

**MEMORANDUM**

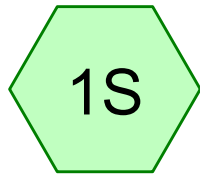
**DATE:** December 23, 2021  
**BY:** Craig Harris, PE  
**SUBJECT:** Stormwater Memo  
**PROJECT:** Hedges Creek – 11345 SW Herman Road, Tualatin, OR  
**PROJECT NO.:** A20120.10

This memorandum is to outline the utility requirements and existing conditions for the proposed Hedges Creek project in Tualatin, OR. The total site area is 904,068SF, and the existing site is an undeveloped field. This project proposes to develop the site with three buildings and the associated parking, sidewalks, and utilities. As a result of these improvements, the proposed site will have 777,000SF of new impervious area.

The project will meet Clean Water Services standards for stormwater management. Storm runoff from the proposed impervious area will be directed via sheet flow to catch basins, piped conveyance, underground detention, and underground treatment vaults. Proprietary treatment vaults will filter the CWS water quality event per CWS standards. Detained runoff will be released at a controlled rate to reduce the peak flow from the 2-year storm to half the existing peak, and to match the existing peak flow during the 5-, 10-, and 25-year storms (see attached HydroCAD Report).

The water leaving the site will flow to a 183' perforated pipe to disperse the flow into the wetlands north of the development, which is the existing destination of runoff from the site.

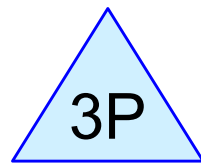




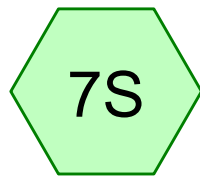
Predeveloped Basin A



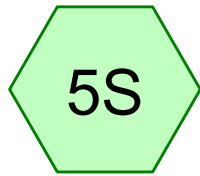
Developed Basin A



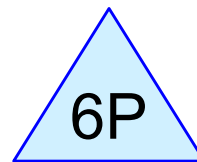
Detention A



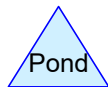
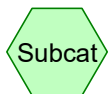
Predeveloped Basin B



Developed Basin B



Detention B



# Walgraves

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Type IA 24-hr 2-YR Rainfall=2.50"

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## Summary for Subcatchment 1S: Predeveloped Basin A

Runoff = 1.56 cfs @ 8.31 hrs, Volume= 0.922 af, Depth= 0.74"

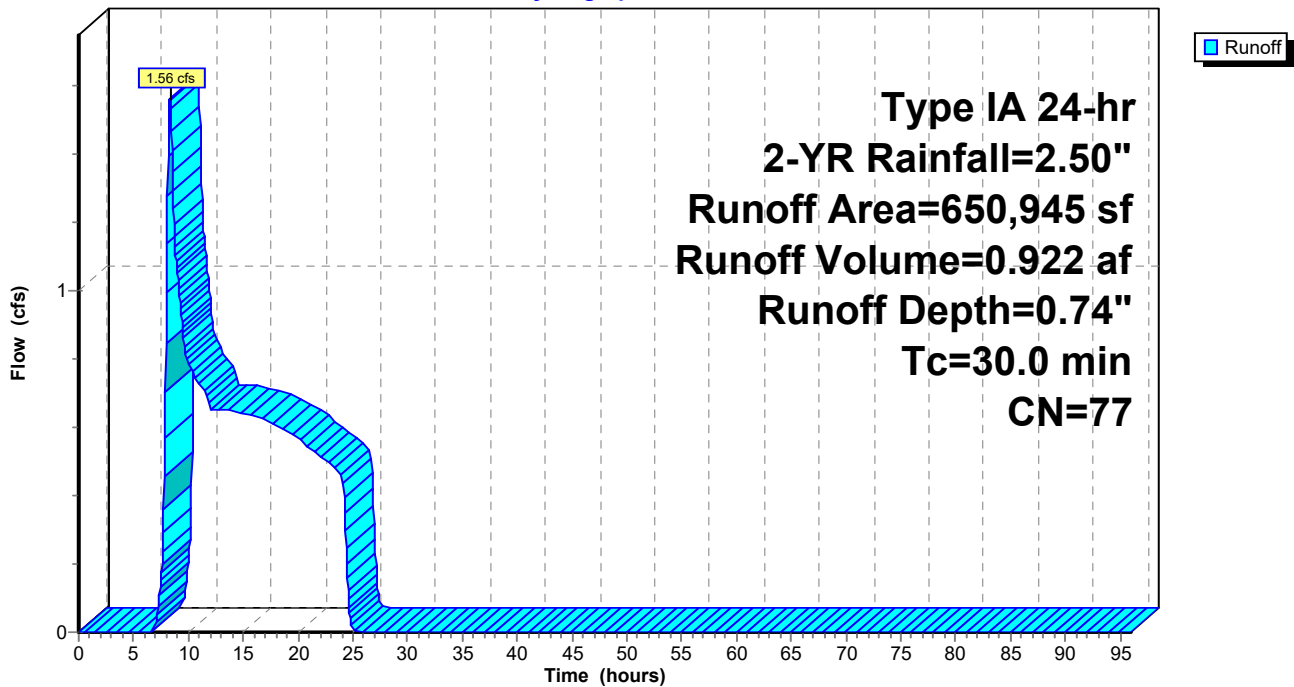
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
Type IA 24-hr 2-YR Rainfall=2.50"

Area (sf)	CN	Description
* 650,945	77	>75% Grass cover, Good, HSG D
650,945		100.00% Pervious Area

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

## Subcatchment 1S: Predeveloped Basin A

Hydrograph



# Walgraves

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Type IA 24-hr 2-YR Rainfall=2.50"

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## Summary for Subcatchment 2S: Developed Basin A

Runoff = 8.75 cfs @ 7.86 hrs, Volume= 2.828 af, Depth= 2.27"

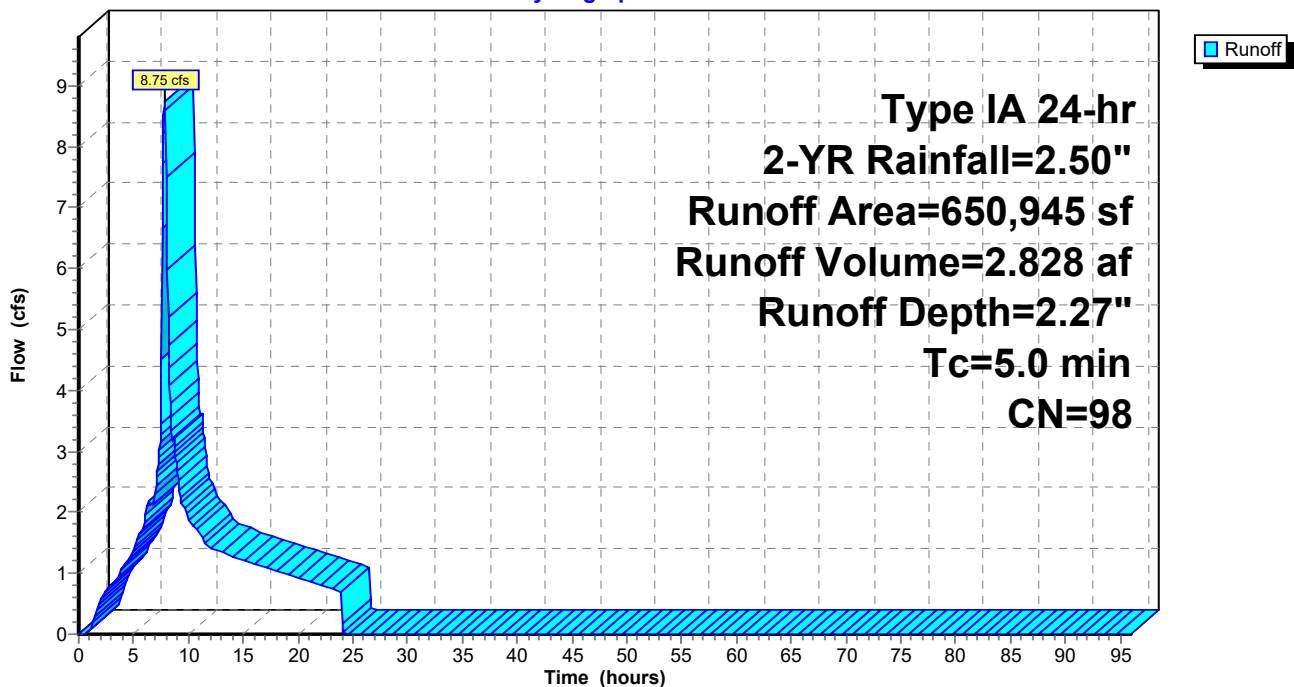
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
Type IA 24-hr 2-YR Rainfall=2.50"

Area (sf)	CN	Description
* 650,945	98	
650,945		100.00% Impervious Area

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

## Subcatchment 2S: Developed Basin A

Hydrograph



**Summary for Subcatchment 5S: Developed Basin B**

Runoff = 1.69 cfs @ 7.86 hrs, Volume= 0.548 af, Depth= 2.27"

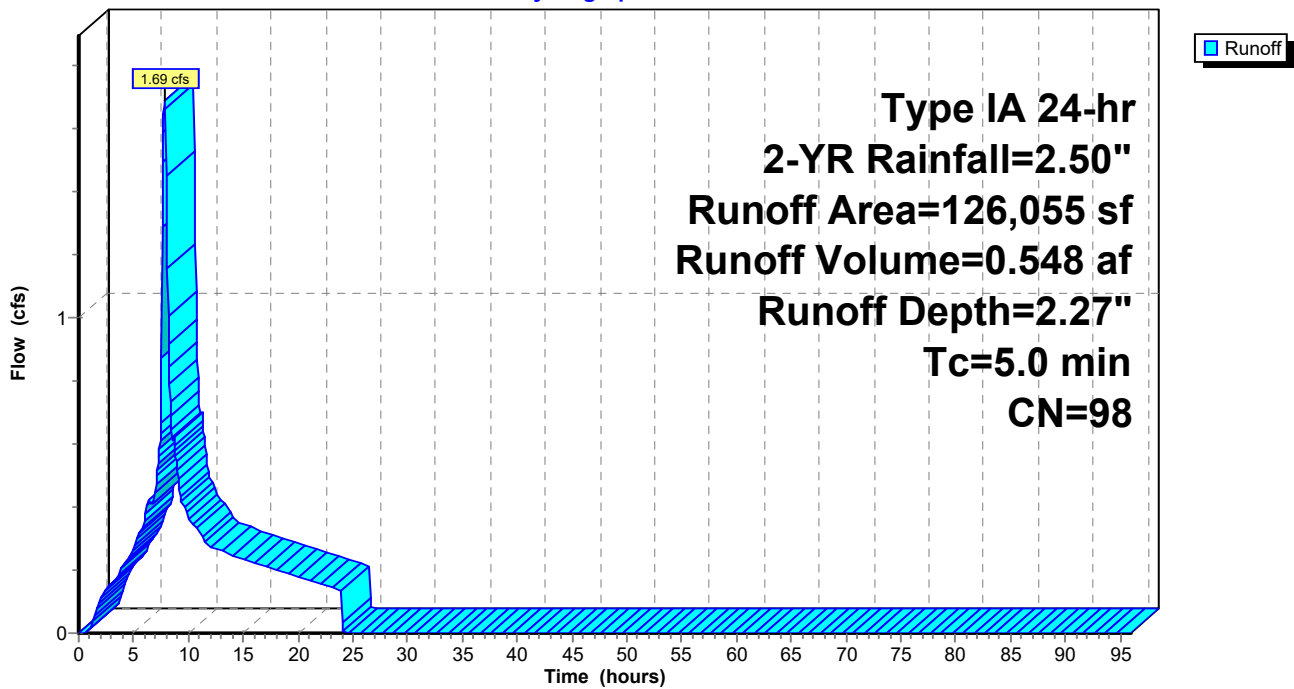
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
Type IA 24-hr 2-YR Rainfall=2.50"

	Area (sf)	CN	Description
*	69,225	98	Concrete
*	56,830	98	Roof
	126,055	98	Weighted Average
	126,055		100.00% Impervious Area

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

**Subcatchment 5S: Developed Basin B**

Hydrograph



**Summary for Subcatchment 7S: Predeveloped Basin B**

Runoff = 0.40 cfs @ 7.93 hrs, Volume= 0.179 af, Depth= 0.74"

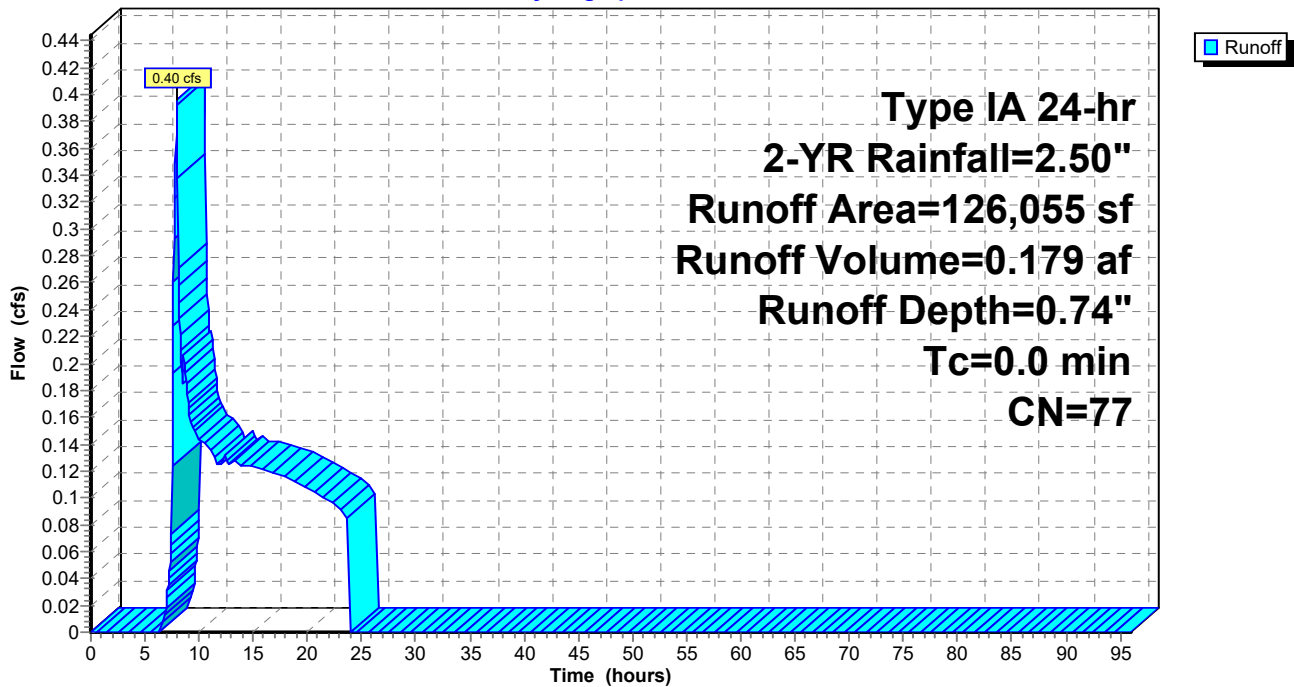
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
 Type IA 24-hr 2-YR Rainfall=2.50"

Area (sf)	CN	Description
* 126,055	77	
126,055		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.0					Direct Entry, 20

**Subcatchment 7S: Predeveloped Basin B**

Hydrograph



# Walgraves

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Type IA 24-hr 2-YR Rainfall=2.50"

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## Summary for Pond 3P: Detention A

Inflow Area = 14.944 ac, 100.00% Impervious, Inflow Depth = 2.27" for 2-YR event  
Inflow = 8.75 cfs @ 7.86 hrs, Volume= 2.828 af  
Outflow = 0.78 cfs @ 22.70 hrs, Volume= 2.828 af, Atten= 91%, Lag= 890.2 min  
Primary = 0.78 cfs @ 22.70 hrs, Volume= 2.828 af

Routing by Stor-Ind method, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
Peak Elev= 3.47' @ 22.70 hrs Surf.Area= 0.457 ac Storage= 1.670 af

Plug-Flow detention time= 1,113.9 min calculated for 2.828 af (100% of inflow)  
Center-of-Mass det. time= 1,113.5 min ( 1,785.4 - 671.9 )

Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	1.947 af	<b>52.0" Round Pipe Storage</b> L= 5,750.0'

Device	Routing	Invert	Outlet Devices
#1	Primary	0.00'	<b>4.0" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads
#2	Primary	3.85'	<b>24.0" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads

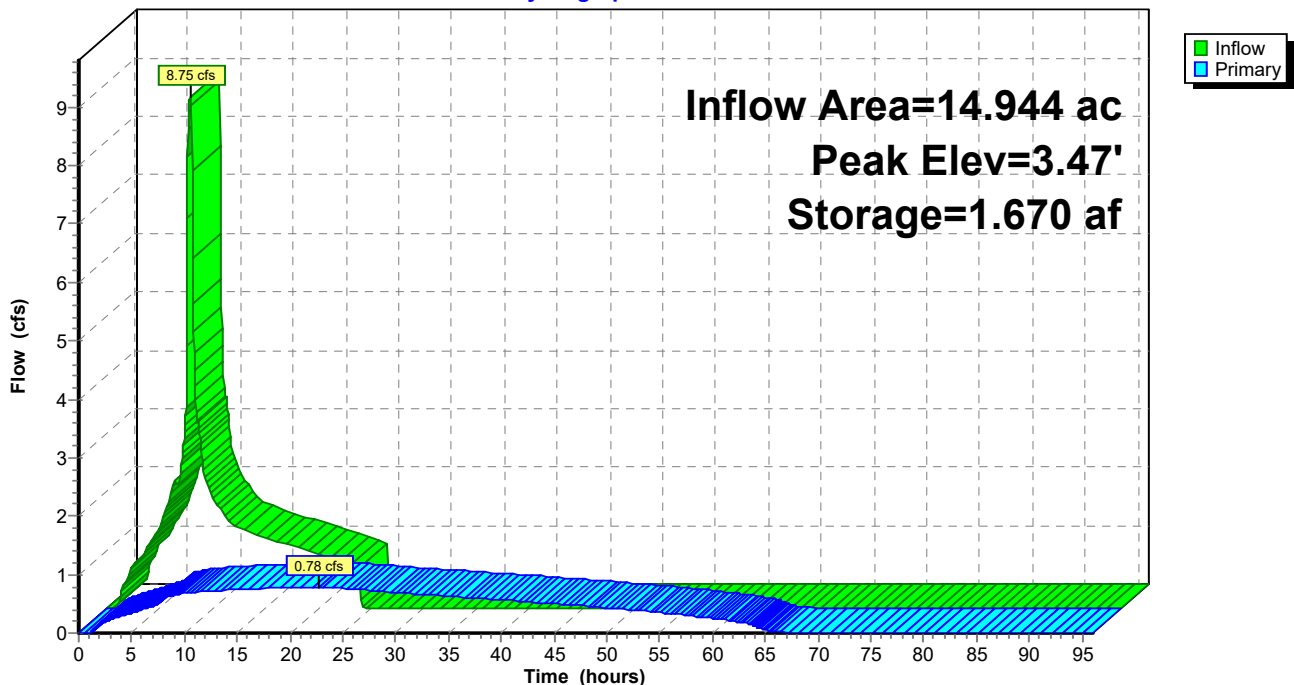
**Primary OutFlow** Max=0.78 cfs @ 22.70 hrs HW=3.47' (Free Discharge)

1=Orifice/Grate (Orifice Controls 0.78 cfs @ 8.97 fps)

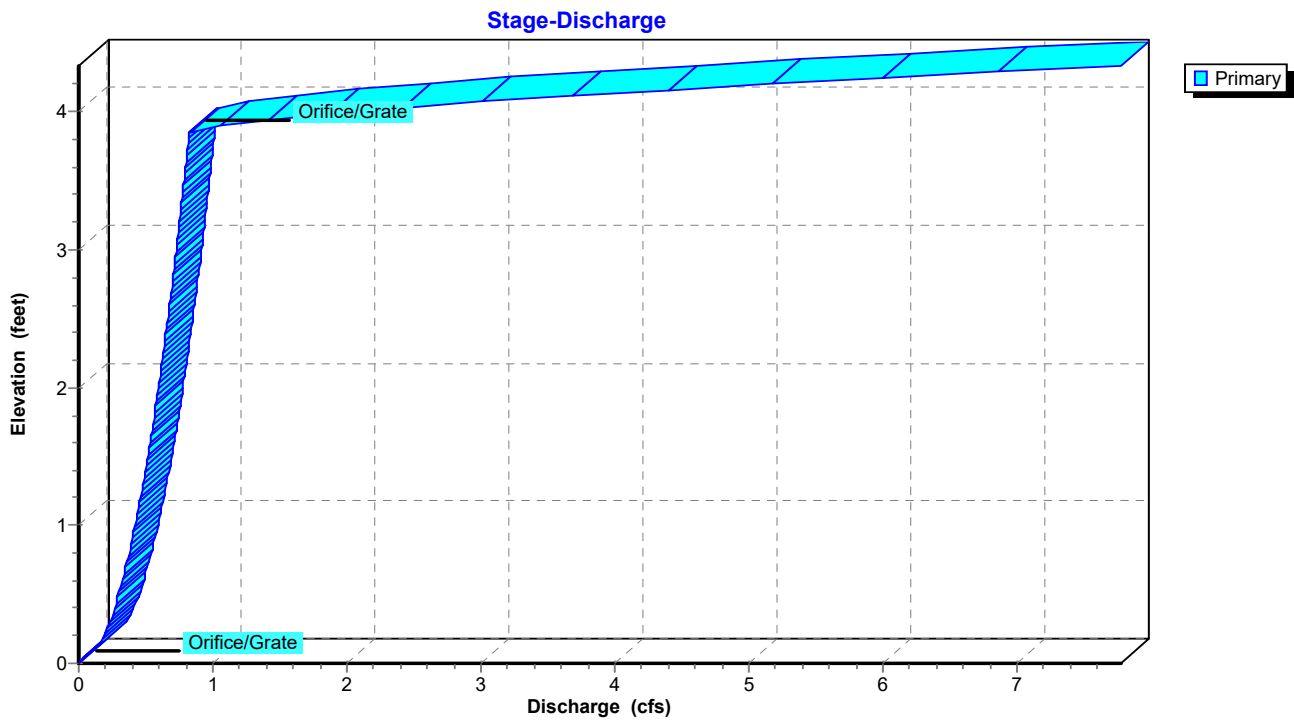
2=Orifice/Grate ( Controls 0.00 cfs)

## Pond 3P: Detention A

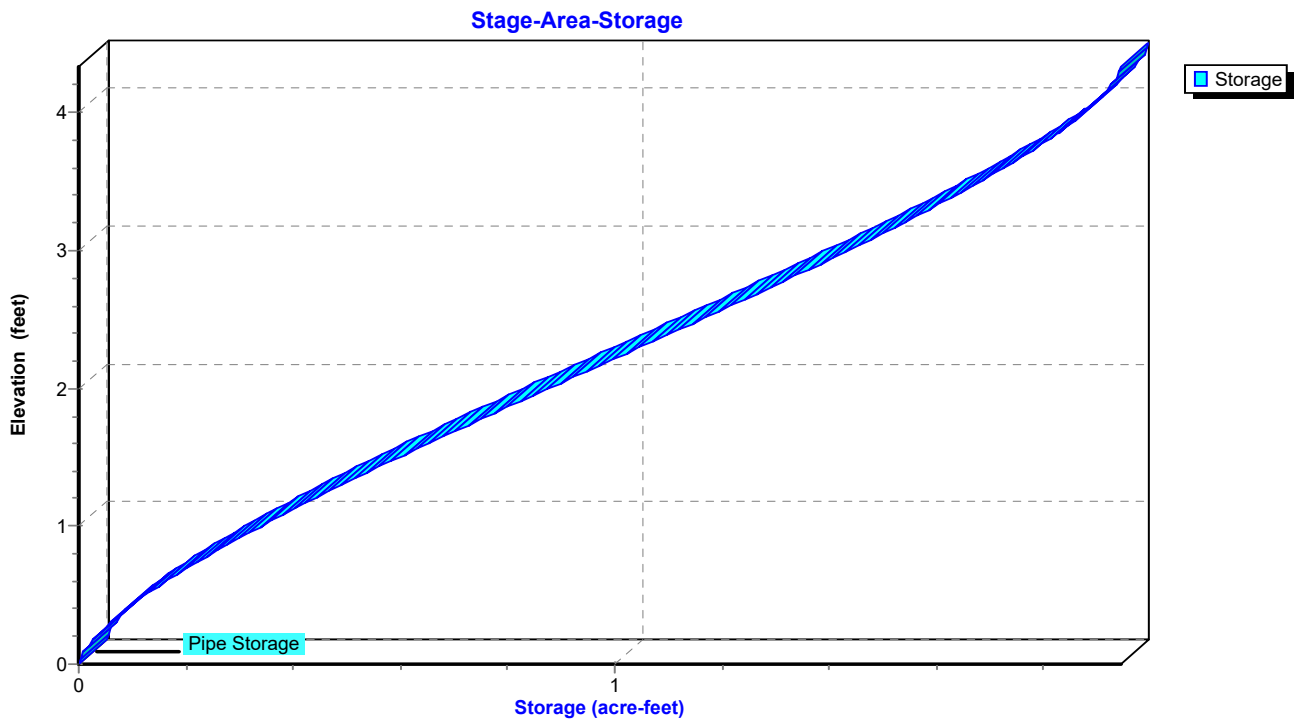
Hydrograph



### Pond 3P: Detention A



### Pond 3P: Detention A





# Walgraves

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Type IA 24-hr 2-YR Rainfall=2.50"

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## Summary for Pond 6P: Detention B

Inflow Area = 2.894 ac, 100.00% Impervious, Inflow Depth = 2.27" for 2-YR event  
Inflow = 1.69 cfs @ 7.86 hrs, Volume= 0.548 af  
Outflow = 0.20 cfs @ 18.15 hrs, Volume= 0.548 af, Atten= 88%, Lag= 617.3 min  
Primary = 0.20 cfs @ 18.15 hrs, Volume= 0.548 af

Routing by Stor-Ind method, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
Peak Elev= 2.10' @ 18.15 hrs Surf.Area= 0.177 ac Storage= 0.260 af

Plug-Flow detention time= 721.9 min calculated for 0.547 af (100% of inflow)  
Center-of-Mass det. time= 722.4 min ( 1,394.3 - 671.9 )

Volume	Invert	Avail.Storage	Storage Description
#1A	0.00'	0.000 af	<b>20.41'W x 200.00'L x 2.75'H Field A</b> 0.258 af Overall - 0.163 af Embedded = 0.094 af x 0.0% Voids
#2A	0.00'	0.163 af	<b>CMP Arch 49x33 x 40 Inside #1</b> Effective Size= 49.0"W x 33.0"H => 8.90 sf x 20.00'L = 178.0 cf Overall Size= 49.0"W x 33.0"H x 20.00'L 40 Chambers in 4 Rows
#3B	0.00'	0.000 af	<b>25.85'W x 140.00'L x 2.75'H Field B</b> 0.228 af Overall - 0.143 af Embedded = 0.085 af x 0.0% Voids
#4B	0.00'	0.143 af	<b>CMP Arch 49x33 x 35 Inside #3</b> Effective Size= 49.0"W x 33.0"H => 8.90 sf x 20.00'L = 178.0 cf Overall Size= 49.0"W x 33.0"H x 20.00'L 35 Chambers in 5 Rows
		0.306 af	Total Available Storage

Storage Group A created with Chamber Wizard

Storage Group B created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	0.00'	<b>2.3" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads
#2	Primary	2.10'	<b>6.0" W x 5.0" H Vert. Orifice/Grate</b> C= 0.600
#3	Primary	2.52'	<b>24.0" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads

**Primary OutFlow** Max=0.20 cfs @ 18.15 hrs HW=2.10' (Free Discharge)

1=Orifice/Grate (Orifice Controls 0.20 cfs @ 6.98 fps)

2=Orifice/Grate ( Controls 0.00 cfs)

3=Orifice/Grate ( Controls 0.00 cfs)

**Pond 6P: Detention B - Chamber Wizard Field A**

**Chamber Model = CMP Arch 49x33 (1/2" Corrugated Pipe Arch, AISI Handbook 1994, Table 2.18)**

Effective Size= 49.0"W x 33.0"H => 8.90 sf x 20.00'L = 178.0 cf

Overall Size= 49.0"W x 33.0"H x 20.00'L

49.0" Wide + 16.3" Spacing = 65.3" C-C Row Spacing

10 Chambers/Row x 20.00' Long = 200.00' Row Length

4 Rows x 49.0" Wide + 16.3" Spacing x 3 = 20.41' Base Width

33.0" Chamber Height = 2.75' Field Height

40 Chambers x 178.0 cf = 7,118.3 cf Chamber Storage

11,224.6 cf Field - 7,118.3 cf Chambers = 4,106.3 cf Stone x 0.0% Voids = 0.0 cf Stone Storage

Chamber Storage = 7,118.3 cf = 0.163 af

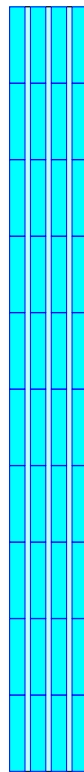
Overall Storage Efficiency = 63.4%

Overall System Size = 200.00' x 20.41' x 2.75'

40 Chambers

415.7 cy Field

152.1 cy Stone



**Pond 6P: Detention B - Chamber Wizard Field B**

**Chamber Model = CMP Arch 49x33 (1/2" Corrugated Pipe Arch, AISI Handbook 1994, Table 2.18)**

Effective Size= 49.0"W x 33.0"H => 8.90 sf x 20.00'L = 178.0 cf

Overall Size= 49.0"W x 33.0"H x 20.00'L

49.0" Wide + 16.3" Spacing = 65.3" C-C Row Spacing

7 Chambers/Row x 20.00' Long = 140.00' Row Length

5 Rows x 49.0" Wide + 16.3" Spacing x 4 = 25.85' Base Width

33.0" Chamber Height = 2.75' Field Height

35 Chambers x 178.0 cf = 6,228.5 cf Chamber Storage

9,952.3 cf Field - 6,228.5 cf Chambers = 3,723.8 cf Stone x 0.0% Voids = 0.0 cf Stone Storage

Chamber Storage = 6,228.5 cf = 0.143 af

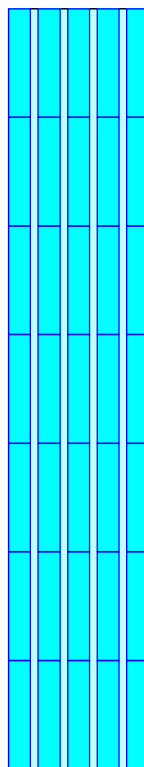
Overall Storage Efficiency = 62.6%

Overall System Size = 140.00' x 25.85' x 2.75'

35 Chambers

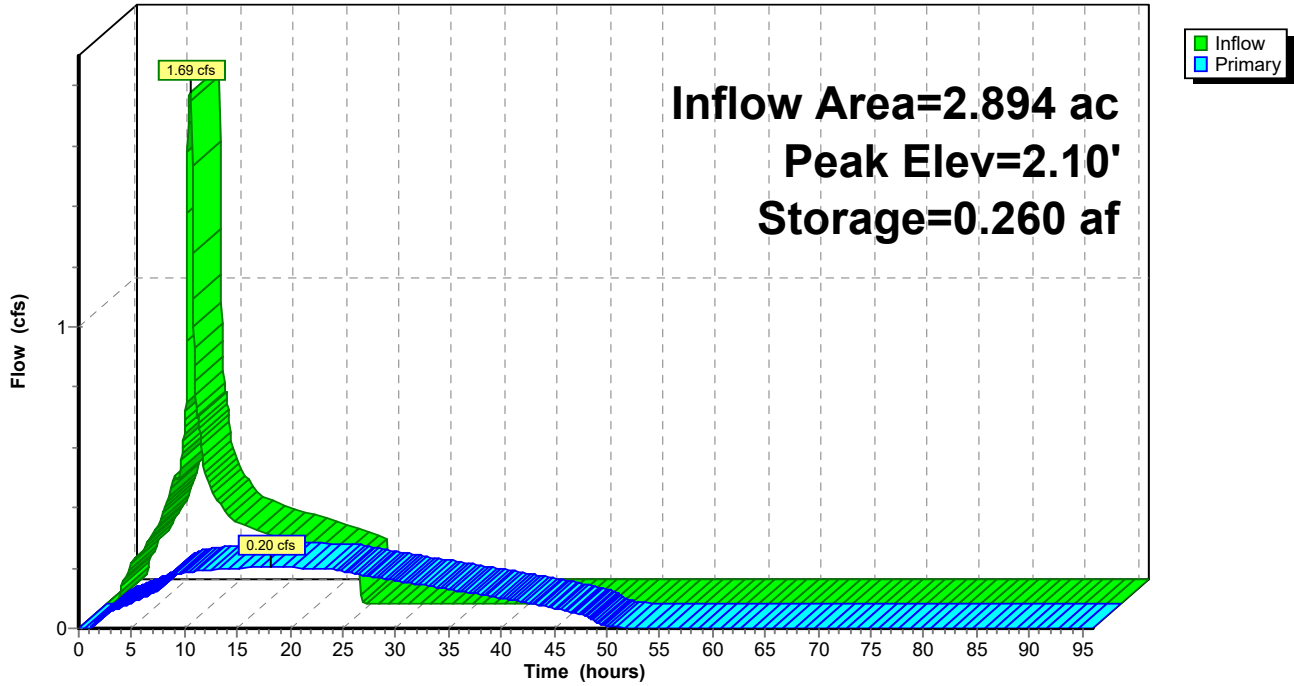
368.6 cy Field

137.9 cy Stone



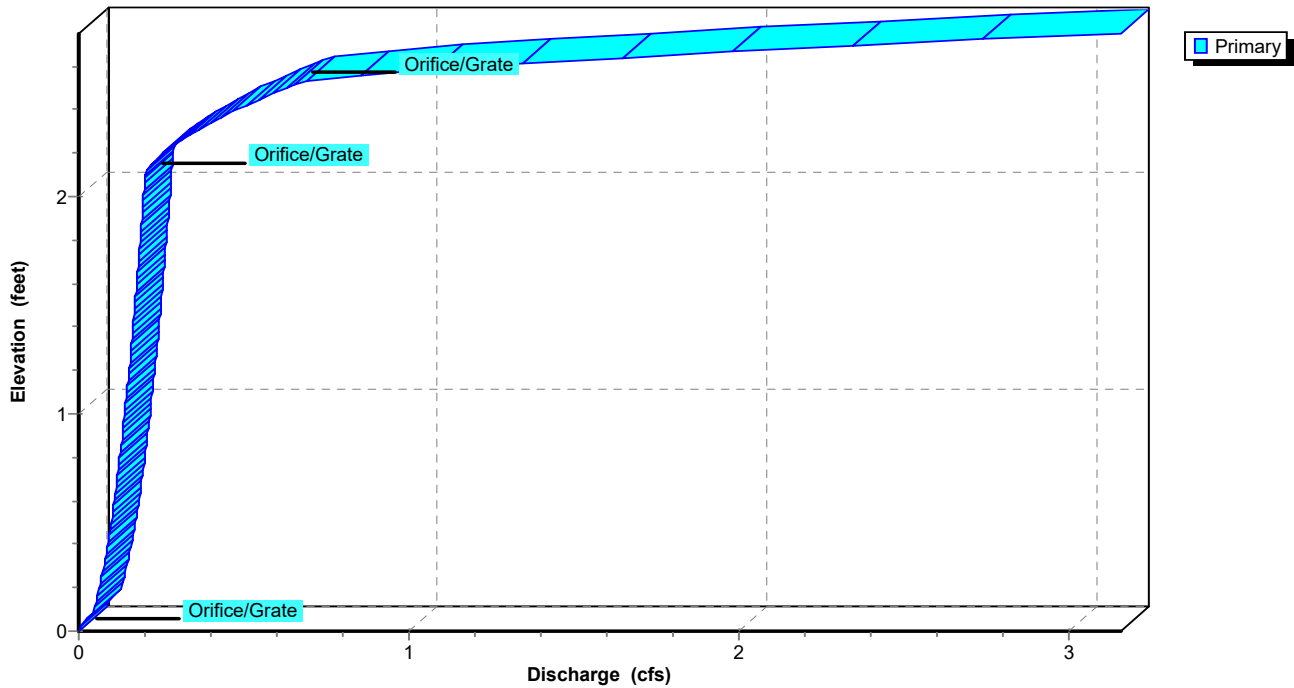
### Pond 6P: Detention B

Hydrograph



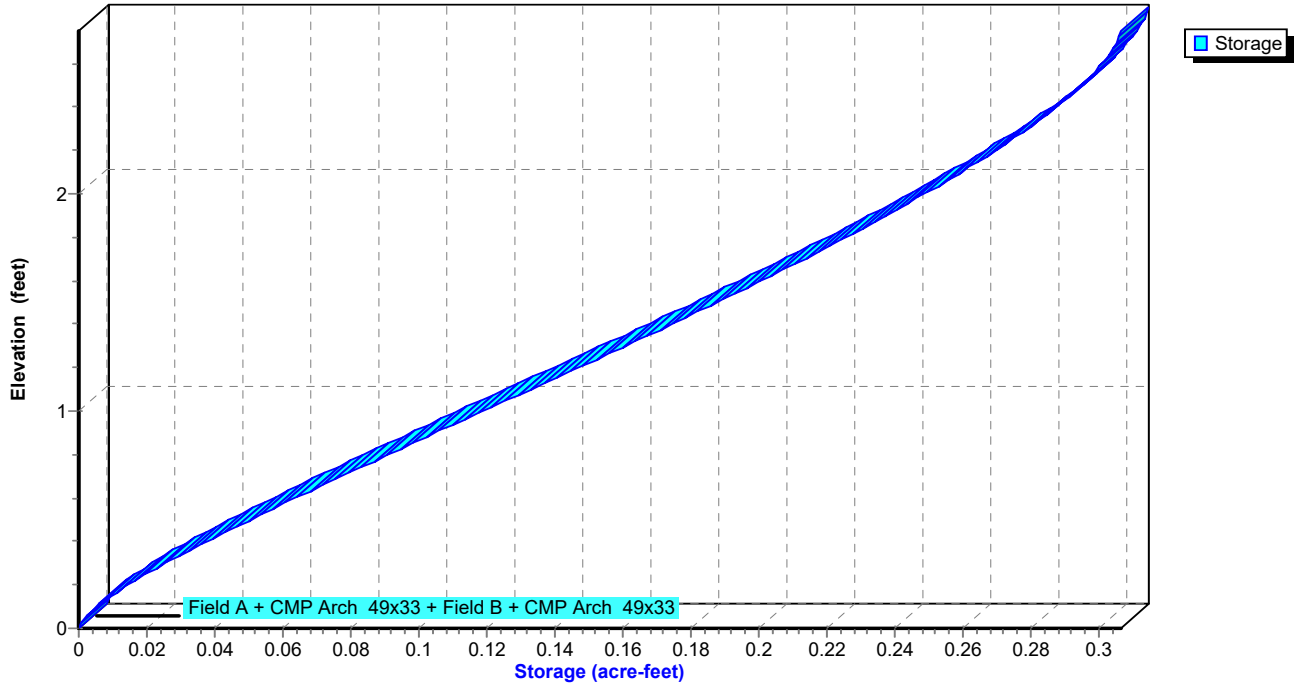
### Pond 6P: Detention B

Stage-Discharge



### Pond 6P: Detention B

Stage-Area-Storage



**Summary for Subcatchment 1S: Predeveloped Basin A**

Runoff = 2.86 cfs @ 8.27 hrs, Volume= 1.421 af, Depth= 1.14"

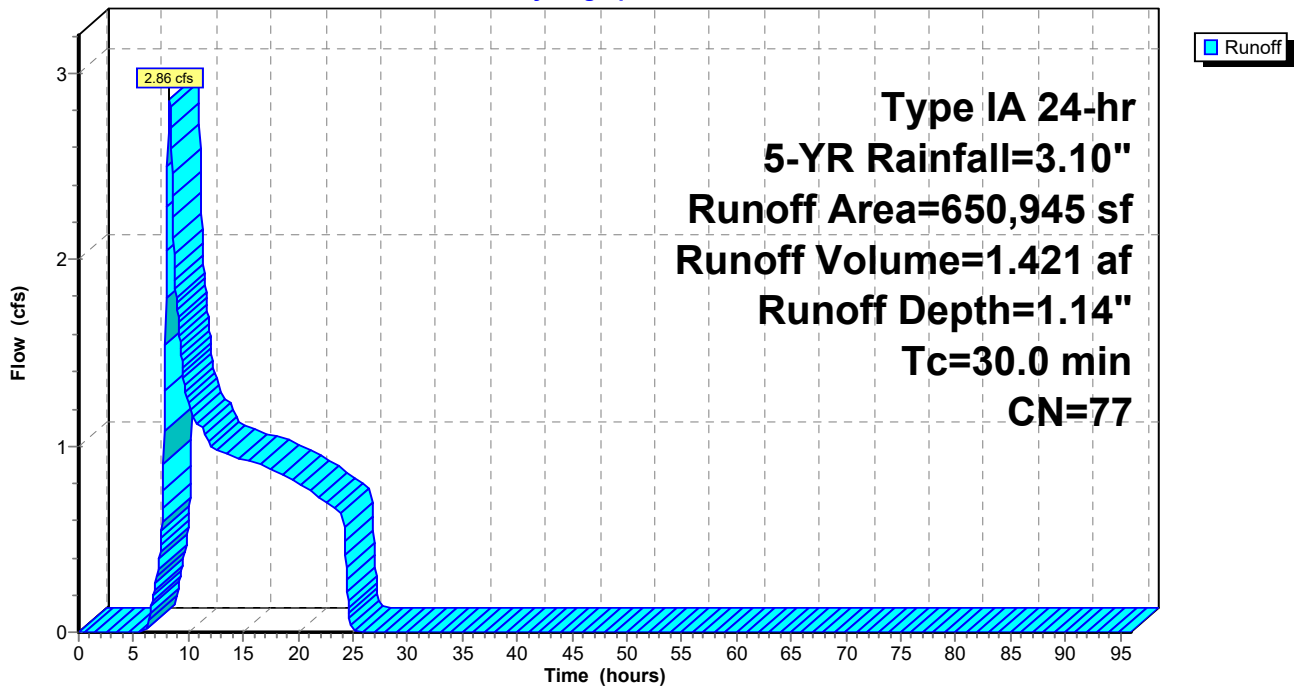
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
 Type IA 24-hr 5-YR Rainfall=3.10"

Area (sf)	CN	Description
* 650,945	77	>75% Grass cover, Good, HSG D
650,945		100.00% Pervious Area

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

**Subcatchment 1S: Predeveloped Basin A**

Hydrograph



# Walgraves

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Type IA 24-hr 5-YR Rainfall=3.10"

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## Summary for Subcatchment 2S: Developed Basin A

Runoff = 10.97 cfs @ 7.86 hrs, Volume= 3.571 af, Depth= 2.87"

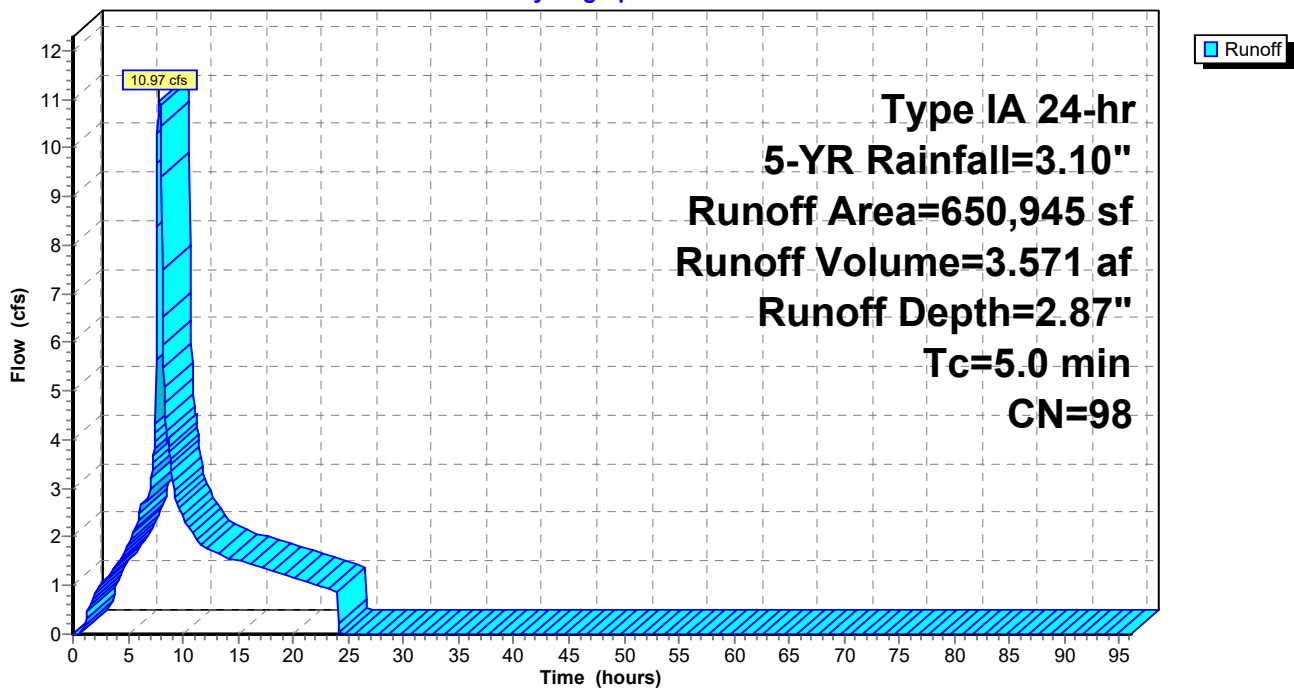
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
Type IA 24-hr 5-YR Rainfall=3.10"

Area (sf)	CN	Description
* 650,945	98	
650,945		100.00% Impervious Area

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

## Subcatchment 2S: Developed Basin A

Hydrograph



**Summary for Subcatchment 5S: Developed Basin B**

Runoff = 2.12 cfs @ 7.86 hrs, Volume= 0.692 af, Depth= 2.87"

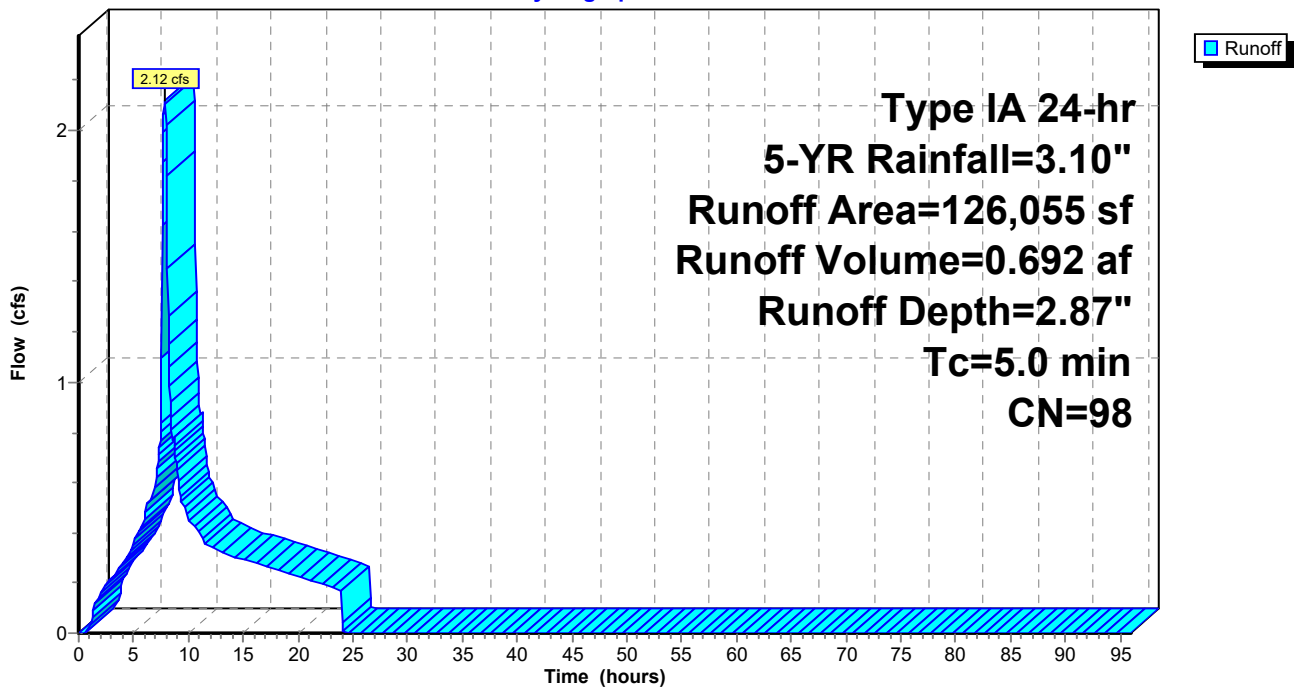
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
 Type IA 24-hr 5-YR Rainfall=3.10"

	Area (sf)	CN	Description
*	69,225	98	Concrete
*	56,830	98	Roof
	126,055	98	Weighted Average
	126,055		100.00% Impervious Area

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

**Subcatchment 5S: Developed Basin B**

Hydrograph





**Summary for Subcatchment 7S: Predeveloped Basin B**

Runoff = 0.70 cfs @ 7.93 hrs, Volume= 0.275 af, Depth= 1.14"

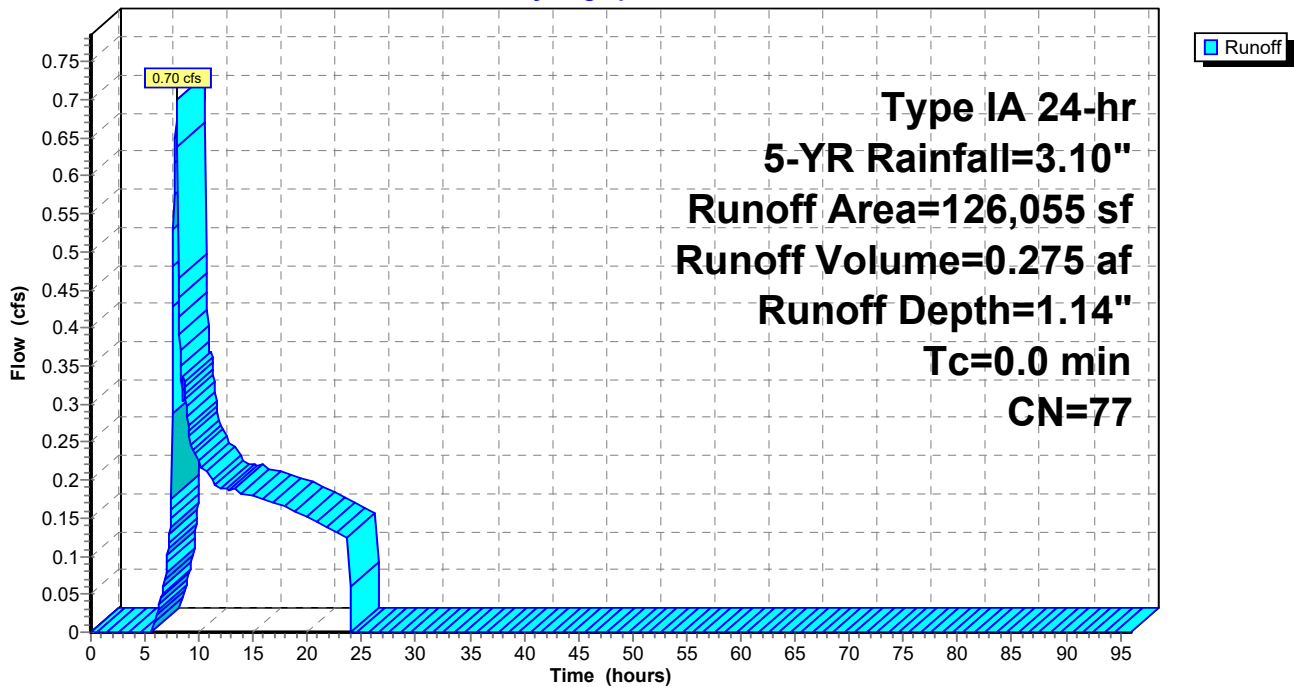
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
 Type IA 24-hr 5-YR Rainfall=3.10"

Area (sf)	CN	Description
* 126,055	77	
126,055		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.0					Direct Entry, 20

**Subcatchment 7S: Predeveloped Basin B**

Hydrograph



**Summary for Pond 3P: Detention A**

Inflow Area = 14.944 ac, 100.00% Impervious, Inflow Depth = 2.87" for 5-YR event  
 Inflow = 10.97 cfs @ 7.86 hrs, Volume= 3.571 af  
 Outflow = 1.62 cfs @ 13.50 hrs, Volume= 3.571 af, Atten= 85%, Lag= 338.7 min  
 Primary = 1.62 cfs @ 13.50 hrs, Volume= 3.571 af

Routing by Stor-Ind method, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
 Peak Elev= 3.96' @ 13.50 hrs Surf.Area= 0.320 ac Storage= 1.866 af

Plug-Flow detention time= 1,047.1 min calculated for 3.571 af (100% of inflow)  
 Center-of-Mass det. time= 1,046.8 min ( 1,712.2 - 665.4 )

Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	1.947 af	<b>52.0" Round Pipe Storage</b> L= 5,750.0'

Device	Routing	Invert	Outlet Devices
#1	Primary	0.00'	<b>4.0" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads
#2	Primary	3.85'	<b>24.0" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads

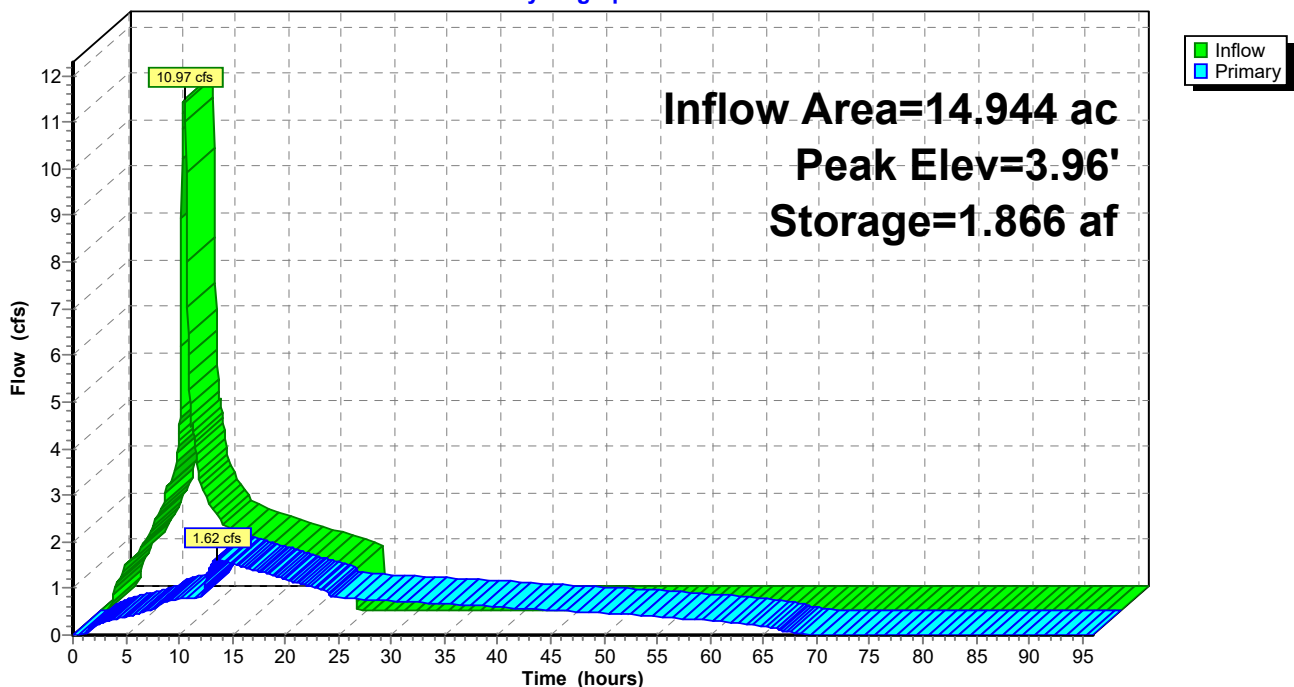
**Primary OutFlow** Max=1.61 cfs @ 13.50 hrs HW=3.96' (Free Discharge)

1=Orifice/Grate (Orifice Controls 0.84 cfs @ 9.58 fps)

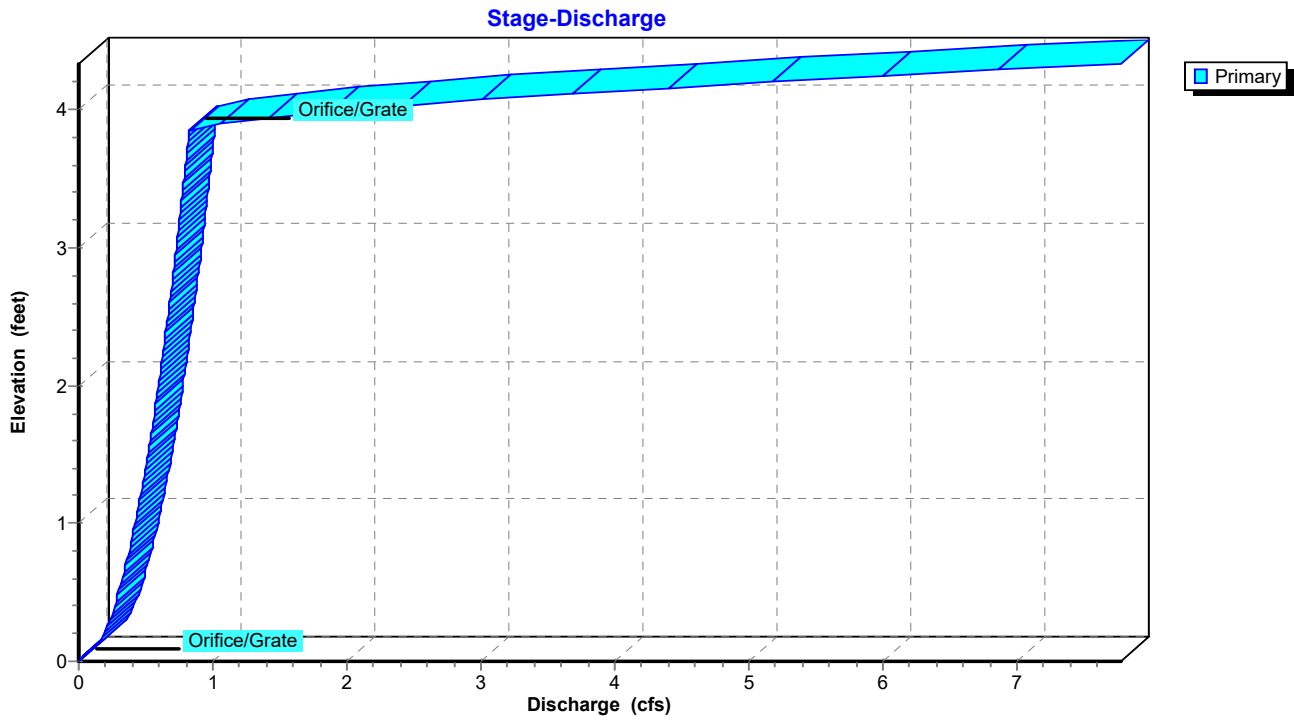
2=Orifice/Grate (Weir Controls 0.78 cfs @ 1.10 fps)

**Pond 3P: Detention A**

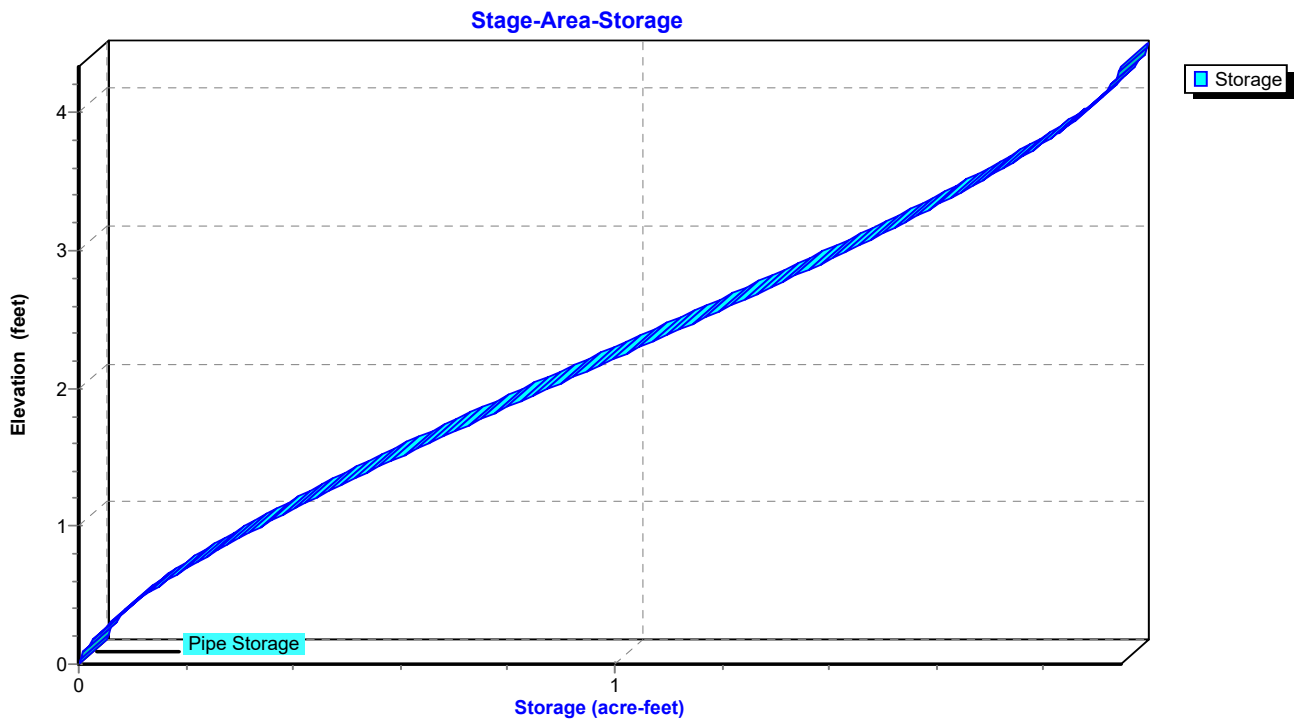
Hydrograph



### Pond 3P: Detention A



### Pond 3P: Detention A



# Walgraves

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Type IA 24-hr 5-YR Rainfall=3.10"

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## Summary for Pond 6P: Detention B

Inflow Area = 2.894 ac, 100.00% Impervious, Inflow Depth = 2.87" for 5-YR event  
Inflow = 2.12 cfs @ 7.86 hrs, Volume= 0.692 af  
Outflow = 0.41 cfs @ 10.86 hrs, Volume= 0.692 af, Atten= 81%, Lag= 180.0 min  
Primary = 0.41 cfs @ 10.86 hrs, Volume= 0.692 af

Routing by Stor-Ind method, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
Peak Elev= 2.35' @ 10.86 hrs Surf.Area= 0.177 ac Storage= 0.283 af

Plug-Flow detention time= 639.0 min calculated for 0.692 af (100% of inflow)  
Center-of-Mass det. time= 638.6 min ( 1,304.1 - 665.4 )

Volume	Invert	Avail.Storage	Storage Description
#1A	0.00'	0.000 af	<b>20.41'W x 200.00'L x 2.75'H Field A</b> 0.258 af Overall - 0.163 af Embedded = 0.094 af x 0.0% Voids
#2A	0.00'	0.163 af	<b>CMP Arch 49x33 x 40 Inside #1</b> Effective Size= 49.0"W x 33.0"H => 8.90 sf x 20.00'L = 178.0 cf Overall Size= 49.0"W x 33.0"H x 20.00'L 40 Chambers in 4 Rows
#3B	0.00'	0.000 af	<b>25.85'W x 140.00'L x 2.75'H Field B</b> 0.228 af Overall - 0.143 af Embedded = 0.085 af x 0.0% Voids
#4B	0.00'	0.143 af	<b>CMP Arch 49x33 x 35 Inside #3</b> Effective Size= 49.0"W x 33.0"H => 8.90 sf x 20.00'L = 178.0 cf Overall Size= 49.0"W x 33.0"H x 20.00'L 35 Chambers in 5 Rows
		0.306 af	Total Available Storage

Storage Group A created with Chamber Wizard

Storage Group B created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	0.00'	<b>2.3" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads
#2	Primary	2.10'	<b>6.0" W x 5.0" H Vert. Orifice/Grate</b> C= 0.600
#3	Primary	2.52'	<b>24.0" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads

**Primary OutFlow** Max=0.41 cfs @ 10.86 hrs HW=2.35' (Free Discharge)

1=Orifice/Grate (Orifice Controls 0.21 cfs @ 7.38 fps)

2=Orifice/Grate (Orifice Controls 0.20 cfs @ 1.59 fps)

3=Orifice/Grate ( Controls 0.00 cfs)

**Pond 6P: Detention B - Chamber Wizard Field A**

**Chamber Model = CMP Arch 49x33 (1/2" Corrugated Pipe Arch, AISI Handbook 1994, Table 2.18)**

Effective Size= 49.0"W x 33.0"H => 8.90 sf x 20.00'L = 178.0 cf

Overall Size= 49.0"W x 33.0"H x 20.00'L

49.0" Wide + 16.3" Spacing = 65.3" C-C Row Spacing

10 Chambers/Row x 20.00' Long = 200.00' Row Length

4 Rows x 49.0" Wide + 16.3" Spacing x 3 = 20.41' Base Width

33.0" Chamber Height = 2.75' Field Height

40 Chambers x 178.0 cf = 7,118.3 cf Chamber Storage

11,224.6 cf Field - 7,118.3 cf Chambers = 4,106.3 cf Stone x 0.0% Voids = 0.0 cf Stone Storage

Chamber Storage = 7,118.3 cf = 0.163 af

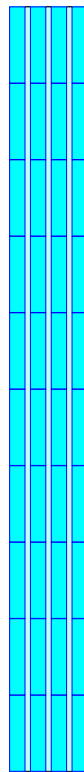
Overall Storage Efficiency = 63.4%

Overall System Size = 200.00' x 20.41' x 2.75'

40 Chambers

415.7 cy Field

152.1 cy Stone



**Pond 6P: Detention B - Chamber Wizard Field B**

**Chamber Model = CMP Arch 49x33 (1/2" Corrugated Pipe Arch, AISI Handbook 1994, Table 2.18)**

Effective Size= 49.0"W x 33.0"H => 8.90 sf x 20.00'L = 178.0 cf

Overall Size= 49.0"W x 33.0"H x 20.00'L

49.0" Wide + 16.3" Spacing = 65.3" C-C Row Spacing

7 Chambers/Row x 20.00' Long = 140.00' Row Length

5 Rows x 49.0" Wide + 16.3" Spacing x 4 = 25.85' Base Width

33.0" Chamber Height = 2.75' Field Height

35 Chambers x 178.0 cf = 6,228.5 cf Chamber Storage

9,952.3 cf Field - 6,228.5 cf Chambers = 3,723.8 cf Stone x 0.0% Voids = 0.0 cf Stone Storage

Chamber Storage = 6,228.5 cf = 0.143 af

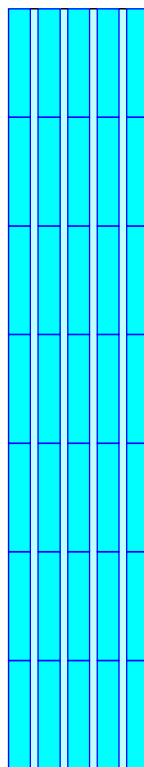
Overall Storage Efficiency = 62.6%

Overall System Size = 140.00' x 25.85' x 2.75'

35 Chambers

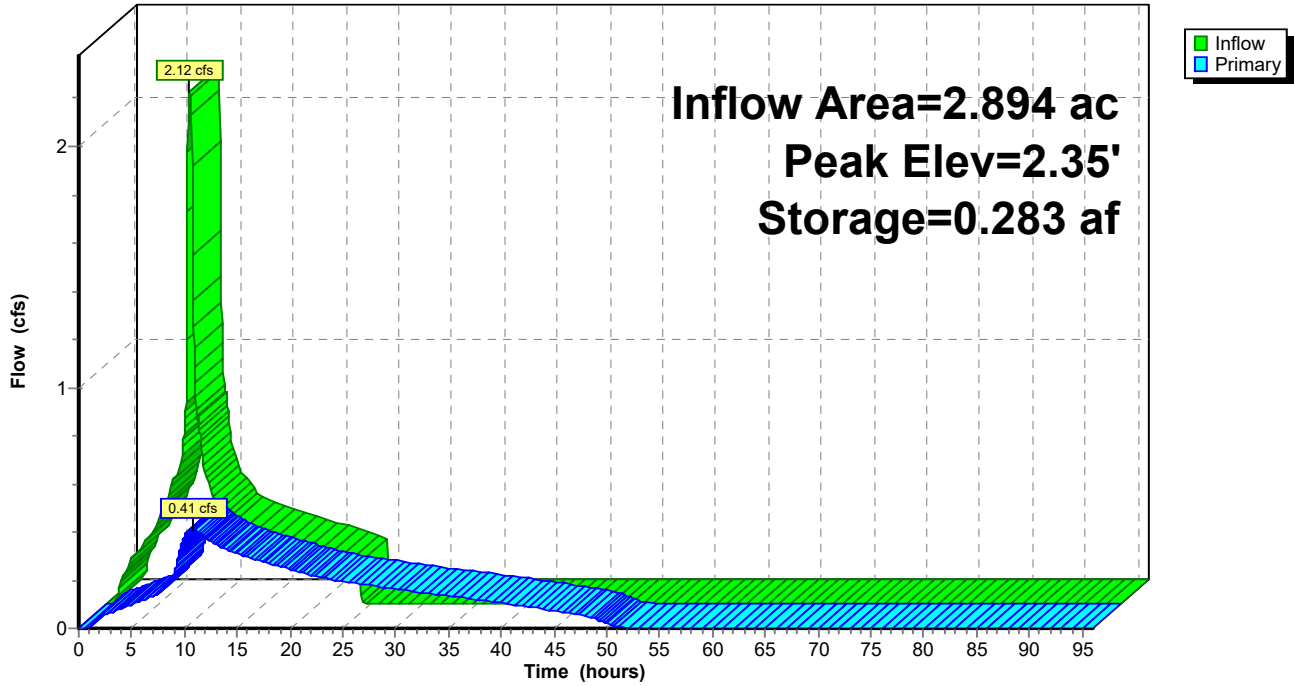
368.6 cy Field

137.9 cy Stone



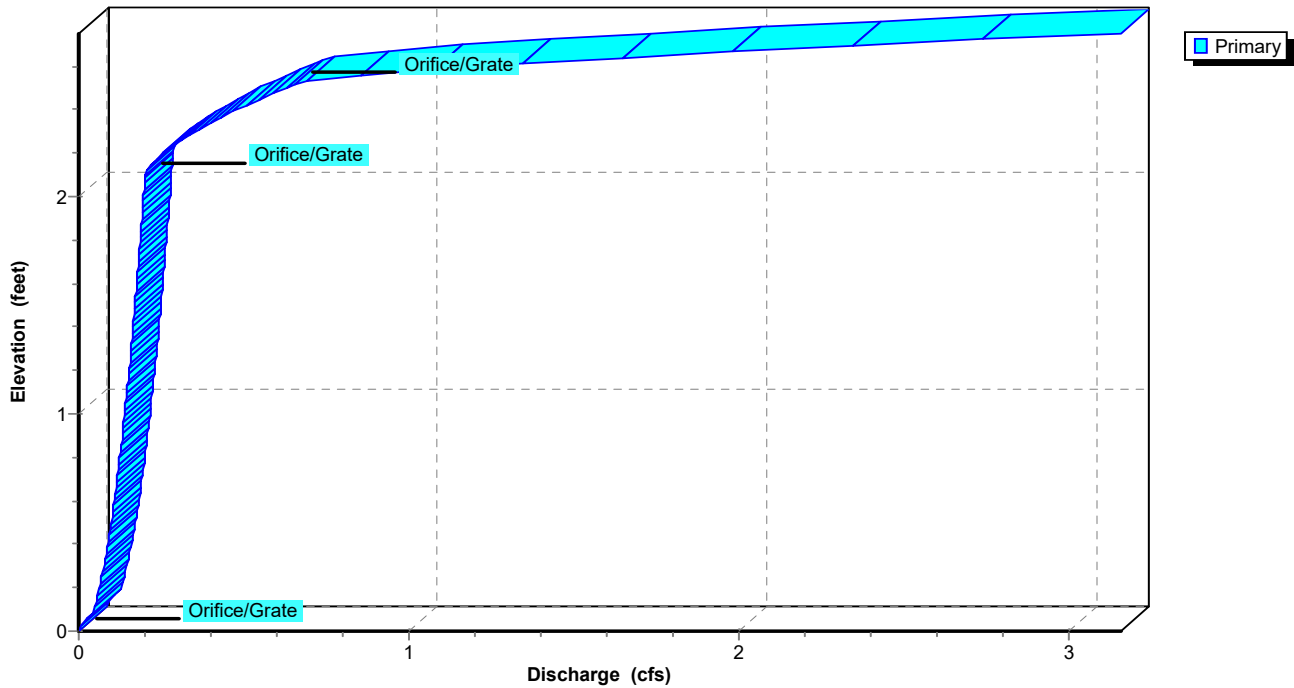
### Pond 6P: Detention B

Hydrograph



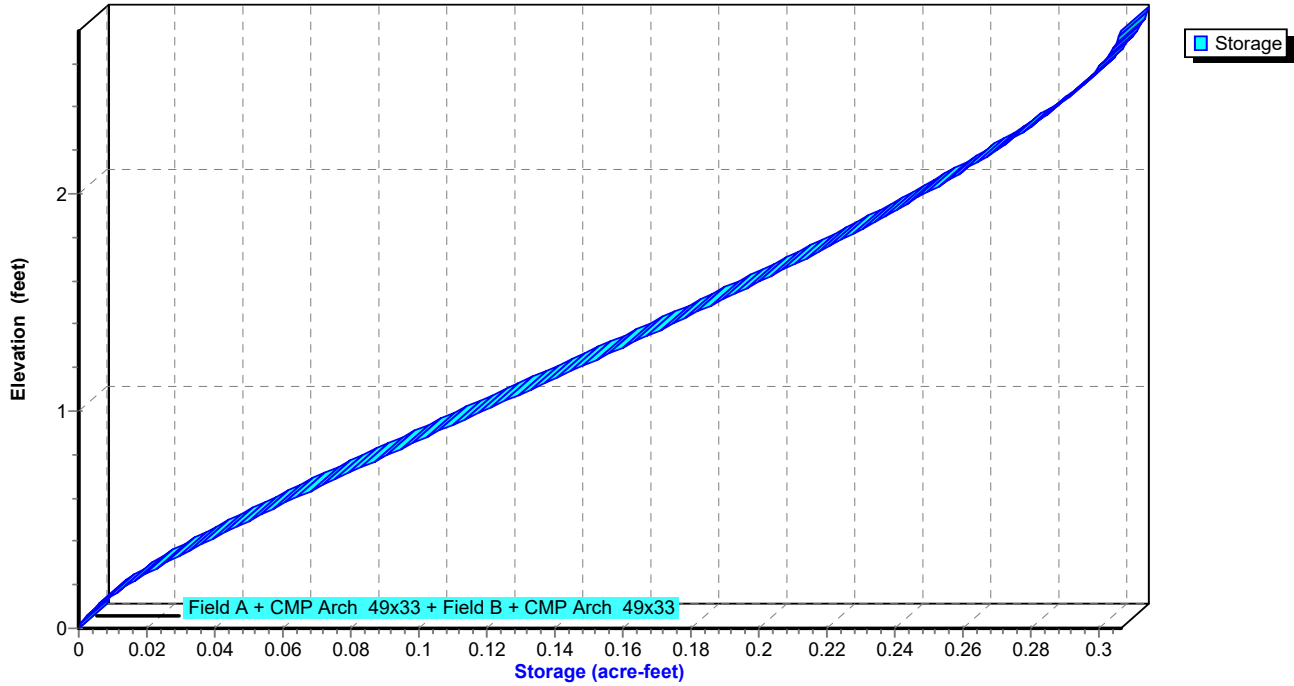
### Pond 6P: Detention B

Stage-Discharge



### Pond 6P: Detention B

Stage-Area-Storage





**Summary for Subcatchment 1S: Predeveloped Basin A**

Runoff = 3.71 cfs @ 8.26 hrs, Volume= 1.735 af, Depth= 1.39"

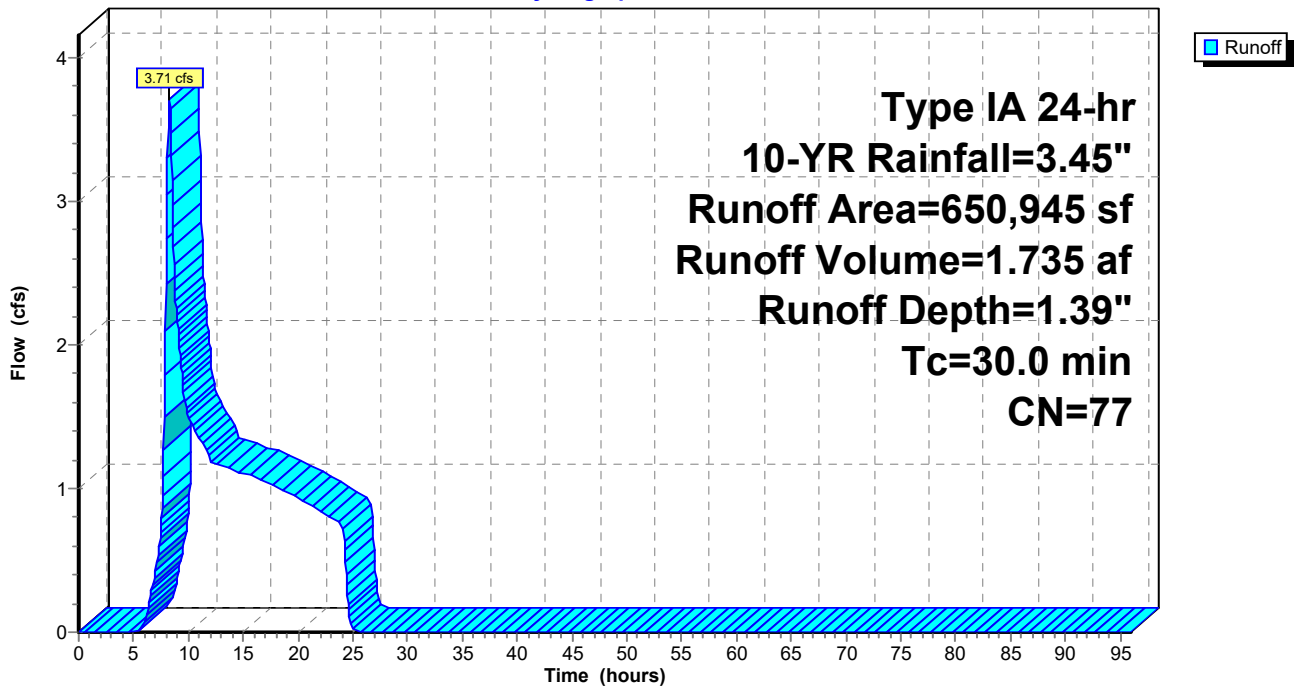
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
 Type IA 24-hr 10-YR Rainfall=3.45"

Area (sf)	CN	Description
* 650,945	77	>75% Grass cover, Good, HSG D
650,945		100.00% Pervious Area

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

**Subcatchment 1S: Predeveloped Basin A**

Hydrograph



**Summary for Subcatchment 2S: Developed Basin A**

Runoff = 12.26 cfs @ 7.86 hrs, Volume= 4.006 af, Depth= 3.22"

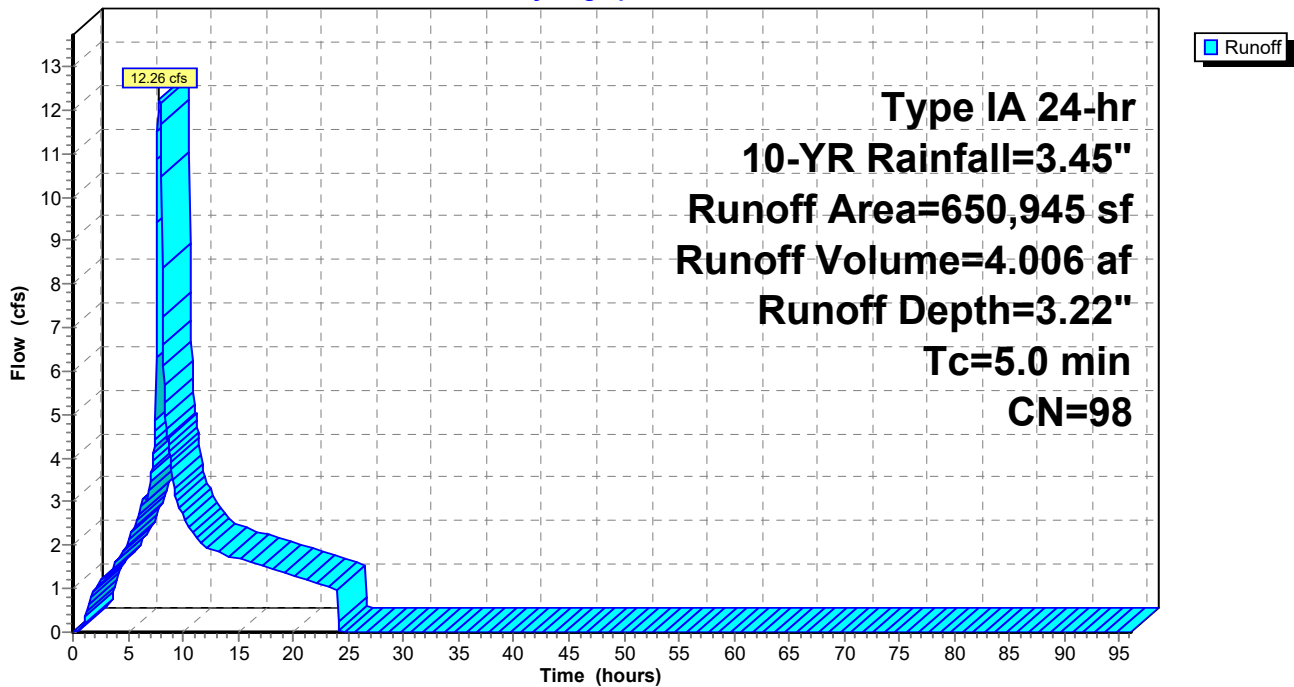
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
 Type IA 24-hr 10-YR Rainfall=3.45"

Area (sf)	CN	Description
* 650,945	98	
650,945		100.00% Impervious Area

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

**Subcatchment 2S: Developed Basin A**

Hydrograph



**Summary for Subcatchment 5S: Developed Basin B**

Runoff = 2.37 cfs @ 7.86 hrs, Volume= 0.776 af, Depth= 3.22"

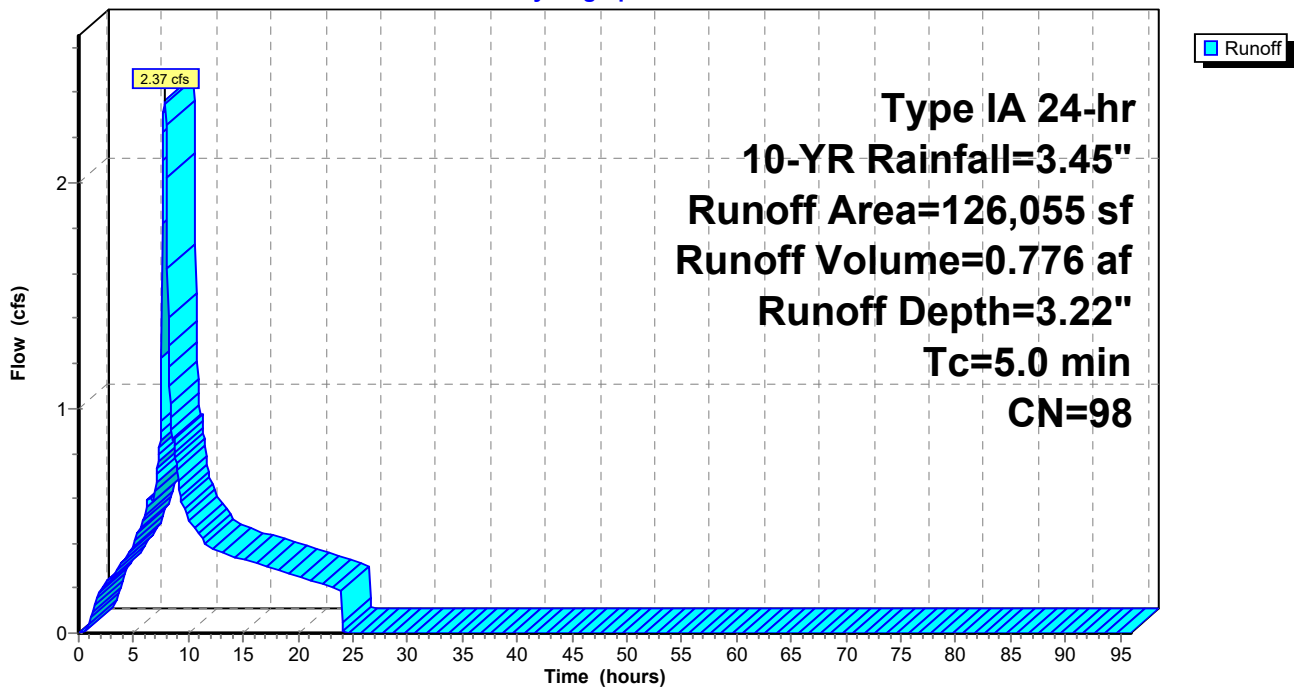
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
Type IA 24-hr 10-YR Rainfall=3.45"

	Area (sf)	CN	Description
*	69,225	98	Concrete
*	56,830	98	Roof
	126,055	98	Weighted Average
	126,055		100.00% Impervious Area

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

**Subcatchment 5S: Developed Basin B**

Hydrograph



**Summary for Subcatchment 7S: Predeveloped Basin B**

Runoff = 0.88 cfs @ 7.92 hrs, Volume= 0.336 af, Depth= 1.39"

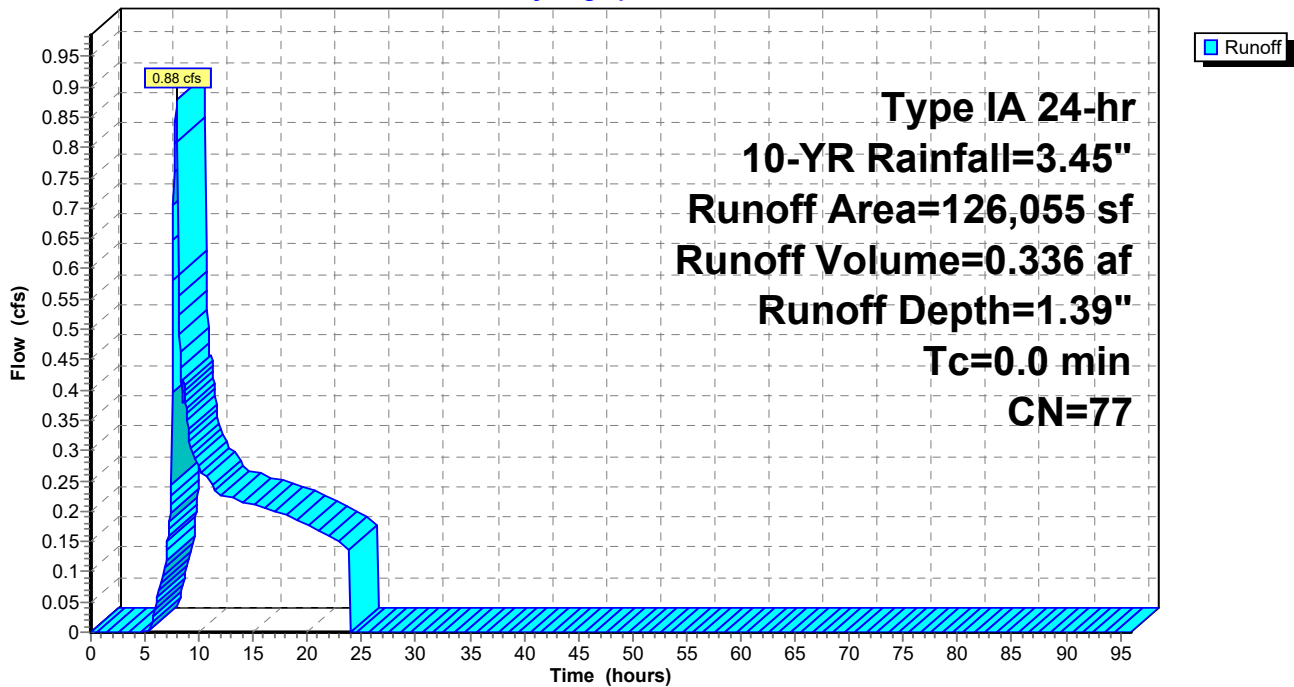
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
Type IA 24-hr 10-YR Rainfall=3.45"

Area (sf)	CN	Description
* 126,055	77	
126,055		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.0					Direct Entry, 20

**Subcatchment 7S: Predeveloped Basin B**

Hydrograph



**Summary for Pond 3P: Detention A**

Inflow Area = 14.944 ac, 100.00% Impervious, Inflow Depth = 3.22" for 10-YR event  
 Inflow = 12.26 cfs @ 7.86 hrs, Volume= 4.006 af  
 Outflow = 2.30 cfs @ 11.01 hrs, Volume= 4.006 af, Atten= 81%, Lag= 189.2 min  
 Primary = 2.30 cfs @ 11.01 hrs, Volume= 4.006 af

Routing by Stor-Ind method, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
 Peak Elev= 4.02' @ 11.01 hrs Surf.Area= 0.296 ac Storage= 1.884 af

Plug-Flow detention time= 952.1 min calculated for 4.004 af (100% of inflow)  
 Center-of-Mass det. time= 953.0 min ( 1,615.6 - 662.5 )

Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	1.947 af	<b>52.0" Round Pipe Storage</b> L= 5,750.0'

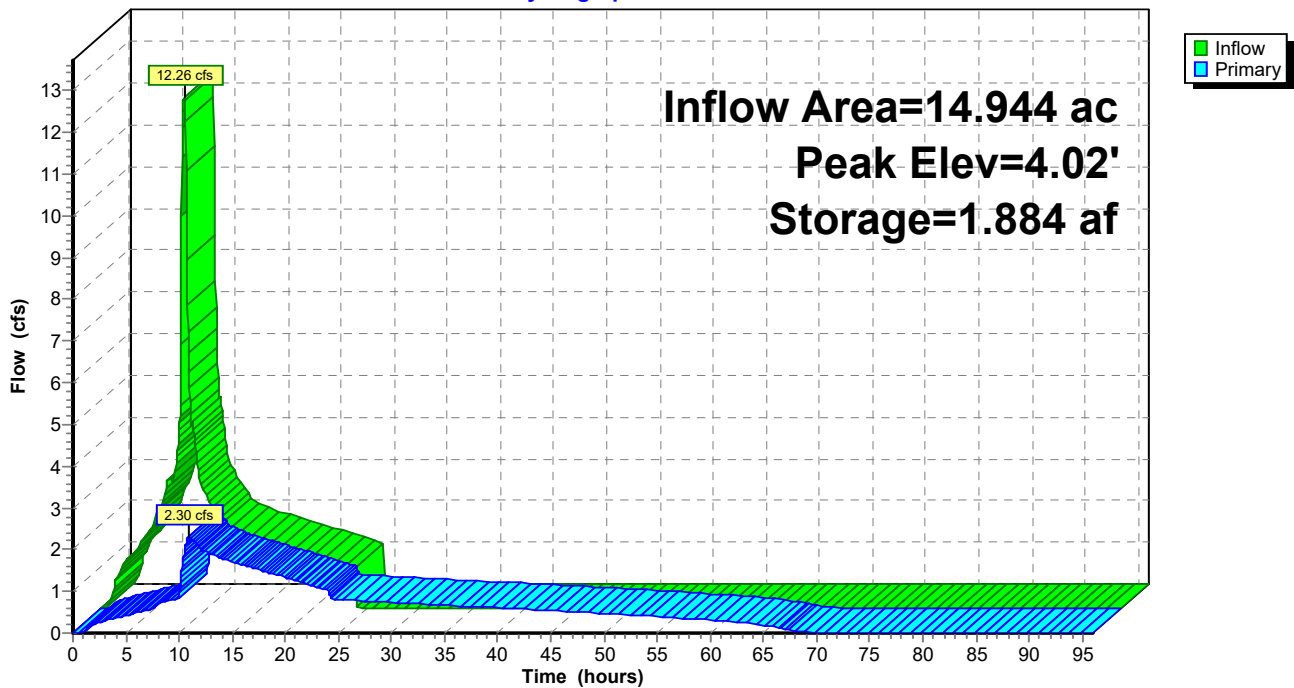
Device	Routing	Invert	Outlet Devices
#1	Primary	0.00'	<b>4.0" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads
#2	Primary	3.85'	<b>24.0" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads

**Primary OutFlow** Max=2.29 cfs @ 11.01 hrs HW=4.02' (Free Discharge)

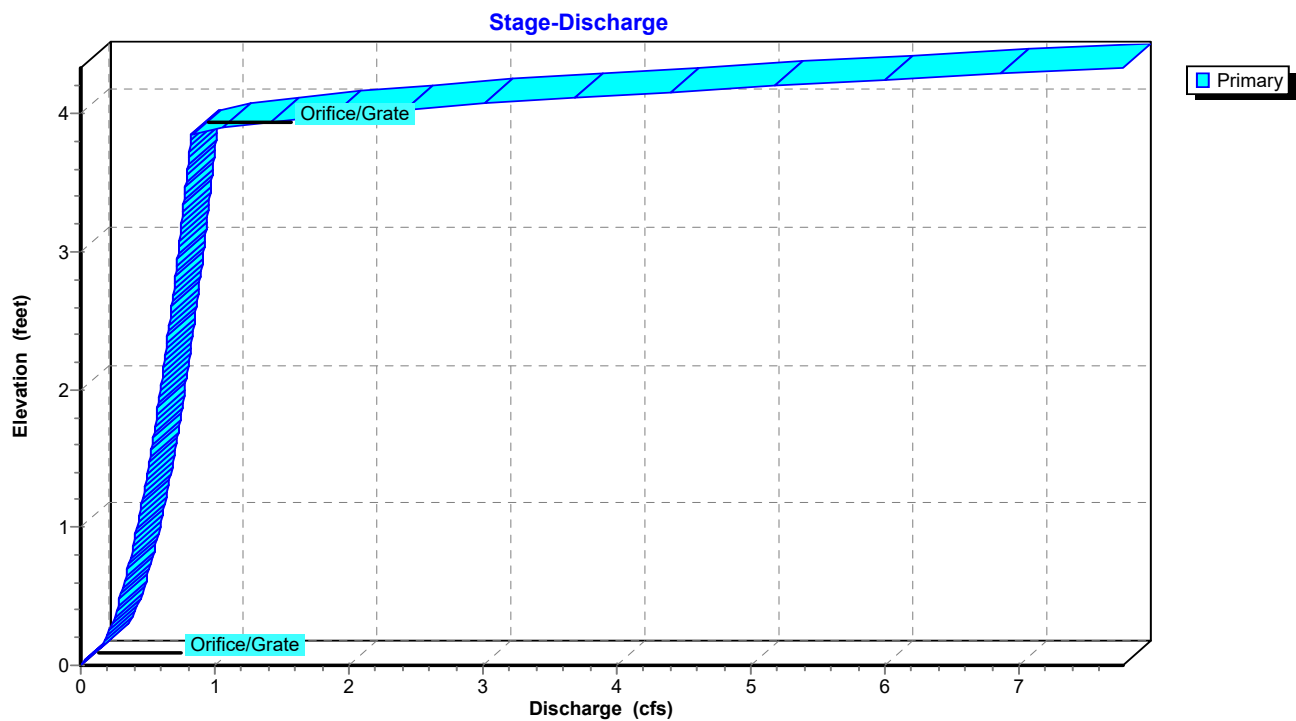
1=Orifice/Grate (Orifice Controls 0.84 cfs @ 9.65 fps)  
 2=Orifice/Grate (Weir Controls 1.45 cfs @ 1.35 fps)

**Pond 3P: Detention A**

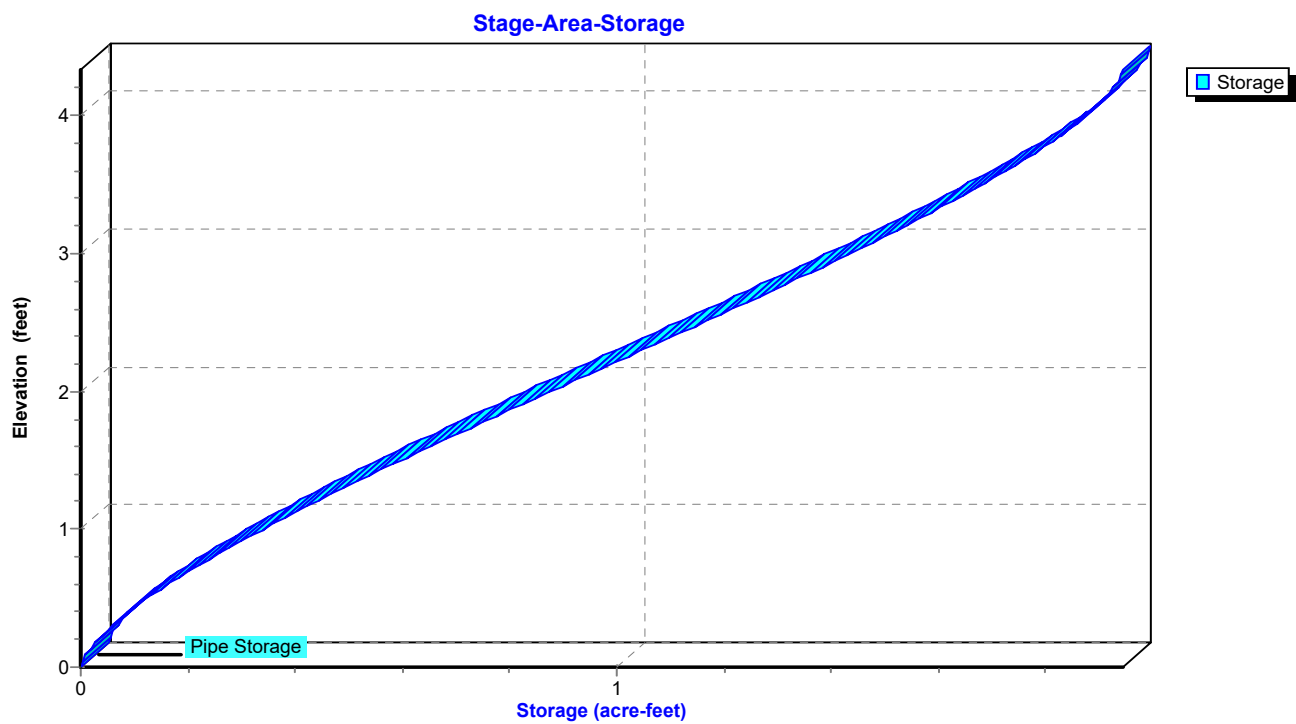
Hydrograph



### Pond 3P: Detention A



### Pond 3P: Detention A



# Walgraves

Prepared by AAI Engineering

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Type IA 24-hr 10-YR Rainfall=3.45"

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## Summary for Pond 6P: Detention B

Inflow Area = 2.894 ac, 100.00% Impervious, Inflow Depth = 3.22" for 10-YR event  
 Inflow = 2.37 cfs @ 7.86 hrs, Volume= 0.776 af  
 Outflow = 0.58 cfs @ 9.36 hrs, Volume= 0.776 af, Atten= 75%, Lag= 90.5 min  
 Primary = 0.58 cfs @ 9.36 hrs, Volume= 0.776 af

Routing by Stor-Ind method, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
 Peak Elev= 2.47' @ 9.36 hrs Surf.Area= 0.177 ac Storage= 0.293 af

Plug-Flow detention time= 586.0 min calculated for 0.775 af (100% of inflow)  
 Center-of-Mass det. time= 586.6 min ( 1,249.1 - 662.5 )

