities.	Insects destroyed or removed from site. Coordinate with people who remove wasps for anti-venom production.
	Tree growth	Tree growth does not allow maintenance access or interferes with maintenance activity. If trees are not interfering with access, leave trees alone.	Trees do not hinder maintenance activities. Selectively cultivate trees such as alders for firewood.
Side Slopes of Pond	Erosion	Eroded damage >2 inches deep where cause of damage is still present or where there is potential for continued erosion.	Slopes should be stabilized with appropriate erosion control BMPs e.g. seeding, plastic covers, riprap.
Storage Area, Forebay	Sediment	Accumulated sediment that exceeds 10% of the designed forebay depth, or every three years.	Sediment cleaned out to designed pond shape and depth; reseeded if necessary to control erosion.
Pond Dikes	Settling	Any part of dike which has settled 4 inches lower than the design elevation.	Dike should be built back to the design elevation.
Emergency Overflow, Spillway	Rock missing	Only 1 layer of rock above native soil in an area ≥ 5 ft^2 or any exposure of native soil.	Replace rock to design standards.
II. Debris Barriers - General	Trash and debris	Trash or debris that is plugging ≥20% of the openings in the barrier.	Barrier clear to receive capacity flow.

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
Metal	Damaged/missing bars	Bars are bent out of shape ≥ 3 inches.	Bars in place with no bend ≥ 3/4".
		Bars or entire barrier is missing.	Bars in place according to design.
		Bars are loose and rust is causing 50% deterioration to any part of the barrier.	Repair or replace barrier to standards.
III. Fencing - General	Missing or broken parts	Any defect in the fence that permits easy entrance to the facility.	Parts in place to provide adequate security.
		Parts broken or missing.	Broken or missing parts replaced.
	Erosion	Erosion ≥ 4 inches deep and 12 - 18 inches wide permitting an opening under the fence.	No opening under the fence ≥ 4 inches in depth.
Wire Fences	Damaged parts	Posts out of plumb more than 6 inches.	Posts plumb within 1½ inches.
		Top rails bent more than 6 inches.	Top rail free of bends ≥ 1 inch.
		Any part of fence (including posts, top rails and fabric) ≥ 1 foot out of design alignment.	Fence is aligned and meets design standards.
		Missing or loose tension wire.	Tension wire in place & holding fabric.
		Missing or loose barbed wire sagging more than 2½ inches between posts.	Barbed wire in place with < 3/4 inch sag between posts.
		Extension arm missing, broken or bent out of shape more than 1½ inches.	Extension arm in place with no bends larger than 3/4 inch.
	Deteriorated paint or protective coating	Part(s) that have a rusting or scaling condition which has affected structural adequacy.	Structurally adequate posts or parts with a uniform protective coating.
	Openings in fabric	Openings in fabric are such that an 8 inch diameter ball could fit through.	No openings in fence.
IV. Gates - General	Damaged or missing members	Missing gate or locking device.	Gates and locking devices in place.
		Broken or missing hinges such that gate cannot be easily opened and closed by maintenance personnel.	Hinges intact & lubed, gate working freely.
		Gate is out of plumb ≥ 6 inches and ≥ 1 foot out of design alignment.	Gate is aligned & vertical.
		Missing stretcher bar, stretcher bands and ties.	Stretcher bar, bands & ties in place.
		See "Fencing" standard, above.	See "Fencing" standard, above.
V. Access Roads, Easements - General	Trash and debris	Exceeds 1 $ft^3/1000\ ft^2$ or the amount that would fill a standard size garbage can.	Trash & debris cleared from site.
	Blocked roadway	Debris which could damage vehicle tires.	Roadway free of such debris.
		Obstructions which reduce clearance above road surface to < 14 feet.	Roadway overhead clear to 14 feet high.

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
V. Access Roads, Easements, continued	Blocked roadway, continued	Any obstructions restricting access to a 10 - 12 foot width for a distance of ≥ 12 feet or any point restricting access to a < 10 foot width.	Obstruction moved to allow at least a 12 foot access route.
	Settlement, potholes, mushy spots, ruts	When any surface exceeds 6 inches in depth and 6 ft^2 in area. In general, any surface defect which prevents or hinders maintenance access.	Road surface uniformly smooth with no evidence of potholes, settlement, mushy spots or ruts.
	Vegetation in surface	Weeds growing in the road surface that are ≥ 6 inches tall and < 6 inches apart within a 400 ft^2 area.	Road surface free of weeds taller than 2 inches.
	Erosion damage	Erosion within 1 foot of the roadway ≥ 8 inches wide & 6 inches deep.	Shoulder free of erosion & matching the surrounding road.
	Weeds and brush	Weeds and brush exceed 18 inches in height or hinder maintenance access.	Weeds and brush cut to 2 inches in height or cleared in such a way as to allow maintenance access.

I-5.7.13 BMP E2.75: Riprap

Maintenance

- Riprap coverings should be inspected on a regular basis and after every large storm event.
- All temporary and permanent erosion and sediment control practices shall be maintained and repaired as needed to assure continued performance of their intended function. All maintenance and repair shall be conducted in accordance with an approved manual.