Volume	Invert	Avail.Storage	Storage Description
#1A	0.00'	0.000 af	<b>20.41'W x 200.00'L x 2.75'H Field A</b> 0.258 af Overall - 0.163 af Embedded = 0.094 af x 0.0% Voids
#2A	0.00'	0.163 af	<b>CMP Arch 49x33 x 40 Inside #1</b> Effective Size= 49.0"W x 33.0"H => 8.90 sf x 20.00'L = 178.0 cf Overall Size= 49.0"W x 33.0"H x 20.00'L 40 Chambers in 4 Rows
#3B	0.00'	0.000 af	<b>25.85'W x 140.00'L x 2.75'H Field B</b> 0.228 af Overall - 0.143 af Embedded = 0.085 af x 0.0% Voids
#4B	0.00'	0.143 af	<b>CMP Arch 49x33 x 35 Inside #3</b> Effective Size= 49.0"W x 33.0"H => 8.90 sf x 20.00'L = 178.0 cf Overall Size= 49.0"W x 33.0"H x 20.00'L 35 Chambers in 5 Rows
		0.306 af	Total Available Storage

Storage Group A created with Chamber Wizard

Storage Group B created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	0.00'	<b>2.3" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads
#2	Primary	2.10'	<b>6.0" W x 5.0" H Vert. Orifice/Grate</b> C= 0.600
#3	Primary	2.52'	<b>24.0" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads

**Primary OutFlow** Max=0.58 cfs @ 9.36 hrs HW=2.47' (Free Discharge)

1=Orifice/Grate (Orifice Controls 0.22 cfs @ 7.57 fps)

2=Orifice/Grate (Orifice Controls 0.37 cfs @ 1.96 fps)

3=Orifice/Grate ( Controls 0.00 cfs)

**Pond 6P: Detention B - Chamber Wizard Field A**

**Chamber Model = CMP Arch 49x33 (1/2" Corrugated Pipe Arch, AISI Handbook 1994, Table 2.18)**

Effective Size= 49.0"W x 33.0"H => 8.90 sf x 20.00'L = 178.0 cf

Overall Size= 49.0"W x 33.0"H x 20.00'L

49.0" Wide + 16.3" Spacing = 65.3" C-C Row Spacing

10 Chambers/Row x 20.00' Long = 200.00' Row Length

4 Rows x 49.0" Wide + 16.3" Spacing x 3 = 20.41' Base Width

33.0" Chamber Height = 2.75' Field Height

40 Chambers x 178.0 cf = 7,118.3 cf Chamber Storage

11,224.6 cf Field - 7,118.3 cf Chambers = 4,106.3 cf Stone x 0.0% Voids = 0.0 cf Stone Storage

Chamber Storage = 7,118.3 cf = 0.163 af

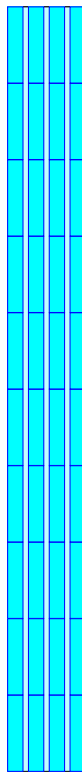
Overall Storage Efficiency = 63.4%

Overall System Size = 200.00' x 20.41' x 2.75'

40 Chambers

415.7 cy Field

152.1 cy Stone





**Pond 6P: Detention B - Chamber Wizard Field B**

**Chamber Model = CMP Arch 49x33 (1/2" Corrugated Pipe Arch, AISI Handbook 1994, Table 2.18)**

Effective Size= 49.0"W x 33.0"H => 8.90 sf x 20.00'L = 178.0 cf

Overall Size= 49.0"W x 33.0"H x 20.00'L

49.0" Wide + 16.3" Spacing = 65.3" C-C Row Spacing

7 Chambers/Row x 20.00' Long = 140.00' Row Length

5 Rows x 49.0" Wide + 16.3" Spacing x 4 = 25.85' Base Width

33.0" Chamber Height = 2.75' Field Height

35 Chambers x 178.0 cf = 6,228.5 cf Chamber Storage

9,952.3 cf Field - 6,228.5 cf Chambers = 3,723.8 cf Stone x 0.0% Voids = 0.0 cf Stone Storage

Chamber Storage = 6,228.5 cf = 0.143 af

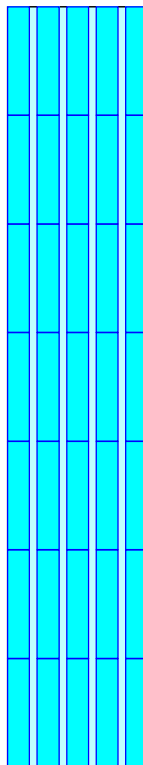
Overall Storage Efficiency = 62.6%

Overall System Size = 140.00' x 25.85' x 2.75'

35 Chambers

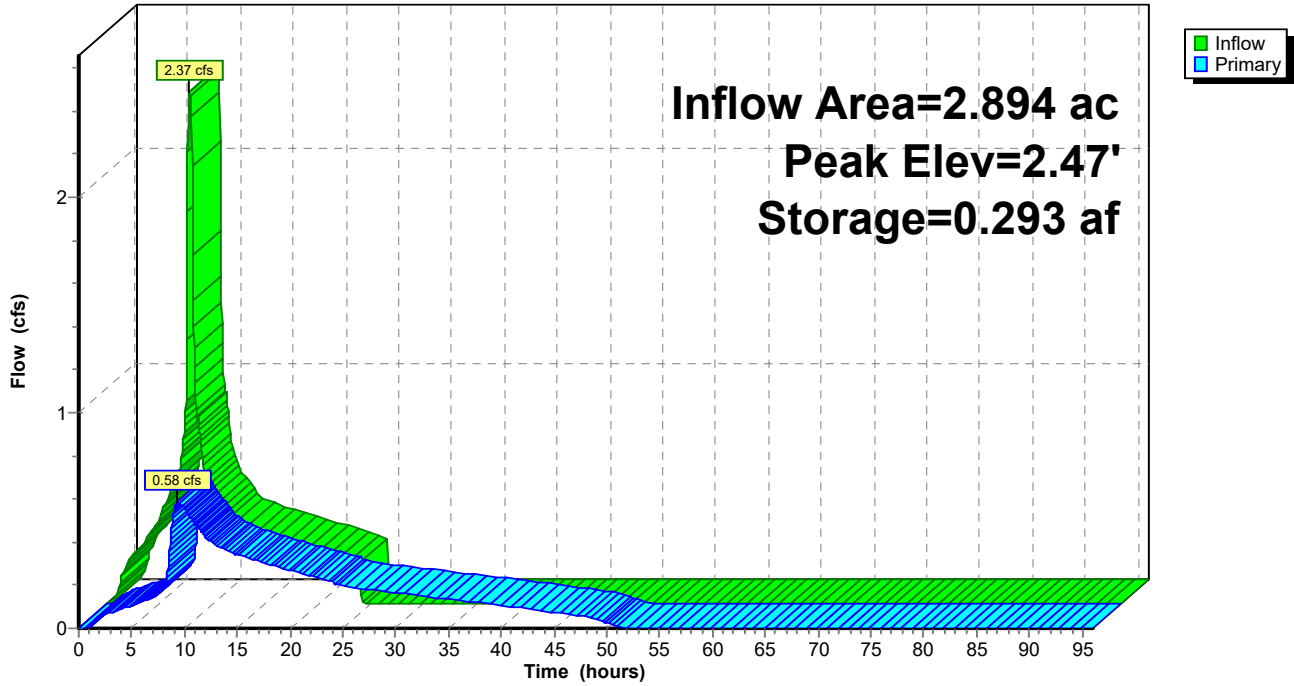
368.6 cy Field

137.9 cy Stone



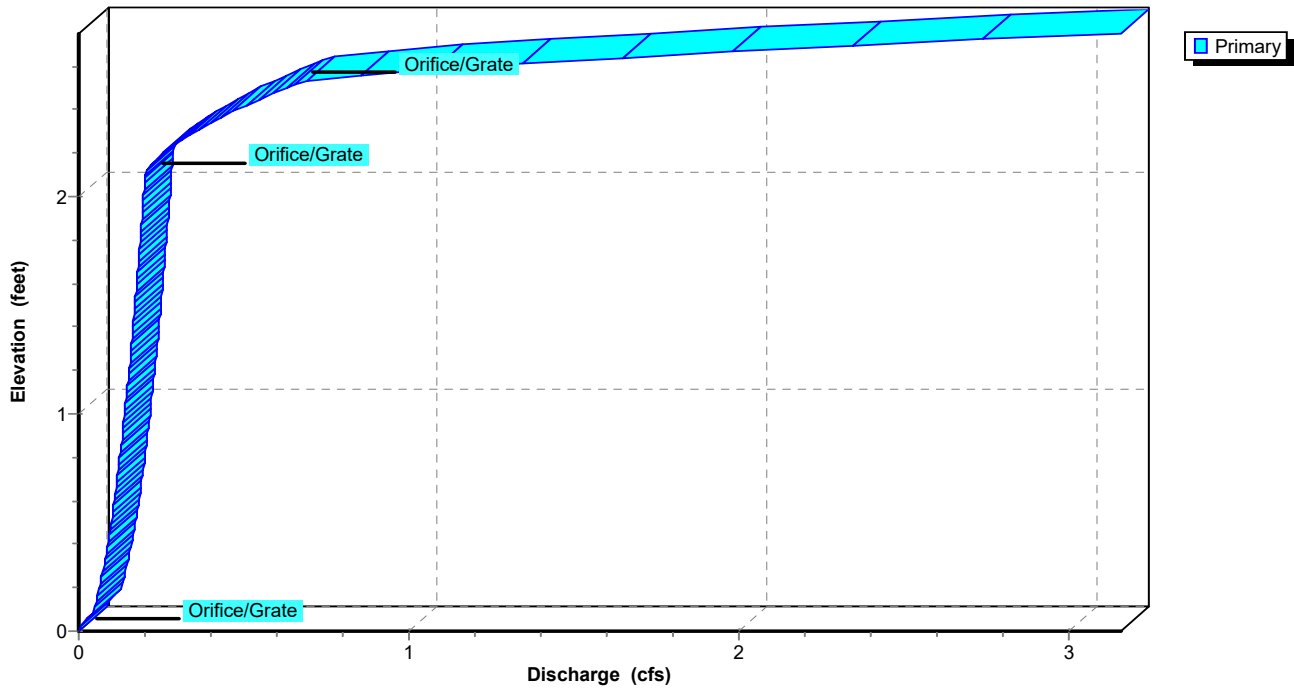
### Pond 6P: Detention B

Hydrograph

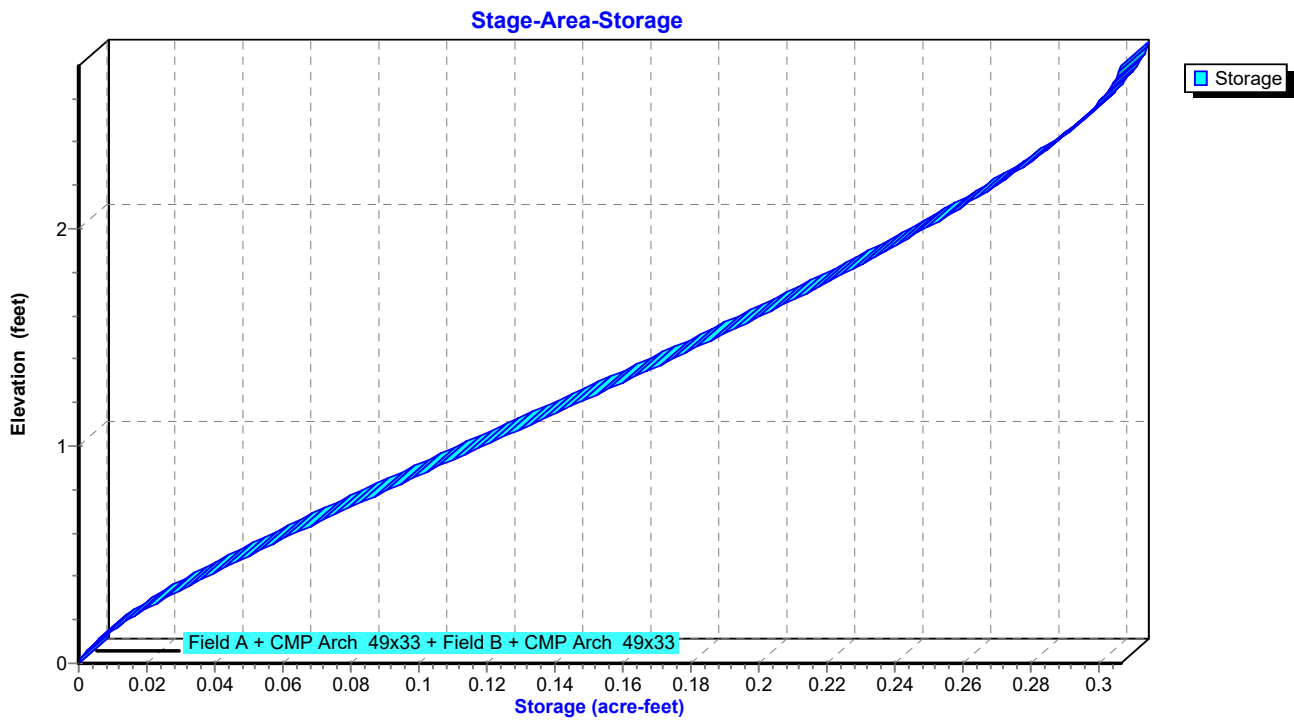


### Pond 6P: Detention B

Stage-Discharge



### Pond 6P: Detention B



**Summary for Subcatchment 1S: Predeveloped Basin A**

Runoff = 4.87 cfs @ 8.25 hrs, Volume= 2.160 af, Depth= 1.73"

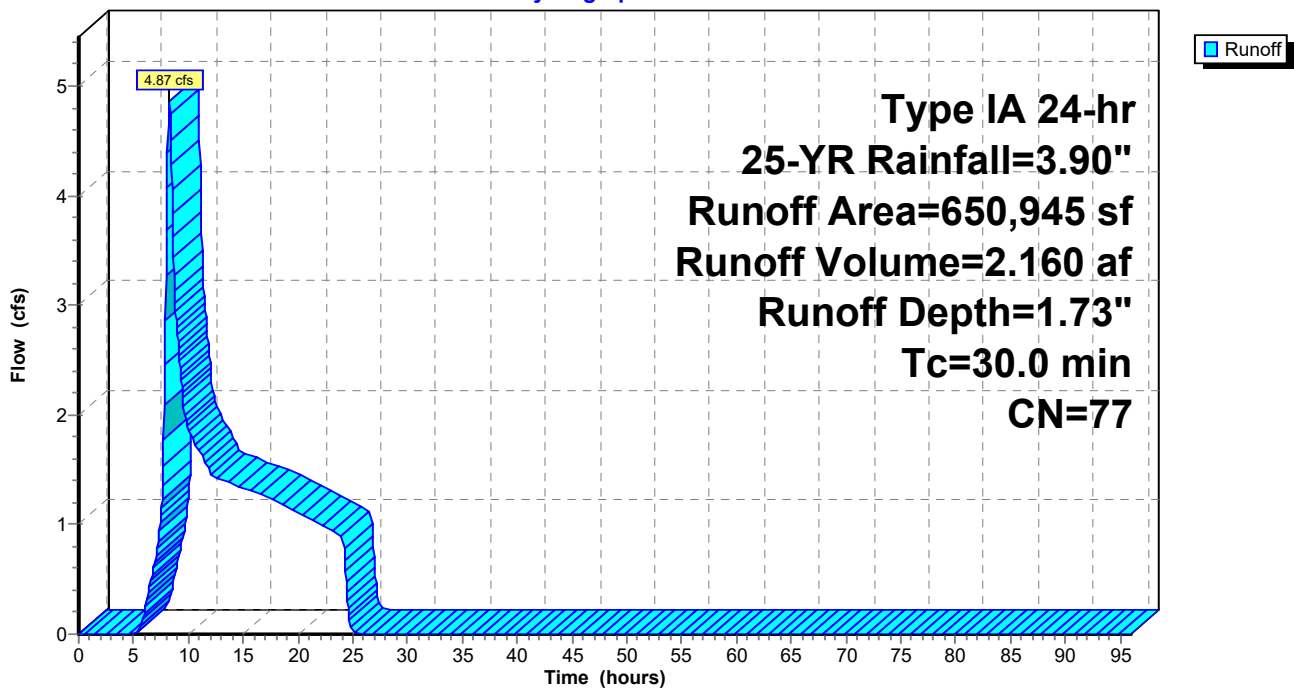
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
 Type IA 24-hr 25-YR Rainfall=3.90"

Area (sf)	CN	Description
* 650,945	77	>75% Grass cover, Good, HSG D
650,945		100.00% Pervious Area

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

**Subcatchment 1S: Predeveloped Basin A**

Hydrograph



**Summary for Subcatchment 2S: Developed Basin A**

Runoff = 13.91 cfs @ 7.86 hrs, Volume= 4.564 af, Depth= 3.67"

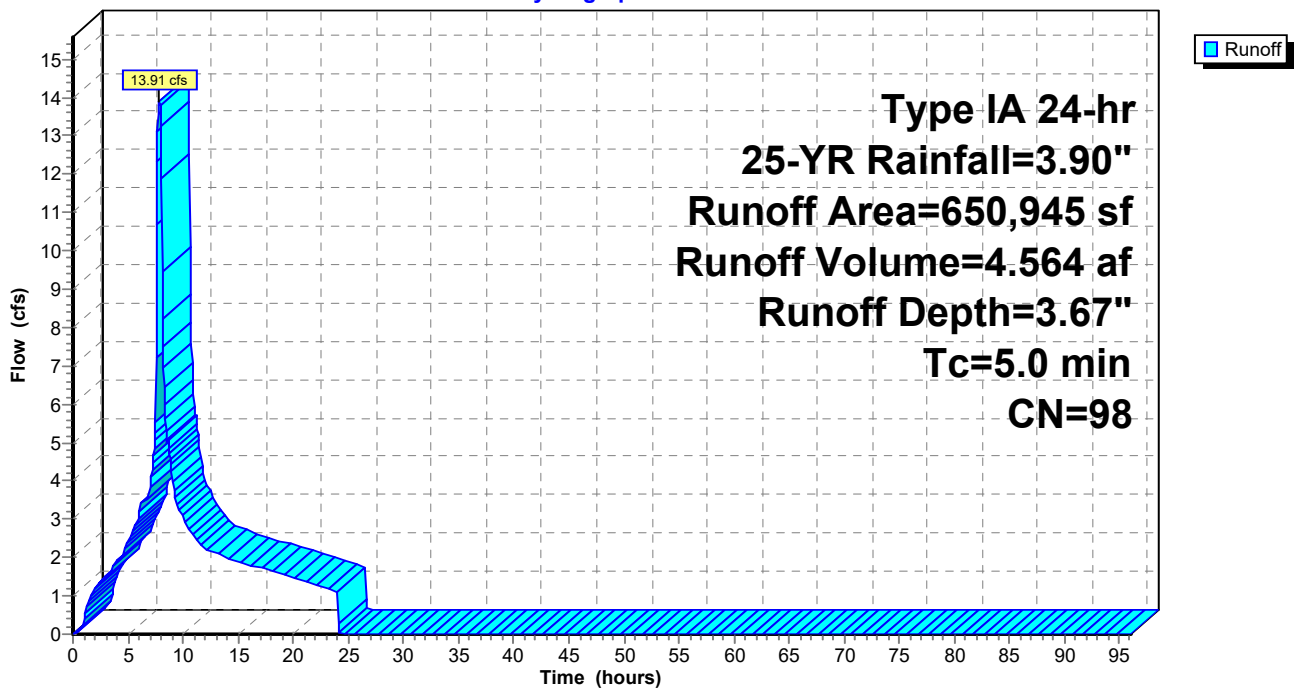
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
 Type IA 24-hr 25-YR Rainfall=3.90"

Area (sf)	CN	Description
* 650,945	98	
650,945		100.00% Impervious Area

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

**Subcatchment 2S: Developed Basin A**

Hydrograph



**Summary for Subcatchment 5S: Developed Basin B**

Runoff = 2.69 cfs @ 7.86 hrs, Volume= 0.884 af, Depth= 3.67"

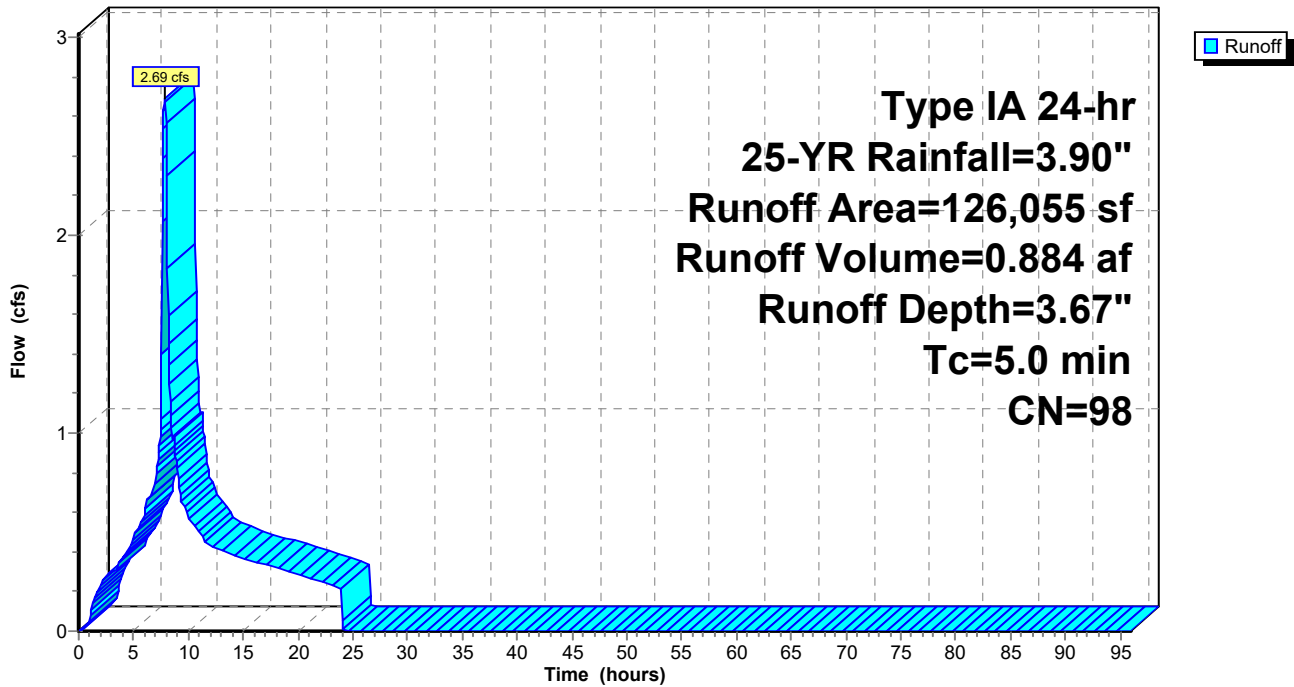
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
 Type IA 24-hr 25-YR Rainfall=3.90"

	Area (sf)	CN	Description
*	69,225	98	Concrete
*	56,830	98	Roof
	126,055	98	Weighted Average
	126,055		100.00% Impervious Area

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

**Subcatchment 5S: Developed Basin B**

Hydrograph



**Summary for Subcatchment 7S: Predeveloped Basin B**

Runoff = 1.14 cfs @ 7.90 hrs, Volume= 0.418 af, Depth= 1.73"

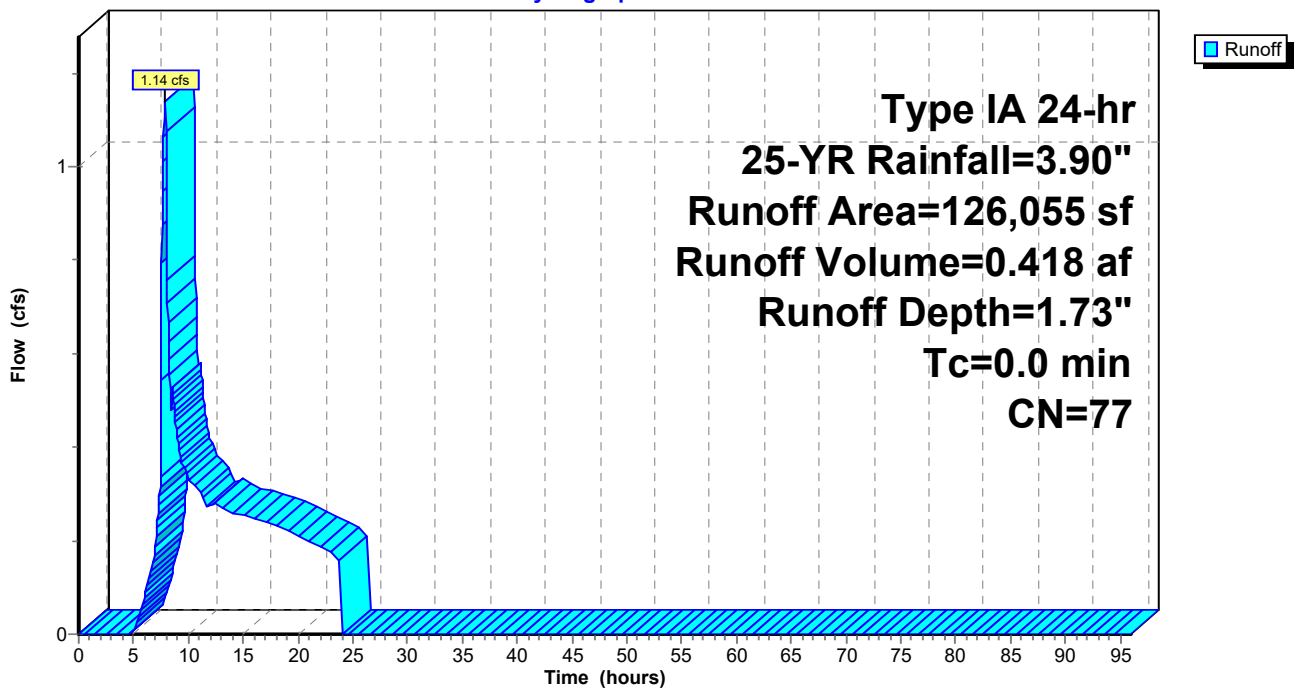
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
Type IA 24-hr 25-YR Rainfall=3.90"

Area (sf)	CN	Description
* 126,055	77	
126,055		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.0					Direct Entry, 20

**Subcatchment 7S: Predeveloped Basin B**

Hydrograph



**Summary for Pond 3P: Detention A**

Inflow Area = 14.944 ac, 100.00% Impervious, Inflow Depth = 3.67" for 25-YR event  
 Inflow = 13.91 cfs @ 7.86 hrs, Volume= 4.564 af  
 Outflow = 3.49 cfs @ 9.32 hrs, Volume= 4.564 af, Atten= 75%, Lag= 87.7 min  
 Primary = 3.49 cfs @ 9.32 hrs, Volume= 4.564 af

Routing by Stor-Ind method, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
 Peak Elev= 4.10' @ 9.32 hrs Surf.Area= 0.256 ac Storage= 1.907 af

Plug-Flow detention time= 849.9 min calculated for 4.562 af (100% of inflow)  
 Center-of-Mass det. time= 850.9 min ( 1,510.4 - 659.5 )

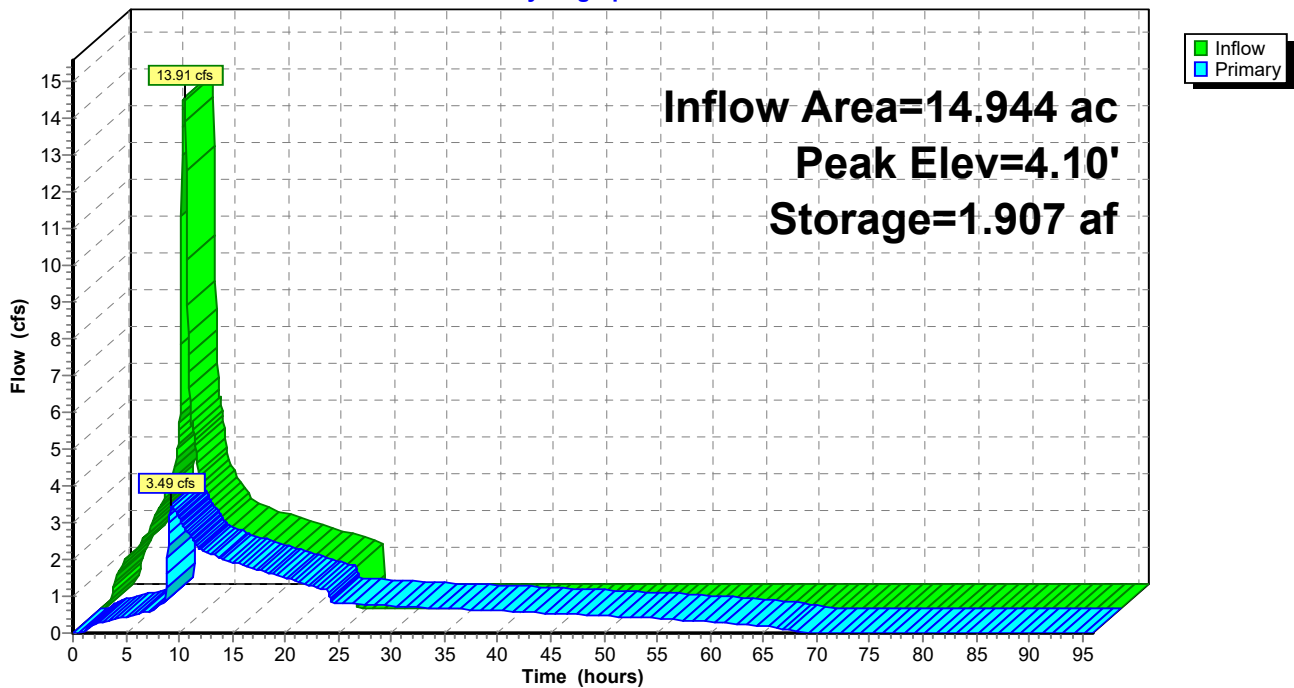
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	1.947 af	<b>52.0" Round Pipe Storage</b> L= 5,750.0'

Device	Routing	Invert	Outlet Devices
#1	Primary	0.00'	<b>4.0" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads
#2	Primary	3.85'	<b>24.0" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads

**Primary OutFlow** Max=3.48 cfs @ 9.32 hrs HW=4.10' (Free Discharge)  
 1=Orifice/Grate (Orifice Controls 0.85 cfs @ 9.75 fps)  
 2=Orifice/Grate (Weir Controls 2.63 cfs @ 1.65 fps)

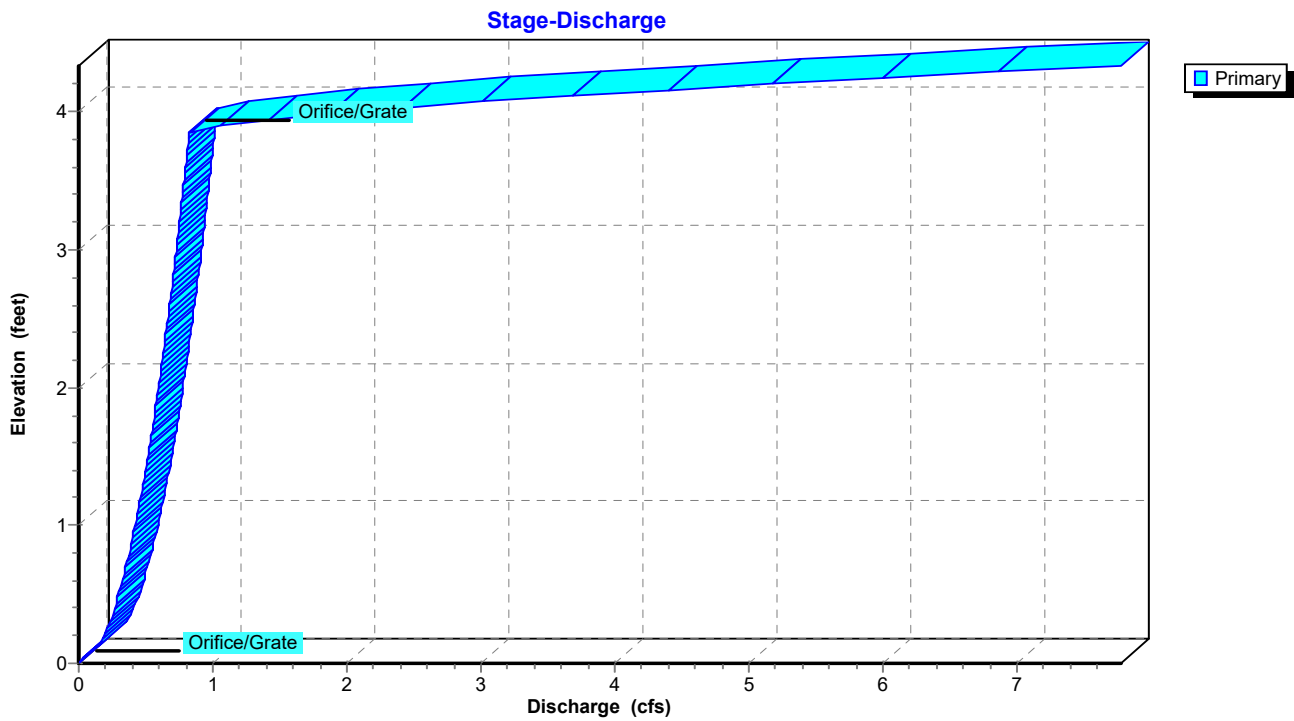
**Pond 3P: Detention A**

Hydrograph

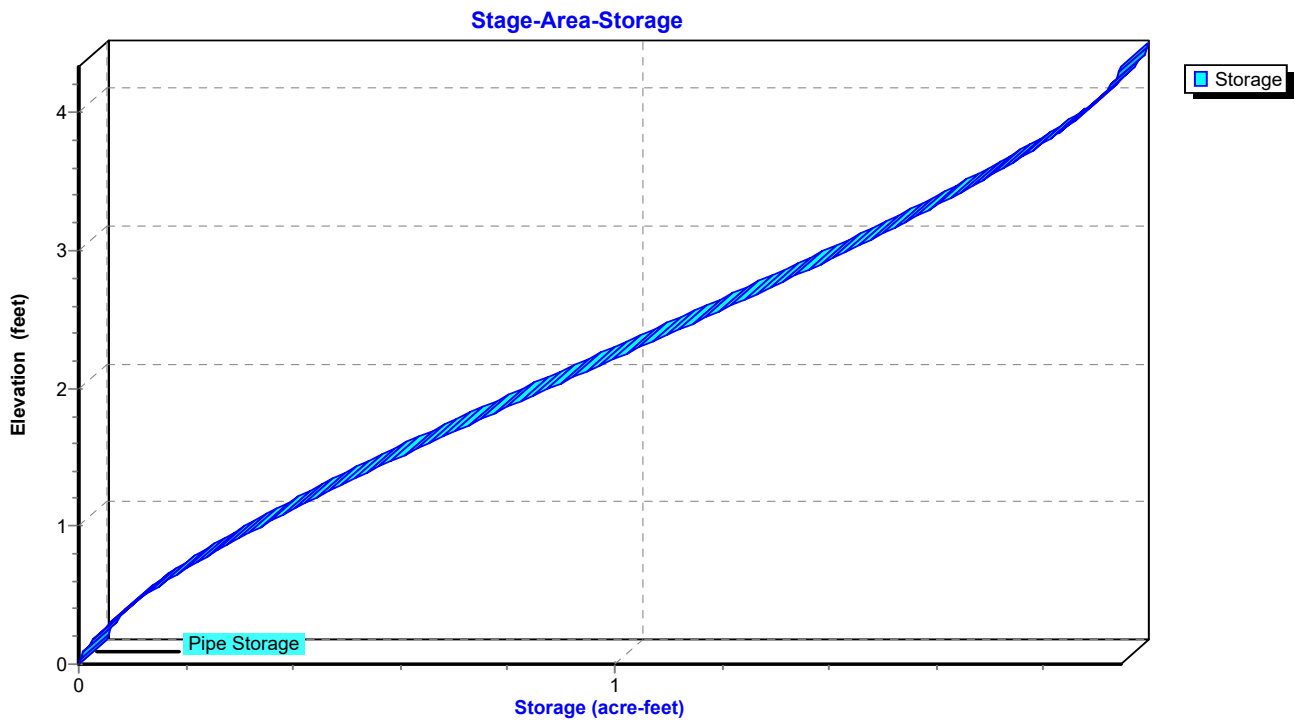




### Pond 3P: Detention A



### Pond 3P: Detention A



# Walgraves

Prepared by AAI Engineering

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Type IA 24-hr 25-YR Rainfall=3.90"

Printed 12/21/2021

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## Summary for Pond 6P: Detention B

Inflow Area = 2.894 ac, 100.00% Impervious, Inflow Depth = 3.67" for 25-YR event  
Inflow = 2.69 cfs @ 7.86 hrs, Volume= 0.884 af  
Outflow = 1.08 cfs @ 8.41 hrs, Volume= 0.884 af, Atten= 60%, Lag= 33.5 min  
Primary = 1.08 cfs @ 8.41 hrs, Volume= 0.884 af

Routing by Stor-Ind method, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
Peak Elev= 2.59' @ 8.41 hrs Surf.Area= 0.177 ac Storage= 0.300 af

Plug-Flow detention time= 528.9 min calculated for 0.883 af (100% of inflow)  
Center-of-Mass det. time= 529.5 min ( 1,189.0 - 659.5 )

Volume	Invert	Avail.Storage	Storage Description
#1A	0.00'	0.000 af	<b>20.41'W x 200.00'L x 2.75'H Field A</b> 0.258 af Overall - 0.163 af Embedded = 0.094 af x 0.0% Voids
#2A	0.00'	0.163 af	<b>CMP Arch 49x33 x 40 Inside #1</b> Effective Size= 49.0"W x 33.0"H => 8.90 sf x 20.00'L = 178.0 cf Overall Size= 49.0"W x 33.0"H x 20.00'L 40 Chambers in 4 Rows
#3B	0.00'	0.000 af	<b>25.85'W x 140.00'L x 2.75'H Field B</b> 0.228 af Overall - 0.143 af Embedded = 0.085 af x 0.0% Voids
#4B	0.00'	0.143 af	<b>CMP Arch 49x33 x 35 Inside #3</b> Effective Size= 49.0"W x 33.0"H => 8.90 sf x 20.00'L = 178.0 cf Overall Size= 49.0"W x 33.0"H x 20.00'L 35 Chambers in 5 Rows
		0.306 af	Total Available Storage

Storage Group A created with Chamber Wizard

Storage Group B created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	0.00'	<b>2.3" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads
#2	Primary	2.10'	<b>6.0" W x 5.0" H Vert. Orifice/Grate</b> C= 0.600
#3	Primary	2.52'	<b>24.0" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads

**Primary OutFlow** Max=1.07 cfs @ 8.41 hrs HW=2.58' (Free Discharge)

1=Orifice/Grate (Orifice Controls 0.22 cfs @ 7.74 fps)

2=Orifice/Grate (Orifice Controls 0.51 cfs @ 2.46 fps)

3=Orifice/Grate (Weir Controls 0.34 cfs @ 0.83 fps)

**Pond 6P: Detention B - Chamber Wizard Field A**

**Chamber Model = CMP Arch 49x33 (1/2" Corrugated Pipe Arch, AISI Handbook 1994, Table 2.18)**

Effective Size= 49.0"W x 33.0"H => 8.90 sf x 20.00'L = 178.0 cf

Overall Size= 49.0"W x 33.0"H x 20.00'L

49.0" Wide + 16.3" Spacing = 65.3" C-C Row Spacing

10 Chambers/Row x 20.00' Long = 200.00' Row Length

4 Rows x 49.0" Wide + 16.3" Spacing x 3 = 20.41' Base Width

33.0" Chamber Height = 2.75' Field Height

40 Chambers x 178.0 cf = 7,118.3 cf Chamber Storage

11,224.6 cf Field - 7,118.3 cf Chambers = 4,106.3 cf Stone x 0.0% Voids = 0.0 cf Stone Storage

Chamber Storage = 7,118.3 cf = 0.163 af

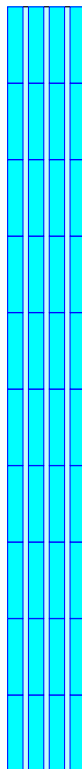
Overall Storage Efficiency = 63.4%

Overall System Size = 200.00' x 20.41' x 2.75'

40 Chambers

415.7 cy Field

152.1 cy Stone



**Pond 6P: Detention B - Chamber Wizard Field B**

**Chamber Model = CMP Arch 49x33 (1/2" Corrugated Pipe Arch, AISI Handbook 1994, Table 2.18)**

Effective Size= 49.0"W x 33.0"H => 8.90 sf x 20.00'L = 178.0 cf

Overall Size= 49.0"W x 33.0"H x 20.00'L

49.0" Wide + 16.3" Spacing = 65.3" C-C Row Spacing

7 Chambers/Row x 20.00' Long = 140.00' Row Length

5 Rows x 49.0" Wide + 16.3" Spacing x 4 = 25.85' Base Width

33.0" Chamber Height = 2.75' Field Height

35 Chambers x 178.0 cf = 6,228.5 cf Chamber Storage

9,952.3 cf Field - 6,228.5 cf Chambers = 3,723.8 cf Stone x 0.0% Voids = 0.0 cf Stone Storage

Chamber Storage = 6,228.5 cf = 0.143 af

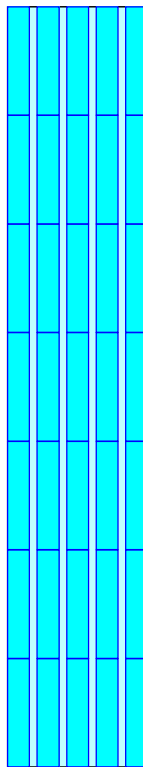
Overall Storage Efficiency = 62.6%

Overall System Size = 140.00' x 25.85' x 2.75'

35 Chambers

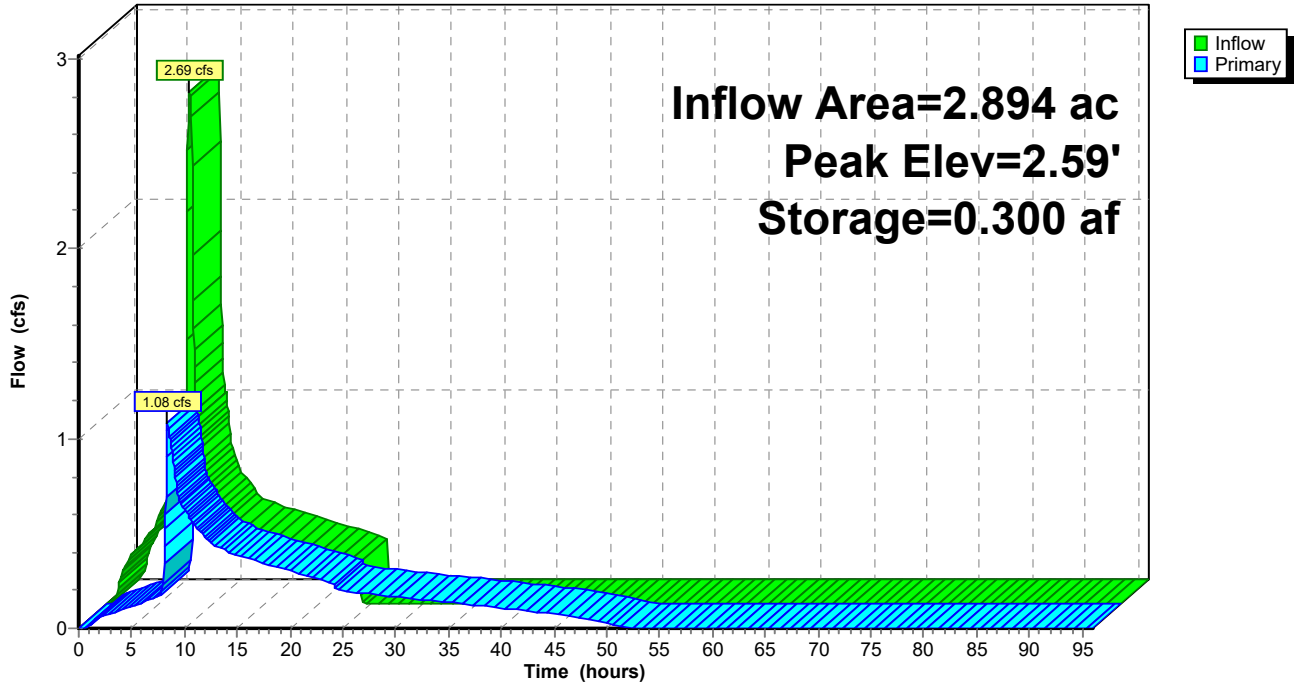
368.6 cy Field

137.9 cy Stone



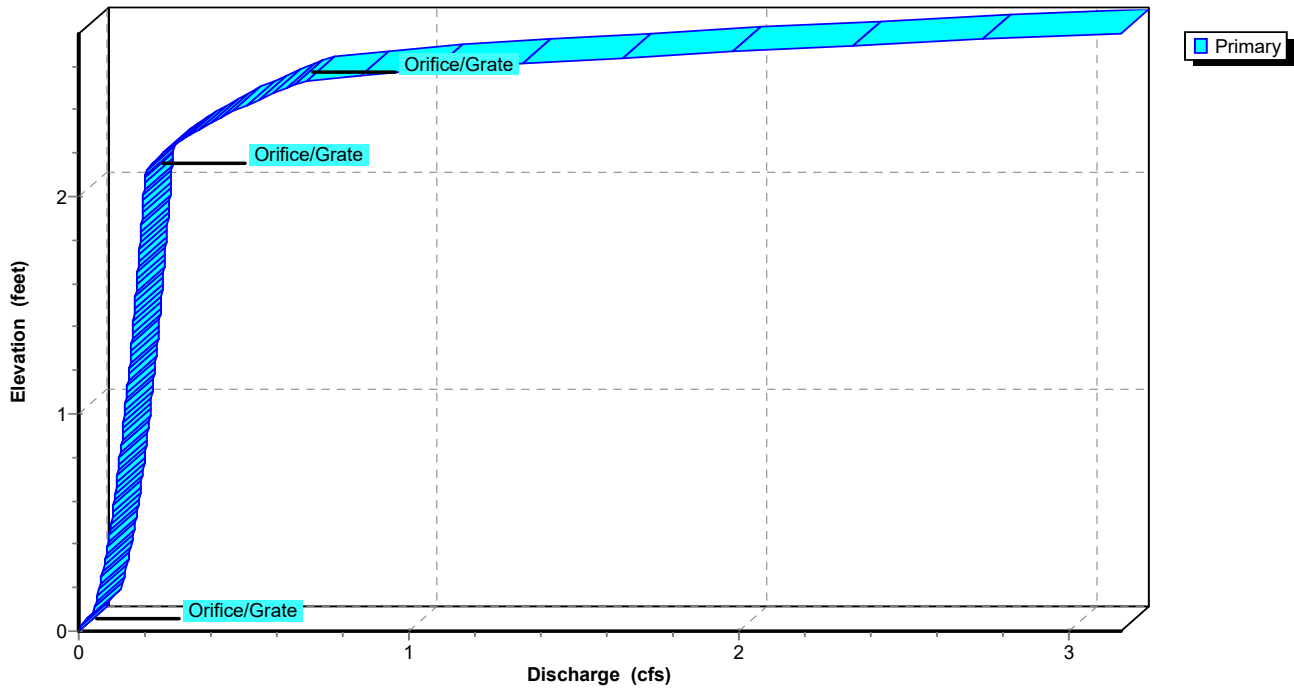
### Pond 6P: Detention B

Hydrograph



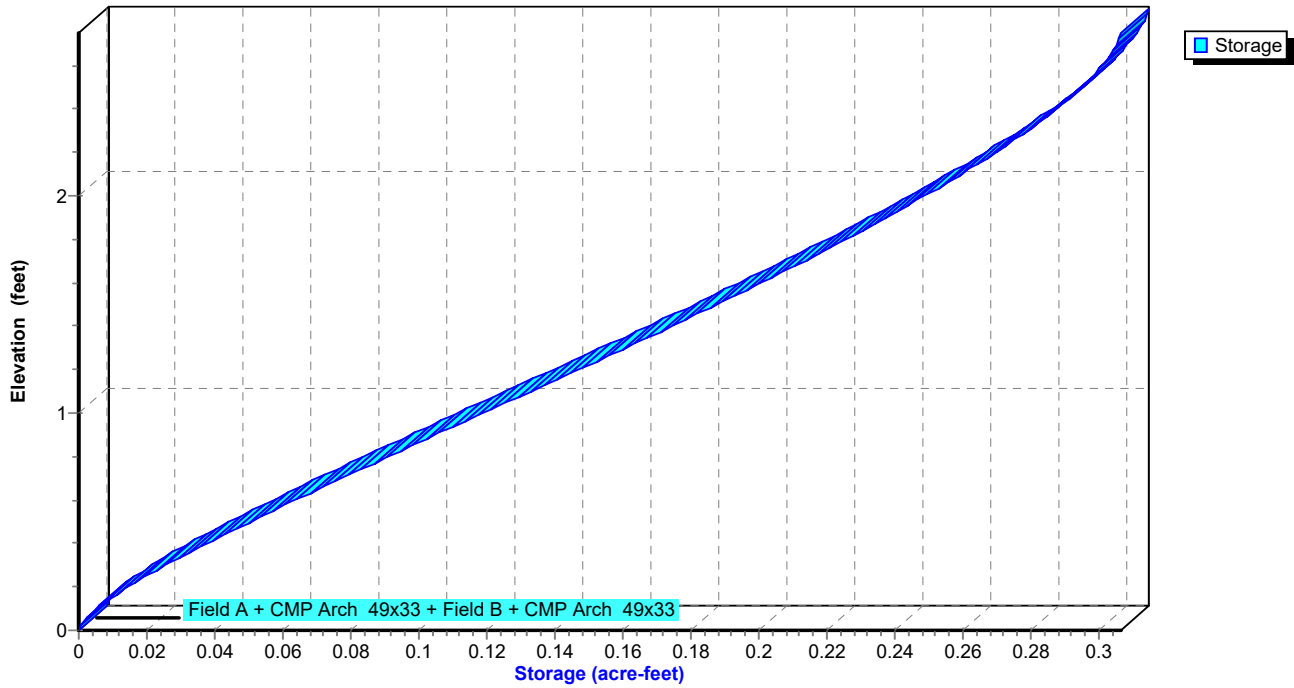
### Pond 6P: Detention B

Stage-Discharge



### Pond 6P: Detention B

Stage-Area-Storage



**Summary for Subcatchment 1S: Predeveloped Basin A**

Runoff = 6.51 cfs @ 8.24 hrs, Volume= 2.753 af, Depth= 2.21"

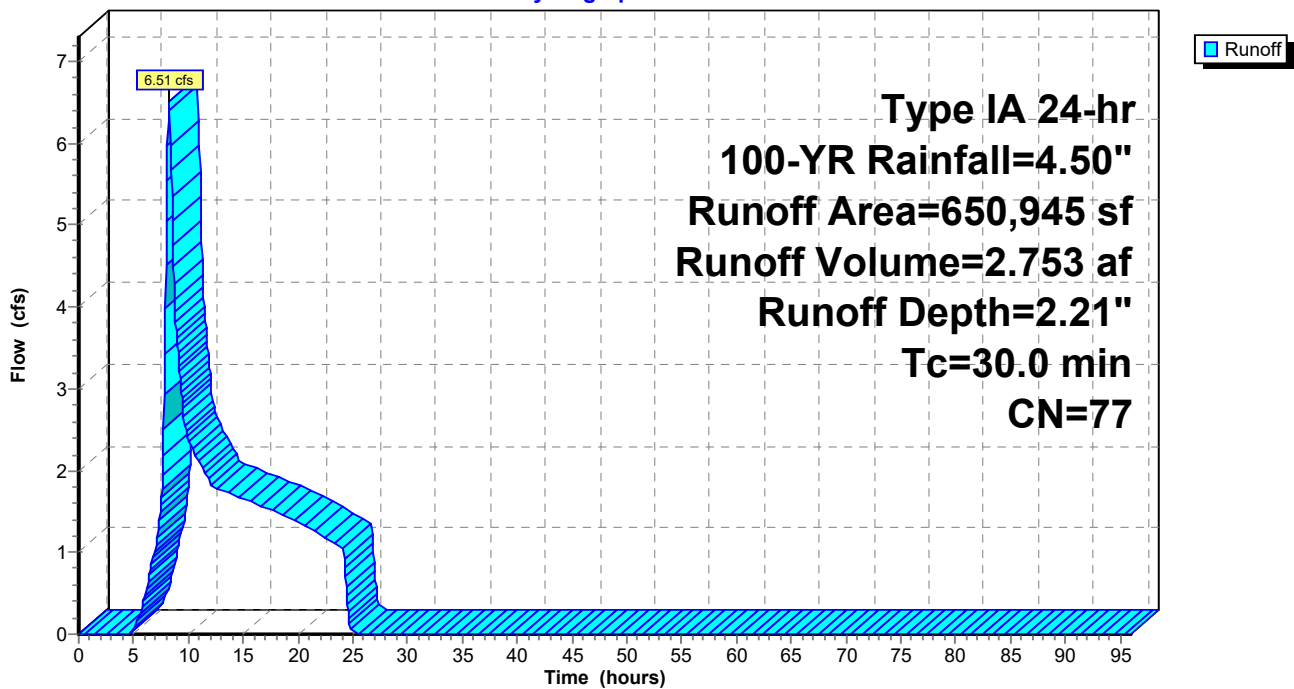
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
 Type IA 24-hr 100-YR Rainfall=4.50"

Area (sf)	CN	Description
* 650,945	77	>75% Grass cover, Good, HSG D
650,945		100.00% Pervious Area

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

**Subcatchment 1S: Predeveloped Basin A**

Hydrograph



**Summary for Subcatchment 2S: Developed Basin A**

Runoff = 16.11 cfs @ 7.85 hrs, Volume= 5.310 af, Depth= 4.26"

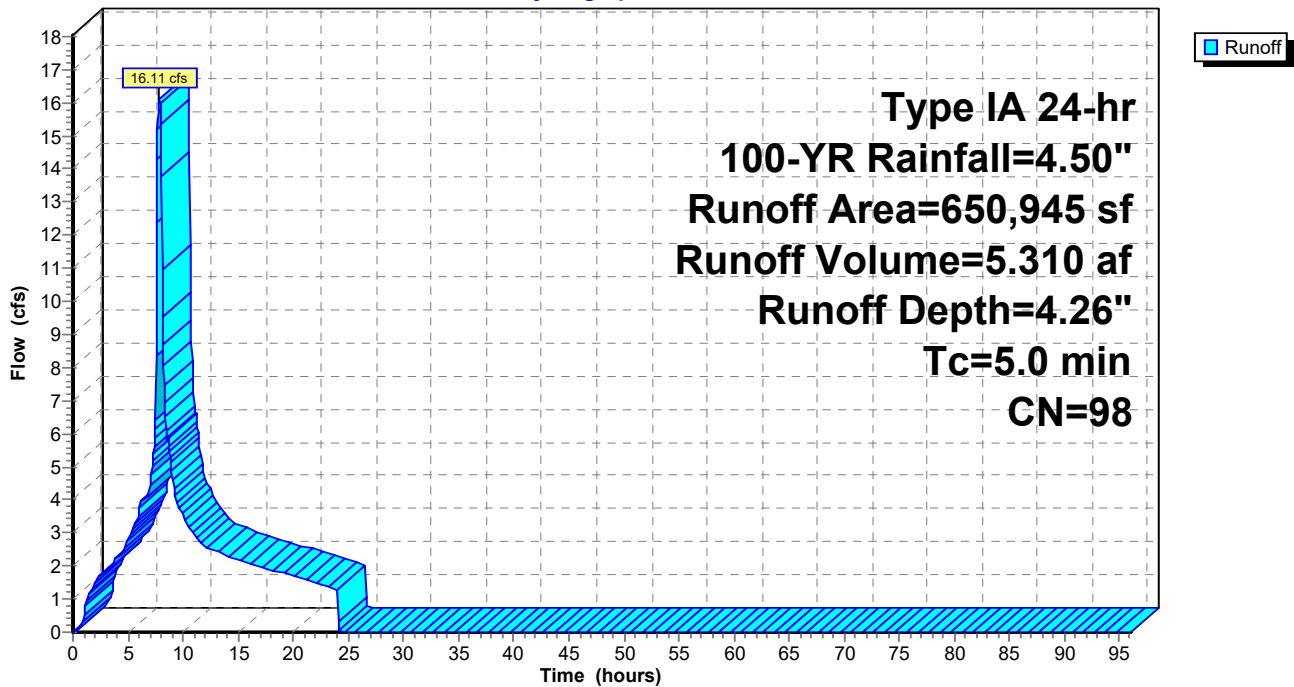
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
 Type IA 24-hr 100-YR Rainfall=4.50"

Area (sf)	CN	Description
* 650,945	98	
650,945		100.00% Impervious Area

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

**Subcatchment 2S: Developed Basin A**

Hydrograph





**Summary for Subcatchment 5S: Developed Basin B**

Runoff = 3.12 cfs @ 7.85 hrs, Volume= 1.028 af, Depth= 4.26"

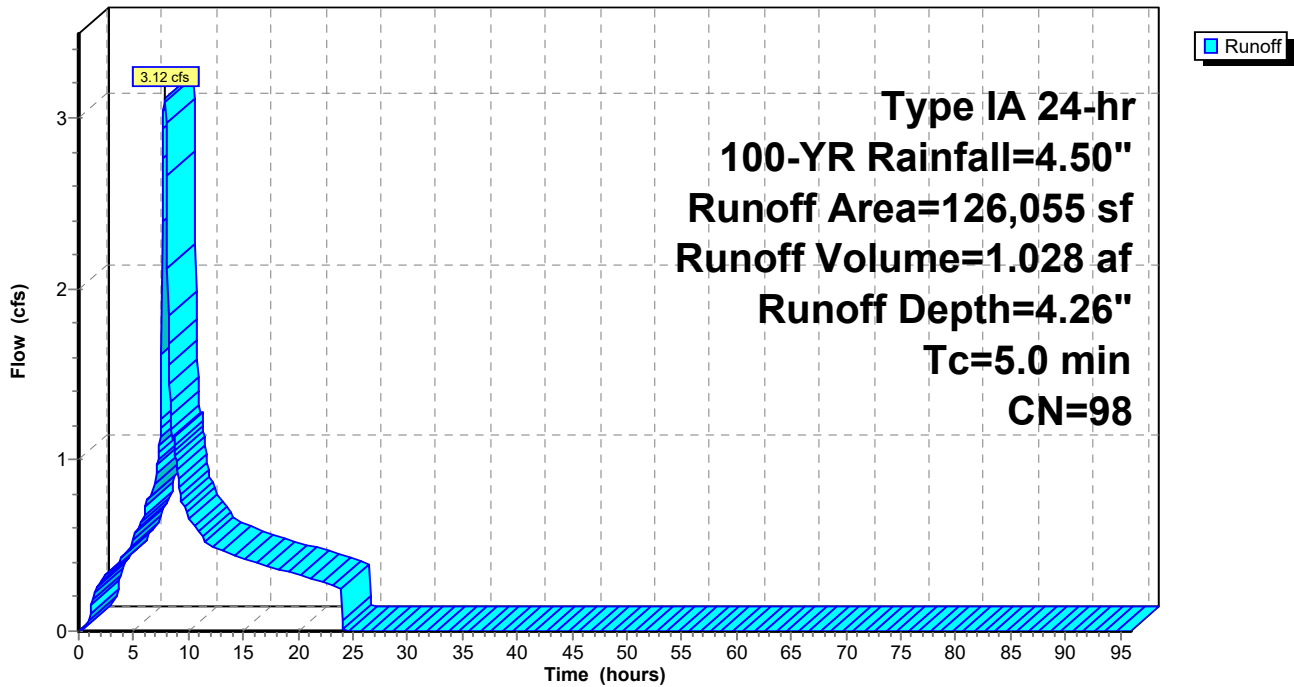
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
 Type IA 24-hr 100-YR Rainfall=4.50"

	Area (sf)	CN	Description
*	69,225	98	Concrete
*	56,830	98	Roof
	126,055	98	Weighted Average
	126,055		100.00% Impervious Area

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

**Subcatchment 5S: Developed Basin B**

Hydrograph



# Walgraves

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Type IA 24-hr 100-YR Rainfall=4.50"

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## Summary for Subcatchment 7S: Predeveloped Basin B

Runoff = 1.51 cfs @ 7.89 hrs, Volume= 0.533 af, Depth= 2.21"

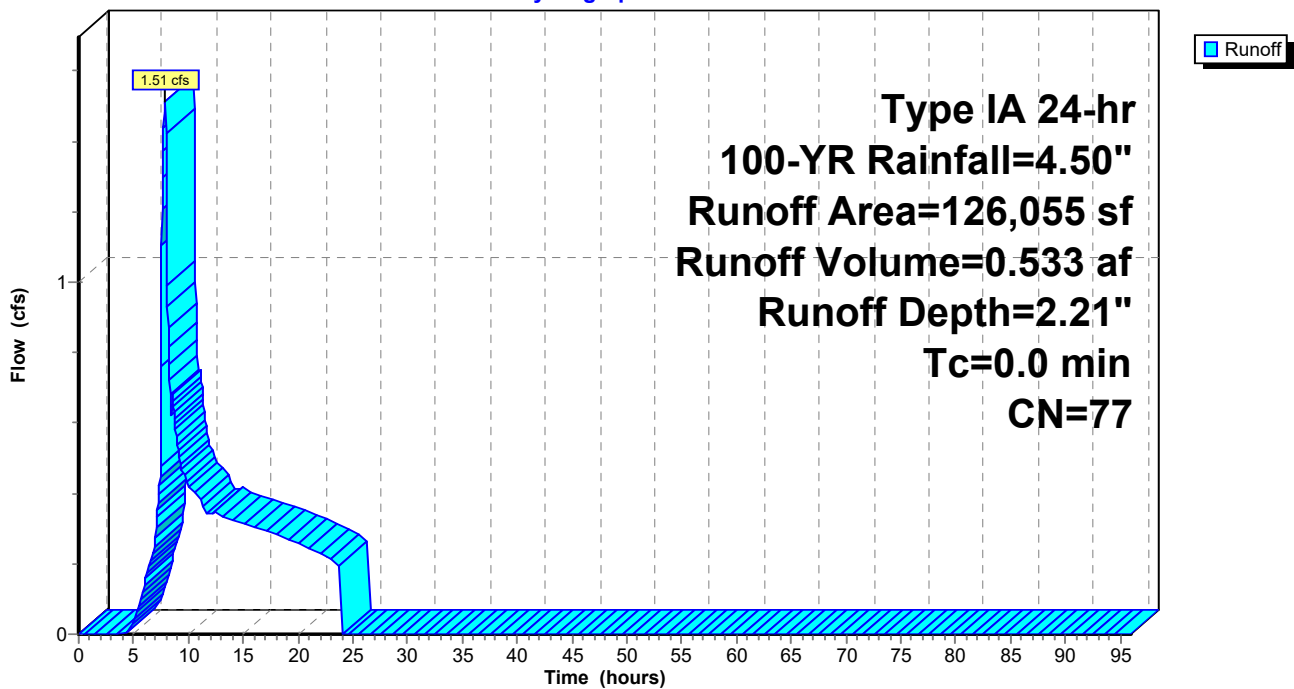
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
Type IA 24-hr 100-YR Rainfall=4.50"

Area (sf)	CN	Description
* 126,055	77	
126,055		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.0					Direct Entry, 20

## Subcatchment 7S: Predeveloped Basin B

Hydrograph



**Summary for Pond 3P: Detention A**

Inflow Area = 14.944 ac, 100.00% Impervious, Inflow Depth = 4.26" for 100-YR event  
 Inflow = 16.11 cfs @ 7.85 hrs, Volume= 5.310 af  
 Outflow = 6.59 cfs @ 8.40 hrs, Volume= 5.310 af, Atten= 59%, Lag= 32.6 min  
 Primary = 6.59 cfs @ 8.40 hrs, Volume= 5.310 af

Routing by Stor-Ind method, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
 Peak Elev= 4.28' @ 8.40 hrs Surf.Area= 0.131 ac Storage= 1.942 af

Plug-Flow detention time= 742.7 min calculated for 5.307 af (100% of inflow)  
 Center-of-Mass det. time= 743.7 min ( 1,399.9 - 656.2 )

Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	1.947 af	<b>52.0" Round Pipe Storage</b> L= 5,750.0'

Device	Routing	Invert	Outlet Devices
#1	Primary	0.00'	<b>4.0" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads
#2	Primary	3.85'	<b>24.0" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads

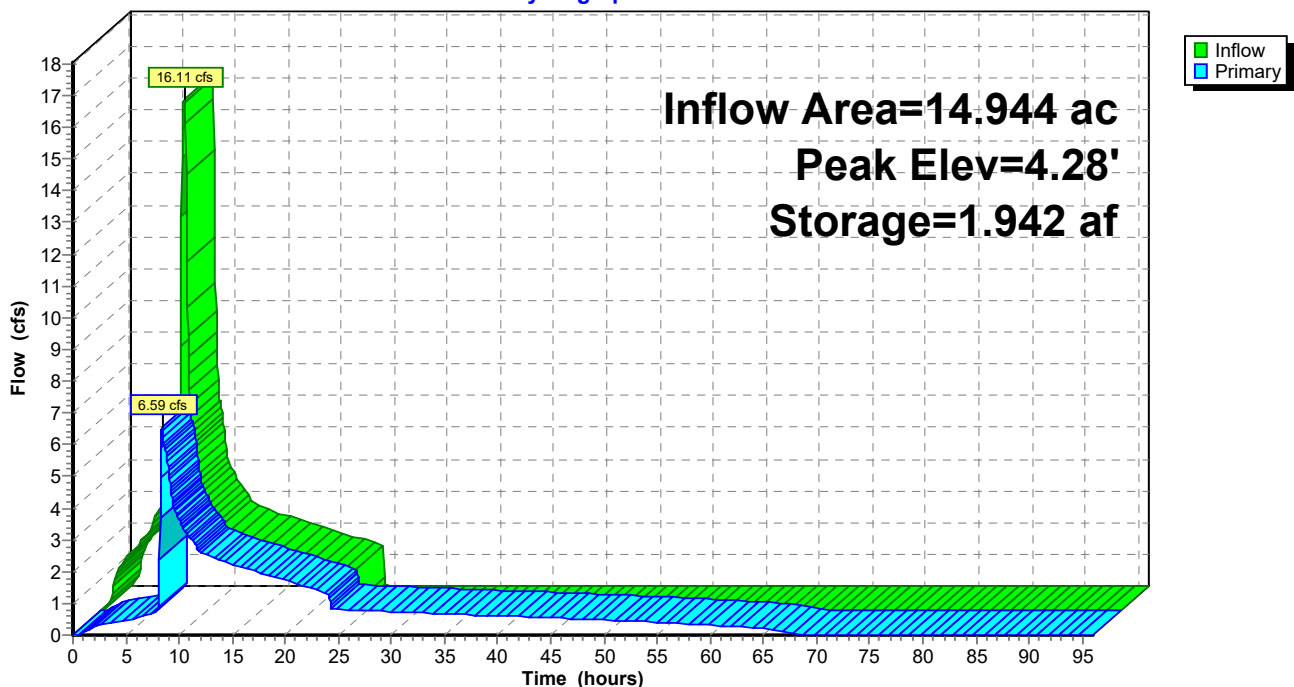
**Primary OutFlow** Max=6.58 cfs @ 8.40 hrs HW=4.28' (Free Discharge)

1=Orifice/Grate (Orifice Controls 0.87 cfs @ 9.96 fps)

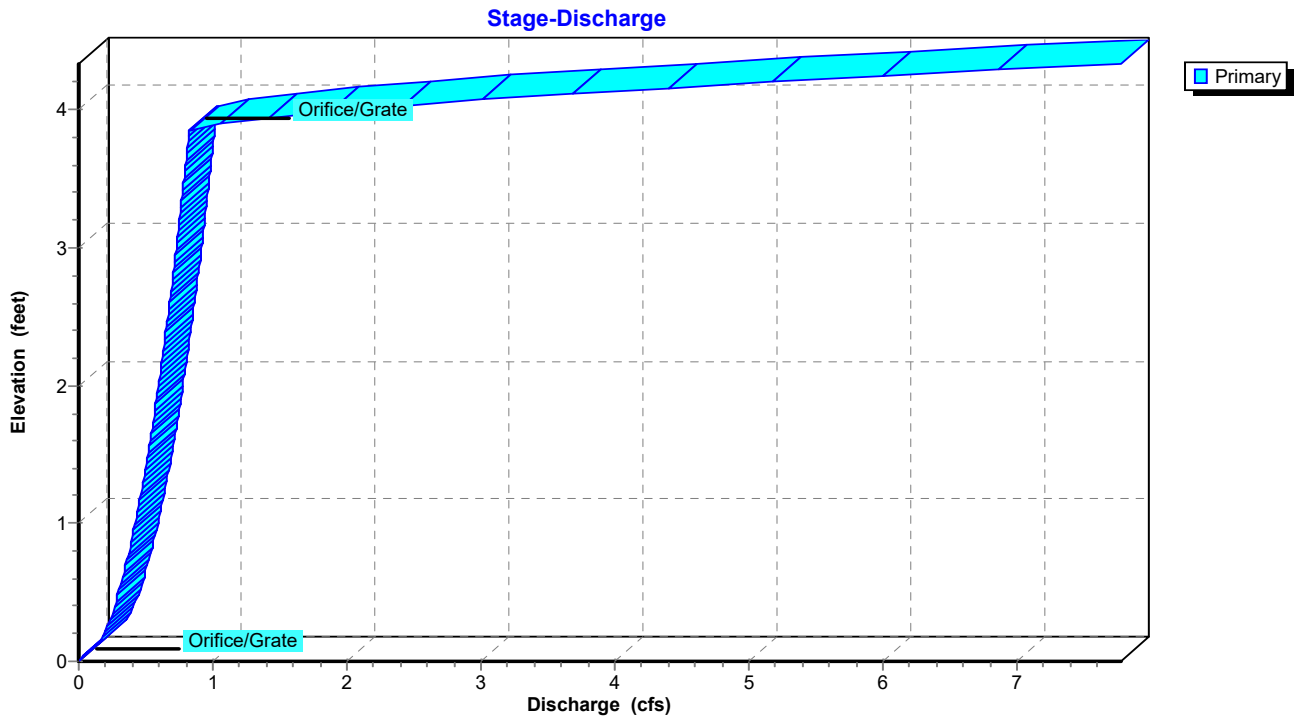
2=Orifice/Grate (Weir Controls 5.71 cfs @ 2.13 fps)

**Pond 3P: Detention A**

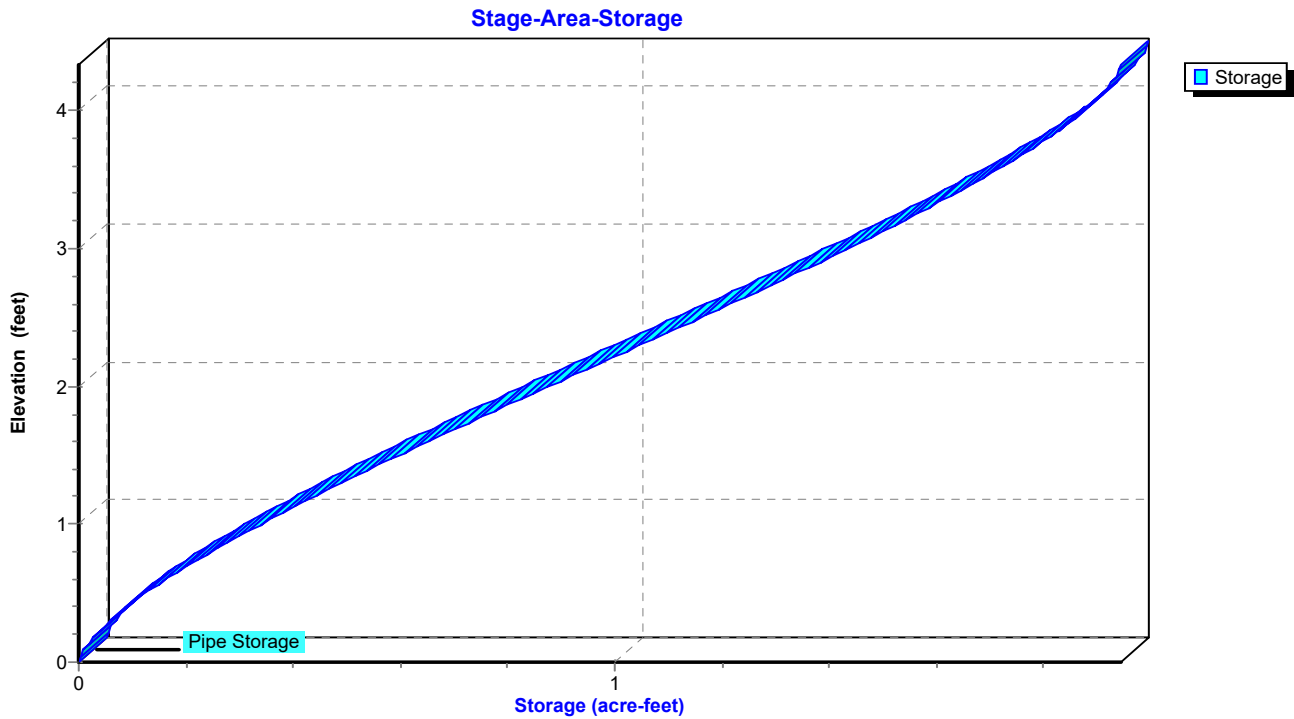
Hydrograph



### Pond 3P: Detention A



### Pond 3P: Detention A



# Walgraves

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Type IA 24-hr 100-YR Rainfall=4.50"

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## Summary for Pond 6P: Detention B

Inflow Area = 2.894 ac, 100.00% Impervious, Inflow Depth = 4.26" for 100-YR event  
Inflow = 3.12 cfs @ 7.85 hrs, Volume= 1.028 af  
Outflow = 3.02 cfs @ 8.02 hrs, Volume= 1.028 af, Atten= 3%, Lag= 9.9 min  
Primary = 3.02 cfs @ 8.02 hrs, Volume= 1.028 af

Routing by Stor-Ind method, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
Peak Elev= 2.74' @ 8.02 hrs Surf.Area= 0.177 ac Storage= 0.306 af

Plug-Flow detention time= 468.1 min calculated for 1.028 af (100% of inflow)  
Center-of-Mass det. time= 468.7 min ( 1,125.0 - 656.2 )

Volume	Invert	Avail.Storage	Storage Description
#1A	0.00'	0.000 af	<b>20.41'W x 200.00'L x 2.75'H Field A</b> 0.258 af Overall - 0.163 af Embedded = 0.094 af x 0.0% Voids
#2A	0.00'	0.163 af	<b>CMP Arch 49x33 x 40 Inside #1</b> Effective Size= 49.0"W x 33.0"H => 8.90 sf x 20.00'L = 178.0 cf Overall Size= 49.0"W x 33.0"H x 20.00'L 40 Chambers in 4 Rows
#3B	0.00'	0.000 af	<b>25.85'W x 140.00'L x 2.75'H Field B</b> 0.228 af Overall - 0.143 af Embedded = 0.085 af x 0.0% Voids
#4B	0.00'	0.143 af	<b>CMP Arch 49x33 x 35 Inside #3</b> Effective Size= 49.0"W x 33.0"H => 8.90 sf x 20.00'L = 178.0 cf Overall Size= 49.0"W x 33.0"H x 20.00'L 35 Chambers in 5 Rows
		0.306 af	Total Available Storage

Storage Group A created with Chamber Wizard

Storage Group B created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	0.00'	<b>2.3" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads
#2	Primary	2.10'	<b>6.0" W x 5.0" H Vert. Orifice/Grate</b> C= 0.600
#3	Primary	2.52'	<b>24.0" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads

**Primary OutFlow** Max=2.86 cfs @ 8.02 hrs HW=2.73' (Free Discharge)

1=Orifice/Grate (Orifice Controls 0.23 cfs @ 7.96 fps)

2=Orifice/Grate (Orifice Controls 0.65 cfs @ 3.10 fps)

3=Orifice/Grate (Weir Controls 1.99 cfs @ 1.50 fps)

**Pond 6P: Detention B - Chamber Wizard Field A**

**Chamber Model = CMP Arch 49x33 (1/2" Corrugated Pipe Arch, AISI Handbook 1994, Table 2.18)**

Effective Size= 49.0"W x 33.0"H => 8.90 sf x 20.00'L = 178.0 cf

Overall Size= 49.0"W x 33.0"H x 20.00'L

49.0" Wide + 16.3" Spacing = 65.3" C-C Row Spacing

10 Chambers/Row x 20.00' Long = 200.00' Row Length

4 Rows x 49.0" Wide + 16.3" Spacing x 3 = 20.41' Base Width

33.0" Chamber Height = 2.75' Field Height

40 Chambers x 178.0 cf = 7,118.3 cf Chamber Storage

11,224.6 cf Field - 7,118.3 cf Chambers = 4,106.3 cf Stone x 0.0% Voids = 0.0 cf Stone Storage

Chamber Storage = 7,118.3 cf = 0.163 af

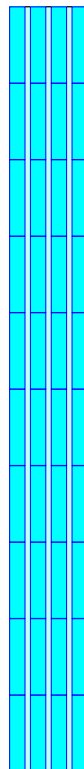
Overall Storage Efficiency = 63.4%

Overall System Size = 200.00' x 20.41' x 2.75'

40 Chambers

415.7 cy Field

152.1 cy Stone



**Pond 6P: Detention B - Chamber Wizard Field B**

**Chamber Model = CMP Arch 49x33 (1/2" Corrugated Pipe Arch, AISI Handbook 1994, Table 2.18)**

Effective Size= 49.0"W x 33.0"H => 8.90 sf x 20.00'L = 178.0 cf

Overall Size= 49.0"W x 33.0"H x 20.00'L

49.0" Wide + 16.3" Spacing = 65.3" C-C Row Spacing

7 Chambers/Row x 20.00' Long = 140.00' Row Length

5 Rows x 49.0" Wide + 16.3" Spacing x 4 = 25.85' Base Width

33.0" Chamber Height = 2.75' Field Height

35 Chambers x 178.0 cf = 6,228.5 cf Chamber Storage

9,952.3 cf Field - 6,228.5 cf Chambers = 3,723.8 cf Stone x 0.0% Voids = 0.0 cf Stone Storage

Chamber Storage = 6,228.5 cf = 0.143 af

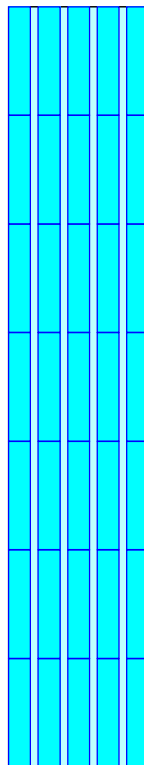
Overall Storage Efficiency = 62.6%

Overall System Size = 140.00' x 25.85' x 2.75'

35 Chambers

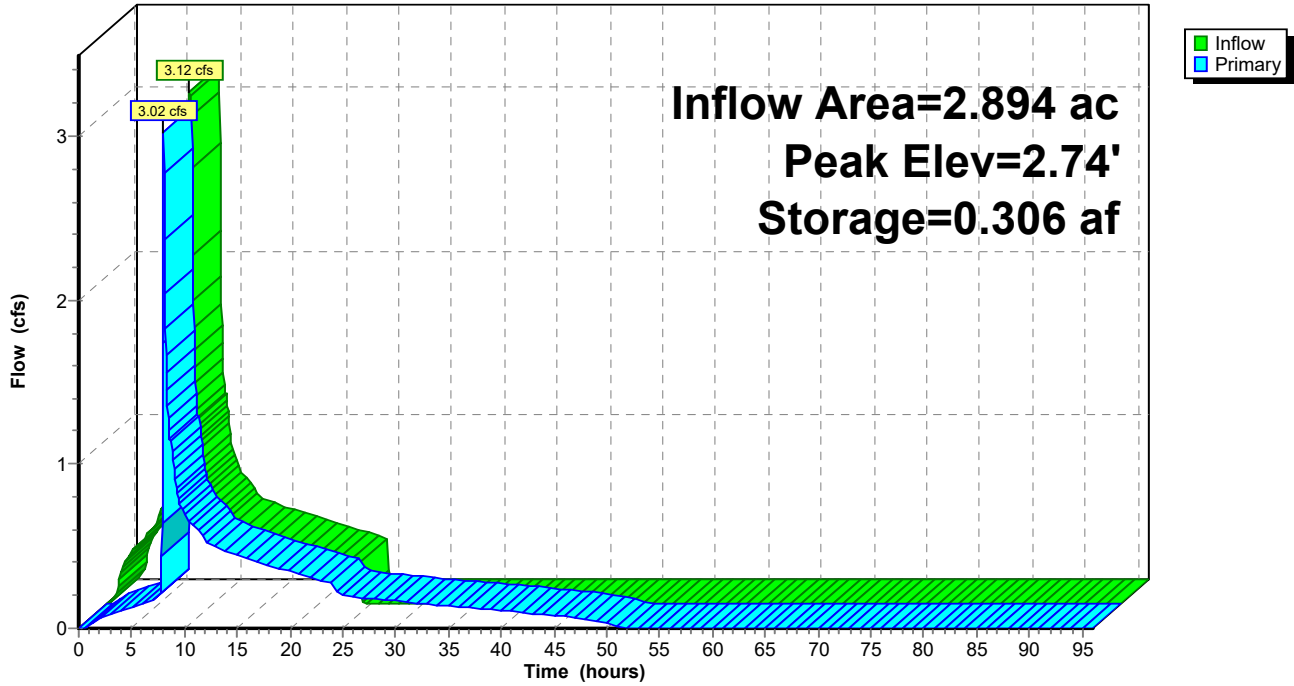
368.6 cy Field

137.9 cy Stone



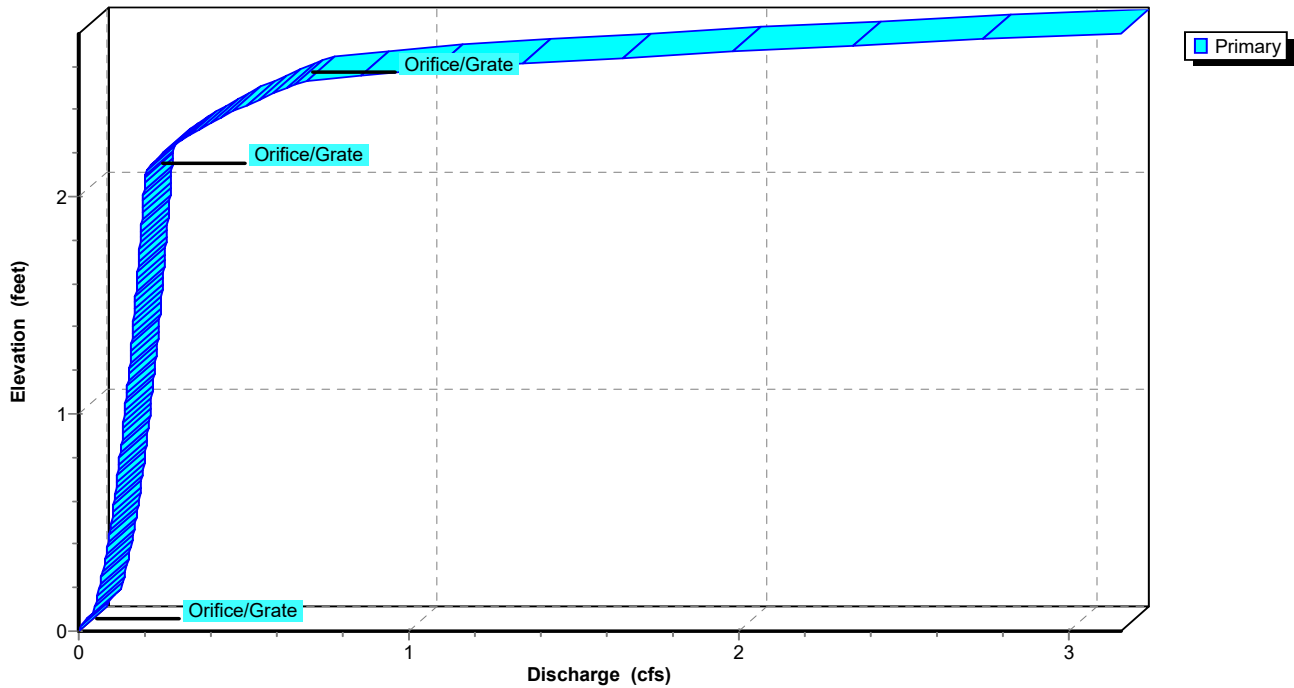
### Pond 6P: Detention B

Hydrograph



### Pond 6P: Detention B

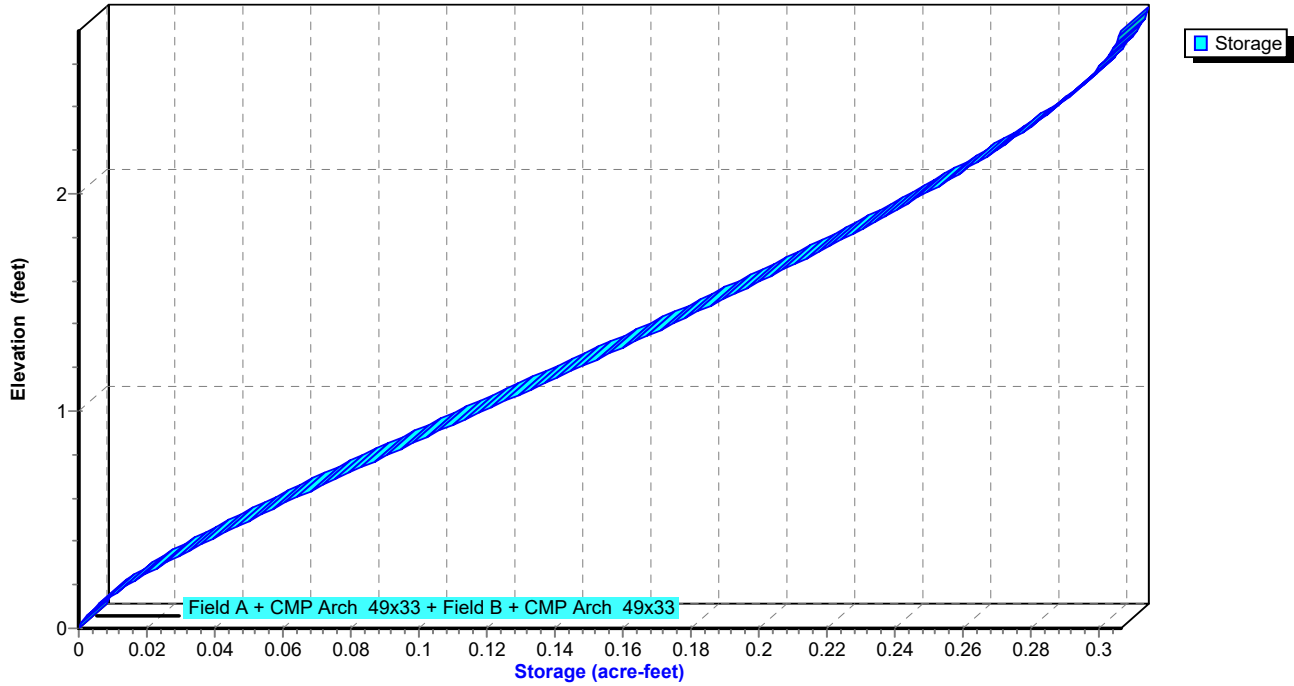
Stage-Discharge





### Pond 6P: Detention B

Stage-Area-Storage



# Walgraves

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Type IA 24-hr WQ Rainfall=0.36"

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## Summary for Subcatchment 1S: Predeveloped Basin A

Runoff = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Depth= 0.00"

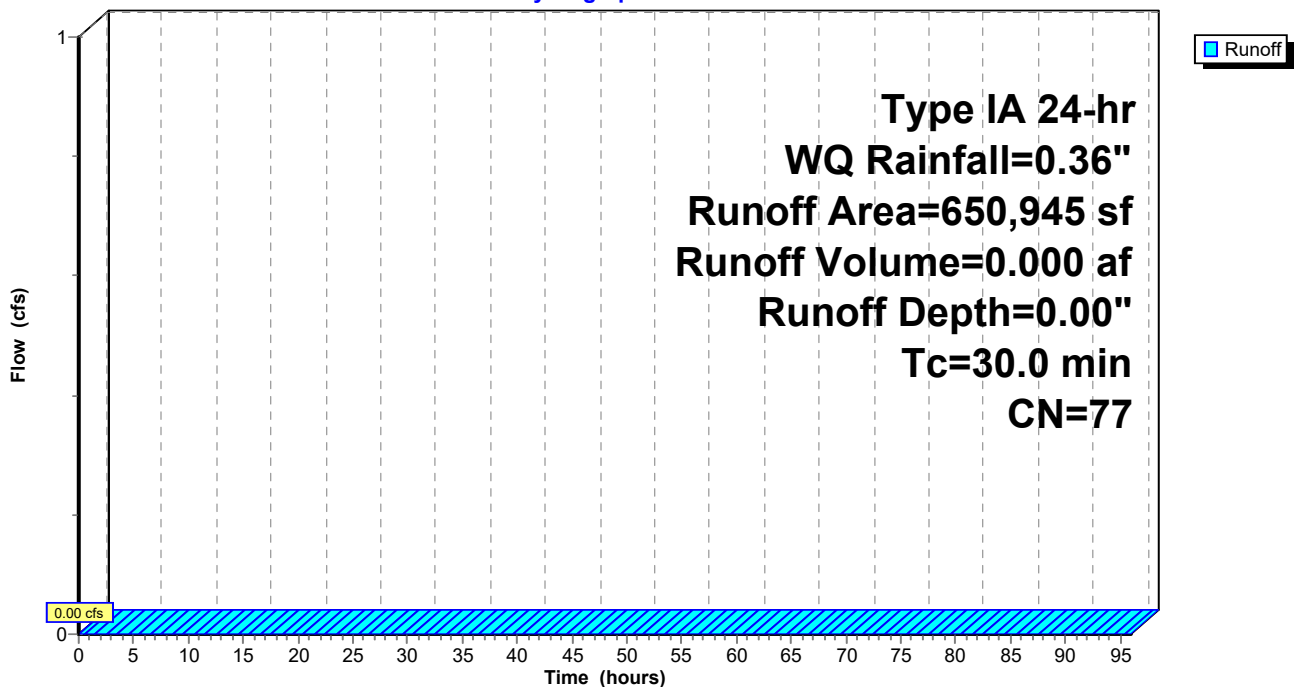
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
Type IA 24-hr WQ Rainfall=0.36"

Area (sf)	CN	Description
* 650,945	77	>75% Grass cover, Good, HSG D
650,945		100.00% Pervious Area

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

## Subcatchment 1S: Predeveloped Basin A

Hydrograph



**Summary for Subcatchment 2S: Developed Basin A**

Runoff = 0.71 cfs @ 7.95 hrs, Volume= 0.242 af, Depth= 0.19"

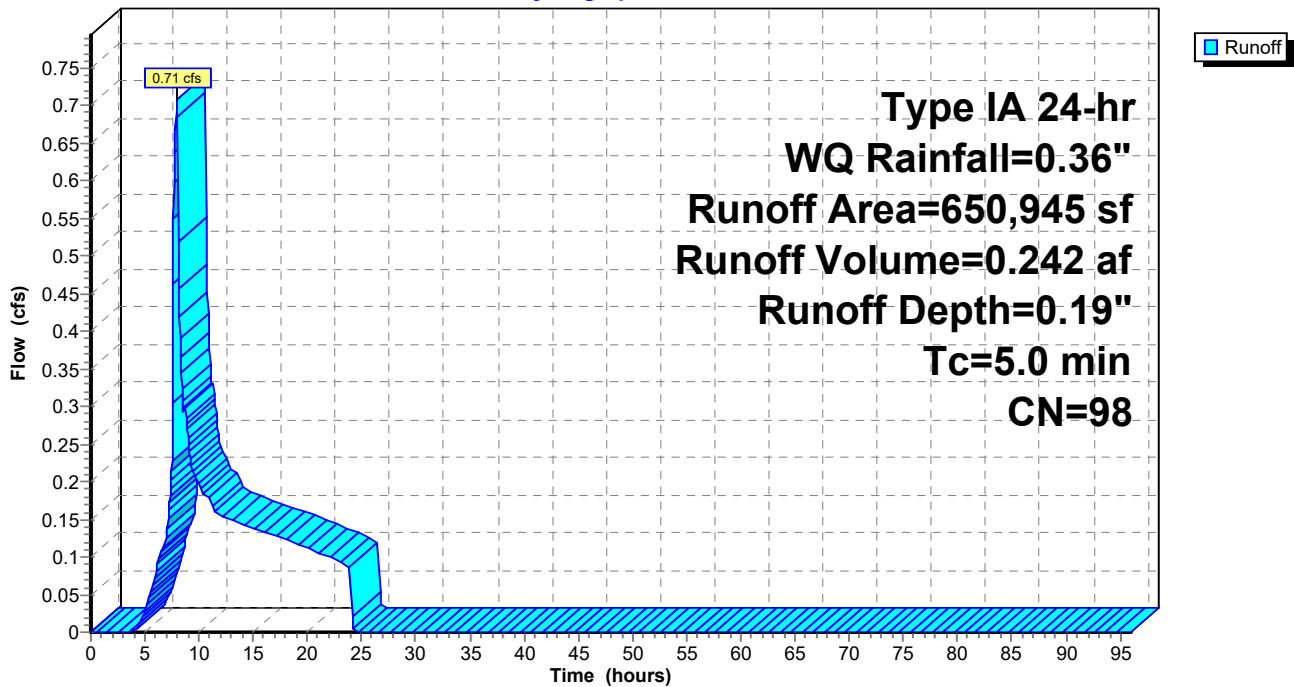
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
Type IA 24-hr WQ Rainfall=0.36"

Area (sf)	CN	Description
* 650,945	98	
650,945		100.00% Impervious Area

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

**Subcatchment 2S: Developed Basin A**

Hydrograph



**Summary for Subcatchment 5S: Developed Basin B**

Runoff = 0.14 cfs @ 7.95 hrs, Volume= 0.047 af, Depth= 0.19"

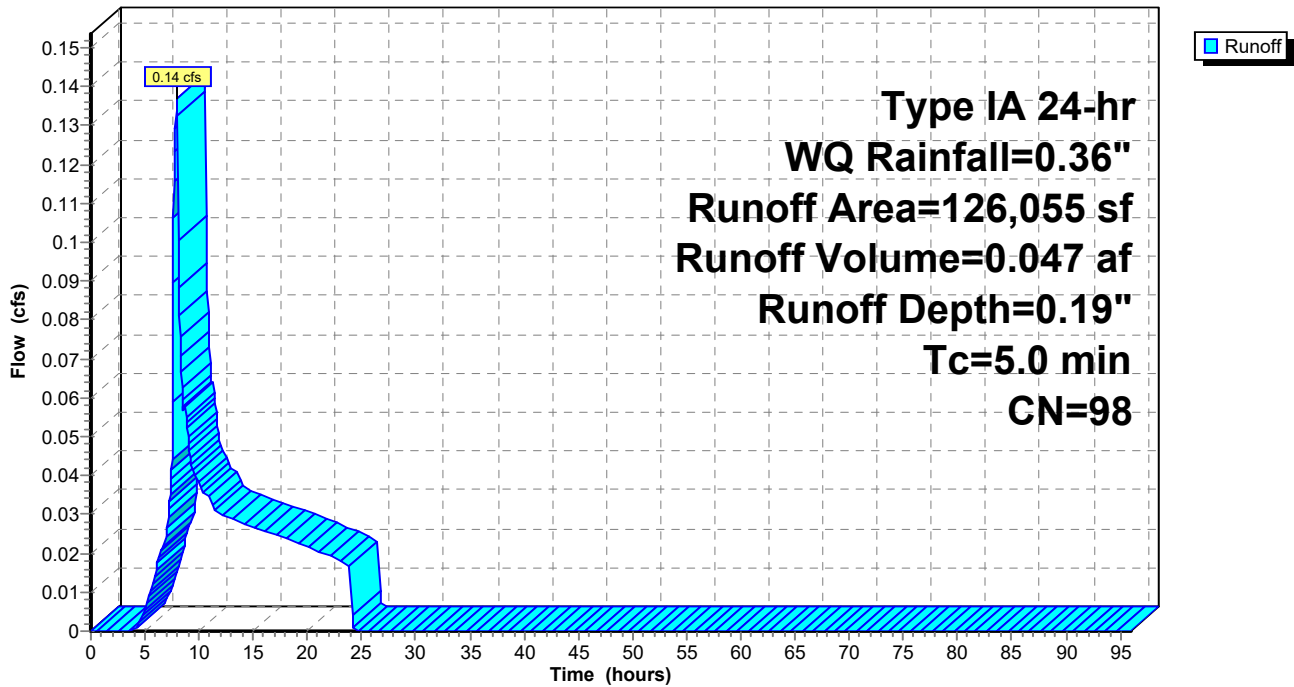
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
Type IA 24-hr WQ Rainfall=0.36"

	Area (sf)	CN	Description
*	69,225	98	Concrete
*	56,830	98	Roof
	126,055	98	Weighted Average
	126,055		100.00% Impervious Area

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

**Subcatchment 5S: Developed Basin B**

Hydrograph



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Type IA 24-hr WQ Rainfall=0.36"

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## Summary for Subcatchment 7S: Predeveloped Basin B

Runoff = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Depth= 0.00"

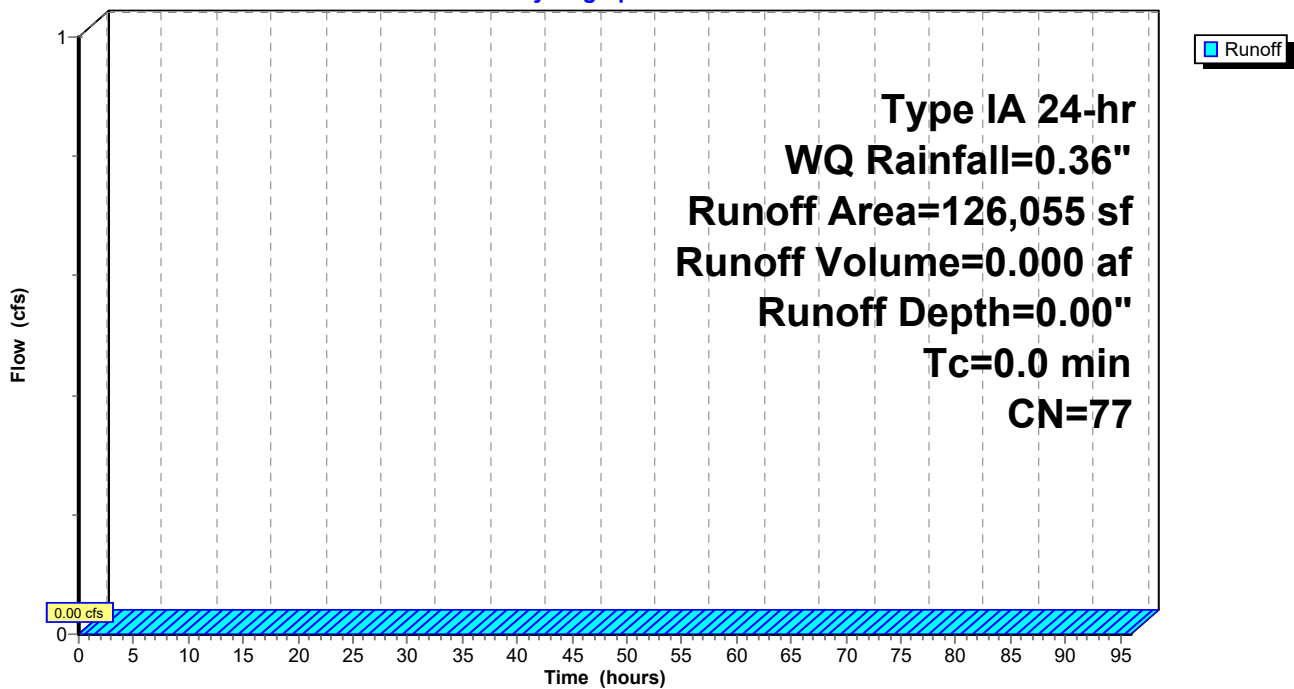
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
Type IA 24-hr WQ Rainfall=0.36"

Area (sf)	CN	Description
* 126,055	77	
126,055		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.0					Direct Entry, 20

## Subcatchment 7S: Predeveloped Basin B

Hydrograph



**Summary for Pond 3P: Detention A**

Inflow Area = 14.944 ac, 100.00% Impervious, Inflow Depth = 0.19" for WQ event  
 Inflow = 0.71 cfs @ 7.95 hrs, Volume= 0.242 af  
 Outflow = 0.21 cfs @ 9.69 hrs, Volume= 0.242 af, Atten= 71%, Lag= 104.4 min  
 Primary = 0.21 cfs @ 9.69 hrs, Volume= 0.242 af

Routing by Stor-Ind method, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
 Peak Elev= 0.24' @ 9.69 hrs Surf.Area= 0.263 ac Storage= 0.043 af

Plug-Flow detention time= 110.3 min calculated for 0.242 af (100% of inflow)  
 Center-of-Mass det. time= 110.5 min ( 897.8 - 787.3 )

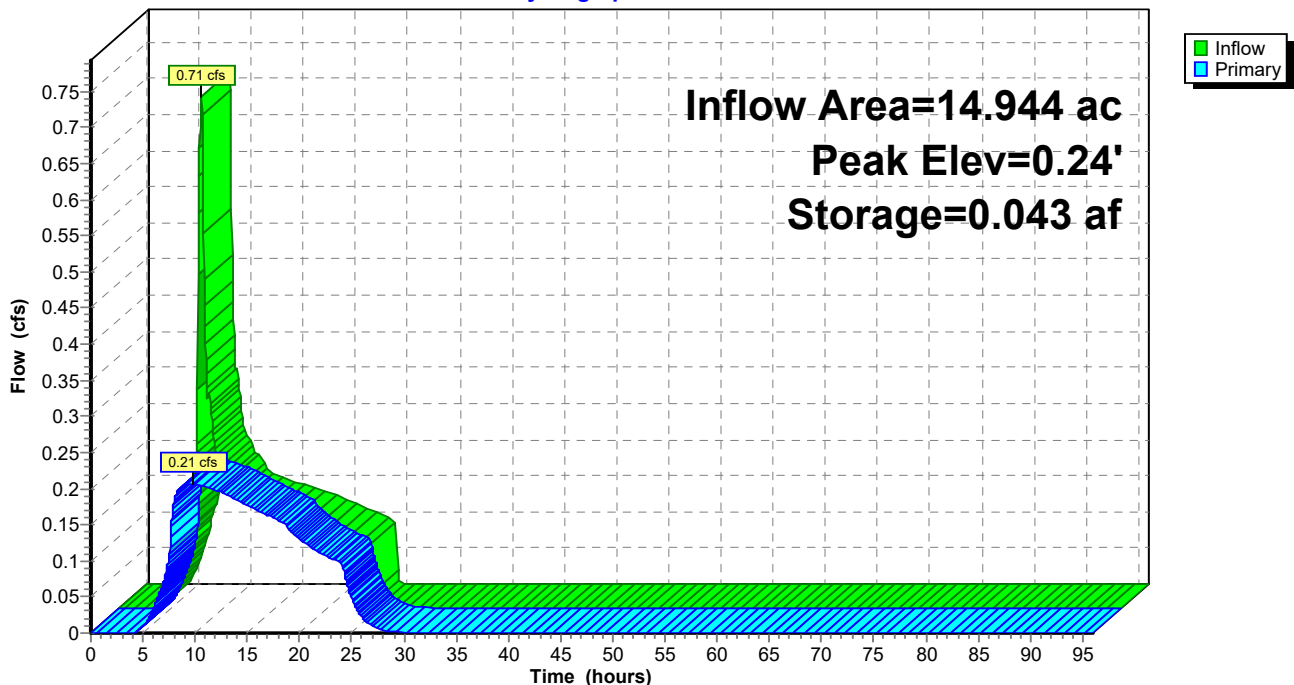
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	1.947 af	<b>52.0" Round Pipe Storage</b> L= 5,750.0'

Device	Routing	Invert	Outlet Devices
#1	Primary	0.00'	<b>4.0" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads
#2	Primary	3.85'	<b>24.0" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads

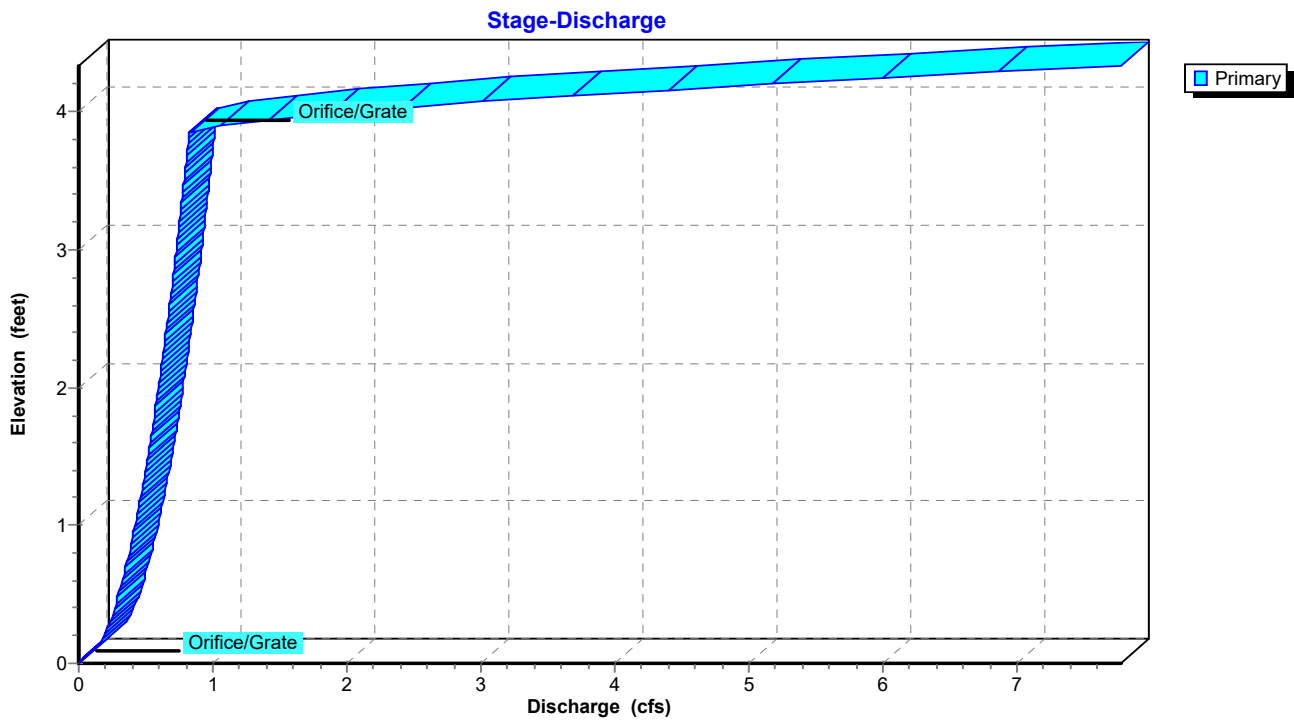
**Primary OutFlow** Max=0.21 cfs @ 9.69 hrs HW=0.24' (Free Discharge)  
 1=Orifice/Grate (Orifice Controls 0.21 cfs @ 2.37 fps)  
 2=Orifice/Grate ( Controls 0.00 cfs)

**Pond 3P: Detention A**

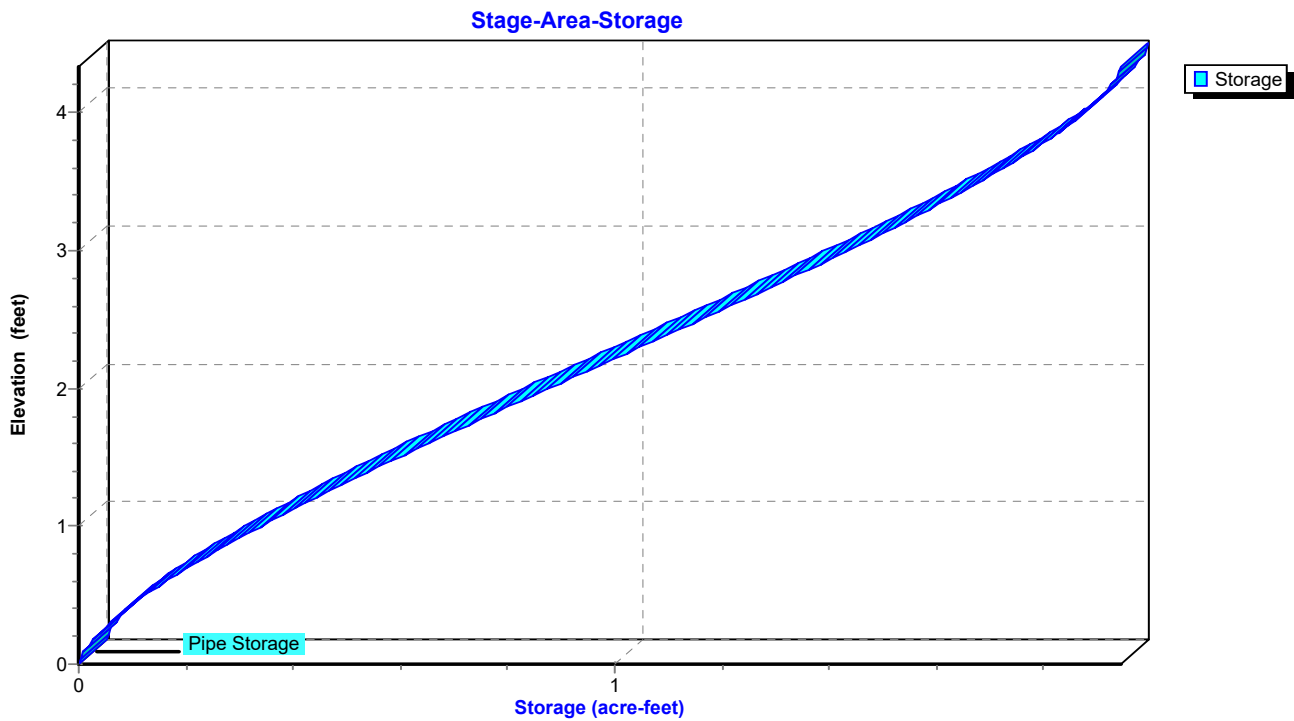
Hydrograph



### Pond 3P: Detention A



### Pond 3P: Detention A



# Walgraves

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Type IA 24-hr WQ Rainfall=0.36"

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## Summary for Pond 6P: Detention B

Inflow Area = 2.894 ac, 100.00% Impervious, Inflow Depth = 0.19" for WQ event  
Inflow = 0.14 cfs @ 7.95 hrs, Volume= 0.047 af  
Outflow = 0.05 cfs @ 9.04 hrs, Volume= 0.047 af, Atten= 65%, Lag= 65.5 min  
Primary = 0.05 cfs @ 9.04 hrs, Volume= 0.047 af

Routing by Stor-Ind method, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
Peak Elev= 0.12' @ 9.04 hrs Surf.Area= 0.177 ac Storage= 0.007 af

Plug-Flow detention time= 74.3 min calculated for 0.047 af (100% of inflow)  
Center-of-Mass det. time= 74.4 min ( 861.7 - 787.3 )

Volume	Invert	Avail.Storage	Storage Description
#1A	0.00'	0.000 af	<b>20.41'W x 200.00'L x 2.75'H Field A</b> 0.258 af Overall - 0.163 af Embedded = 0.094 af x 0.0% Voids
#2A	0.00'	0.163 af	<b>CMP Arch 49x33 x 40 Inside #1</b> Effective Size= 49.0"W x 33.0"H => 8.90 sf x 20.00'L = 178.0 cf Overall Size= 49.0"W x 33.0"H x 20.00'L 40 Chambers in 4 Rows
#3B	0.00'	0.000 af	<b>25.85'W x 140.00'L x 2.75'H Field B</b> 0.228 af Overall - 0.143 af Embedded = 0.085 af x 0.0% Voids
#4B	0.00'	0.143 af	<b>CMP Arch 49x33 x 35 Inside #3</b> Effective Size= 49.0"W x 33.0"H => 8.90 sf x 20.00'L = 178.0 cf Overall Size= 49.0"W x 33.0"H x 20.00'L 35 Chambers in 5 Rows
		0.306 af	Total Available Storage

Storage Group A created with Chamber Wizard

Storage Group B created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	0.00'	<b>2.3" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads
#2	Primary	2.10'	<b>6.0" W x 5.0" H Vert. Orifice/Grate</b> C= 0.600
#3	Primary	2.52'	<b>24.0" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads

**Primary OutFlow** Max=0.05 cfs @ 9.04 hrs HW=0.12' (Free Discharge)

1=Orifice/Grate (Orifice Controls 0.05 cfs @ 1.68 fps)

2=Orifice/Grate ( Controls 0.00 cfs)

3=Orifice/Grate ( Controls 0.00 cfs)



**Pond 6P: Detention B - Chamber Wizard Field A**

**Chamber Model = CMP Arch 49x33 (1/2" Corrugated Pipe Arch, AISI Handbook 1994, Table 2.18)**

Effective Size= 49.0"W x 33.0"H => 8.90 sf x 20.00'L = 178.0 cf

Overall Size= 49.0"W x 33.0"H x 20.00'L

49.0" Wide + 16.3" Spacing = 65.3" C-C Row Spacing

10 Chambers/Row x 20.00' Long = 200.00' Row Length

4 Rows x 49.0" Wide + 16.3" Spacing x 3 = 20.41' Base Width

33.0" Chamber Height = 2.75' Field Height

40 Chambers x 178.0 cf = 7,118.3 cf Chamber Storage

11,224.6 cf Field - 7,118.3 cf Chambers = 4,106.3 cf Stone x 0.0% Voids = 0.0 cf Stone Storage

Chamber Storage = 7,118.3 cf = 0.163 af

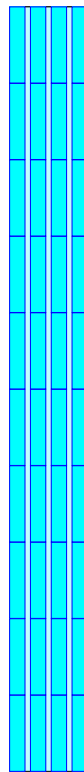
Overall Storage Efficiency = 63.4%

Overall System Size = 200.00' x 20.41' x 2.75'

40 Chambers

415.7 cy Field

152.1 cy Stone



**Pond 6P: Detention B - Chamber Wizard Field B**

**Chamber Model = CMP Arch 49x33 (1/2" Corrugated Pipe Arch, AISI Handbook 1994, Table 2.18)**

Effective Size= 49.0"W x 33.0"H => 8.90 sf x 20.00'L = 178.0 cf

Overall Size= 49.0"W x 33.0"H x 20.00'L

49.0" Wide + 16.3" Spacing = 65.3" C-C Row Spacing

7 Chambers/Row x 20.00' Long = 140.00' Row Length

5 Rows x 49.0" Wide + 16.3" Spacing x 4 = 25.85' Base Width

33.0" Chamber Height = 2.75' Field Height

35 Chambers x 178.0 cf = 6,228.5 cf Chamber Storage

9,952.3 cf Field - 6,228.5 cf Chambers = 3,723.8 cf Stone x 0.0% Voids = 0.0 cf Stone Storage

Chamber Storage = 6,228.5 cf = 0.143 af

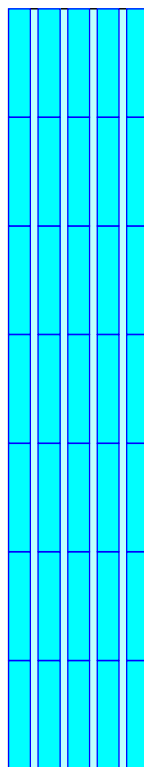
Overall Storage Efficiency = 62.6%

Overall System Size = 140.00' x 25.85' x 2.75'

35 Chambers

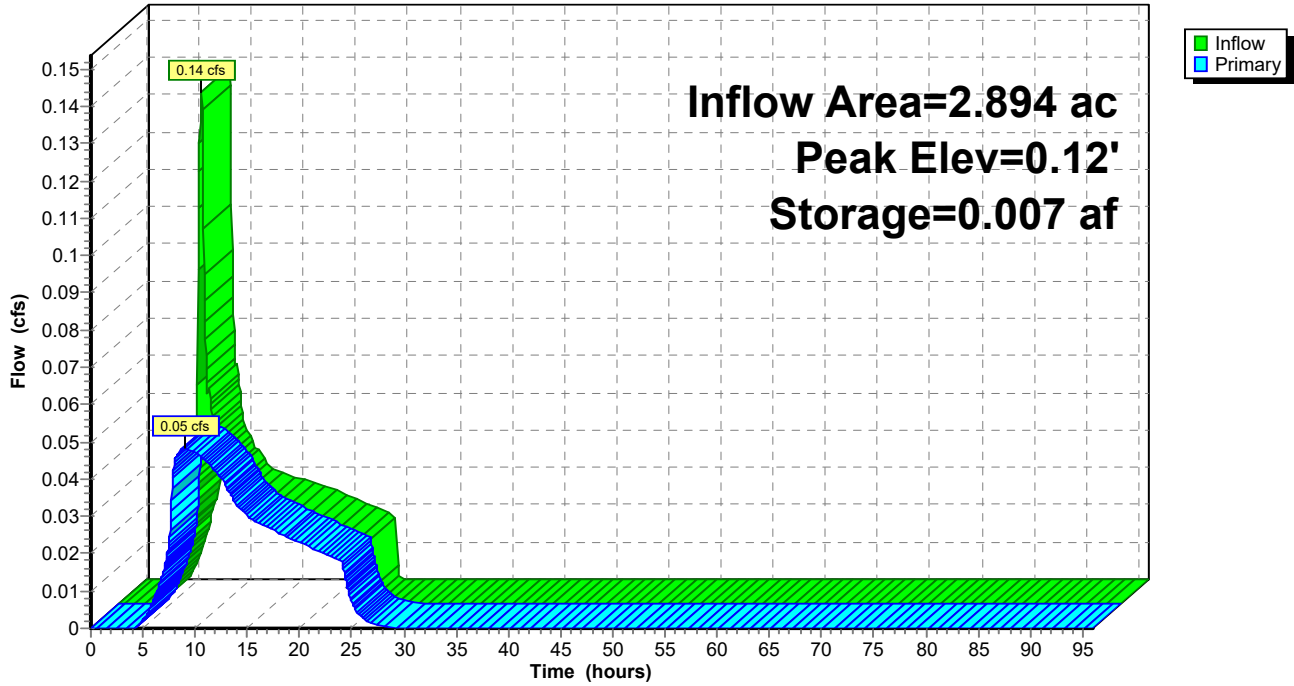
368.6 cy Field

137.9 cy Stone



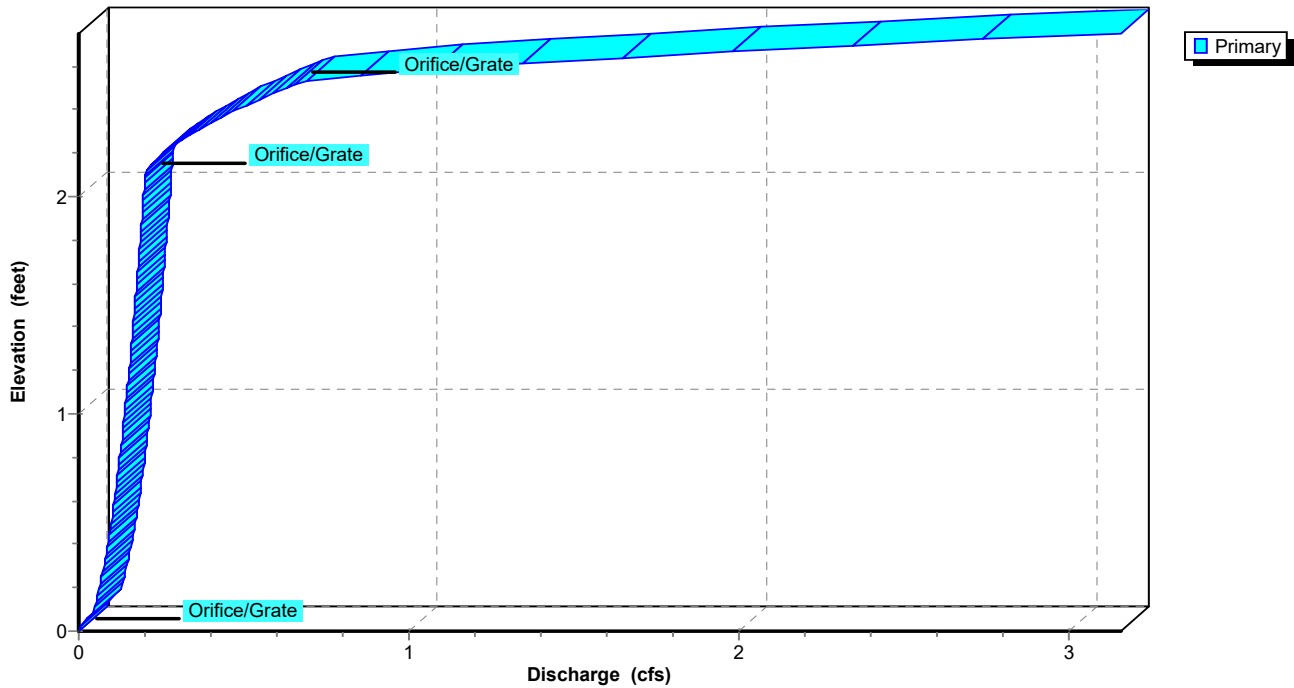
### Pond 6P: Detention B

Hydrograph



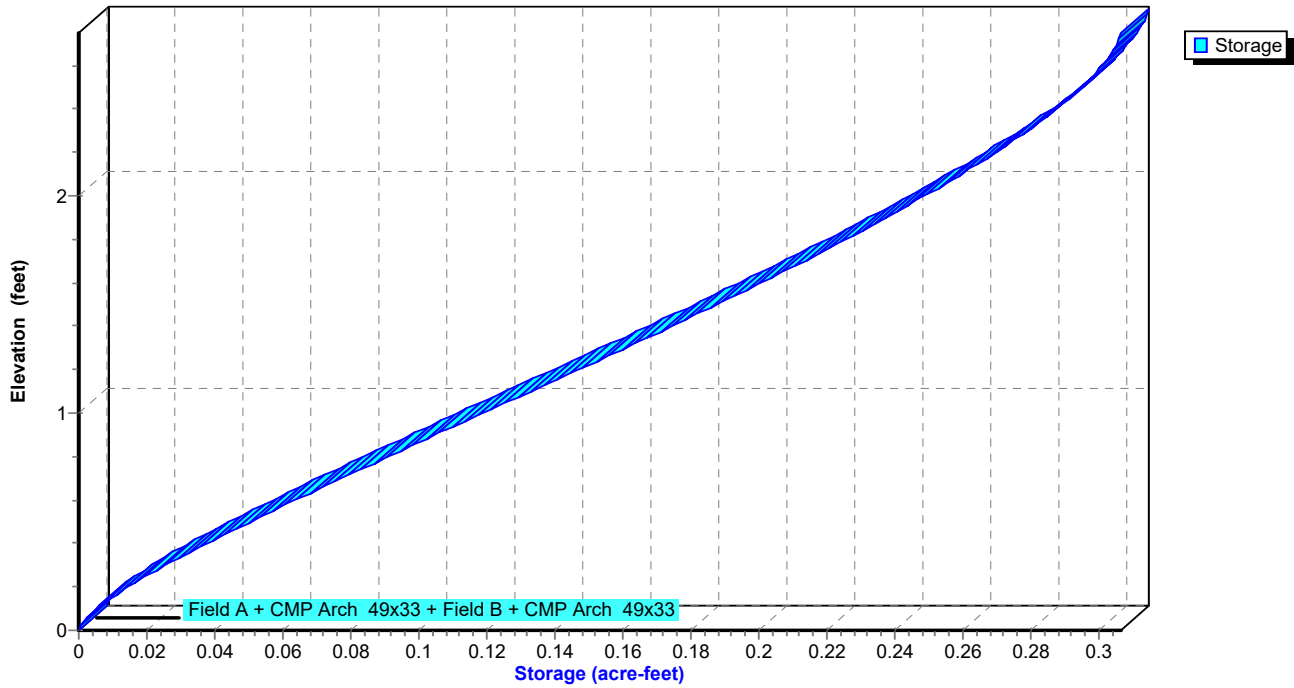
### Pond 6P: Detention B

Stage-Discharge



### Pond 6P: Detention B

Stage-Area-Storage





# Hedges Creek

## STORMWATER REPORT

11345 SW Herman Road  
Tualatin, Oregon

*Revised February 25, 2022*

January 25, 2022

April 25, 2022

The information contained in this report was prepared by  
and under direct supervision of the undersigned:

Craig Harris, PE

**AAI Engineering**

4875 S.W. Griffith Drive

Suite 100

Beaverton, Oregon 97005

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[craigh@aaieng.com](mailto:craigh@aaieng.com)

AAI Project Number: A20120.10

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III. Conveyance Calculations.....	5
IV. Downstream Analysis.....	5
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### Appendix C

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### Appendix E

Erosion Control Plans

### Appendix F

Geotechnical Report

### Appendix G

Stormwater Calculations

### Appendix H

Operations and Maintenance Manual

# Hedges Creek

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## I. Project Summary

This report has been prepared to outline the existing and proposed on-site stormwater conditions for the Hedges Creek project. This report is based on topographic survey, GIS information and field observations.

The project site is located in Tualatin, Oregon. The total site area is approximately 922,022 square feet (21.17 acres). The site currently consists of an open field and slopes from south to north.

The primary purpose of this project is to develop the site for three new shell warehouse buildings, parking and drive aisle. The onsite improvements will consist of 750,581 square feet (17.23 acres) of total impervious area. In addition to the onsite improvements, stormwater management will be provided, including conveyance, water quality treatment, and flow control with detention.

## II. Stormwater Design

No runoff from adjacent properties is anticipated to be captured by the proposed facilities. In addition, all site impervious runoff will be completely managed on site and will not drain onto adjacent properties. The stormwater management for this project is designed according to the requirements outlined in the Oregon DEQ Section 401 Water Quality Certification Post-Construction Stormwater Management Plan Submission Guidelines, SLOPES V stormwater requirements, Clean Water Services Design and Construction Standards, and City of Tualatin Construction Code.

The soils on site have been tested for infiltration, resulting in a raw rate of 0.1-0.2 in/hour. The native soil is low-infiltration silt, and it has been determined that incorporating infiltration into the stormwater design is not feasible.

The site is hydraulically divided into several basins. The basins collect runoff from roofs and onsite impervious areas including parking, drive areas, and sidewalks. Pavement areas runoff is collected in sumped catch basins for pretreatment, while roof drain runoff is collected and routed to sumped manholes for treatment.

Two northern basins, including two surface parking areas, will address water quality treatment by using the vegetated corridor as a filter strips, per CWS R&O 19-5 4.09.12. A total area of 2,540 square feet of improved vegetated corridor will be able to treat ±40,550 square feet of impervious area according to CWS Simplified Sizing. These filter strips will have 1' wide gravel trenches along the upper end to create a level discharge into the treatment area. The remaining basins (699,048 square feet) will be treated post-detention using Bio-Clean's stormwater biofiltration system vaults sized using a water quality event of 0.36" with rainfall over 4 hours for the respective basin areas.

After the stormwater is filtered, most flows are routed to underground detention systems where stormwater is detained to predeveloped flow rates through the use of a flow control tee. The orifices in the flow control tees are designed to restrict post-developed flows to pre-developed rates during the 2-



# Hedges Creek

---

and 10-year events. Flows in excess of these events will bypass the flow control systems. Two small basins with a combined area of  $\pm 40,550$  square feet will not enter detention systems due to a lack of hydraulic drop available. However, orifices for the detention systems have been designed accounting for these basins. The sum of the flows from the complete system results in flows matching the predeveloped flow rates for the site.

Once all stormwater has been treated for the water quality treatment event and detained as necessary, it will be discharged into adjacent wetland surrounding Hedges Creek to the north of the site.

### III. Conveyance Calculations

All proposed storm mains and services are sized to convey up to the 25-yr storm event.

### IV. Downstream Analysis

No negative impacts are anticipated downstream as the proposed system will discharge directly into the wetland that receives runoff from the existing site, and there are no downstream structures. Treatment and flow-matching will prevent the wetland and creek from any potential negative effects from the development.

### VI. Engineering Conclusion

Based on the requirements for this project, the proposed site facilities are adequately designed to manage the proposed development conditions and should be approved as designed.

**Appendix A**

Existing Conditions

**EROSION CONTROL PLAN NOTES**

- APPROVAL OF THIS EROSION/SEDIMENTATION CONTROL (ESC) PLAN DOES NOT CONSTITUTE AN APPROVAL OF PERMANENT ROAD OR DRAINAGE DESIGN (E.G., SIZE AND LOCATION OF ROADS, RESTRICTORS, CHANNELS, RETENTION FACILITIES, UTILITIES, ETC.).
- THE IMPLEMENTATION OF THESE ESC PLANS AND THE CONSTRUCTION, MAINTENANCE, REPLACEMENT, AND UPGRADING OF THESE ESC FACILITIES IS THE RESPONSIBILITY OF THE CONTRACTOR UNTIL ALL CONSTRUCTION IS COMPLETED AND APPROVED AND PERMANENT VEGETATION/LANDSCAPING IS ESTABLISHED.
- THE BOUNDARIES OF THE CLEARING LIMITS SHOWN ON THIS PLAN SHALL BE CLEARLY FLAGGED IN THE FIELD PRIOR TO CONSTRUCTION. DURING THE CONSTRUCTION PERIOD, NO DISTURBANCE BEYOND THE FLAGGED CLEARING LIMITS SHALL BE PERMITTED. THE FLAGGING SHALL BE MAINTAINED BY THE CONTRACTOR FOR THE DURATION OF CONSTRUCTION.
- THE ESC FACILITIES SHOWN ON THIS PLAN MUST BE CONSTRUCTED IN CONJUNCTION WITH ALL CLEARING AND GRADING ACTIVITIES, AND IN SUCH A MANNER AS TO ENSURE THAT SEDIMENT AND SEDIMENT LADEN WATER DO NOT ENTER THE DRAINAGE SYSTEM, ROADWAYS, OR VIOLATE APPLICABLE WATER STANDARDS.
- THE ESC FACILITIES SHOWN ON THIS PLAN ARE THE MINIMUM REQUIREMENTS FOR ANTICIPATED SITE CONDITIONS. DURING THE CONSTRUCTION PERIOD, THESE ESC FACILITIES SHALL BE UPGRADED AS NEEDED FOR UNEXPECTED STORM EVENTS AND TO ENSURE THAT SEDIMENT AND SEDIMENT LADEN WATER DO NOT LEAVE THE SITE.
- THE ESC FACILITIES SHALL BE INSPECTED DAILY BY THE CONTRACTOR AND MAINTAINED AS NECESSARY TO ENSURE THEIR CONTINUED FUNCTIONING.
- THE ESC FACILITIES ON INACTIVE SITES MAY REDUCE FREQUENCY OF INSPECTIONS WHERE STABILIZATION STEPS IN SECTION 2.2.20 HAVE BEEN COMPLETED. AFTER BECOMING INACTIVE, THE ESC FACILITIES SHALL BE INSPECTED AND MAINTAINED TWICE THE FIRST MONTH, NO LESS THAN 14 CALENDAR DAYS APART, THEN A MINIMUM OF ONCE A MONTH OR WITHIN THE 24 HOURS FOLLOWING A STORM EVENT.
- AT NO TIME SHALL MORE THAN ONE FOOT OF SEDIMENT BE ALLOWED TO ACCUMULATE WITHIN A TRAPPED CATCH BASIN. ALL CATCH BASINS AND CONVEYANCE LINES SHALL BE CLEANED PRIOR TO PAVING. THE CLEANING OPERATION SHALL NOT FLUSH SEDIMENT LADEN WATER INTO THE DOWNSTREAM SYSTEM.
- STABILIZED CONSTRUCTION ENTRANCES SHALL BE INSTALLED AT THE BEGINNING OF CONSTRUCTION AND MAINTAINED FOR THE DURATION OF THE PROJECT. ADDITIONAL MEASURES MAY BE REQUIRED TO ENSURE THAT ALL PAVED AREAS ARE KEPT CLEAN FOR THE DURATION OF THE PROJECT.

**PRE-CONSTRUCTION, CLEARING AND DEMOLITION NOTES**

- ALL BASE ESC MEASURES (INLET PROTECTION, PERIMETER SEDIMENT CONTROL, GRAVEL CONSTRUCTION ENTRANCES, ETC.) MUST BE IN PLACE, FUNCTIONAL, AND APPROVED IN AN INITIAL INSPECTION, PRIOR TO COMMENCEMENT OF CONSTRUCTION ACTIVITIES.
- SEDIMENT BARRIERS APPROVED FOR USE INCLUDE SEDIMENT FENCE, BERMS CONSTRUCTED OUT OF MULCH, CHIPPINGS, OR OTHER SUITABLE MATERIAL, STRAW WATTLES, OR OTHER APPROVED MATERIALS.
- SENSITIVE RESOURCES INCLUDING, BUT NOT LIMITED TO, TREES, WETLANDS, AND RIPARIAN PROTECTION AREAS SHALL BE CLEARLY DELINEATED WITH ORANGE CONSTRUCTION FENCING OR CHAIN LINK FENCING IN A MANNER THAT IS CLEARLY VISIBLE TO ANYONE IN THE AREA. NO ACTIVITIES ARE PERMITTED TO OCCUR BEYOND THE CONSTRUCTION BARRIER.
- CONSTRUCTION ENTRANCES SHALL BE INSTALLED AT THE BEGINNING OF CONSTRUCTION AND MAINTAINED FOR THE DURATION OF THE PROJECT. ADDITIONAL MEASURES INCLUDING, BUT NOT LIMITED TO, STREET SWEEPING AND VACUUMING, MAY BE REQUIRED TO INSURE THAT ALL PAVED AREAS ARE KEPT CLEAN FOR THE DURATION OF THE PROJECT.
- RUN-ON AND RUN-OFF CONTROLS SHALL BE IN PLACE AND FUNCTIONING PRIOR TO BEGINNING SUBSTANTIAL CONSTRUCTION ACTIVITIES. RUN-ON AND RUN-OFF CONTROL MEASURES INCLUDE: SLOPE DRAINS (WITH OUTLET PROTECTION), CHECK DAMS, SURFACE ROUGHENING, AND BANK STABILIZATION.

**LEGEND**

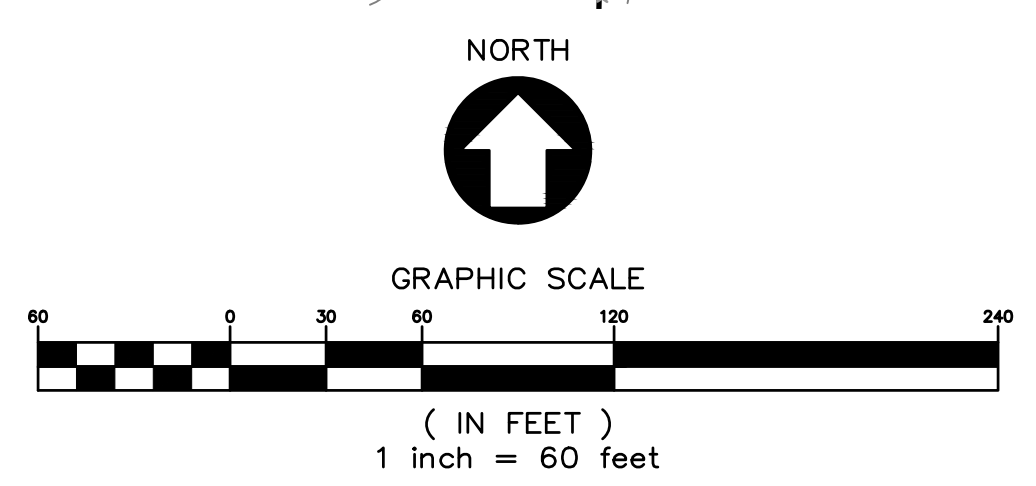
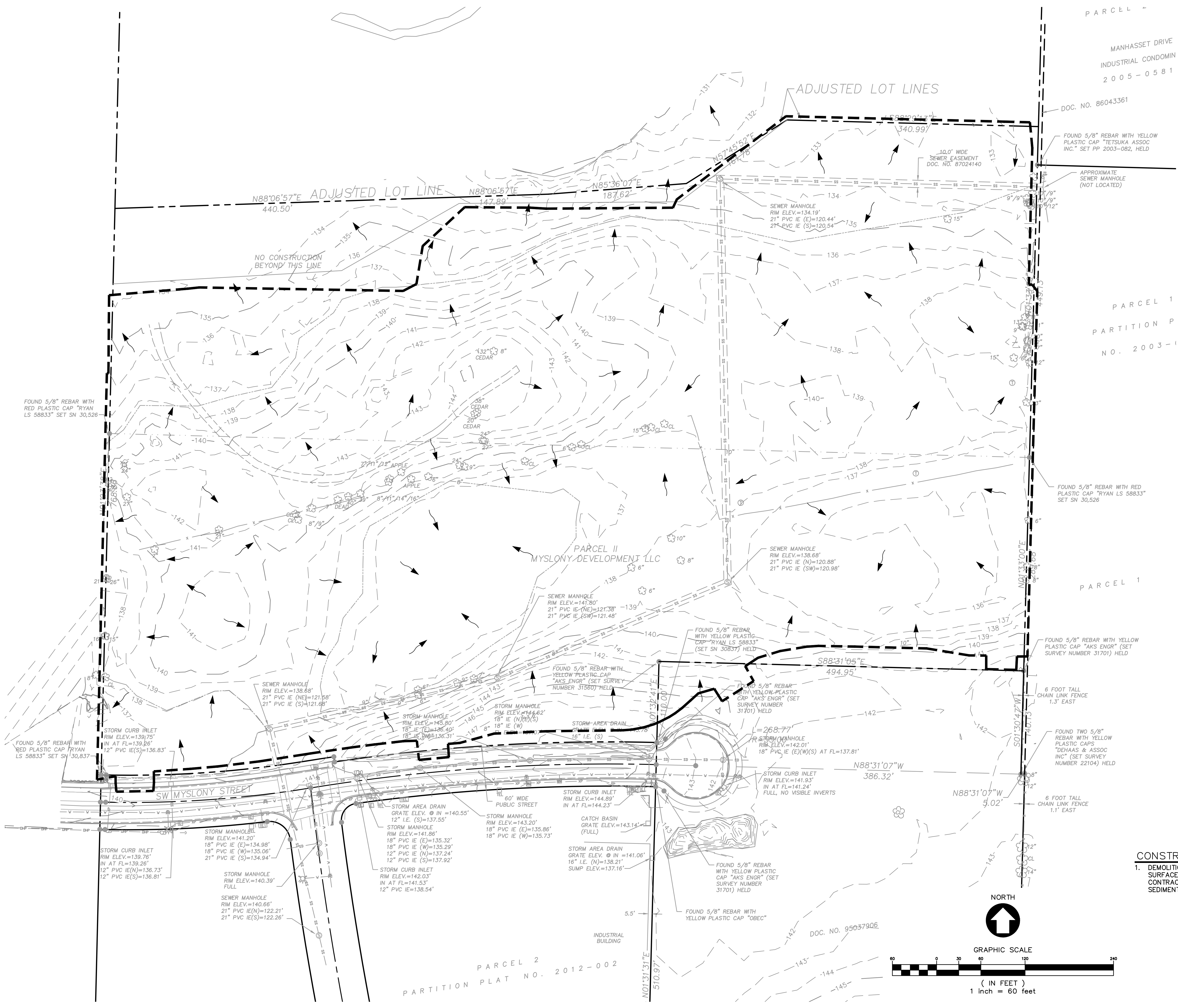
EXISTING CONTOUR MINOR	--- 102 ---
EXISTING CONTOUR MAJOR	--- 100 ---
LIMIT OF DISTURBANCE	-----
FLOW ARROW	→

**CONSTRUCTION SEQUENCING & STORM FACILITY NOTES**

- DEMOLITION WILL REMOVE IMPERVIOUS SURFACES. UNTIL NEW IMPERVIOUS SURFACES ARE INSTALLED, STORMWATER WILL BE INFILTRATED IN PLACE. CONTRACTOR TO INSTALL EROSION CONTROL MEASURES AS NEEDED TO PREVENT SEDIMENT LADEN RUNOFF FROM LEAVING THE SITE.

CONTRACTOR SHALL ENSURE THAT POSITIVE DRAINAGE IS MAINTAINED ACROSS EXPOSED AREAS AND NO LOW POINTS ARE CREATED ON-SITE AHEAD OF HOLIDAYS/WEEKENDS OR WHEN THERE IS ANY CHANCE OF RAIN.

THESE EROSION AND SEDIMENT CONTROL PLANS ASSUME "DRY WEATHER" CONSTRUCTION "WET WEATHER" CONSTRUCTION MEASURES NEED TO BE APPLIED BETWEEN OCTOBER 1ST AND MAY 31ST



SHEET TITLE

EXISTING CONDITIONS

DATE: 03/04/22

DRAWN: HJD

CHECKED: CNH

REVISIONS:

CONTRACTOR SHALL ENSURE THAT POSITIVE DRAINAGE IS MAINTAINED ACROSS EXPOSED AREAS AND NO LOW POINTS ARE CREATED ON-SITE AHEAD OF HOLIDAYS/WEEKENDS OR WHEN THERE IS ANY CHANCE OF RAIN.

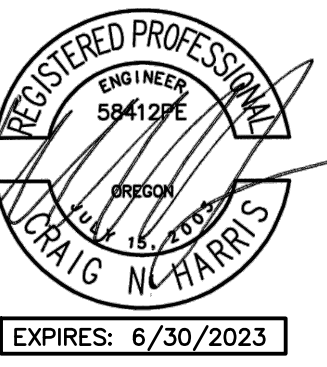
THESE EROSION AND SEDIMENT CONTROL PLANS ASSUME "DRY WEATHER" CONSTRUCTION "WET WEATHER" CONSTRUCTION MEASURES NEED TO BE APPLIED BETWEEN OCTOBER 1ST AND MAY 31ST

SHEET NUMBER

**EC2.0**

JOB NUMBER: A20120.10

**Appendix B**  
Hardscape Plan



AAI ENGINEERING INC.  
4875 SW Center Drive, Suite 100, Beaverton, OR 97005  
503.638.0888 Fax 503.638.0888

**PHELAN**  
DEVELOPMENT  
450 Newport Center Drive, Suite 405  
Newport Beach, CA 92660

HEDGES CREEK  
TUALATIN, OR

**SHEET NOTES**

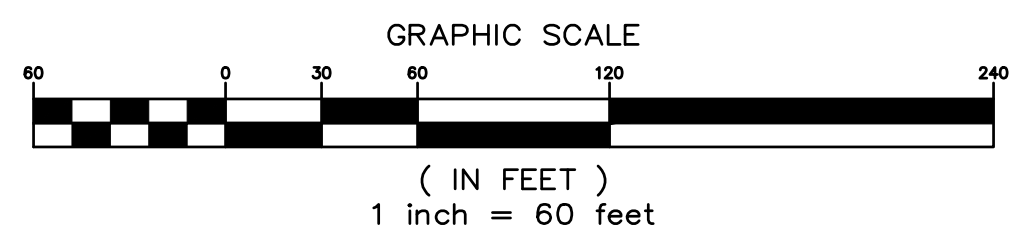
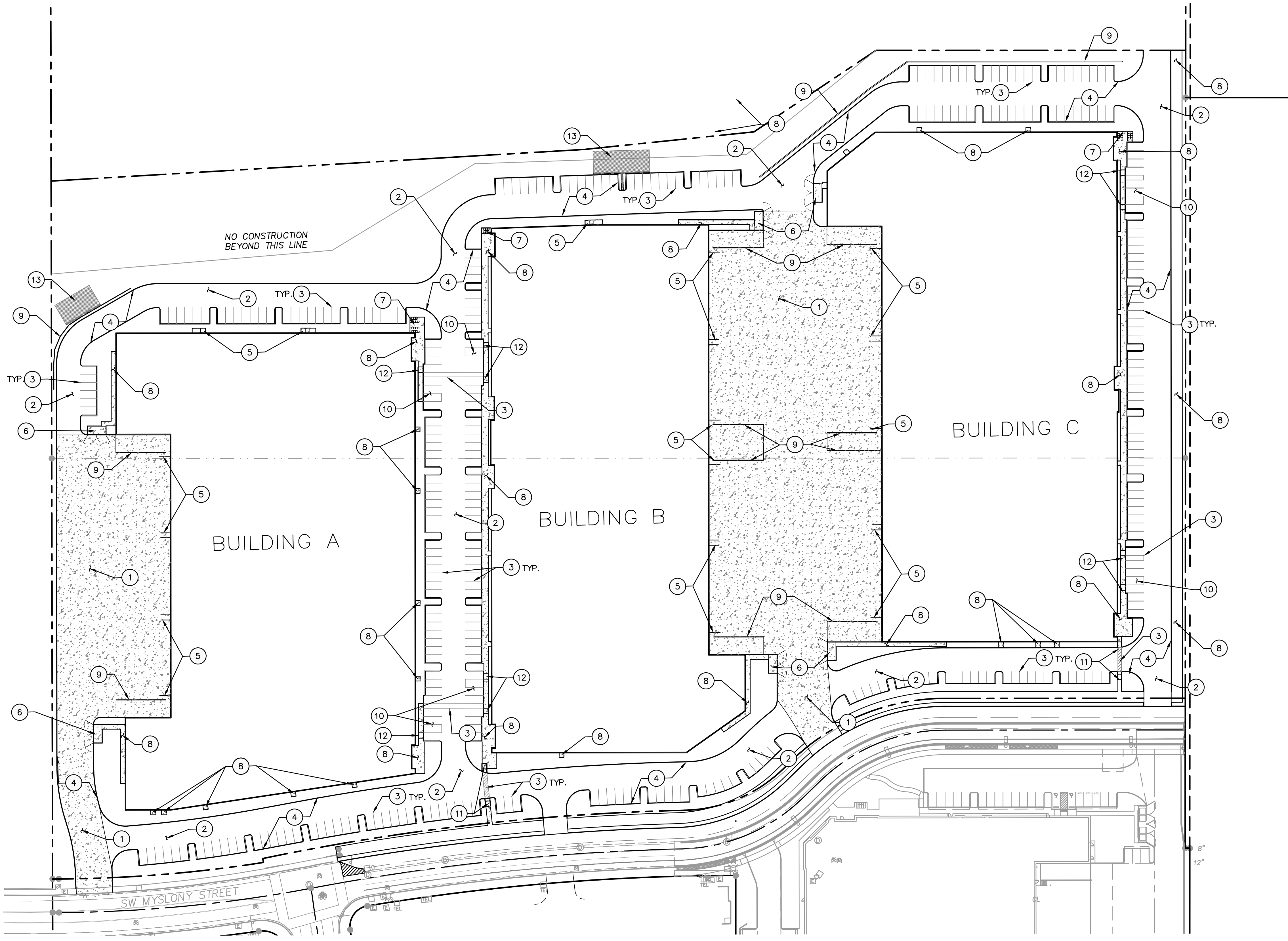
1. SEE ARCHITECTURAL PLANS FOR ADDITIONAL SITE INFORMATION.
2. THE CONTRACTOR SHALL HAVE A FULL SET OF THE CURRENT APPROVED CONSTRUCTION DOCUMENTS INCLUDING ADDENDA ON THE PROJECT SITE AT ALL TIMES.
3. THE CONTRACTOR SHALL KEEP THE ENGINEER AND JURISDICTION INFORMED OF CONSTRUCTION PROGRESS TO FACILITATE SITE OBSERVATIONS AT REQUIRED INTERVALS. 24-HOUR NOTICE IS REQUIRED.

**(X) CONSTRUCTION NOTES**

1. INSTALL CONCRETE TRUCK DRIVING SURFACE PER DETAIL 2/C4.0
2. INSTALL ASPHALT SURFACING PER DETAIL 1/C4.0
3. INSTALL STRIPING. SEE ARCHITECTURAL PLANS.
4. INSTALL CURB PER DETAIL 4/C4.0
5. INSTALL STAIRS. SEE ARCHITECTURAL PLANS.
6. INSTALL TRASH ENCLOSURE. SEE ARCHITECTURAL PLANS.
7. INSTALL BICYCLE PARKING. SEE ARCHITECTURAL PLANS.
8. INSTALL SIDEWALK PER DETAIL 3/C4.0
9. INSTALL DESIGN BUILD WALL
10. INSTALL ADA PARKING PER DETAIL 7/C4.0
11. INSTALL ADA CURB RAMP PER DETAIL 5/C4.0
12. INSTALL ADA CURB RAMP PER DETAIL 6/C4.0
13. INSTALL VEGETATIVE CORRIDOR AS FILTER STRIP PER CWS DETAIL 770/C4.4

**LEGEND**

- PROPERTY LINE
- CONCRETE SURFACING



SHEET TITLE

SITE PLAN

DATE: 08/02/2021

DRAWN: KPM

CHECKED: CNH

REVISIONS:

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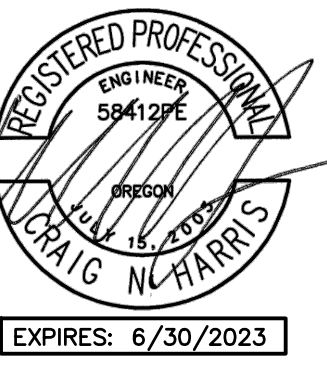
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3/01/2022

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**Appendix C**

Storm Plan and Details



AAI ENGINEERING  
4875 SW Center Drive, Suite 100, Beaverton, OR 97005  
503.638.0888 | www.aaieng.com

**PHELAN**  
DEVELOPMENT  
450 Newport Center Drive, Suite 405  
Newport Beach, CA 92660



HEDGES CREEK  
TUALATIN, OR

SHEET TITLE

GRADING OVERVIEW

DATE: 08/02/2021

DRAWN: KPM

CHECKED: CNH

REVISIONS:

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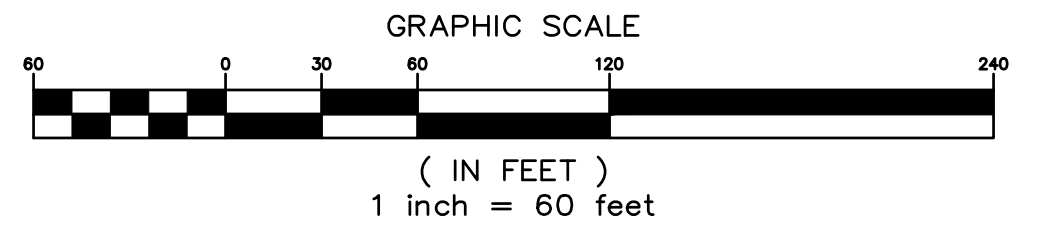
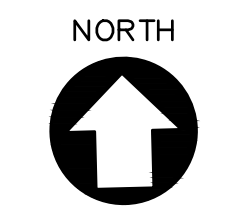
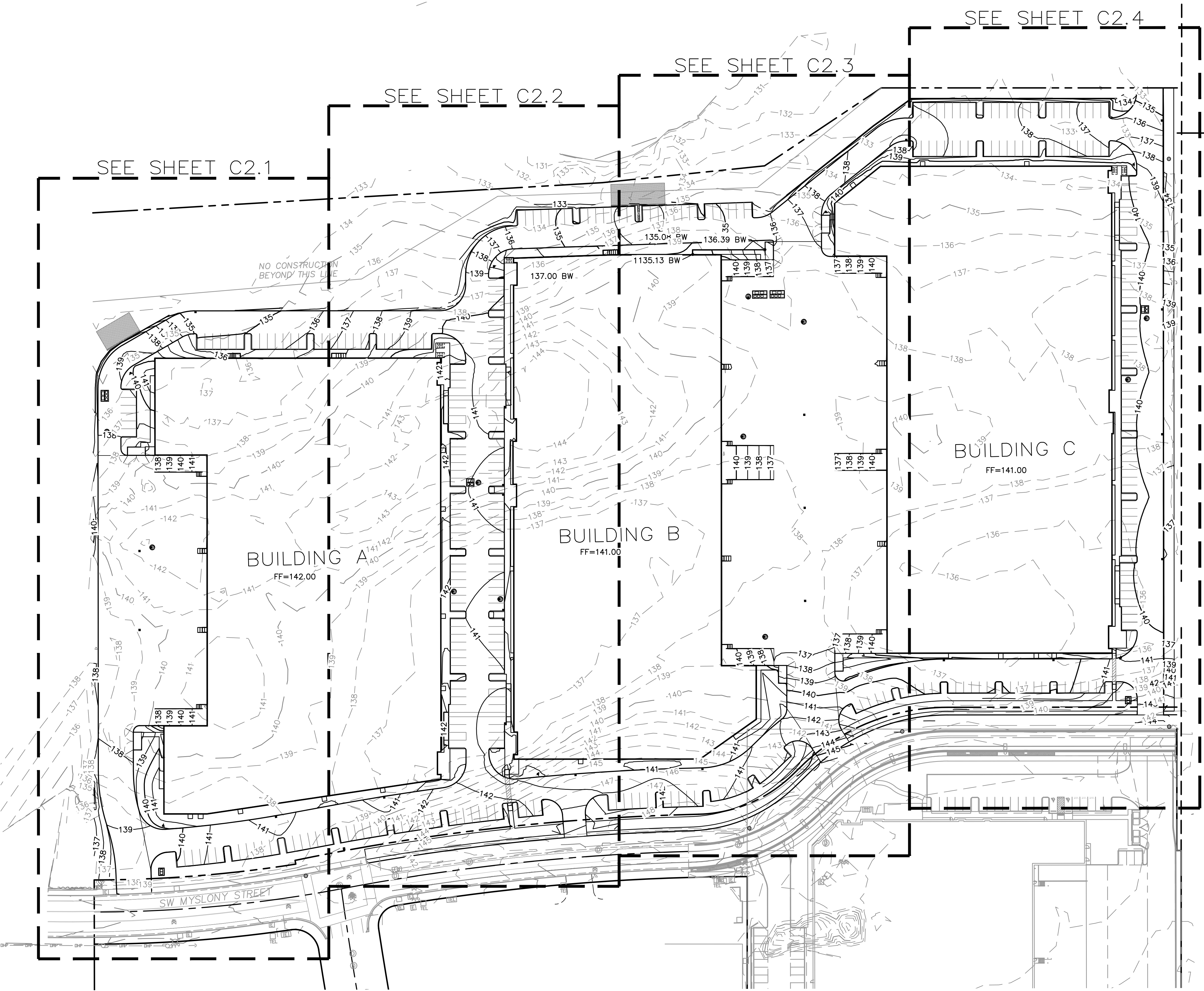
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SHEET NOTES

1. CURB HEIGHTS ARE 6" UNLESS NOTED OTHERWISE.
2. LANDINGS ON ACCESSIBLE ROUTES SHALL NOT EXCEED 2% IN ANY DIRECTION.
3. ALL ACCESSIBLE ROUTES SHALL COMPLY WITH CURRENT ADA ACCESSIBILITY GUIDELINES FOR BUILDING AND FACILITIES (ADAAG).
4. ALL WALKWAYS FROM ACCESSIBLE UNITS ARE DESIGNED TO NOT REQUIRE HANDRAILS. THEREFORE, RAMPS WITH SLOPES STEEPER THAN 5.0% AND LESS THAN 8.33% SHALL NOT EXCEED 0.5' RISE OR 6.0' LENGTH.
5. FINISH GRADES ARE TO BE BROUGHT TO WITHIN 0.08 FT IN 10 FT OF THE GRADES SHOWN AT SUBGRADE AND TO WITHIN 0.03 FT IN 10 FT AT FINISH GRADE. CONTRACTOR TO ALLOW FOR PLACEMENT OF REQUIRED TOPSOIL IN ROUGH GRADING.
6. GRADING ELEVATIONS AS SHOWN ON SITE AND LANDSCAPE PLANS ARE FINISHED GRADE WHICH INCLUDES SUBGRADE SOIL, TOPSOIL, SOIL AMENDMENTS, ROCKERY AND RUNOFF PROTECTION CONTRACTOR IS RESPONSIBLE TO COORDINATE GRADING WITH BOTH EXCAVATOR AND LANDSCAPE CONTRACTOR.

LEGEND

EXISTING CONTOUR MINOR	- - - - - 102
EXISTING CONTOUR MAJOR	— — — — — 100
PROPOSED CONTOUR MINOR	- - - - - 102
PROPOSED CONTOUR MAJOR	— — — — — 100



3/01/2022

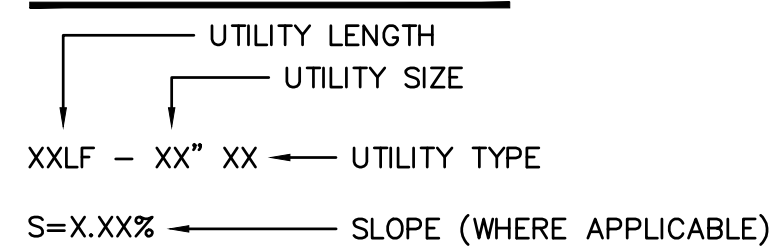
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SHEET NOTES

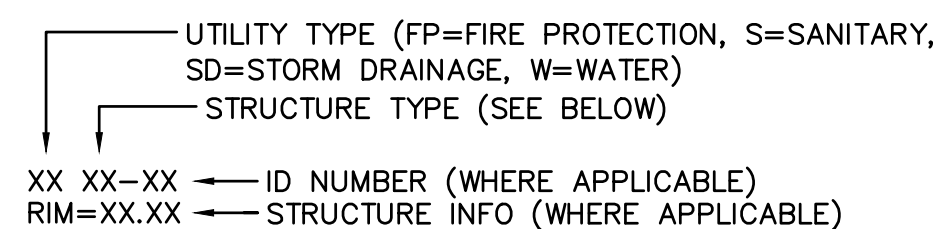
- ALL SANITARY PIPING SHALL BE PVC 3034 OR APPROVED EQUAL UNLESS NOTED OTHERWISE.
- THIS PLAN IS GENERALLY DIAGRAMMATIC. IT DOES NOT SHOW EVERY JOINT, BEND, FITTING, OR ACCESSORY REQUIRED FOR CONSTRUCTION.
- CLEAN OUTS SHALL BE INSTALLED IN CONFORMANCE WITH UPC CHAPTER SEVEN, SECTION 707 AND SECTION 719. THIS PLAN MAY NOT SHOW ALL REQUIRED CLEAN OUTS.
- DOMESTIC WATER AND FIRE LINES AND ACCESSORIES BETWEEN THE WATER METER AND THE BUILDING SHALL BE INSTALLED BY A LICENSED PLUMBER EMPLOYED BY A LICENSED PLUMBING CONTRACTOR.
- UTILITIES WITHIN FIVE FEET OF A BUILDING SHALL BE CONSTRUCTED OF MATERIALS APPROVED FOR INTERIOR USE AS DESCRIBED IN THE CURRENT EDITION OF THE UPC.
- INLETS AND OUTLETS TO ON-SITE MANHOLES SHALL HAVE FLEXIBLE CONNECTION NO CLOSER THAN 12" AND NO FARTHER THAN 36" FROM THE MANHOLE.
- CONTRACTOR TO VERIFY SANITARY AND WATER SIZING AND INVERTS WITH APPROVED PLUMBING PLANS PRIOR TO ORDERING MATERIALS OR BEGINNING CONSTRUCTION OF SAID UTILITIES.
- ALL STORM AND SANITARY FITTINGS TO BE ECCENTRIC FITTINGS UNLESS OTHERWISE NOTED.

LABEL LEGEND

PIPE LABELS



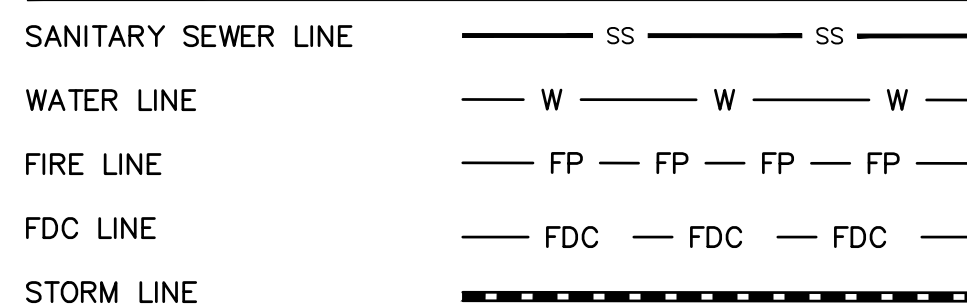
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STRUCTURE TYPES

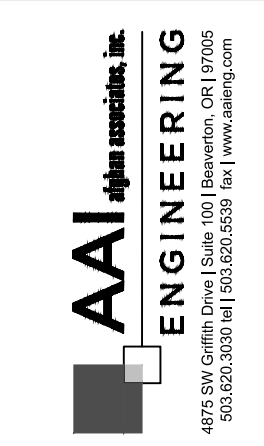
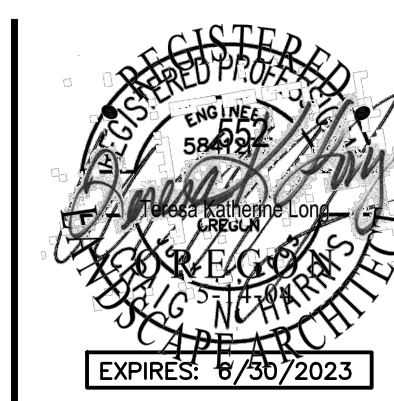
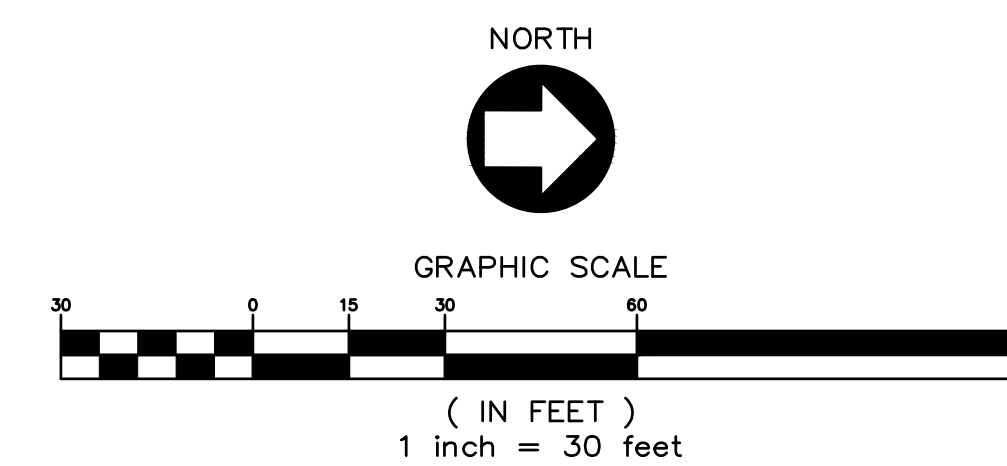
TYPE	DESCRIPTION
BF	BACKFLOW PREVENTION DEVICE PER DETAIL 3/C4.1
CB	CATCH BASIN PER DETAIL 2/C4.1
FCMH	FLOW CONTROL MANHOLE PER DETAIL 5/C4.1
FV	FIRE VAULT PER DETAIL 614/C4.2
MH	MANHOLE PER DETAIL 010/C4.2
WQV	WATER QUALITY VAULT
WM	WATER METER PER DETAIL 634/C4.1

LEGEND

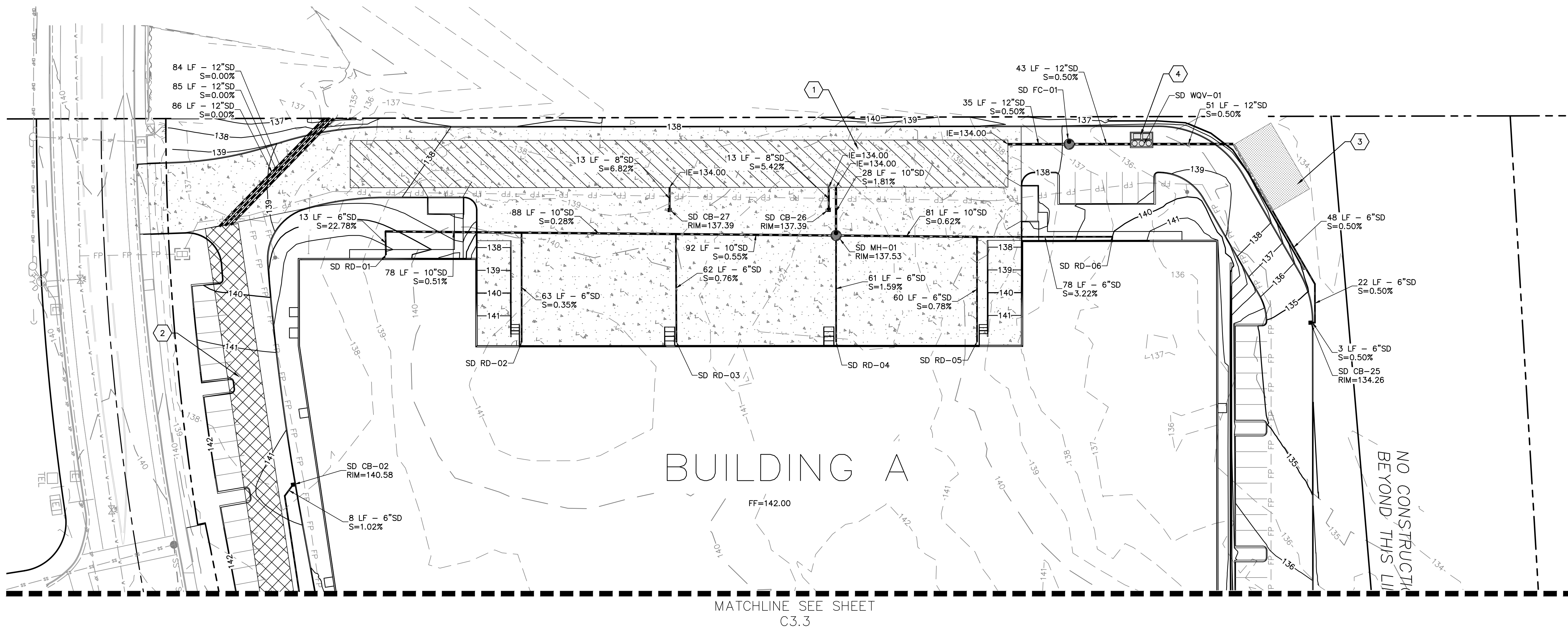


STORM NOTES

- INSTALL CULTEC CHAMBERS (SYSTEM #1). REFER TO MANUFACTURER'S DETAILS FOR SPECIFICATION.
- INSTALL CULTECH CHAMBERS FOR FLOOD STORAGE DIVIDED INTO TWO SECTIONS. REFER TO MANUFACTURER'S DETAILS FOR SPECIFICATIONS.
- INSTALL VEGETATIVE CORRIDOR AS FILTER STRIP PER CWS DETAIL 770/C4.4.
- INSTALL MODULAR WETLANDS VAULT PER DETAIL ON SHEET C4.3



**PHELAN**  
D E V E L O P M E N T  
450 Newport Center Drive, Suite 405  
Newport Beach, CA 92660



SHEET TITLE  
STORM PLAN

DATE: 08/02/2021  
DRAWN: KPM  
CHECKED: CNH

REVISIONS:

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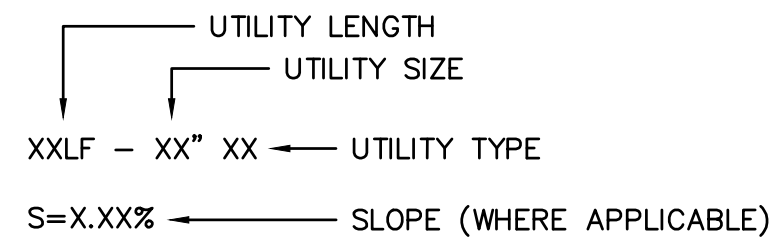


SHEET NOTES

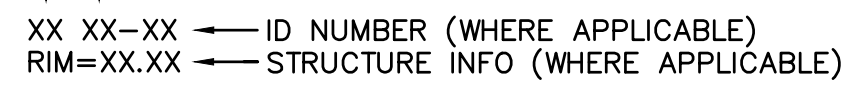
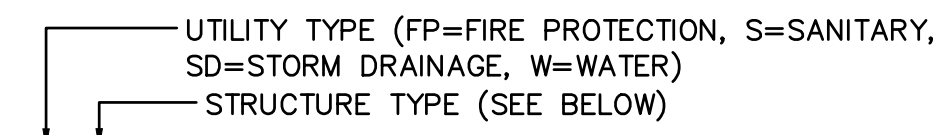
- ALL SANITARY PIPING SHALL BE PVC 3034 OR APPROVED EQUAL UNLESS NOTED OTHERWISE.
- THIS PLAN IS GENERALLY DIAGRAMMATIC. IT DOES NOT SHOW EVERY JOINT, BEND, FITTING, OR ACCESSORY REQUIRED FOR CONSTRUCTION.
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- DOMESTIC WATER AND FIRE LINES AND ACCESSORIES BETWEEN THE WATER METER AND THE BUILDING SHALL BE INSTALLED BY A LICENSED PLUMBER EMPLOYED BY A LICENSED PLUMBING CONTRACTOR.
- UTILITIES WITHIN FIVE FEET OF A BUILDING SHALL BE CONSTRUCTED OF MATERIALS APPROVED FOR INTERIOR USE AS DESCRIBED IN THE CURRENT EDITION OF THE UPC.
- INLETS AND OUTLETS TO ON-SITE MANHOLES SHALL HAVE FLEXIBLE CONNECTION NO CLOSER THAN 12" AND NO FARTHER THAN 36" FROM THE MANHOLE.
- CONTRACTOR TO VERIFY SANITARY AND WATER SIZING AND INVERTS WITH APPROVED PLUMBING PLANS PRIOR TO ORDERING MATERIALS OR BEGINNING CONSTRUCTION OF SAID UTILITIES.
- ALL STORM AND SANITARY FITTINGS TO BE ECCENTRIC FITTINGS UNLESS OTHERWISE NOTED.

LABEL LEGEND

PIPE LABELS



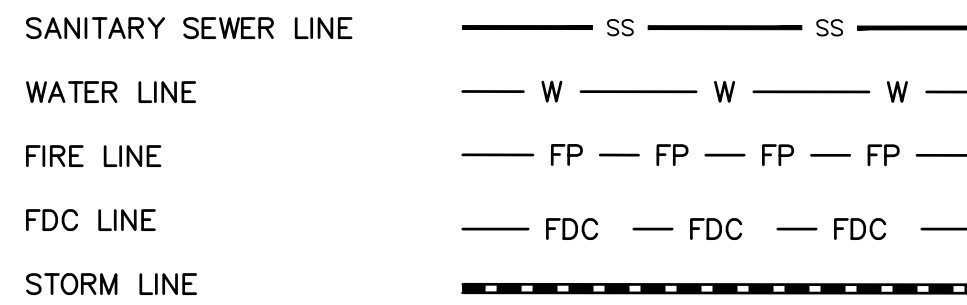
STRUCTURE LABELS



STRUCTURE TYPES

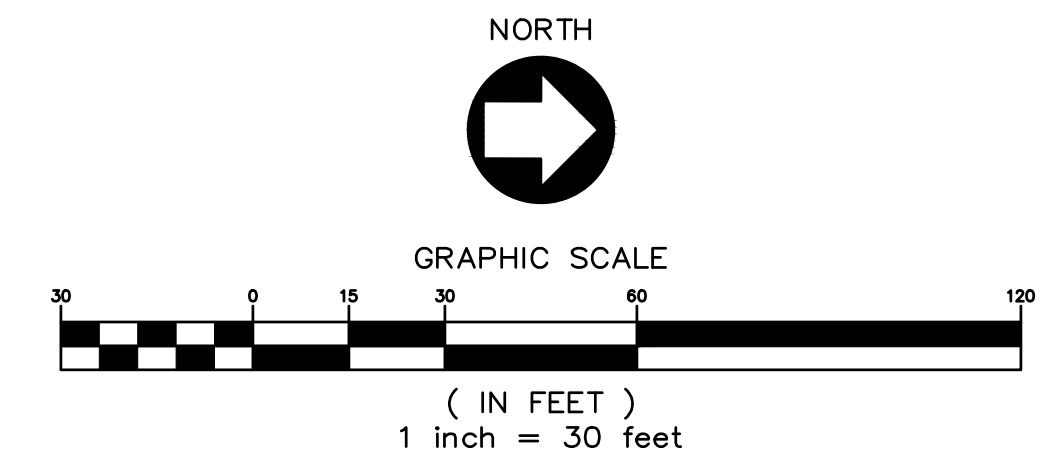
TYPE	DESCRIPTION
BF	BACKFLOW PREVENTION DEVICE PER DETAIL 3/C4.1
CB	CATCH BASIN PER DETAIL 2/C4.1
FCMH	FLOW CONTROL MANHOLE PER DETAIL 5/C4.1
FV	FIRE VAULT PER DETAIL 614/C4.2
MH	MANHOLE PER DETAIL 010/C4.2
WQV	WATER QUALITY VAULT
WM	WATER METER PER DETAIL 634/C4.1

LEGEND



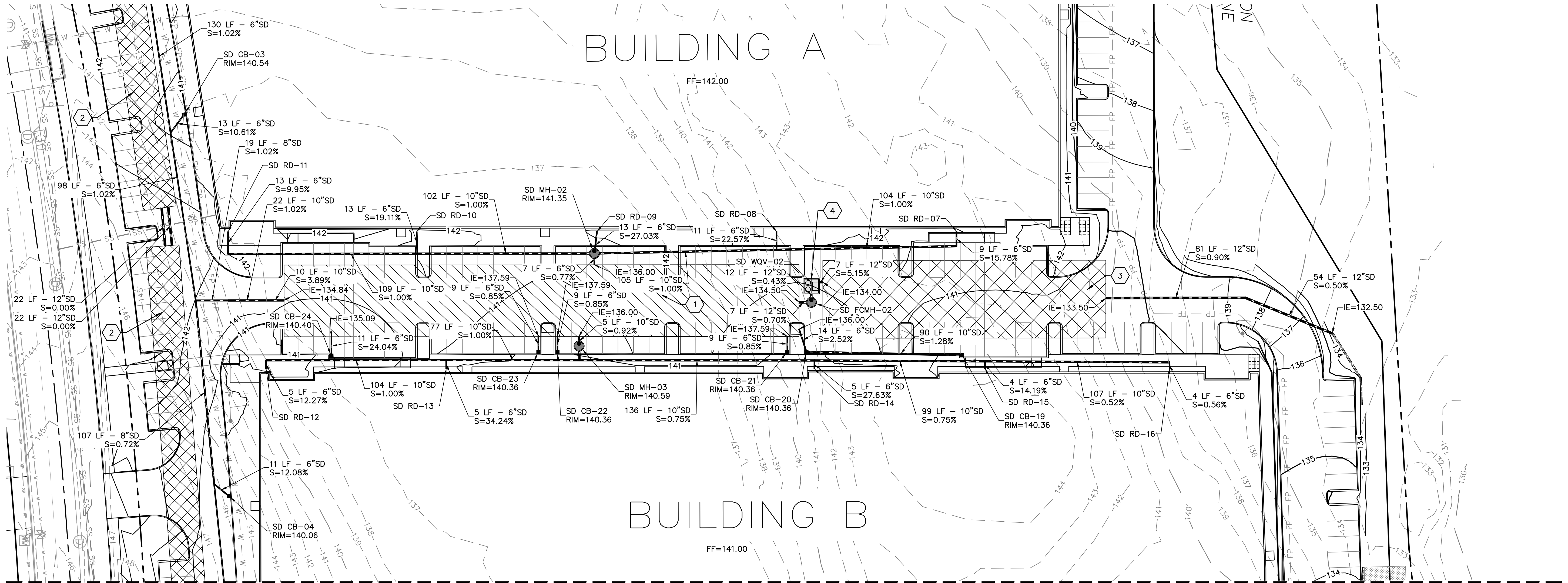
STORM NOTES

- INSTALL CULTEC CHAMBERS (SYSTEM #2). REFER TO MANUFACTURER'S DETAILS FOR SPECIFICATION.
- INSTALL CULTECH CHAMBERS FOR FLOOD STORAGE DIVIDED INTO TWO SECTIONS (SYSTEM #1F). REFER TO MANUFACTURER'S DETAILS FOR SPECIFICATIONS.
- INSTALL CULTECH CHAMBERS FOR FLOOD STORAGE (SYSTEM #2F). REFER TO MANUFACTURER'S DETAILS FOR SPECIFICATIONS.
- INSTALL MODULAR WETLANDS VAULT PER DETAIL ON SHEET C4.3.



**PHELAN**  
 ENGINEERING  
 450 Newport Center Drive, Suite 405  
 Newport Beach, CA 92660

HEDGES CREEK  
 TUALATIN, OR



SHEET TITLE

STORM PLAN

DATE: 08/02/2021

DRAWN: KPM

CHECKED: CNH

REVISIONS:

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SHEET NUMBER

C3.3

JOB NUMBER: A20120.10

3/01/2022



SHEET NOTES

- ALL SANITARY PIPING SHALL BE PVC 3034 OR APPROVED EQUAL UNLESS NOTED OTHERWISE.
- THIS PLAN IS GENERALLY DIAGRAMMATIC. IT DOES NOT SHOW EVERY JOINT, BEND, FITTING, OR ACCESSORY REQUIRED FOR CONSTRUCTION.
- CLEAN OUTS SHALL BE INSTALLED IN CONFORMANCE WITH UPC CHAPTER SEVEN, SECTION 707 AND SECTION 719. THIS PLAN MAY NOT SHOW ALL REQUIRED CLEAN OUTS.
- DOMESTIC WATER AND FIRE LINES AND ACCESSORIES BETWEEN THE WATER METER AND THE BUILDING SHALL BE INSTALLED BY A LICENSED PLUMBER EMPLOYED BY A LICENSED PLUMBING CONTRACTOR.
- UTILITIES WITHIN FIVE FEET OF A BUILDING SHALL BE CONSTRUCTED OF MATERIALS APPROVED FOR INTERIOR USE AS DESCRIBED IN THE CURRENT EDITION OF THE UPC.
- INLETS AND OUTLETS TO ON-SITE MANHOLES SHALL HAVE FLEXIBLE CONNECTION NO CLOSER THAN 12" AND NO FARTHER THAN 36" FROM THE MANHOLE.
- CONTRACTOR TO VERIFY SANITARY AND WATER SIZING AND INVERTS WITH APPROVED PLUMBING PLANS PRIOR TO ORDERING MATERIALS OR BEGINNING CONSTRUCTION OF SAID UTILITIES.
- ALL STORM AND SANITARY FITTINGS TO BE ECCENTRIC FITTINGS UNLESS OTHERWISE NOTED.

LABEL LEGEND

PIPE LABELS

UTILITY LENGTH  
UTILITY SIZE  
XXLF - XX" XX — UTILITY TYPE  
S=X.XX% — SLOPE (WHERE APPLICABLE)

STRUCTURE LABELS

UTILITY TYPE (FP=FIRE PROTECTION, S=SANITARY, SD=STORM DRAINAGE, W=WATER)  
STRUCTURE TYPE (SEE BELOW)  
XX XX-XX — ID NUMBER (WHERE APPLICABLE)  
RIM=XX.XX — STRUCTURE INFO (WHERE APPLICABLE)

STRUCTURE TYPES

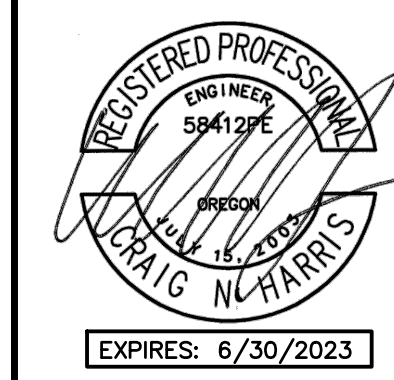
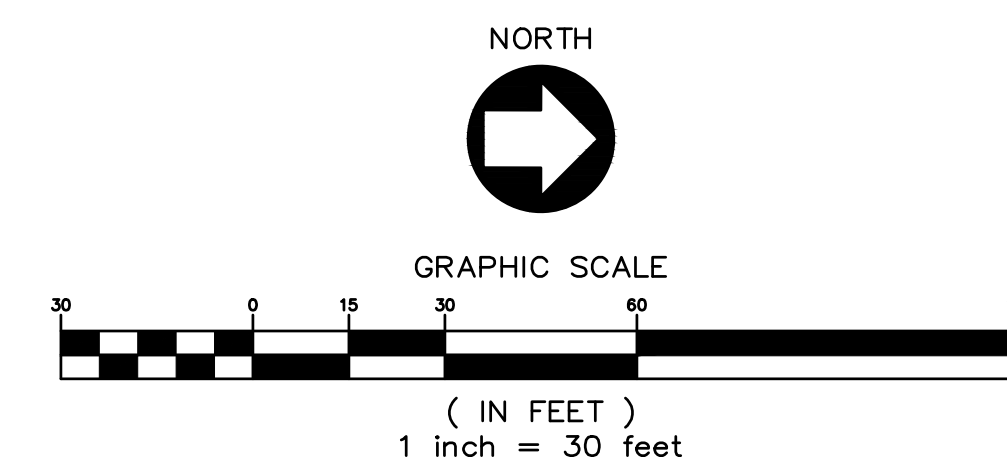
TYPE	DESCRIPTION
BF	BACKFLOW PREVENTION DEVICE PER DETAIL 3/C4.1
CB	CATCH BASIN PER DETAIL 2/C4.1
FCMH	FLOW CONTROL MANHOLE PER DETAIL 5/C4.1
FV	FIRE VAULT PER DETAIL 614/C4.2
MH	MANHOLE PER DETAIL 010/C4.2
WQV	WATER QUALITY VAULT
WM	WATER METER PER DETAIL 634/C4.1

LEGEND

SANITARY SEWER LINE — SS — SS — SS —  
WATER LINE — W — W — W —  
FIRE LINE — FP — FP — FP — FP —  
FDC LINE — FDC — FDC — FDC —  
STORM LINE — — — — —

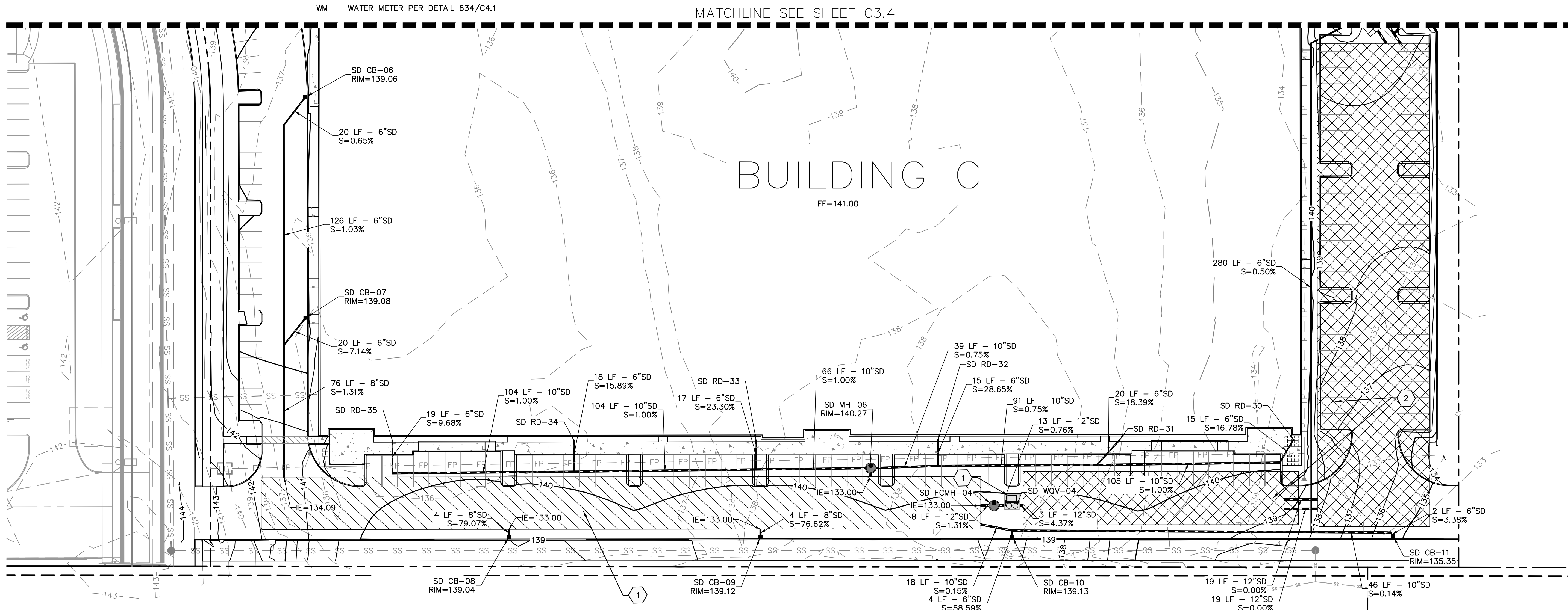
STORM NOTES

- INSTALL CULTEC CHAMBERS (SYSTEM #4). REFER TO MANUFACTURER'S DETAILS FOR SPECIFICATIONS.
- INSTALL CULTECH CHAMBERS FOR FLOOD STORAGE DIVIDED INTO FOUR SECTIONS (SYSTEM #3F). REFER TO MANUFACTURER'S DETAILS FOR SPECIFICATIONS.
- INSTALL MODULAR WETLANDS VAULT PER DETAIL ON SHEET C4.4.



AAI ENGINEERING INC.  
4875 SW Center Drive, Suite 100, Beaverton, OR 97005  
503.638.0888 Fax 503.638.0888

**PHELAN**  
ENGINEERING  
450 Newport Center Drive, Suite 405  
Newport Beach, CA 92660



SHEET TITLE  
**STORM PLAN**

DATE: 08/02/2021  
DRAWN: KPM  
CHECKED: CNH

REVISIONS:

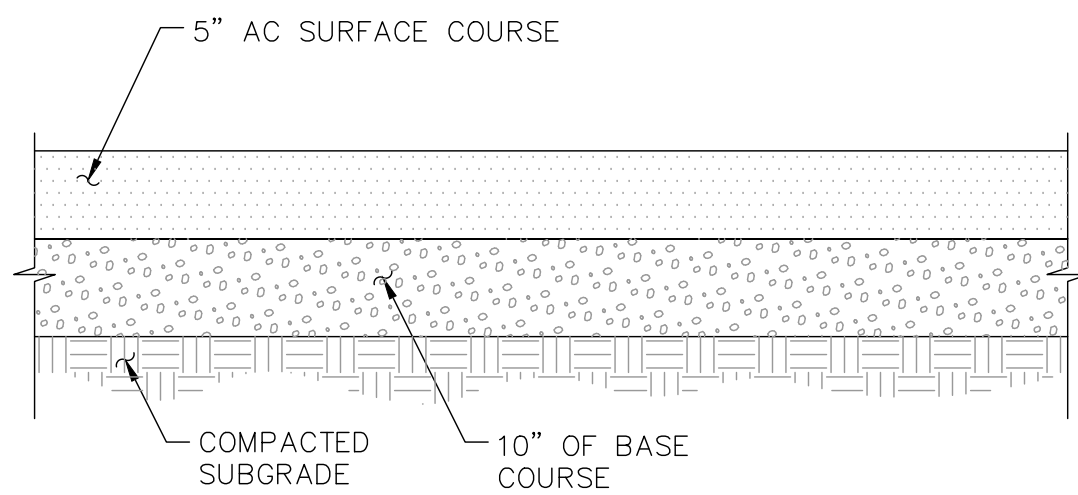
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SHEET NUMBER  
**C3.5**

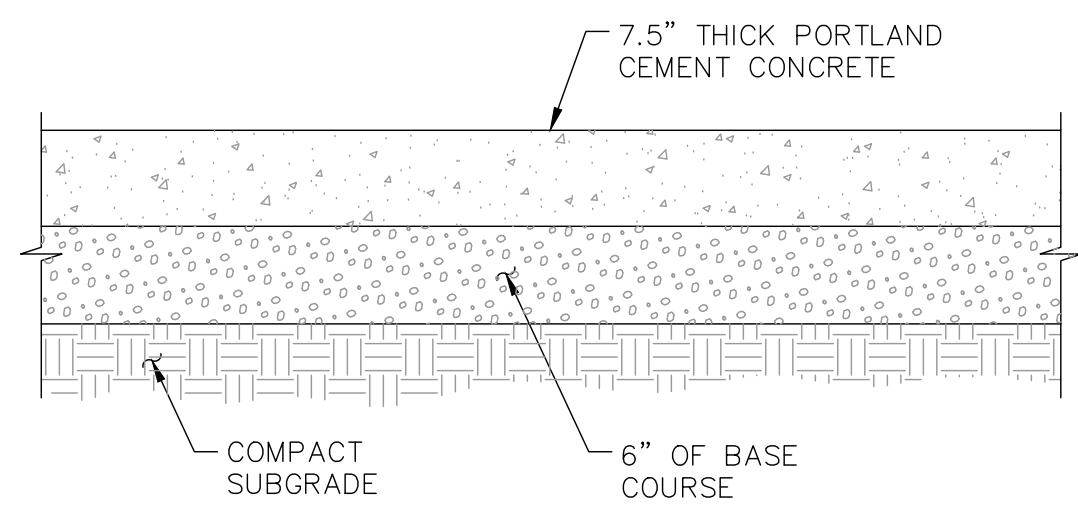
3/01/2022

JOB NUMBER: A20120.10

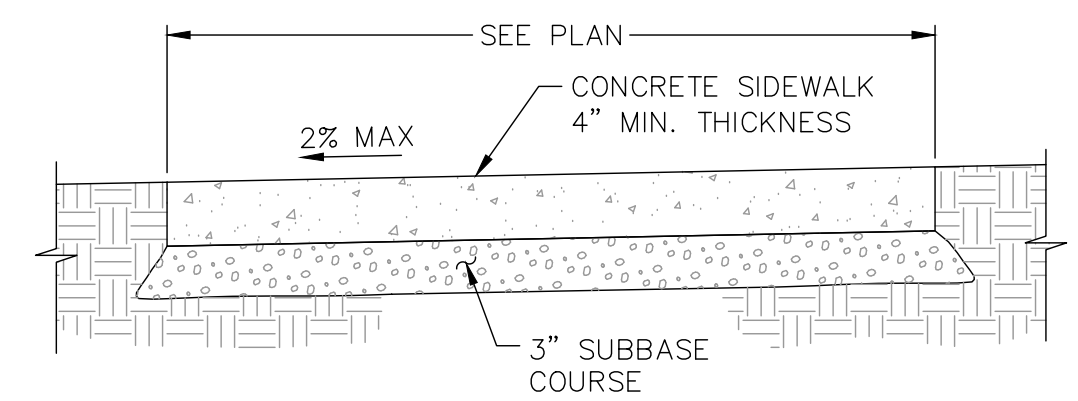
F:\2020\A20120.10 - Walgroves\Civil\Cad\Sheets\A20120.C30.UTILITY.dwg : May 17, 22 - 2:04 PM thornlmc



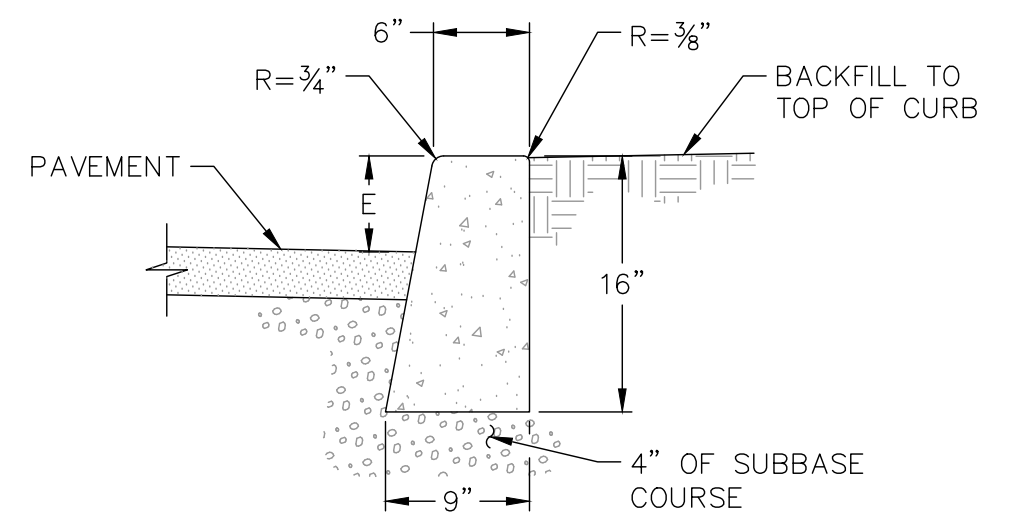
1 STANDARD ASPHALT PAVEMENT SECTION  
SCALE: NTS



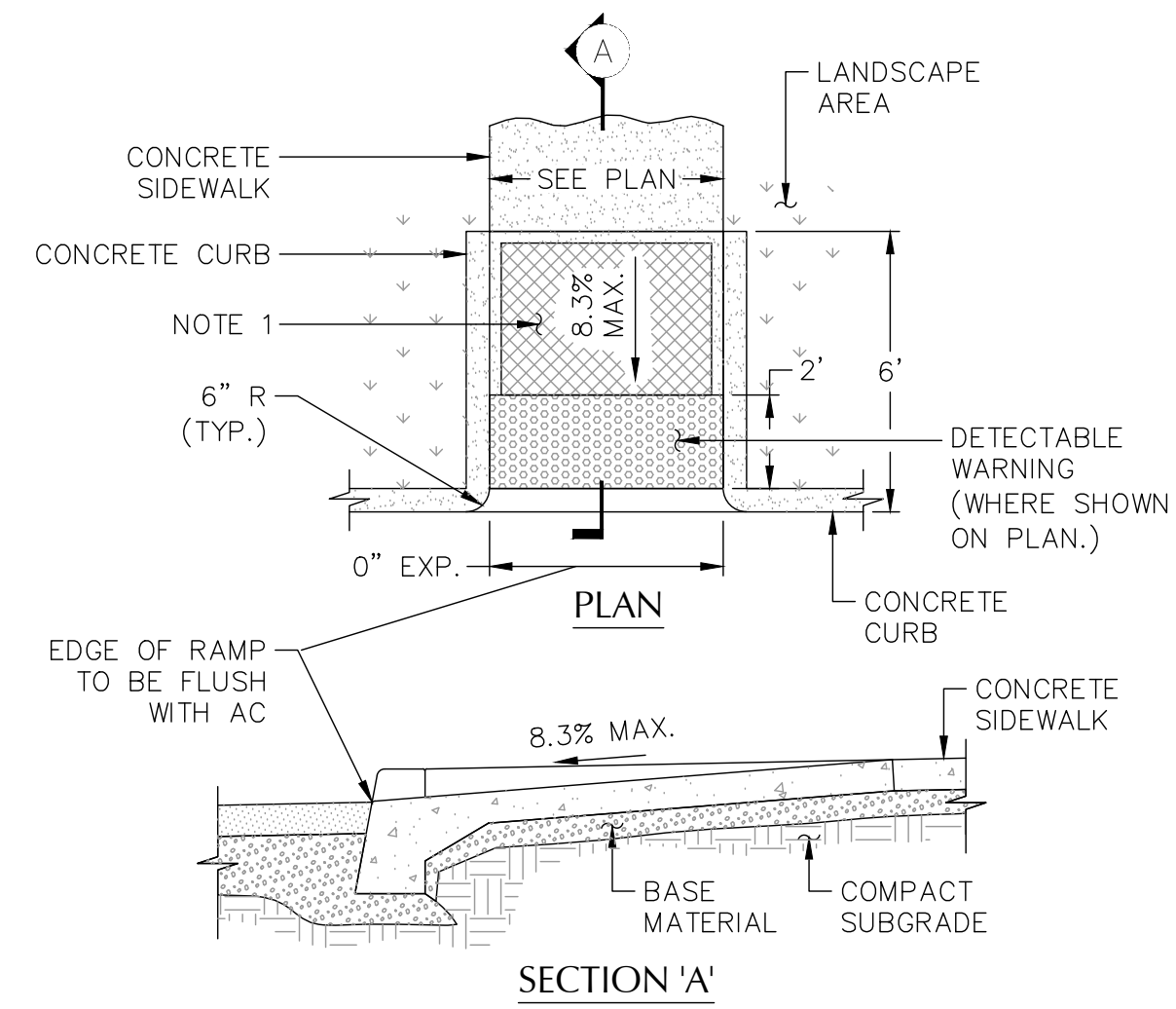
2 CONCRETE PAVEMENT SECTION  
SCALE: NTS



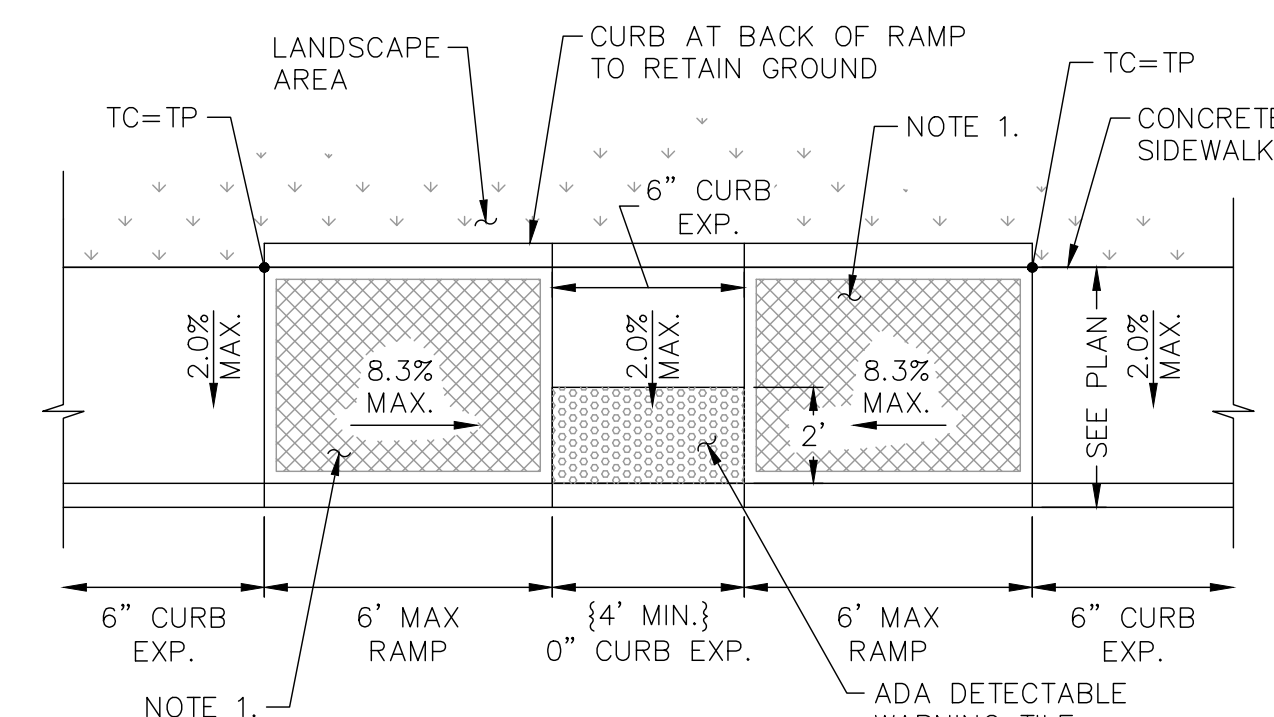
3 CONCRETE SIDEWALK  
SCALE: NTS



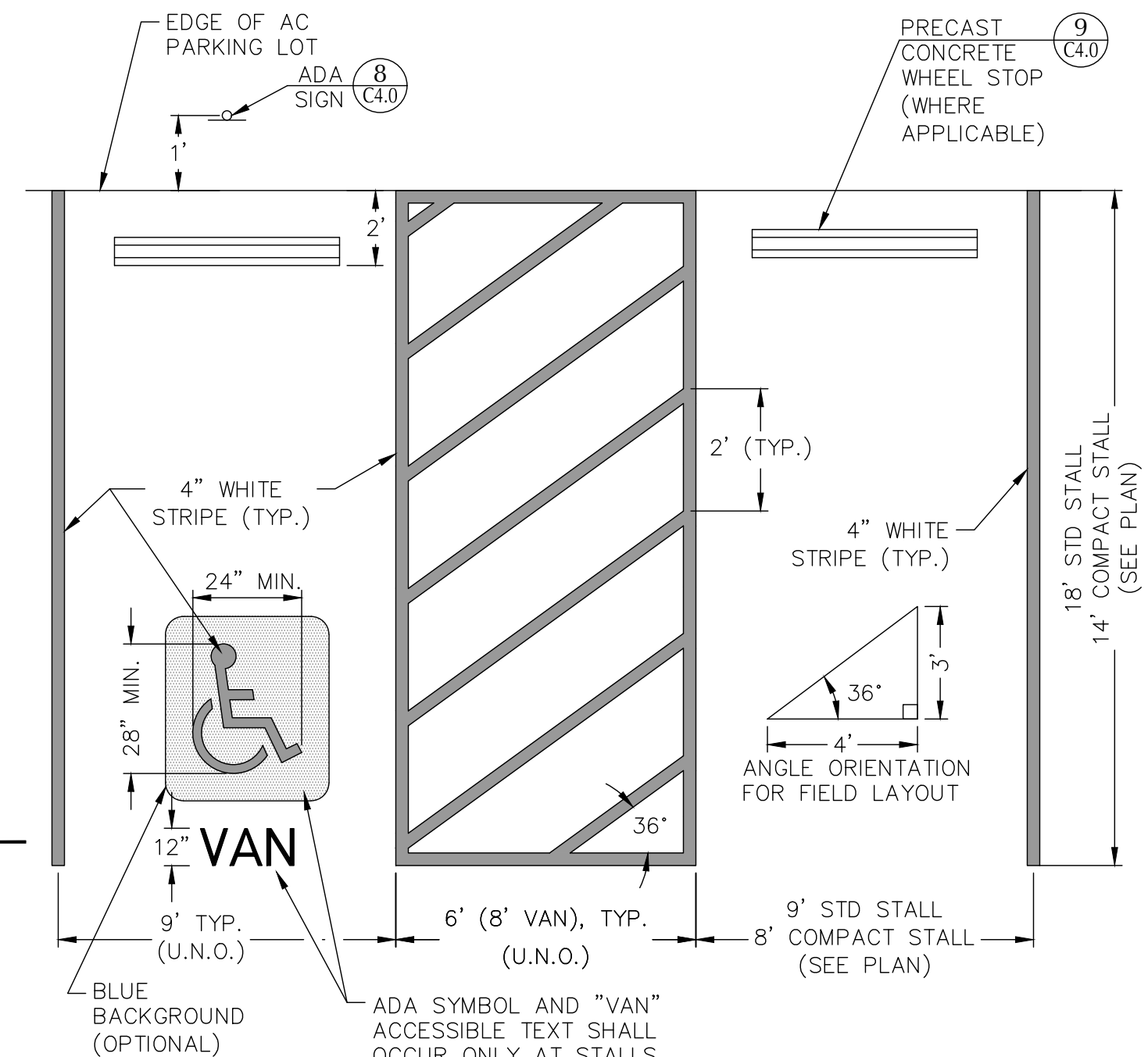
4 CONCRETE CURB - STANDARD  
SCALE: NTS



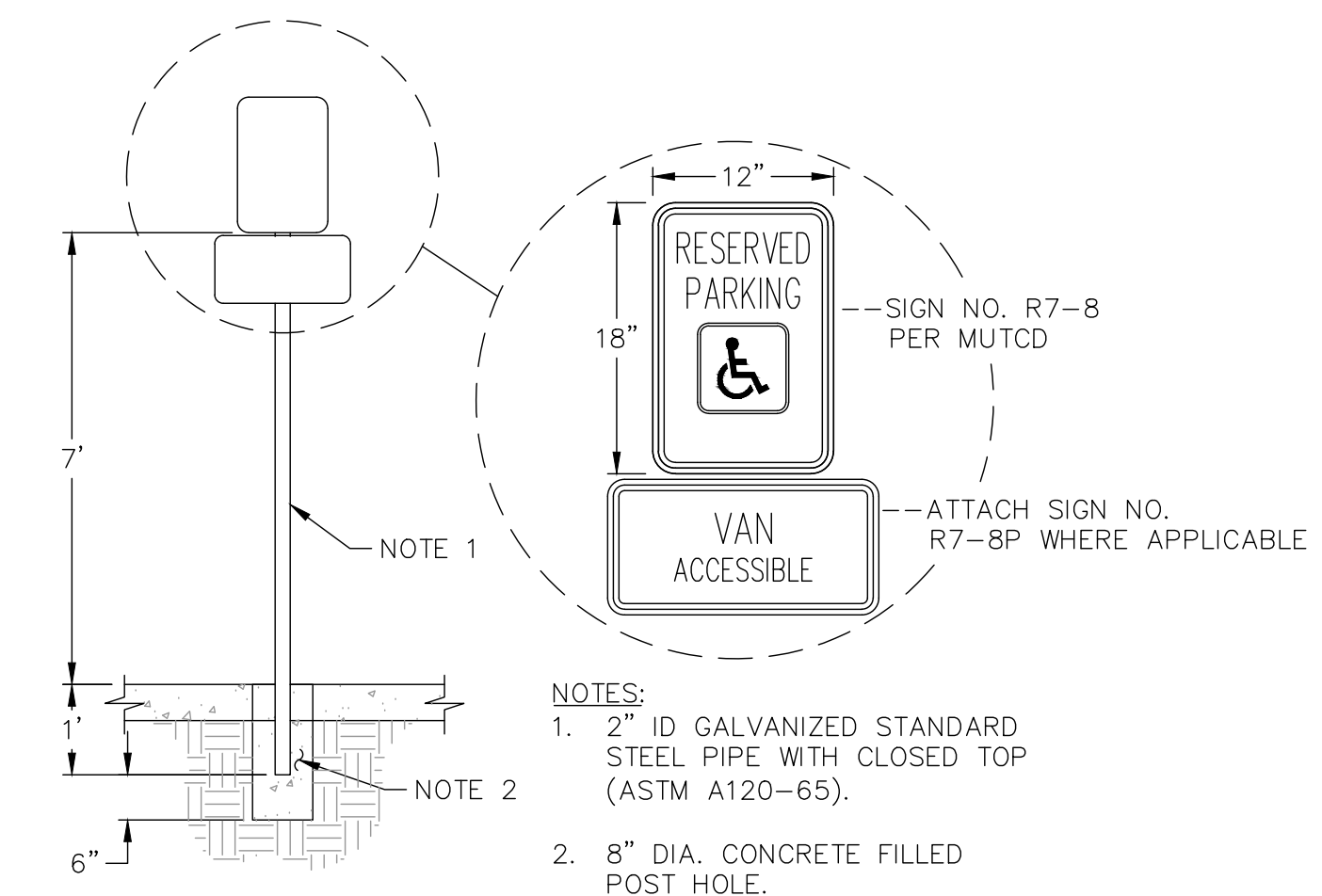
5 CURB RAMP - TYPE 2  
SCALE: NTS



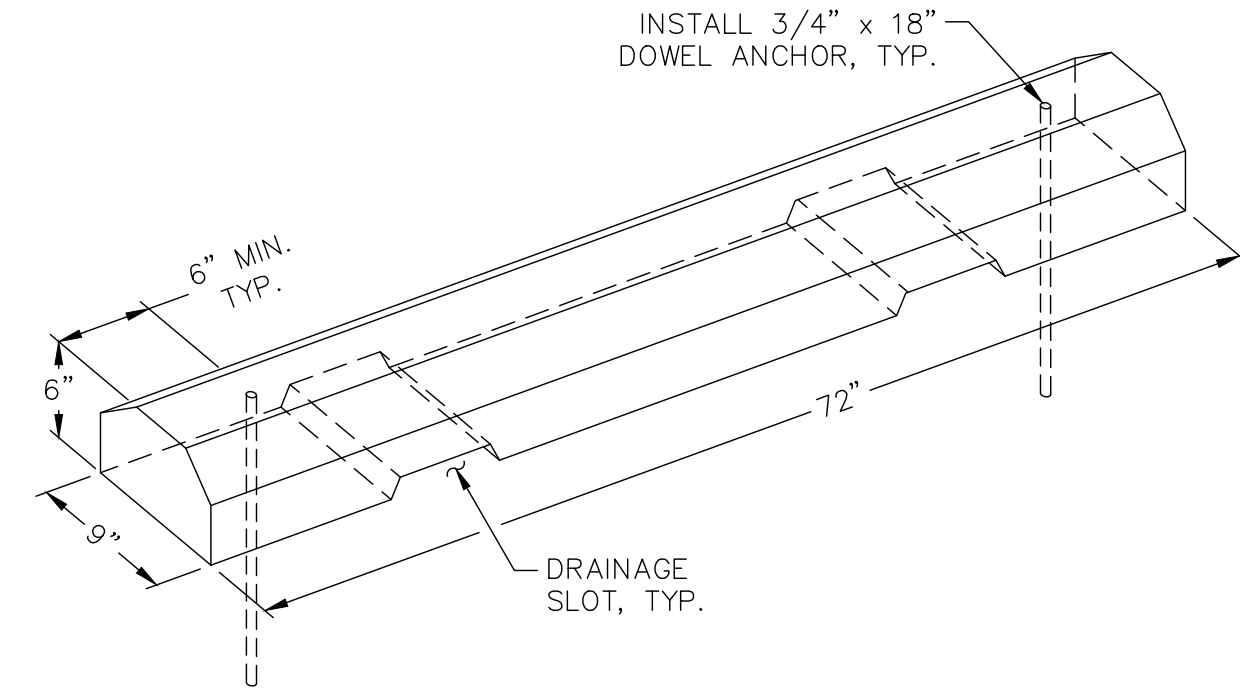
6 CURB RAMP - TYPE 5  
SCALE: NTS



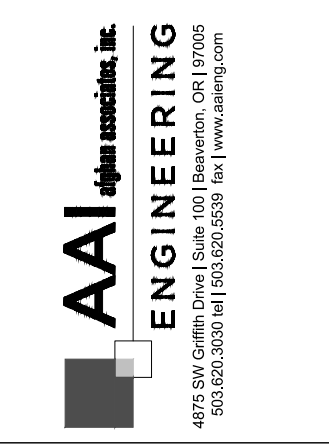
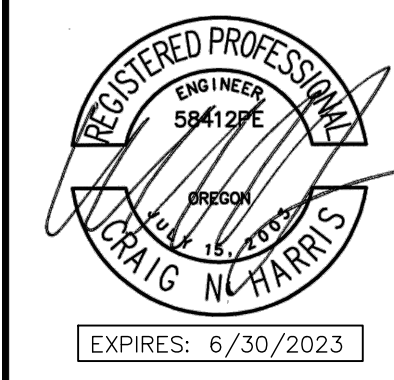
7 TYPICAL PARKING LAYOUT  
SCALE: NTS



8 ADA PARKING SIGN - TYPE 1  
SCALE: NTS



9 PRECAST CONCRETE WHEEL STOP  
SCALE: NTS

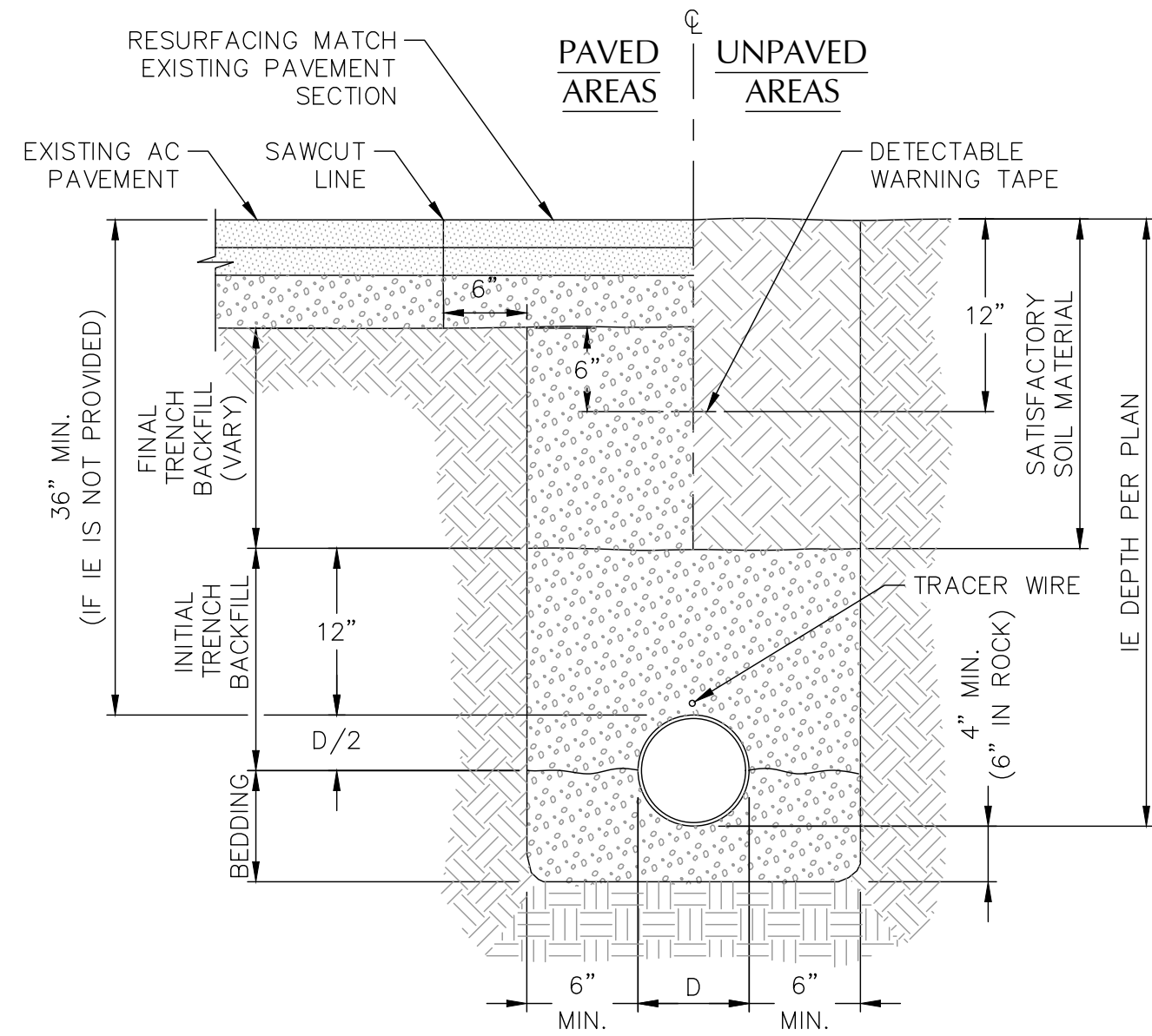


HEDGES CREEK  
TUALATIN, OR

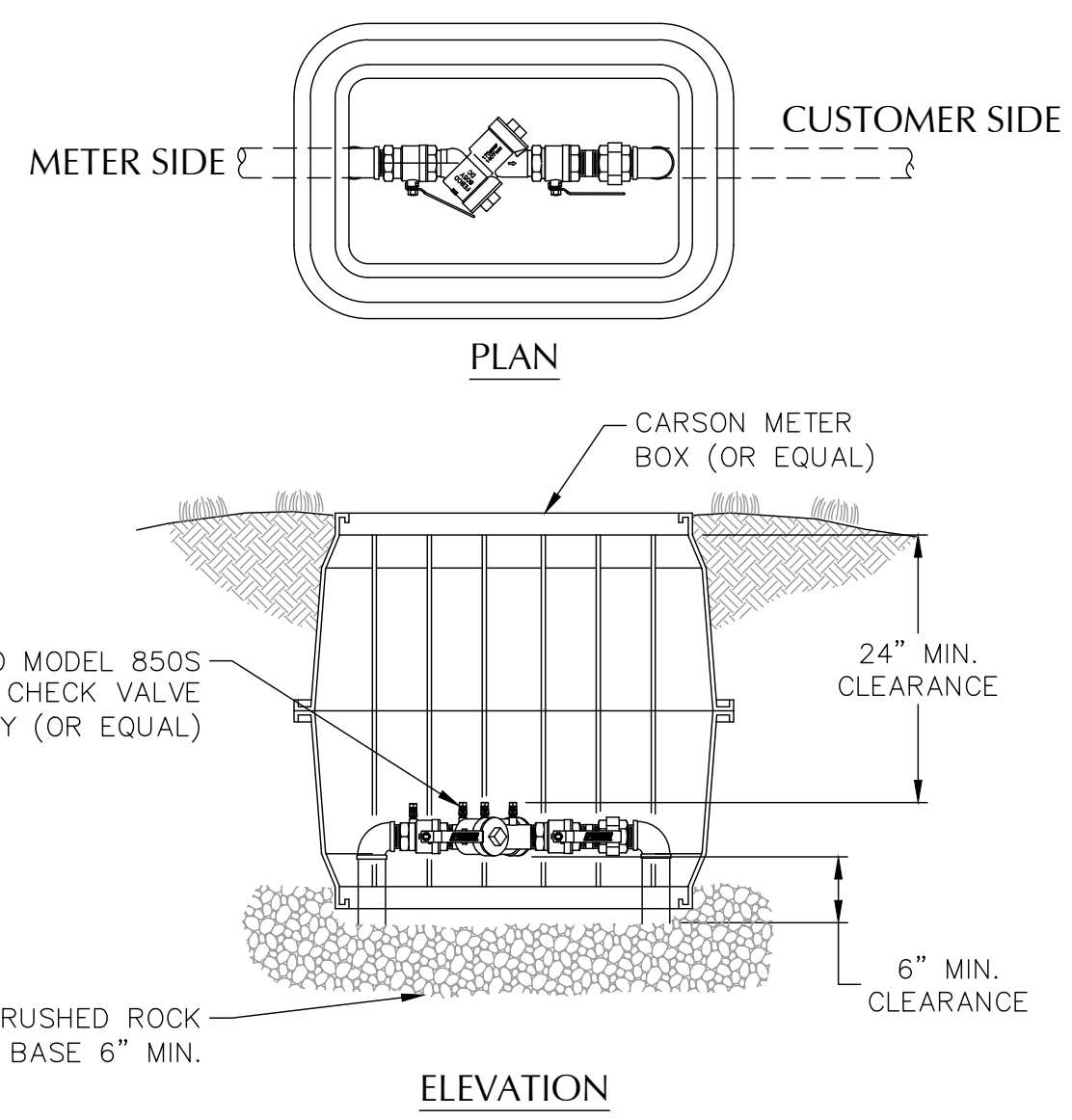
SHEET TITLE  
DETAILS  
DATE: 08/02/2021  
DRAWN: KPM  
CHECKED: CNH  
REVISIONS:

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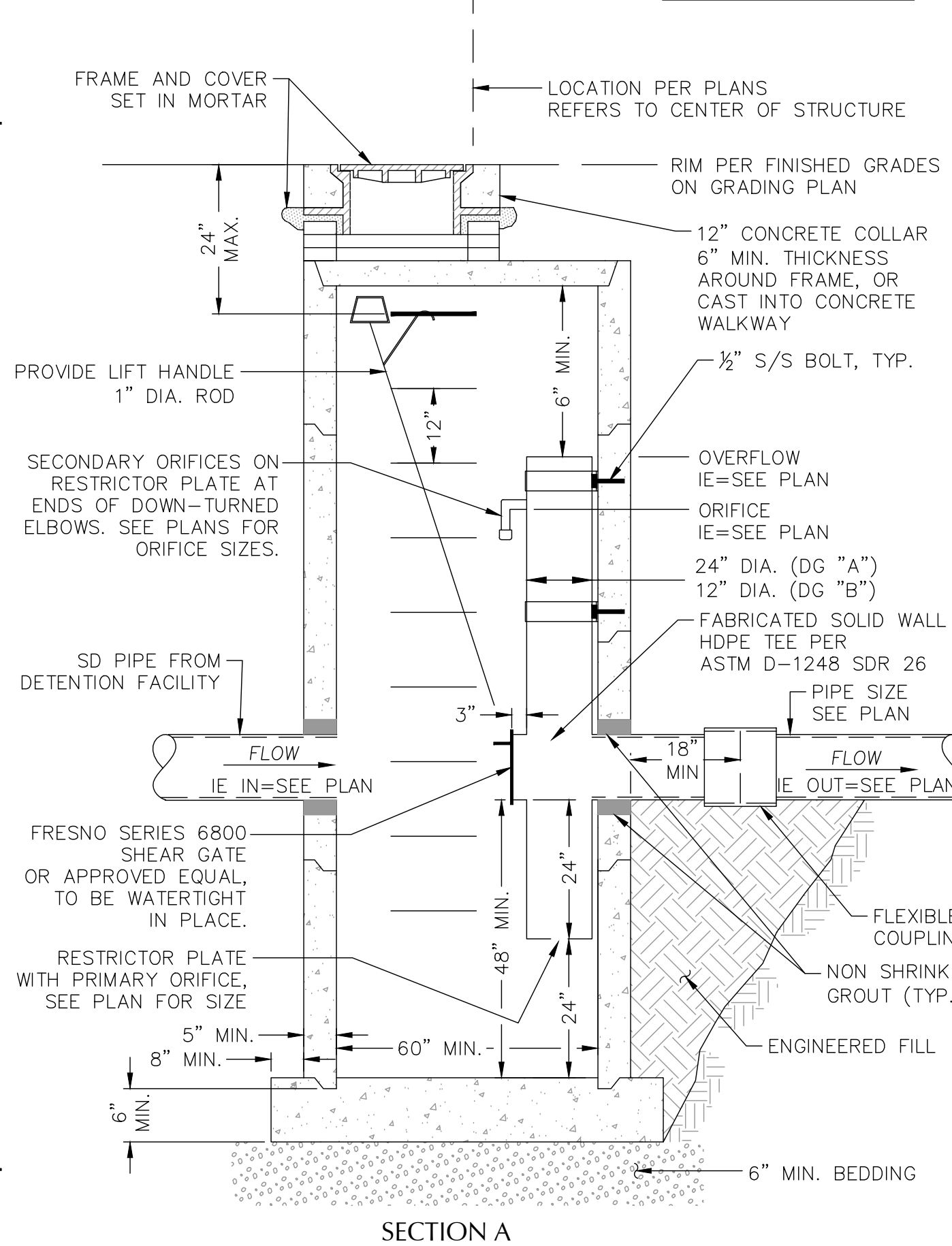
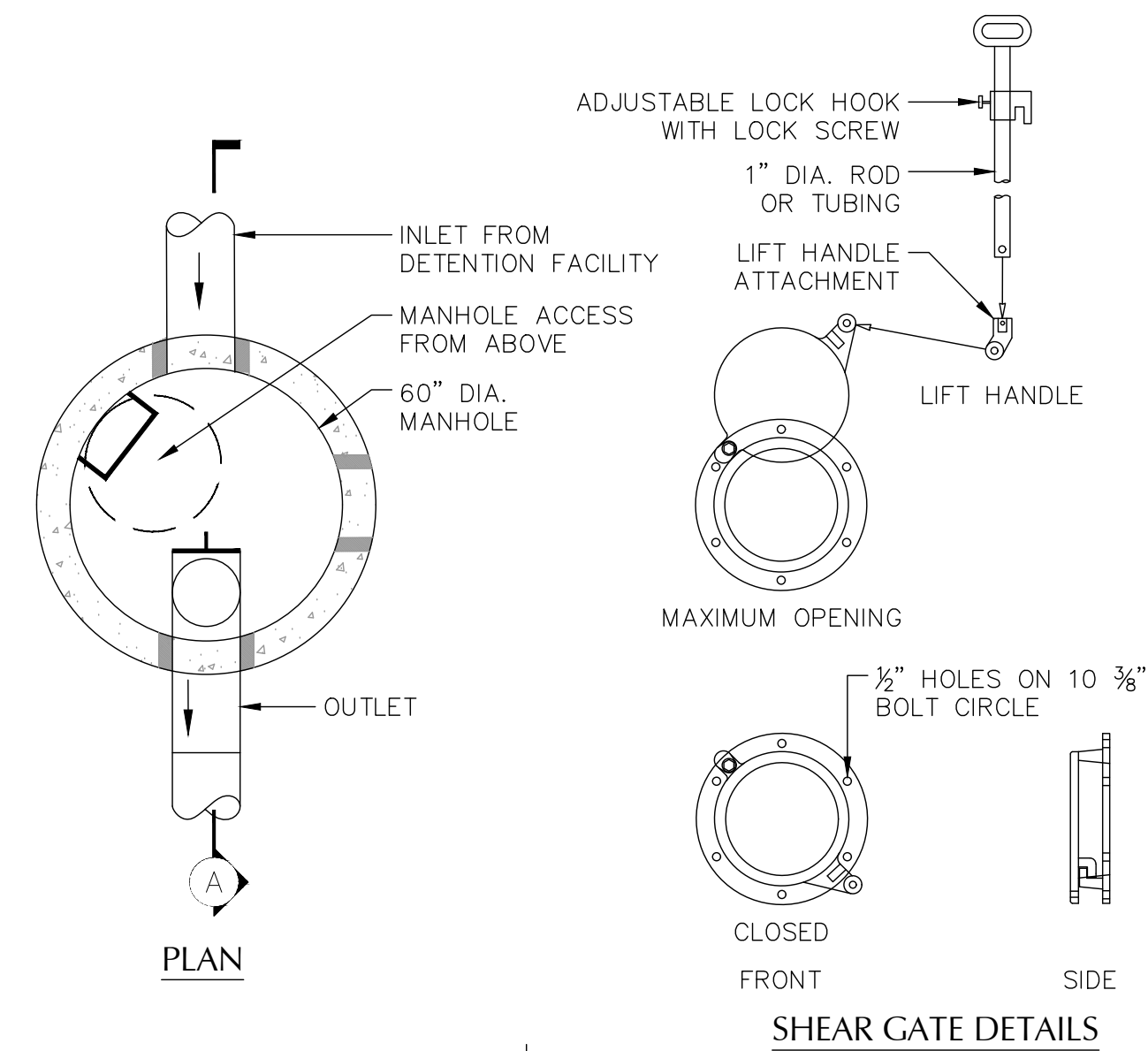
SHEET NUMBER  
C4.0



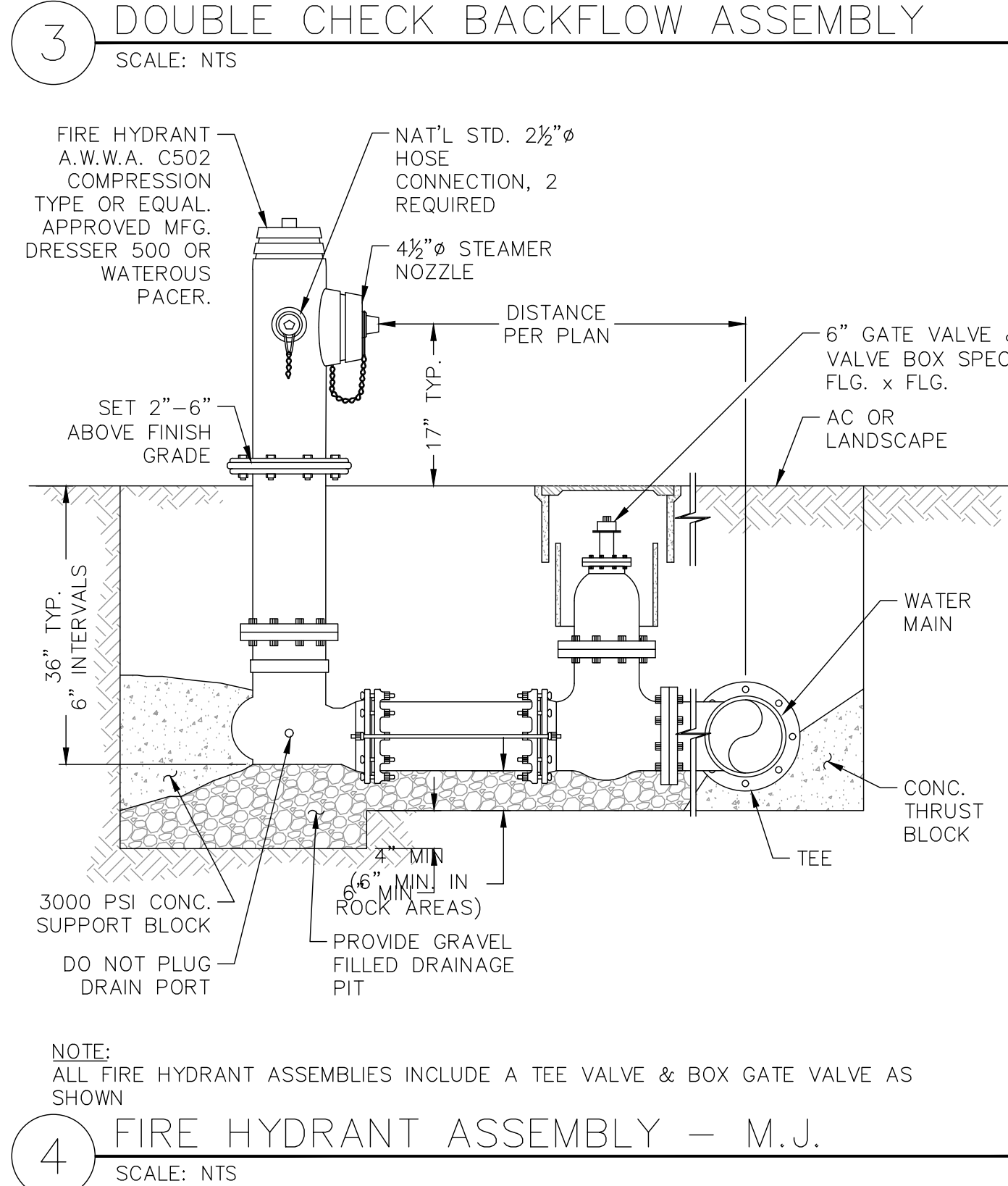
1 TYPICAL PIPE BEDDING AND BACKFILL  
SCALE: NTS



2 DOUBLE CHECK BACKFLOW ASSEMBLY  
SCALE: NTS



3 SHEAR GATE DETAILS  
SCALE: NTS



4 FIRE HYDRANT ASSEMBLY - M.J.  
SCALE: NTS



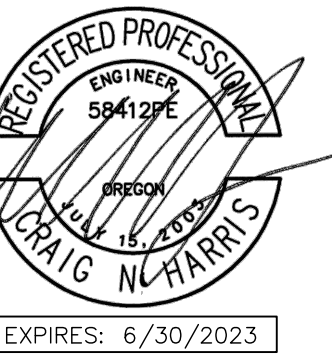
5 FLOW CONTROL MANHOLE  
SCALE: NTS

6 TRAPPED CATCH BASIN  
SCALE: NTS

7 DOUBLE CHECK BACKFLOW ASSEMBLY  
SCALE: NTS

8 FIRE HYDRANT ASSEMBLY - M.J.  
SCALE: NTS

9 SHEAR GATE DETAILS  
SCALE: NTS

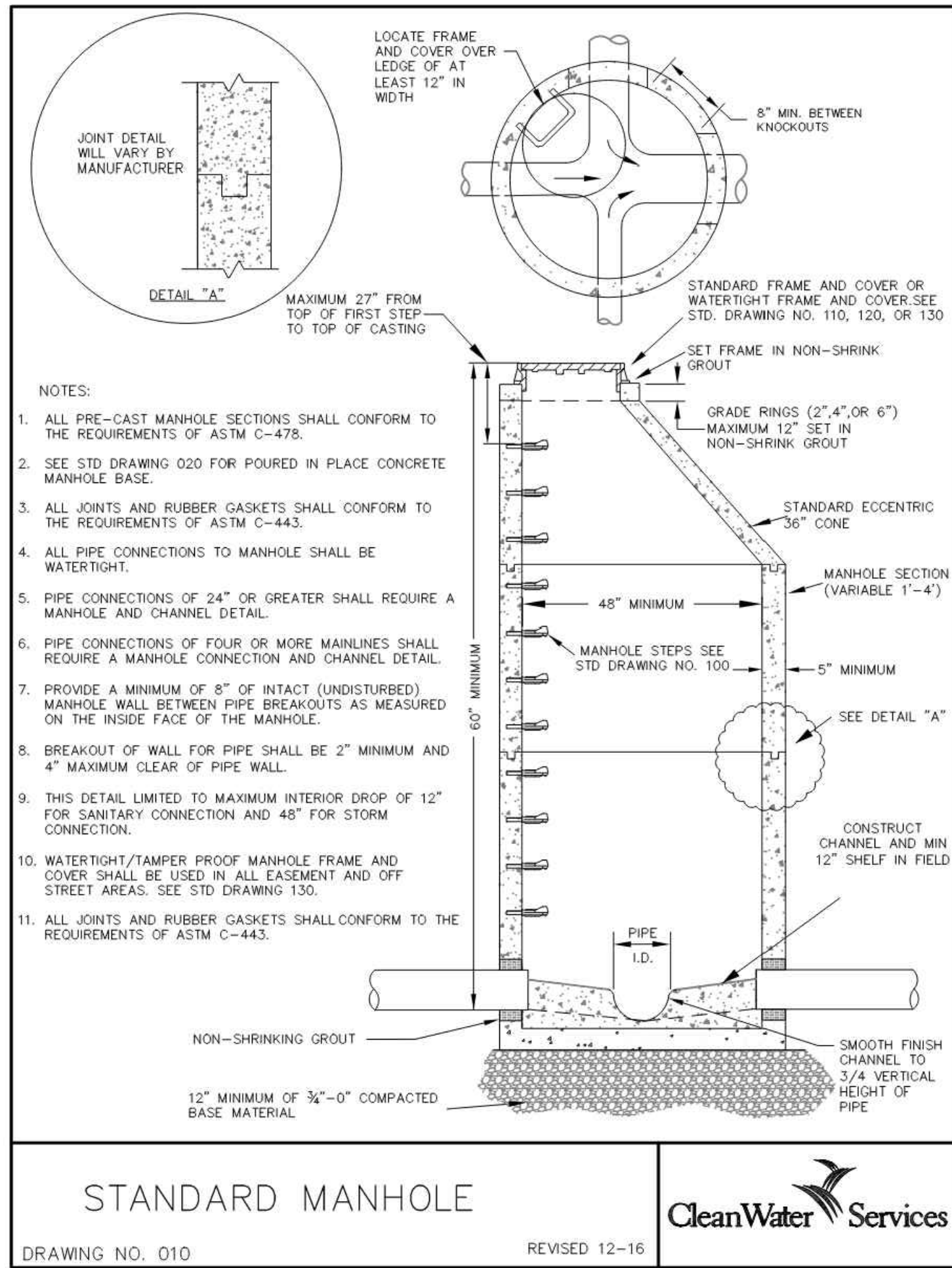


HEDGES CREEK  
TUALATIN, OR

SHEET TITLE  
DETAILS  
DATE: 08/02/2021  
DRAWN: KPM  
CHECKED: CNH  
REVISIONS:

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SHEET NUMBER

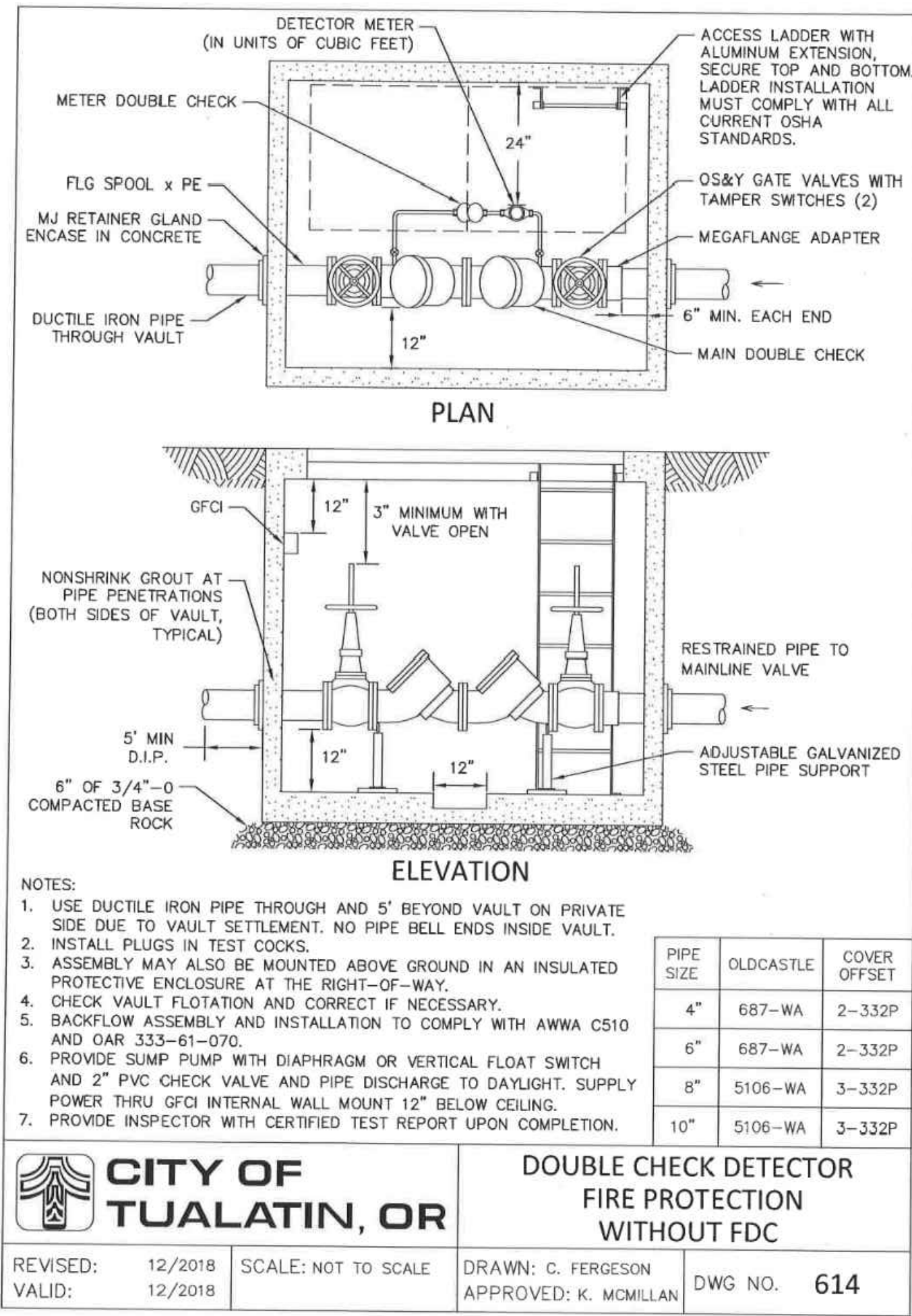
C4.1



STANDARD MANHOLE

DRAWING NO. 010

REVISED 12-16



CITY OF TUALATIN, OR

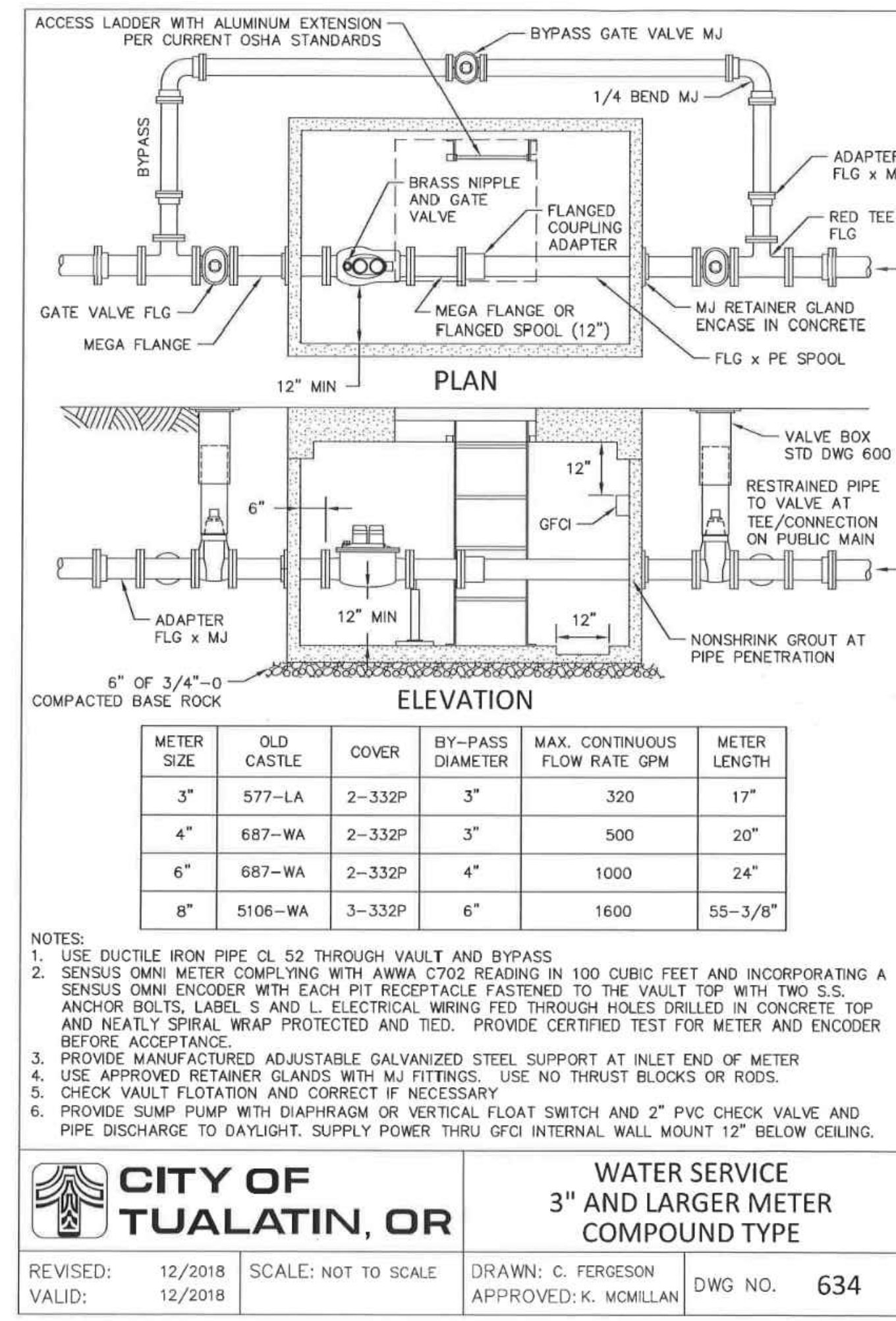
DOUBLE CHECK DETECTOR FIRE PROTECTION WITHOUT FDC

REVISED: 12/2018  
VALID: 12/2018

SCALE: NOT TO SCALE

DRAWN: C. FERGESON  
APPROVED: K. MCMILLAN

DWG NO. 614



CITY OF TUALATIN, OR

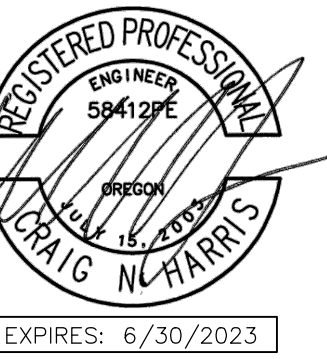
WATER SERVICE 3" AND LARGER METER COMPOUND TYPE

REVISED: 12/2018  
VALID: 12/2018

SCALE: NOT TO SCALE

DRAWN: C. FERGESON  
APPROVED: K. MCMILLAN

DWG NO. 634



HEDGES CREEK  
TUALATIN, OR

SHEET TITLE

DETAILS

DATE: 08/02/2021

DRAWN: KPM

CHECKED: CNH

REVISIONS:

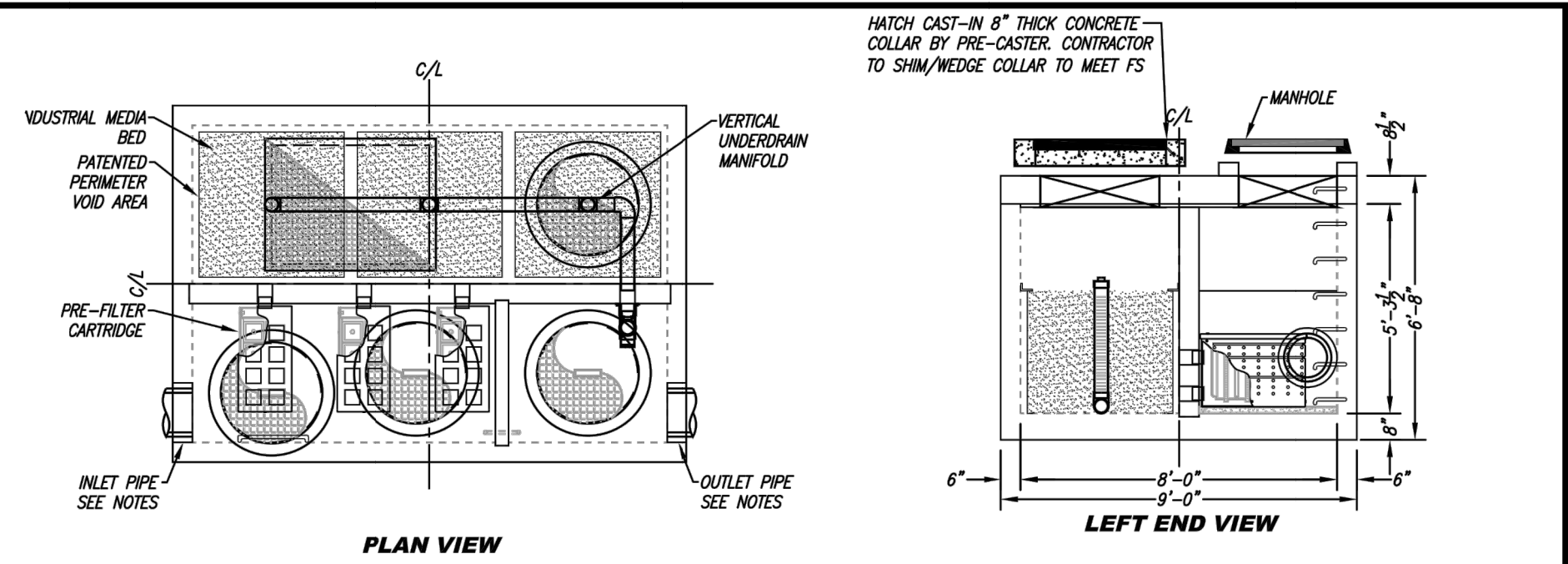
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SHEET NUMBER

C4.2

SITE SPECIFIC DATA			
PROJECT NUMBER	15270		
PROJECT NAME	HEDGES CREEK		
PROJECT LOCATION	TUALATIN, OR		
STRUCTURE ID	SYSTEM #1		
TREATMENT REQUIRED		FLOW BASED (CFS)	
VOLUME BASED (CF)	N/A		
PEAK BYPASS REQUIRED (CFS) - IF APPLICABLE	TBD		
PIPE DATA	I.E.	MATERIAL	DIAMETER
INLET PIPE	1.00	CPEP	12"
OUTLET PIPE	0.00	CPEP	12"
PRE-TREATMENT		BIOFILTRATION	DISCHARGE
RIM ELEVATION	7.00	7.00	7.00
SURFACE LOAD	HS-20	HS-20	HS-20
FRAME & COVER	2EA #30"	36"X48" & #30"	#30"
WETLANDMEDIA VOLUME (CY)	4.71		
ORIFICE SIZE (DIA. INCHES)	5 EA #1.41"		
NOTES: INDUSTRIAL MEDIA NEEDED			



- INSTALLATION NOTES**
- CONTRACTOR TO PROVIDE ALL LABOR, EQUIPMENT, MATERIALS AND INCIDENTALS REQUIRED TO OFFLOAD AND INSTALL THE SYSTEM AND APPURTENANCES IN ACCORDANCE WITH THIS DRAWING AND THE MANUFACTURER'S SPECIFICATIONS, UNLESS OTHERWISE STATED IN MANUFACTURER'S CONTRACT.
  - UNIT MUST BE INSTALLED ON LEVEL BASE. MANUFACTURER RECOMMENDS A MINIMUM 6" LEVEL ROCK BASE UNLESS SPECIFIED BY THE PROJECT ENGINEER. CONTRACTOR IS RESPONSIBLE FOR VERIFYING PROJECT ENGINEER'S RECOMMENDED BASE SPECIFICATIONS.
  - CONTRACTOR TO SUPPLY AND INSTALL ALL EXTERNAL CONNECTING PIPES. ALL PIPES MUST BE FLUSH WITH INSIDE SURFACE OF CONCRETE (PIPES CANNOT INTRUDE BEYOND FLUSH). INVERT OF OUTFLOW PIPE MUST BE FLUSH WITH DISCHARGE CHAMBER FLOOR. ALL PIPES SHALL BE SEALED WATERIGHT PER MANUFACTURER'S STANDARD CONNECTION DETAIL.
  - CONTRACTOR RESPONSIBLE FOR INSTALLATION OF ALL PIPES, RISERS, MANHOLES, AND HATCHES. CONTRACTOR TO GROUT ALL MANHOLES AND HATCHES TO MATCH FINISHED SURFACE UNLESS SPECIFIED OTHERWISE.
  - VEGETATION SUPPLIED AND INSTALLED BY OTHERS. ALL UNITS WITH VEGETATION MUST HAVE DRIP OR SPRAY IRRIGATION SUPPLIED AND INSTALLED BY OTHERS.
  - CONTRACTOR RESPONSIBLE FOR CONTACTING BIO CLEAN FOR ACTIVATION OF UNIT. MANUFACTURER'S WARRANTY IS VOID WITHOUT PROPER ACTIVATION BY A BIO CLEAN REPRESENTATIVE.

**GENERAL NOTES**

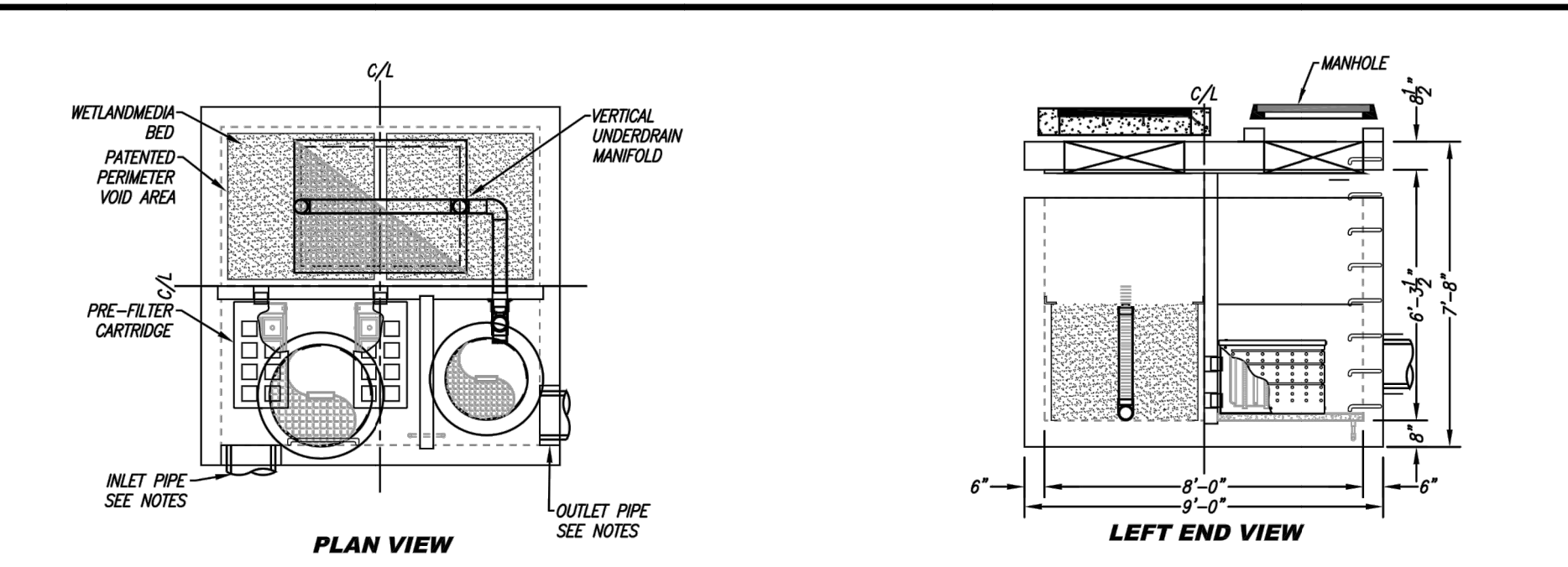
- MANUFACTURER TO PROVIDE ALL MATERIALS UNLESS OTHERWISE NOTED.
- ALL DIMENSIONS, ELEVATIONS, SPECIFICATIONS AND CAPACITIES ARE SUBJECT TO CHANGE. FOR PROJECT SPECIFIC DRAWINGS DETAILING EXACT DIMENSIONS, WEIGHTS AND ACCESSORIES PLEASE CONTACT BIO CLEAN.

**INTERNAL BYPASS DISCLOSURE:**  
THE DESIGN AND CAPACITY OF THE PEAK CONVEYANCE METHOD TO BE REVIEWED AND APPROVED BY THE ENGINEER OF RECORD. HGL(S) AT PEAK FLOW SHALL BE ASSESSED TO ENSURE NO UPSTREAM FLOODING. PEAK HGL AND BYPASS CAPACITY SHOWN ON DRAWING ARE USED FOR GUIDANCE ONLY.

TREATMENT FLOW (CFS)	0.320
OPERATING HEAD (FT)	3.1
PRE-TREATMENT LOADING RATE (GPM/SF)	1.9
INDUSTRIAL MEDIA LOADING RATE (GPM/SF)	1.0

**MWS-L-8-12-5'-4"-V-UG**  
 STORMWATER BIOFILTRATION SYSTEM  
 STANDARD DETAIL

SITE SPECIFIC DATA			
PROJECT NUMBER	15270		
PROJECT NAME	HEDGES CREEK		
PROJECT LOCATION	TUALATIN, OR		
STRUCTURE ID	SYSTEM #2		
TREATMENT REQUIRED		FLOW BASED (CFS)	
VOLUME BASED (CF)	N/A		
PEAK BYPASS REQUIRED (CFS) - IF APPLICABLE	TBD		
PIPE DATA	I.E.	MATERIAL	DIAMETER
INLET PIPE 1	1.00	CPEP	12"
OUTLET PIPE	0.00	CPEP	12"
PRE-TREATMENT		BIOFILTRATION	DISCHARGE
RIM ELEVATION	8.00	8.00	8.00
SURFACE LOAD	HS-20	HS-20	HS-20
FRAME & COVER	#30"	36" X 48"	#24"
WETLANDMEDIA VOLUME (CY)	2.97		
ORIFICE SIZE (DIA. INCHES)	5 EA #1.12"		
NOTES: PRELIMINARY NOT FOR CONSTRUCTION. INDUSTRIAL MEDIA NEEDED			



- INSTALLATION NOTES**
- CONTRACTOR TO PROVIDE ALL LABOR, EQUIPMENT, MATERIALS AND INCIDENTALS REQUIRED TO OFFLOAD AND INSTALL THE SYSTEM AND APPURTENANCES IN ACCORDANCE WITH THIS DRAWING AND THE MANUFACTURER'S SPECIFICATIONS, UNLESS OTHERWISE STATED IN MANUFACTURER'S CONTRACT.
  - UNIT MUST BE INSTALLED ON LEVEL BASE. MANUFACTURER RECOMMENDS A MINIMUM 6" LEVEL ROCK BASE UNLESS SPECIFIED BY THE PROJECT ENGINEER. CONTRACTOR IS RESPONSIBLE FOR VERIFYING PROJECT ENGINEER'S RECOMMENDED BASE SPECIFICATIONS.
  - CONTRACTOR TO SUPPLY AND INSTALL ALL EXTERNAL CONNECTING PIPES. ALL PIPES MUST BE FLUSH WITH INSIDE SURFACE OF CONCRETE (PIPES CANNOT INTRUDE BEYOND FLUSH). INVERT OF OUTFLOW PIPE MUST BE FLUSH WITH DISCHARGE CHAMBER FLOOR. ALL PIPES SHALL BE SEALED WATERIGHT PER MANUFACTURER'S STANDARD CONNECTION DETAIL.
  - CONTRACTOR RESPONSIBLE FOR INSTALLATION OF ALL PIPES, RISERS, MANHOLES, AND HATCHES. CONTRACTOR TO GROUT ALL MANHOLES AND HATCHES TO MATCH FINISHED SURFACE UNLESS SPECIFIED OTHERWISE.
  - VEGETATION SUPPLIED AND INSTALLED BY OTHERS. ALL UNITS WITH VEGETATION MUST HAVE DRIP OR SPRAY IRRIGATION SUPPLIED AND INSTALLED BY OTHERS.
  - CONTRACTOR RESPONSIBLE FOR CONTACTING BIO CLEAN FOR ACTIVATION OF UNIT. MANUFACTURER'S WARRANTY IS VOID WITHOUT PROPER ACTIVATION BY A BIO CLEAN REPRESENTATIVE.

**GENERAL NOTES**

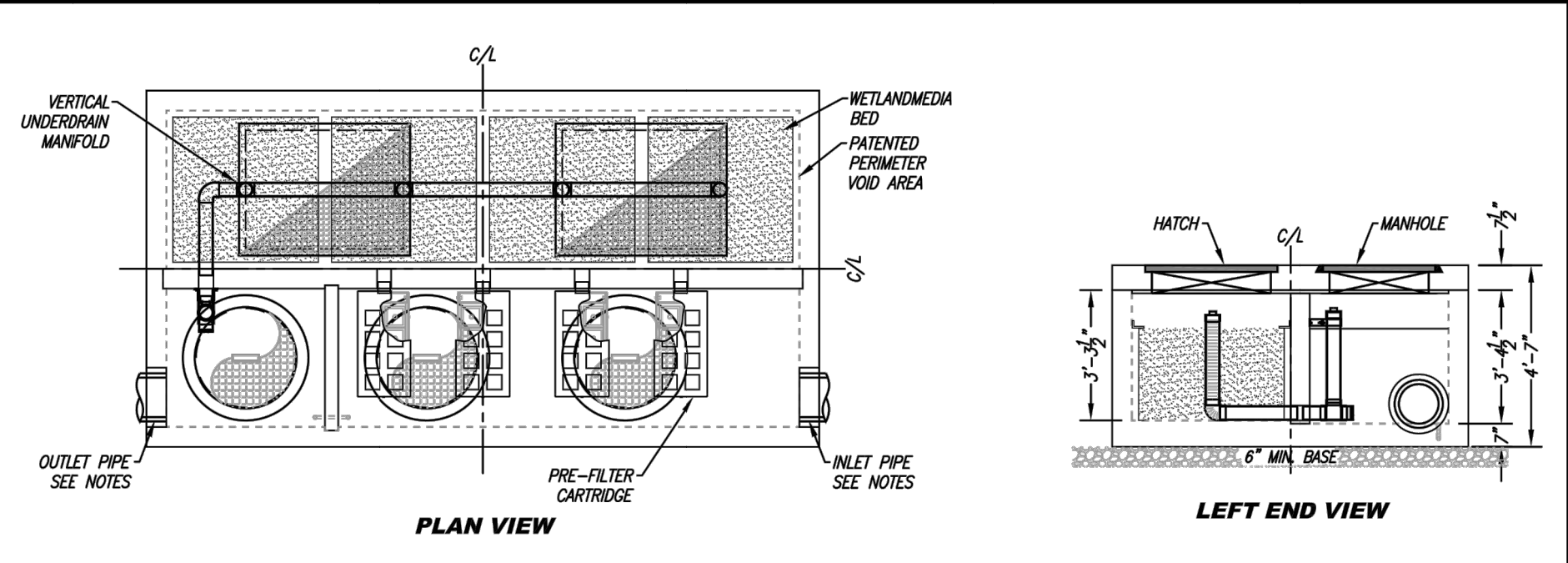
- MANUFACTURER TO PROVIDE ALL MATERIALS UNLESS OTHERWISE NOTED.
- ALL DIMENSIONS, ELEVATIONS, SPECIFICATIONS AND CAPACITIES ARE SUBJECT TO CHANGE. FOR PROJECT SPECIFIC DRAWINGS DETAILING EXACT DIMENSIONS, WEIGHTS AND ACCESSORIES PLEASE CONTACT BIO CLEAN.

**INTERNAL BYPASS DISCLOSURE:**  
THE DESIGN AND CAPACITY OF THE PEAK CONVEYANCE METHOD TO BE REVIEWED AND APPROVED BY THE ENGINEER OF RECORD. HGL(S) AT PEAK FLOW SHALL BE ASSESSED TO ENSURE NO UPSTREAM FLOODING. PEAK HGL AND BYPASS CAPACITY SHOWN ON DRAWING ARE USED FOR GUIDANCE ONLY.

TREATMENT FLOW (CFS)	0.20
OPERATING HEAD (FT)	2.9
PRE-TREATMENT LOADING RATE (GPM/SF)	1.8
INDUSTRIAL MEDIA LOADING RATE (GPM/SF)	1.0

**MWS-L-8-8-6'-4"-V-UG**  
 STORMWATER BIOFILTRATION SYSTEM  
 STANDARD DETAIL

SITE SPECIFIC DATA			
PROJECT NUMBER	15270		
PROJECT NAME	HEDGES CREEK		
PROJECT LOCATION	TUALATIN, OR		
STRUCTURE ID	SYSTEM #3, UNIT1		
TREATMENT REQUIRED		FLOW BASED (CFS)	
VOLUME BASED (CF)	N/A		
PEAK BYPASS REQUIRED (CFS) - IF APPLICABLE	TBD		
PIPE DATA	I.E.	MATERIAL	DIAMETER
INLET PIPE 1	1.00	CPEP	12"
OUTLET PIPE	0.00	CPEP	12"
PRE-TREATMENT		BIOFILTRATION	DISCHARGE
RIM ELEVATION	4.00	4.00	4.00
SURFACE LOAD	HS-20	HS-20	HS-20
FRAME & COVER	2EA #30"	2EA 36" X 48"	#30"
INDUSTRIAL MEDIA VOLUME (CY)	4.73		
ORIFICE SIZE (DIA. INCHES)	5 EA # 1.61"		
NOTES: PRELIMINARY NOT FOR CONSTRUCTION. *TOTAL TWO MWS IS NEEDED TO PROVIDE TREATMENT FLOW RATE. INDUSTRIAL MEDIA NEEDED.			



- INSTALLATION NOTES**
- CONTRACTOR TO PROVIDE ALL LABOR, EQUIPMENT, MATERIALS AND INCIDENTALS REQUIRED TO OFFLOAD AND INSTALL THE SYSTEM AND APPURTENANCES IN ACCORDANCE WITH THIS DRAWING AND THE MANUFACTURER'S SPECIFICATIONS, UNLESS OTHERWISE STATED IN MANUFACTURER'S CONTRACT.
  - UNIT MUST BE INSTALLED ON LEVEL BASE. MANUFACTURER RECOMMENDS A MINIMUM 6" LEVEL ROCK BASE UNLESS SPECIFIED BY THE PROJECT ENGINEER. CONTRACTOR IS RESPONSIBLE FOR VERIFYING PROJECT ENGINEER'S RECOMMENDED BASE SPECIFICATIONS.
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  - CONTRACTOR RESPONSIBLE FOR CONTACTING BIO CLEAN FOR ACTIVATION OF UNIT. MANUFACTURER'S WARRANTY IS VOID WITHOUT PROPER ACTIVATION BY A BIO CLEAN REPRESENTATIVE.

**GENERAL NOTES**

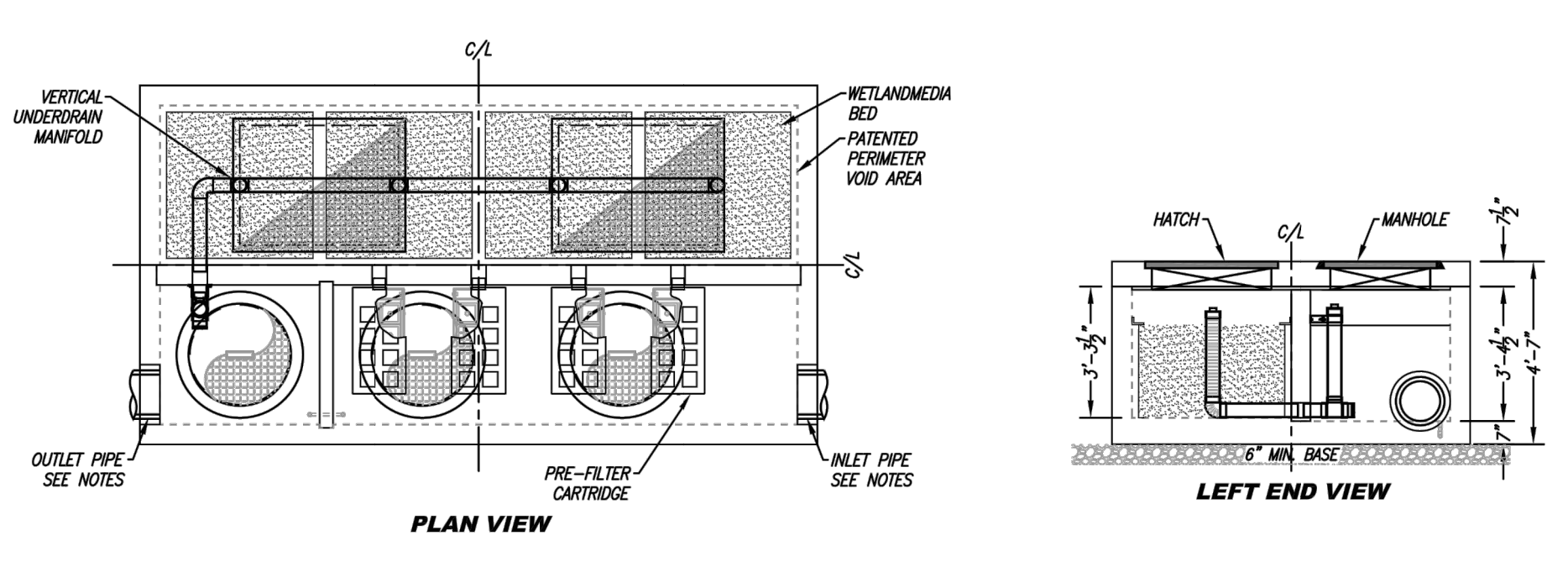
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- ALL DIMENSIONS, ELEVATIONS, SPECIFICATIONS AND CAPACITIES ARE SUBJECT TO CHANGE. FOR PROJECT SPECIFIC DRAWINGS DETAILING EXACT DIMENSIONS, WEIGHTS AND ACCESSORIES PLEASE CONTACT BIO CLEAN.

**INTERNAL BYPASS DISCLOSURE:**  
THE DESIGN AND CAPACITY OF THE PEAK CONVEYANCE METHOD TO BE REVIEWED AND APPROVED BY THE ENGINEER OF RECORD. HGL(S) AT PEAK FLOW SHALL BE ASSESSED TO ENSURE NO UPSTREAM FLOODING. PEAK HGL AND BYPASS CAPACITY SHOWN ON DRAWING ARE USED FOR GUIDANCE ONLY.

TREATMENT FLOW (CFS)	0.31
OPERATING HEAD (FT)	2.3
PRE-TREATMENT LOADING RATE (GPM/SF)	1.4
WETLAND MEDIA LOADING RATE (GPM/SF)	1.0

**MWS-L-8-16-3'-4"-V-UG**  
 STORMWATER BIOFILTRATION SYSTEM  
 STANDARD DETAIL

SITE SPECIFIC DATA			
PROJECT NUMBER	15270		
PROJECT NAME	HEDGES CREEK		
PROJECT LOCATION	TUALATIN, OR		
STRUCTURE ID	SYSTEM #3, UNIT2		
TREATMENT REQUIRED		FLOW BASED (CFS)	
VOLUME BASED (CF)	N/A		
PEAK BYPASS REQUIRED (CFS) - IF APPLICABLE	TBD		
PIPE DATA	I.E.	MATERIAL	DIAMETER
INLET PIPE 1	1.00	CPEP	12"
OUTLET PIPE	0.00	CPEP	12"
PRE-TREATMENT		BIOFILTRATION	DISCHARGE
RIM ELEVATION	4.00	4.00	4.00
SURFACE LOAD	HS-20	HS-20	HS-20
FRAME & COVER	2EA #30"	2EA 36" X 48"	#30"
INDUSTRIAL MEDIA VOLUME (CY)	4.73		
ORIFICE SIZE (DIA. INCHES)	5 EA # 1.61"		
NOTES: PRELIMINARY NOT FOR CONSTRUCTION. *TOTAL TWO MWS IS NEEDED TO PROVIDE TREATMENT FLOW RATE. INDUSTRIAL MEDIA NEEDED.			



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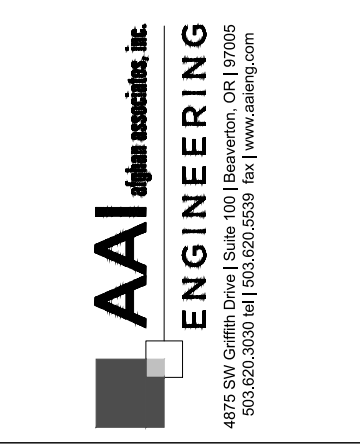
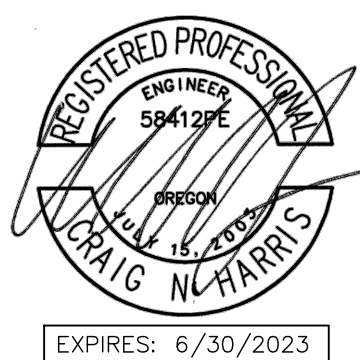
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TREATMENT FLOW (CFS)	0.31
OPERATING HEAD (FT)	2.3
PRE-TREATMENT LOADING RATE (GPM/SF)	1.4
WETLAND MEDIA LOADING RATE (GPM/SF)	1.0

**MWS-L-8-16-3'-4"-V-UG**  
 STORMWATER BIOFILTRATION SYSTEM  
 STANDARD DETAIL



HEDGES CREEK  
TUALATIN, OR

SHEET TITLE  
DETAILS

DATE: 08/02/2021  
DRAWN: KPM  
CHECKED: CNH  
REVISIONS:

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SHEET NUMBER

C4.3

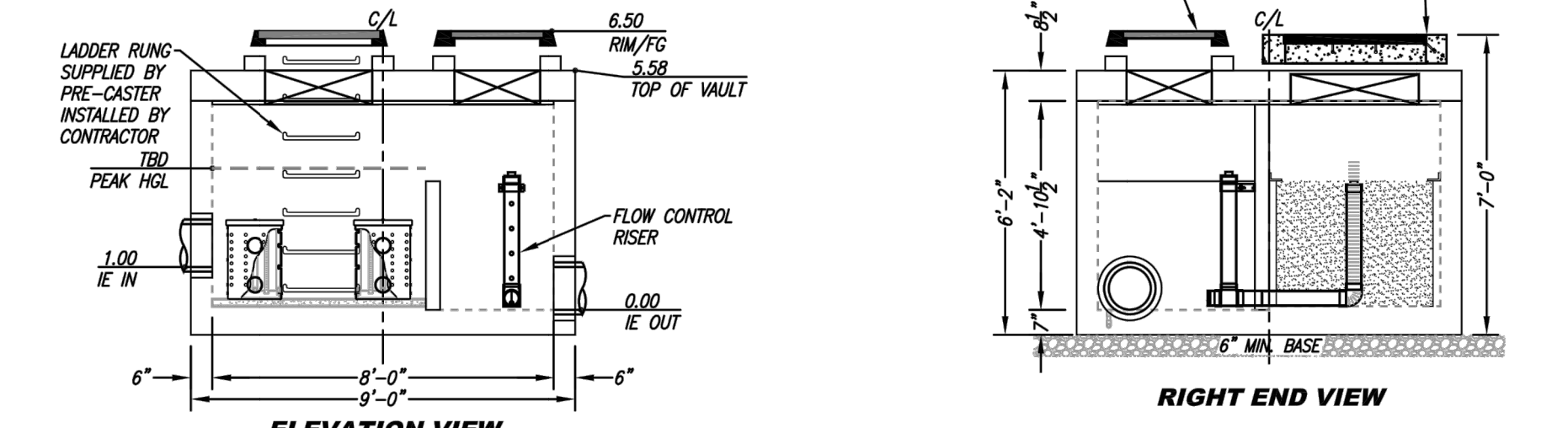
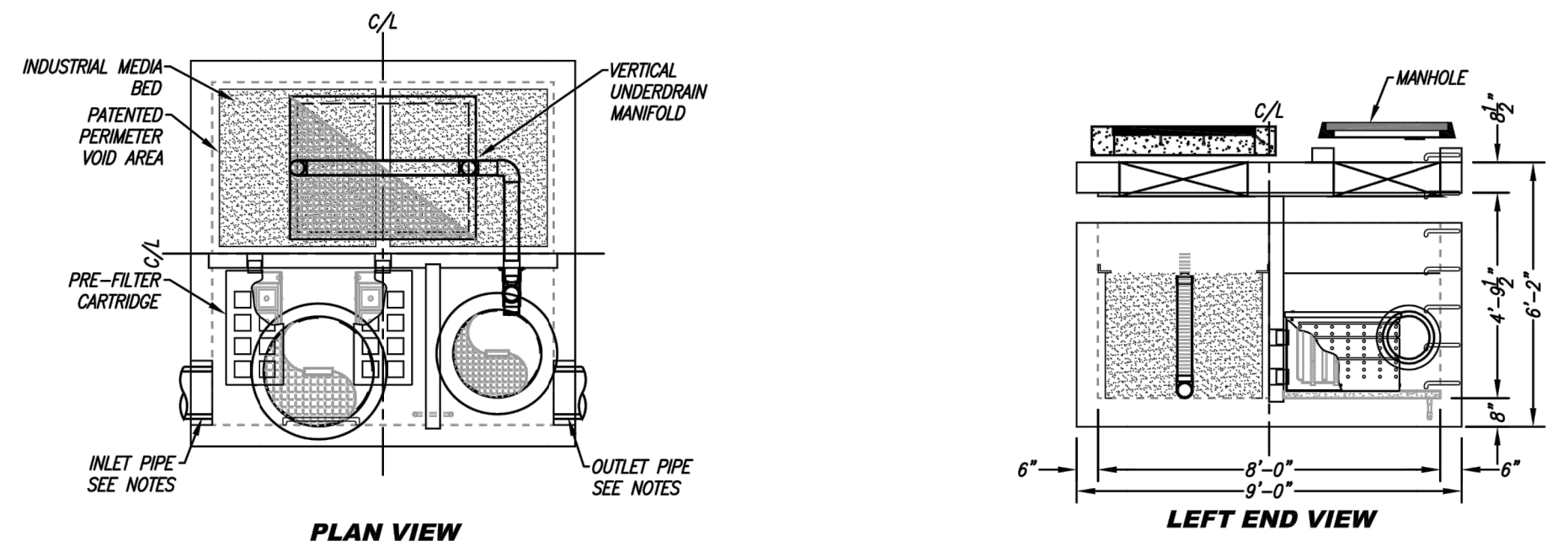
SITE SPECIFIC DATA			
PROJECT NUMBER	15270		
PROJECT NAME	HEDGES CREEK		
PROJECT LOCATION	TUALATIN, OR		
STRUCTURE ID	SYSTEM #4		
TREATMENT REQUIRED			
VOLUME BASED (CF)	FLOW BASED (CFS)		
N/A	0.18		
TREATMENT HGL AVAILABLE (FT)	N/A		
PEAK BYPASS REQUIRED (CFS) - IF APPLICABLE	TBD		
PIPE DATA	I.E.	MATERIAL	DIAMETER
INLET PIPE 1	1.00	CPEP	12"
OUTLET PIPE	0.00	CPEP	12"
	PRETREATMENT	BIOFILTRATION	DISCHARGE
RIM ELEVATION	6.50	6.50	6.50
SURFACE LOAD	HS-20	HS-20	HS-20
FRAME & COVER	#30"	36" X 48"	#24"
WETLAND MEDIA VOLUME (CY)	2.97		
ORIFICE SIZE (DIA. INCHES)	5 EA #1.12"		
NOTES: PRELIMINARY NOT FOR CONSTRUCTION. INDUSTRIAL MEDIA NEEDED			

INSTALLATION NOTES

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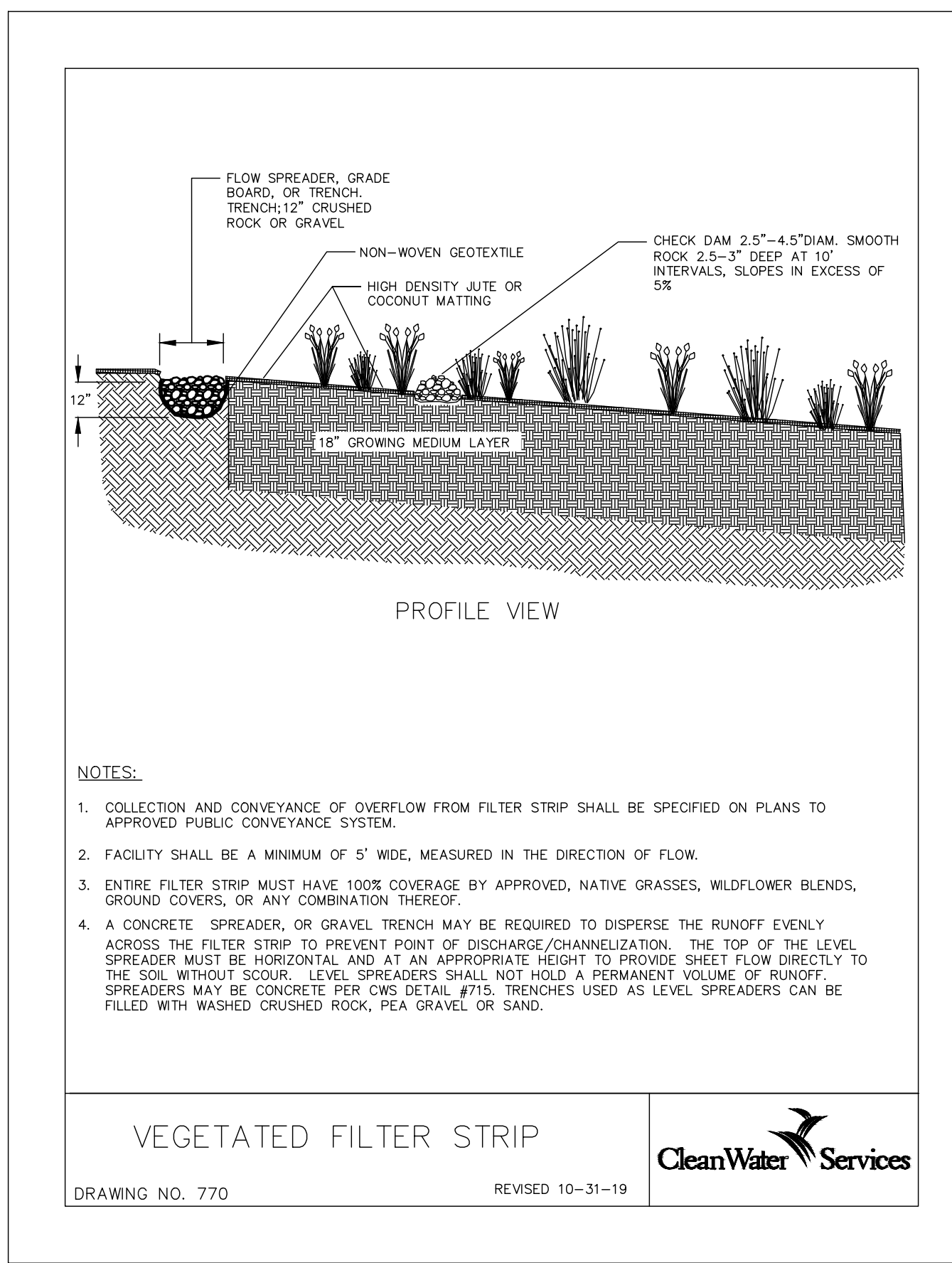
INTERNAL BYPASS DISCLOSURE:

TREATMENT FLOW (CFS)	0.20
OPERATING HEAD (FT)	2.9
PRETREATMENT LOADING RATE (GPM/SF)	1.8
INDUSTRIAL MEDIA LOADING RATE (GPM/SF)	1.0

WETLANDS PROPRIETARY AND CONFIDENTIAL: THE INFORMATION CONTAINED IN THIS DOCUMENT IS THE SOLE PROPERTY OF WETLANDS AND ITS COMPANIES. THIS DOCUMENT, IN WHOLE OR IN PART, MAY BE USED, REPRODUCED OR MODIFIED IN ANY MANNER WITHOUT THE WRITTEN CONSENT OF WETLANDS.

BioClean A Forterra Company

MWS-L-8-8-4'-10"-V-UG STORMWATER BIOFILTRATION SYSTEM STANDARD DETAIL



- NOTES:
- COLLECTION AND CONVEYANCE OF OVERFLOW FROM FILTER STRIP SHALL BE SPECIFIED ON PLANS TO APPROVED PUBLIC CONVEYANCE SYSTEM.
  - FACILITY SHALL BE A MINIMUM OF 5' WIDE, MEASURED IN THE DIRECTION OF FLOW.
  - ENTIRE FILTER STRIP MUST HAVE 100% COVERAGE BY APPROVED, NATIVE GRASSES, WILDFLOWER BLENDS, GROUND COVERS, OR ANY COMBINATION THEREOF.
  - A CONCRETE SPREADER, OR GRAVEL TRENCH MAY BE REQUIRED TO DISPERSE THE RUNOFF EVENLY ACROSS THE FILTER STRIP TO PREVENT POINT OF DISCHARGE/CHANNELIZATION. THE TOP OF THE LEVEL SPREADER MUST BE HORIZONTAL AND AT AN APPROPRIATE HEIGHT TO PROVIDE SHEET FLOW DIRECTLY TO THE SOIL WITHOUT SCOUR. LEVEL SPREADERS SHALL NOT HOLD A PERMANENT VOLUME OF RUNOFF. SPREADERS MAY BE CONCRETE PER CWS DETAIL #715. TRENCHES USED AS LEVEL SPREADERS CAN BE FILLED WITH WASHED CRUSHED ROCK, PEA GRAVEL OR SAND.

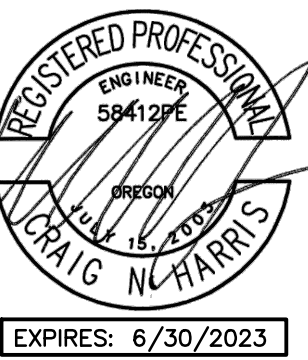
VEGETATED FILTER STRIP

CleanWater Services

DRAWING NO. 770 REVISED 10-31-19



**Appendix D**  
Basin Map



AAI ENGINEERING  
445 SW Green Street, Suite 100 (Beverman, OR) 97005  
503.333.0001 | 503.333.0009 | www.aaieng.com

**PHELAN**  
DEVELOPMENT  
450 Newport Center Drive, Suite 405  
Newport Beach, CA 92660

HEDGES CREEK  
TUALATIN, OR

SHEET TITLE

BASIN MAP

DATE: 08/02/2021

DRAWN: KPM

CHECKED: CNH

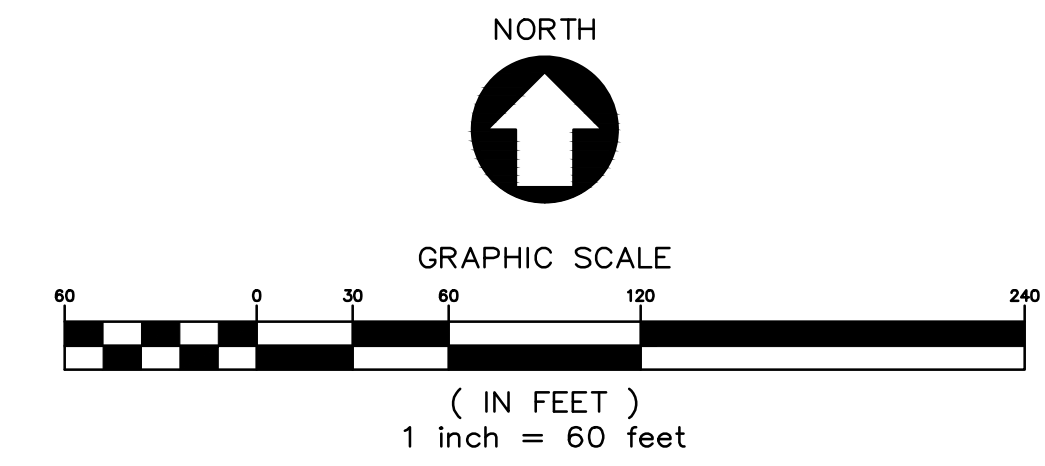
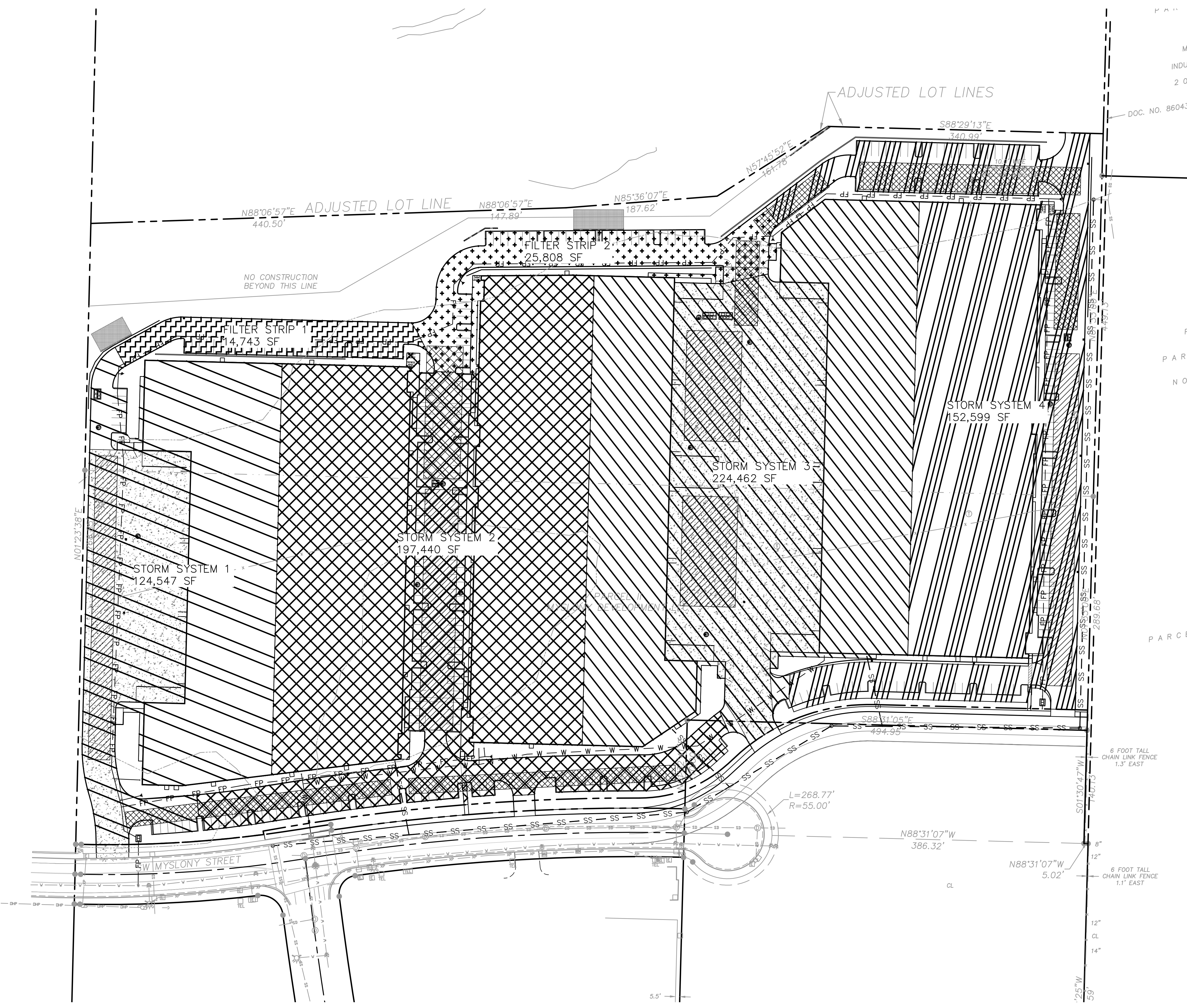
REVISIONS:

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SHEET NUMBER

JOB NUMBER: A20120.10



3/01/2022

F:\2020\A20120.10 - Walgraves\Documents\Reports\Storm Report\20120.Basin Map.dwg : Apr. 25, 22 - 11:37 AM thornltonc

**Appendix E**  
Erosion Control Plans



**Appendix F**  
Geotechnical Report

# **REPORT OF GEOTECHNICAL ENGINEERING SERVICES**

**New Commercial Buildings and Site Infrastructure  
Walgraeves Property, 11345 SW Herman Road  
Tualatin, Oregon**

**Geotech  
Solutions Inc.**

July 20, 2020

GSI Project: phelan-19-7-gi

July 20, 2020

phelan-19-7-gi

Phelan Development

Tania Chavez; [tchavez@phelandevco.com](mailto:tchavez@phelandevco.com)

Mike DeArmey [mdearmey@phelandevco.com](mailto:mdearmey@phelandevco.com)

Kyle Bertelsen; [kyle@phelandevco.com](mailto:kyle@phelandevco.com)

## **REPORT OF GEOTECHNICAL ENGINEERING SERVICES Commercial Buildings and Site Infrastructure Walgraeves Property, 11345 Herman Road, Tualatin, Oregon**

As authorized, herein we present our report of geotechnical engineering services for the proposed project. Based on information you provided roughly 15 acres of the site is to be developed with three commercial tilt-up concrete buildings of 49,000 and 168,000 square feet. Building loads are expected to be up to 200 kips for columns, 6 kips per foot for walls, and 500 psf for floors. Truck docks, pavement, and utilities are planned. The purpose of our work was to investigate the soil conditions and provide geotechnical engineering for design by others. Our specific scope of work included the following:

- Provide principal-level geotechnical project management including client communications, management of field and subcontracted services, report writing, analyses, and invoicing.
- Review previous reports, geologic maps and vicinity geotechnical information as indicators of subsurface conditions.
- Complete a site reconnaissance to observe surface features relevant to geotechnical issues, such as topography, vegetation, presence and condition of springs, exposed soils and rock, and evidence of previous grading.
- Identify exploration locations and complete a “one call” public locate and a private utility locate for locatable utilities (limited to metallic or with tracer wire). As-built utilities are also requested from the owner. Un-locatable utilities are the responsibility of the owner, and our scope does not include any related utility repair.
- Explore subsurface conditions with the following:
  - Advance 5 CPT probes, including 3 up to 80 feet and 2 up to 50 feet or refusal to encounter stiff soils or rock, and include shear wave velocity testing in one CPT and ppd testing in each.
  - Excavate up to 12 test pits to depths of up to 12 feet.
- Classify and sample materials encountered and maintain a detailed log of the explorations.
- Complete same day falling head infiltration testing on one test pit.
- Determine the moisture content of selected samples obtained from the explorations and complete soil classification testing as necessary, and organic content testing for organic soils if encountered.
- Provide recommendations for earthwork including site preparation, slope inclinations, potential for rock excavation, reuse of any existing fill in place or stabilization such as geogrid or cement amending, seasonal material usage, compaction criteria, utility trench backfill, and the need for subsurface drainage.
- Evaluate site liquefaction potential and estimate site deformations and provide qualitative means to address unsuitable deformations if needed.
- If organic or highly compressible soils are present, evaluate the need for preloading or surcharging including heights, materials and rough timing estimates, or qualitative means if stabilization such as

///

deep soil mixing, deep drains or use of pile supported buildings. For piles include analyses of two types in collaboration with structural engineers provided loading, including vertical and lateral capacities, embedment, and installation criteria.

- Provide recommendations for shallow foundations including suitable soils, stabilization, bearing pressures, sliding coefficient, and a seismic site class.
- Provide recommendations for slab support, including a subgrade modulus, underslab rock thickness and materials, and the need for stabilization, and underslab drainage if needed.
- Provide recommendations for building and site cantilevered retaining walls, including lateral earth pressures, foundations, resistance to lateral loads, backfill, and drainage.
- If site MSE walls are planned provide soil parameters for design by others, including soil strength, unit weight, bearing, drainage, backfill, and temporary slope cuts.
- Provide recommendations for pavements including subgrade preparation and stabilization, and base rock and asphalt concrete and portland cement concrete thicknesses.
- Provide a written report summarizing the results of our geotechnical evaluation.

## **SITE OBSERVATIONS AND CONDITIONS**

### **Surface Conditions**

The property is located in the southern portion of the 11345 SW Herman Road address, immediately north of the eastern terminus of SW Myslony Street in Tualatin, Oregon as shown on the attached **Site Plan**. The site is relatively gently sloping down from the south to the north in the southern building areas, and relatively flat beyond that. An apparent low area is present in the southwest in a tilled field. Elevation changes for the east and west building pads are up to roughly 5 feet, with the central pad up to 10 feet. The site is vegetated primarily with grass that is currently grazed, scattered brush, and brush lines with shallow Myslony Creek to the west and north. Aerial photos show little change in the last 25 years. The Tualatin River is roughly one mile to the northwest and north. Adjacent developments are low rise industrial and commercial.

### **Subsurface Conditions**

**General** – Subsurface conditions at the site were explored by test pits and cone penetrometer probes in July, 2020. Twelve test pits were distributed across the proposed site development area and advanced to depths of up to 12 feet with a backhoe. Five cone penetrometer probes were completed to depths of 52 to 72 feet to refusal in high tip resistance soils. Approximate exploration locations are shown on the attached **Site Plan**. Specific subsurface conditions observed at each exploration are described in the attached **Logs**.

Our explorations encountered a primary root zone of roughly 4 to 7 inches in roughly one foot of tilled agricultural soils in most of the test pits, with expected root zones of one foot or more near trees and heavier brush. Underlying the topsoil most explorations encountered an upper soft to medium stiff silt layer, which included organic silt and peat in the southern-most explorations, underlain by layered sand and silt with dense sand or weathered rock presenting refusal at depth. These units are described in further detail in the following sections.

### **Upper Silt Unit**

This unit extended to depths of generally 4 to 10 feet in our explorations, and in the southern explorations included very soft soils, organic silt, and some layers of non-fibrous fine peat (where more than 60% of the material was organic by dry weight in one sample – organic test results attached). The



silt was generally soft to medium stiff and dry in the upper 1-3 feet in our mid-summer explorations, with moisture contents ranging from 8% where dry and inorganic, to 65% where moist with some organics. The silt is often very soft in the wet season. The silt has a low plasticity, moderate dry strength, but low strength when remolded in wet conditions. The organic portions of the silt, including fine peat, are very soft, highly compressible, and have a very low strength. Moisture contents in organic silt and peat ranged from 65% to over 307%, with organic contents of 22% to 64%.

Cone readings indicate low tip resistance and high friction ratios where organic.

### **Layered Silt and Sand**

This unit extends below the upper silt unit to depths of roughly 45 to 55 feet in the CPT logs, and includes layers of dense sand from the 9 to 15 foot range. This unit was deposited in catastrophic flooding and is layered in rhythmites, as can be seen on the attached CPT logs. Occasional presence of gravel may represent depositional scour products from nearby basalt scour channels, and gravelly layers were noted near the base of most of the southwestern test pits. Moisture contents were as low as 13% where gravelly, and 37% where primarily silt. Tip resistance generally ranged from 20 to 80 tsf below the dense sand section, with friction ratios of 1.5-3.5%. Shear wave velocities in this unit in explorations to the south ranged from roughly 600-1000 ft/sec.

### **Lower Silt Unit**

This unit was encountered in a roughly 10 foot thickness below the layered sand and silt. The friction ratios were higher at 2.5-5% and indicated some clay content, with lower tip resistance.

### **Terminal Unit**

Tip resistance refusal or total system pressure refusal was met in each CPT at depths of 52 to 72 feet. This lower unit is interpreted as likely residual soils from weathered basalt.

**Laboratory Testing** – Laboratory testing included moisture content testing, organic content testing, and qualitative plasticity evaluations for classification, and are attached. Consolidation testing and CPT correlations from the southern neighboring site were also used.

**Infiltration Testing** – Cased, double ring configuration falling head infiltration testing was completed in TP-10 at a depth of 4 feet. After initial saturation, readings were taken over time and the lowest rate time interval from testing indicated a raw rate ranging from 0.1 to 0.2 in<sup>3</sup>/hr/in<sup>2</sup>. This is a typical low rate for the areas silt soils and is a raw rate not to be used for design.

**Groundwater** – We observe significant and rapid groundwater seepage in the southwestern test pits at depths of 9 to 10 feet in our mid-summer explorations. CPT pore pressure dissipation testing indicated water levels at 3 to 8 feet. However, due to the low permeability of the silt soils, perched ground water conditions likely exist at shallow depths during wet periods and during the wet season, particularly in the lower site areas which in the southwest may include ponding.

## **CONCLUSIONS AND RECOMMENDATIONS**

### **General**

Based on the results of our explorations, laboratory testing, and engineering analyses, it is our opinion that the site can be developed following the recommendations contained herein. Southern site areas

contain compressible organic soil, and ground improvement and fill settlement monitoring are required in this area. To the north the proposed structures can be supported on continuous perimeter footings and interior spread footings connected by grade beams or a reinforced slab to address moderate risk liquefaction deflections. Construction in all but the driest late summer conditions will require extensive stabilization in the form of cement amending or working blankets and haul roads. Our geotechnical engineering recommendations are provided in the following sections.

### **Site Preparation**

**General** - Prior to earthwork construction, the site must be prepared by removing any existing structures, utilities, and any loose surficial or undocumented fill. Any excavation resulting from the aforementioned preparation must be brought back to grade with structural fill. Site preparation for earthwork will also require the removal of the root zone and topsoil from all pavement, building, hardscaping, and fill areas. The root zone thickness observed in our explorations was generally 4-6 inches, but tilled organics are present to generally one foot. Deeper stripping depths may be required in areas of loose organic soil.

Root balls from trees and shrubs may extend several feet and grubbing operations can cause considerable subgrade disturbance. All disturbed material must be removed to undisturbed subgrade and backfilled with structural fill. In general, roots greater than one inch in diameter must be removed as well as areas of concentrated smaller roots.

The test pit excavations were backfilled using relatively minimal compactive effort. Therefore, soft spots can be expected at these locations. We recommend that test pits located in the building area be completely removed and replaced with structural fill. Test pits located within paved areas must be removed to a depth of 3.0 feet below finished subgrade and the resulting excavation brought back to grade with structural fill.

**Stabilization and Soft Areas** - After stripping, we must be contacted to evaluate the exposed subgrade. This evaluation can be done by proof rolling in dry conditions or probing during wet conditions. Soft areas will require over-excavation and backfilling with well graded, angular crushed rock compacted as structural fill, overlying a separation geosynthetic such as a Propex Geotex 801 or equivalent. A geogrid may also be required, such as a Tensar BXSQ 2020 or equivalent black punched and drawn biaxial geogrid.

As an alternative to the methods described above, stabilization may be possible by soil amendment using portland cement. Amendment requires an experienced contractor using specialty spreading and mixing equipment. Typically, 5 to 6 percent cement is used for an amendment (i.e. mix) depth of 12 inches. However, the materials used and quantities can vary based on moisture and organic contents, plasticity, and required amendment depth. Compaction and grading of amended soils must be completed within 4 hours of mixing, and the amended soil must be allowed to cure for 4 days prior to trafficking. Generally, 50 percent of mixed particles should pass a No. 4 sieve.

The permeability of amended soil is very low. The surface of amended soils in building and pavement areas must therefore be sloped at a minimum of 0.5 percent to prevent collection of surface water during construction. Amended soils must be removed from all landscape areas prior to planting.

**Working Blankets and Haul Roads** - Construction equipment must not operate directly on the subgrade, as it is susceptible to disturbance and softening. Rock working blankets and haul roads placed over a geosynthetic in a thickened advancing pad can be used to protect subgrades. We recommend that sound, angular, pit run or crushed basalt with no more than 6 percent passing a #200 sieve be used to construct haul roads and working blankets, overlying the preceding separation geosynthetic. Working blankets must be at least 12 inches thick, and haul roads at least 24 inches thick. If the preceding geogrid is used these can be reduced to 10 inches and 18 inches, respectively. Alternatively, the soils could be amended to a minimum depth of 16 inches and covered with a minimum of 3 inches of crushed rock. Some repair of working blankets and haul roads should be expected.

The preceding rock and amendment thicknesses are the minimum recommended. Subgrade protection is the responsibility of the contractor and thicker sections may be required based on subgrade conditions during construction and type and frequency of construction equipment.

### **Earthwork**

**Fill** – The on-site fine grained in-organic soil can be used for structural fill if properly moisture conditioned. Use of this material will not be feasible during wet conditions. Even during dry summer conditions, the on-site soils will require drying by scarification and frequent mixing in thin lifts. The upper few feet may require adding moisture in mid-summer conditions. Once moisture contents are within 3 percent of optimum, the material must be compacted to at least 92 percent relative to ASTM D1557 (modified proctor) using a tamping foot type compactor. Fill must be placed in lifts no greater than 10 inches in loose thickness. In addition to meeting density specifications, fill will also need to pass a proof roll using a loaded dump truck, water truck, or similar size equipment.

In wet conditions, fill must be imported granular soil with less than 6 percent fines, such as clean crushed or pit run rock. This material must also be compacted to 95 percent relative to ASTM D1557. Alternatively, fills can be amended. We must be consulted to evaluate amendment of fills, as the amendment materials, quantities, and processes need to be adapted to actual site conditions at the time of amendment. Amending fill soils is more difficult than amending soils in-situ due to equipment access on very soft material. Typically, all-wheel-drive spreading equipment with off road tires, a high-powered mixer, 5 percent cement, and a mixing depth 2 inches greater than the lift thickness would be a starting point. Building fills with amended soil would allow for all lifts except the final to be placed consecutively without significant cure time.

**Trenches** – Utility trenches may encounter ground water seepage and moderate to severe caving must be expected where seepage is present, including flowing conditions in sandy soils if encountered. Shoring of utility trenches will be required for depths greater than 4 feet and where groundwater seepage is present. We recommend that the type and design of the shoring system be the responsibility of the contractor, who is in the best position to choose a system that fits the overall plan of operation.

Depending on the excavation depth and amount of groundwater seepage, dewatering may be necessary for construction of underground utilities. Flow rates for dewatering are likely to vary depending on location, soil type, and the season during which the excavation occurs. The dewatering systems, if necessary, must be capable of adapting to variable flows.

Pipe bedding must be installed in accordance with the pipe manufacturers' recommendations. If groundwater is present in the base of the utility trench excavation, we recommend overexcavating the trench by 12 to 18 inches and placing trench stabilization material in the base. Trench stabilization material must consist of well-graded, crushed rock or crushed gravel with a maximum particle size of 4 inches and be free of deleterious materials. The percent passing the U.S. Standard No. 200 Sieve must be less than 5 percent by weight when tested in accordance with ASTM C 117.

Trench backfill above the pipe zone must consist of well graded, angular crushed rock or sand fill with no more than 7 percent passing a #200 sieve. Trench backfill must be compacted to 92 percent relative to ASTM D-1557, and construction of hard surfaces, such as sidewalks or pavement, must not occur within one week of backfilling.

### **Seismic Design**

**General** - In accordance with the International Building Code (IBC) as adapted by State of Oregon Structural Specialty Code (SOSSC) and based on our explorations, testing, and experience in the site vicinity, the site class if F, but the low period structures planned should be evaluated using the parameters associated with Site Class D.

**Liquefaction and Lateral Spreading** - Liquefaction can occur in loose, saturated, non-plastic soils. Strong shaking, such as that experienced during earthquakes, causes the densification and subsequent settlement of these soils and high pore pressures which greatly weaken the soil. Some less plastic sand and sandy layers in the profile at depth are subject to deformation or liquefaction in design level crustal and CSZ (Cascadia Subduction Zone) earthquakes. Free field settlements were generally calculated at 3 to 7 inches total in the top 60 feet, with 1-2 inches coming from 10-30 feet in depth. Differential settlement at building levels is estimated at 1-2 inches over a few hundred feet. This movement can be addressed using the foundation recommendations herein.

Lateral spreading is not expected on the relatively flat site, as it is also roughly one mile from a free face of the Tualatin River.

### **Fill Settlement Monitoring and Ground Improvement**

The southern portion of the site has underlying highly compressible soils and organic silt layers up to 5 feet thick starting at depths of 2 to 4 feet. The explorations where these soils were encountered are shown on the attached **Site Plan**. In the thickest of these soils, settlement of up to 4 inches under 5 feet of new fill, or 500 psf floor slab loads could occur, higher when these loads are combined. In addition, long term settlement is expected. Because of the magnitude of the settlement and variation in compressible thickness of these layers, differential settlement would be high. Therefore, in building areas underlain by these soils we recommend ground improvement and fill settlement monitoring. Ground improvement such as rigid inclusions of grout or aggregate piers (discussed later in this report) is likely suitable. Doing ground improvement prior to mass filling may be more suitable for speed, cost, and settlement reasons for the modest building loads planned. Fill settlement should be monitored using settlement plates. We should be consulted once a grading plan is finalized to assist with plate locations, with at least 6 plates likely needed. Plates must be surveyed to the nearest 0.01 feet prior to filling, then twice a week during filling and weekly thereafter as determined by the geotechnical engineer and the ground improvement designer.

## Foundations

**Southern compressible soils and ground improvement** - The southern portion of the site has underlying highly compressible organic silt layers up to 5 feet thick starting at depths of 2 to 4 feet. The explorations where these soils were encountered are shown on the attached Site Plan. These soils could compress up to 4 inches under 200 kip column loads and 6 kip per foot wall loads, with differential settlement high due to the variable presence and thickness of these soils. We analyzed use of over-excavation to 4 feet and replacement with crushed rock pads. This reduced settlement to about 2 inches, but likely at a higher cost than some forms of ground improvement. Therefore, we recommend use of designed ground improvement (and settlement monitoring of fills) in the area shown in the attached figure. Ground improvement is a specialty contractor design build system. With proper ground improvement, conventional foundations can be used.

For the preceding site and loading conditions, ground improvement in the form of aggregate piers or rigid inclusions is likely the best option. Most often in this locale short aggregate piers are used. That process includes augering out soil and installing lifts of heavily rammed/compacted rock in the resulting hole. This provides an improved overall stiffness for building support. Such piers would need to extend to a depth estimated at 11 feet below the existing ground surface in order to penetrate the organic soils. The specialty contractor must design the actual system depth. We expect that summer construction would not require extensive use of casing as our test pits did not exhibit caving at shallow depths. Wet sandy layers encountered may require casing in any season, particularly where seepage is present. Typically, aggregate piers are concentrated under foundation elements, and spaced at 9 to 12 feet under slab areas. Piers are typically 30 to 48 inches in diameter.

**Foundation Bearing Pressures** - Bearing pressures in the southern area can be designed by the specialty contractor depending on the intensity of the ground improvement. We recommend using a bearing pressure of 2,500 psf over properly designed ground improvement and fill for consistency with the northern areas.

Because of liquefaction, we recommend perimeter continuous footings and interior spread footings that are connected by reinforced grade beams or are tied to a reinforced slab. Foundations must bear in the native medium stiff or stiffer silt, properly constructed structural fill, or ground improvement. Footings must be embedded at least 18 inches below the lowest adjacent, exterior grade. Footings can be designed for an allowable net bearing pressure of 2,500 psf when founded as recommended. The preceding bearing pressure can be increased to 5,000 psf for temporary wind and seismic loads.

Continuous footings should be no less than 18 inches wide, and pad footings should be no less than 24 inches wide. Resistance to lateral loads can be obtained by a passive equivalent fluid pressure of 350 pcf against suitable footings, ignoring the top 12 inches of embedment, and by a footing base friction coefficient of 0.35. Each of these includes a safety factor of 1.5. Properly founded footings are expected to settle less than a total of 1 inch, with less than 1/2 inch differentially.

If footing construction is to occur in wet conditions, a few inches of crushed rock should be placed at the base of footings to reduce subgrade disturbance and softening during construction.

## Slabs

The ground improvement contractor must evaluate expected settlement from fill and building slab loads in the southern area. The goal is to design for floor loads up to 500 psf with less than one inch of post construction settlement, which is the load and settlement expected from the non-improved northern areas. In dry summer conditions, where the slabs are poured prior to the wet season, a minimum of six inches of clean, angular crushed rock with no more than 5 % passing a #200 sieve is recommended for under slab rock. Increased rock thicknesses and stabilization will be required for construction in wet conditions and where used as a working blanket or haul road per the **Stabilization** section in this report. Prior to slab rock placement the subgrade will need to be evaluated by us by probing or observing a proof rolling using a fully loaded dump truck or similar load. Underslab rock must be compacted to 92 % compaction relative to ASTM D1557, and must pass a proof roll. In addition, any areas contaminated with fines must be removed and replaced with clean rock. If the base rock is saturated or trapping water, this water must be removed prior to slab placement.

**Floor Moisture** - Some flooring manufacturers require specific slab moisture levels and/or vapor barriers to validate the warranties on their products. A properly installed and protected vapor flow retardant can reduce slab moistures. If moisture sensitive floor coverings or operations are planned, we recommend a vapor barrier be used. Typically, a reinforced product or thicker product (such as a 15 mil STEGO wrap or equivalent) can be used. Experienced contractors using special concrete mix design and placement have been successful placing concrete directly over the vapor barrier which overlies the rock. This reduces the issue of water trapped in the rock between the slab and vapor barrier, which otherwise requires removal. In either case, slab moisture must be tested/monitored until it meets floor covering manufacturer's recommendations.

## Retaining Walls

**General** - The following recommendations are based on the assumptions that (1) Walls are conventional concrete cantilever walls (2) Wall backfill consists of level, well-drained, angular, granular material, (3) Walls are less than 5 feet in height, and (4) No surcharges such as stockpiled soil or equipment are placed within 5 feet of the wall.

Walls restrained against rotation should be designed using an equivalent fluid pressure of 50 pcf. Walls not restrained against rotation should be designed using an equivalent fluid pressure of 30 pcf. Seismic design for roughly one inch of deflection can be evaluated for a seismically induced rectangular wall pressure of 11H (to determine if this controls wall design or the preceding static condition).

Wall foundations should be designed as recommended herein for shallow foundations.

**Backfill** - Retaining walls should be backfilled with clean, imported, granular soil with less than 6 percent fines, such as clean sand or rock. This material should also be compacted to a minimum of 92 percent relative to ASTM D-1557 (modified proctor). Within 3 feet of the wall, backfill should be compacted to not more than 90 percent relative to ASTM D-1557 using hand-operated equipment. Retaining structures typically rotate and displace up to 1 percent of the wall height during development of active pressures behind the wall. We therefore recommend that construction of improvements adjacent to the top of walls be delayed until approximately two weeks after wall construction and backfill.

**Drainage**

**General** - We recommend installing perimeter foundation drains around all exterior foundations. The surface around the building perimeter must be sloped to drain away from the building. As stated previously, our retaining wall recommendations are based on fully drained conditions. All retaining walls must include a drain constructed as described in the following section.

**Foundation and Wall Drains** - Foundation and retaining wall drains should consist of a two-foot wide zone of drain rock encompassing a 4-inch diameter perforated pipe, all enclosed with a non-woven filter fabric. The drain rock should have no more than 2 percent passing a #200 sieve and should extend to within one foot of the ground surface. The geosynthetic should have an AOS of a #70 sieve, a minimum permittivity of 1.0 sec<sup>-1</sup>, and a minimum puncture resistance of 80 pounds (such as a Propex Geotex 601 or approved equivalent). For walls a composite drain board such as an Amerdrain 500/520 could be used above the footing drain for wall drainage. In either case one foot of low permeability soil (such as the on-site silt) should be placed over the fabric at the top of the drain to isolate the drain from surface runoff.

**Infiltration**

**Design** - Based on the results of our testing and analyses, infiltration rates in the silt unit are very low, and combined with the high seasonal ground water, preclude using infiltration systems.

**Pavement**

**Asphalt Concrete** – At the time of this report we did not have specific information regarding the type and frequency of expected traffic. We therefore developed new asphalt concrete pavement thicknesses for areas exposed to passenger vehicles only and areas exposed to up to 25 trucks per day based on a 20-year design life with a mix of 3-to 5-axle trucks. Traffic volumes can be revised if specific data is available.

Our pavement analyses is based on AASHTO methods and subgrade of structural fill, cement amended fill, or undisturbed medium stiff or better native silt having a resilient modulus of 6,000 psi and prepared as recommended herein. We have also assumed that roadway construction will be completed during an extended period of dry weather. The results of our analyses based on these parameters are provided in the table below. Each of these sections can support a 75,000 GVW fire truck.

<u>Traffic</u>	<u>18K ESAL's</u>	<u>AC (inches)</u>	<u>CR (inches)</u>
Passenger Vehicle Only	-	3	6
Up to 10 Trucks Per Day	75,000	3.5	9
Up to 25 Trucks Per Day	188,000	4.5	9
Up to 50 Trucks Per Day	376,000	5	10

The thicknesses listed in the preceding table are the minimum acceptable for construction during an extended period of dry summer weather where the roadway is not used as a haul road or working blanket and will not be trafficked in wet conditions prior to paving. Increased rock thicknesses and stabilization will be required for such uses and for all construction during wet conditions per the **Stabilization** and **Working Blankets and Haul Roads** sections in this report. Crushed rock must conform to ODOT base rock standards and have less than 6 percent passing the #200 sieve. Asphalt

concrete must be 1/2" dense graded level 2 HMAC compacted to a minimum of 91 percent of a Rice Density.

**Portland Cement Concrete** - We developed PCC pavement thicknesses at the site for the assumed one-way traffic levels as shown in the table below. Each of these sections is based on AASHTO methods with no reduction for wander and a composite modulus of subgrade reaction of 350 pci (AASHTO Figure 3.3 with  $M_r = 6,000$  psi and 6 inches crushed rock base). Other parameters include 4,000 psi compressive strength portland cement concrete (PCC), and plain jointed concrete **without** load transfer devices or tied concrete shoulders. PCC pavements over trench backfill should not be placed within one week of fill installation unless survey data indicates that settlement of the backfill is complete. Increased rock sections are required for wet season and wet conditions per **Working Blankets and Haul Roads** herein.

Traffic	18k ESALS	PCC (inches)	CRB (inches)
Up to 10 Trucks Per Day	75,000	6	6
Up to 25 Trucks Per Day	188,000	7	6
Up to 50 Trucks Per Day	376,000	7.5	6

**Subgrade Preparation** - The pavement subgrade must be prepared in accordance with the **Earthwork and Site Preparation** recommendations presented in this report. All pavement subgrades must pass a wheel roll prior to paving. Soft areas must be repaired per the preceding **Stabilization** section.

**LIMITATIONS AND OBSERVATION DURING CONSTRUCTION**

We have prepared this report for use by Phelan Development and the design and construction teams for this project only. The information herein could be used for bidding or estimating purposes but must not be construed as a warranty of subsurface conditions. We have made observations only at the aforementioned locations and only to the stated depths. These observations do not reflect soil types, strata thicknesses, water levels or seepage that may exist between observations. We must be consulted to observe all foundation bearing surfaces, subgrade stabilization, proof rolling of slab and pavement subgrades, installation of structural fill, subsurface drainage, and cut and fill slopes. We must be consulted to review final design and specifications in order to see that our recommendations are suitably followed. If any changes are made to the anticipated locations, loads, configurations, or construction timing, our recommendations may not be applicable, and we must be consulted. The preceding recommendations must be considered preliminary, as actual soil conditions may vary. In order for our recommendations to be final, we must be retained to observe actual subsurface conditions encountered. Our observations will allow us to interpret actual conditions and adapt our recommendations if needed.

Within the limitations of scope, schedule and budget, our services have been executed in accordance with the generally accepted practices in this area at the time this report was prepared. No warranty, expressed or implied, is given.



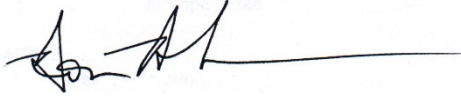


July 20, 2020

phelan-19-7-gi

We appreciate the opportunity to work with you on this project and look forward to our continued involvement. Please call if you have any questions.

Sincerely,



Don Rondema, MS, PE, GE  
Principal



Attachments – Site Plan, Guidelines for Classification, Test Pit Logs, CPT Logs, Moisture Contents, Organic Contents.



BASE PHOTO FROM GOOGLE EARTH 2019

**Test Pit #    Depth (ft)    Soil Description**

Explorations completed on July 16, 2020 with a John Deere 310E Backhoe (Approx. 15,000 pounds).

**TP-1**

**Location:** NE portion of site.

**Surface conditions:** Medium grass.

- 0 – 2    Medium stiff, brown SILT, with trace roots and trace gravel; dry. primary root zone 5 inches.
- 2 – 3    Stiff, brown SILT, with trace gravel and trace sand; moist.
- 3 – 5    Dense, gray/brown medium SAND, with some silt and some gravels/cobbles; moist.
- 5 – 12    Very dense, gray/brown coarse SAND, with some gravels/cobbles and trace silt; moist becoming wet at 7'.

No caving. Slow seepage below 7 feet.

**TP-2**

**Location:** E portion of site.

**Surface conditions:** Medium grass.

- 0 – 2    Medium stiff, brown SILT, with trace roots and trace gravel; dry. primary root zone 7 inches.
- 2 – 4    Stiff, brown SILT, with some gravel and trace sand; moist.
- 4 – 8    Dense, brown silty fine SAND, with trace gravels/cobbles; moist.
- 8 – 12    Dense, brown/gray medium to coarse SAND, with some gravels; moist.

No caving. No seepage.

**TP-3**

**Location:** E portion of site.

**Surface conditions:** Medium grass.

- 0 – 1    Medium stiff, brown SILT, with trace roots and trace gravel; dry. primary root zone 7 inches.
- 1 – 4    Stiff, brown SILT, with some gravel; moist.
- 4 – 12    Dense, brown, medium to coarse SAND, with some gravels and some silt; moist. 8 ft becomes with trace silt.

No caving. No seepage.

**TP-4**

**Location:** SE portion of site.

**Surface conditions:** Medium grass.

- 0 – 2    Medium stiff, brown SILT, with trace roots; dry. primary root zone 6 inches.
- 2 – 7    Soft, black ORGANIC SILT; moist to wet.
- 7 – 12    Loose, gray fine SAND with some silt; wet

No caving. Rapid seepage below 11'.

**Test Pit #**    **Depth (ft)**    **Soil Description**

**TP-5**

**Location:** SE portion of site.

**Surface conditions:** Medium grass.

- 0 – 2    Medium stiff, brown SILT, with trace roots; dry. primary root zone 5 inches.
- 2 – 4    Stiff, brown/red/orange SILT; moist.
- 4 – 7    Dense, gray/orange silty SAND; moist.
- 7 – 12    Dense, gray fine SAND, with trace to some silt; moist.

No caving. Rapid seepage at 12'.

**TP-6**

**Location:** S portion of site.

**Surface conditions:** Tilled soil.

- 0 – 1    Very soft, brown SILT, trace roots; dry.
- 1 – 2    Medium stiff, brown SILT; moist.
- 2 – 6    Dense, gray/orange sandy SILT; moist.
- 6 – 7    Soft, dark brown ORGANIC SILT; moist.
- 7 – 11    Loose, gray fine SAND, with some silt; moist.  
9 ft Becomes with trace silt, wet.
- 11 – 12    Dense, gray coarse gravelly SAND with trace cobbles and silt; wet.

Minor caving near 10 feet. Rapid seepage below 10'.

**TP-7**

**Location:** Central portion of site.

**Surface conditions:** Medium grass.

- 0 – 3    Medium stiff, brown SILT, with trace roots and trace gravel; dry. primary root zone 6 inches.
- 3 – 5    Stiff, brown SILT, with some gravel; moist.
- 5 – 12    Dense, brown and brownish-gray, medium to coarse SAND, with some gravels and trace silt; moist.

No caving. No seepage.

**TP-8**

**Location:** Central portion of site.

**Surface conditions:** Medium grass.

- 0 – 1    Medium stiff, brown SILT, with trace roots and trace gravel; dry. primary root zone 5 inches.
- 1 – 5    Stiff, brown SILT, with some gravel; moist.
- 5 – 12    Dense, brown and brownish-gray, medium to coarse SAND, with some gravels and trace silt; moist.

No caving. No seepage.

**Test Pit #    Depth (ft)    Soil Description**

**TP-9**

**Location:** S portion of site.

**Surface conditions:** Tilled soil.

- 0 – 1    Loose, brown SILT, trace roots; dry.
- 1 – 3    Medium stiff, brown SILT; moist.
- 3 – 8    Very soft, dark brown ORGANIC SILT to PEAT; moist.
- 8 – 11    Medium dense, gray fine SAND, with some silt and trace gravel; moist
- 11 – 12    Dense, gray coarse gravelly SAND with occasional cobbles; wet.

No caving. Rapid seepage below 10'.

**TP-10**

**Location:** SW portion of site.

**Surface conditions:** Tilled soil.

- 0 – 1    Loose, brown SILT, trace roots; dry.
- 1 – 2    Soft, brown SILT; moist.
- 2 – 6    Soft, dark brown/gray SILT; moist.
- 6 – 8    Loose, brown/gray silty SAND; moist
- 8 – 10    Medium dense, gray fine SAND, with some silt and trace gravel; moist
- 10 – 12    Dense, gray coarse gravelly SAND with occasional cobble; moist.

No caving. Rapid seepage below 10'.

**TP-11**

**Location:** SW portion of site.

**Surface conditions:** Tilled soil.

- 0 – 1    Loose, brown SILT, trace roots; dry. primary root zone 6 inches.
- 1 – 3    Medium stiff, brown SILT; moist.
- 3 – 8    Soft, dark brown ORGANIC SILT; moist.
- 8 – 9    Medium dense, gray fine SAND, with some silt and trace gravel; moist
- 9 – 12    Dense, gray coarse gravelly SAND with occasional cobbles; wet.

No caving. Rapid seepage below 10'.

**TP-12**

**Location:** SW portion of site.

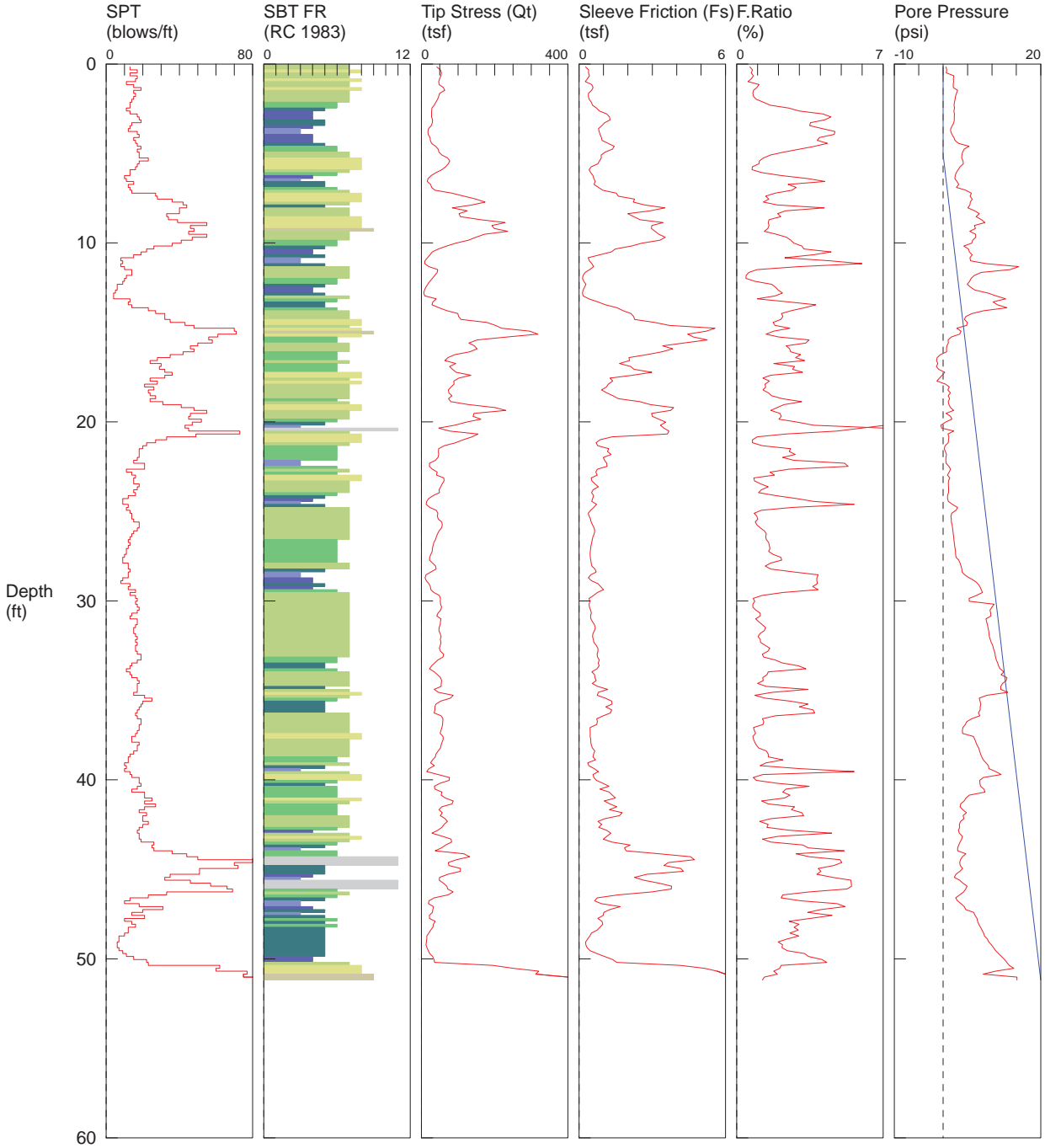
**Surface conditions:** Tilled soil.

- 0 – 1    Loose, brown SILT, trace roots; dry. primary root zone 8 inches.
- 1 – 3    Medium stiff, brown SILT; moist.
- 3 – 7    Soft, dark brown ORGANIC SILT to PEAT; moist.
- 7 – 10    Medium dense, gray fine SAND, with some silt and trace gravel; moist  
8 ft becomes dense and medium to coarse with some gravel.
- 10 – 12    Dense, gray coarse gravelly SAND with trace cobbles; wet.

No caving. Rapid seepage below 10'.

# Geotech Solutions / P-1 / 11345 SW Herman Rd Tualatin

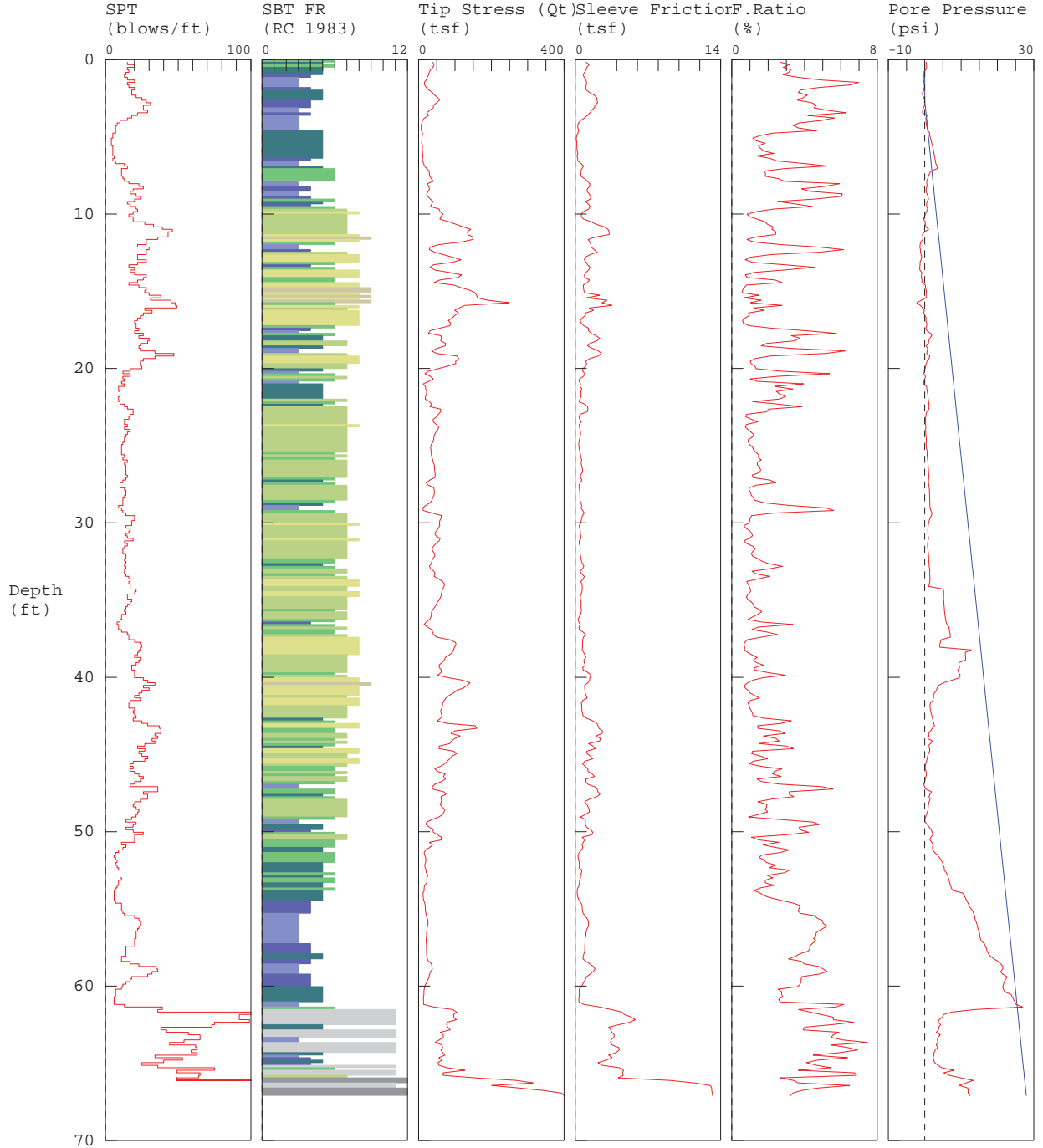
OPERATOR: OGE DMM  
 CONE ID: DDG1532  
 HOLE NUMBER: P-1  
 TEST DATE: 7/14/2020 8:58:13 AM  
 TOTAL DEPTH: 51.181 ft



- |                          |                             |                            |                                |
|--------------------------|-----------------------------|----------------------------|--------------------------------|
| 1 sensitive fine grained | 4 silty clay to clay        | 7 silty sand to sandy silt | 10 gravelly sand to sand       |
| 2 organic material       | 5 clayey silt to silty clay | 8 sand to silty sand       | 11 very stiff fine grained (*) |
| 3 clay                   | 6 sandy silt to clayey silt | 9 sand                     | 12 sand to clayey sand (*)     |
- \*SBT/SPT CORRELATION: UBC-1983

# Geotech Solutions / P-2 / 11345 SW Herman Rd Tualatin

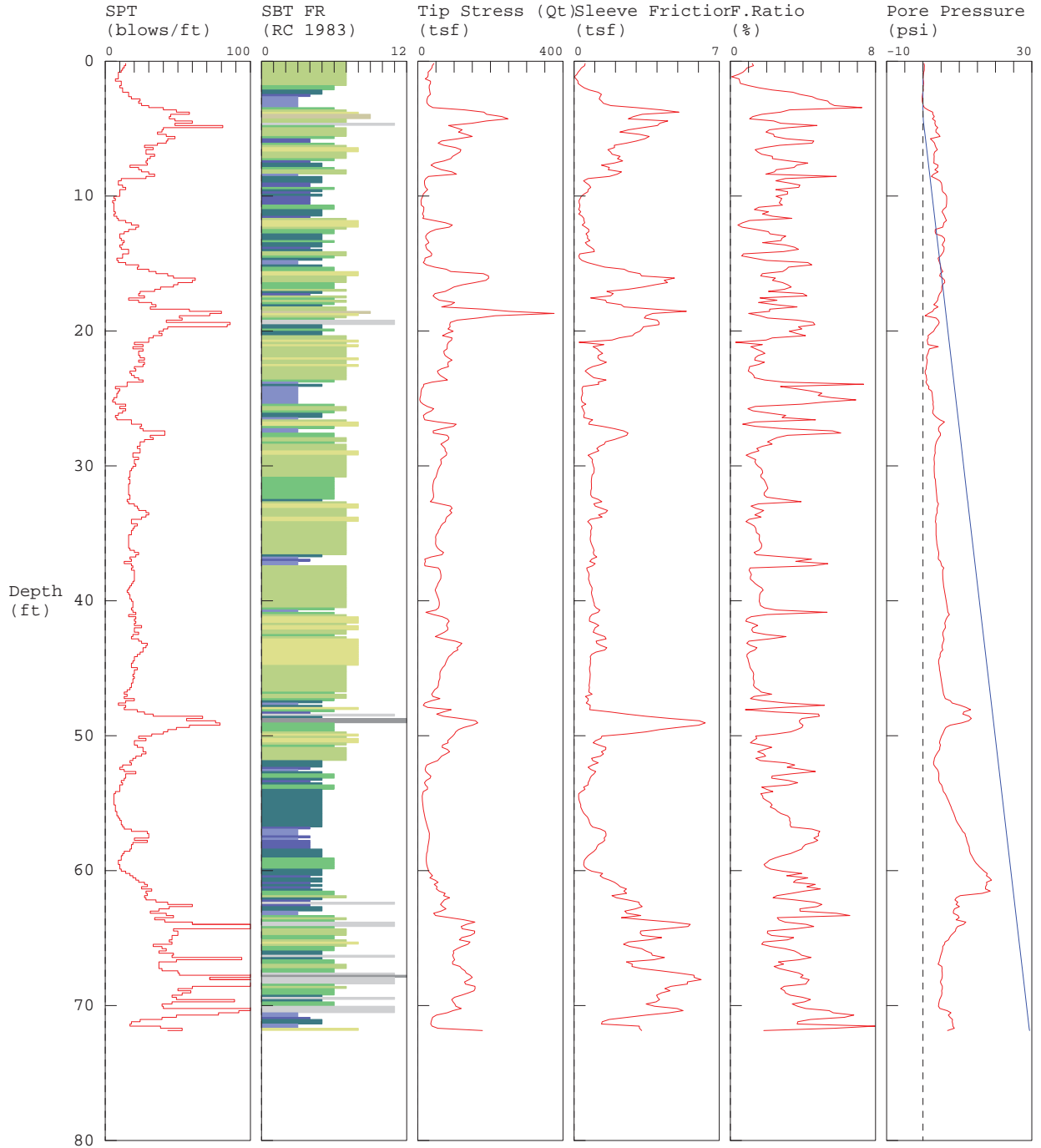
OPERATOR: OGE DMM  
 CONE ID: DDG1532  
 HOLE NUMBER: P-2  
 TEST DATE: 7/14/2020 10:06:14 AM  
 TOTAL DEPTH: 67.093 ft



- |   |                    |   |                     |   |                     |    |                             |
|---|--------------------|---|---------------------|---|---------------------|----|-----------------------------|
| 1 | sensitive fine gra | 4 | silty clay to cl    | 7 | silty sand to sandy | 10 | gravelly sand to sand       |
| 2 | organic materia    | 5 | clayey silt to silt | 8 | sand to silty sa    | 11 | very stiff fine grained (*) |
| 3 | clay               | 6 | sandy silt to claye | 9 | sand                | 12 | sand to clayey sand (*)     |
- \*SBT/SPT CORRELATION: UBC-1983

# Geotech Solutions / P-3 / 11345 SW Herman Rd Tualatin

OPERATOR: OGE DMM  
 CONE ID: DDG1532  
 HOLE NUMBER: P-3  
 TEST DATE: 7/14/2020 11:23:50 AM  
 TOTAL DEPTH: 71.850 ft

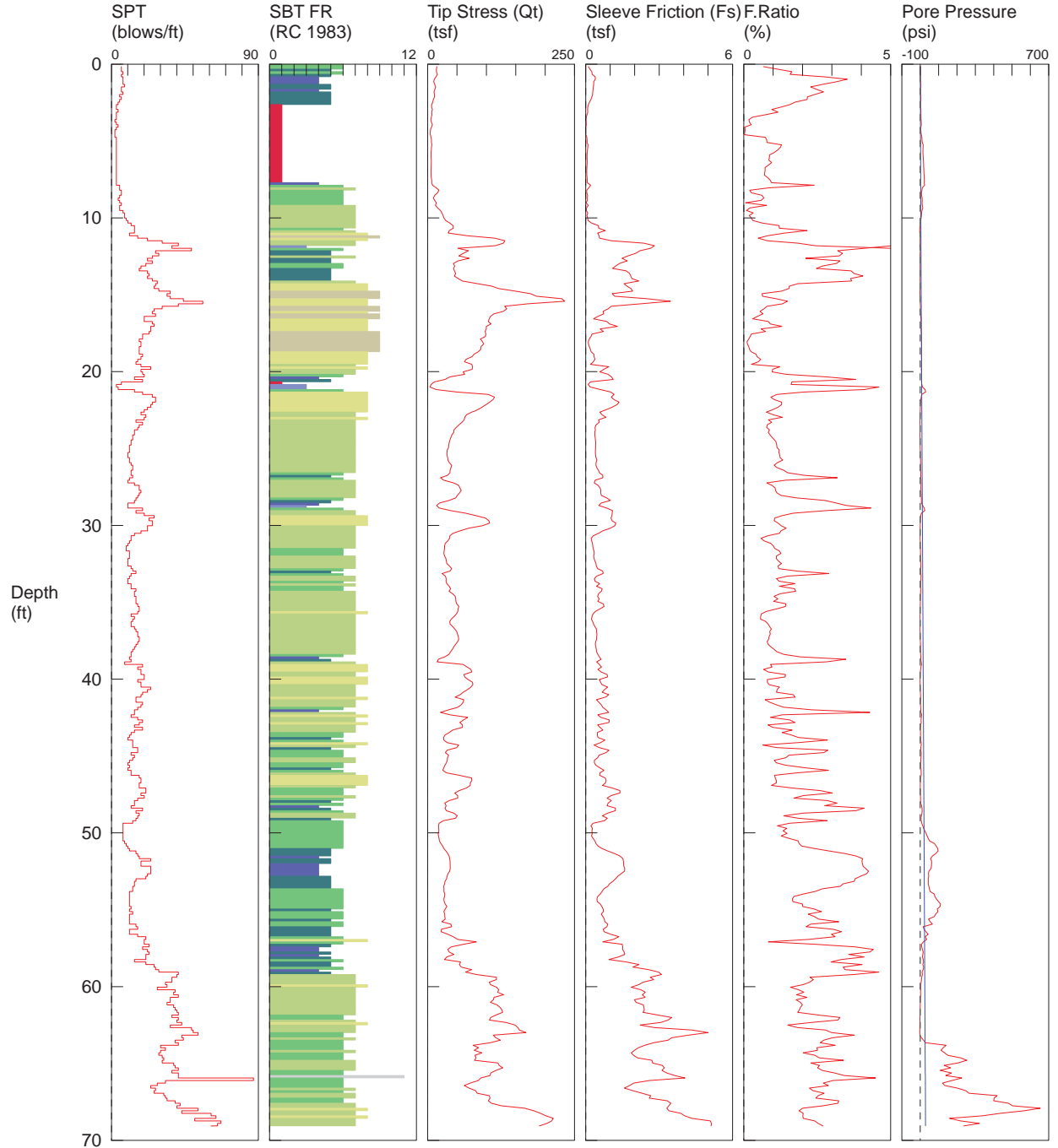


- |   |                    |   |                     |   |                     |    |                             |
|---|--------------------|---|---------------------|---|---------------------|----|-----------------------------|
| 1 | sensitive fine gra | 4 | silty clay to cl    | 7 | silty sand to sandy | 10 | gravelly sand to sand       |
| 2 | organic materia    | 5 | clayey silt to silt | 8 | sand to silty sa    | 11 | very stiff fine grained (*) |
| 3 | clay               | 6 | sandy silt to claye | 9 | sand                | 12 | sand to clayey sand (*)     |
- \*SBT/SPT CORRELATION: UBC-1983



# Geotech Solutions / P-4 / 11345 SW Herman Rd Tualatin

OPERATOR: OGE DMM  
 CONE ID: DDG1532  
 HOLE NUMBER: P-4  
 TEST DATE: 7/15/2020 8:03:50 AM  
 TOTAL DEPTH: 69.062 ft

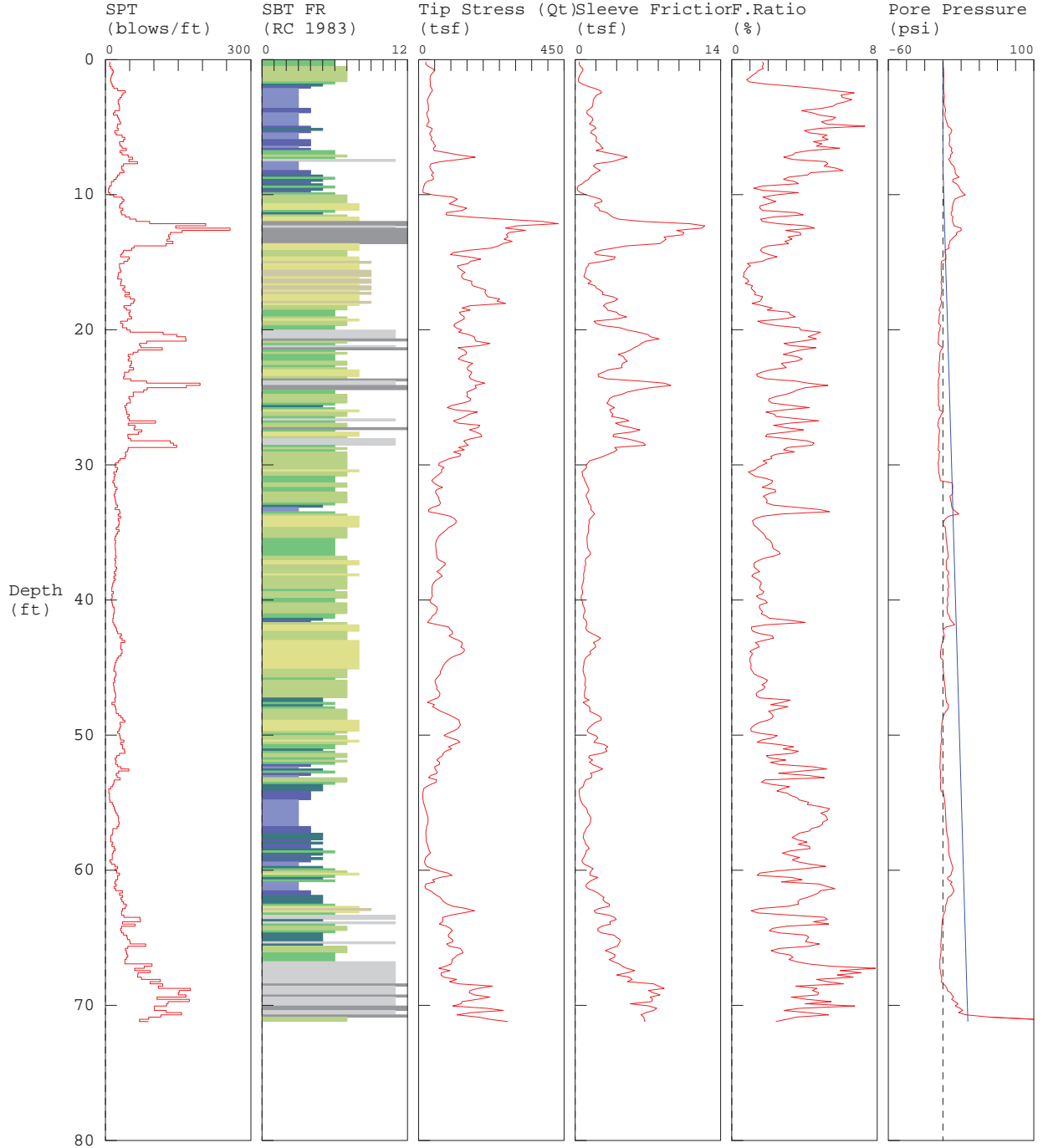


- |                          |                             |                            |                                |
|--------------------------|-----------------------------|----------------------------|--------------------------------|
| 1 sensitive fine grained | 4 silty clay to clay        | 7 silty sand to sandy silt | 10 gravelly sand to sand       |
| 2 organic material       | 5 clayey silt to silty clay | 8 sand to silty sand       | 11 very stiff fine grained (*) |
| 3 clay                   | 6 sandy silt to clayey silt | 9 sand                     | 12 sand to clayey sand (*)     |

\*SBT/SPT CORRELATION: UBC-1983

# Geotech Solutions / P-5 / 11345 SW Herman Rd Tualatin

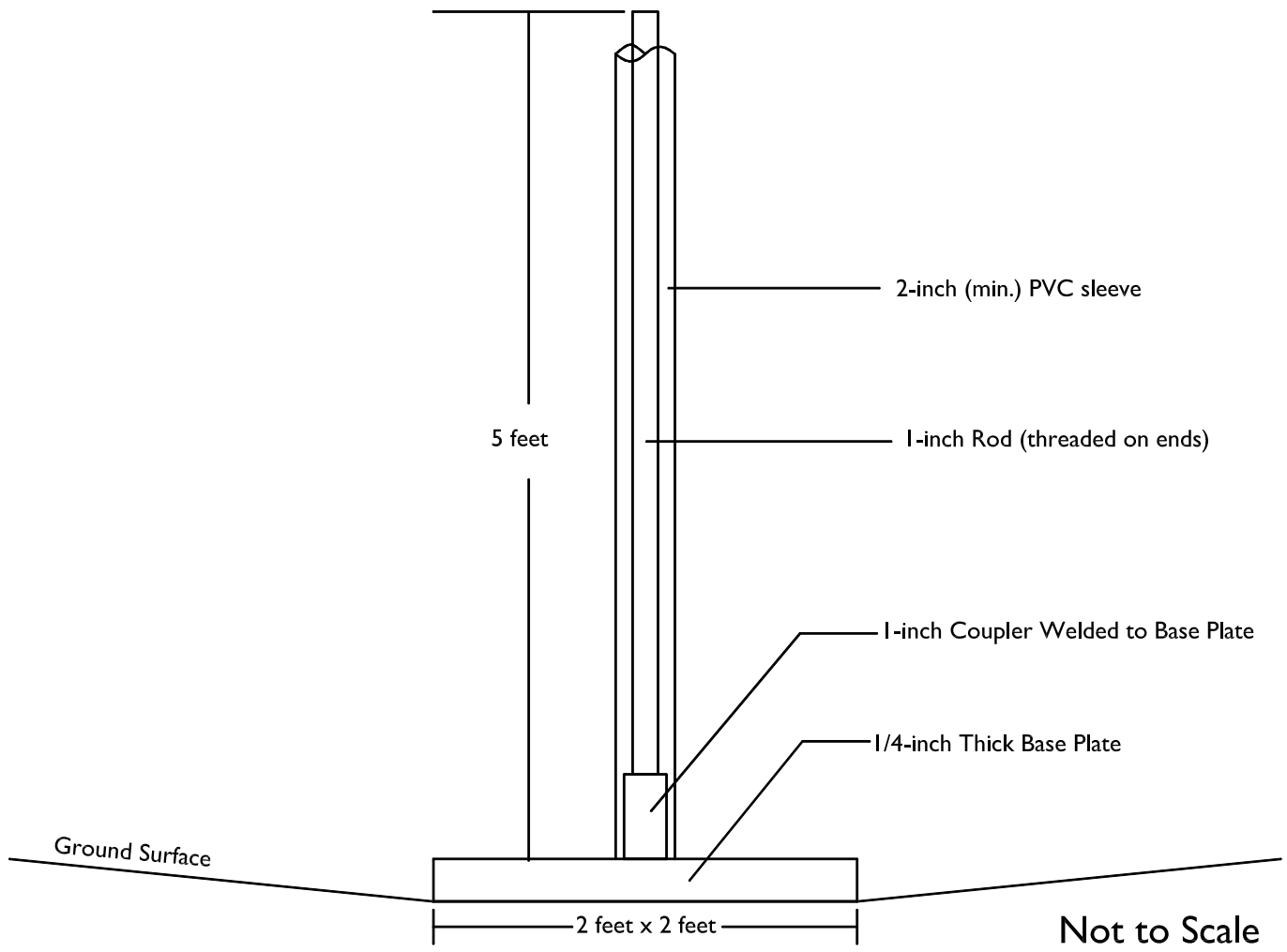
OPERATOR: OGE DMM  
 CONE ID: DDG1532  
 HOLE NUMBER: P-5  
 TEST DATE: 7/15/2020 9:14:16 AM  
 TOTAL DEPTH: 71.194 ft



- |                      |                       |                       |                                |
|----------------------|-----------------------|-----------------------|--------------------------------|
| 1 sensitive fine gra | 4 silty clay to cl    | 7 silty sand to sandy | 10 gravelly sand to sand       |
| 2 organic materia    | 5 clayey silt to silt | 8 sand to silty sa    | 11 very stiff fine grained (*) |
| 3 clay               | 6 sandy silt to claye | 9 sand                | 12 sand to clayey sand (*)     |
- \*SBT/SPT CORRELATION: UBC-1983

Exploration	Depth, ft	Moisture Content
TP-2	1.0	8%
TP-1	1.0	12%
TP-8	1.0	12%
TP-7	1.0	12%
TP-3	1.0	16%
TP-10	1.0	18%
TP-11	1.0	19%
TP-5	1.0	27%
TP-6	1.0	39%
TP-12	1.0	42%
TP-9	1.0	62%
TP-4	1.0	65%
TP-8	4.0	11%
TP-3	4.0	17%
TP-1	4.0	17%
TP-2	4.0	22%
TP-7	4.0	22%
TP-10	4.0	24%
TP-6	4.0	27%
TP-5	4.0	33%
TP-11	4.0	41%
TP-4	4.0	65%
TP-12	4.0	108%
TP-9	4.0	307%
TP-5	8.0	32%
TP-11	8.0	32%
TP-2	8.0	34%
TP-7	10.0	13%
TP-3	10.0	16%
TP-6	10.0	31%
TP-4	10.0	37%
TP-8	12.0	17%
TP-1	12.0	31%
TP-12	12.0	33%

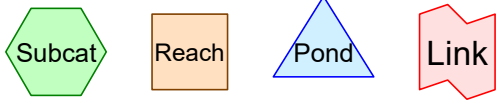
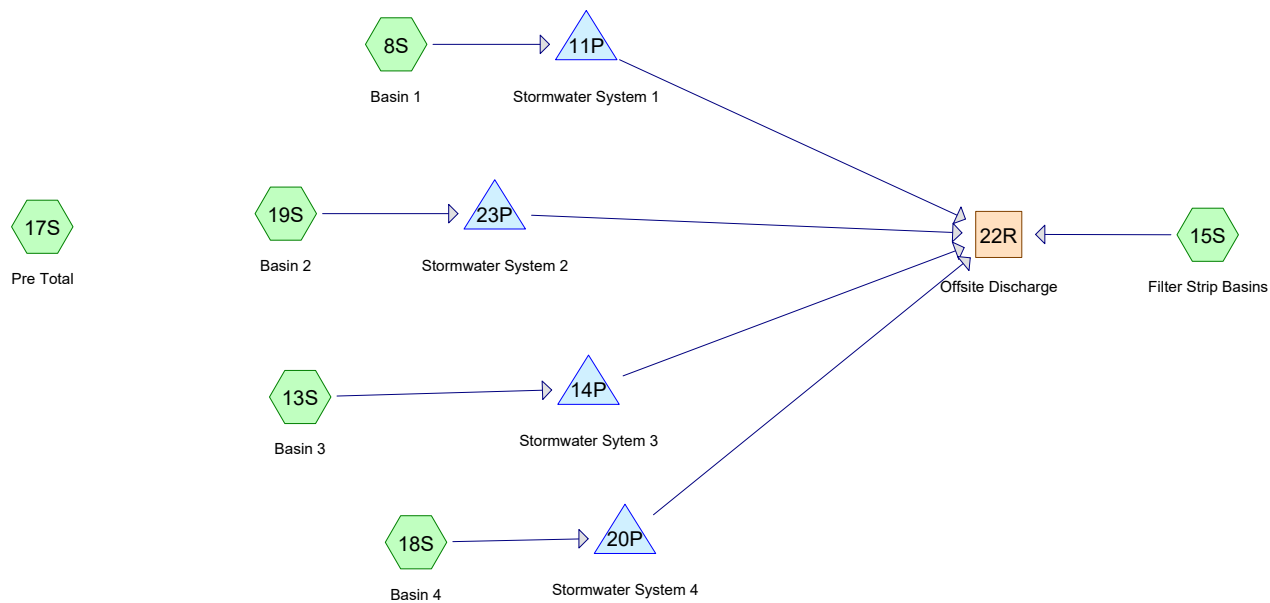
<b>Exploration</b>	<b>Depth, ft</b>	<b>Organic Content</b>
TP-9	4.0	60.4%
TP-12	4.0	22.3%



**Note:** Base plate should be seated level on firm soil.

**Appendix G**

Stormwater Calculations



**Routing Diagram for Walgraves**  
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# Walgraves

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## Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
17.002	98	(8S, 13S, 15S, 18S, 19S)
17.002	80	>75% Grass cover, Good, HSG D (17S)
<b>34.004</b>	<b>89</b>	<b>TOTAL AREA</b>



# Walgraves

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## Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
0.000	HSG A	
0.000	HSG B	
0.000	HSG C	
17.002	HSG D	17S
17.002	Other	8S, 13S, 15S, 18S, 19S
<b>34.004</b>		<b>TOTAL AREA</b>

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## Ground Covers (all nodes)

HSG-A (acres)	HSG-B (acres)	HSG-C (acres)	HSG-D (acres)	Other (acres)	Total (acres)	Ground Cover	Subcatchment Numbers
0.000	0.000	0.000	0.000	17.002	17.002		8S, 13S, 15S, 18S, 19S
0.000	0.000	0.000	17.002	0.000	17.002	>75% Grass cover, Good	17S
<b>0.000</b>	<b>0.000</b>	<b>0.000</b>	<b>17.002</b>	<b>17.002</b>	<b>34.004</b>	<b>TOTAL AREA</b>	

**Walgraves**

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Type IA 24-hr 2-YR Rainfall=2.50"

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Time span=0.00-96.00 hrs, dt=0.05 hrs, 1921 points  
 Runoff by SCS TR-20 method, UH=SCS, Weighted-CN  
 Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

<b>Subcatchment8S: Basin 1</b>	Runoff Area=125,547 sf 100.00% Impervious Runoff Depth=2.27" Tc=5.0 min CN=98 Runoff=1.69 cfs 0.545 af
<b>Subcatchment13S: Basin 3</b>	Runoff Area=224,462 sf 100.00% Impervious Runoff Depth=2.27" Tc=5.0 min CN=98 Runoff=3.02 cfs 0.975 af
<b>Subcatchment15S: Filter Strip Basins</b>	Runoff Area=40,551 sf 100.00% Impervious Runoff Depth=2.27" Tc=10.0 min CN=98 Runoff=0.54 cfs 0.176 af
<b>Subcatchment17S: Pre Total</b>	Runoff Area=740,599 sf 0.00% Impervious Runoff Depth=0.89" Tc=30.0 min CN=80 Runoff=2.48 cfs 1.259 af
<b>Subcatchment18S: Basin 4</b>	Runoff Area=152,599 sf 100.00% Impervious Runoff Depth=2.27" Tc=5.0 min CN=98 Runoff=2.05 cfs 0.663 af
<b>Subcatchment19S: Basin 2</b>	Runoff Area=197,440 sf 100.00% Impervious Runoff Depth=2.27" Tc=5.0 min CN=98 Runoff=2.65 cfs 0.858 af
<b>Reach 22R: Offsite Discharge</b>	Avg. Flow Depth=0.09' Max Vel=0.22 fps Inflow=1.25 cfs 2.839 af n=0.035 L=300.0' S=0.0008 '/' Capacity=29.46 cfs Outflow=1.10 cfs 2.828 af
<b>Pond 11P: Stormwater System 1</b>	Peak Elev=135.46' Storage=0.270 af Inflow=1.69 cfs 0.545 af Outflow=0.21 cfs 0.525 af
<b>Pond 14P: Stormwater System 3</b>	Peak Elev=134.00' Storage=0.396 af Inflow=3.02 cfs 0.975 af Outflow=0.60 cfs 0.933 af
<b>Pond 20P: Stormwater System 4</b>	Peak Elev=134.72' Storage=0.452 af Inflow=2.05 cfs 0.663 af Outflow=0.17 cfs 0.625 af
<b>Pond 23P: Stormwater System 2</b>	Peak Elev=137.33' Storage=0.718 af Inflow=2.65 cfs 0.858 af Outflow=0.22 cfs 0.580 af

**Total Runoff Area = 34.004 ac Runoff Volume = 4.477 af Average Runoff Depth = 1.58"**  
**50.00% Pervious = 17.002 ac 50.00% Impervious = 17.002 ac**

**Summary for Subcatchment 8S: Basin 1**

[49] Hint:  $T_c < 2dt$  may require smaller dt

Runoff = 1.69 cfs @ 7.86 hrs, Volume= 0.545 af, Depth= 2.27"

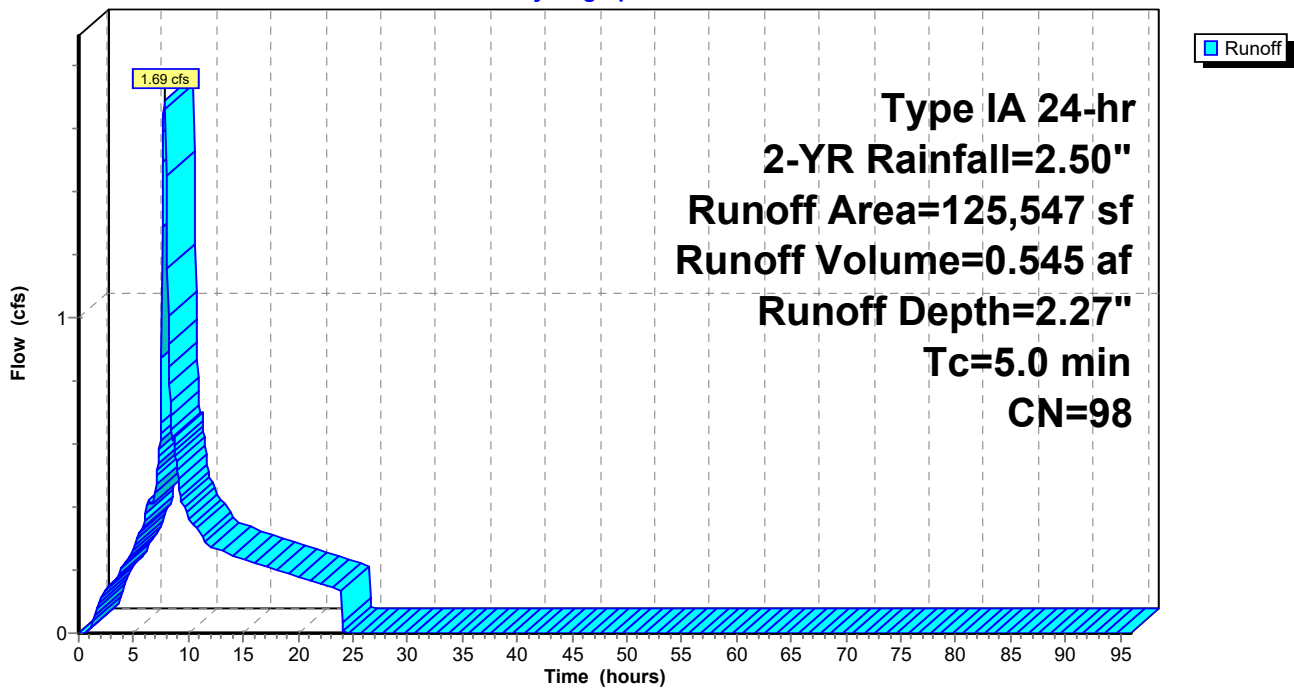
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
 Type IA 24-hr 2-YR Rainfall=2.50"

Area (sf)	CN	Description
* 125,547	98	
125,547		100.00% Impervious Area

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

**Subcatchment 8S: Basin 1**

Hydrograph



**Summary for Subcatchment 13S: Basin 3**

[49] Hint: Tc<2dt may require smaller dt

Runoff = 3.02 cfs @ 7.86 hrs, Volume= 0.975 af, Depth= 2.27"

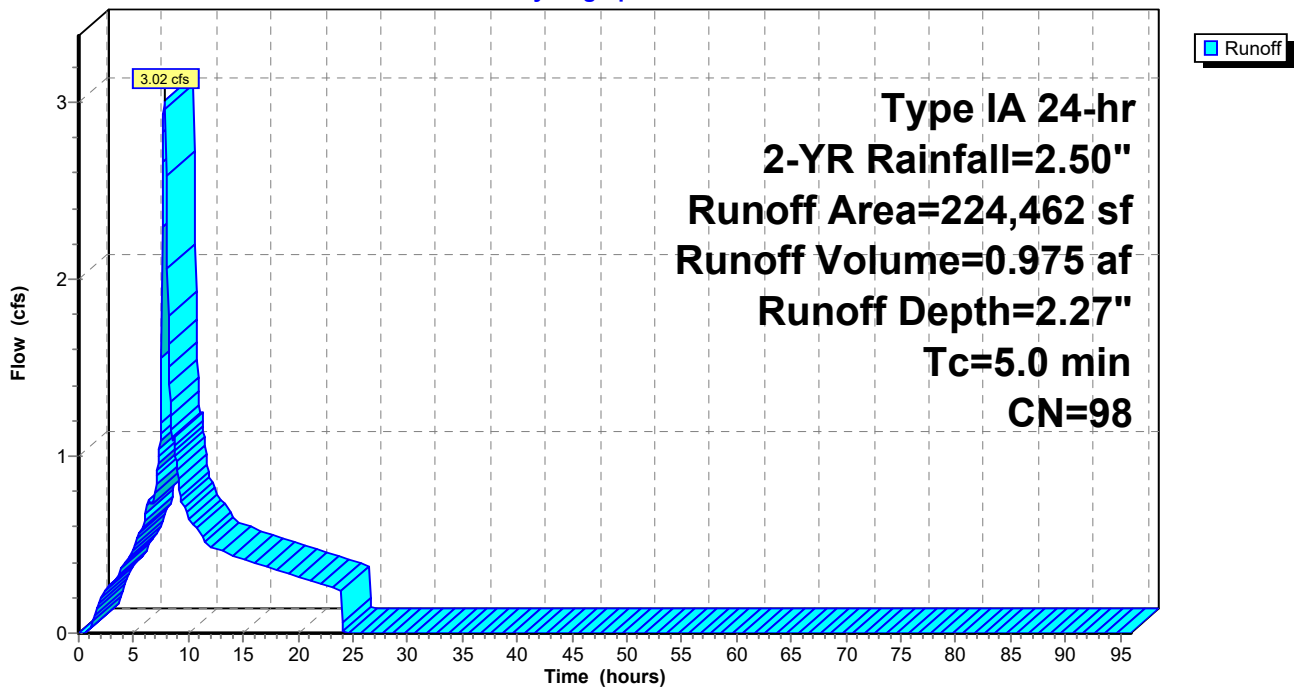
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
 Type IA 24-hr 2-YR Rainfall=2.50"

Area (sf)	CN	Description
* 224,462	98	
224,462		100.00% Impervious Area

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

**Subcatchment 13S: Basin 3**

Hydrograph



**Summary for Subcatchment 15S: Filter Strip Basins**

Runoff = 0.54 cfs @ 7.94 hrs, Volume= 0.176 af, Depth= 2.27"

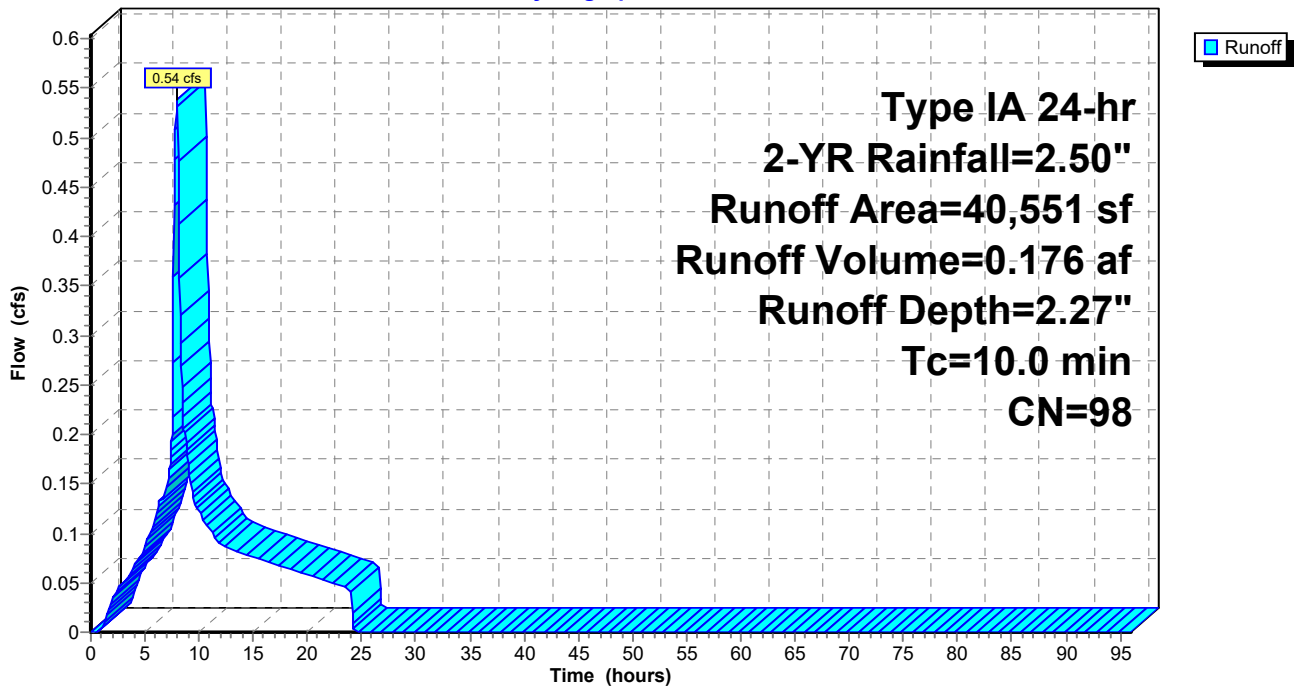
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
 Type IA 24-hr 2-YR Rainfall=2.50"

Area (sf)	CN	Description
* 40,551	98	
40,551		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.0					Direct Entry, 20

**Subcatchment 15S: Filter Strip Basins**

Hydrograph



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Type IA 24-hr 2-YR Rainfall=2.50"

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## Summary for Subcatchment 17S: Pre Total

Runoff = 2.48 cfs @ 8.28 hrs, Volume= 1.259 af, Depth= 0.89"

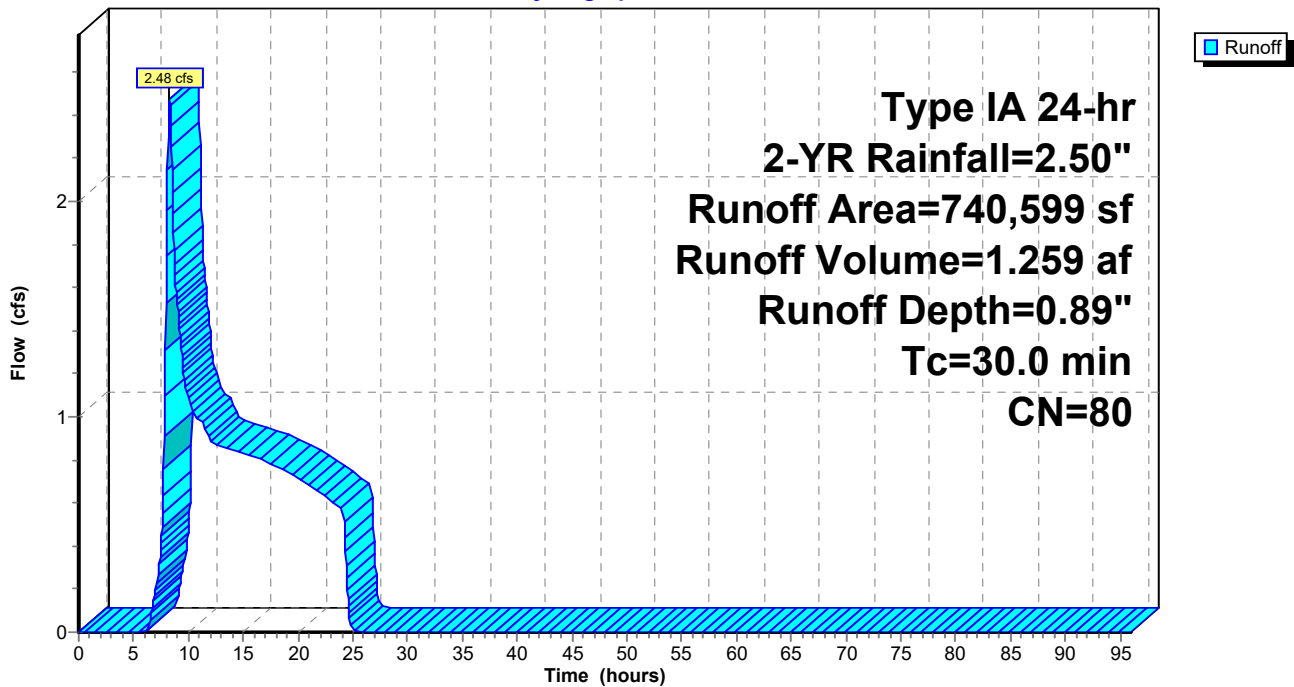
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
Type IA 24-hr 2-YR Rainfall=2.50"

Area (sf)	CN	Description
740,599	80	>75% Grass cover, Good, HSG D
740,599		100.00% Pervious Area

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

## Subcatchment 17S: Pre Total

Hydrograph



### Summary for Subcatchment 18S: Basin 4

[49] Hint:  $T_c < 2dt$  may require smaller dt

Runoff = 2.05 cfs @ 7.86 hrs, Volume= 0.663 af, Depth= 2.27"

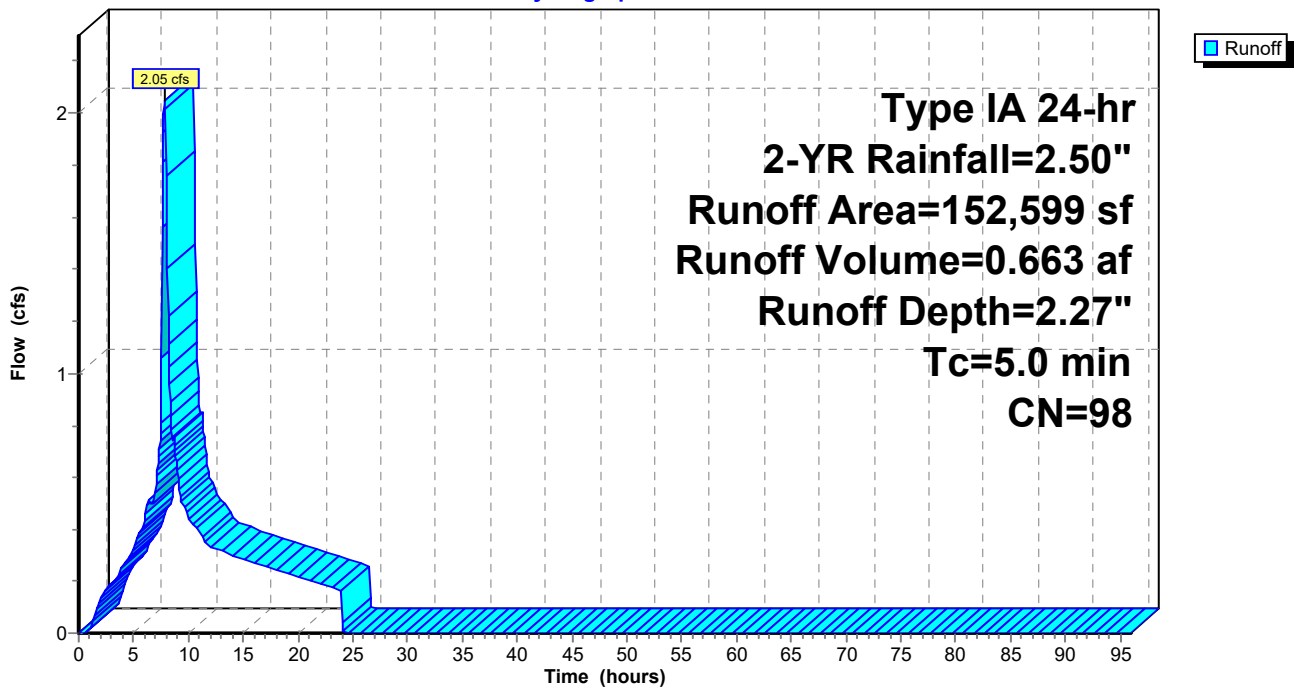
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
Type IA 24-hr 2-YR Rainfall=2.50"

Area (sf)	CN	Description
* 152,599	98	
152,599		100.00% Impervious Area

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

### Subcatchment 18S: Basin 4

Hydrograph





**Summary for Subcatchment 19S: Basin 2**

[49] Hint:  $T_c < 2dt$  may require smaller dt

Runoff = 2.65 cfs @ 7.86 hrs, Volume= 0.858 af, Depth= 2.27"

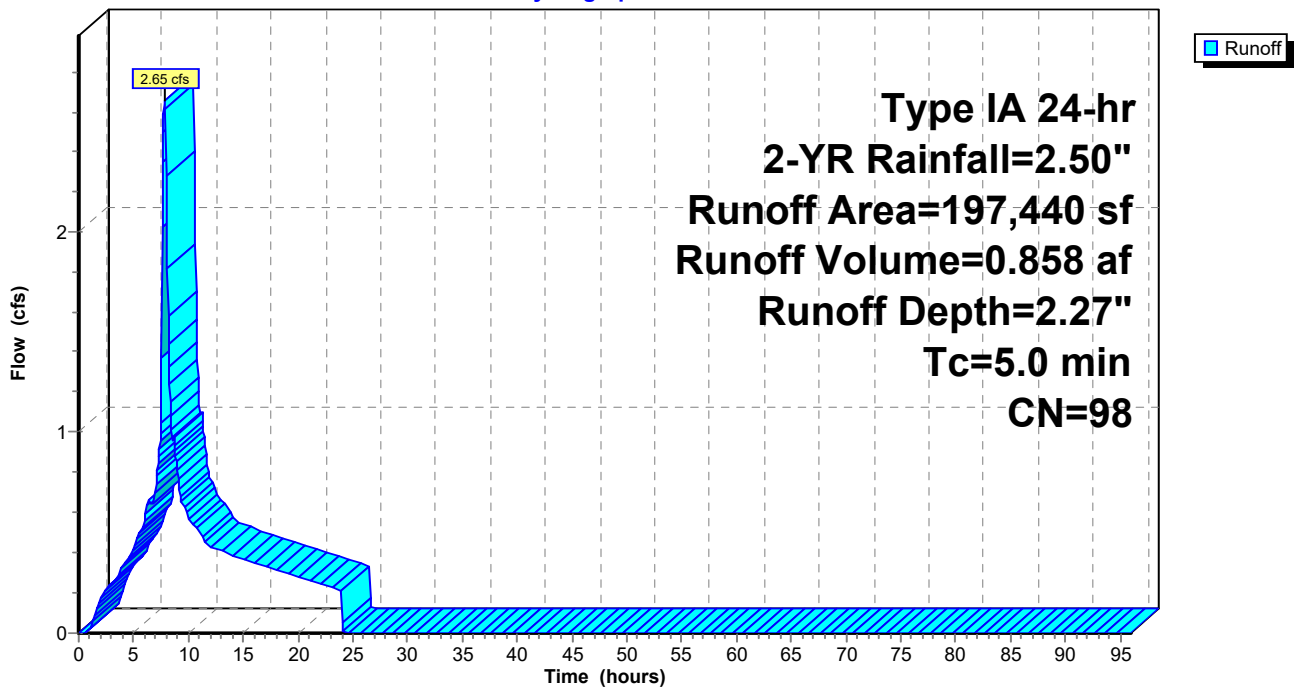
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
 Type IA 24-hr 2-YR Rainfall=2.50"

Area (sf)	CN	Description
* 197,440	98	
197,440		100.00% Impervious Area

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

**Subcatchment 19S: Basin 2**

Hydrograph



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## Summary for Reach 22R: Offsite Discharge

Reach modeled with shallow side slopes to best mimic the overland flow created at the discharge points.

[81] Warning: Exceeded Pond 14P by 0.50' @ 0.00 hrs

[81] Warning: Exceeded Pond 20P by 0.50' @ 0.00 hrs

Inflow Area = 17.002 ac, 100.00% Impervious, Inflow Depth > 2.00" for 2-YR event  
Inflow = 1.25 cfs @ 8.04 hrs, Volume= 2.839 af  
Outflow = 1.10 cfs @ 8.63 hrs, Volume= 2.828 af, Atten= 11%, Lag= 35.8 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
Max. Velocity= 0.22 fps, Min. Travel Time= 22.9 min  
Avg. Velocity = 0.13 fps, Avg. Travel Time= 37.6 min

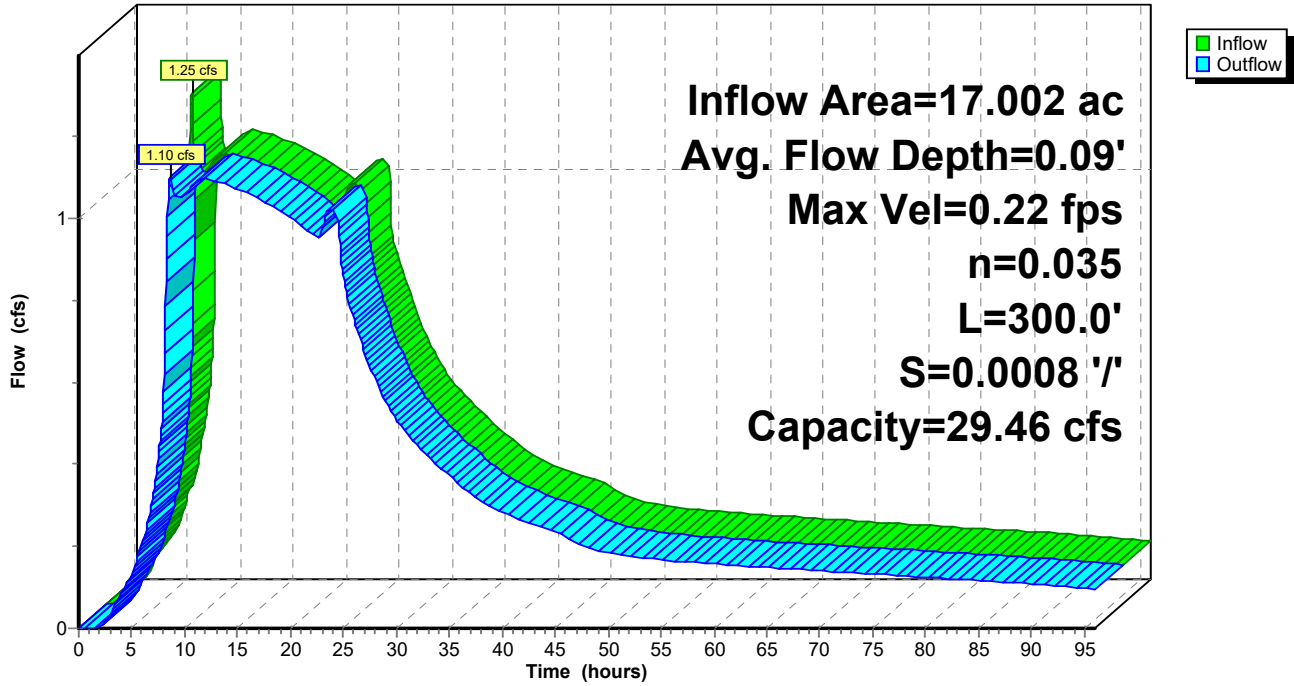
Peak Storage= 1,517 cf @ 8.25 hrs  
Average Depth at Peak Storage= 0.09'  
Bank-Full Depth= 0.50' Flow Area= 50.0 sf, Capacity= 29.46 cfs

50.00' x 0.50' deep channel, n= 0.035 High grass  
Side Slope Z-value= 100.0 ' ' Top Width= 150.00'  
Length= 300.0' Slope= 0.0008 ' '  
Inlet Invert= 133.00', Outlet Invert= 132.75'



### Reach 22R: Offsite Discharge

Hydrograph



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Type IA 24-hr 2-YR Rainfall=2.50"

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## Summary for Pond 11P: Stormwater System 1

Inflow Area = 2.882 ac, 100.00% Impervious, Inflow Depth = 2.27" for 2-YR event  
Inflow = 1.69 cfs @ 7.86 hrs, Volume= 0.545 af  
Outflow = 0.21 cfs @ 16.91 hrs, Volume= 0.525 af, Atten= 87%, Lag= 543.1 min  
Primary = 0.21 cfs @ 16.91 hrs, Volume= 0.525 af

Routing by Stor-Ind method, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
Peak Elev= 135.46' @ 16.91 hrs Surf.Area= 0.246 ac Storage= 0.270 af

Plug-Flow detention time= 808.6 min calculated for 0.525 af (96% of inflow)  
Center-of-Mass det. time= 780.3 min ( 1,452.3 - 671.9 )

Volume	Invert	Avail.Storage	Storage Description
#1A	133.50'	0.149 af	<b>28.33"W x 377.50'L x 2.04'H Field A</b> 0.501 af Overall - 0.128 af Embedded = 0.373 af x 40.0% Voids
#2A	134.00'	0.128 af	<b>Cultec C-100HD x 400 Inside #1</b> Effective Size= 32.1"W x 12.0"H => 1.86 sf x 7.50'L = 14.0 cf Overall Size= 36.0"W x 12.5"H x 8.00'L with 0.50' Overlap Row Length Adjustment= +0.50' x 1.86 sf x 8 rows
		0.278 af	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	133.50'	<b>0.5" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads
#2	Primary	133.80'	<b>2.5" Vert. Orifice/Grate</b> C= 0.600
#3	Primary	135.50'	<b>24.0" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads

**Primary OutFlow** Max=0.21 cfs @ 16.91 hrs HW=135.46' (Free Discharge)

- 1=Orifice/Grate (Orifice Controls 0.01 cfs @ 6.74 fps)
- 2=Orifice/Grate (Orifice Controls 0.20 cfs @ 6.01 fps)
- 3=Orifice/Grate ( Controls 0.00 cfs)

**Pond 11P: Stormwater System 1 - Chamber Wizard Field A**

**Chamber Model = Cultec C-100HD (Cultec Contactor® 100HD)**

Effective Size= 32.1"W x 12.0"H => 1.86 sf x 7.50'L = 14.0 cf

Overall Size= 36.0"W x 12.5"H x 8.00'L with 0.50' Overlap

Row Length Adjustment= +0.50' x 1.86 sf x 8 rows

36.0" Wide + 4.0" Spacing = 40.0" C-C Row Spacing

50 Chambers/Row x 7.50' Long +0.50' Row Adjustment = 375.50' Row Length +12.0" End Stone x 2 = 377.50' Base Length

8 Rows x 36.0" Wide + 4.0" Spacing x 7 + 12.0" Side Stone x 2 = 28.33' Base Width

6.0" Base + 12.5" Chamber Height + 6.0" Cover = 2.04' Field Height

400 Chambers x 14.0 cf +0.50' Row Adjustment x 1.86 sf x 8 Rows = 5,591.9 cf Chamber Storage

21,837.3 cf Field - 5,591.9 cf Chambers = 16,245.4 cf Stone x 40.0% Voids = 6,498.2 cf Stone Storage

Chamber Storage + Stone Storage = 12,090.1 cf = 0.278 af

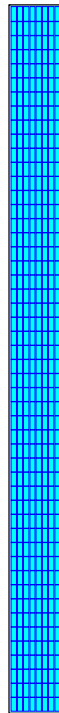
Overall Storage Efficiency = 55.4%

Overall System Size = 377.50' x 28.33' x 2.04'

400 Chambers

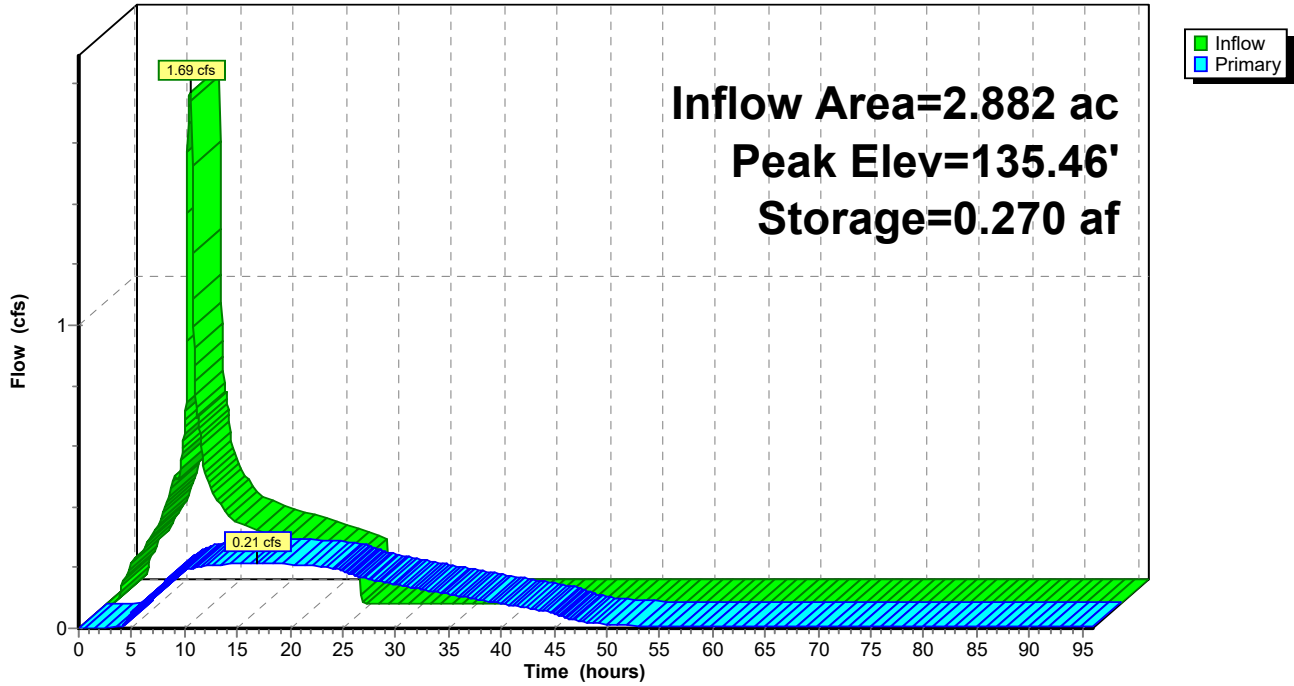
808.8 cy Field

601.7 cy Stone



### Pond 11P: Stormwater System 1

Hydrograph



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## Summary for Pond 14P: Stormwater Sytem 3

Inflow Area = 5.153 ac, 100.00% Impervious, Inflow Depth = 2.27" for 2-YR event  
Inflow = 3.02 cfs @ 7.86 hrs, Volume= 0.975 af  
Outflow = 0.60 cfs @ 10.73 hrs, Volume= 0.933 af, Atten= 80%, Lag= 172.0 min  
Primary = 0.60 cfs @ 10.73 hrs, Volume= 0.933 af

Routing by Stor-Ind method, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
Peak Elev= 134.00' @ 10.73 hrs Surf.Area= 0.427 ac Storage= 0.396 af

Plug-Flow detention time= 653.5 min calculated for 0.933 af (96% of inflow)  
Center-of-Mass det. time= 623.7 min ( 1,295.7 - 671.9 )

Volume	Invert	Avail.Storage	Storage Description
#1A	132.50'	0.257 af	<b>68.33"W x 272.50'L x 2.04'H Field A</b> 0.873 af Overall - 0.231 af Embedded = 0.642 af x 40.0% Voids
#2A	133.00'	0.231 af	<b>Cultec C-100HD x 720 Inside #1</b> Effective Size= 32.1"W x 12.0"H => 1.86 sf x 7.50'L = 14.0 cf Overall Size= 36.0"W x 12.5"H x 8.00'L with 0.50' Overlap Row Length Adjustment= +0.50' x 1.86 sf x 20 rows
		0.488 af	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	132.50'	<b>1.0" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads
#2	Primary	133.05'	<b>5.0" Vert. Orifice/Grate</b> C= 0.600
#3	Primary	134.30'	<b>24.0" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads

**Primary OutFlow** Max=0.60 cfs @ 10.73 hrs HW=134.00' (Free Discharge)

- 1=Orifice/Grate (Orifice Controls 0.03 cfs @ 5.90 fps)
- 2=Orifice/Grate (Orifice Controls 0.57 cfs @ 4.16 fps)
- 3=Orifice/Grate ( Controls 0.00 cfs)

**Pond 14P: Stormwater Sytem 3 - Chamber Wizard Field A**

**Chamber Model = Cultec C-100HD (Cultec Contactor® 100HD)**

Effective Size= 32.1"W x 12.0"H => 1.86 sf x 7.50'L = 14.0 cf

Overall Size= 36.0"W x 12.5"H x 8.00'L with 0.50' Overlap

Row Length Adjustment= +0.50' x 1.86 sf x 20 rows

36.0" Wide + 4.0" Spacing = 40.0" C-C Row Spacing

36 Chambers/Row x 7.50' Long +0.50' Row Adjustment = 270.50' Row Length +12.0" End Stone x 2 = 272.50' Base Length

20 Rows x 36.0" Wide + 4.0" Spacing x 19 + 12.0" Side Stone x 2 = 68.33' Base Width

6.0" Base + 12.5" Chamber Height + 6.0" Cover = 2.04' Field Height

720 Chambers x 14.0 cf +0.50' Row Adjustment x 1.86 sf x 20 Rows = 10,070.7 cf Chamber Storage

38,017.5 cf Field - 10,070.7 cf Chambers = 27,946.8 cf Stone x 40.0% Voids = 11,178.7 cf Stone Storage

Chamber Storage + Stone Storage = 21,249.4 cf = 0.488 af

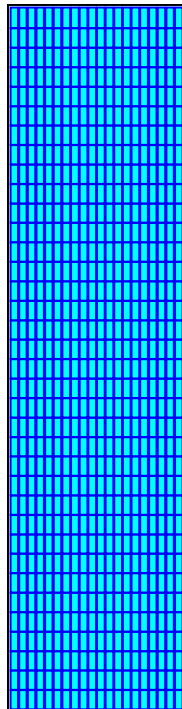
Overall Storage Efficiency = 55.9%

Overall System Size = 272.50' x 68.33' x 2.04'

720 Chambers

1,408.1 cy Field

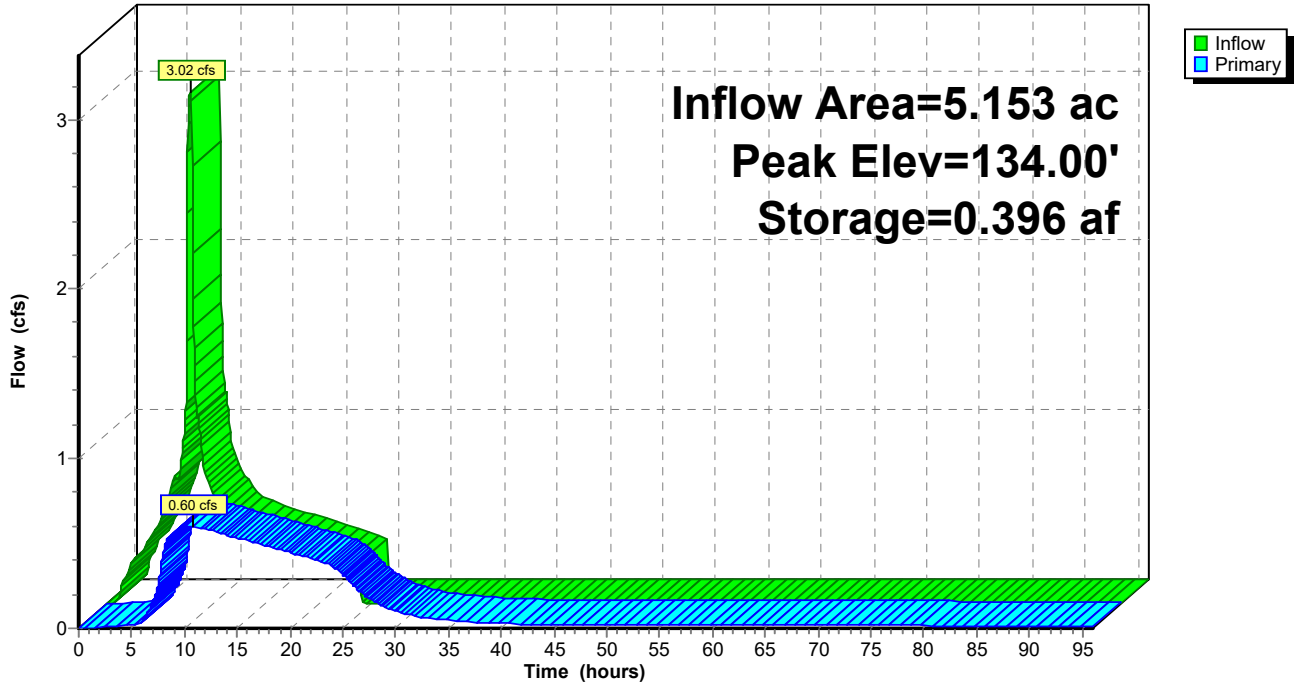
1,035.1 cy Stone





### Pond 14P: Stormwater Sytem 3

Hydrograph



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## Summary for Pond 20P: Stormwater System 4

Inflow Area = 3.503 ac, 100.00% Impervious, Inflow Depth = 2.27" for 2-YR event  
 Inflow = 2.05 cfs @ 7.86 hrs, Volume= 0.663 af  
 Outflow = 0.17 cfs @ 23.59 hrs, Volume= 0.625 af, Atten= 92%, Lag= 943.5 min  
 Primary = 0.17 cfs @ 23.59 hrs, Volume= 0.625 af

Routing by Stor-Ind method, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
 Peak Elev= 134.72' @ 23.59 hrs Surf.Area= 0.283 ac Storage= 0.452 af

Plug-Flow detention time= 1,750.3 min calculated for 0.625 af (94% of inflow)  
 Center-of-Mass det. time= 1,709.5 min ( 2,381.4 - 671.9 )

Volume	Invert	Avail.Storage	Storage Description
#1A	132.50'	0.266 af	<b>30.00'W x 411.50'L x 4.00'H Field A</b> 1.134 af Overall - 0.468 af Embedded = 0.665 af x 40.0% Voids
#2A	133.00'	0.468 af	<b>Cultec R-360HD x 555 Inside #1</b> Effective Size= 54.9"W x 36.0"H => 9.99 sf x 3.67'L = 36.6 cf Overall Size= 60.0"W x 36.0"H x 4.17'L with 0.50' Overlap 555 Chambers in 5 Rows Cap Storage= +6.5 cf x 2 x 5 rows = 64.6 cf
		0.734 af	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	132.50'	<b>1.5" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads
#2	Primary	134.00'	<b>2.0" Vert. Orifice/Grate</b> C= 0.600
#3	Primary	136.25'	<b>24.0" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads

**Primary OutFlow** Max=0.17 cfs @ 23.59 hrs HW=134.72' (Free Discharge)

- 1=Orifice/Grate (Orifice Controls 0.09 cfs @ 7.17 fps)
- 2=Orifice/Grate (Orifice Controls 0.08 cfs @ 3.83 fps)
- 3=Orifice/Grate ( Controls 0.00 cfs)

## Walgraves

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Type IA 24-hr 2-YR Rainfall=2.50"

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### Pond 20P: Stormwater System 4 - Chamber Wizard Field A

#### Chamber Model = Cultec R-360HD (Cultec Recharger® 360HD)

Effective Size= 54.9"W x 36.0"H => 9.99 sf x 3.67'L = 36.6 cf

Overall Size= 60.0"W x 36.0"H x 4.17'L with 0.50' Overlap

Cap Storage= +6.5 cf x 2 x 5 rows = 64.6 cf

60.0" Wide + 9.0" Spacing = 69.0" C-C Row Spacing

111 Chambers/Row x 3.67' Long +1.25' Cap Length x 2 = 409.50' Row Length +12.0" End Stone x 2 =  
411.50' Base Length

5 Rows x 60.0" Wide + 9.0" Spacing x 4 + 12.0" Side Stone x 2 = 30.00' Base Width

6.0" Base + 36.0" Chamber Height + 6.0" Cover = 4.00' Field Height

555 Chambers x 36.6 cf + 6.5 cf Cap Volume x 2 x 5 Rows = 20,402.4 cf Chamber Storage

49,380.0 cf Field - 20,402.4 cf Chambers = 28,977.6 cf Stone x 40.0% Voids = 11,591.0 cf Stone Storage

Chamber Storage + Stone Storage = 31,993.4 cf = 0.734 af

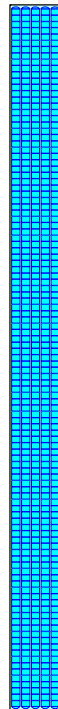
Overall Storage Efficiency = 64.8%

Overall System Size = 411.50' x 30.00' x 4.00'

555 Chambers

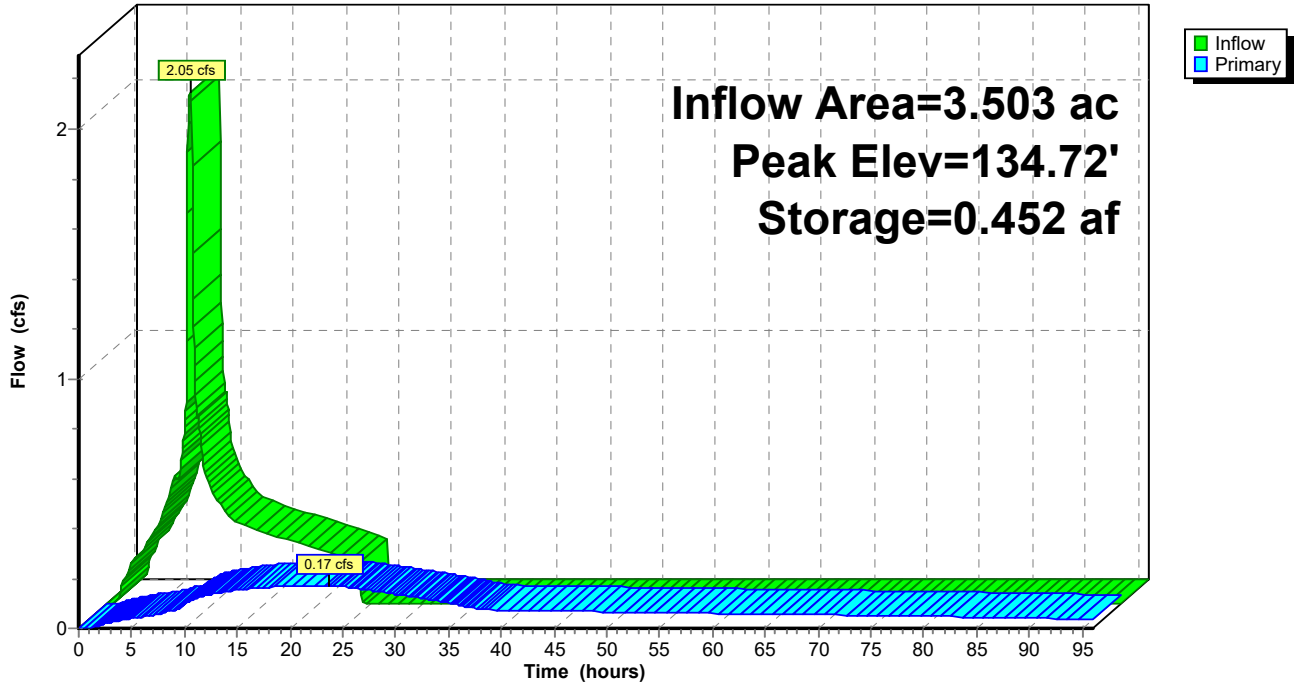
1,828.9 cy Field

1,073.2 cy Stone



**Pond 20P: Stormwater System 4**

Hydrograph



# Walgraves

Prepared by AAI Engineering

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Type IA 24-hr 2-YR Rainfall=2.50"

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## Summary for Pond 23P: Stormwater System 2

Inflow Area = 4.533 ac, 100.00% Impervious, Inflow Depth = 2.27" for 2-YR event  
 Inflow = 2.65 cfs @ 7.86 hrs, Volume= 0.858 af  
 Outflow = 0.22 cfs @ 23.43 hrs, Volume= 0.580 af, Atten= 92%, Lag= 934.4 min  
 Primary = 0.22 cfs @ 23.43 hrs, Volume= 0.580 af

Routing by Stor-Ind method, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
 Peak Elev= 137.33' @ 23.43 hrs Surf.Area= 0.284 ac Storage= 0.718 af

Plug-Flow detention time= 2,268.5 min calculated for 0.579 af (68% of inflow)  
 Center-of-Mass det. time= 2,072.7 min ( 2,744.6 - 671.9 )

Volume	Invert	Avail.Storage	Storage Description
#1A	133.50'	0.265 af	<b>41.50"W x 297.83'L x 4.00'H Field A</b> 1.135 af Overall - 0.473 af Embedded = 0.662 af x 40.0% Voids
#2A	134.00'	0.473 af	<b>Cultec R-360HD x 560 Inside #1</b> Effective Size= 54.9"W x 36.0"H => 9.99 sf x 3.67'L = 36.6 cf Overall Size= 60.0"W x 36.0"H x 4.17'L with 0.50' Overlap 560 Chambers in 7 Rows Cap Storage= +6.5 cf x 2 x 7 rows = 90.4 cf
		0.738 af	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	133.50'	<b>0.5" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads
#2	Primary	134.50'	<b>1.5" Vert. Orifice/Grate</b> C= 0.600
#3	Primary	137.30'	<b>24.0" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads

**Primary OutFlow** Max=0.21 cfs @ 23.43 hrs HW=137.33' (Free Discharge)

- 1=Orifice/Grate (Orifice Controls 0.01 cfs @ 9.42 fps)
- 2=Orifice/Grate (Orifice Controls 0.10 cfs @ 8.01 fps)
- 3=Orifice/Grate (Weir Controls 0.09 cfs @ 0.54 fps)

**Pond 23P: Stormwater System 2 - Chamber Wizard Field A**

**Chamber Model = Cultec R-360HD (Cultec Recharger® 360HD)**

Effective Size= 54.9"W x 36.0"H => 9.99 sf x 3.67'L = 36.6 cf

Overall Size= 60.0"W x 36.0"H x 4.17'L with 0.50' Overlap

Cap Storage= +6.5 cf x 2 x 7 rows = 90.4 cf

60.0" Wide + 9.0" Spacing = 69.0" C-C Row Spacing

80 Chambers/Row x 3.67' Long +1.25' Cap Length x 2 = 295.83' Row Length +12.0" End Stone x 2 = 297.83' Base Length

7 Rows x 60.0" Wide + 9.0" Spacing x 6 + 12.0" Side Stone x 2 = 41.50' Base Width

6.0" Base + 36.0" Chamber Height + 6.0" Cover = 4.00' Field Height

560 Chambers x 36.6 cf + 6.5 cf Cap Volume x 2 x 7 Rows = 20,611.5 cf Chamber Storage

49,440.3 cf Field - 20,611.5 cf Chambers = 28,828.9 cf Stone x 40.0% Voids = 11,531.6 cf Stone Storage

Chamber Storage + Stone Storage = 32,143.0 cf = 0.738 af

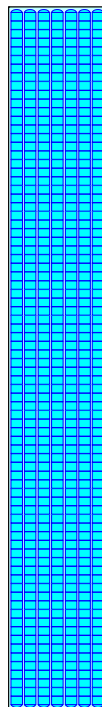
Overall Storage Efficiency = 65.0%

Overall System Size = 297.83' x 41.50' x 4.00'

560 Chambers

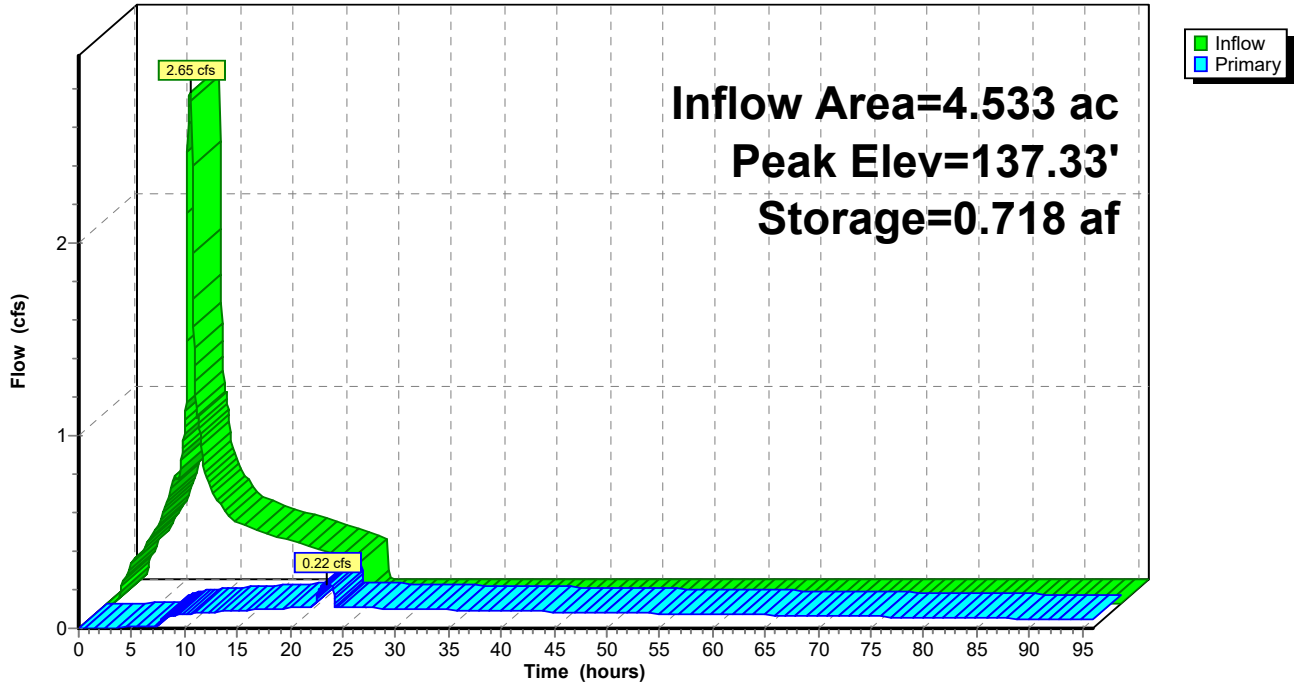
1,831.1 cy Field

1,067.7 cy Stone



### Pond 23P: Stormwater System 2

Hydrograph



**Walgraves**

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Type IA 24-hr 5-YR Rainfall=3.10"

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Time span=0.00-96.00 hrs, dt=0.05 hrs, 1921 points  
 Runoff by SCS TR-20 method, UH=SCS, Weighted-CN  
 Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

<b>Subcatchment8S: Basin 1</b>	Runoff Area=125,547 sf 100.00% Impervious Runoff Depth=2.87" Tc=5.0 min CN=98 Runoff=2.12 cfs 0.689 af
<b>Subcatchment13S: Basin 3</b>	Runoff Area=224,462 sf 100.00% Impervious Runoff Depth=2.87" Tc=5.0 min CN=98 Runoff=3.78 cfs 1.231 af
<b>Subcatchment15S: Filter Strip Basins</b>	Runoff Area=40,551 sf 100.00% Impervious Runoff Depth=2.87" Tc=10.0 min CN=98 Runoff=0.68 cfs 0.222 af
<b>Subcatchment17S: Pre Total</b>	Runoff Area=740,599 sf 0.00% Impervious Runoff Depth=1.33" Tc=30.0 min CN=80 Runoff=4.15 cfs 1.878 af
<b>Subcatchment18S: Basin 4</b>	Runoff Area=152,599 sf 100.00% Impervious Runoff Depth=2.87" Tc=5.0 min CN=98 Runoff=2.57 cfs 0.837 af
<b>Subcatchment19S: Basin 2</b>	Runoff Area=197,440 sf 100.00% Impervious Runoff Depth=2.87" Tc=5.0 min CN=98 Runoff=3.33 cfs 1.083 af
<b>Reach 22R: Offsite Discharge</b>	Avg. Flow Depth=0.12' Max Vel=0.27 fps Inflow=2.33 cfs 3.660 af n=0.035 L=300.0' S=0.0008 '/' Capacity=29.46 cfs Outflow=2.03 cfs 3.650 af
<b>Pond 11P: Stormwater System 1</b>	Peak Elev=135.59' Storage=0.278 af Inflow=2.12 cfs 0.689 af Outflow=0.73 cfs 0.668 af
<b>Pond 14P: Stormwater System 3</b>	Peak Elev=134.38' Storage=0.460 af Inflow=3.78 cfs 1.231 af Outflow=1.17 cfs 1.188 af
<b>Pond 20P: Stormwater System 4</b>	Peak Elev=135.28' Storage=0.565 af Inflow=2.57 cfs 0.837 af Outflow=0.21 cfs 0.776 af
<b>Pond 23P: Stormwater System 2</b>	Peak Elev=137.36' Storage=0.723 af Inflow=3.33 cfs 1.083 af Outflow=0.46 cfs 0.805 af

**Total Runoff Area = 34.004 ac Runoff Volume = 5.941 af Average Runoff Depth = 2.10"**  
**50.00% Pervious = 17.002 ac 50.00% Impervious = 17.002 ac**



**Summary for Subcatchment 8S: Basin 1**

[49] Hint: Tc<2dt may require smaller dt

Runoff = 2.12 cfs @ 7.86 hrs, Volume= 0.689 af, Depth= 2.87"

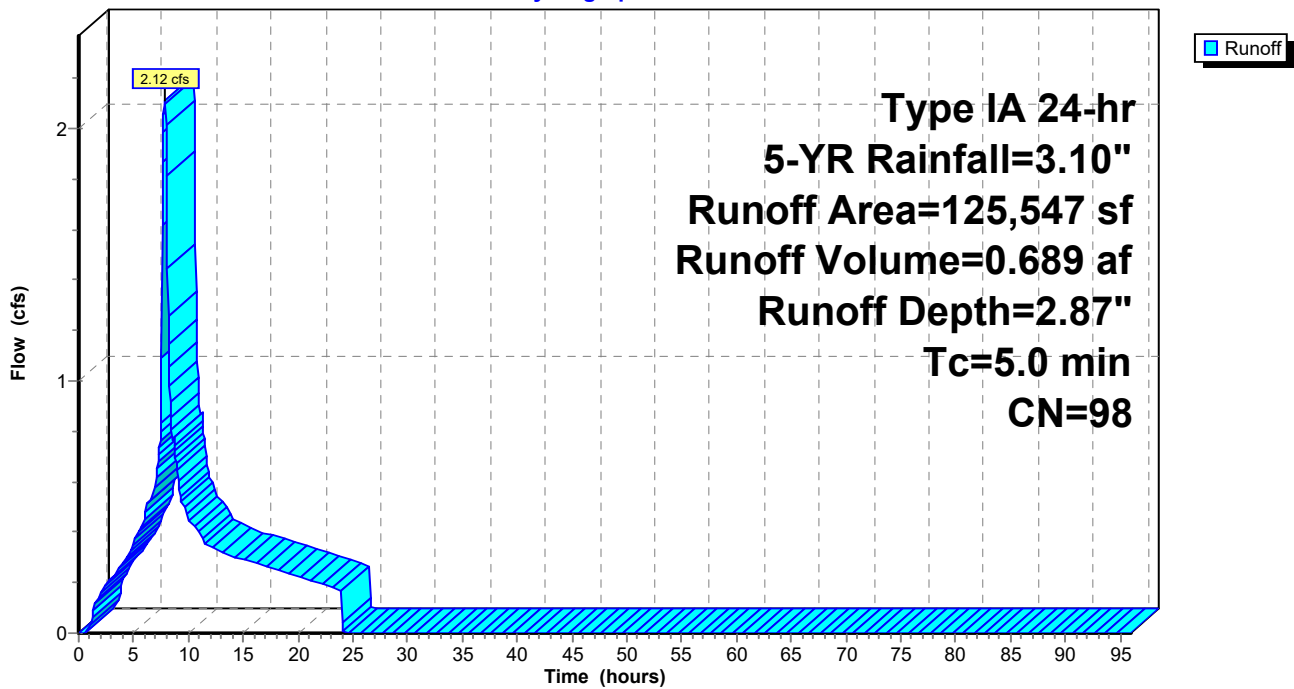
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
 Type IA 24-hr 5-YR Rainfall=3.10"

Area (sf)	CN	Description
* 125,547	98	
125,547		100.00% Impervious Area

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

**Subcatchment 8S: Basin 1**

Hydrograph



**Summary for Subcatchment 13S: Basin 3**

[49] Hint:  $T_c < 2dt$  may require smaller dt

Runoff = 3.78 cfs @ 7.86 hrs, Volume= 1.231 af, Depth= 2.87"

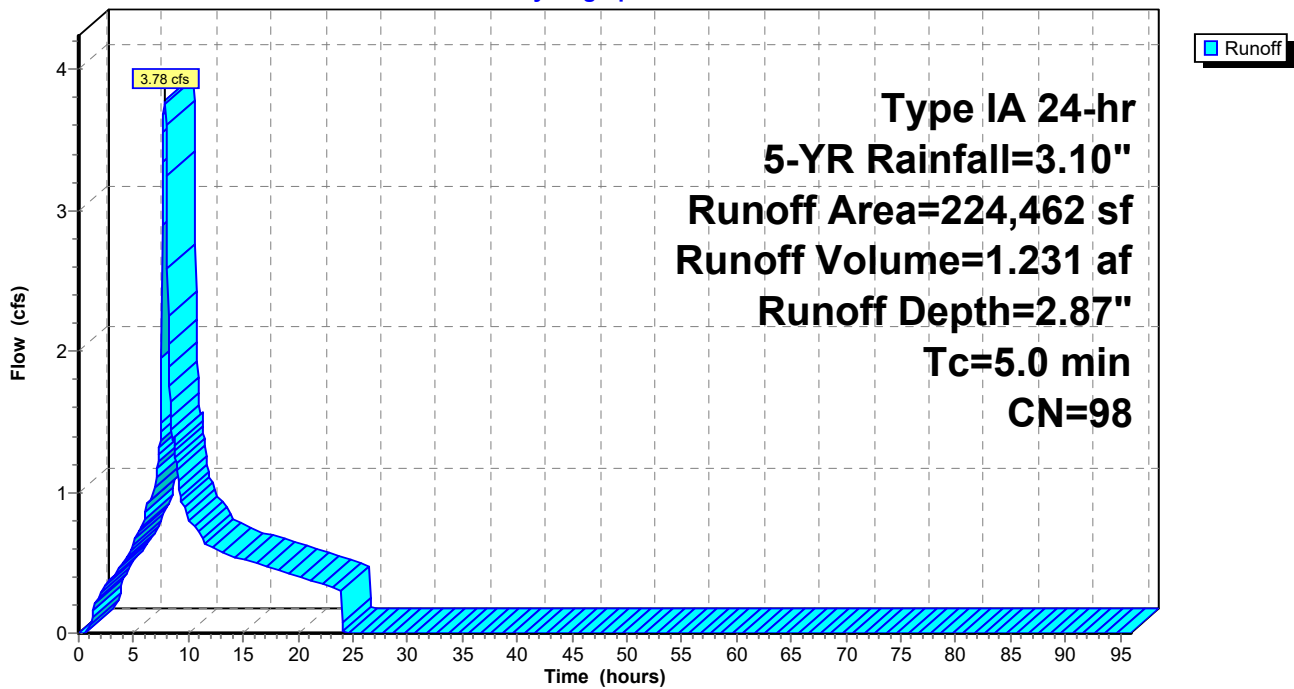
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
 Type IA 24-hr 5-YR Rainfall=3.10"

Area (sf)	CN	Description
* 224,462	98	
224,462		100.00% Impervious Area

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

**Subcatchment 13S: Basin 3**

Hydrograph



**Summary for Subcatchment 15S: Filter Strip Basins**

Runoff = 0.68 cfs @ 7.94 hrs, Volume= 0.222 af, Depth= 2.87"

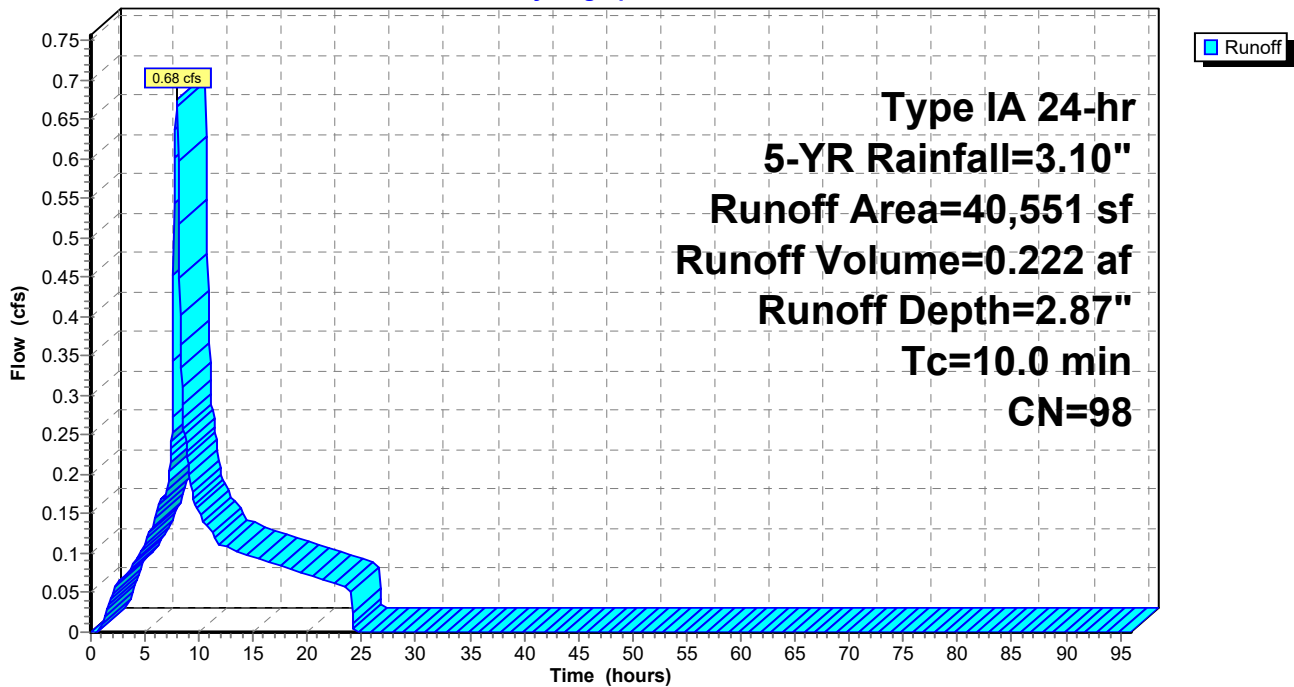
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
 Type IA 24-hr 5-YR Rainfall=3.10"

Area (sf)	CN	Description
* 40,551	98	
40,551		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.0					Direct Entry, 20

**Subcatchment 15S: Filter Strip Basins**

Hydrograph



**Walgraves**

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Type IA 24-hr 5-YR Rainfall=3.10"

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**Summary for Subcatchment 17S: Pre Total**

Runoff = 4.15 cfs @ 8.26 hrs, Volume= 1.878 af, Depth= 1.33"

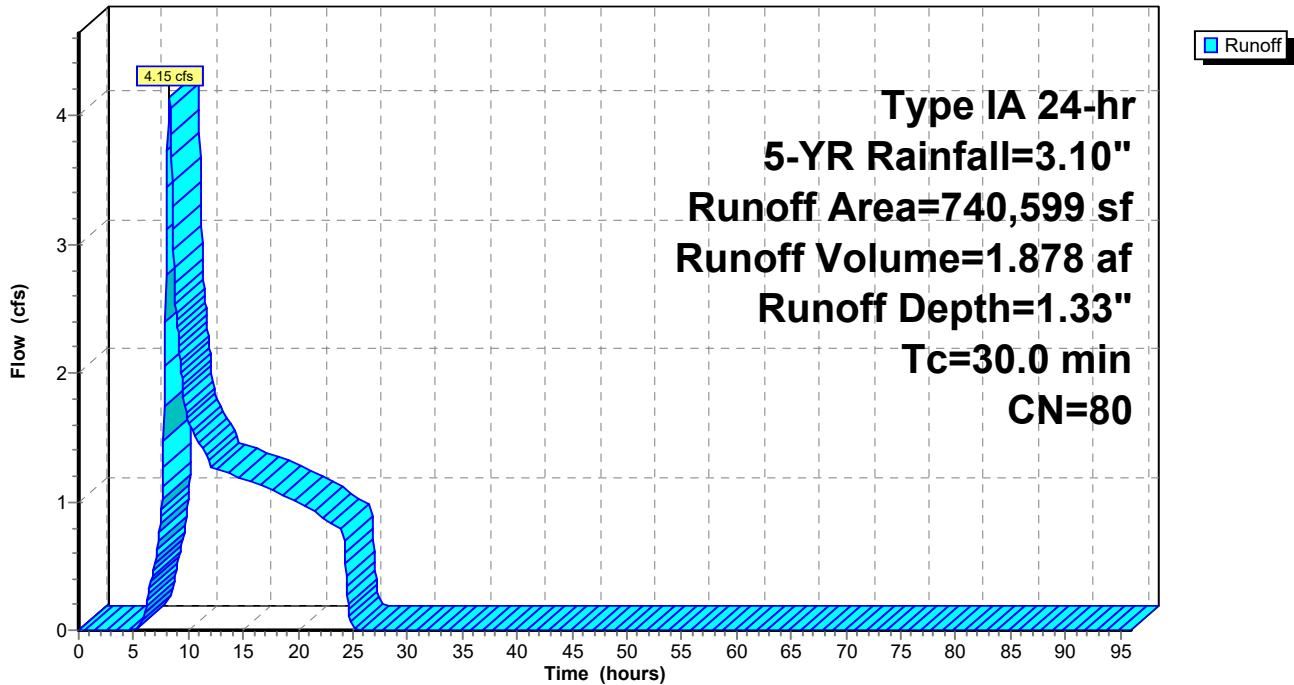
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
Type IA 24-hr 5-YR Rainfall=3.10"

Area (sf)	CN	Description
740,599	80	>75% Grass cover, Good, HSG D
740,599		100.00% Pervious Area

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

**Subcatchment 17S: Pre Total**

Hydrograph



**Summary for Subcatchment 18S: Basin 4**

[49] Hint:  $T_c < 2dt$  may require smaller dt

Runoff = 2.57 cfs @ 7.86 hrs, Volume= 0.837 af, Depth= 2.87"

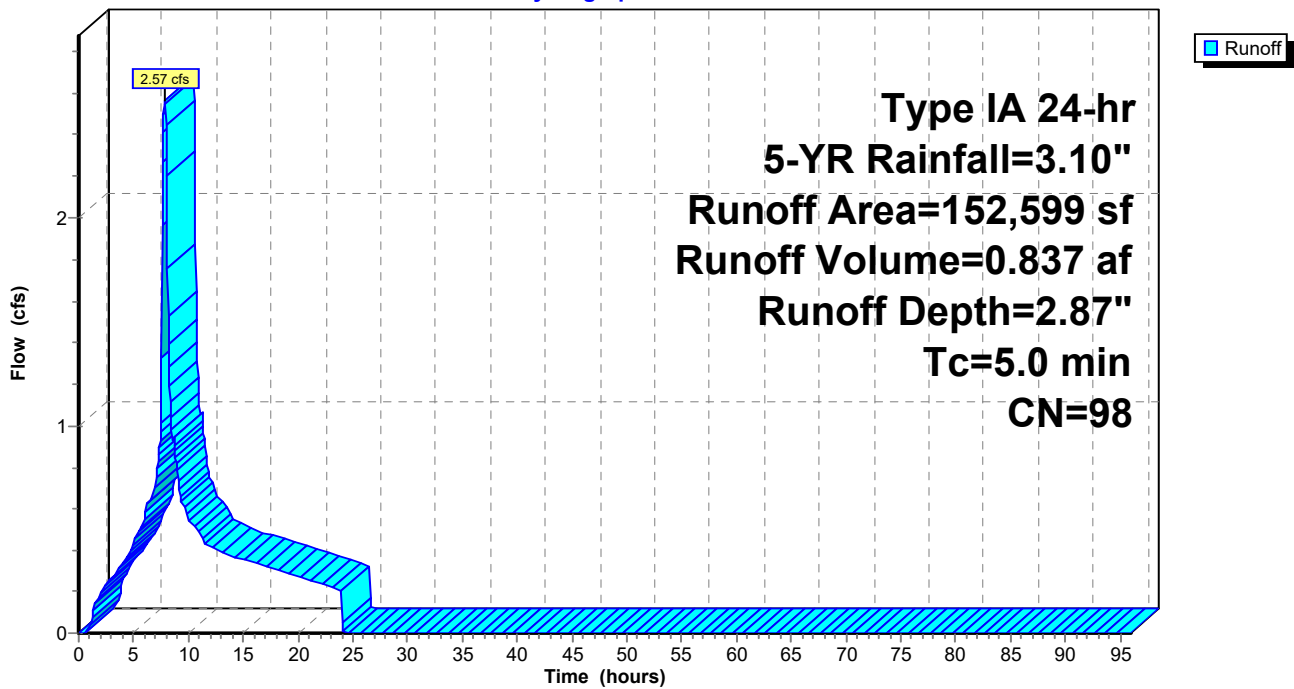
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
 Type IA 24-hr 5-YR Rainfall=3.10"

Area (sf)	CN	Description
* 152,599	98	
152,599		100.00% Impervious Area

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

**Subcatchment 18S: Basin 4**

Hydrograph



**Summary for Subcatchment 19S: Basin 2**

[49] Hint:  $T_c < 2dt$  may require smaller dt

Runoff = 3.33 cfs @ 7.86 hrs, Volume= 1.083 af, Depth= 2.87"

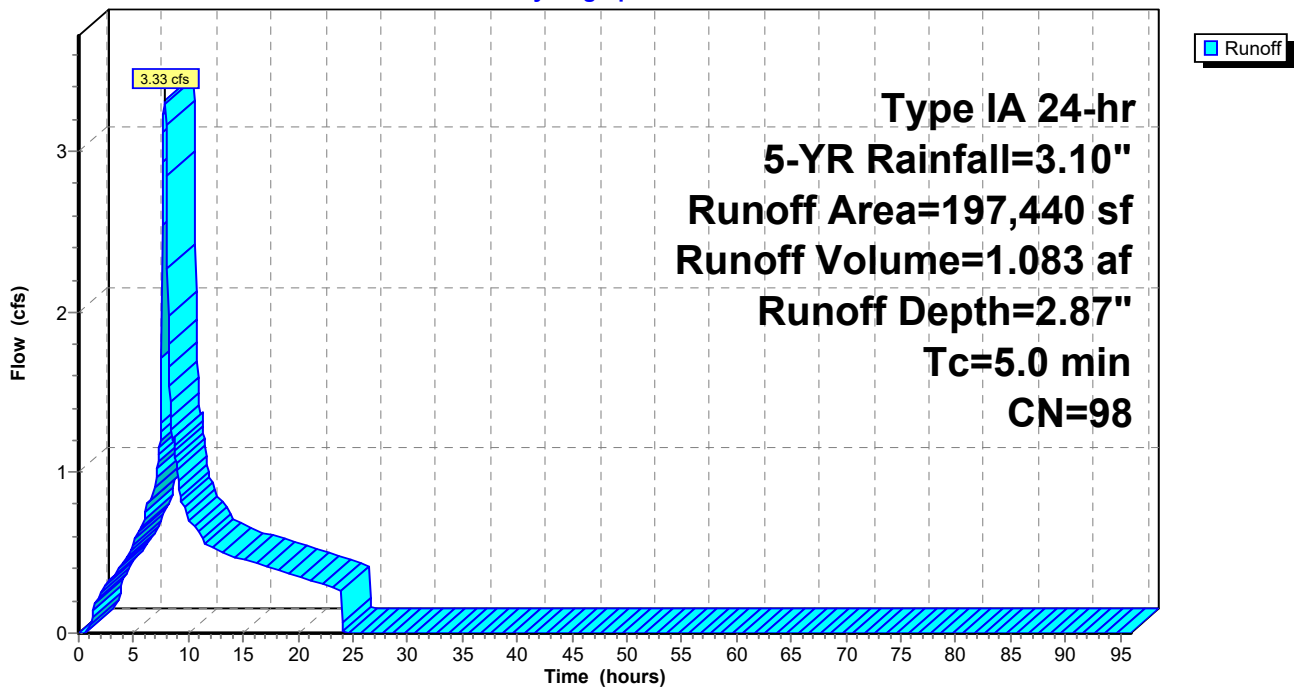
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
 Type IA 24-hr 5-YR Rainfall=3.10"

Area (sf)	CN	Description
* 197,440	98	
197,440		100.00% Impervious Area

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

**Subcatchment 19S: Basin 2**

Hydrograph



**Summary for Reach 22R: Offsite Discharge**

Reach modeled with shallow side slopes to best mimic the overland flow created at the discharge points.

[81] Warning: Exceeded Pond 14P by 0.50' @ 0.00 hrs

[81] Warning: Exceeded Pond 20P by 0.50' @ 0.00 hrs

Inflow Area =	17.002 ac, 100.00% Impervious,	Inflow Depth > 2.58"	for 5-YR event
Inflow =	2.33 cfs @ 9.01 hrs,	Volume=	3.660 af
Outflow =	2.03 cfs @ 9.58 hrs,	Volume=	3.650 af, Atten= 13%, Lag= 34.6 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
 Max. Velocity= 0.27 fps, Min. Travel Time= 18.7 min  
 Avg. Velocity = 0.14 fps, Avg. Travel Time= 35.3 min

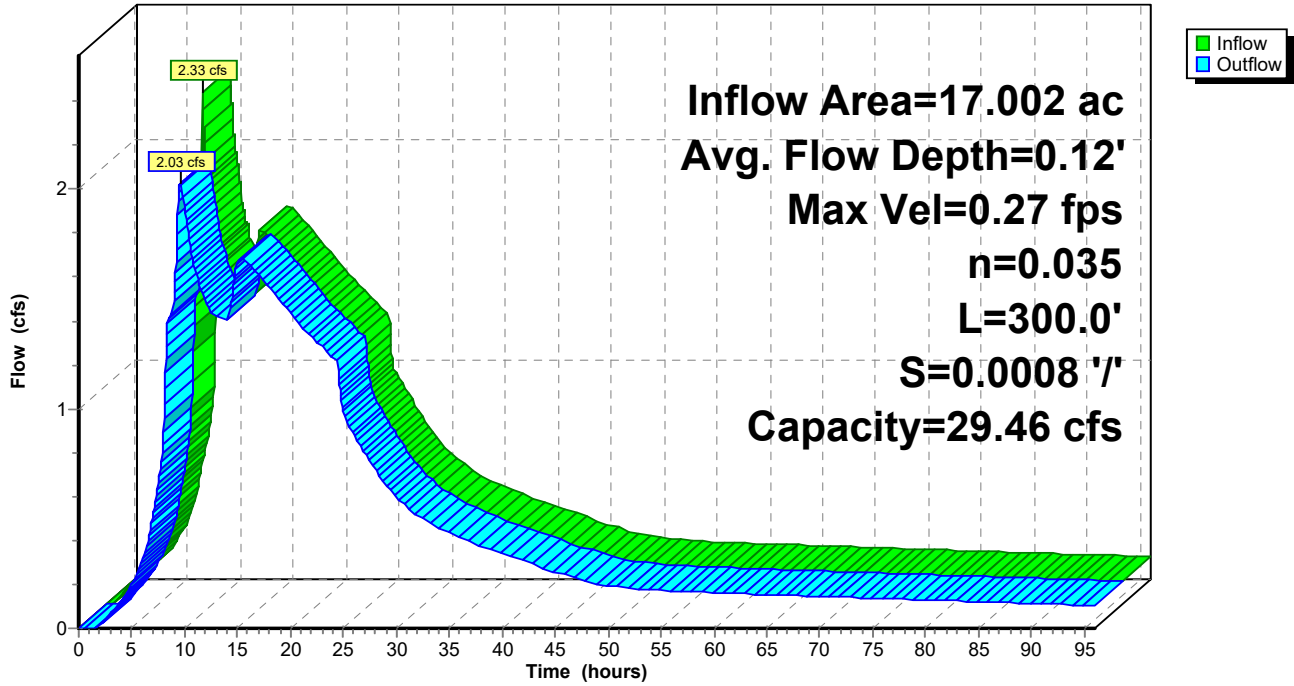
Peak Storage= 2,275 cf @ 9.27 hrs  
 Average Depth at Peak Storage= 0.12'  
 Bank-Full Depth= 0.50' Flow Area= 50.0 sf, Capacity= 29.46 cfs

50.00' x 0.50' deep channel, n= 0.035 High grass  
 Side Slope Z-value= 100.0 '/' Top Width= 150.00'  
 Length= 300.0' Slope= 0.0008 '/'  
 Inlet Invert= 133.00', Outlet Invert= 132.75'



### Reach 22R: Offsite Discharge

Hydrograph





**Summary for Pond 11P: Stormwater System 1**

[93] Warning: Storage range exceeded by 0.04'

[85] Warning: Oscillations may require smaller dt or Finer Routing (severity=15)

Inflow Area = 2.882 ac, 100.00% Impervious, Inflow Depth = 2.87" for 5-YR event  
 Inflow = 2.12 cfs @ 7.86 hrs, Volume= 0.689 af  
 Outflow = 0.73 cfs @ 9.01 hrs, Volume= 0.668 af, Atten= 65%, Lag= 69.0 min  
 Primary = 0.73 cfs @ 9.01 hrs, Volume= 0.668 af

Routing by Stor-Ind method, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
 Peak Elev= 135.59' @ 9.01 hrs Surf.Area= 0.246 ac Storage= 0.278 af

Plug-Flow detention time= 691.9 min calculated for 0.668 af (97% of inflow)  
 Center-of-Mass det. time= 668.9 min ( 1,334.4 - 665.4 )

Volume	Invert	Avail.Storage	Storage Description
#1A	133.50'	0.149 af	<b>28.33'W x 377.50'L x 2.04'H Field A</b> 0.501 af Overall - 0.128 af Embedded = 0.373 af x 40.0% Voids
#2A	134.00'	0.128 af	<b>Cultec C-100HD</b> x 400 Inside #1 Effective Size= 32.1"W x 12.0"H => 1.86 sf x 7.50'L = 14.0 cf Overall Size= 36.0"W x 12.5"H x 8.00'L with 0.50' Overlap Row Length Adjustment= +0.50' x 1.86 sf x 8 rows
		0.278 af	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	133.50'	<b>0.5" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads
#2	Primary	133.80'	<b>2.5" Vert. Orifice/Grate</b> C= 0.600
#3	Primary	135.50'	<b>24.0" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads

**Primary OutFlow** Max=0.70 cfs @ 9.01 hrs HW=135.58' (Free Discharge)

- 1=Orifice/Grate (Orifice Controls 0.01 cfs @ 6.95 fps)
- 2=Orifice/Grate (Orifice Controls 0.21 cfs @ 6.24 fps)
- 3=Orifice/Grate (Weir Controls 0.47 cfs @ 0.93 fps)

**Pond 11P: Stormwater System 1 - Chamber Wizard Field A**

**Chamber Model = Cultec C-100HD (Cultec Contactor® 100HD)**

Effective Size= 32.1"W x 12.0"H => 1.86 sf x 7.50'L = 14.0 cf

Overall Size= 36.0"W x 12.5"H x 8.00'L with 0.50' Overlap

Row Length Adjustment= +0.50' x 1.86 sf x 8 rows

36.0" Wide + 4.0" Spacing = 40.0" C-C Row Spacing

50 Chambers/Row x 7.50' Long +0.50' Row Adjustment = 375.50' Row Length +12.0" End Stone x 2 = 377.50' Base Length

8 Rows x 36.0" Wide + 4.0" Spacing x 7 + 12.0" Side Stone x 2 = 28.33' Base Width

6.0" Base + 12.5" Chamber Height + 6.0" Cover = 2.04' Field Height

400 Chambers x 14.0 cf +0.50' Row Adjustment x 1.86 sf x 8 Rows = 5,591.9 cf Chamber Storage

21,837.3 cf Field - 5,591.9 cf Chambers = 16,245.4 cf Stone x 40.0% Voids = 6,498.2 cf Stone Storage

Chamber Storage + Stone Storage = 12,090.1 cf = 0.278 af

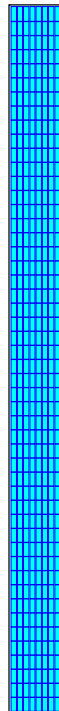
Overall Storage Efficiency = 55.4%

Overall System Size = 377.50' x 28.33' x 2.04'

400 Chambers

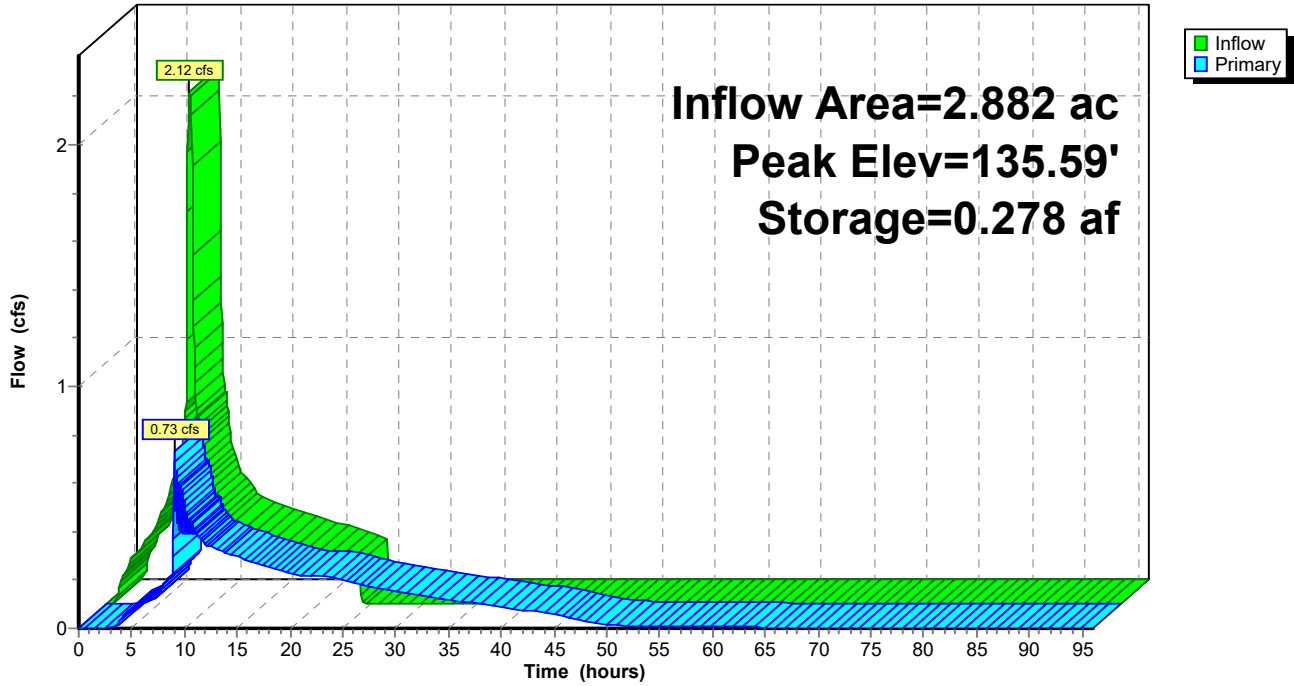
808.8 cy Field

601.7 cy Stone



### Pond 11P: Stormwater System 1

Hydrograph



# Walgraves

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Type IA 24-hr 5-YR Rainfall=3.10"

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## Summary for Pond 14P: Stormwater Sytem 3

Inflow Area = 5.153 ac, 100.00% Impervious, Inflow Depth = 2.87" for 5-YR event  
Inflow = 3.78 cfs @ 7.86 hrs, Volume= 1.231 af  
Outflow = 1.17 cfs @ 8.96 hrs, Volume= 1.188 af, Atten= 69%, Lag= 65.9 min  
Primary = 1.17 cfs @ 8.96 hrs, Volume= 1.188 af

Routing by Stor-Ind method, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
Peak Elev= 134.38' @ 8.96 hrs Surf.Area= 0.427 ac Storage= 0.460 af

Plug-Flow detention time= 579.2 min calculated for 1.188 af (96% of inflow)  
Center-of-Mass det. time= 554.7 min ( 1,220.2 - 665.4 )

Volume	Invert	Avail.Storage	Storage Description
#1A	132.50'	0.257 af	<b>68.33"W x 272.50'L x 2.04'H Field A</b> 0.873 af Overall - 0.231 af Embedded = 0.642 af x 40.0% Voids
#2A	133.00'	0.231 af	<b>Cultec C-100HD x 720 Inside #1</b> Effective Size= 32.1"W x 12.0"H => 1.86 sf x 7.50'L = 14.0 cf Overall Size= 36.0"W x 12.5"H x 8.00'L with 0.50' Overlap Row Length Adjustment= +0.50' x 1.86 sf x 20 rows
		0.488 af	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	132.50'	<b>1.0" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads
#2	Primary	133.05'	<b>5.0" Vert. Orifice/Grate</b> C= 0.600
#3	Primary	134.30'	<b>24.0" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads

**Primary OutFlow** Max=1.17 cfs @ 8.96 hrs HW=134.38' (Free Discharge)

- 1=Orifice/Grate (Orifice Controls 0.04 cfs @ 6.60 fps)
- 2=Orifice/Grate (Orifice Controls 0.69 cfs @ 5.09 fps)
- 3=Orifice/Grate (Weir Controls 0.44 cfs @ 0.91 fps)

**Pond 14P: Stormwater Sytem 3 - Chamber Wizard Field A**

**Chamber Model = Cultec C-100HD (Cultec Contactor® 100HD)**

Effective Size= 32.1"W x 12.0"H => 1.86 sf x 7.50'L = 14.0 cf

Overall Size= 36.0"W x 12.5"H x 8.00'L with 0.50' Overlap

Row Length Adjustment= +0.50' x 1.86 sf x 20 rows

36.0" Wide + 4.0" Spacing = 40.0" C-C Row Spacing

36 Chambers/Row x 7.50' Long +0.50' Row Adjustment = 270.50' Row Length +12.0" End Stone x 2 = 272.50' Base Length

20 Rows x 36.0" Wide + 4.0" Spacing x 19 + 12.0" Side Stone x 2 = 68.33' Base Width

6.0" Base + 12.5" Chamber Height + 6.0" Cover = 2.04' Field Height

720 Chambers x 14.0 cf +0.50' Row Adjustment x 1.86 sf x 20 Rows = 10,070.7 cf Chamber Storage

38,017.5 cf Field - 10,070.7 cf Chambers = 27,946.8 cf Stone x 40.0% Voids = 11,178.7 cf Stone Storage

Chamber Storage + Stone Storage = 21,249.4 cf = 0.488 af

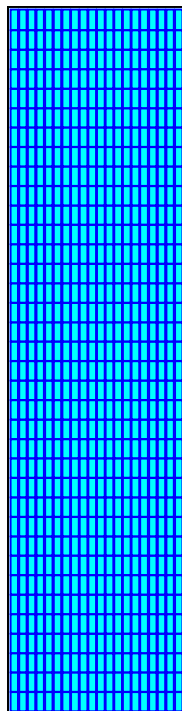
Overall Storage Efficiency = 55.9%

Overall System Size = 272.50' x 68.33' x 2.04'

720 Chambers

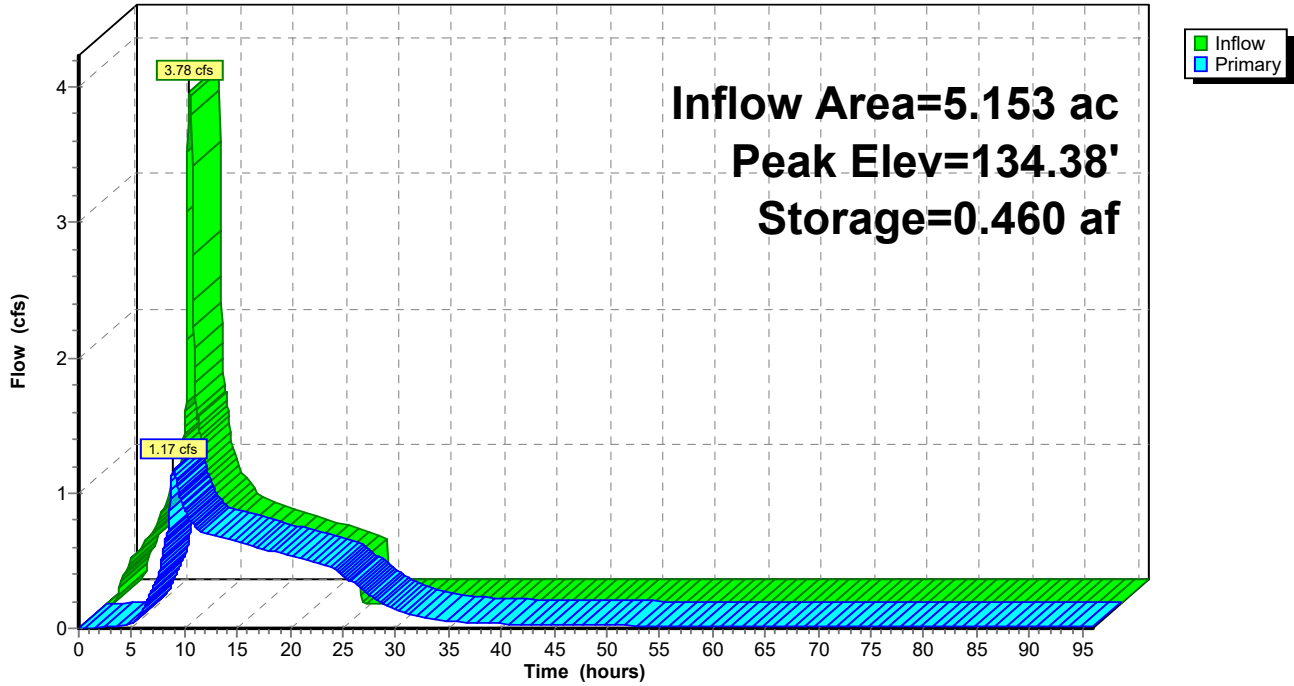
1,408.1 cy Field

1,035.1 cy Stone



**Pond 14P: Stormwater Sytem 3**

Hydrograph



# Walgraves

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Type IA 24-hr 5-YR Rainfall=3.10"

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## Summary for Pond 20P: Stormwater System 4

Inflow Area = 3.503 ac, 100.00% Impervious, Inflow Depth = 2.87" for 5-YR event  
Inflow = 2.57 cfs @ 7.86 hrs, Volume= 0.837 af  
Outflow = 0.21 cfs @ 23.57 hrs, Volume= 0.776 af, Atten= 92%, Lag= 942.9 min  
Primary = 0.21 cfs @ 23.57 hrs, Volume= 0.776 af

Routing by Stor-Ind method, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
Peak Elev= 135.28' @ 23.57 hrs Surf.Area= 0.283 ac Storage= 0.565 af

Plug-Flow detention time= 1,668.1 min calculated for 0.776 af (93% of inflow)  
Center-of-Mass det. time= 1,616.3 min ( 2,281.8 - 665.4 )

Volume	Invert	Avail.Storage	Storage Description
#1A	132.50'	0.266 af	<b>30.00'W x 411.50'L x 4.00'H Field A</b> 1.134 af Overall - 0.468 af Embedded = 0.665 af x 40.0% Voids
#2A	133.00'	0.468 af	<b>Cultec R-360HD x 555 Inside #1</b> Effective Size= 54.9"W x 36.0"H => 9.99 sf x 3.67'L = 36.6 cf Overall Size= 60.0"W x 36.0"H x 4.17'L with 0.50' Overlap 555 Chambers in 5 Rows Cap Storage= +6.5 cf x 2 x 5 rows = 64.6 cf
		0.734 af	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	132.50'	<b>1.5" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads
#2	Primary	134.00'	<b>2.0" Vert. Orifice/Grate</b> C= 0.600
#3	Primary	136.25'	<b>24.0" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads

**Primary OutFlow** Max=0.21 cfs @ 23.57 hrs HW=135.28' (Free Discharge)

- 1=Orifice/Grate (Orifice Controls 0.10 cfs @ 8.03 fps)
- 2=Orifice/Grate (Orifice Controls 0.11 cfs @ 5.27 fps)
- 3=Orifice/Grate ( Controls 0.00 cfs)

# Walgraves

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Type IA 24-hr 5-YR Rainfall=3.10"

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## Pond 20P: Stormwater System 4 - Chamber Wizard Field A

### Chamber Model = Cultec R-360HD (Cultec Recharger® 360HD)

Effective Size= 54.9"W x 36.0"H => 9.99 sf x 3.67'L = 36.6 cf

Overall Size= 60.0"W x 36.0"H x 4.17'L with 0.50' Overlap

Cap Storage= +6.5 cf x 2 x 5 rows = 64.6 cf

60.0" Wide + 9.0" Spacing = 69.0" C-C Row Spacing

111 Chambers/Row x 3.67' Long +1.25' Cap Length x 2 = 409.50' Row Length +12.0" End Stone x 2 = 411.50' Base Length

5 Rows x 60.0" Wide + 9.0" Spacing x 4 + 12.0" Side Stone x 2 = 30.00' Base Width

6.0" Base + 36.0" Chamber Height + 6.0" Cover = 4.00' Field Height

555 Chambers x 36.6 cf + 6.5 cf Cap Volume x 2 x 5 Rows = 20,402.4 cf Chamber Storage

49,380.0 cf Field - 20,402.4 cf Chambers = 28,977.6 cf Stone x 40.0% Voids = 11,591.0 cf Stone Storage

Chamber Storage + Stone Storage = 31,993.4 cf = 0.734 af

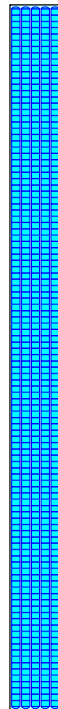
Overall Storage Efficiency = 64.8%

Overall System Size = 411.50' x 30.00' x 4.00'

555 Chambers

1,828.9 cy Field

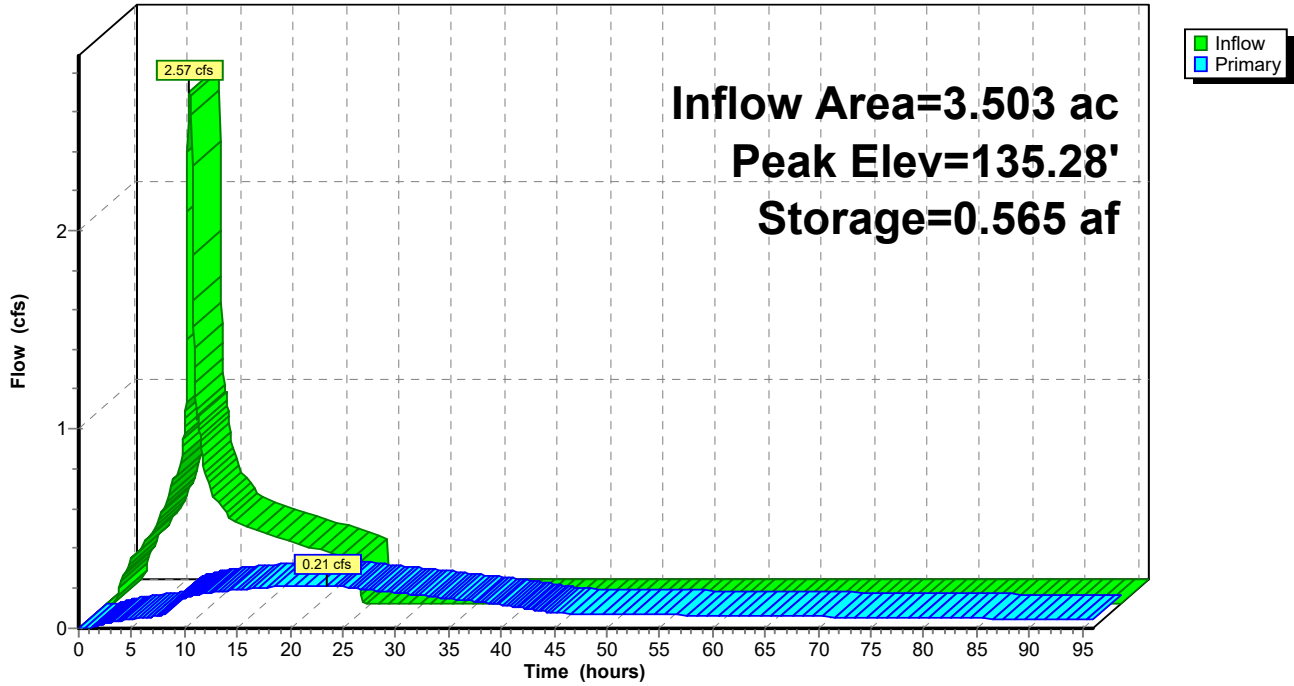
1,073.2 cy Stone





### Pond 20P: Stormwater System 4

Hydrograph



# Walgraves

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Type IA 24-hr 5-YR Rainfall=3.10"

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## Summary for Pond 23P: Stormwater System 2

Inflow Area = 4.533 ac, 100.00% Impervious, Inflow Depth = 2.87" for 5-YR event  
 Inflow = 3.33 cfs @ 7.86 hrs, Volume= 1.083 af  
 Outflow = 0.46 cfs @ 14.77 hrs, Volume= 0.805 af, Atten= 86%, Lag= 414.7 min  
 Primary = 0.46 cfs @ 14.77 hrs, Volume= 0.805 af

Routing by Stor-Ind method, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
 Peak Elev= 137.36' @ 14.77 hrs Surf.Area= 0.284 ac Storage= 0.723 af

Plug-Flow detention time= 1,771.9 min calculated for 0.804 af (74% of inflow)  
 Center-of-Mass det. time= 1,608.7 min ( 2,274.1 - 665.4 )

Volume	Invert	Avail.Storage	Storage Description
#1A	133.50'	0.265 af	<b>41.50"W x 297.83'L x 4.00'H Field A</b> 1.135 af Overall - 0.473 af Embedded = 0.662 af x 40.0% Voids
#2A	134.00'	0.473 af	<b>Cultec R-360HD x 560 Inside #1</b> Effective Size= 54.9"W x 36.0"H => 9.99 sf x 3.67'L = 36.6 cf Overall Size= 60.0"W x 36.0"H x 4.17'L with 0.50' Overlap 560 Chambers in 7 Rows Cap Storage= +6.5 cf x 2 x 7 rows = 90.4 cf
		0.738 af	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	133.50'	<b>0.5" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads
#2	Primary	134.50'	<b>1.5" Vert. Orifice/Grate</b> C= 0.600
#3	Primary	137.30'	<b>24.0" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads

**Primary OutFlow** Max=0.45 cfs @ 14.77 hrs HW=137.36' (Free Discharge)

- 1=Orifice/Grate (Orifice Controls 0.01 cfs @ 9.47 fps)
- 2=Orifice/Grate (Orifice Controls 0.10 cfs @ 8.06 fps)
- 3=Orifice/Grate (Weir Controls 0.34 cfs @ 0.83 fps)

**Pond 23P: Stormwater System 2 - Chamber Wizard Field A**

**Chamber Model = Cultec R-360HD (Cultec Recharger® 360HD)**

Effective Size= 54.9"W x 36.0"H => 9.99 sf x 3.67'L = 36.6 cf

Overall Size= 60.0"W x 36.0"H x 4.17'L with 0.50' Overlap

Cap Storage= +6.5 cf x 2 x 7 rows = 90.4 cf

60.0" Wide + 9.0" Spacing = 69.0" C-C Row Spacing

80 Chambers/Row x 3.67' Long +1.25' Cap Length x 2 = 295.83' Row Length +12.0" End Stone x 2 = 297.83' Base Length

7 Rows x 60.0" Wide + 9.0" Spacing x 6 + 12.0" Side Stone x 2 = 41.50' Base Width

6.0" Base + 36.0" Chamber Height + 6.0" Cover = 4.00' Field Height

560 Chambers x 36.6 cf + 6.5 cf Cap Volume x 2 x 7 Rows = 20,611.5 cf Chamber Storage

49,440.3 cf Field - 20,611.5 cf Chambers = 28,828.9 cf Stone x 40.0% Voids = 11,531.6 cf Stone Storage

Chamber Storage + Stone Storage = 32,143.0 cf = 0.738 af

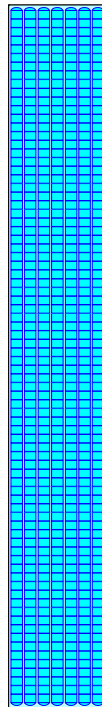
Overall Storage Efficiency = 65.0%

Overall System Size = 297.83' x 41.50' x 4.00'

560 Chambers

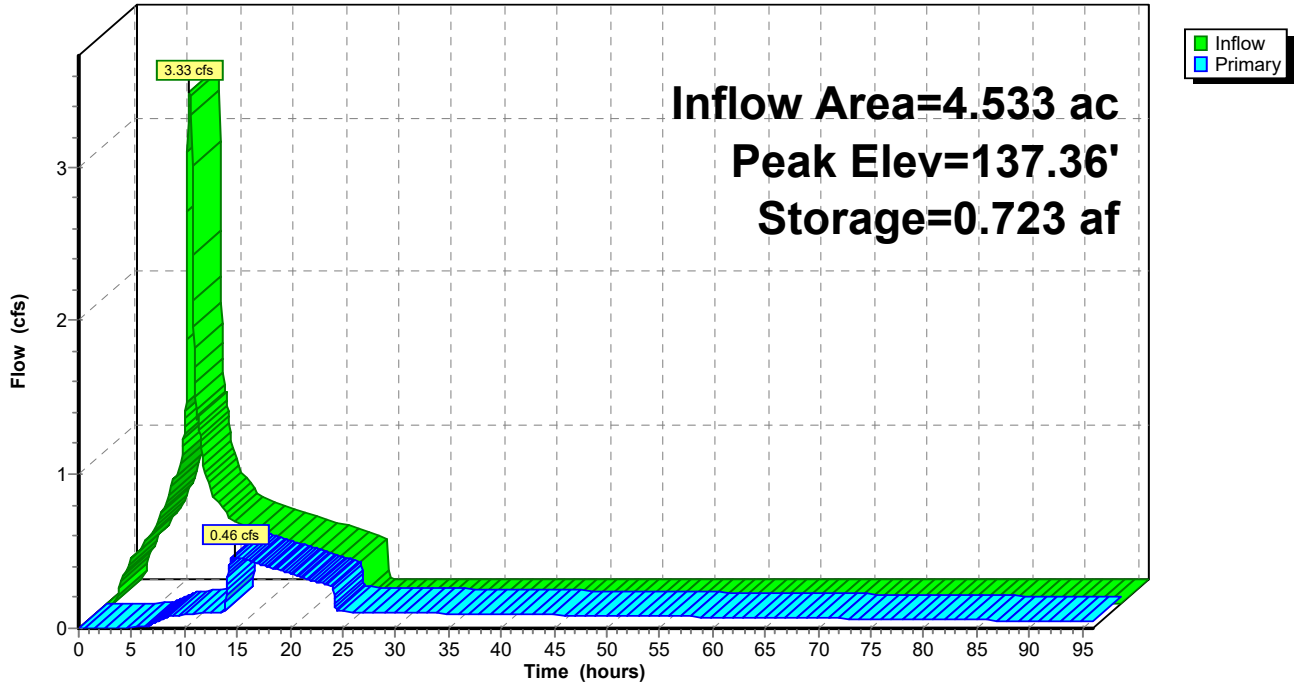
1,831.1 cy Field

1,067.7 cy Stone



### Pond 23P: Stormwater System 2

Hydrograph



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Type IA 24-hr 10-YR Rainfall=3.45"

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Time span=0.00-96.00 hrs, dt=0.05 hrs, 1921 points  
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN  
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

<b>Subcatchment8S: Basin 1</b>	Runoff Area=125,547 sf 100.00% Impervious Runoff Depth=3.22" Tc=5.0 min CN=98 Runoff=2.36 cfs 0.773 af
<b>Subcatchment13S: Basin 3</b>	Runoff Area=224,462 sf 100.00% Impervious Runoff Depth=3.22" Tc=5.0 min CN=98 Runoff=4.23 cfs 1.381 af
<b>Subcatchment15S: Filter Strip Basins</b>	Runoff Area=40,551 sf 100.00% Impervious Runoff Depth=3.22" Tc=10.0 min CN=98 Runoff=0.76 cfs 0.250 af
<b>Subcatchment17S: Pre Total</b>	Runoff Area=740,599 sf 0.00% Impervious Runoff Depth=1.60" Tc=30.0 min CN=80 Runoff=5.20 cfs 2.262 af
<b>Subcatchment18S: Basin 4</b>	Runoff Area=152,599 sf 100.00% Impervious Runoff Depth=3.22" Tc=5.0 min CN=98 Runoff=2.87 cfs 0.939 af
<b>Subcatchment19S: Basin 2</b>	Runoff Area=197,440 sf 100.00% Impervious Runoff Depth=3.22" Tc=5.0 min CN=98 Runoff=3.72 cfs 1.215 af
<b>Reach 22R: Offsite Discharge</b>	Avg. Flow Depth=0.15' Max Vel=0.30 fps Inflow=3.60 cfs 4.140 af n=0.035 L=300.0' S=0.0008 '/' Capacity=29.46 cfs Outflow=2.99 cfs 4.130 af
<b>Pond 11P: Stormwater System 1</b>	Peak Elev=135.63' Storage=0.278 af Inflow=2.36 cfs 0.773 af Outflow=1.17 cfs 0.752 af
<b>Pond 14P: Stormwater Sytem 3</b>	Peak Elev=134.44' Storage=0.470 af Inflow=4.23 cfs 1.381 af Outflow=1.83 cfs 1.338 af
<b>Pond 20P: Stormwater System 4</b>	Peak Elev=135.67' Storage=0.634 af Inflow=2.87 cfs 0.939 af Outflow=0.24 cfs 0.865 af
<b>Pond 23P: Stormwater System 2</b>	Peak Elev=137.38' Storage=0.725 af Inflow=3.72 cfs 1.215 af Outflow=0.60 cfs 0.936 af

**Total Runoff Area = 34.004 ac Runoff Volume = 6.820 af Average Runoff Depth = 2.41"**  
**50.00% Pervious = 17.002 ac 50.00% Impervious = 17.002 ac**

**Summary for Subcatchment 8S: Basin 1**

[49] Hint:  $T_c < 2dt$  may require smaller dt

Runoff = 2.36 cfs @ 7.86 hrs, Volume= 0.773 af, Depth= 3.22"

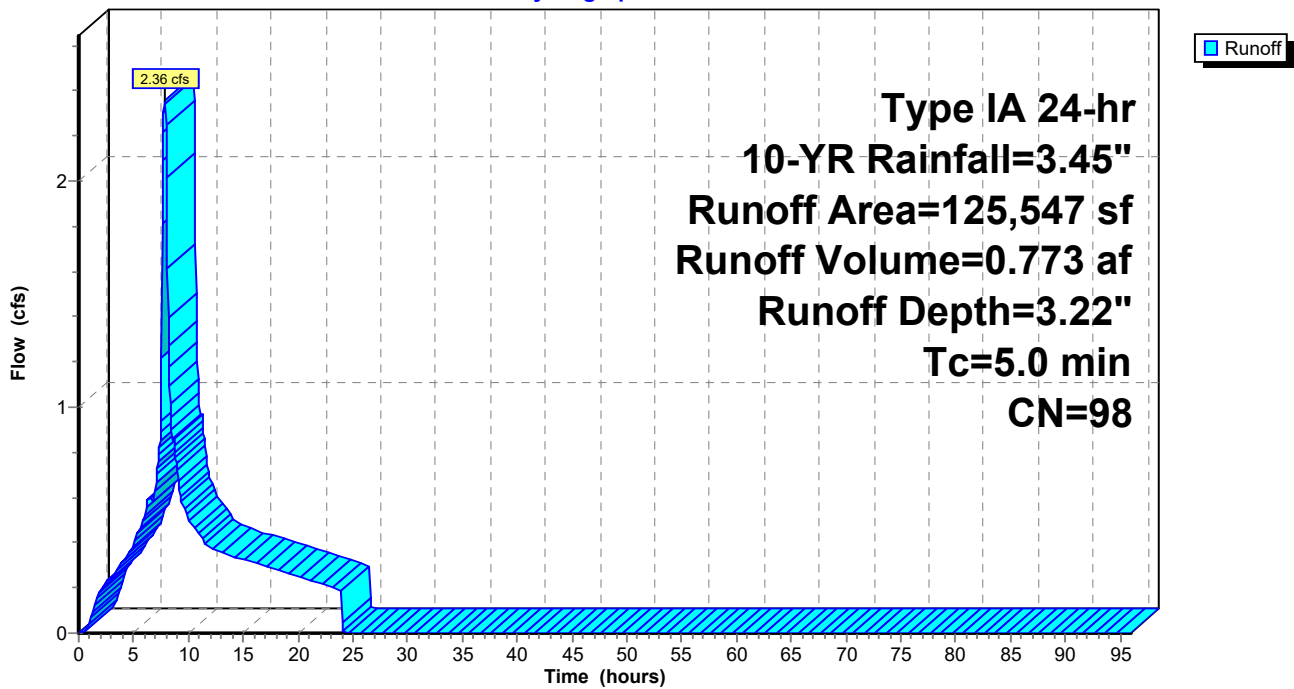
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
Type IA 24-hr 10-YR Rainfall=3.45"

Area (sf)	CN	Description
* 125,547	98	
125,547		100.00% Impervious Area

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

**Subcatchment 8S: Basin 1**

Hydrograph



**Summary for Subcatchment 13S: Basin 3**

[49] Hint: Tc<2dt may require smaller dt

Runoff = 4.23 cfs @ 7.86 hrs, Volume= 1.381 af, Depth= 3.22"

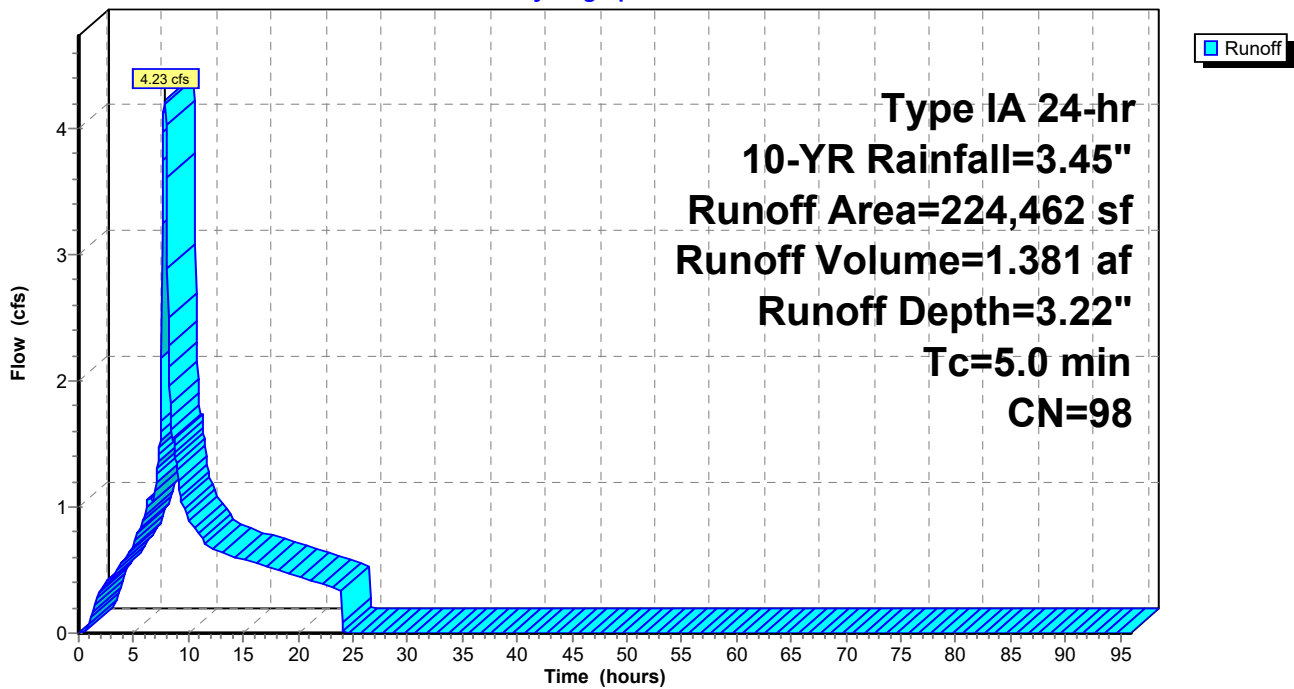
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
Type IA 24-hr 10-YR Rainfall=3.45"

Area (sf)	CN	Description
* 224,462	98	
224,462		100.00% Impervious Area

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

**Subcatchment 13S: Basin 3**

Hydrograph



**Summary for Subcatchment 15S: Filter Strip Basins**

Runoff = 0.76 cfs @ 7.94 hrs, Volume= 0.250 af, Depth= 3.22"

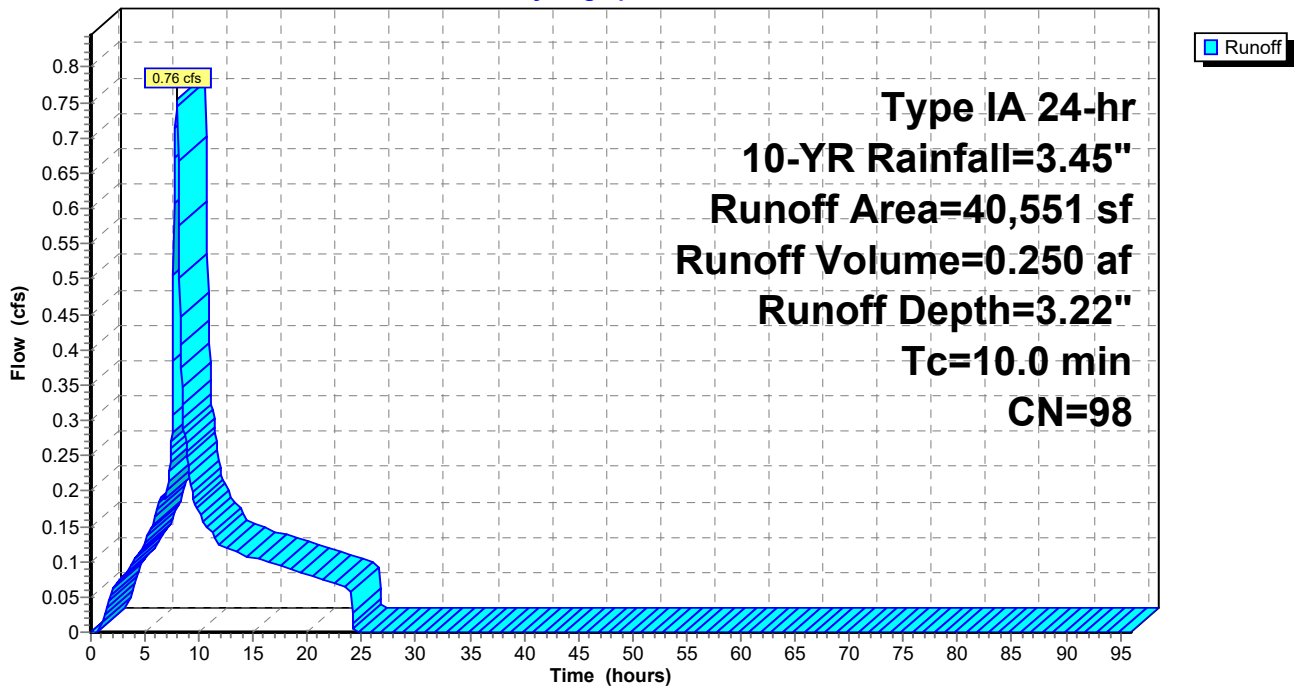
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
 Type IA 24-hr 10-YR Rainfall=3.45"

Area (sf)	CN	Description
* 40,551	98	
40,551		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.0					Direct Entry, 20

**Subcatchment 15S: Filter Strip Basins**

Hydrograph





**Summary for Subcatchment 17S: Pre Total**

Runoff = 5.20 cfs @ 8.25 hrs, Volume= 2.262 af, Depth= 1.60"

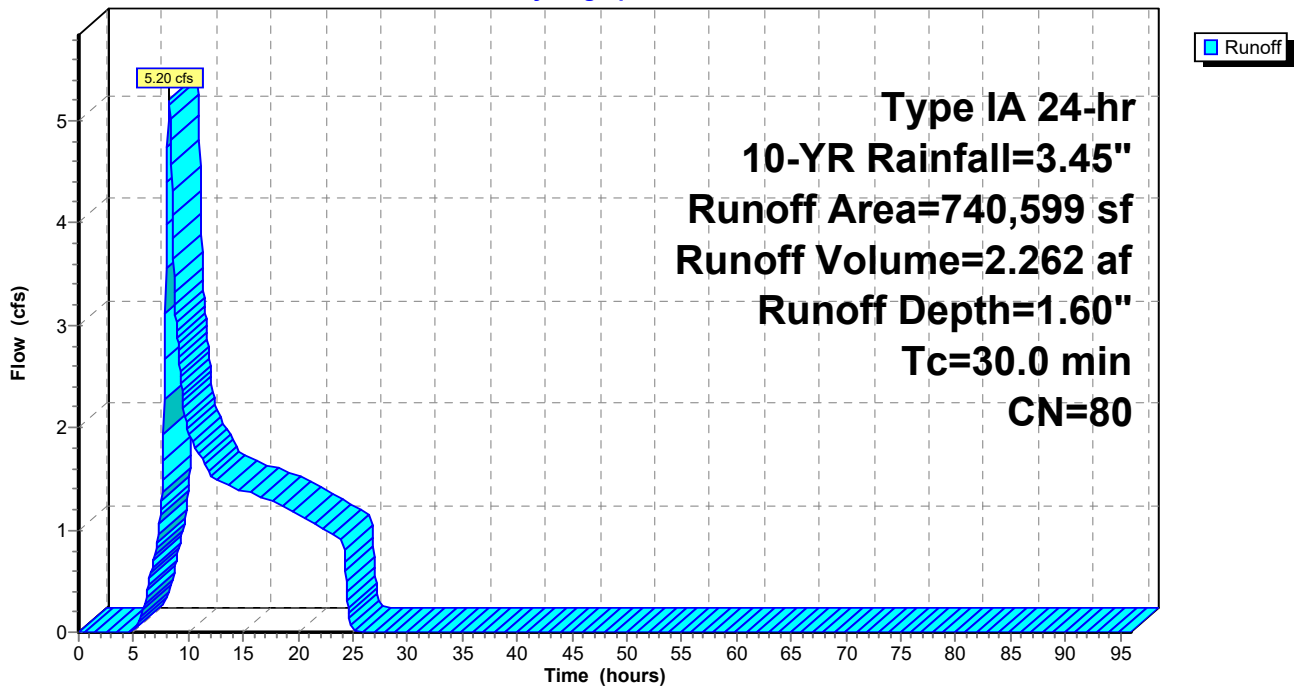
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
Type IA 24-hr 10-YR Rainfall=3.45"

Area (sf)	CN	Description
740,599	80	>75% Grass cover, Good, HSG D
740,599		100.00% Pervious Area

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

**Subcatchment 17S: Pre Total**

Hydrograph



**Summary for Subcatchment 18S: Basin 4**

[49] Hint: Tc<2dt may require smaller dt

Runoff = 2.87 cfs @ 7.86 hrs, Volume= 0.939 af, Depth= 3.22"

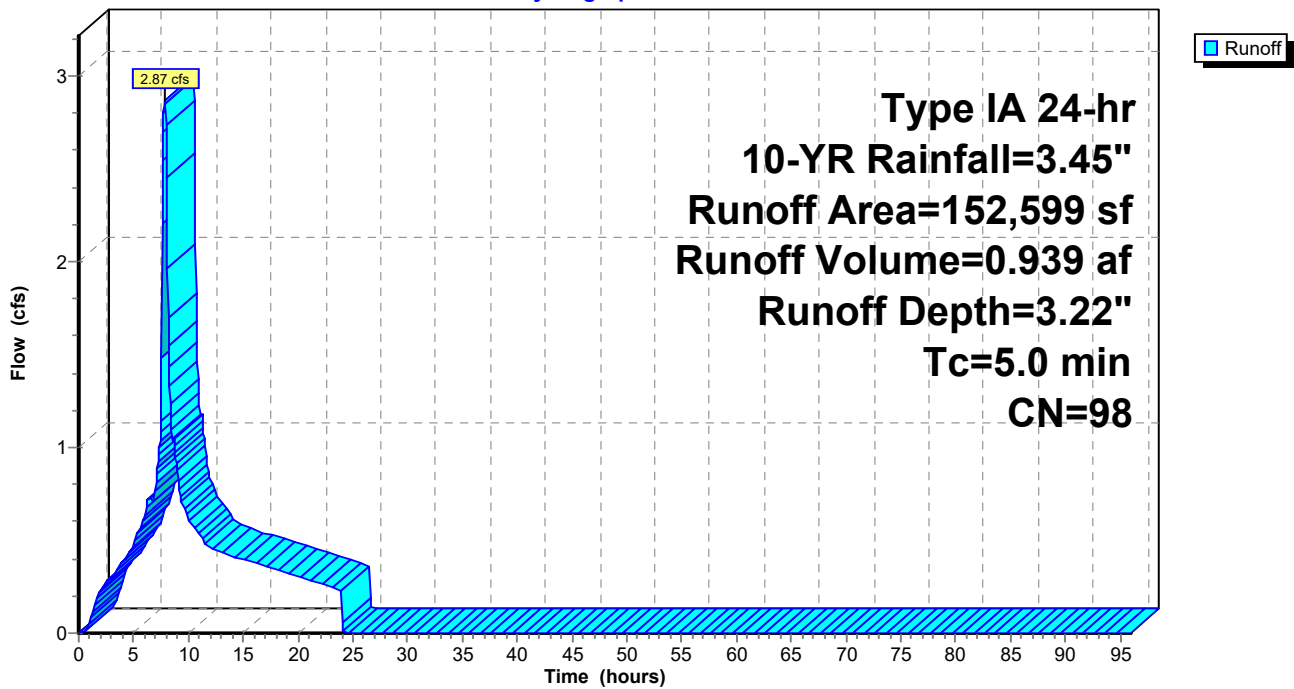
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
Type IA 24-hr 10-YR Rainfall=3.45"

Area (sf)	CN	Description
* 152,599	98	
152,599		100.00% Impervious Area

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

**Subcatchment 18S: Basin 4**

Hydrograph



**Summary for Subcatchment 19S: Basin 2**

[49] Hint:  $T_c < 2dt$  may require smaller dt

Runoff = 3.72 cfs @ 7.86 hrs, Volume= 1.215 af, Depth= 3.22"

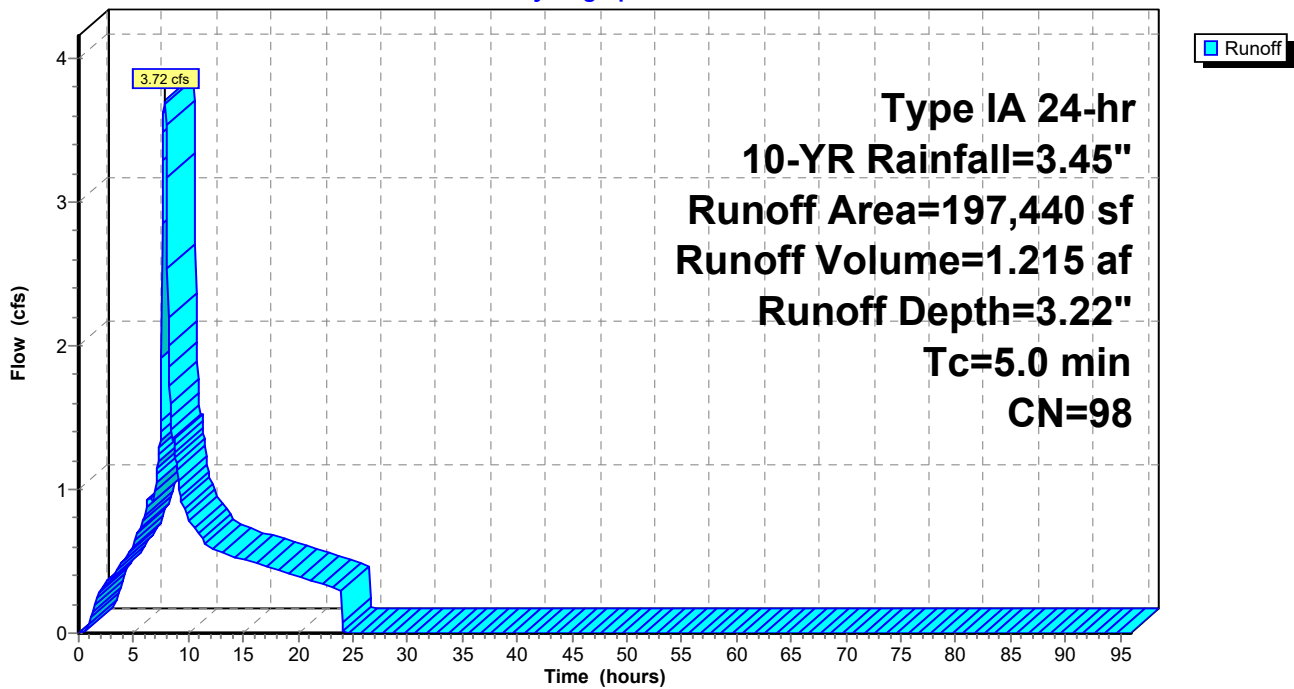
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
 Type IA 24-hr 10-YR Rainfall=3.45"

Area (sf)	CN	Description
* 197,440	98	
197,440		100.00% Impervious Area

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

**Subcatchment 19S: Basin 2**

Hydrograph



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Type IA 24-hr 10-YR Rainfall=3.45"

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## Summary for Reach 22R: Offsite Discharge

Reach modeled with shallow side slopes to best mimic the overland flow created at the discharge points.

[81] Warning: Exceeded Pond 14P by 0.50' @ 0.00 hrs

[81] Warning: Exceeded Pond 20P by 0.50' @ 0.00 hrs

Inflow Area = 17.002 ac, 100.00% Impervious, Inflow Depth > 2.92" for 10-YR event  
Inflow = 3.60 cfs @ 8.32 hrs, Volume= 4.140 af  
Outflow = 2.99 cfs @ 8.96 hrs, Volume= 4.130 af, Atten= 17%, Lag= 38.1 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
Max. Velocity= 0.30 fps, Min. Travel Time= 16.5 min  
Avg. Velocity = 0.15 fps, Avg. Travel Time= 34.3 min

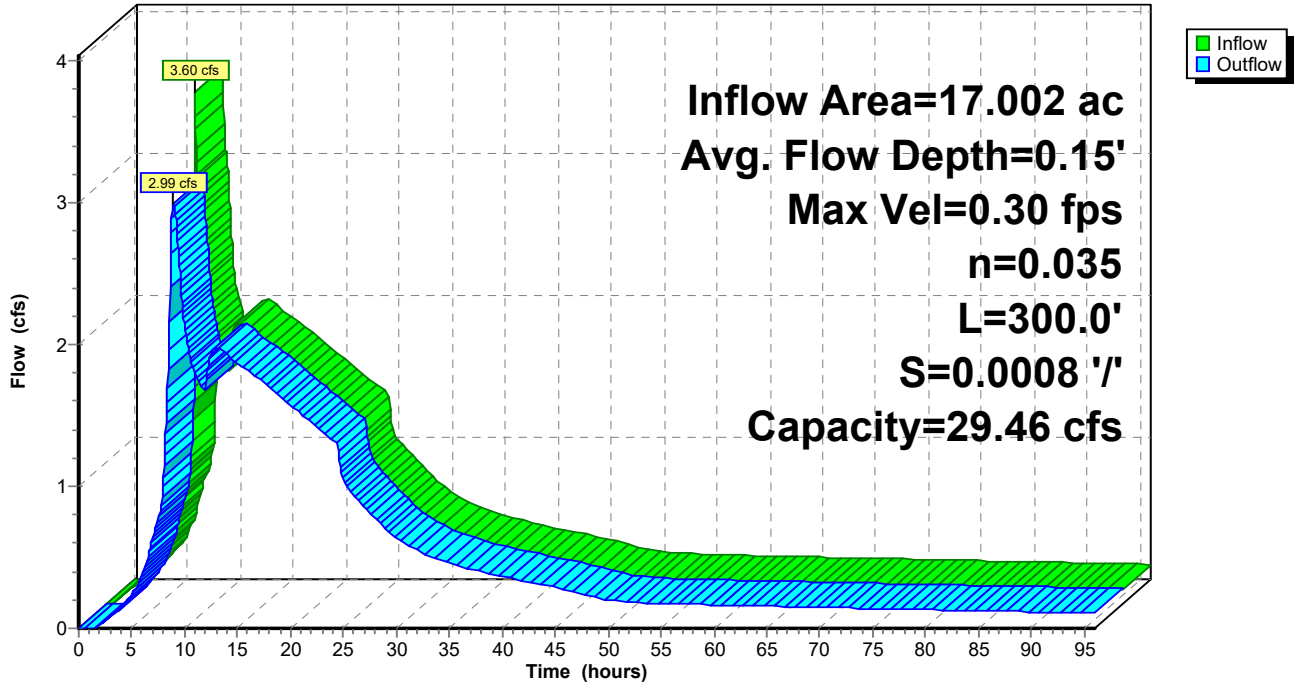
Peak Storage= 2,960 cf @ 8.68 hrs  
Average Depth at Peak Storage= 0.15'  
Bank-Full Depth= 0.50' Flow Area= 50.0 sf, Capacity= 29.46 cfs

50.00' x 0.50' deep channel, n= 0.035 High grass  
Side Slope Z-value= 100.0 ' ' Top Width= 150.00'  
Length= 300.0' Slope= 0.0008 ' '  
Inlet Invert= 133.00', Outlet Invert= 132.75'



### Reach 22R: Offsite Discharge

Hydrograph



**Summary for Pond 11P: Stormwater System 1**

[93] Warning: Storage range exceeded by 0.09'

[85] Warning: Oscillations may require smaller dt or Finer Routing (severity=14)

Inflow Area = 2.882 ac, 100.00% Impervious, Inflow Depth = 3.22" for 10-YR event  
 Inflow = 2.36 cfs @ 7.86 hrs, Volume= 0.773 af  
 Outflow = 1.17 cfs @ 8.32 hrs, Volume= 0.752 af, Atten= 50%, Lag= 27.8 min  
 Primary = 1.17 cfs @ 8.32 hrs, Volume= 0.752 af

Routing by Stor-Ind method, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
 Peak Elev= 135.63' @ 8.32 hrs Surf.Area= 0.246 ac Storage= 0.278 af

Plug-Flow detention time= 625.5 min calculated for 0.751 af (97% of inflow)  
 Center-of-Mass det. time= 606.8 min ( 1,269.3 - 662.5 )

Volume	Invert	Avail.Storage	Storage Description
#1A	133.50'	0.149 af	<b>28.33'W x 377.50'L x 2.04'H Field A</b> 0.501 af Overall - 0.128 af Embedded = 0.373 af x 40.0% Voids
#2A	134.00'	0.128 af	<b>Cultec C-100HD x 400</b> Inside #1 Effective Size= 32.1"W x 12.0"H => 1.86 sf x 7.50'L = 14.0 cf Overall Size= 36.0"W x 12.5"H x 8.00'L with 0.50' Overlap Row Length Adjustment= +0.50' x 1.86 sf x 8 rows
		0.278 af	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	133.50'	<b>0.5" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads
#2	Primary	133.80'	<b>2.5" Vert. Orifice/Grate</b> C= 0.600
#3	Primary	135.50'	<b>24.0" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads

**Primary OutFlow** Max=1.06 cfs @ 8.32 hrs HW=135.62' (Free Discharge)

- 1=Orifice/Grate (Orifice Controls 0.01 cfs @ 7.01 fps)
- 2=Orifice/Grate (Orifice Controls 0.21 cfs @ 6.30 fps)
- 3=Orifice/Grate (Weir Controls 0.84 cfs @ 1.13 fps)

**Pond 11P: Stormwater System 1 - Chamber Wizard Field A**

**Chamber Model = Cultec C-100HD (Cultec Contactor® 100HD)**

Effective Size= 32.1"W x 12.0"H => 1.86 sf x 7.50'L = 14.0 cf

Overall Size= 36.0"W x 12.5"H x 8.00'L with 0.50' Overlap

Row Length Adjustment= +0.50' x 1.86 sf x 8 rows

36.0" Wide + 4.0" Spacing = 40.0" C-C Row Spacing

50 Chambers/Row x 7.50' Long +0.50' Row Adjustment = 375.50' Row Length +12.0" End Stone x 2 = 377.50' Base Length

8 Rows x 36.0" Wide + 4.0" Spacing x 7 + 12.0" Side Stone x 2 = 28.33' Base Width

6.0" Base + 12.5" Chamber Height + 6.0" Cover = 2.04' Field Height

400 Chambers x 14.0 cf +0.50' Row Adjustment x 1.86 sf x 8 Rows = 5,591.9 cf Chamber Storage

21,837.3 cf Field - 5,591.9 cf Chambers = 16,245.4 cf Stone x 40.0% Voids = 6,498.2 cf Stone Storage

Chamber Storage + Stone Storage = 12,090.1 cf = 0.278 af

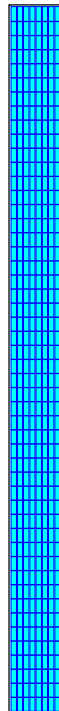
Overall Storage Efficiency = 55.4%

Overall System Size = 377.50' x 28.33' x 2.04'

400 Chambers

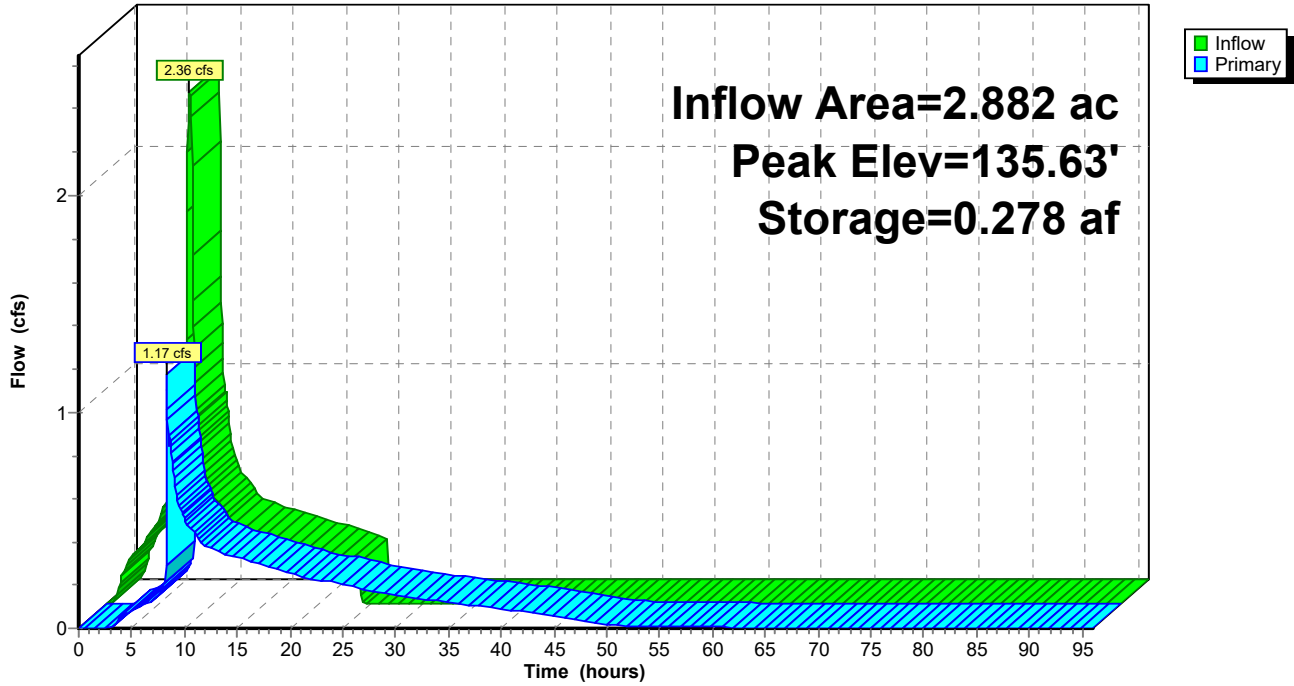
808.8 cy Field

601.7 cy Stone



### Pond 11P: Stormwater System 1

Hydrograph





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## Summary for Pond 14P: Stormwater Sytem 3

Inflow Area = 5.153 ac, 100.00% Impervious, Inflow Depth = 3.22" for 10-YR event  
Inflow = 4.23 cfs @ 7.86 hrs, Volume= 1.381 af  
Outflow = 1.83 cfs @ 8.35 hrs, Volume= 1.338 af, Atten= 57%, Lag= 29.8 min  
Primary = 1.83 cfs @ 8.35 hrs, Volume= 1.338 af

Routing by Stor-Ind method, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
Peak Elev= 134.44' @ 8.35 hrs Surf.Area= 0.427 ac Storage= 0.470 af

Plug-Flow detention time= 535.6 min calculated for 1.337 af (97% of inflow)  
Center-of-Mass det. time= 513.5 min ( 1,176.1 - 662.5 )

Volume	Invert	Avail.Storage	Storage Description
#1A	132.50'	0.257 af	<b>68.33"W x 272.50'L x 2.04'H Field A</b> 0.873 af Overall - 0.231 af Embedded = 0.642 af x 40.0% Voids
#2A	133.00'	0.231 af	<b>Cultec C-100HD x 720 Inside #1</b> Effective Size= 32.1"W x 12.0"H => 1.86 sf x 7.50'L = 14.0 cf Overall Size= 36.0"W x 12.5"H x 8.00'L with 0.50' Overlap Row Length Adjustment= +0.50' x 1.86 sf x 20 rows
		0.488 af	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	132.50'	<b>1.0" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads
#2	Primary	133.05'	<b>5.0" Vert. Orifice/Grate</b> C= 0.600
#3	Primary	134.30'	<b>24.0" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads

**Primary OutFlow** Max=1.83 cfs @ 8.35 hrs HW=134.44' (Free Discharge)

- 1=Orifice/Grate (Orifice Controls 0.04 cfs @ 6.71 fps)
- 2=Orifice/Grate (Orifice Controls 0.71 cfs @ 5.23 fps)
- 3=Orifice/Grate (Weir Controls 1.08 cfs @ 1.22 fps)

**Pond 14P: Stormwater Sytem 3 - Chamber Wizard Field A**

**Chamber Model = Cultec C-100HD (Cultec Contactor® 100HD)**

Effective Size= 32.1"W x 12.0"H => 1.86 sf x 7.50'L = 14.0 cf

Overall Size= 36.0"W x 12.5"H x 8.00'L with 0.50' Overlap

Row Length Adjustment= +0.50' x 1.86 sf x 20 rows

36.0" Wide + 4.0" Spacing = 40.0" C-C Row Spacing

36 Chambers/Row x 7.50' Long +0.50' Row Adjustment = 270.50' Row Length +12.0" End Stone x 2 = 272.50' Base Length

20 Rows x 36.0" Wide + 4.0" Spacing x 19 + 12.0" Side Stone x 2 = 68.33' Base Width

6.0" Base + 12.5" Chamber Height + 6.0" Cover = 2.04' Field Height

720 Chambers x 14.0 cf +0.50' Row Adjustment x 1.86 sf x 20 Rows = 10,070.7 cf Chamber Storage

38,017.5 cf Field - 10,070.7 cf Chambers = 27,946.8 cf Stone x 40.0% Voids = 11,178.7 cf Stone Storage

Chamber Storage + Stone Storage = 21,249.4 cf = 0.488 af

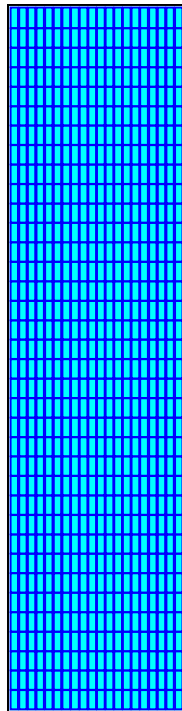
Overall Storage Efficiency = 55.9%

Overall System Size = 272.50' x 68.33' x 2.04'

720 Chambers

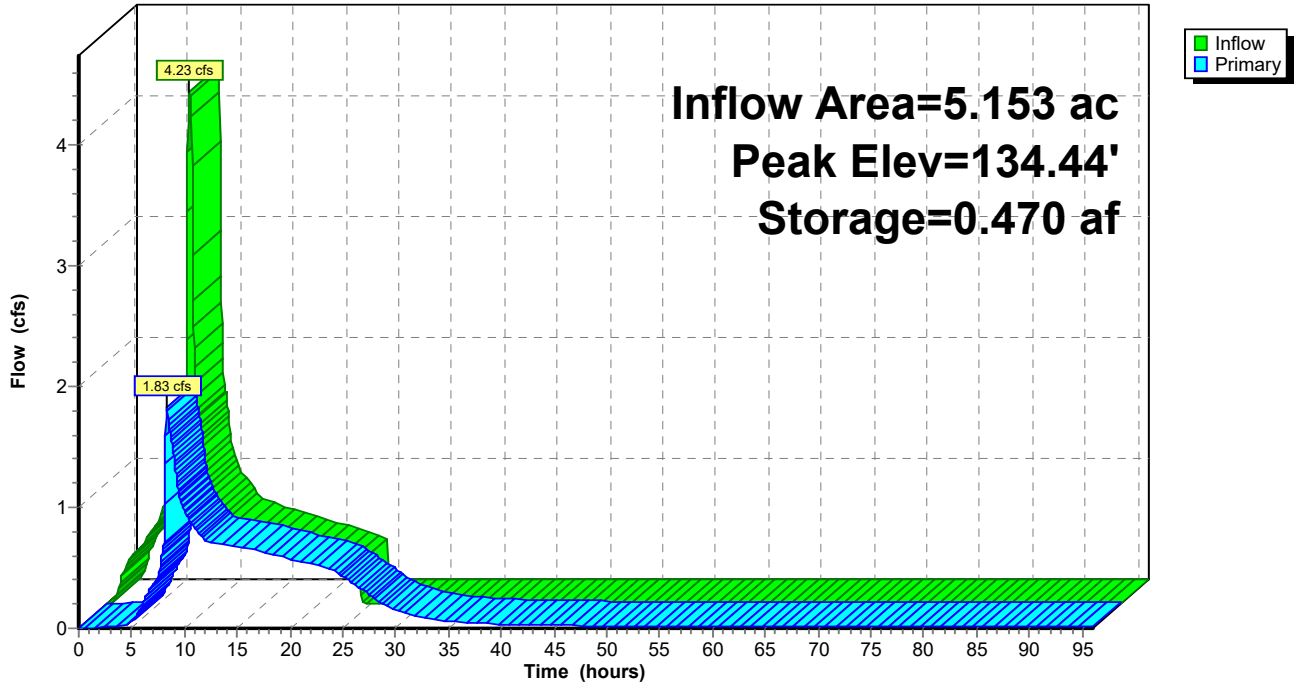
1,408.1 cy Field

1,035.1 cy Stone



### Pond 14P: Stormwater Sytem 3

Hydrograph



# Walgraves

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Type IA 24-hr 10-YR Rainfall=3.45"

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## Summary for Pond 20P: Stormwater System 4

Inflow Area = 3.503 ac, 100.00% Impervious, Inflow Depth = 3.22" for 10-YR event  
Inflow = 2.87 cfs @ 7.86 hrs, Volume= 0.939 af  
Outflow = 0.24 cfs @ 23.57 hrs, Volume= 0.865 af, Atten= 92%, Lag= 942.5 min  
Primary = 0.24 cfs @ 23.57 hrs, Volume= 0.865 af

Routing by Stor-Ind method, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
Peak Elev= 135.67' @ 23.57 hrs Surf.Area= 0.283 ac Storage= 0.634 af

Plug-Flow detention time= 1,642.1 min calculated for 0.865 af (92% of inflow)  
Center-of-Mass det. time= 1,584.2 min ( 2,246.8 - 662.5 )

Volume	Invert	Avail.Storage	Storage Description
#1A	132.50'	0.266 af	<b>30.00'W x 411.50'L x 4.00'H Field A</b> 1.134 af Overall - 0.468 af Embedded = 0.665 af x 40.0% Voids
#2A	133.00'	0.468 af	<b>Cultec R-360HD x 555 Inside #1</b> Effective Size= 54.9"W x 36.0"H => 9.99 sf x 3.67'L = 36.6 cf Overall Size= 60.0"W x 36.0"H x 4.17'L with 0.50' Overlap 555 Chambers in 5 Rows Cap Storage= +6.5 cf x 2 x 5 rows = 64.6 cf
		0.734 af	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	132.50'	<b>1.5" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads
#2	Primary	134.00'	<b>2.0" Vert. Orifice/Grate</b> C= 0.600
#3	Primary	136.25'	<b>24.0" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads

**Primary OutFlow** Max=0.24 cfs @ 23.57 hrs HW=135.67' (Free Discharge)

1=Orifice/Grate (Orifice Controls 0.11 cfs @ 8.58 fps)

2=Orifice/Grate (Orifice Controls 0.13 cfs @ 6.07 fps)

3=Orifice/Grate ( Controls 0.00 cfs)

**Pond 20P: Stormwater System 4 - Chamber Wizard Field A**

**Chamber Model = Cultec R-360HD (Cultec Recharger® 360HD)**

Effective Size= 54.9"W x 36.0"H => 9.99 sf x 3.67'L = 36.6 cf

Overall Size= 60.0"W x 36.0"H x 4.17'L with 0.50' Overlap

Cap Storage= +6.5 cf x 2 x 5 rows = 64.6 cf

60.0" Wide + 9.0" Spacing = 69.0" C-C Row Spacing

111 Chambers/Row x 3.67' Long +1.25' Cap Length x 2 = 409.50' Row Length +12.0" End Stone x 2 = 411.50' Base Length

5 Rows x 60.0" Wide + 9.0" Spacing x 4 + 12.0" Side Stone x 2 = 30.00' Base Width

6.0" Base + 36.0" Chamber Height + 6.0" Cover = 4.00' Field Height

555 Chambers x 36.6 cf + 6.5 cf Cap Volume x 2 x 5 Rows = 20,402.4 cf Chamber Storage

49,380.0 cf Field - 20,402.4 cf Chambers = 28,977.6 cf Stone x 40.0% Voids = 11,591.0 cf Stone Storage

Chamber Storage + Stone Storage = 31,993.4 cf = 0.734 af

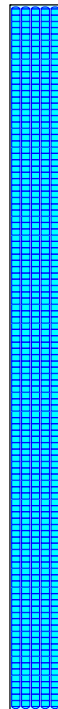
Overall Storage Efficiency = 64.8%

Overall System Size = 411.50' x 30.00' x 4.00'

555 Chambers

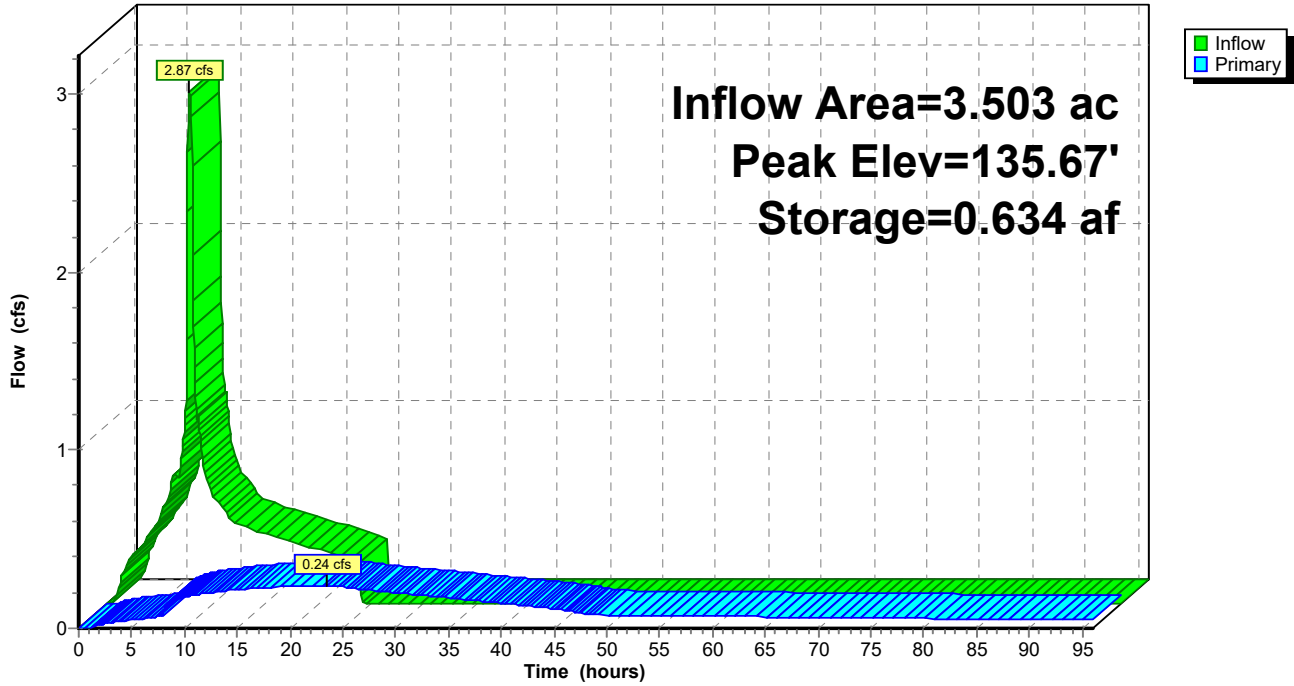
1,828.9 cy Field

1,073.2 cy Stone



### Pond 20P: Stormwater System 4

Hydrograph



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## Summary for Pond 23P: Stormwater System 2

Inflow Area = 4.533 ac, 100.00% Impervious, Inflow Depth = 3.22" for 10-YR event  
Inflow = 3.72 cfs @ 7.86 hrs, Volume= 1.215 af  
Outflow = 0.60 cfs @ 12.56 hrs, Volume= 0.936 af, Atten= 84%, Lag= 282.0 min  
Primary = 0.60 cfs @ 12.56 hrs, Volume= 0.936 af

Routing by Stor-Ind method, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
Peak Elev= 137.38' @ 12.56 hrs Surf.Area= 0.284 ac Storage= 0.725 af

Plug-Flow detention time= 1,563.1 min calculated for 0.936 af (77% of inflow)  
Center-of-Mass det. time= 1,412.8 min ( 2,075.3 - 662.5 )

Volume	Invert	Avail.Storage	Storage Description
#1A	133.50'	0.265 af	<b>41.50"W x 297.83'L x 4.00'H Field A</b> 1.135 af Overall - 0.473 af Embedded = 0.662 af x 40.0% Voids
#2A	134.00'	0.473 af	<b>Cultec R-360HD x 560 Inside #1</b> Effective Size= 54.9"W x 36.0"H => 9.99 sf x 3.67'L = 36.6 cf Overall Size= 60.0"W x 36.0"H x 4.17'L with 0.50' Overlap 560 Chambers in 7 Rows Cap Storage= +6.5 cf x 2 x 7 rows = 90.4 cf
		0.738 af	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	133.50'	<b>0.5" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads
#2	Primary	134.50'	<b>1.5" Vert. Orifice/Grate</b> C= 0.600
#3	Primary	137.30'	<b>24.0" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads

**Primary OutFlow** Max=0.60 cfs @ 12.56 hrs HW=137.38' (Free Discharge)

- 1=Orifice/Grate (Orifice Controls 0.01 cfs @ 9.49 fps)
- 2=Orifice/Grate (Orifice Controls 0.10 cfs @ 8.09 fps)
- 3=Orifice/Grate (Weir Controls 0.48 cfs @ 0.94 fps)

**Pond 23P: Stormwater System 2 - Chamber Wizard Field A**

**Chamber Model = Cultec R-360HD (Cultec Recharger® 360HD)**

Effective Size= 54.9"W x 36.0"H => 9.99 sf x 3.67'L = 36.6 cf

Overall Size= 60.0"W x 36.0"H x 4.17'L with 0.50' Overlap

Cap Storage= +6.5 cf x 2 x 7 rows = 90.4 cf

60.0" Wide + 9.0" Spacing = 69.0" C-C Row Spacing

80 Chambers/Row x 3.67' Long +1.25' Cap Length x 2 = 295.83' Row Length +12.0" End Stone x 2 = 297.83' Base Length

7 Rows x 60.0" Wide + 9.0" Spacing x 6 + 12.0" Side Stone x 2 = 41.50' Base Width

6.0" Base + 36.0" Chamber Height + 6.0" Cover = 4.00' Field Height

560 Chambers x 36.6 cf + 6.5 cf Cap Volume x 2 x 7 Rows = 20,611.5 cf Chamber Storage

49,440.3 cf Field - 20,611.5 cf Chambers = 28,828.9 cf Stone x 40.0% Voids = 11,531.6 cf Stone Storage

Chamber Storage + Stone Storage = 32,143.0 cf = 0.738 af

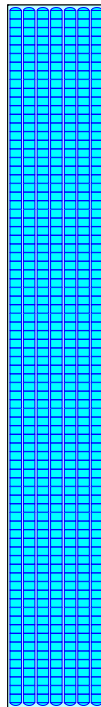
Overall Storage Efficiency = 65.0%

Overall System Size = 297.83' x 41.50' x 4.00'

560 Chambers

1,831.1 cy Field

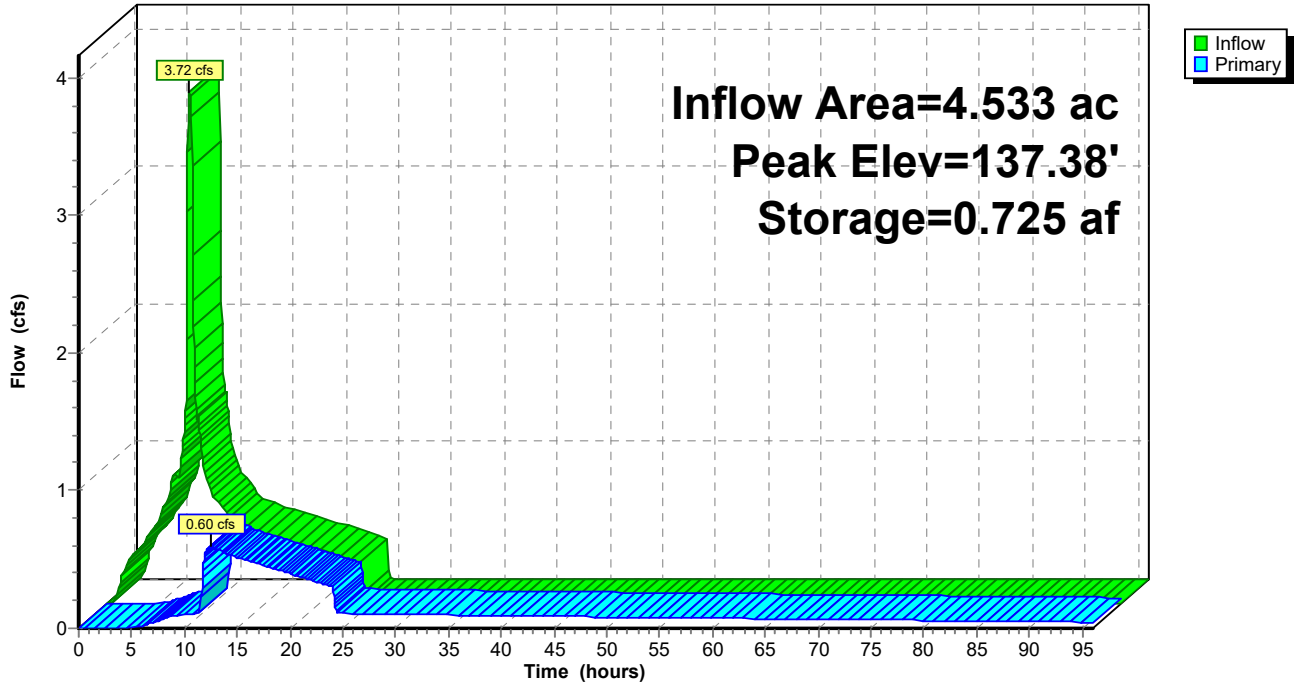
1,067.7 cy Stone





**Pond 23P: Stormwater System 2**

Hydrograph



**Walgraves**

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Time span=0.00-96.00 hrs, dt=0.05 hrs, 1921 points  
 Runoff by SCS TR-20 method, UH=SCS, Weighted-CN  
 Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

<b>Subcatchment8S: Basin 1</b>	Runoff Area=125,547 sf 100.00% Impervious Runoff Depth=3.67" Tc=5.0 min CN=98 Runoff=2.68 cfs 0.880 af
<b>Subcatchment13S: Basin 3</b>	Runoff Area=224,462 sf 100.00% Impervious Runoff Depth=3.67" Tc=5.0 min CN=98 Runoff=4.80 cfs 1.574 af
<b>Subcatchment15S: Filter Strip Basins</b>	Runoff Area=40,551 sf 100.00% Impervious Runoff Depth=3.67" Tc=10.0 min CN=98 Runoff=0.86 cfs 0.284 af
<b>Subcatchment17S: Pre Total</b>	Runoff Area=740,599 sf 0.00% Impervious Runoff Depth=1.96" Tc=30.0 min CN=80 Runoff=6.63 cfs 2.776 af
<b>Subcatchment18S: Basin 4</b>	Runoff Area=152,599 sf 100.00% Impervious Runoff Depth=3.67" Tc=5.0 min CN=98 Runoff=3.26 cfs 1.070 af
<b>Subcatchment19S: Basin 2</b>	Runoff Area=197,440 sf 100.00% Impervious Runoff Depth=3.67" Tc=5.0 min CN=98 Runoff=4.22 cfs 1.384 af
<b>Reach 22R: Offsite Discharge</b>	Avg. Flow Depth=0.20' Max Vel=0.35 fps Inflow=7.59 cfs 4.762 af n=0.035 L=300.0' S=0.0008 '/' Capacity=29.46 cfs Outflow=4.93 cfs 4.752 af
<b>Pond 11P: Stormwater System 1</b>	Peak Elev=135.80' Storage=0.278 af Inflow=2.68 cfs 0.880 af Outflow=3.51 cfs 0.859 af
<b>Pond 14P: Stormwater System 3</b>	Peak Elev=134.58' Storage=0.488 af Inflow=4.80 cfs 1.574 af Outflow=3.83 cfs 1.530 af
<b>Pond 20P: Stormwater System 4</b>	Peak Elev=136.27' Storage=0.708 af Inflow=3.26 cfs 1.070 af Outflow=0.34 cfs 0.983 af
<b>Pond 23P: Stormwater System 2</b>	Peak Elev=137.41' Storage=0.727 af Inflow=4.22 cfs 1.384 af Outflow=0.85 cfs 1.106 af

**Total Runoff Area = 34.004 ac Runoff Volume = 7.969 af Average Runoff Depth = 2.81"**  
**50.00% Pervious = 17.002 ac 50.00% Impervious = 17.002 ac**

**Summary for Subcatchment 8S: Basin 1**

[49] Hint:  $T_c < 2dt$  may require smaller dt

Runoff = 2.68 cfs @ 7.86 hrs, Volume= 0.880 af, Depth= 3.67"

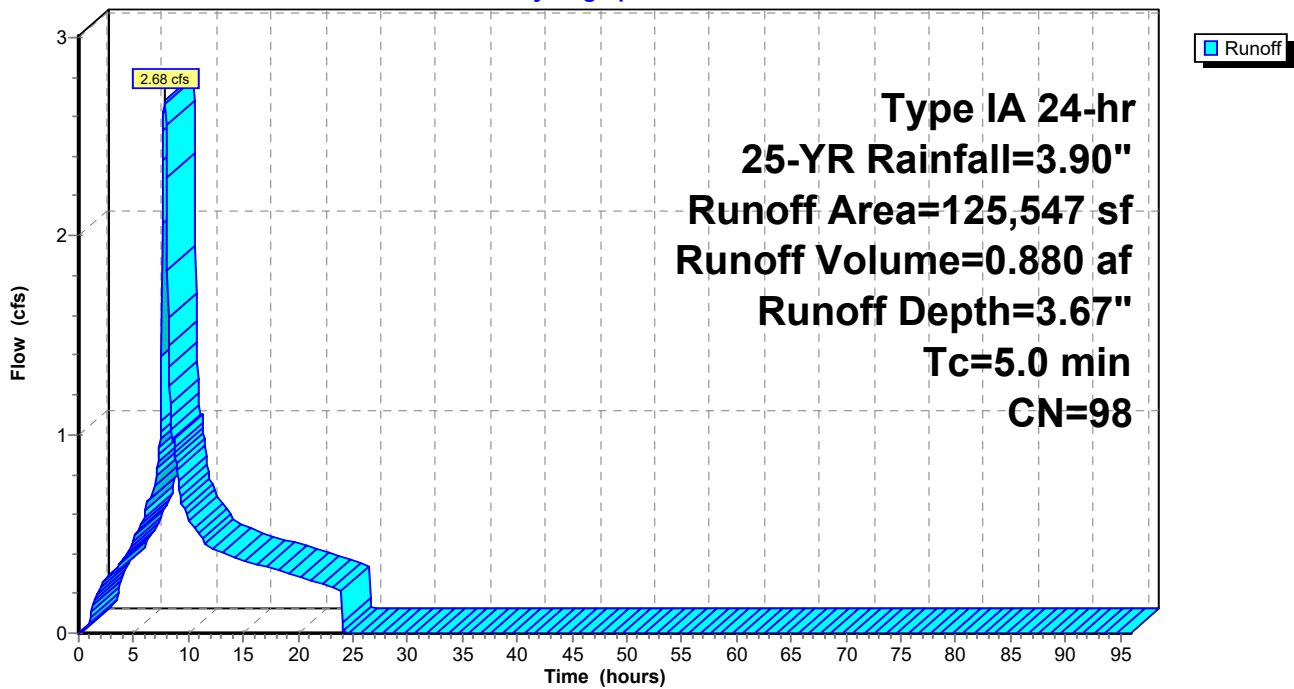
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
 Type IA 24-hr 25-YR Rainfall=3.90"

Area (sf)	CN	Description
* 125,547	98	
125,547		100.00% Impervious Area

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

**Subcatchment 8S: Basin 1**

Hydrograph



**Summary for Subcatchment 13S: Basin 3**

[49] Hint: Tc<2dt may require smaller dt

Runoff = 4.80 cfs @ 7.86 hrs, Volume= 1.574 af, Depth= 3.67"

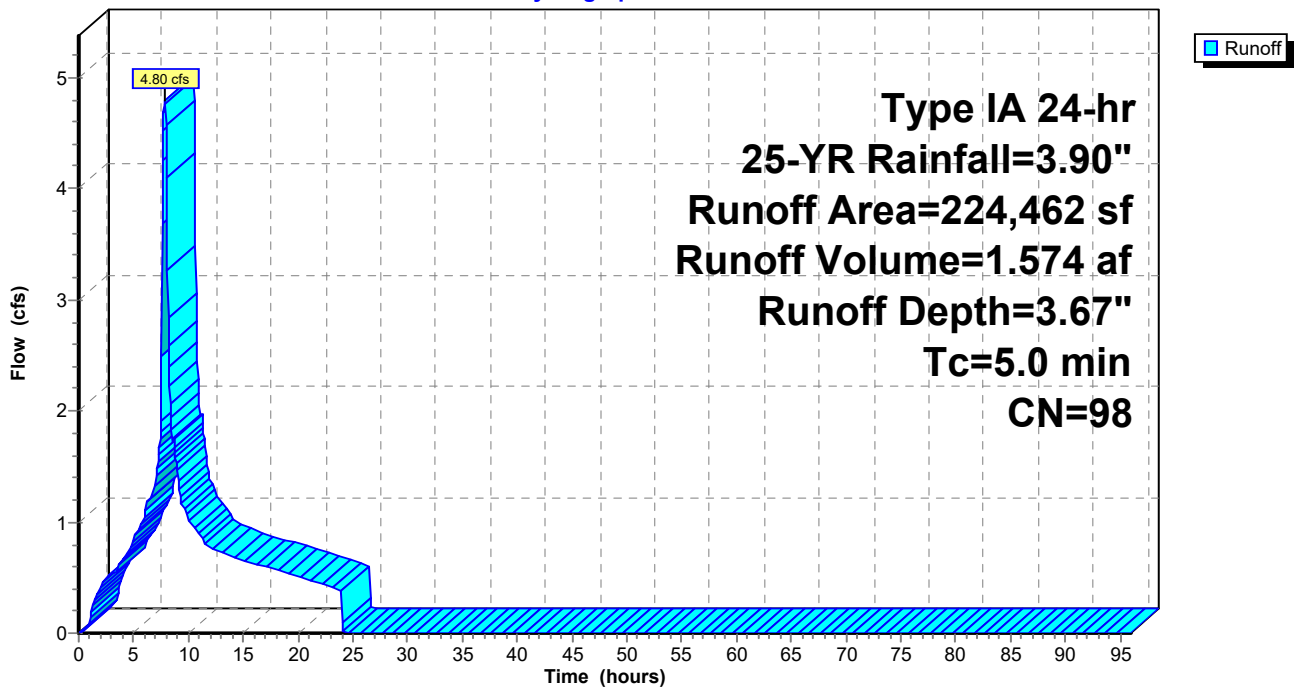
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
 Type IA 24-hr 25-YR Rainfall=3.90"

Area (sf)	CN	Description
* 224,462	98	
224,462		100.00% Impervious Area

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

**Subcatchment 13S: Basin 3**

Hydrograph



**Summary for Subcatchment 15S: Filter Strip Basins**

Runoff = 0.86 cfs @ 7.94 hrs, Volume= 0.284 af, Depth= 3.67"

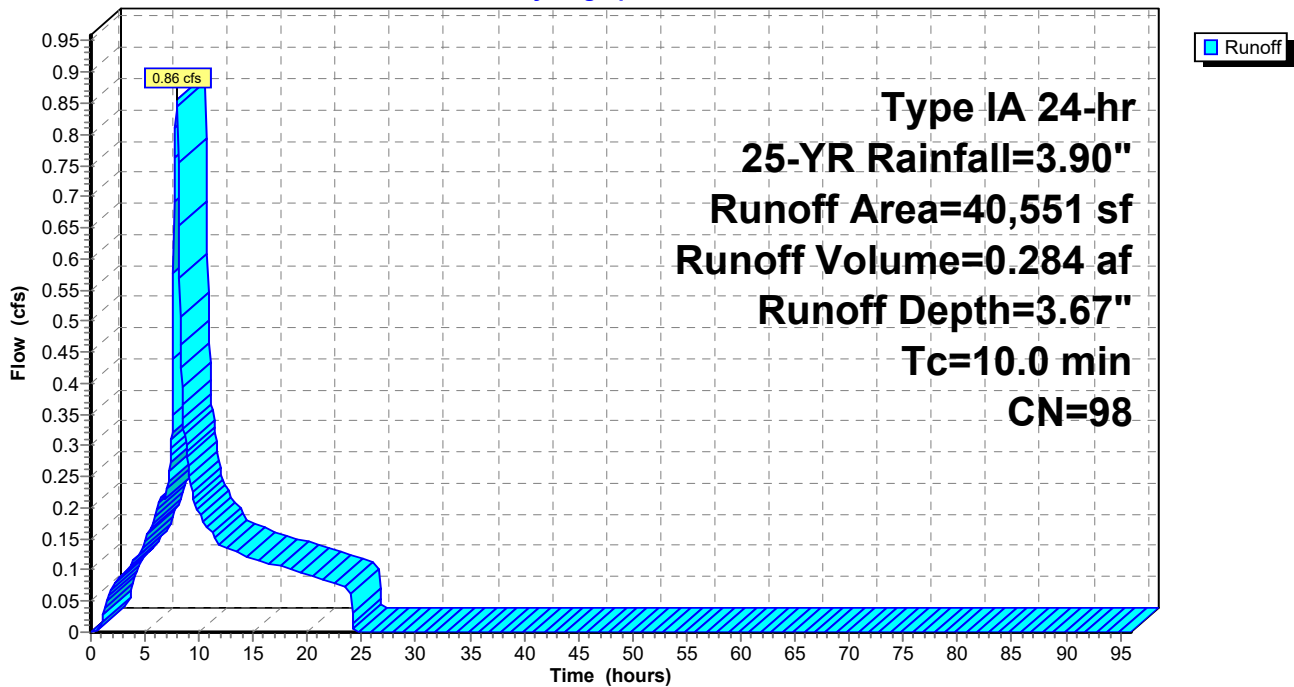
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
 Type IA 24-hr 25-YR Rainfall=3.90"

Area (sf)	CN	Description
* 40,551	98	
40,551		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.0					Direct Entry, 20

**Subcatchment 15S: Filter Strip Basins**

Hydrograph



**Summary for Subcatchment 17S: Pre Total**

Runoff = 6.63 cfs @ 8.24 hrs, Volume= 2.776 af, Depth= 1.96"

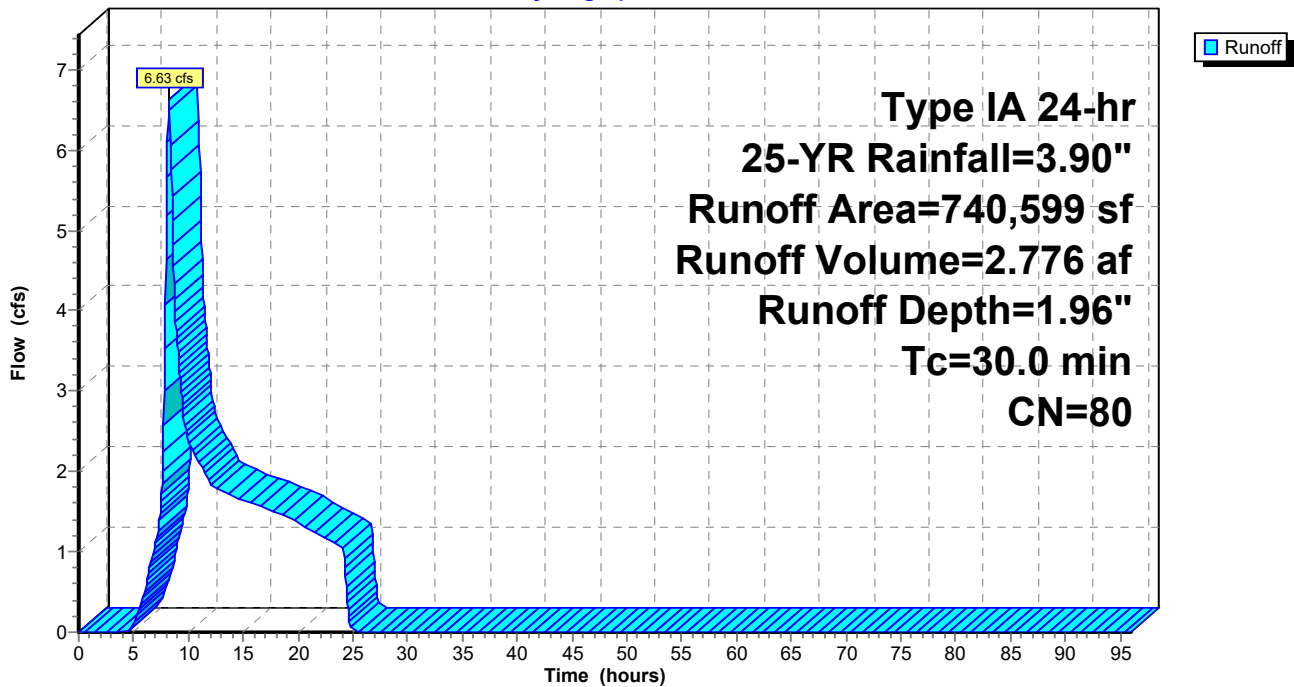
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
 Type IA 24-hr 25-YR Rainfall=3.90"

Area (sf)	CN	Description
740,599	80	>75% Grass cover, Good, HSG D
740,599		100.00% Pervious Area

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

**Subcatchment 17S: Pre Total**

Hydrograph



**Summary for Subcatchment 18S: Basin 4**

[49] Hint: Tc<2dt may require smaller dt

Runoff = 3.26 cfs @ 7.86 hrs, Volume= 1.070 af, Depth= 3.67"

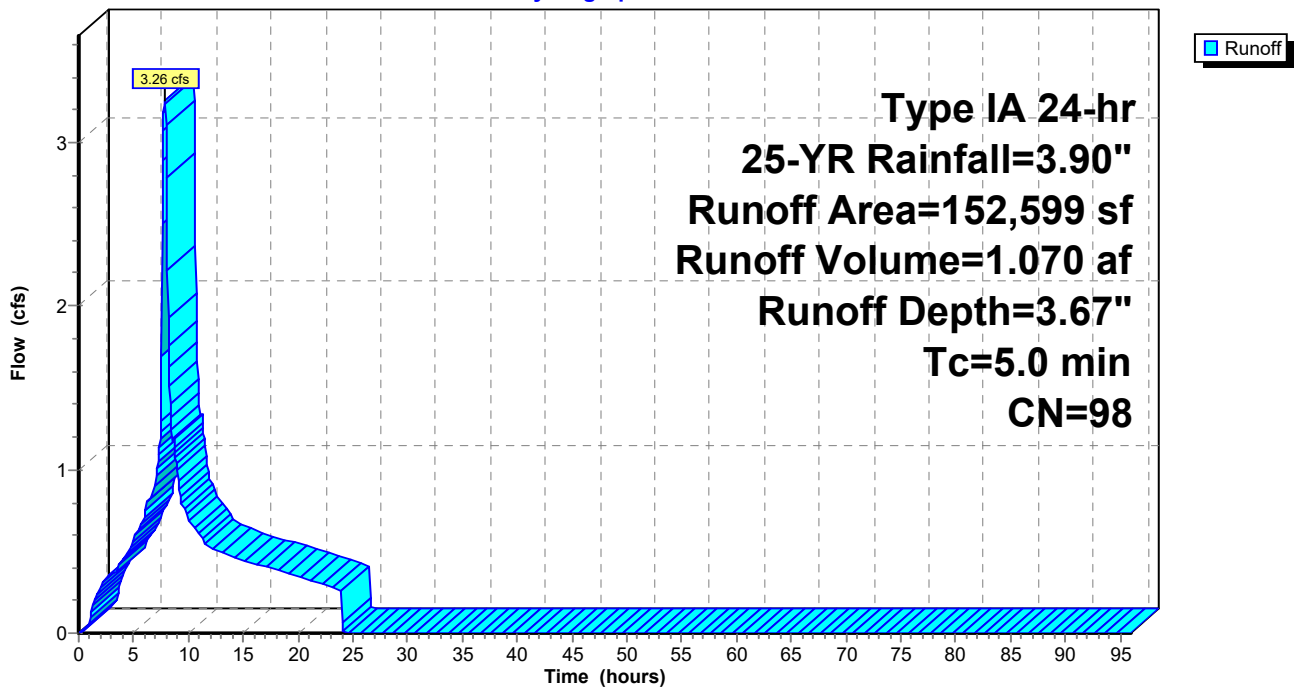
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
 Type IA 24-hr 25-YR Rainfall=3.90"

Area (sf)	CN	Description
* 152,599	98	
152,599		100.00% Impervious Area

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

**Subcatchment 18S: Basin 4**

Hydrograph



**Summary for Subcatchment 19S: Basin 2**

[49] Hint: Tc<2dt may require smaller dt

Runoff = 4.22 cfs @ 7.86 hrs, Volume= 1.384 af, Depth= 3.67"

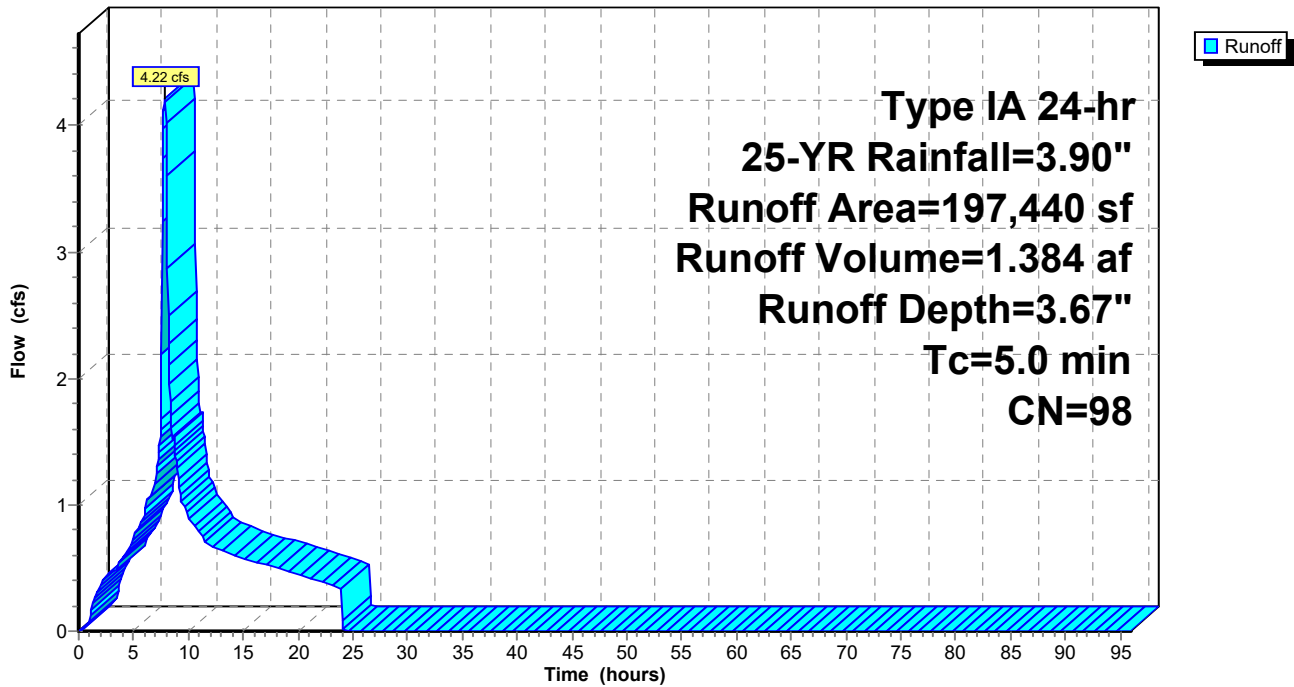
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
 Type IA 24-hr 25-YR Rainfall=3.90"

Area (sf)	CN	Description
* 197,440	98	
197,440		100.00% Impervious Area

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

**Subcatchment 19S: Basin 2**

Hydrograph





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Type IA 24-hr 25-YR Rainfall=3.90"

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## Summary for Reach 22R: Offsite Discharge

Reach modeled with shallow side slopes to best mimic the overland flow created at the discharge points.

[81] Warning: Exceeded Pond 14P by 0.50' @ 0.00 hrs

[81] Warning: Exceeded Pond 20P by 0.50' @ 0.00 hrs

Inflow Area = 17.002 ac, 100.00% Impervious, Inflow Depth > 3.36" for 25-YR event  
Inflow = 7.59 cfs @ 8.10 hrs, Volume= 4.762 af  
Outflow = 4.93 cfs @ 8.49 hrs, Volume= 4.752 af, Atten= 35%, Lag= 23.5 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
Max. Velocity= 0.35 fps, Min. Travel Time= 14.1 min  
Avg. Velocity = 0.15 fps, Avg. Travel Time= 33.2 min

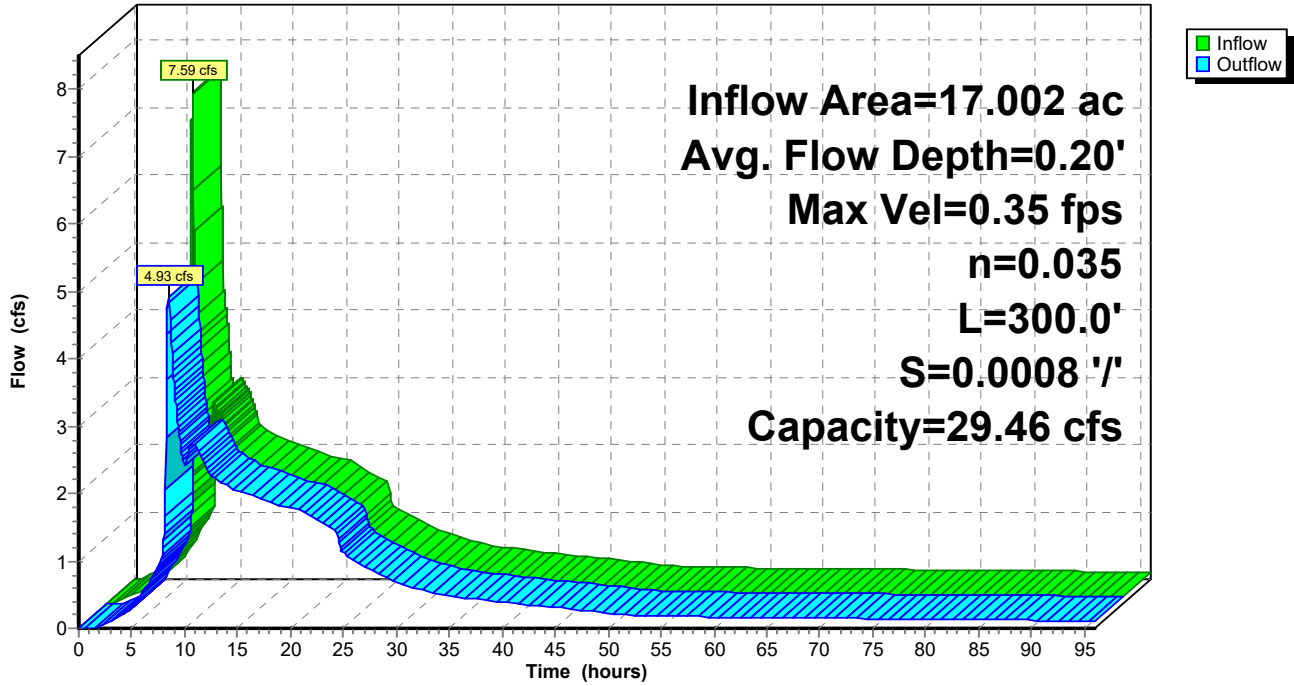
Peak Storage= 4,185 cf @ 8.25 hrs  
Average Depth at Peak Storage= 0.20'  
Bank-Full Depth= 0.50' Flow Area= 50.0 sf, Capacity= 29.46 cfs

50.00' x 0.50' deep channel, n= 0.035 High grass  
Side Slope Z-value= 100.0 ' ' Top Width= 150.00'  
Length= 300.0' Slope= 0.0008 ' '  
Inlet Invert= 133.00', Outlet Invert= 132.75'



### Reach 22R: Offsite Discharge

Hydrograph



**Summary for Pond 11P: Stormwater System 1**

[93] Warning: Storage range exceeded by 0.26'

[88] Warning: Qout>Qin may require smaller dt or Finer Routing

[85] Warning: Oscillations may require smaller dt or Finer Routing (severity=44)

Inflow Area = 2.882 ac, 100.00% Impervious, Inflow Depth = 3.67" for 25-YR event  
 Inflow = 2.68 cfs @ 7.86 hrs, Volume= 0.880 af  
 Outflow = 3.51 cfs @ 8.01 hrs, Volume= 0.859 af, Atten= 0%, Lag= 9.0 min  
 Primary = 3.51 cfs @ 8.01 hrs, Volume= 0.859 af

Routing by Stor-Ind method, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
 Peak Elev= 135.80' @ 8.01 hrs Surf.Area= 0.246 ac Storage= 0.278 af

Plug-Flow detention time= 556.0 min calculated for 0.859 af (98% of inflow)  
 Center-of-Mass det. time= 539.7 min ( 1,199.1 - 659.5 )

Volume	Invert	Avail.Storage	Storage Description
#1A	133.50'	0.149 af	<b>28.33'W x 377.50'L x 2.04'H Field A</b> 0.501 af Overall - 0.128 af Embedded = 0.373 af x 40.0% Voids
#2A	134.00'	0.128 af	<b>Cultec C-100HD</b> x 400 Inside #1 Effective Size= 32.1"W x 12.0"H => 1.86 sf x 7.50'L = 14.0 cf Overall Size= 36.0"W x 12.5"H x 8.00'L with 0.50' Overlap Row Length Adjustment= +0.50' x 1.86 sf x 8 rows
		0.278 af	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	133.50'	<b>0.5" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads
#2	Primary	133.80'	<b>2.5" Vert. Orifice/Grate</b> C= 0.600
#3	Primary	135.50'	<b>24.0" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads

**Primary OutFlow** Max=3.23 cfs @ 8.01 hrs HW=135.78' (Free Discharge)

- 1=Orifice/Grate (Orifice Controls 0.01 cfs @ 7.27 fps)
- 2=Orifice/Grate (Orifice Controls 0.22 cfs @ 6.59 fps)
- 3=Orifice/Grate (Weir Controls 2.99 cfs @ 1.72 fps)

**Pond 11P: Stormwater System 1 - Chamber Wizard Field A**

**Chamber Model = Cultec C-100HD (Cultec Contactor® 100HD)**

Effective Size= 32.1"W x 12.0"H => 1.86 sf x 7.50'L = 14.0 cf

Overall Size= 36.0"W x 12.5"H x 8.00'L with 0.50' Overlap

Row Length Adjustment= +0.50' x 1.86 sf x 8 rows

36.0" Wide + 4.0" Spacing = 40.0" C-C Row Spacing

50 Chambers/Row x 7.50' Long +0.50' Row Adjustment = 375.50' Row Length +12.0" End Stone x 2 = 377.50' Base Length

8 Rows x 36.0" Wide + 4.0" Spacing x 7 + 12.0" Side Stone x 2 = 28.33' Base Width

6.0" Base + 12.5" Chamber Height + 6.0" Cover = 2.04' Field Height

400 Chambers x 14.0 cf +0.50' Row Adjustment x 1.86 sf x 8 Rows = 5,591.9 cf Chamber Storage

21,837.3 cf Field - 5,591.9 cf Chambers = 16,245.4 cf Stone x 40.0% Voids = 6,498.2 cf Stone Storage

Chamber Storage + Stone Storage = 12,090.1 cf = 0.278 af

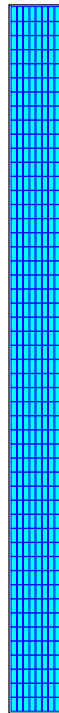
Overall Storage Efficiency = 55.4%

Overall System Size = 377.50' x 28.33' x 2.04'

400 Chambers

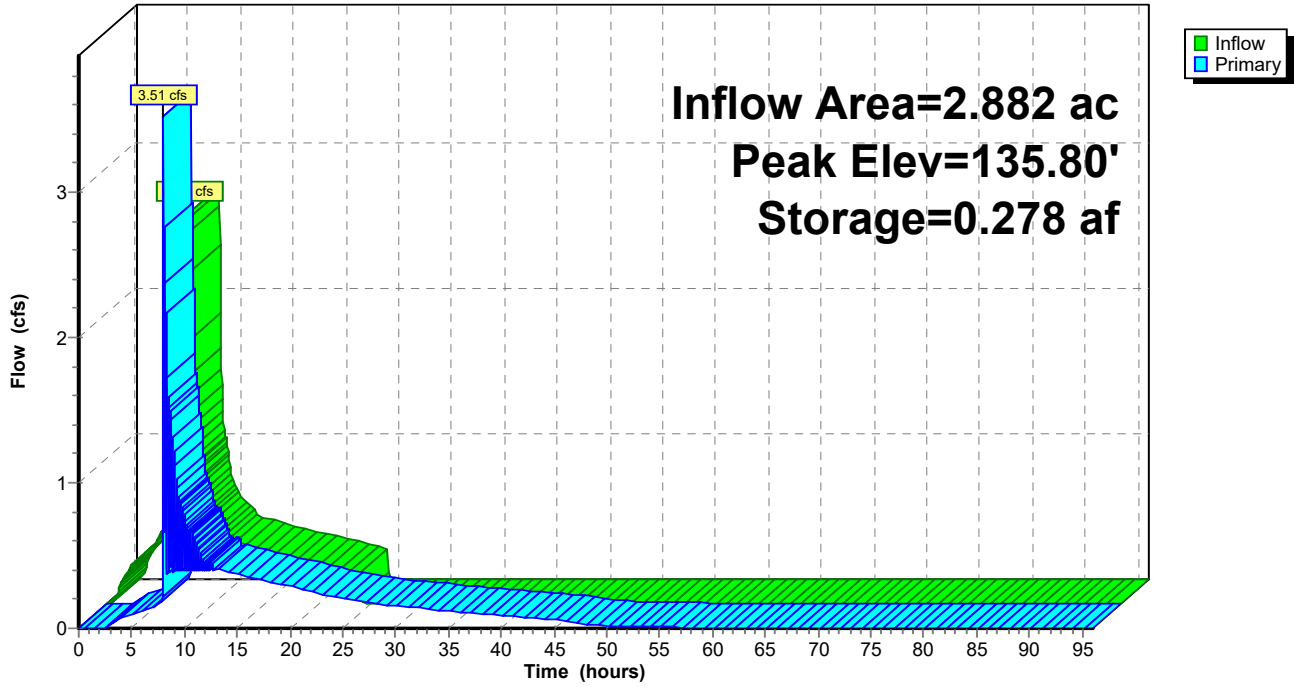
808.8 cy Field

601.7 cy Stone



### Pond 11P: Stormwater System 1

Hydrograph



**Summary for Pond 14P: Stormwater Sytem 3**

[93] Warning: Storage range exceeded by 0.04'

Inflow Area = 5.153 ac, 100.00% Impervious, Inflow Depth = 3.67" for 25-YR event  
 Inflow = 4.80 cfs @ 7.86 hrs, Volume= 1.574 af  
 Outflow = 3.83 cfs @ 8.10 hrs, Volume= 1.530 af, Atten= 20%, Lag= 14.6 min  
 Primary = 3.83 cfs @ 8.10 hrs, Volume= 1.530 af

Routing by Stor-Ind method, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
 Peak Elev= 134.58' @ 8.10 hrs Surf.Area= 0.427 ac Storage= 0.488 af

Plug-Flow detention time= 488.8 min calculated for 1.529 af (97% of inflow)  
 Center-of-Mass det. time= 469.3 min ( 1,128.7 - 659.5 )

Volume	Invert	Avail.Storage	Storage Description
#1A	132.50'	0.257 af	<b>68.33"W x 272.50'L x 2.04'H Field A</b> 0.873 af Overall - 0.231 af Embedded = 0.642 af x 40.0% Voids
#2A	133.00'	0.231 af	<b>Cultec C-100HD x 720 Inside #1</b> Effective Size= 32.1"W x 12.0"H => 1.86 sf x 7.50'L = 14.0 cf Overall Size= 36.0"W x 12.5"H x 8.00'L with 0.50' Overlap Row Length Adjustment= +0.50' x 1.86 sf x 20 rows
		0.488 af	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	132.50'	<b>1.0" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads
#2	Primary	133.05'	<b>5.0" Vert. Orifice/Grate</b> C= 0.600
#3	Primary	134.30'	<b>24.0" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads

**Primary OutFlow** Max=3.81 cfs @ 8.10 hrs HW=134.58' (Free Discharge)

- 1=Orifice/Grate (Orifice Controls 0.04 cfs @ 6.94 fps)
- 2=Orifice/Grate (Orifice Controls 0.75 cfs @ 5.53 fps)
- 3=Orifice/Grate (Weir Controls 3.02 cfs @ 1.73 fps)

**Pond 14P: Stormwater Sytem 3 - Chamber Wizard Field A**

**Chamber Model = Cultec C-100HD (Cultec Contactor® 100HD)**

Effective Size= 32.1"W x 12.0"H => 1.86 sf x 7.50'L = 14.0 cf

Overall Size= 36.0"W x 12.5"H x 8.00'L with 0.50' Overlap

Row Length Adjustment= +0.50' x 1.86 sf x 20 rows

36.0" Wide + 4.0" Spacing = 40.0" C-C Row Spacing

36 Chambers/Row x 7.50' Long +0.50' Row Adjustment = 270.50' Row Length +12.0" End Stone x 2 = 272.50' Base Length

20 Rows x 36.0" Wide + 4.0" Spacing x 19 + 12.0" Side Stone x 2 = 68.33' Base Width

6.0" Base + 12.5" Chamber Height + 6.0" Cover = 2.04' Field Height

720 Chambers x 14.0 cf +0.50' Row Adjustment x 1.86 sf x 20 Rows = 10,070.7 cf Chamber Storage

38,017.5 cf Field - 10,070.7 cf Chambers = 27,946.8 cf Stone x 40.0% Voids = 11,178.7 cf Stone Storage

Chamber Storage + Stone Storage = 21,249.4 cf = 0.488 af

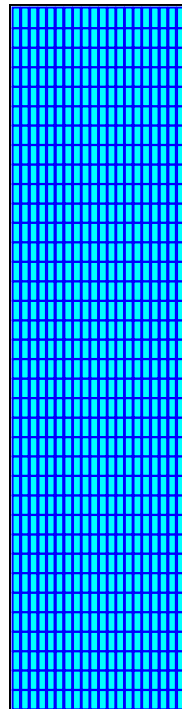
Overall Storage Efficiency = 55.9%

Overall System Size = 272.50' x 68.33' x 2.04'

720 Chambers

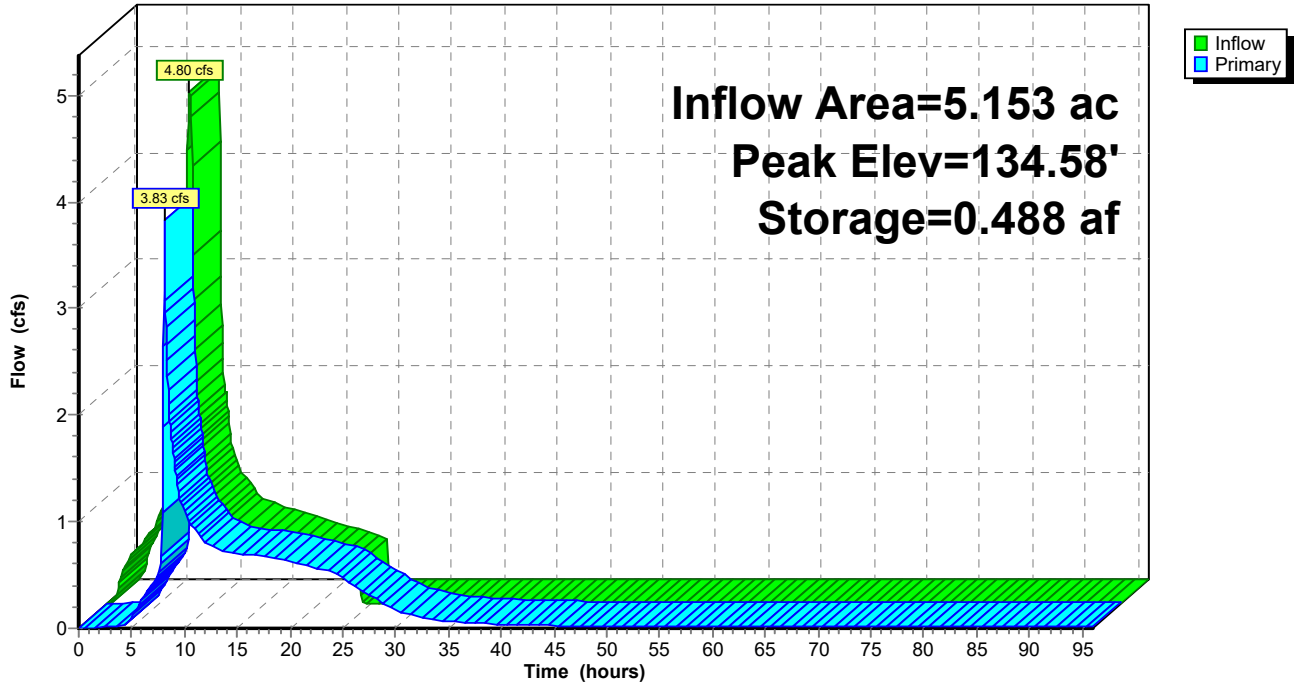
1,408.1 cy Field

1,035.1 cy Stone



### Pond 14P: Stormwater Sytem 3

Hydrograph





# Walgraves

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Type IA 24-hr 25-YR Rainfall=3.90"

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## Summary for Pond 20P: Stormwater System 4

Inflow Area = 3.503 ac, 100.00% Impervious, Inflow Depth = 3.67" for 25-YR event  
Inflow = 3.26 cfs @ 7.86 hrs, Volume= 1.070 af  
Outflow = 0.34 cfs @ 20.10 hrs, Volume= 0.983 af, Atten= 90%, Lag= 734.6 min  
Primary = 0.34 cfs @ 20.10 hrs, Volume= 0.983 af

Routing by Stor-Ind method, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
Peak Elev= 136.27' @ 20.10 hrs Surf.Area= 0.283 ac Storage= 0.708 af

Plug-Flow detention time= 1,593.3 min calculated for 0.983 af (92% of inflow)  
Center-of-Mass det. time= 1,533.5 min ( 2,193.0 - 659.5 )

Volume	Invert	Avail.Storage	Storage Description
#1A	132.50'	0.266 af	<b>30.00'W x 411.50'L x 4.00'H Field A</b> 1.134 af Overall - 0.468 af Embedded = 0.665 af x 40.0% Voids
#2A	133.00'	0.468 af	<b>Cultec R-360HD x 555 Inside #1</b> Effective Size= 54.9"W x 36.0"H => 9.99 sf x 3.67'L = 36.6 cf Overall Size= 60.0"W x 36.0"H x 4.17'L with 0.50' Overlap 555 Chambers in 5 Rows Cap Storage= +6.5 cf x 2 x 5 rows = 64.6 cf
		0.734 af	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	132.50'	<b>1.5" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads
#2	Primary	134.00'	<b>2.0" Vert. Orifice/Grate</b> C= 0.600
#3	Primary	136.25'	<b>24.0" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads

**Primary OutFlow** Max=0.33 cfs @ 20.10 hrs HW=136.27' (Free Discharge)

- 1=Orifice/Grate (Orifice Controls 0.11 cfs @ 9.35 fps)
- 2=Orifice/Grate (Orifice Controls 0.16 cfs @ 7.12 fps)
- 3=Orifice/Grate (Weir Controls 0.06 cfs @ 0.46 fps)

**Pond 20P: Stormwater System 4 - Chamber Wizard Field A**

**Chamber Model = Cultec R-360HD (Cultec Recharger® 360HD)**

Effective Size= 54.9"W x 36.0"H => 9.99 sf x 3.67'L = 36.6 cf

Overall Size= 60.0"W x 36.0"H x 4.17'L with 0.50' Overlap

Cap Storage= +6.5 cf x 2 x 5 rows = 64.6 cf

60.0" Wide + 9.0" Spacing = 69.0" C-C Row Spacing

111 Chambers/Row x 3.67' Long +1.25' Cap Length x 2 = 409.50' Row Length +12.0" End Stone x 2 = 411.50' Base Length

5 Rows x 60.0" Wide + 9.0" Spacing x 4 + 12.0" Side Stone x 2 = 30.00' Base Width

6.0" Base + 36.0" Chamber Height + 6.0" Cover = 4.00' Field Height

555 Chambers x 36.6 cf + 6.5 cf Cap Volume x 2 x 5 Rows = 20,402.4 cf Chamber Storage

49,380.0 cf Field - 20,402.4 cf Chambers = 28,977.6 cf Stone x 40.0% Voids = 11,591.0 cf Stone Storage

Chamber Storage + Stone Storage = 31,993.4 cf = 0.734 af

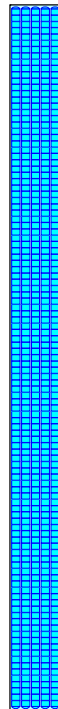
Overall Storage Efficiency = 64.8%

Overall System Size = 411.50' x 30.00' x 4.00'

555 Chambers

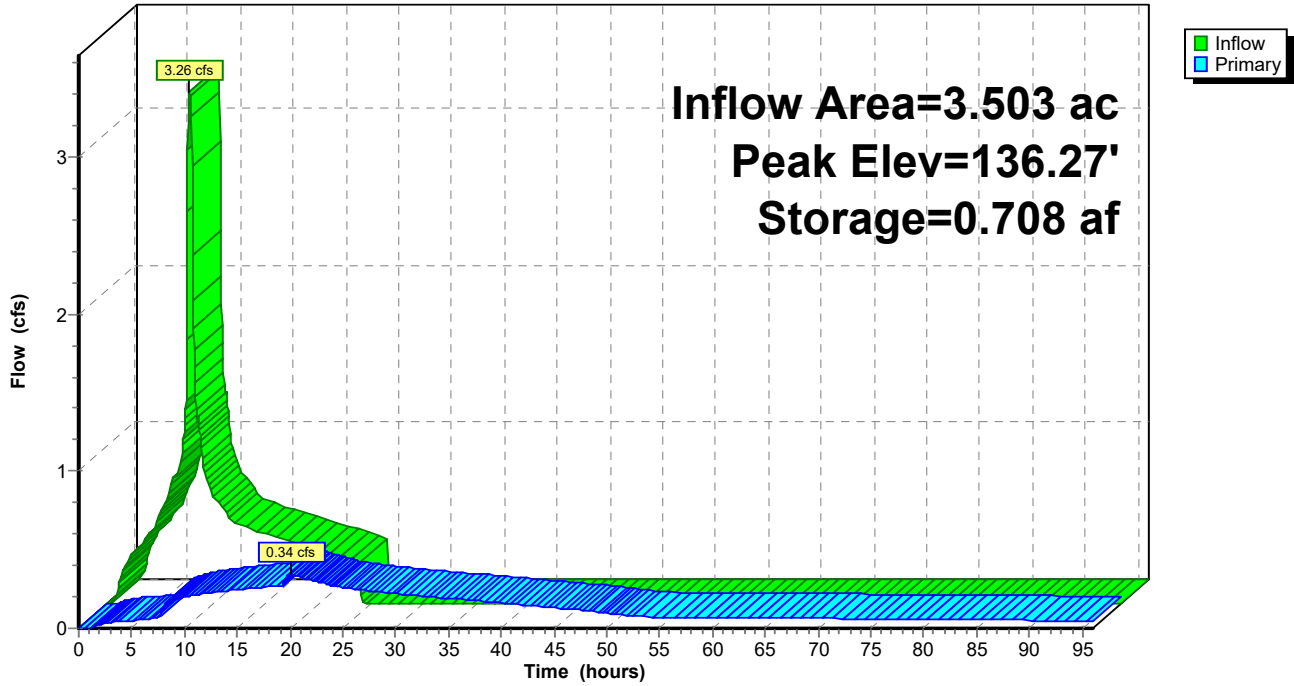
1,828.9 cy Field

1,073.2 cy Stone



### Pond 20P: Stormwater System 4

Hydrograph



# Walgraves

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Type IA 24-hr 25-YR Rainfall=3.90"

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## Summary for Pond 23P: Stormwater System 2

Inflow Area = 4.533 ac, 100.00% Impervious, Inflow Depth = 3.67" for 25-YR event  
Inflow = 4.22 cfs @ 7.86 hrs, Volume= 1.384 af  
Outflow = 0.85 cfs @ 10.32 hrs, Volume= 1.106 af, Atten= 80%, Lag= 148.1 min  
Primary = 0.85 cfs @ 10.32 hrs, Volume= 1.106 af

Routing by Stor-Ind method, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
Peak Elev= 137.41' @ 10.32 hrs Surf.Area= 0.284 ac Storage= 0.727 af

Plug-Flow detention time= 1,351.2 min calculated for 1.105 af (80% of inflow)  
Center-of-Mass det. time= 1,217.9 min ( 1,877.4 - 659.5 )

Volume	Invert	Avail.Storage	Storage Description
#1A	133.50'	0.265 af	<b>41.50'W x 297.83'L x 4.00'H Field A</b> 1.135 af Overall - 0.473 af Embedded = 0.662 af x 40.0% Voids
#2A	134.00'	0.473 af	<b>Cultec R-360HD x 560 Inside #1</b> Effective Size= 54.9"W x 36.0"H => 9.99 sf x 3.67'L = 36.6 cf Overall Size= 60.0"W x 36.0"H x 4.17'L with 0.50' Overlap 560 Chambers in 7 Rows Cap Storage= +6.5 cf x 2 x 7 rows = 90.4 cf
		0.738 af	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	133.50'	<b>0.5" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads
#2	Primary	134.50'	<b>1.5" Vert. Orifice/Grate</b> C= 0.600
#3	Primary	137.30'	<b>24.0" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads

**Primary OutFlow** Max=0.84 cfs @ 10.32 hrs HW=137.41' (Free Discharge)

1=Orifice/Grate (Orifice Controls 0.01 cfs @ 9.52 fps)

2=Orifice/Grate (Orifice Controls 0.10 cfs @ 8.12 fps)

3=Orifice/Grate (Weir Controls 0.73 cfs @ 1.07 fps)

**Pond 23P: Stormwater System 2 - Chamber Wizard Field A**

**Chamber Model = Cultec R-360HD (Cultec Recharger® 360HD)**

Effective Size= 54.9"W x 36.0"H => 9.99 sf x 3.67'L = 36.6 cf

Overall Size= 60.0"W x 36.0"H x 4.17'L with 0.50' Overlap

Cap Storage= +6.5 cf x 2 x 7 rows = 90.4 cf

60.0" Wide + 9.0" Spacing = 69.0" C-C Row Spacing

80 Chambers/Row x 3.67' Long +1.25' Cap Length x 2 = 295.83' Row Length +12.0" End Stone x 2 = 297.83' Base Length

7 Rows x 60.0" Wide + 9.0" Spacing x 6 + 12.0" Side Stone x 2 = 41.50' Base Width

6.0" Base + 36.0" Chamber Height + 6.0" Cover = 4.00' Field Height

560 Chambers x 36.6 cf + 6.5 cf Cap Volume x 2 x 7 Rows = 20,611.5 cf Chamber Storage

49,440.3 cf Field - 20,611.5 cf Chambers = 28,828.9 cf Stone x 40.0% Voids = 11,531.6 cf Stone Storage

Chamber Storage + Stone Storage = 32,143.0 cf = 0.738 af

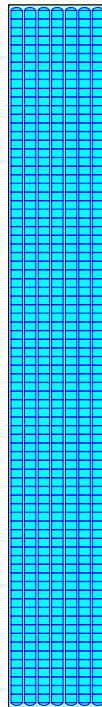
Overall Storage Efficiency = 65.0%

Overall System Size = 297.83' x 41.50' x 4.00'

560 Chambers

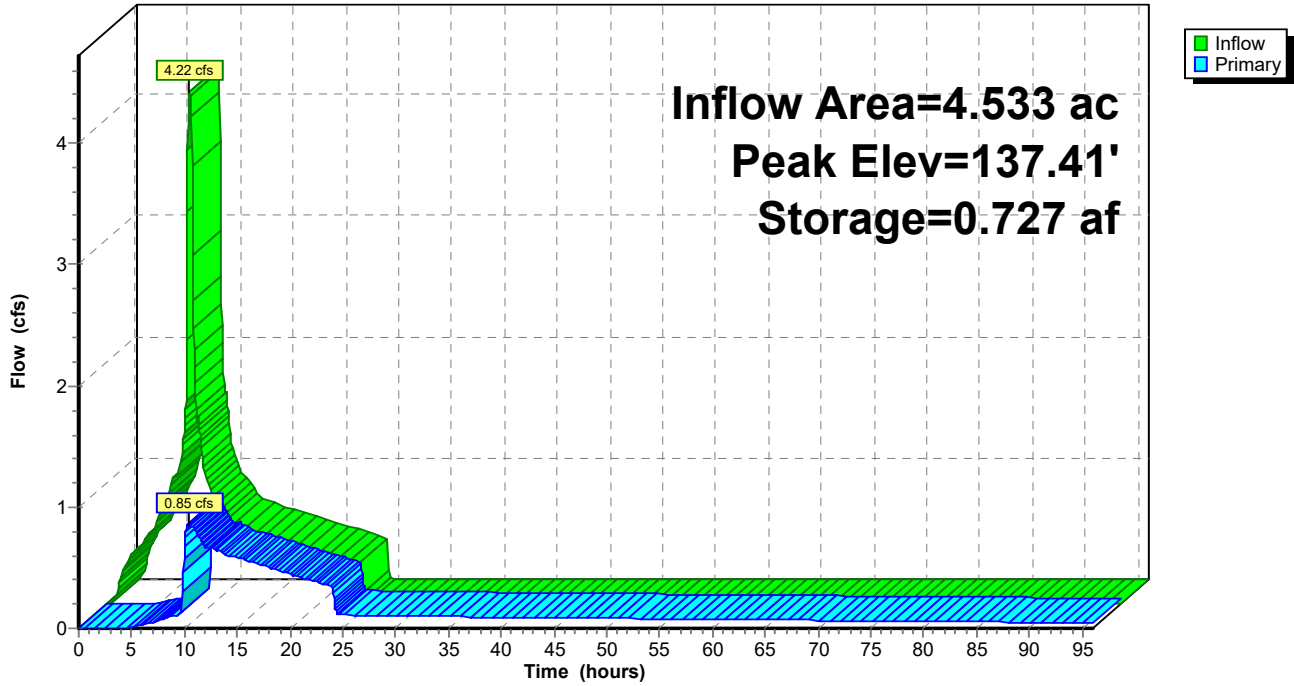
1,831.1 cy Field

1,067.7 cy Stone



**Pond 23P: Stormwater System 2**

Hydrograph



**Walgraves**

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Type IA 24-hr 100-YR Rainfall=4.50"

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Time span=0.00-96.00 hrs, dt=0.05 hrs, 1921 points  
 Runoff by SCS TR-20 method, UH=SCS, Weighted-CN  
 Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

<b>Subcatchment8S: Basin 1</b>	Runoff Area=125,547 sf 100.00% Impervious Runoff Depth=4.26" Tc=5.0 min CN=98 Runoff=3.11 cfs 1.024 af
<b>Subcatchment13S: Basin 3</b>	Runoff Area=224,462 sf 100.00% Impervious Runoff Depth=4.26" Tc=5.0 min CN=98 Runoff=5.56 cfs 1.831 af
<b>Subcatchment15S: Filter Strip Basins</b>	Runoff Area=40,551 sf 100.00% Impervious Runoff Depth=4.26" Tc=10.0 min CN=98 Runoff=0.99 cfs 0.331 af
<b>Subcatchment17S: Pre Total</b>	Runoff Area=740,599 sf 0.00% Impervious Runoff Depth=2.46" Tc=30.0 min CN=80 Runoff=8.63 cfs 3.488 af
<b>Subcatchment18S: Basin 4</b>	Runoff Area=152,599 sf 100.00% Impervious Runoff Depth=4.26" Tc=5.0 min CN=98 Runoff=3.78 cfs 1.245 af
<b>Subcatchment19S: Basin 2</b>	Runoff Area=197,440 sf 100.00% Impervious Runoff Depth=4.26" Tc=5.0 min CN=98 Runoff=4.89 cfs 1.611 af
<b>Reach 22R: Offsite Discharge</b>	Avg. Flow Depth=0.26' Max Vel=0.41 fps Inflow=11.91 cfs 5.609 af n=0.035 L=300.0' S=0.0008 '/' Capacity=29.46 cfs Outflow=8.01 cfs 5.599 af
<b>Pond 11P: Stormwater System 1</b>	Peak Elev=135.88' Storage=0.278 af Inflow=3.11 cfs 1.024 af Outflow=5.08 cfs 1.003 af
<b>Pond 14P: Stormwater System 3</b>	Peak Elev=134.68' Storage=0.488 af Inflow=5.56 cfs 1.831 af Outflow=5.61 cfs 1.786 af
<b>Pond 20P: Stormwater System 4</b>	Peak Elev=136.31' Storage=0.713 af Inflow=3.78 cfs 1.245 af Outflow=0.57 cfs 1.157 af
<b>Pond 23P: Stormwater System 2</b>	Peak Elev=137.46' Storage=0.734 af Inflow=4.89 cfs 1.611 af Outflow=1.49 cfs 1.332 af

**Total Runoff Area = 34.004 ac Runoff Volume = 9.529 af Average Runoff Depth = 3.36"**  
**50.00% Pervious = 17.002 ac 50.00% Impervious = 17.002 ac**

**Summary for Subcatchment 8S: Basin 1**

[49] Hint:  $T_c < 2dt$  may require smaller dt

Runoff = 3.11 cfs @ 7.85 hrs, Volume= 1.024 af, Depth= 4.26"

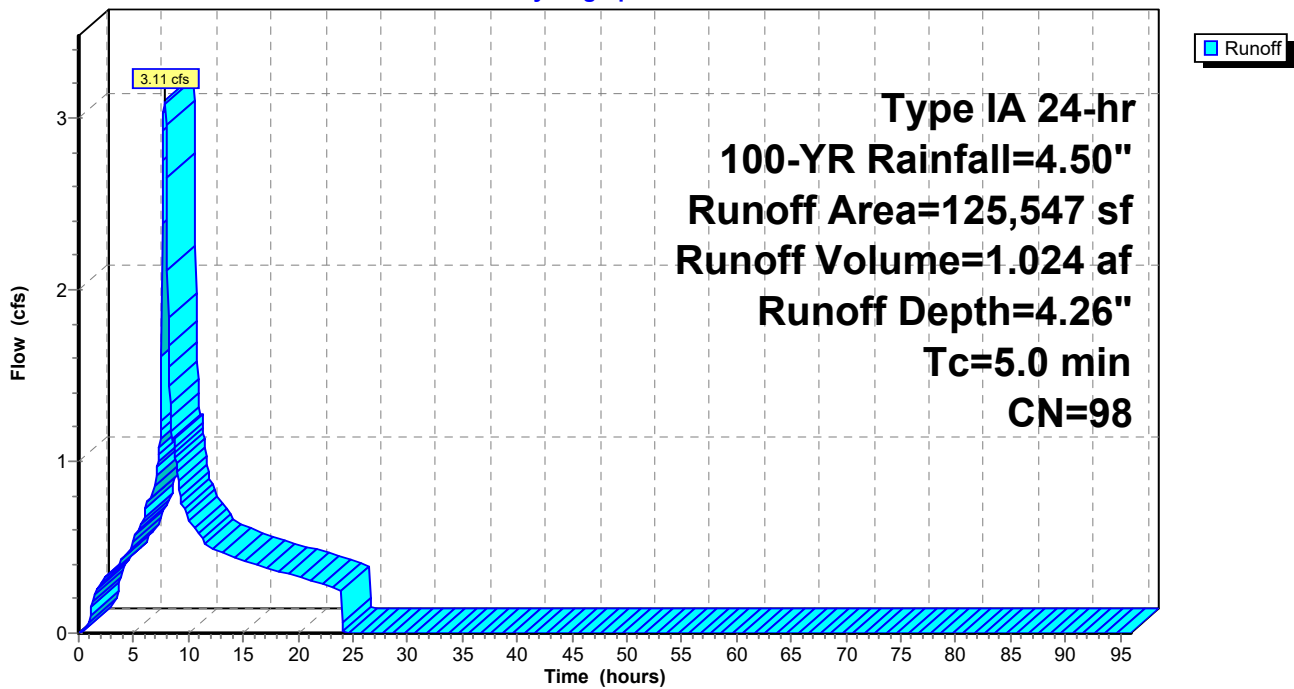
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
 Type IA 24-hr 100-YR Rainfall=4.50"

Area (sf)	CN	Description
* 125,547	98	
125,547		100.00% Impervious Area

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

**Subcatchment 8S: Basin 1**

Hydrograph





**Summary for Subcatchment 13S: Basin 3**

[49] Hint: Tc<2dt may require smaller dt

Runoff = 5.56 cfs @ 7.85 hrs, Volume= 1.831 af, Depth= 4.26"

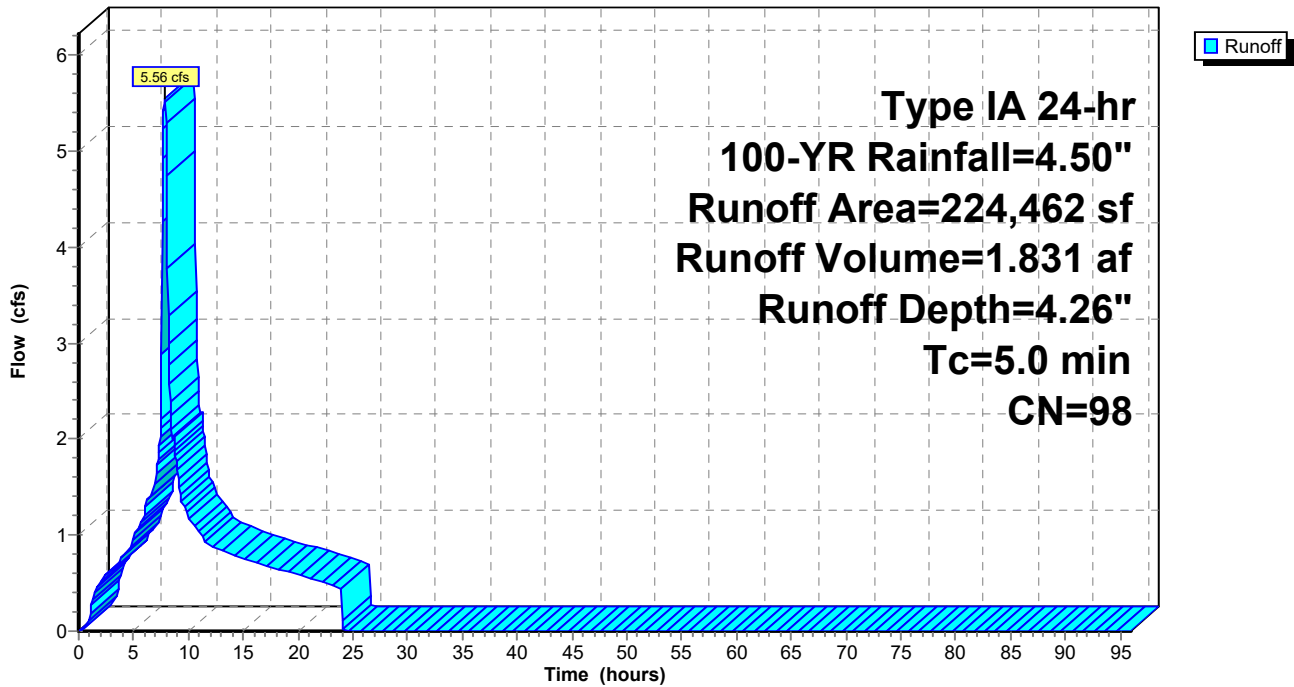
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
 Type IA 24-hr 100-YR Rainfall=4.50"

Area (sf)	CN	Description
* 224,462	98	
224,462		100.00% Impervious Area

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

**Subcatchment 13S: Basin 3**

Hydrograph



**Summary for Subcatchment 15S: Filter Strip Basins**

Runoff = 0.99 cfs @ 7.94 hrs, Volume= 0.331 af, Depth= 4.26"

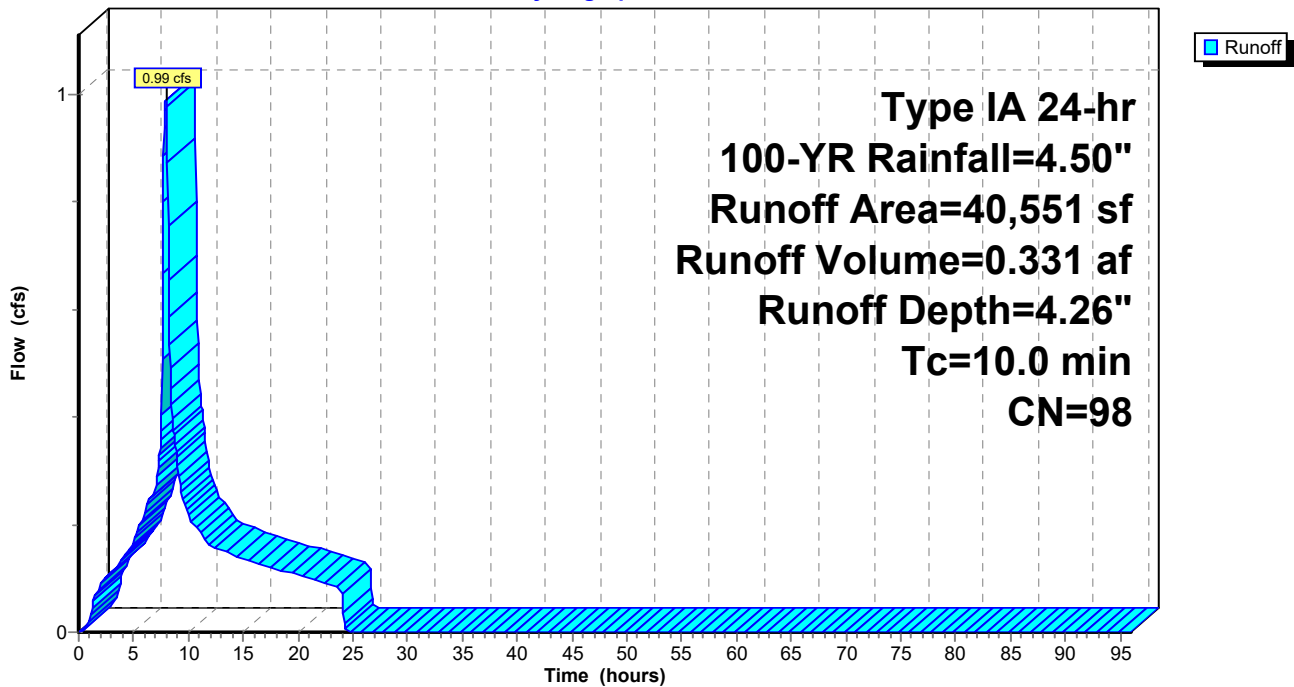
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
 Type IA 24-hr 100-YR Rainfall=4.50"

Area (sf)	CN	Description
* 40,551	98	
40,551		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.0					Direct Entry, 20

**Subcatchment 15S: Filter Strip Basins**

Hydrograph



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Type IA 24-hr 100-YR Rainfall=4.50"

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## Summary for Subcatchment 17S: Pre Total

Runoff = 8.63 cfs @ 8.23 hrs, Volume= 3.488 af, Depth= 2.46"

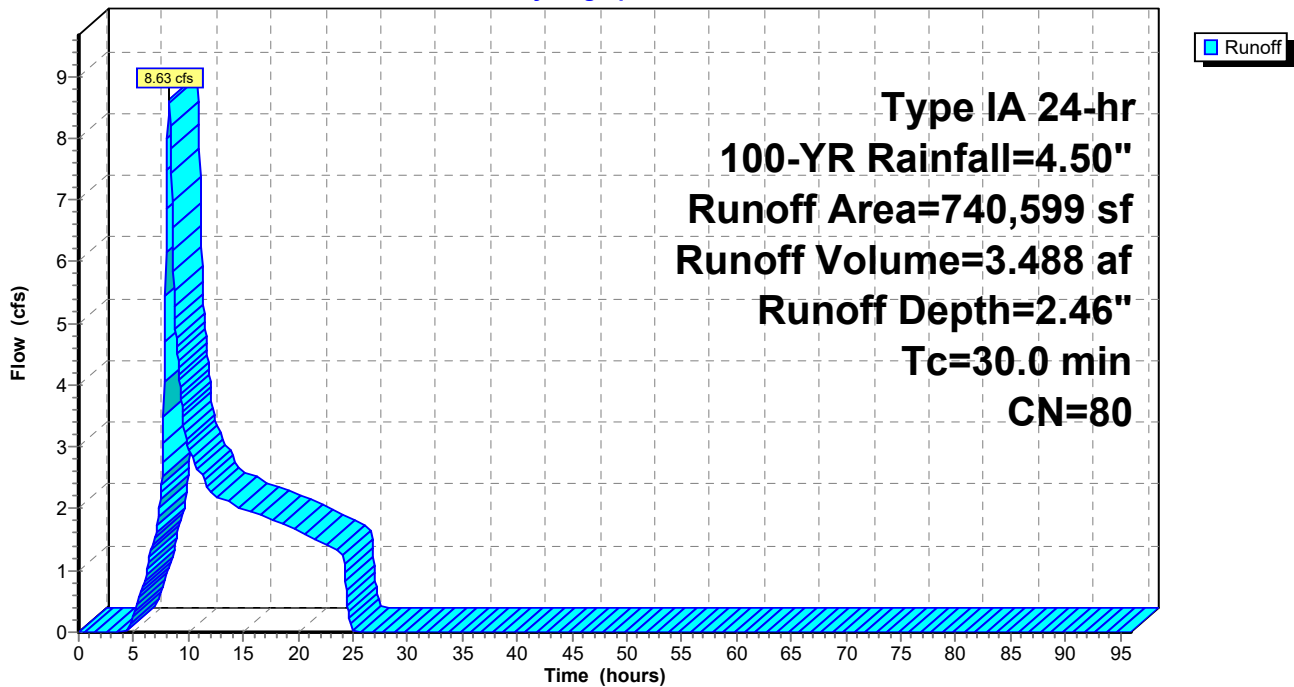
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
Type IA 24-hr 100-YR Rainfall=4.50"

Area (sf)	CN	Description
740,599	80	>75% Grass cover, Good, HSG D
740,599		100.00% Pervious Area

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

## Subcatchment 17S: Pre Total

Hydrograph



**Summary for Subcatchment 18S: Basin 4**

[49] Hint:  $T_c < 2dt$  may require smaller dt

Runoff = 3.78 cfs @ 7.85 hrs, Volume= 1.245 af, Depth= 4.26"

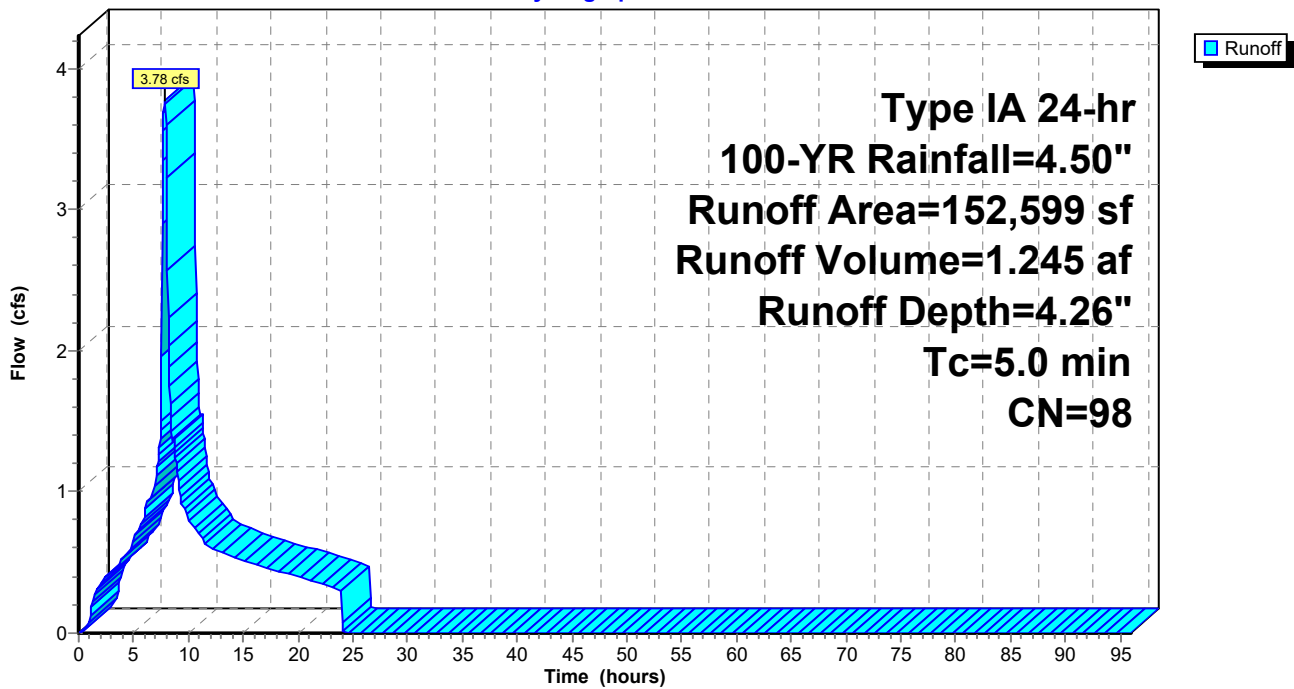
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
 Type IA 24-hr 100-YR Rainfall=4.50"

Area (sf)	CN	Description
* 152,599	98	
152,599		100.00% Impervious Area

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

**Subcatchment 18S: Basin 4**

Hydrograph



**Summary for Subcatchment 19S: Basin 2**

[49] Hint:  $T_c < 2dt$  may require smaller dt

Runoff = 4.89 cfs @ 7.85 hrs, Volume= 1.611 af, Depth= 4.26"

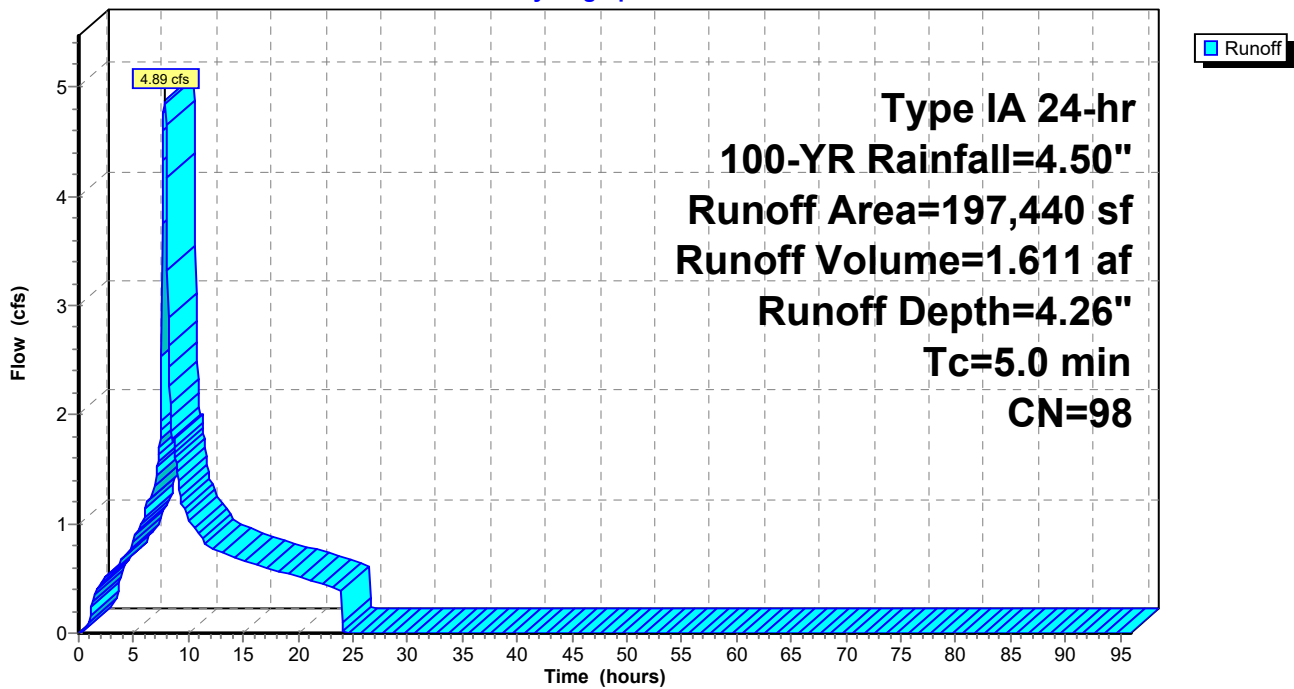
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
 Type IA 24-hr 100-YR Rainfall=4.50"

Area (sf)	CN	Description
* 197,440	98	
197,440		100.00% Impervious Area

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

**Subcatchment 19S: Basin 2**

Hydrograph



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Type IA 24-hr 100-YR Rainfall=4.50"

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## Summary for Reach 22R: Offsite Discharge

Reach modeled with shallow side slopes to best mimic the overland flow created at the discharge points.

[81] Warning: Exceeded Pond 14P by 0.50' @ 0.00 hrs

[81] Warning: Exceeded Pond 20P by 0.50' @ 0.00 hrs

Inflow Area =	17.002 ac, 100.00% Impervious, Inflow Depth > 3.96"	for 100-YR event
Inflow =	11.91 cfs @ 7.90 hrs, Volume=	5.609 af
Outflow =	8.01 cfs @ 8.27 hrs, Volume=	5.599 af, Atten= 33%, Lag= 22.5 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs

Max. Velocity= 0.41 fps, Min. Travel Time= 12.2 min

Avg. Velocity = 0.16 fps, Avg. Travel Time= 32.3 min

Peak Storage= 5,886 cf @ 8.07 hrs

Average Depth at Peak Storage= 0.26'

Bank-Full Depth= 0.50' Flow Area= 50.0 sf, Capacity= 29.46 cfs

50.00' x 0.50' deep channel, n= 0.035 High grass

Side Slope Z-value= 100.0 ' / ' Top Width= 150.00'

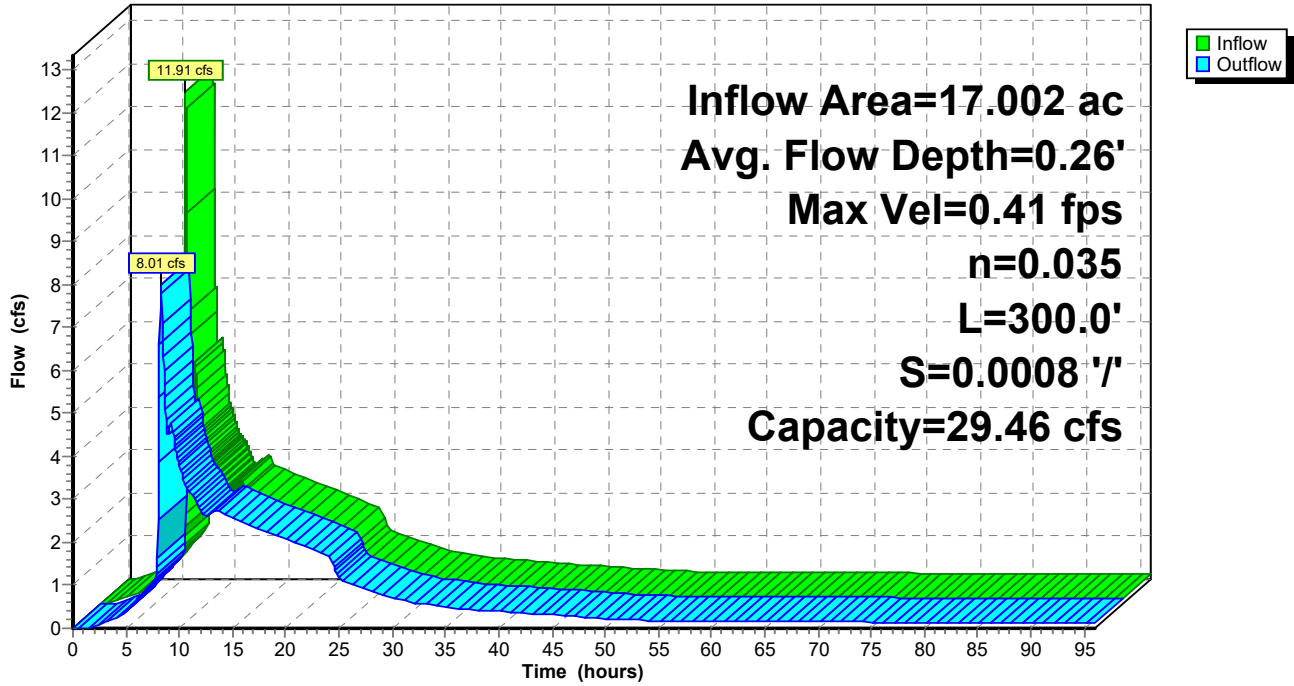
Length= 300.0' Slope= 0.0008 ' / '

Inlet Invert= 133.00', Outlet Invert= 132.75'



### Reach 22R: Offsite Discharge

Hydrograph



**Summary for Pond 11P: Stormwater System 1**

[93] Warning: Storage range exceeded by 0.34'

[88] Warning: Qout>Qin may require smaller dt or Finer Routing

[85] Warning: Oscillations may require smaller dt or Finer Routing (severity=75)

Inflow Area = 2.882 ac, 100.00% Impervious, Inflow Depth = 4.26" for 100-YR event  
 Inflow = 3.11 cfs @ 7.85 hrs, Volume= 1.024 af  
 Outflow = 5.08 cfs @ 7.90 hrs, Volume= 1.003 af, Atten= 0%, Lag= 2.7 min  
 Primary = 5.08 cfs @ 7.90 hrs, Volume= 1.003 af

Routing by Stor-Ind method, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
 Peak Elev= 135.88' @ 7.90 hrs Surf.Area= 0.246 ac Storage= 0.278 af

Plug-Flow detention time= 484.2 min calculated for 1.003 af (98% of inflow)  
 Center-of-Mass det. time= 470.3 min ( 1,126.5 - 656.2 )

Volume	Invert	Avail.Storage	Storage Description
#1A	133.50'	0.149 af	<b>28.33'W x 377.50'L x 2.04'H Field A</b> 0.501 af Overall - 0.128 af Embedded = 0.373 af x 40.0% Voids
#2A	134.00'	0.128 af	<b>Cultec C-100HD</b> x 400 Inside #1 Effective Size= 32.1"W x 12.0"H => 1.86 sf x 7.50'L = 14.0 cf Overall Size= 36.0"W x 12.5"H x 8.00'L with 0.50' Overlap Row Length Adjustment= +0.50' x 1.86 sf x 8 rows
		0.278 af	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	133.50'	<b>0.5" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads
#2	Primary	133.80'	<b>2.5" Vert. Orifice/Grate</b> C= 0.600
#3	Primary	135.50'	<b>24.0" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads

**Primary OutFlow** Max=5.06 cfs @ 7.90 hrs HW=135.88' (Free Discharge)

- 1=Orifice/Grate (Orifice Controls 0.01 cfs @ 7.43 fps)
- 2=Orifice/Grate (Orifice Controls 0.23 cfs @ 6.77 fps)
- 3=Orifice/Grate (Weir Controls 4.82 cfs @ 2.02 fps)



**Pond 11P: Stormwater System 1 - Chamber Wizard Field A**

**Chamber Model = Cultec C-100HD (Cultec Contactor® 100HD)**

Effective Size= 32.1"W x 12.0"H => 1.86 sf x 7.50'L = 14.0 cf

Overall Size= 36.0"W x 12.5"H x 8.00'L with 0.50' Overlap

Row Length Adjustment= +0.50' x 1.86 sf x 8 rows

36.0" Wide + 4.0" Spacing = 40.0" C-C Row Spacing

50 Chambers/Row x 7.50' Long +0.50' Row Adjustment = 375.50' Row Length +12.0" End Stone x 2 = 377.50' Base Length

8 Rows x 36.0" Wide + 4.0" Spacing x 7 + 12.0" Side Stone x 2 = 28.33' Base Width

6.0" Base + 12.5" Chamber Height + 6.0" Cover = 2.04' Field Height

400 Chambers x 14.0 cf +0.50' Row Adjustment x 1.86 sf x 8 Rows = 5,591.9 cf Chamber Storage

21,837.3 cf Field - 5,591.9 cf Chambers = 16,245.4 cf Stone x 40.0% Voids = 6,498.2 cf Stone Storage

Chamber Storage + Stone Storage = 12,090.1 cf = 0.278 af

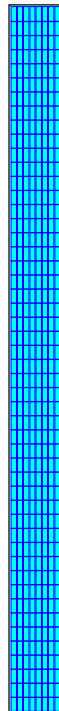
Overall Storage Efficiency = 55.4%

Overall System Size = 377.50' x 28.33' x 2.04'

400 Chambers

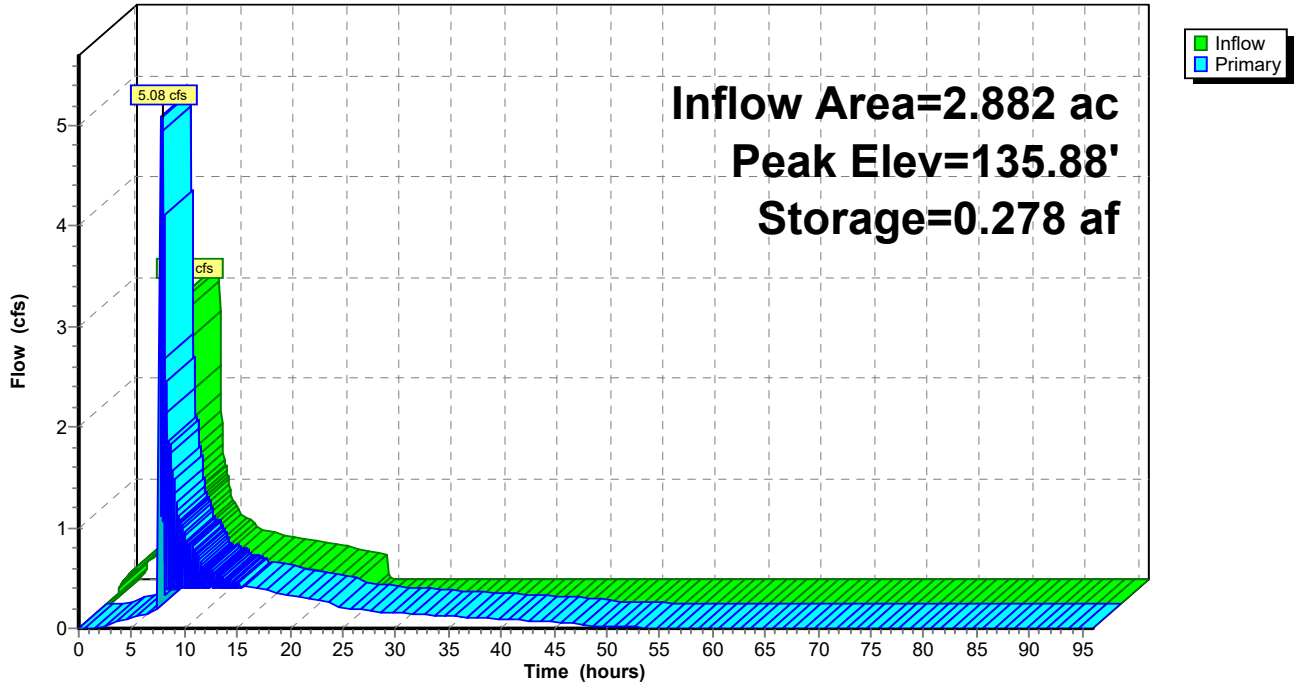
808.8 cy Field

601.7 cy Stone



### Pond 11P: Stormwater System 1

Hydrograph



# Walgraves

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Type IA 24-hr 100-YR Rainfall=4.50"

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## Summary for Pond 14P: Stormwater Sytem 3

[93] Warning: Storage range exceeded by 0.14'

[88] Warning: Qout>Qin may require smaller dt or Finer Routing

Inflow Area = 5.153 ac, 100.00% Impervious, Inflow Depth = 4.26" for 100-YR event  
Inflow = 5.56 cfs @ 7.85 hrs, Volume= 1.831 af  
Outflow = 5.61 cfs @ 7.89 hrs, Volume= 1.786 af, Atten= 0%, Lag= 2.2 min  
Primary = 5.61 cfs @ 7.89 hrs, Volume= 1.786 af

Routing by Stor-Ind method, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
Peak Elev= 134.68' @ 7.89 hrs Surf.Area= 0.427 ac Storage= 0.488 af

Plug-Flow detention time= 439.1 min calculated for 1.786 af (98% of inflow)  
Center-of-Mass det. time= 420.2 min ( 1,076.4 - 656.2 )

Volume	Invert	Avail.Storage	Storage Description
#1A	132.50'	0.257 af	<b>68.33"W x 272.50"L x 2.04'H Field A</b> 0.873 af Overall - 0.231 af Embedded = 0.642 af x 40.0% Voids
#2A	133.00'	0.231 af	<b>Cultec C-100HD</b> x 720 Inside #1 Effective Size= 32.1"W x 12.0"H => 1.86 sf x 7.50'L = 14.0 cf Overall Size= 36.0"W x 12.5"H x 8.00'L with 0.50' Overlap Row Length Adjustment= +0.50' x 1.86 sf x 20 rows
		0.488 af	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	132.50'	<b>1.0" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads
#2	Primary	133.05'	<b>5.0" Vert. Orifice/Grate</b> C= 0.600
#3	Primary	134.30'	<b>24.0" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads

**Primary OutFlow** Max=5.58 cfs @ 7.89 hrs HW=134.68' (Free Discharge)

1=Orifice/Grate (Orifice Controls 0.04 cfs @ 7.10 fps)

2=Orifice/Grate (Orifice Controls 0.78 cfs @ 5.74 fps)

3=Orifice/Grate (Weir Controls 4.76 cfs @ 2.01 fps)

**Pond 14P: Stormwater Sytem 3 - Chamber Wizard Field A**

**Chamber Model = Cultec C-100HD (Cultec Contactor® 100HD)**

Effective Size= 32.1"W x 12.0"H => 1.86 sf x 7.50'L = 14.0 cf

Overall Size= 36.0"W x 12.5"H x 8.00'L with 0.50' Overlap

Row Length Adjustment= +0.50' x 1.86 sf x 20 rows

36.0" Wide + 4.0" Spacing = 40.0" C-C Row Spacing

36 Chambers/Row x 7.50' Long +0.50' Row Adjustment = 270.50' Row Length +12.0" End Stone x 2 = 272.50' Base Length

20 Rows x 36.0" Wide + 4.0" Spacing x 19 + 12.0" Side Stone x 2 = 68.33' Base Width

6.0" Base + 12.5" Chamber Height + 6.0" Cover = 2.04' Field Height

720 Chambers x 14.0 cf +0.50' Row Adjustment x 1.86 sf x 20 Rows = 10,070.7 cf Chamber Storage

38,017.5 cf Field - 10,070.7 cf Chambers = 27,946.8 cf Stone x 40.0% Voids = 11,178.7 cf Stone Storage

Chamber Storage + Stone Storage = 21,249.4 cf = 0.488 af

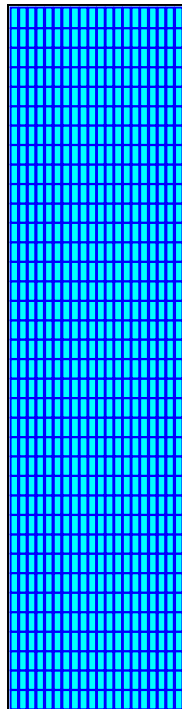
Overall Storage Efficiency = 55.9%

Overall System Size = 272.50' x 68.33' x 2.04'

720 Chambers

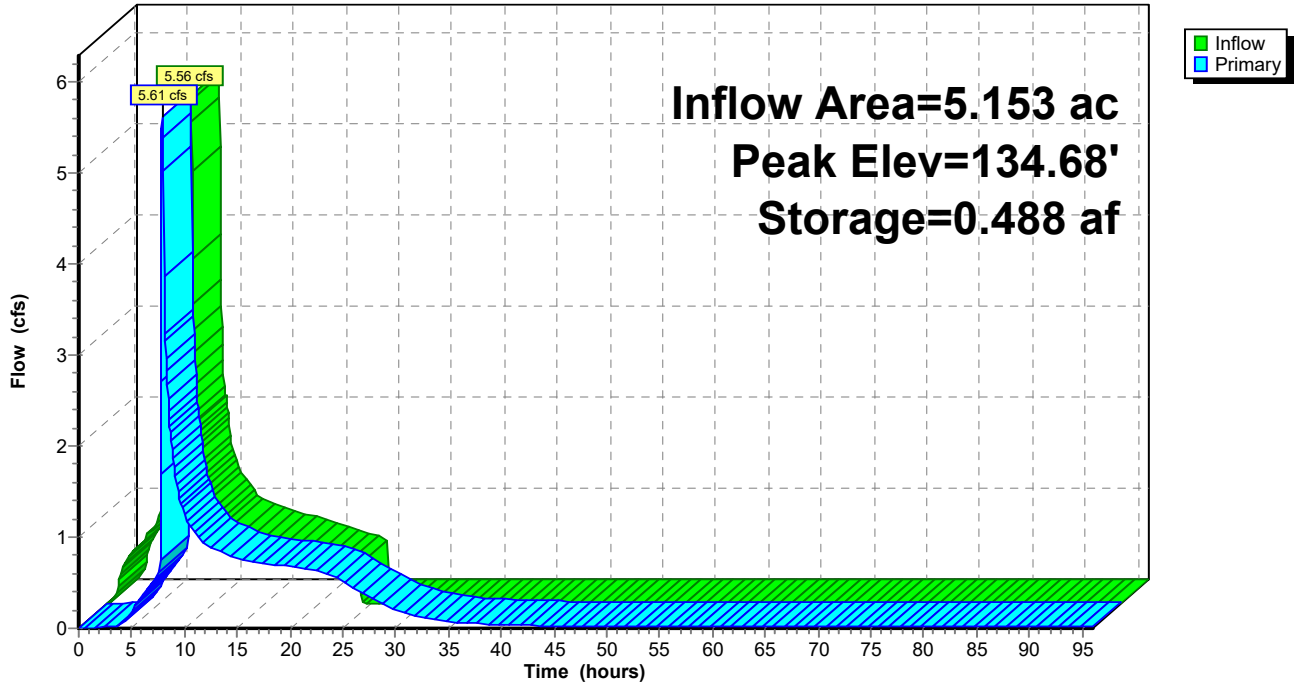
1,408.1 cy Field

1,035.1 cy Stone



### Pond 14P: Stormwater Sytem 3

Hydrograph



# Walgraves

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Type IA 24-hr 100-YR Rainfall=4.50"

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## Summary for Pond 20P: Stormwater System 4

Inflow Area = 3.503 ac, 100.00% Impervious, Inflow Depth = 4.26" for 100-YR event  
 Inflow = 3.78 cfs @ 7.85 hrs, Volume= 1.245 af  
 Outflow = 0.57 cfs @ 13.28 hrs, Volume= 1.157 af, Atten= 85%, Lag= 325.7 min  
 Primary = 0.57 cfs @ 13.28 hrs, Volume= 1.157 af

Routing by Stor-Ind method, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
 Peak Elev= 136.31' @ 13.28 hrs Surf.Area= 0.283 ac Storage= 0.713 af

Plug-Flow detention time= 1,401.3 min calculated for 1.157 af (93% of inflow)  
 Center-of-Mass det. time= 1,349.1 min ( 2,005.4 - 656.2 )

Volume	Invert	Avail.Storage	Storage Description
#1A	132.50'	0.266 af	<b>30.00'W x 411.50'L x 4.00'H Field A</b> 1.134 af Overall - 0.468 af Embedded = 0.665 af x 40.0% Voids
#2A	133.00'	0.468 af	<b>Cultec R-360HD x 555 Inside #1</b> Effective Size= 54.9"W x 36.0"H => 9.99 sf x 3.67'L = 36.6 cf Overall Size= 60.0"W x 36.0"H x 4.17'L with 0.50' Overlap 555 Chambers in 5 Rows Cap Storage= +6.5 cf x 2 x 5 rows = 64.6 cf
		0.734 af	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	132.50'	<b>1.5" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads
#2	Primary	134.00'	<b>2.0" Vert. Orifice/Grate</b> C= 0.600
#3	Primary	136.25'	<b>24.0" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads

**Primary OutFlow** Max=0.57 cfs @ 13.28 hrs HW=136.31' (Free Discharge)

- 1=Orifice/Grate (Orifice Controls 0.12 cfs @ 9.40 fps)
- 2=Orifice/Grate (Orifice Controls 0.16 cfs @ 7.18 fps)
- 3=Orifice/Grate (Weir Controls 0.29 cfs @ 0.79 fps)

**Pond 20P: Stormwater System 4 - Chamber Wizard Field A**

**Chamber Model = Cultec R-360HD (Cultec Recharger® 360HD)**

Effective Size= 54.9"W x 36.0"H => 9.99 sf x 3.67'L = 36.6 cf

Overall Size= 60.0"W x 36.0"H x 4.17'L with 0.50' Overlap

Cap Storage= +6.5 cf x 2 x 5 rows = 64.6 cf

60.0" Wide + 9.0" Spacing = 69.0" C-C Row Spacing

111 Chambers/Row x 3.67' Long +1.25' Cap Length x 2 = 409.50' Row Length +12.0" End Stone x 2 = 411.50' Base Length

5 Rows x 60.0" Wide + 9.0" Spacing x 4 + 12.0" Side Stone x 2 = 30.00' Base Width

6.0" Base + 36.0" Chamber Height + 6.0" Cover = 4.00' Field Height

555 Chambers x 36.6 cf + 6.5 cf Cap Volume x 2 x 5 Rows = 20,402.4 cf Chamber Storage

49,380.0 cf Field - 20,402.4 cf Chambers = 28,977.6 cf Stone x 40.0% Voids = 11,591.0 cf Stone Storage

Chamber Storage + Stone Storage = 31,993.4 cf = 0.734 af

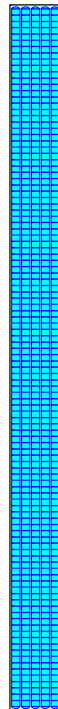
Overall Storage Efficiency = 64.8%

Overall System Size = 411.50' x 30.00' x 4.00'

555 Chambers

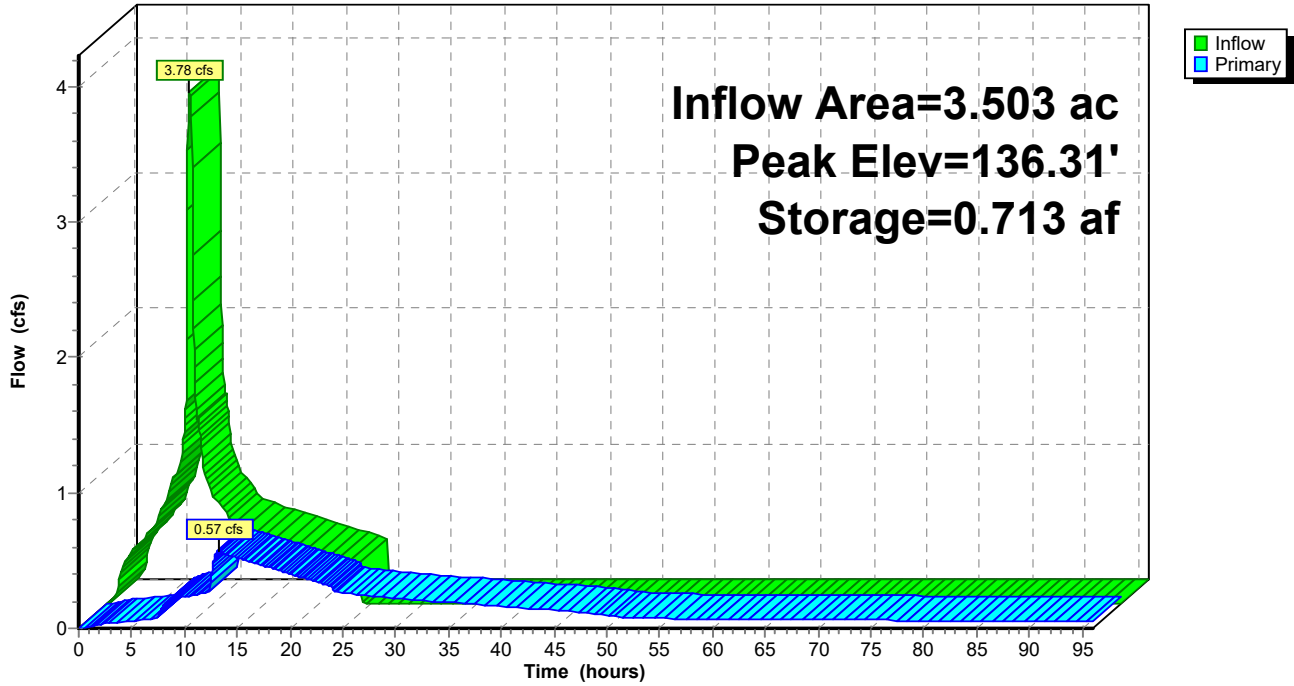
1,828.9 cy Field

1,073.2 cy Stone



### Pond 20P: Stormwater System 4

Hydrograph





# Walgraves

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Type IA 24-hr 100-YR Rainfall=4.50"

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## Summary for Pond 23P: Stormwater System 2

Inflow Area = 4.533 ac, 100.00% Impervious, Inflow Depth = 4.26" for 100-YR event  
Inflow = 4.89 cfs @ 7.85 hrs, Volume= 1.611 af  
Outflow = 1.49 cfs @ 8.97 hrs, Volume= 1.332 af, Atten= 69%, Lag= 66.9 min  
Primary = 1.49 cfs @ 8.97 hrs, Volume= 1.332 af

Routing by Stor-Ind method, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
Peak Elev= 137.46' @ 8.97 hrs Surf.Area= 0.284 ac Storage= 0.734 af

Plug-Flow detention time= 1,144.2 min calculated for 1.331 af (83% of inflow)  
Center-of-Mass det. time= 1,027.2 min ( 1,683.4 - 656.2 )

Volume	Invert	Avail.Storage	Storage Description
#1A	133.50'	0.265 af	<b>41.50'W x 297.83'L x 4.00'H Field A</b> 1.135 af Overall - 0.473 af Embedded = 0.662 af x 40.0% Voids
#2A	134.00'	0.473 af	<b>Cultec R-360HD x 560 Inside #1</b> Effective Size= 54.9"W x 36.0"H => 9.99 sf x 3.67'L = 36.6 cf Overall Size= 60.0"W x 36.0"H x 4.17'L with 0.50' Overlap 560 Chambers in 7 Rows Cap Storage= +6.5 cf x 2 x 7 rows = 90.4 cf
		0.738 af	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	133.50'	<b>0.5" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads
#2	Primary	134.50'	<b>1.5" Vert. Orifice/Grate</b> C= 0.600
#3	Primary	137.30'	<b>24.0" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads

**Primary OutFlow** Max=1.49 cfs @ 8.97 hrs HW=137.46' (Free Discharge)

- 1=Orifice/Grate (Orifice Controls 0.01 cfs @ 9.59 fps)
- 2=Orifice/Grate (Orifice Controls 0.10 cfs @ 8.20 fps)
- 3=Orifice/Grate (Weir Controls 1.37 cfs @ 1.33 fps)

**Pond 23P: Stormwater System 2 - Chamber Wizard Field A**

**Chamber Model = Cultec R-360HD (Cultec Recharger® 360HD)**

Effective Size= 54.9"W x 36.0"H => 9.99 sf x 3.67'L = 36.6 cf

Overall Size= 60.0"W x 36.0"H x 4.17'L with 0.50' Overlap

Cap Storage= +6.5 cf x 2 x 7 rows = 90.4 cf

60.0" Wide + 9.0" Spacing = 69.0" C-C Row Spacing

80 Chambers/Row x 3.67' Long +1.25' Cap Length x 2 = 295.83' Row Length +12.0" End Stone x 2 = 297.83' Base Length

7 Rows x 60.0" Wide + 9.0" Spacing x 6 + 12.0" Side Stone x 2 = 41.50' Base Width

6.0" Base + 36.0" Chamber Height + 6.0" Cover = 4.00' Field Height

560 Chambers x 36.6 cf + 6.5 cf Cap Volume x 2 x 7 Rows = 20,611.5 cf Chamber Storage

49,440.3 cf Field - 20,611.5 cf Chambers = 28,828.9 cf Stone x 40.0% Voids = 11,531.6 cf Stone Storage

Chamber Storage + Stone Storage = 32,143.0 cf = 0.738 af

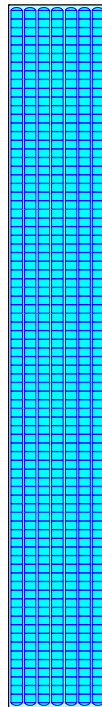
Overall Storage Efficiency = 65.0%

Overall System Size = 297.83' x 41.50' x 4.00'

560 Chambers

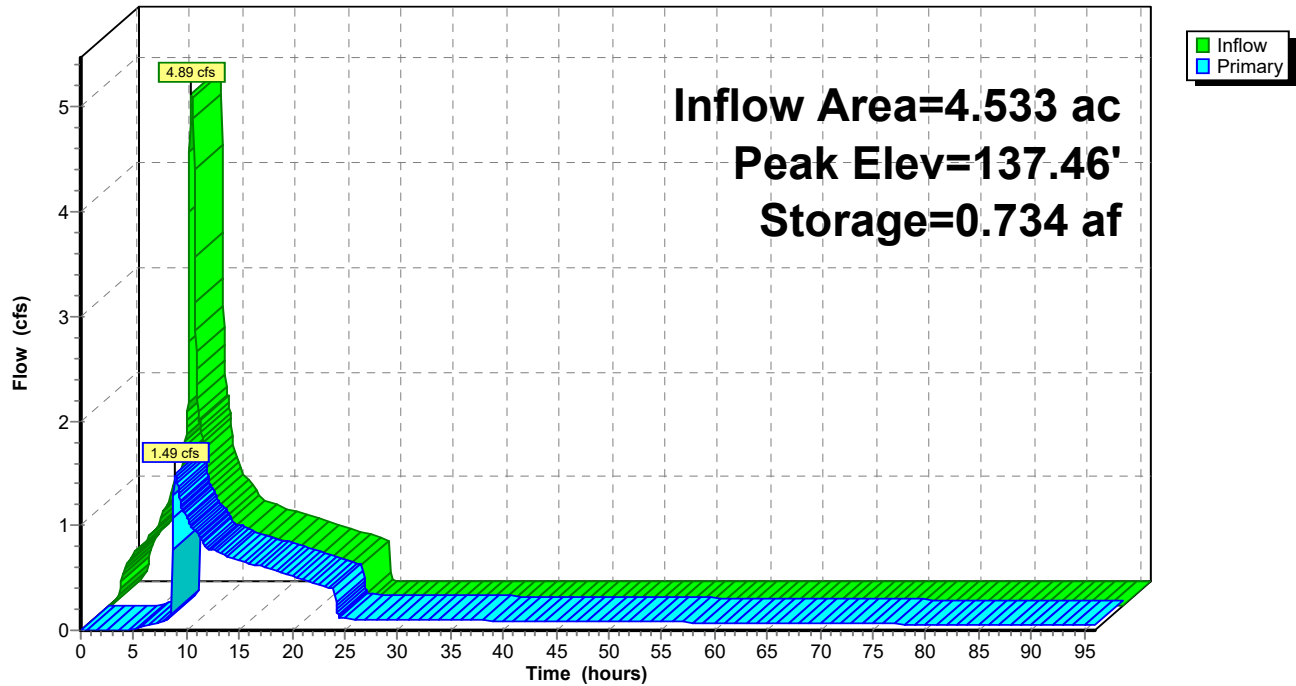
1,831.1 cy Field

1,067.7 cy Stone



### Pond 23P: Stormwater System 2

Hydrograph



**Walgraves**

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Type IA 24-hr WQ Rainfall=0.36"

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Time span=0.00-96.00 hrs, dt=0.05 hrs, 1921 points  
 Runoff by SCS TR-20 method, UH=SCS, Weighted-CN  
 Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

<b>Subcatchment8S: Basin 1</b>	Runoff Area=125,547 sf 100.00% Impervious Runoff Depth=0.19" Tc=5.0 min CN=98 Runoff=0.14 cfs 0.047 af
<b>Subcatchment13S: Basin 3</b>	Runoff Area=224,462 sf 100.00% Impervious Runoff Depth=0.19" Tc=5.0 min CN=98 Runoff=0.24 cfs 0.084 af
<b>Subcatchment15S: Filter Strip Basins</b>	Runoff Area=40,551 sf 100.00% Impervious Runoff Depth=0.19" Tc=10.0 min CN=98 Runoff=0.04 cfs 0.015 af
<b>Subcatchment17S: Pre Total</b>	Runoff Area=740,599 sf 0.00% Impervious Runoff Depth=0.00" Tc=30.0 min CN=80 Runoff=0.00 cfs 0.000 af
<b>Subcatchment18S: Basin 4</b>	Runoff Area=152,599 sf 100.00% Impervious Runoff Depth=0.19" Tc=5.0 min CN=98 Runoff=0.17 cfs 0.057 af
<b>Subcatchment19S: Basin 2</b>	Runoff Area=197,440 sf 100.00% Impervious Runoff Depth=0.19" Tc=5.0 min CN=98 Runoff=0.21 cfs 0.074 af
<b>Reach 22R: Offsite Discharge</b>	Avg. Flow Depth=0.02' Max Vel=0.08 fps Inflow=0.07 cfs 0.215 af n=0.035 L=300.0' S=0.0008 '/' Capacity=29.46 cfs Outflow=0.07 cfs 0.212 af
<b>Pond 11P: Stormwater System 1</b>	Peak Elev=133.88' Storage=0.037 af Inflow=0.14 cfs 0.047 af Outflow=0.02 cfs 0.032 af
<b>Pond 14P: Stormwater System 3</b>	Peak Elev=132.88' Storage=0.065 af Inflow=0.24 cfs 0.084 af Outflow=0.02 cfs 0.079 af
<b>Pond 20P: Stormwater System 4</b>	Peak Elev=132.70' Storage=0.023 af Inflow=0.17 cfs 0.057 af Outflow=0.03 cfs 0.057 af
<b>Pond 23P: Stormwater System 2</b>	Peak Elev=134.05' Storage=0.068 af Inflow=0.21 cfs 0.074 af Outflow=0.00 cfs 0.032 af

**Total Runoff Area = 34.004 ac Runoff Volume = 0.276 af Average Runoff Depth = 0.10"**  
**50.00% Pervious = 17.002 ac 50.00% Impervious = 17.002 ac**

**Summary for Subcatchment 8S: Basin 1**

[49] Hint:  $T_c < 2dt$  may require smaller dt

Runoff = 0.14 cfs @ 7.95 hrs, Volume= 0.047 af, Depth= 0.19"

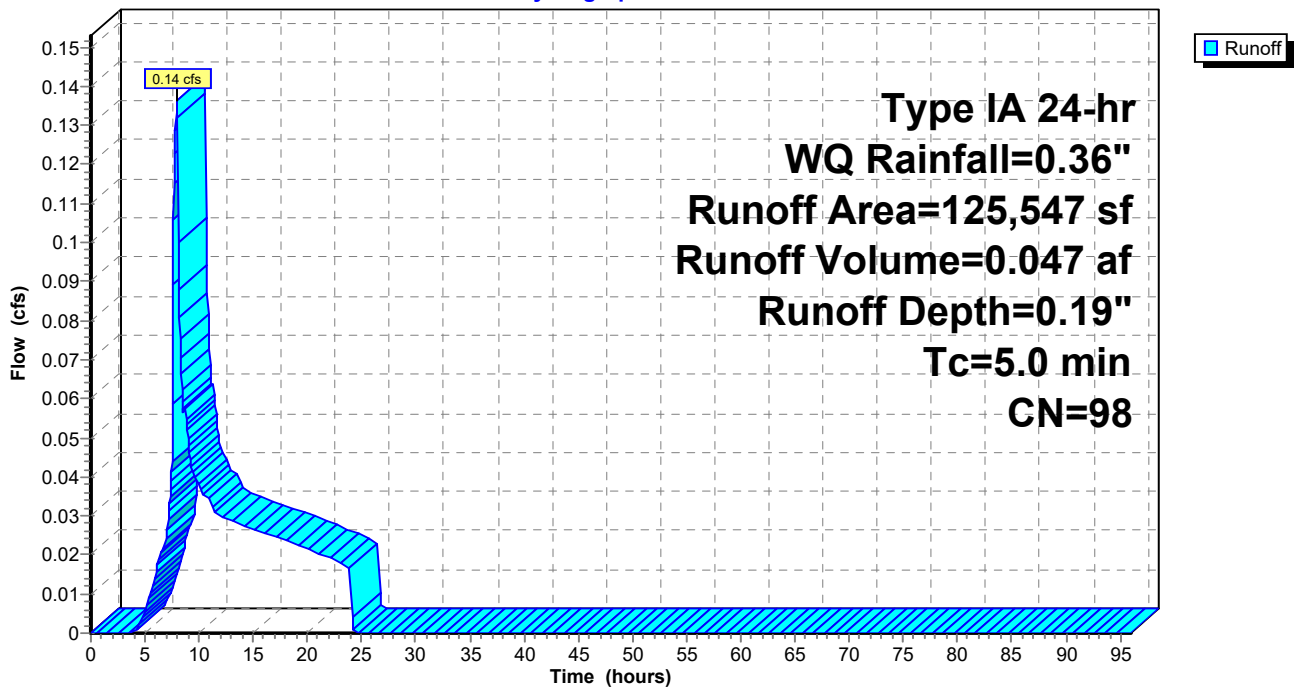
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
 Type IA 24-hr WQ Rainfall=0.36"

Area (sf)	CN	Description
* 125,547	98	
125,547		100.00% Impervious Area

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

**Subcatchment 8S: Basin 1**

Hydrograph



**Summary for Subcatchment 13S: Basin 3**

[49] Hint: Tc<2dt may require smaller dt

Runoff = 0.24 cfs @ 7.95 hrs, Volume= 0.084 af, Depth= 0.19"

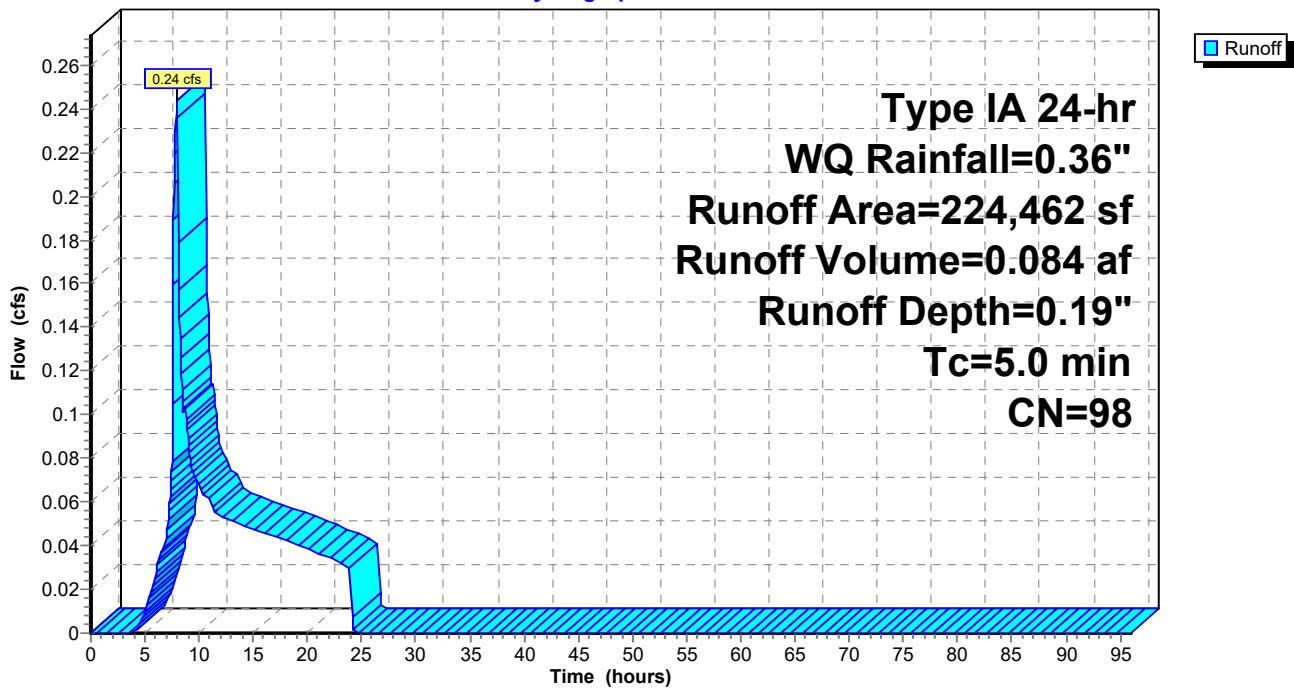
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
Type IA 24-hr WQ Rainfall=0.36"

Area (sf)	CN	Description
* 224,462	98	
224,462		100.00% Impervious Area

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

**Subcatchment 13S: Basin 3**

Hydrograph



**Summary for Subcatchment 15S: Filter Strip Basins**

Runoff = 0.04 cfs @ 8.01 hrs, Volume= 0.015 af, Depth= 0.19"

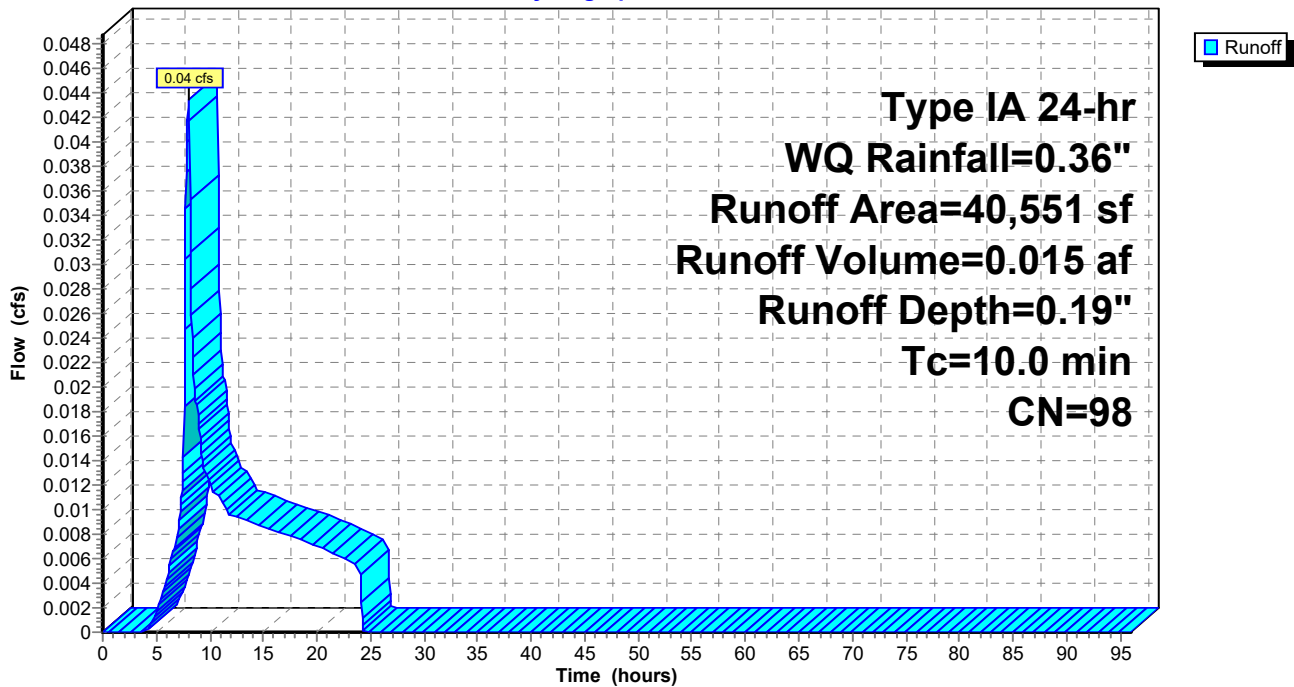
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
 Type IA 24-hr WQ Rainfall=0.36"

Area (sf)	CN	Description
* 40,551	98	
40,551		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.0					Direct Entry, 20

**Subcatchment 15S: Filter Strip Basins**

Hydrograph



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Type IA 24-hr WQ Rainfall=0.36"

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## Summary for Subcatchment 17S: Pre Total

[45] Hint: Runoff=Zero

Runoff = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Depth= 0.00"

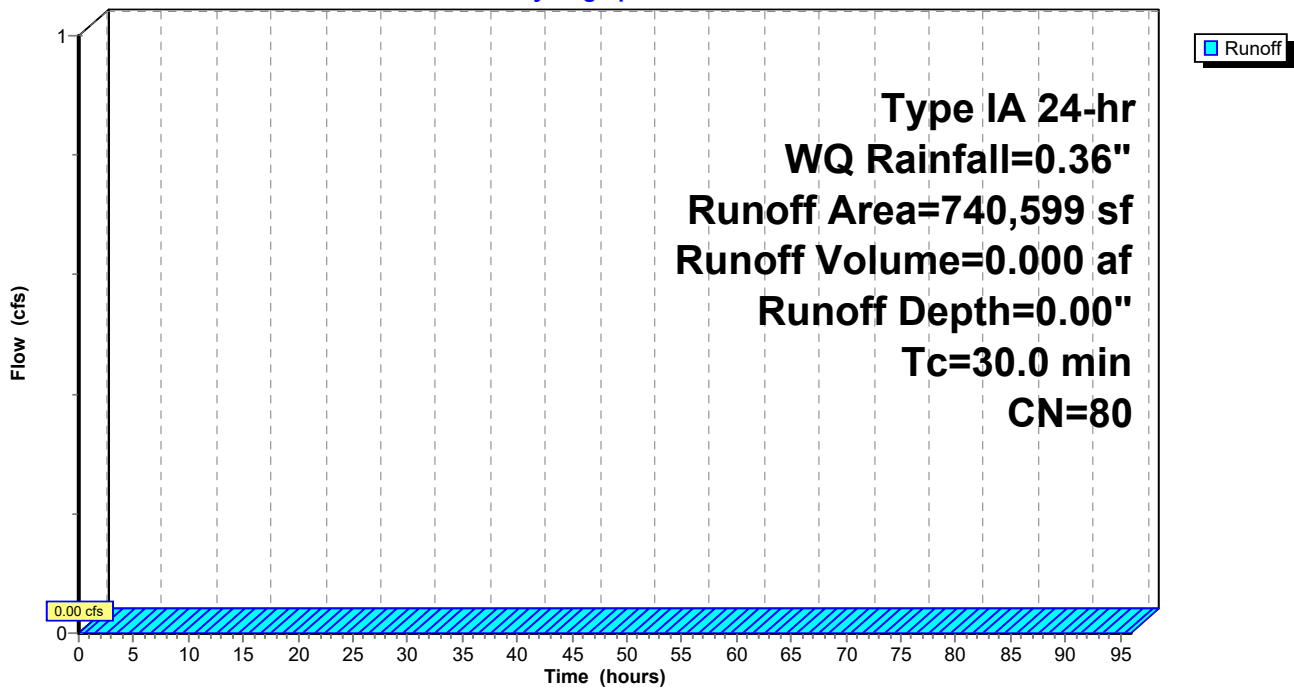
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
Type IA 24-hr WQ Rainfall=0.36"

Area (sf)	CN	Description
740,599	80	>75% Grass cover, Good, HSG D
740,599		100.00% Pervious Area

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

## Subcatchment 17S: Pre Total

Hydrograph





### Summary for Subcatchment 18S: Basin 4

[49] Hint:  $T_c < 2dt$  may require smaller dt

Runoff = 0.17 cfs @ 7.95 hrs, Volume= 0.057 af, Depth= 0.19"

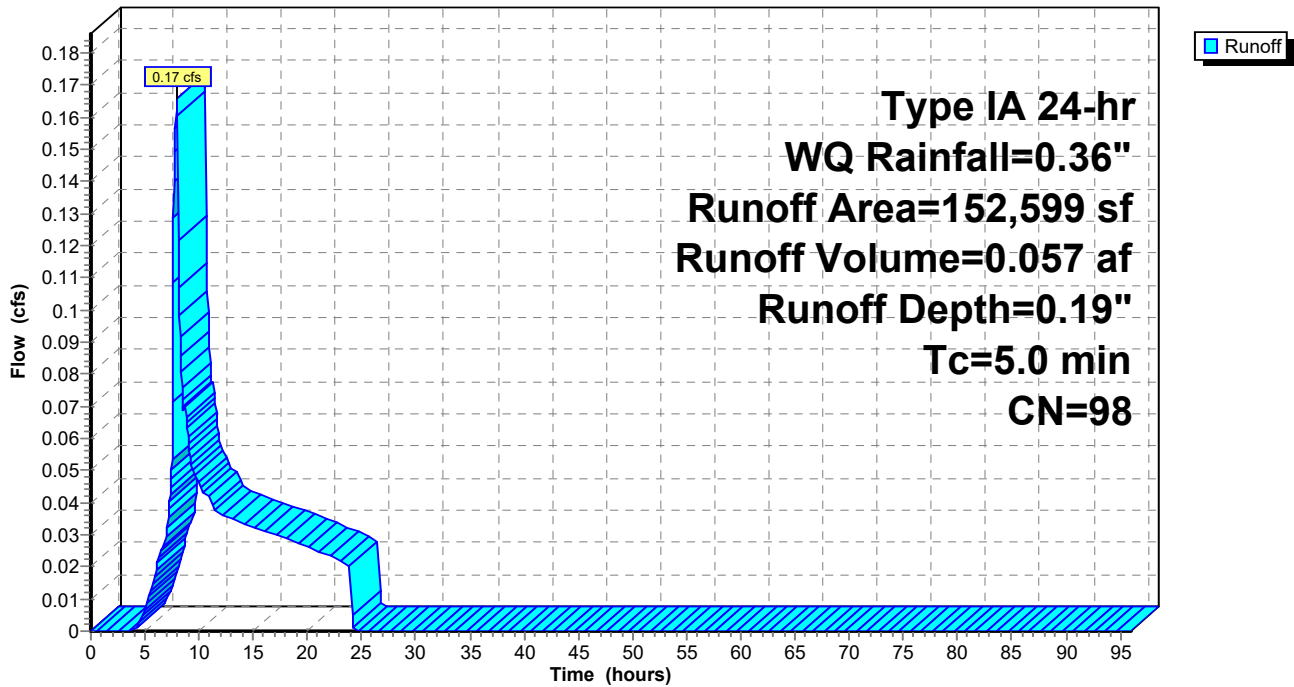
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
Type IA 24-hr WQ Rainfall=0.36"

	Area (sf)	CN	Description
*	152,599	98	
	152,599		100.00% Impervious Area

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

### Subcatchment 18S: Basin 4

Hydrograph



**Summary for Subcatchment 19S: Basin 2**

[49] Hint:  $T_c < 2dt$  may require smaller dt

Runoff = 0.21 cfs @ 7.95 hrs, Volume= 0.074 af, Depth= 0.19"

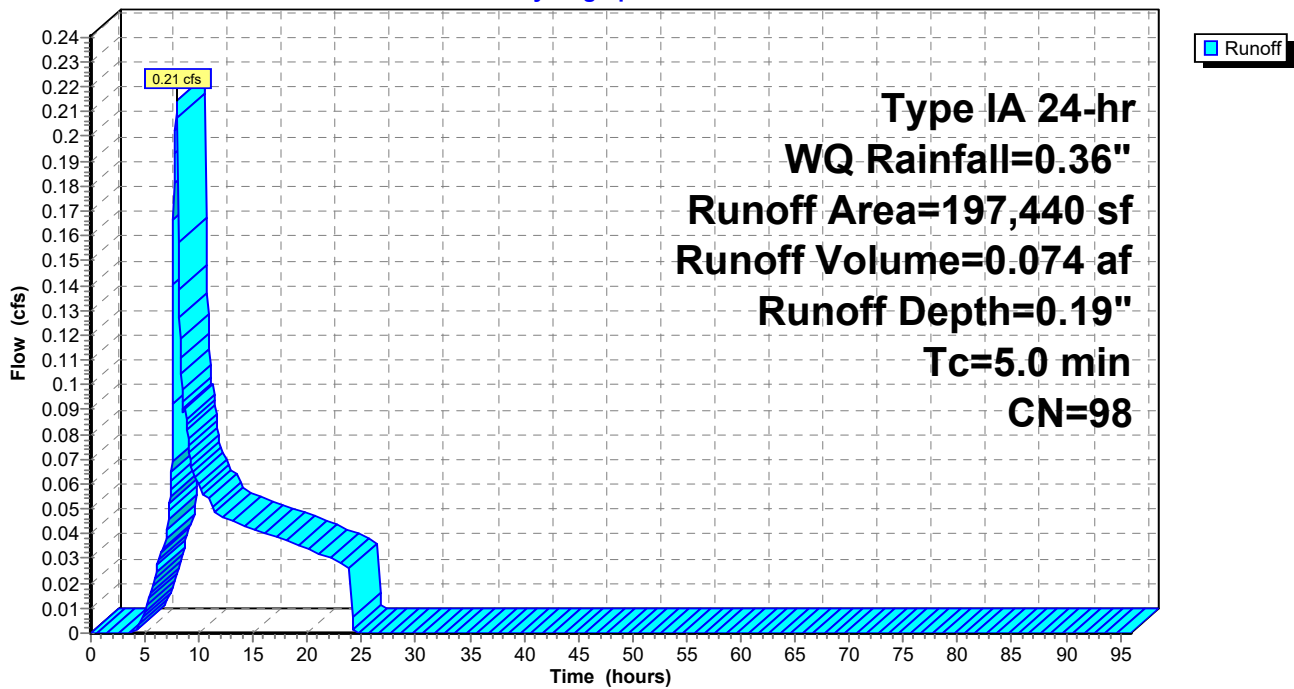
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
Type IA 24-hr WQ Rainfall=0.36"

Area (sf)	CN	Description
* 197,440	98	
197,440		100.00% Impervious Area

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

**Subcatchment 19S: Basin 2**

Hydrograph



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Type IA 24-hr WQ Rainfall=0.36"

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## Summary for Reach 22R: Offsite Discharge

Reach modeled with shallow side slopes to best mimic the overland flow created at the discharge points.

[81] Warning: Exceeded Pond 14P by 0.50' @ 0.00 hrs

[81] Warning: Exceeded Pond 20P by 0.51' @ 61.80 hrs

Inflow Area = 17.002 ac, 100.00% Impervious, Inflow Depth > 0.15" for WQ event  
Inflow = 0.07 cfs @ 8.03 hrs, Volume= 0.215 af  
Outflow = 0.07 cfs @ 25.03 hrs, Volume= 0.212 af, Atten= 6%, Lag= 1,019.9 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
Max. Velocity= 0.08 fps, Min. Travel Time= 63.2 min  
Avg. Velocity = 0.05 fps, Avg. Travel Time= 91.8 min

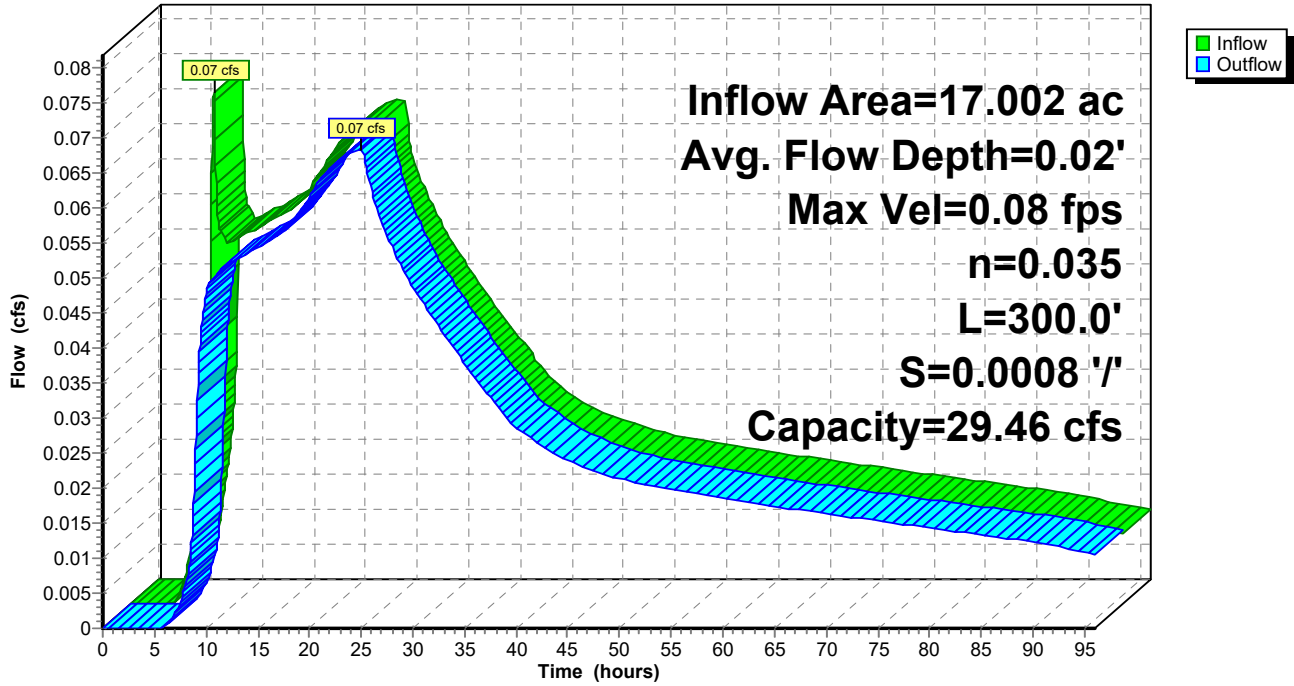
Peak Storage= 259 cf @ 23.98 hrs  
Average Depth at Peak Storage= 0.02'  
Bank-Full Depth= 0.50' Flow Area= 50.0 sf, Capacity= 29.46 cfs

50.00' x 0.50' deep channel, n= 0.035 High grass  
Side Slope Z-value= 100.0 '/' Top Width= 150.00'  
Length= 300.0' Slope= 0.0008 '/'  
Inlet Invert= 133.00', Outlet Invert= 132.75'



### Reach 22R: Offsite Discharge

Hydrograph



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Type IA 24-hr WQ Rainfall=0.36"

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## Summary for Pond 11P: Stormwater System 1

Inflow Area = 2.882 ac, 100.00% Impervious, Inflow Depth = 0.19" for WQ event  
Inflow = 0.14 cfs @ 7.95 hrs, Volume= 0.047 af  
Outflow = 0.02 cfs @ 24.00 hrs, Volume= 0.032 af, Atten= 88%, Lag= 963.1 min  
Primary = 0.02 cfs @ 24.00 hrs, Volume= 0.032 af

Routing by Stor-Ind method, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
Peak Elev= 133.88' @ 24.00 hrs Surf.Area= 0.246 ac Storage= 0.037 af

Plug-Flow detention time= 1,970.0 min calculated for 0.032 af (68% of inflow)  
Center-of-Mass det. time= 1,788.0 min ( 2,575.3 - 787.3 )

Volume	Invert	Avail.Storage	Storage Description
#1A	133.50'	0.149 af	<b>28.33"W x 377.50'L x 2.04'H Field A</b> 0.501 af Overall - 0.128 af Embedded = 0.373 af x 40.0% Voids
#2A	134.00'	0.128 af	<b>Cultec C-100HD</b> x 400 Inside #1 Effective Size= 32.1"W x 12.0"H => 1.86 sf x 7.50'L = 14.0 cf Overall Size= 36.0"W x 12.5"H x 8.00'L with 0.50' Overlap Row Length Adjustment= +0.50' x 1.86 sf x 8 rows
		0.278 af	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	133.50'	<b>0.5" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads
#2	Primary	133.80'	<b>2.5" Vert. Orifice/Grate</b> C= 0.600
#3	Primary	135.50'	<b>24.0" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads

**Primary OutFlow** Max=0.02 cfs @ 24.00 hrs HW=133.88' (Free Discharge)

- 1=Orifice/Grate (Orifice Controls 0.00 cfs @ 2.97 fps)
- 2=Orifice/Grate (Orifice Controls 0.01 cfs @ 0.96 fps)
- 3=Orifice/Grate ( Controls 0.00 cfs)

**Pond 11P: Stormwater System 1 - Chamber Wizard Field A**

**Chamber Model = Cultec C-100HD (Cultec Contactor® 100HD)**

Effective Size= 32.1"W x 12.0"H => 1.86 sf x 7.50'L = 14.0 cf

Overall Size= 36.0"W x 12.5"H x 8.00'L with 0.50' Overlap

Row Length Adjustment= +0.50' x 1.86 sf x 8 rows

36.0" Wide + 4.0" Spacing = 40.0" C-C Row Spacing

50 Chambers/Row x 7.50' Long +0.50' Row Adjustment = 375.50' Row Length +12.0" End Stone x 2 = 377.50' Base Length

8 Rows x 36.0" Wide + 4.0" Spacing x 7 + 12.0" Side Stone x 2 = 28.33' Base Width

6.0" Base + 12.5" Chamber Height + 6.0" Cover = 2.04' Field Height

400 Chambers x 14.0 cf +0.50' Row Adjustment x 1.86 sf x 8 Rows = 5,591.9 cf Chamber Storage

21,837.3 cf Field - 5,591.9 cf Chambers = 16,245.4 cf Stone x 40.0% Voids = 6,498.2 cf Stone Storage

Chamber Storage + Stone Storage = 12,090.1 cf = 0.278 af

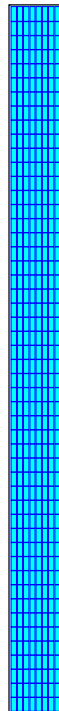
Overall Storage Efficiency = 55.4%

Overall System Size = 377.50' x 28.33' x 2.04'

400 Chambers

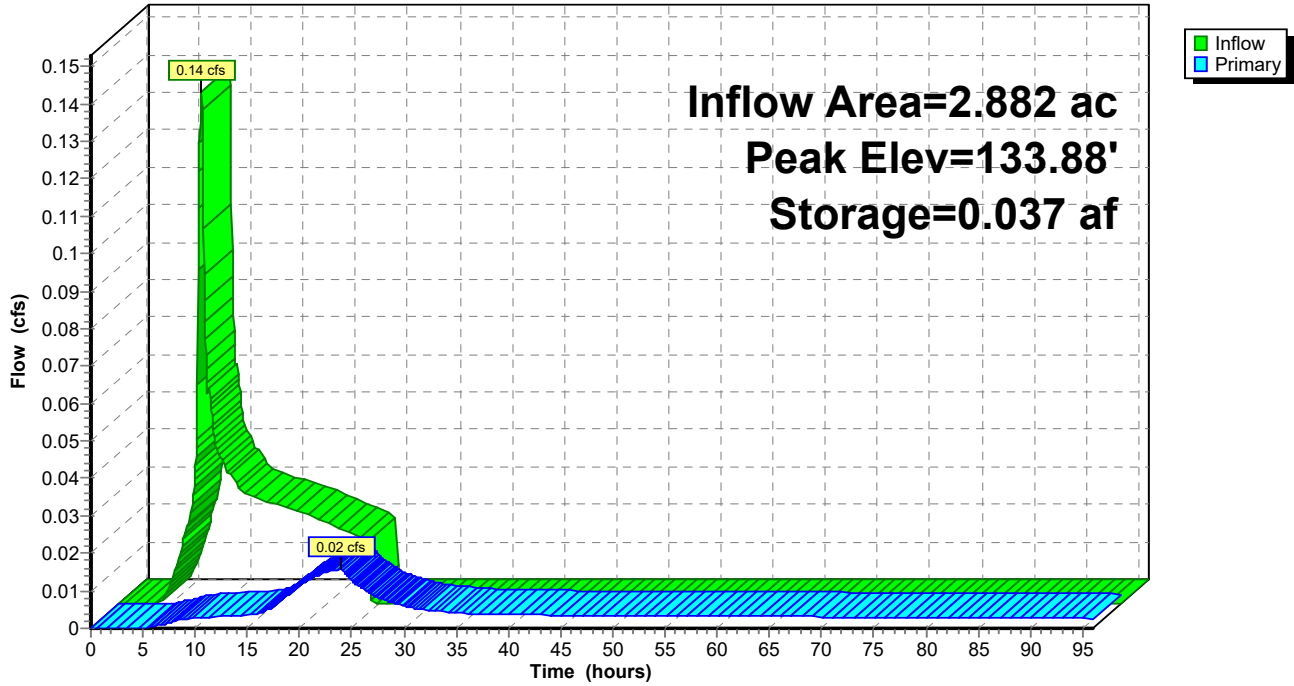
808.8 cy Field

601.7 cy Stone



### Pond 11P: Stormwater System 1

Hydrograph



# Walgraves

Prepared by AAI Engineering

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Type IA 24-hr WQ Rainfall=0.36"

Printed 5/3/2022

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## Summary for Pond 14P: Stormwater Sytem 3

Inflow Area = 5.153 ac, 100.00% Impervious, Inflow Depth = 0.19" for WQ event  
 Inflow = 0.24 cfs @ 7.95 hrs, Volume= 0.084 af  
 Outflow = 0.02 cfs @ 24.07 hrs, Volume= 0.079 af, Atten= 93%, Lag= 967.2 min  
 Primary = 0.02 cfs @ 24.07 hrs, Volume= 0.079 af

Routing by Stor-Ind method, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
 Peak Elev= 132.88' @ 24.07 hrs Surf.Area= 0.427 ac Storage= 0.065 af

Plug-Flow detention time= 1,893.9 min calculated for 0.079 af (94% of inflow)  
 Center-of-Mass det. time= 1,860.1 min ( 2,647.4 - 787.3 )

Volume	Invert	Avail.Storage	Storage Description
#1A	132.50'	0.257 af	<b>68.33"W x 272.50"L x 2.04'H Field A</b> 0.873 af Overall - 0.231 af Embedded = 0.642 af x 40.0% Voids
#2A	133.00'	0.231 af	<b>Cultec C-100HD</b> x 720 Inside #1 Effective Size= 32.1"W x 12.0"H => 1.86 sf x 7.50'L = 14.0 cf Overall Size= 36.0"W x 12.5"H x 8.00'L with 0.50' Overlap Row Length Adjustment= +0.50' x 1.86 sf x 20 rows
		0.488 af	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	132.50'	<b>1.0" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads
#2	Primary	133.05'	<b>5.0" Vert. Orifice/Grate</b> C= 0.600
#3	Primary	134.30'	<b>24.0" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads

**Primary OutFlow** Max=0.02 cfs @ 24.07 hrs HW=132.88' (Free Discharge)

- 1=Orifice/Grate (Orifice Controls 0.02 cfs @ 2.96 fps)
- 2=Orifice/Grate ( Controls 0.00 cfs)
- 3=Orifice/Grate ( Controls 0.00 cfs)



**Pond 14P: Stormwater Sytem 3 - Chamber Wizard Field A**

**Chamber Model = Cultec C-100HD (Cultec Contactor® 100HD)**

Effective Size= 32.1"W x 12.0"H => 1.86 sf x 7.50'L = 14.0 cf

Overall Size= 36.0"W x 12.5"H x 8.00'L with 0.50' Overlap

Row Length Adjustment= +0.50' x 1.86 sf x 20 rows

36.0" Wide + 4.0" Spacing = 40.0" C-C Row Spacing

36 Chambers/Row x 7.50' Long +0.50' Row Adjustment = 270.50' Row Length +12.0" End Stone x 2 = 272.50' Base Length

20 Rows x 36.0" Wide + 4.0" Spacing x 19 + 12.0" Side Stone x 2 = 68.33' Base Width

6.0" Base + 12.5" Chamber Height + 6.0" Cover = 2.04' Field Height

720 Chambers x 14.0 cf +0.50' Row Adjustment x 1.86 sf x 20 Rows = 10,070.7 cf Chamber Storage

38,017.5 cf Field - 10,070.7 cf Chambers = 27,946.8 cf Stone x 40.0% Voids = 11,178.7 cf Stone Storage

Chamber Storage + Stone Storage = 21,249.4 cf = 0.488 af

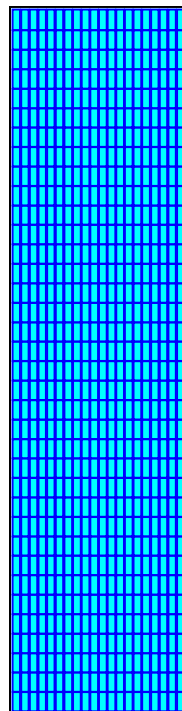
Overall Storage Efficiency = 55.9%

Overall System Size = 272.50' x 68.33' x 2.04'

720 Chambers

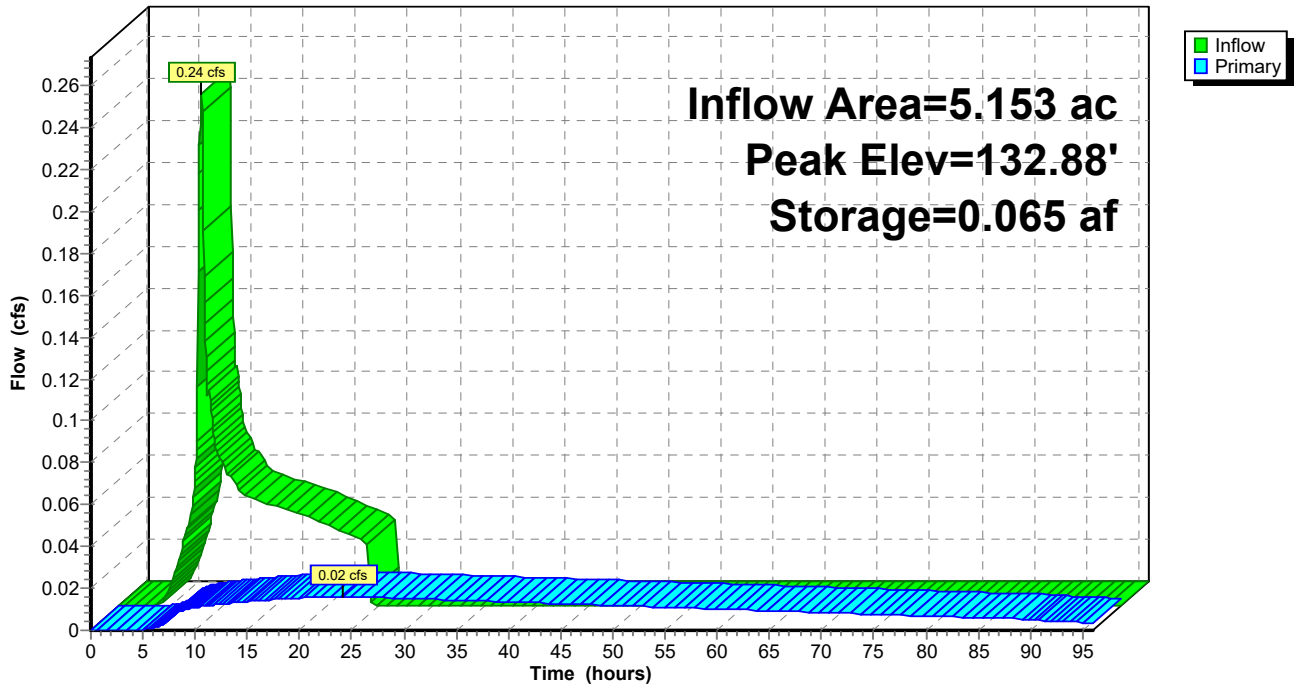
1,408.1 cy Field

1,035.1 cy Stone



### Pond 14P: Stormwater Sytem 3

Hydrograph



# Walgraves

Prepared by AAI Engineering

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Type IA 24-hr WQ Rainfall=0.36"

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## Summary for Pond 20P: Stormwater System 4

Inflow Area = 3.503 ac, 100.00% Impervious, Inflow Depth = 0.19" for WQ event  
 Inflow = 0.17 cfs @ 7.95 hrs, Volume= 0.057 af  
 Outflow = 0.03 cfs @ 19.74 hrs, Volume= 0.057 af, Atten= 84%, Lag= 707.5 min  
 Primary = 0.03 cfs @ 19.74 hrs, Volume= 0.057 af

Routing by Stor-Ind method, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
 Peak Elev= 132.70' @ 19.74 hrs Surf.Area= 0.283 ac Storage= 0.023 af

Plug-Flow detention time= 532.0 min calculated for 0.057 af (100% of inflow)  
 Center-of-Mass det. time= 531.6 min ( 1,318.9 - 787.3 )

Volume	Invert	Avail.Storage	Storage Description
#1A	132.50'	0.266 af	<b>30.00'W x 411.50'L x 4.00'H Field A</b> 1.134 af Overall - 0.468 af Embedded = 0.665 af x 40.0% Voids
#2A	133.00'	0.468 af	<b>Cultec R-360HD x 555 Inside #1</b> Effective Size= 54.9"W x 36.0"H => 9.99 sf x 3.67'L = 36.6 cf Overall Size= 60.0"W x 36.0"H x 4.17'L with 0.50' Overlap 555 Chambers in 5 Rows Cap Storage= +6.5 cf x 2 x 5 rows = 64.6 cf
		0.734 af	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	132.50'	<b>1.5" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads
#2	Primary	134.00'	<b>2.0" Vert. Orifice/Grate</b> C= 0.600
#3	Primary	136.25'	<b>24.0" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads

**Primary OutFlow** Max=0.03 cfs @ 19.74 hrs HW=132.70' (Free Discharge)

- 1=Orifice/Grate (Orifice Controls 0.03 cfs @ 2.17 fps)
- 2=Orifice/Grate ( Controls 0.00 cfs)
- 3=Orifice/Grate ( Controls 0.00 cfs)

**Pond 20P: Stormwater System 4 - Chamber Wizard Field A**

**Chamber Model = Cultec R-360HD (Cultec Recharger® 360HD)**

Effective Size= 54.9"W x 36.0"H => 9.99 sf x 3.67'L = 36.6 cf

Overall Size= 60.0"W x 36.0"H x 4.17'L with 0.50' Overlap

Cap Storage= +6.5 cf x 2 x 5 rows = 64.6 cf

60.0" Wide + 9.0" Spacing = 69.0" C-C Row Spacing

111 Chambers/Row x 3.67' Long +1.25' Cap Length x 2 = 409.50' Row Length +12.0" End Stone x 2 = 411.50' Base Length

5 Rows x 60.0" Wide + 9.0" Spacing x 4 + 12.0" Side Stone x 2 = 30.00' Base Width

6.0" Base + 36.0" Chamber Height + 6.0" Cover = 4.00' Field Height

555 Chambers x 36.6 cf + 6.5 cf Cap Volume x 2 x 5 Rows = 20,402.4 cf Chamber Storage

49,380.0 cf Field - 20,402.4 cf Chambers = 28,977.6 cf Stone x 40.0% Voids = 11,591.0 cf Stone Storage

Chamber Storage + Stone Storage = 31,993.4 cf = 0.734 af

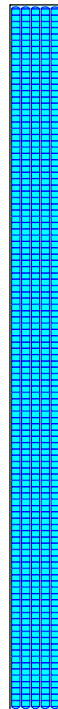
Overall Storage Efficiency = 64.8%

Overall System Size = 411.50' x 30.00' x 4.00'

555 Chambers

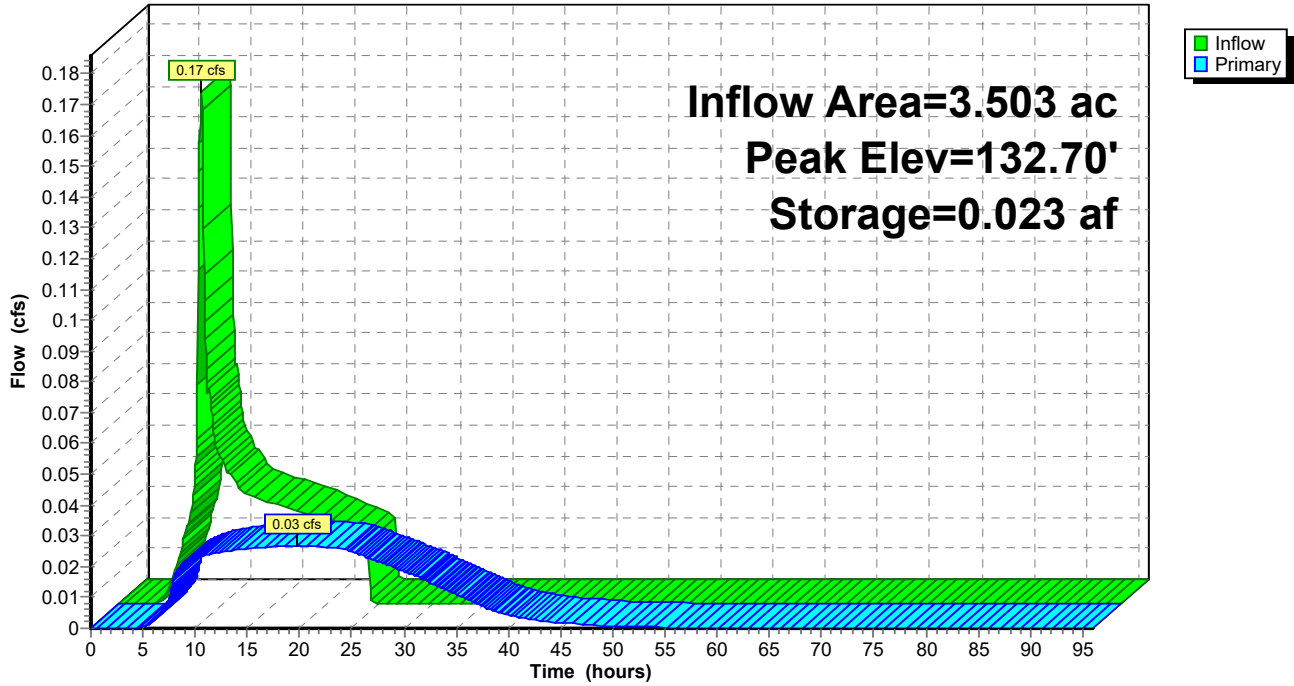
1,828.9 cy Field

1,073.2 cy Stone



### Pond 20P: Stormwater System 4

Hydrograph



# Walgraves

Prepared by AAI Engineering

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Type IA 24-hr WQ Rainfall=0.36"

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## Summary for Pond 23P: Stormwater System 2

Inflow Area = 4.533 ac, 100.00% Impervious, Inflow Depth = 0.19" for WQ event  
Inflow = 0.21 cfs @ 7.95 hrs, Volume= 0.074 af  
Outflow = 0.00 cfs @ 24.12 hrs, Volume= 0.032 af, Atten= 98%, Lag= 970.2 min  
Primary = 0.00 cfs @ 24.12 hrs, Volume= 0.032 af

Routing by Stor-Ind method, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs  
Peak Elev= 134.05' @ 24.12 hrs Surf.Area= 0.284 ac Storage= 0.068 af

Plug-Flow detention time= 2,578.1 min calculated for 0.032 af (44% of inflow)  
Center-of-Mass det. time= 2,292.9 min ( 3,080.2 - 787.3 )

Volume	Invert	Avail.Storage	Storage Description
#1A	133.50'	0.265 af	<b>41.50'W x 297.83'L x 4.00'H Field A</b> 1.135 af Overall - 0.473 af Embedded = 0.662 af x 40.0% Voids
#2A	134.00'	0.473 af	<b>Cultec R-360HD x 560 Inside #1</b> Effective Size= 54.9"W x 36.0"H => 9.99 sf x 3.67'L = 36.6 cf Overall Size= 60.0"W x 36.0"H x 4.17'L with 0.50' Overlap 560 Chambers in 7 Rows Cap Storage= +6.5 cf x 2 x 7 rows = 90.4 cf
		0.738 af	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	133.50'	<b>0.5" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads
#2	Primary	134.50'	<b>1.5" Vert. Orifice/Grate</b> C= 0.600
#3	Primary	137.30'	<b>24.0" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads

**Primary OutFlow** Max=0.00 cfs @ 24.12 hrs HW=134.05' (Free Discharge)

- 1=Orifice/Grate (Orifice Controls 0.00 cfs @ 3.56 fps)
- 2=Orifice/Grate ( Controls 0.00 cfs)
- 3=Orifice/Grate ( Controls 0.00 cfs)

**Pond 23P: Stormwater System 2 - Chamber Wizard Field A**

**Chamber Model = Cultec R-360HD (Cultec Recharger® 360HD)**

Effective Size= 54.9"W x 36.0"H => 9.99 sf x 3.67'L = 36.6 cf

Overall Size= 60.0"W x 36.0"H x 4.17'L with 0.50' Overlap

Cap Storage= +6.5 cf x 2 x 7 rows = 90.4 cf

60.0" Wide + 9.0" Spacing = 69.0" C-C Row Spacing

80 Chambers/Row x 3.67' Long +1.25' Cap Length x 2 = 295.83' Row Length +12.0" End Stone x 2 = 297.83' Base Length

7 Rows x 60.0" Wide + 9.0" Spacing x 6 + 12.0" Side Stone x 2 = 41.50' Base Width

6.0" Base + 36.0" Chamber Height + 6.0" Cover = 4.00' Field Height

560 Chambers x 36.6 cf + 6.5 cf Cap Volume x 2 x 7 Rows = 20,611.5 cf Chamber Storage

49,440.3 cf Field - 20,611.5 cf Chambers = 28,828.9 cf Stone x 40.0% Voids = 11,531.6 cf Stone Storage

Chamber Storage + Stone Storage = 32,143.0 cf = 0.738 af

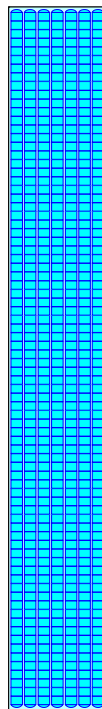
Overall Storage Efficiency = 65.0%

Overall System Size = 297.83' x 41.50' x 4.00'

560 Chambers

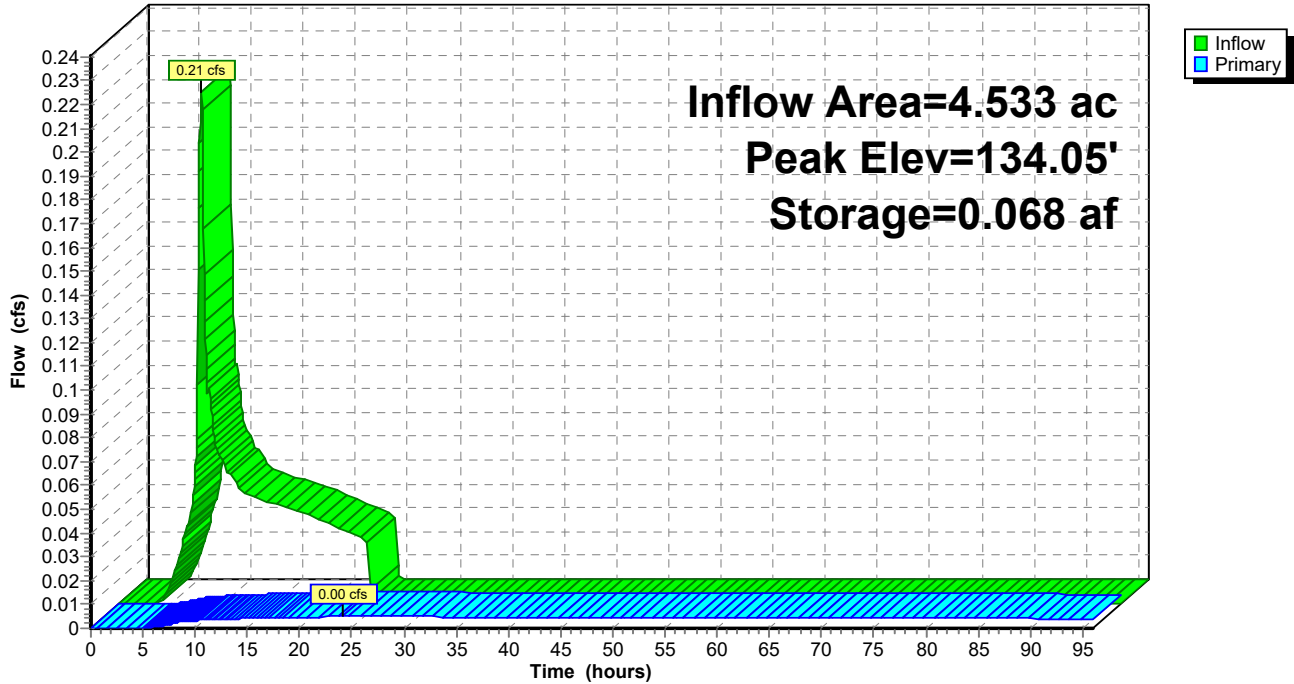
1,831.1 cy Field

1,067.7 cy Stone



### Pond 23P: Stormwater System 2

Hydrograph





**Appendix H**

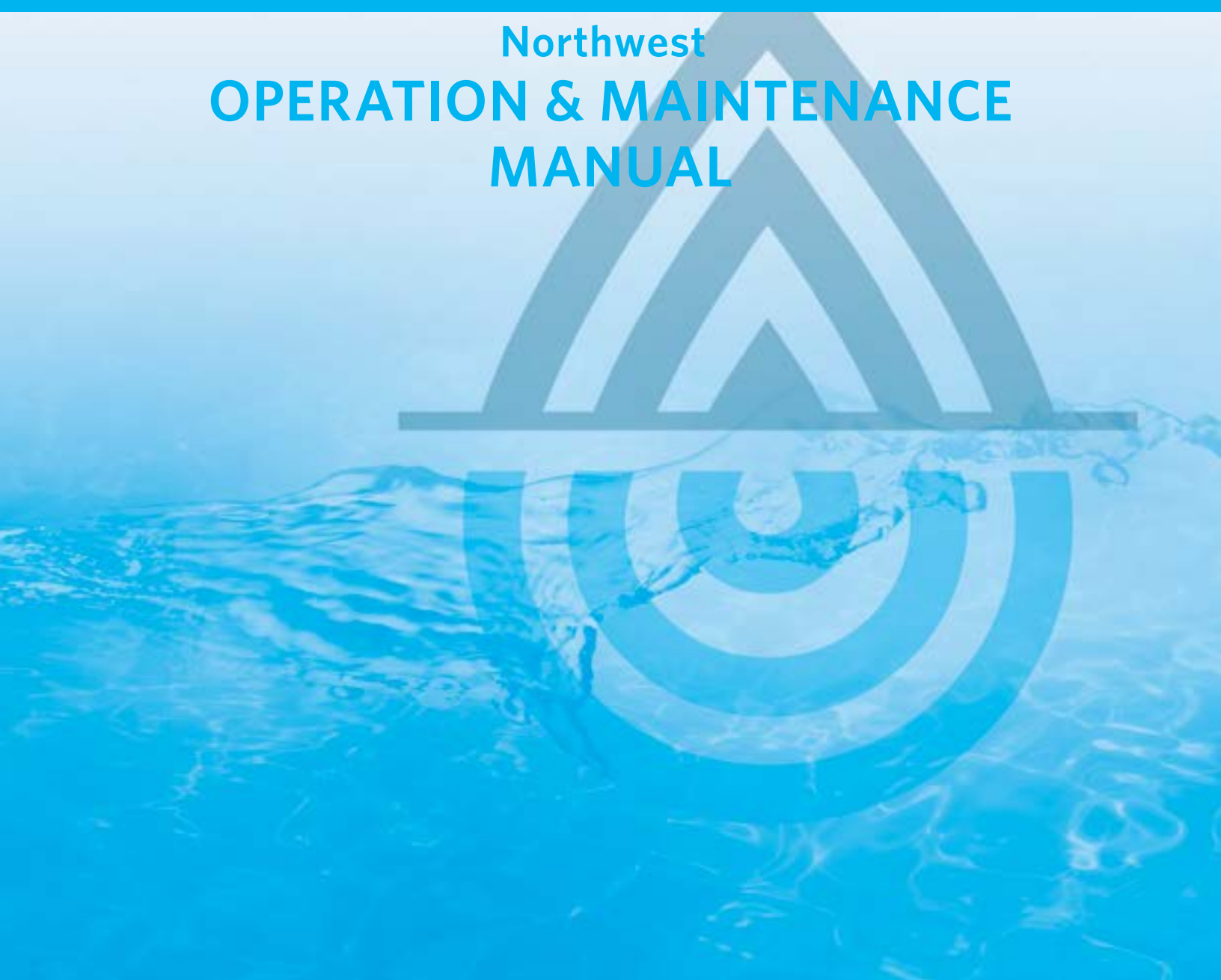
Operations and Maintenance Manual



# Modular Wetlands<sup>®</sup> Linear

A Stormwater Biofiltration Solution

## Northwest OPERATION & MAINTENANCE MANUAL



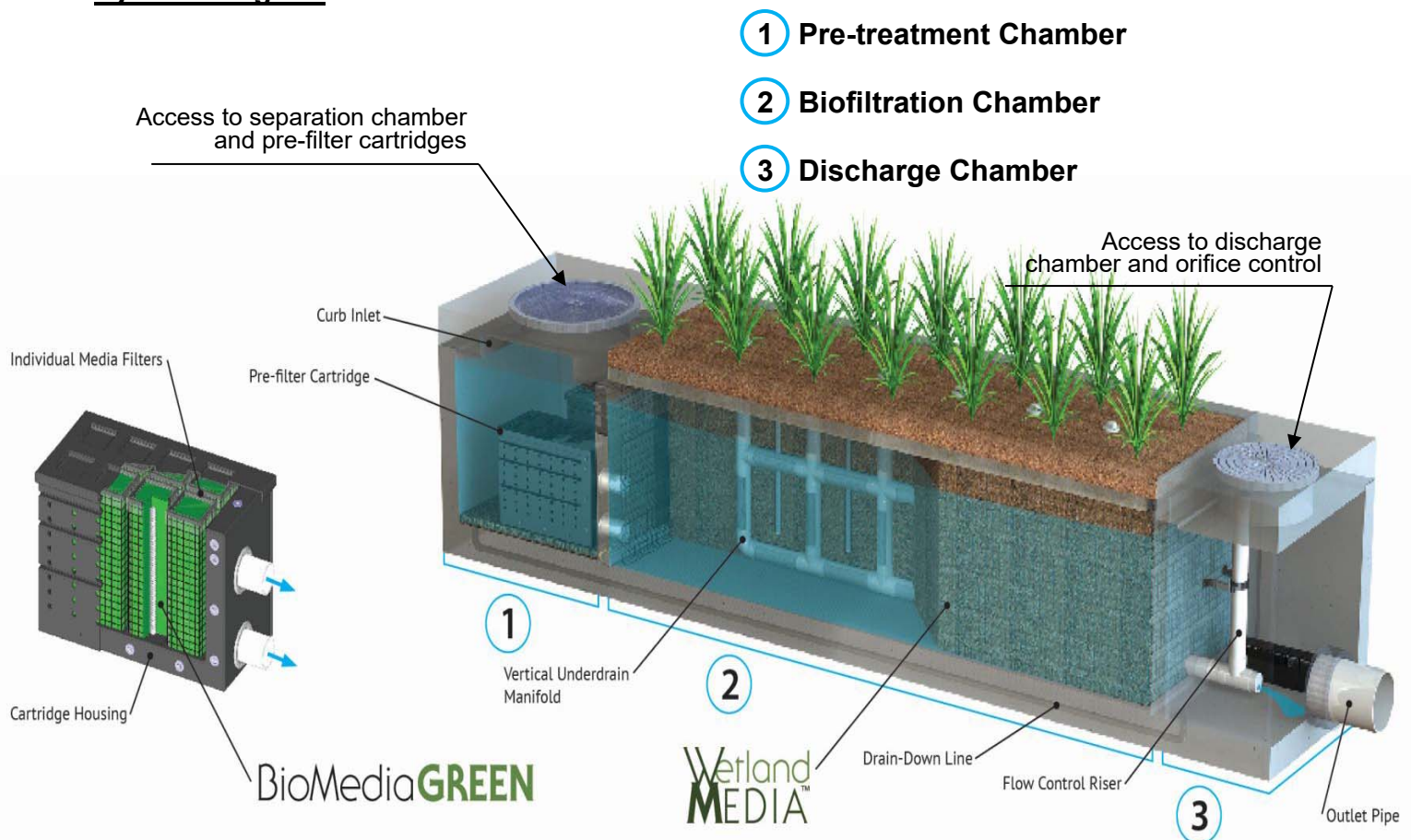


# Inspection Guidelines for Modular Wetland System - Linear

## Inspection Summary

- Inspect Pre-Treatment, Biofiltration and Discharge Chambers – average inspection interval is 6 to 12 months.
  - *(15 minute average inspection time).*
- **NOTE:** Pollutant loading varies greatly from site to site and no two sites are the same. Therefore, the first year requires inspection monthly during the wet season and every other month during the dry season in order to observe and record the amount of pollutant loading the system is receiving.

## System Diagram



## Inspection Overview

As with all stormwater BMPs inspection and maintenance on the MWS Linear is necessary. Stormwater regulations require that all BMPs be inspected and maintained to ensure they are operating as designed to allow for effective pollutant removal and provide protection to receiving water bodies. It is recommended that inspections be performed multiple times during the first year to assess the site specific loading conditions. This is recommended because pollutant loading and pollutant characteristics can vary greatly from site to site. Variables such as nearby soil erosion or construction sites, winter sanding on roads, amount of daily traffic and land use can increase pollutant loading on the system. The first year of inspections can be used to set inspection and maintenance intervals for subsequent years to ensure appropriate maintenance is provided. Without appropriate maintenance a BMP will exceed its storage capacity which can negatively affect its continued performance in removing and retaining captured pollutants.

### Inspection Equipment

Following is a list of equipment to allow for simple and effective inspection of the MWS Linear:

- Modular Wetland Inspection Form
- Flashlight
- Manhole hook or appropriate tools to remove access hatches and covers
- Appropriate traffic control signage and procedures
- Measuring pole and/or tape measure.
- Protective clothing and eye protection.
- 7/16" open or closed ended wrench.
- **Large permanent black marker (initial inspections only – first year)**
- Note: entering a confined space requires appropriate safety and certification. It is generally not required for routine inspections of the system.





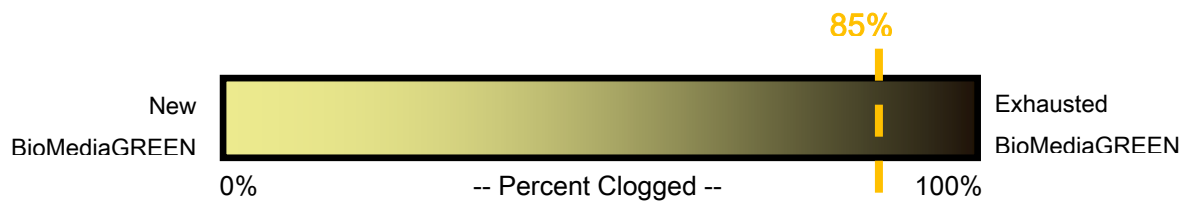
## **Inspection Steps**

The core to any successful stormwater BMP maintenance program is routine inspections. The inspection steps required on the MWS Linear are quick and easy. As mentioned above the first year should be seen as the maintenance interval establishment phase. During the first year more frequent inspections should occur in order to gather loading data and maintenance requirements for that specific site. This information can be used to establish a base for long term inspection and maintenance interval requirements.

The MWS Linear can be inspected through visual observation without entry into the system. All necessary pre-inspection steps must be carried out before inspection occurs, especially traffic control and other safety measures to protect the inspector and near-by pedestrians from any dangers associated with an open access hatch or manhole. Once these access covers have been safely opened the inspection process can proceed:

- Prepare the inspection form by writing in the necessary information including project name, location, date & time, unit number and other info (see inspection form).
- Observe the inside of the system through the access hatches. If minimal light is available and vision into the unit is impaired utilize a flashlight to see inside the system and all of its chambers.
- Look for any out of the ordinary obstructions in the inflow pipe, pre-treatment chamber, biofiltration chamber, discharge chamber or outflow pipe. Write down any observations on the inspection form.
- Through observation and/or digital photographs estimate the amount of trash, debris and sediment accumulated in the pre-treatment chamber. Utilizing a tape measure or measuring stick estimate the amount of trash, debris and sediment in this chamber. Record this depth on the inspection form.

- Through visual observation inspect the condition of the pre-filter cartridges. Look for excessive build-up of sediments on the cartridges, any build-up on the top of the cartridges, or clogging of the holes. Record this information on the inspection form. The pre-filter cartridges can further be inspected by removing the cartridge tops and assessing the color of the BioMediaGREEN filter cubes (requires entry into pre-treatment chamber – see notes above regarding confined space entry). Record the color of the material. New material is a light green in color. As the media becomes clogged it will turn darker in color, eventually becoming dark brown or black. Using the below color indicator record the percentage of media exhausted.



- The biofiltration chamber is generally maintenance free due to the system's advanced pre-treatment chamber. For units which have open planters with vegetation it is recommended that the vegetation be inspected. Look for any plants that are dead or showing signs of disease or other negative stressors. Record the general health of the plants on the inspection and indicate through visual observation or digital photographs if trimming of the vegetation is needed.
- The discharge chamber houses the orifice control structure and is connected to the outflow pipe. It is important to check to ensure the orifice is in proper operating conditions and free of any obstructions. Generally, the discharge chamber will be clean and free of debris. Inspect the water marks on the side walls. If possible, inspect the discharge chamber during a rain event to assess the amount of flow leaving the system while it is at 100% capacity (pre-treatment chamber water level at peak HGL). The water level of the flowing water should be compared to the watermark level on the side walls which is an indicator of the highest discharge rate the system achieved when initially installed. Record on the form is there is any difference in level from watermark in inches.

- NOTE: During the first few storms the water level in the outflow chamber should be observed and a 6" long horizontal watermark line drawn (using a large permanent marker) at the water level in the discharge chamber while the system is operating at 100% capacity. The diagram below illustrates where a line should be drawn. This line is a reference point for future inspections of the system:



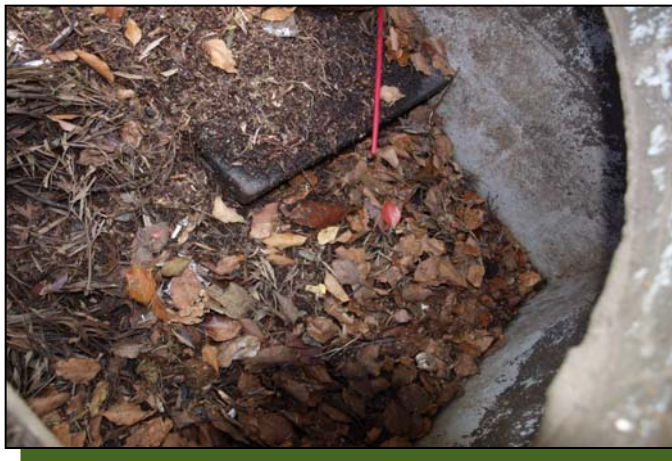
Using a permanent marker draw a 6 inch long horizontal line, as shown, at the higher water level in the MWS Linear discharge chamber.

- Water level in the discharge chamber is a function of flow rate and pipe size. Observation of water level during the first few months of operation can be used as a benchmark level for future inspections. The initial mark and all future observations shall be made when system is at 100% capacity (water level at maximum level in pre-treatment chamber). If future water levels are below this mark when system is at 100% capacity this is an indicator that maintenance to the pre-filter cartridges may be needed.
- Finalize inspection report for analysis by the maintenance manager to determine if maintenance is required.

## **Maintenance Indicators**

Based upon observations made during inspection, maintenance of the system may be required based on the following indicators:

- Missing or damaged internal components or cartridges.
- Obstructions in the system or its inlet or outlet.
- Excessive accumulation of floatables in the pre-treatment chamber in which the length and width of the chamber is fully impacted more than 18”.



- Excessive accumulation of sediment in the pre-treatment chamber of more than 6” in depth.





- Excessive accumulation of sediment on the BioMediaGREEN media housed within the pre-filter cartridges. The following chart shows photos of the condition of the BioMediaGREEN contained within the pre-filter cartridges. When media is more than 85% clogged replacement is required.



- Overgrown vegetation.



- Water level in discharge chamber during 100% operating capacity (pre-treatment chamber water level at max height) is lower than the watermark by 20%.



## **Inspection Notes**

1. Following maintenance and/or inspection, it is recommended the maintenance operator prepare a maintenance/inspection record. The record should include any maintenance activities performed, amount and description of debris collected, and condition of the system and its various filter mechanisms.
2. The owner should keep maintenance/inspection record(s) for a minimum of five years from the date of maintenance. These records should be made available to the governing municipality for inspection upon request at any time.
3. Transport all debris, trash, organics and sediments to approved facility for disposal in accordance with local and state requirements.
4. Entry into chambers may require confined space training based on state and local regulations.
5. No fertilizer shall be used in the Biofiltration Chamber.
6. Irrigation should be provided as recommended by manufacturer and/or landscape architect. Amount of irrigation required is dependent on plant species. Some plants may not require irrigation after initial establishment.

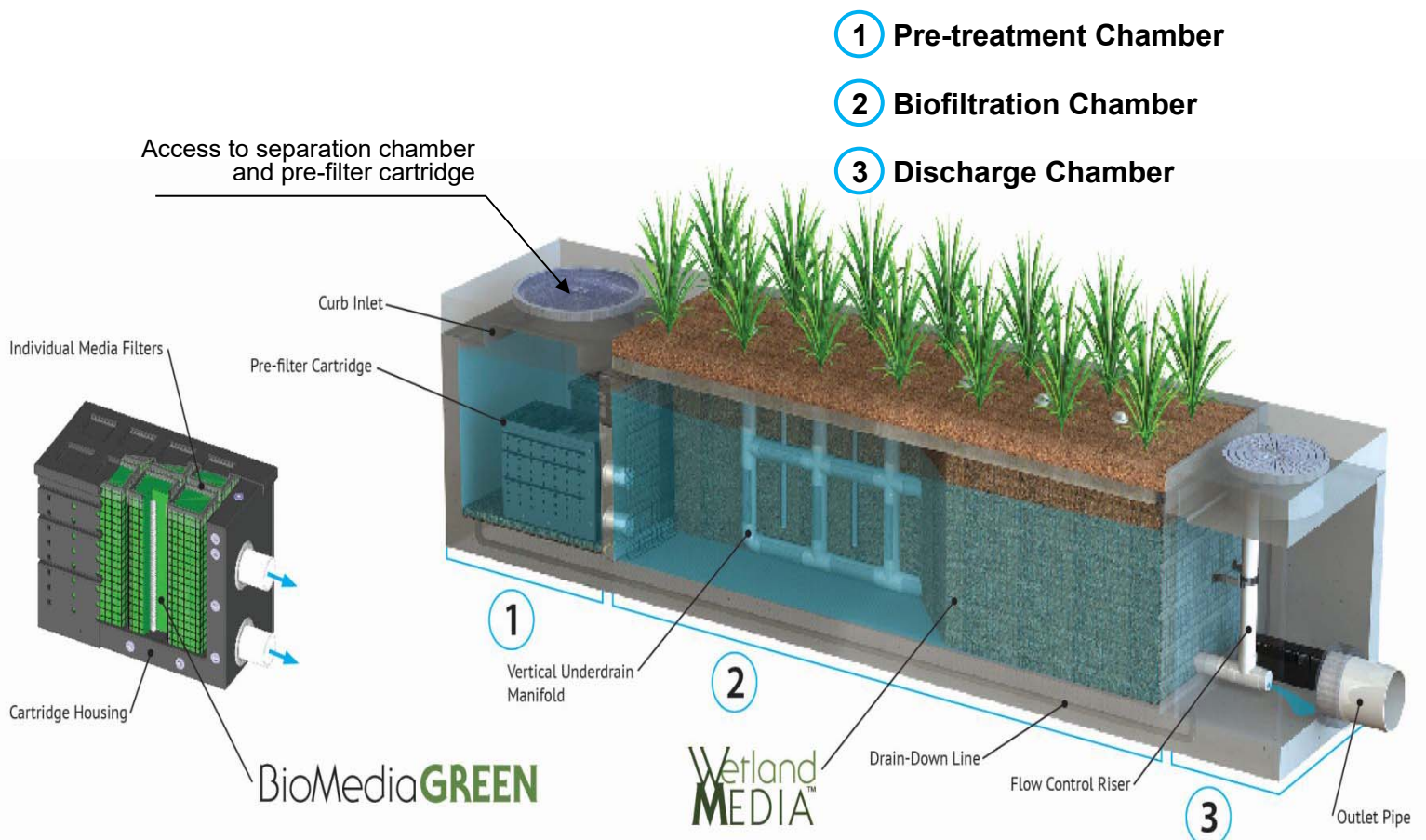


# Maintenance Guidelines for Modular Wetland System - Linear

## Maintenance Summary

- Remove Sediment from Pre-Treatment Chamber – average maintenance interval is 12 to 24 months.
  - (10 minute average service time).
- Replace Pre-Filter Cartridge Media – average maintenance interval 12 to 24 months.
  - (10-15 minute per cartridge average service time).
- Trim Vegetation – average maintenance interval is 6 to 12 months.
  - (Service time varies).

## System Diagram



## Maintenance Overview

The time has come to maintain your Modular Wetland System Linear (MWS Linear). To ensure successful and efficient maintenance on the system we recommend the following. The MWS Linear can be maintained by removing the access hatches over the systems various chambers. All necessary pre-maintenance steps must be carried out before maintenance occurs, especially traffic control and other safety measures to protect the inspector and near-by pedestrians from any dangers associated with an open access hatch or manhole. Once traffic control has been set up per local and state regulations and access covers have been safely opened the maintenance process can begin. It should be noted that some maintenance activities require confined space entry. All confined space requirements must be strictly followed before entry into the system. In addition the following is recommended:

- Prepare the maintenance form by writing in the necessary information including project name, location, date & time, unit number and other info (see maintenance form).
- Set up all appropriate safety and cleaning equipment.
- Ensure traffic control is set up and properly positioned.
- Prepare a pre-checks (OSHA, safety, confined space entry) are performed.

### Maintenance Equipment

Following is a list of equipment required for maintenance of the MWS Linear:

- Modular Wetland Maintenance Form
- Manhole hook or appropriate tools to access hatches and covers
- Protective clothing, flashlight and eye protection.
- 7/16" open or closed ended wrench.
- Vacuum assisted truck with pressure washer.
- Replacement BioMediaGREEN for Pre-Filter Cartridges if required (order from manufacturer).



## Maintenance Steps

1. Pre-treatment Chamber (bottom of chamber)
  - A. Remove access hatch or manhole cover over pre-treatment chamber and position vacuum truck accordingly.
  - B. With a pressure washer spray down pollutants accumulated on walls and pre-filter cartridges.
  - C. Vacuum out Pre-Treatment Chamber and remove all accumulated pollutants including trash, debris and sediments. Be sure to vacuum the floor until pervious pavers are visible and clean.
  - D. If Pre-Filter Cartridges require media replacement move onto step 2. If not, replace access hatch or manhole cover.



Removal of access hatch to gain access below.



Insertion of vacuum hose into separation chamber.



Removal of trash, sediment and debris.



Fully cleaned separation chamber.

2. Pre-Filter Cartridges (attached to wall of pre-treatment chamber)

- A. After finishing step 1 enter pre-treatment chamber.
- B. Unscrew the two bolts holding the lid on each cartridge filter and remove lid.



Pre-filter cartridges with tops on.



Inside cartridges showing media filters ready for replacement.

- C. Place the vacuum hose over each individual media filter to suck out filter media.



Vacuuming out of media filters.

- D. Once filter media has been sucked use a pressure washer to spray down inside of the cartridge and it's containing media cages. Remove cleaned media cages and place to the side. Once removed the vacuum hose can be inserted into the cartridge to vacuum out any remaining material near the bottom of the cartridge.

- E. Reinstall media cages and fill with new media from manufacturer or outside supplier. Manufacturer will provide specification of media and sources to purchase. Utilize the manufacture provided refilling tray and place on top of cartridge. Fill tray with new bulk media and shake down into place. Using your hands slightly compact media into each filter cage. Once cages are full removed refilling tray and replace cartridge top ensuring bolts are properly tightened.



Refilling tray for media replacement.



Refilling tray on cartridge with bulk media.



- F. Exit pre-treatment chamber. Replace access hatch or manhole cover.

### 3. Biofiltration Chamber (middle vegetated chamber)

- A. In general, the biofiltration chamber is maintenance free with the exception of maintaining the vegetation. Using standard gardening tools properly trim back the vegetation to healthy levels. The MWS Linear utilizes vegetation similar to surrounding landscape areas therefore trim vegetation to match surrounding vegetation. If any plants have died replace plants with new ones:





## **Inspection Notes**

1. Following maintenance and/or inspection, it is recommended the maintenance operator prepare a maintenance/inspection record. The record should include any maintenance activities performed, amount and description of debris collected, and condition of the system and its various filter mechanisms.
2. The owner should keep maintenance/inspection record(s) for a minimum of five years from the date of maintenance. These records should be made available to the governing municipality for inspection upon request at any time.
3. Transport all debris, trash, organics and sediments to approved facility for disposal in accordance with local and state requirements.
4. Entry into chambers may require confined space training based on state and local regulations.
5. No fertilizer shall be used in the Biofiltration Chamber.
6. Irrigation should be provided as recommended by manufacturer and/or landscape architect. Amount of irrigation required is dependent on plant species. Some plants may not require irrigation after initial establishment.





## Inspection Form



Modular Wetland System, Inc.

P. 760.433-7640

F. 760-433-3176

E. [Info@modularwetlands.com](mailto:Info@modularwetlands.com)

[www.modularwetlands.com](http://www.modularwetlands.com)



## Maintenance Report



Modular Wetland System, Inc.

P. 760.433-7640

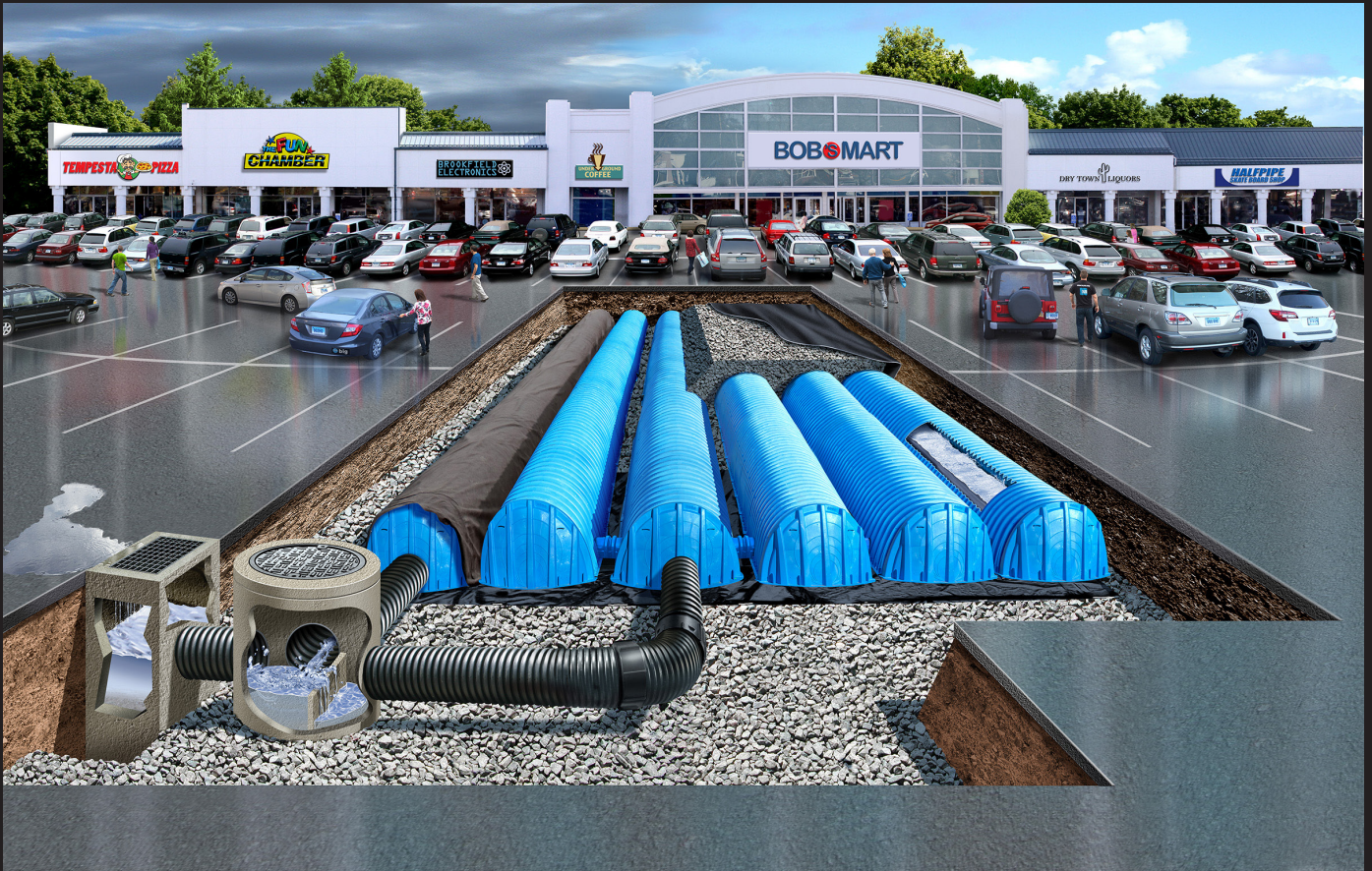
F. 760-433-3176

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# CONTACTOR® & RECHARGER®

## STORMWATER MANAGEMENT SOLUTIONS



## OPERATION & MAINTENANCE GUIDELINES FOR CULTEC STORMWATER MANAGEMENT SYSTEMS



# OPERATIONS AND MAINTENANCE GUIDELINES

## Published by

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*These instructions are for single-layer traffic applications only. For multi-layer applications, contact CULTEC. All illustrations and photos shown herein are examples of typical situations. Be sure to follow the engineer's drawings. Actual designs may vary.*

*This manual contains guidelines recommended by CULTEC, Inc. and may be used in conjunction with, but not to supersede, local regulations or regulatory authorities. OSHA Guidelines must be followed when inspecting or cleaning any structure.*

## Introduction

The CULTEC Subsurface Stormwater Management System is a high-density polyethylene (HDPE) chamber system arranged in parallel rows surrounded by washed stone. The CULTEC chambers create arch-shaped voids within the washed stone to provide stormwater detention, retention, infiltration, and reclamation. Filter fabric is placed between the native soil and stone interface to prevent the intrusion of fines into the system. In order to minimize the amount of sediment which may enter the CULTEC system, a sediment collection device (stormwater pretreatment device) is recommended upstream from the CULTEC chamber system. Examples of pretreatment devices include, but are not limited to, an appropriately sized catch basin with sump, pretreatment catchment device, oil grit separator, or baffled distribution box. Manufactured pretreatment devices may also be used in accordance with CULTEC chambers. Installation, operation, and maintenance of these devices shall be in accordance with manufacturer's recommendations. Almost all of the sediment entering the stormwater management system will be collected within the pretreatment device.

Best Management Practices allow for the maintenance of the preliminary collection systems prior to feeding the CULTEC chambers. The pretreatment structures shall be inspected for any debris that will restrict inlet flow rates. Outfall structures, if any, such as outlet control must also be inspected for any obstructions that would restrict outlet flow rates. OSHA Guidelines must be followed when inspecting or cleaning any structure.

## Operation and Maintenance Requirements

### I. Operation

CULTEC stormwater management systems shall be operated to receive only stormwater run-off in accordance with applicable local regulations. CULTEC subsurface stormwater management chambers operate at peak performance when installed in series with pretreatment. Pretreatment of suspended solids is superior to treatment of solids once they have been introduced into the system. The use of pretreatment is adequate as long as the structure is maintained and the site remains stable with finished impervious surfaces such as parking lots, walkways, and pervious areas are properly maintained. If there is to be an unstable condition, such as improvements to buildings or parking areas, all proper silt control measures shall be implemented according to local regulations.

### II. Inspection and Maintenance Options

- A. The CULTEC system may be equipped with an inspection port located on the inlet row. The inspection port is a circular cast box placed in a rectangular concrete collar. When the lid is removed, a 6-inch (150 mm) pipe with a screw-in plug will be exposed. Remove the plug. This will provide access to the CULTEC Chamber row below. From the surface, through this access, the sediment may be measured at this location. A stadia rod may be used to measure the depth of sediment if any in this row. If the depth of sediment is in excess of 3 inches (76 mm), then this row should be cleaned with high pressure water through a culvert cleaning nozzle. This would be carried out through an upstream manhole or through the CULTEC StormFilter Unit (or other pretreatment device). CCTV inspection of this row can be deployed through this access port to determine if any sediment has accumulated in the inlet row.
- B. If the CULTEC bed is not equipped with an inspection port, then access to the inlet row will be through an upstream manhole or the CULTEC StormFilter.
  1. **Manhole Access**  
This inspection should only be carried out by persons trained in confined space entry and sewer inspection services. After the manhole cover has been removed a gas detector must be lowered into the manhole to ensure that there are not high concentrations of toxic gases present. The inspector should be lowered into the manhole with the proper safety equipment as per OSHA requirements. The inspector may be able to observe sediment from this location. If this is not possible, the inspector will need to deploy a CCTV robot to permit viewing of the sediment.

## 2. StormFilter Access

Remove the manhole cover to allow access to the unit. Typically a 30-inch (750 mm) pipe is used as a riser from the StormFilter to the surface. As in the case with manhole access, this access point requires a technician trained in confined space entry with proper gas detection equipment. This individual must be equipped with the proper safety equipment for entry into the StormFilter. The technician will be lowered onto the StormFilter unit. The hatch on the unit must be removed. Inside the unit are two filters which may be removed according to StormFilter maintenance guidelines. Once these filters are removed the inspector can enter the StormFilter unit to launch the CCTV camera robot.

- C. The inlet row of the CULTEC system is placed on a polyethylene liner to prevent scouring of the washed stone beneath this row. This also facilitates the flushing of this row with high pressure water through a culvert cleaning nozzle. The nozzle is deployed through a manhole or the StormFilter and extended to the end of the row. The water is turned on and the inlet row is back-flushed into the manhole or StormFilter. This water is to be removed from the manhole or StormFilter using a vacuum truck.

## III. Maintenance Guidelines

The following guidelines shall be adhered to for the operation and maintenance of the CULTEC stormwater management system:

- A. The owner shall keep a maintenance log which shall include details of any events which would have an effect on the system's operational capacity.
- B. The operation and maintenance procedure shall be reviewed periodically and changed to meet site conditions.
- C. Maintenance of the stormwater management system shall be performed by qualified workers and shall follow applicable occupational health and safety requirements.
- D. Debris removed from the stormwater management system shall be disposed of in accordance with applicable laws and regulations.

## IV. Suggested Maintenance Schedules

### A. Minor Maintenance

The following suggested schedule shall be followed for routine maintenance during the regular operation of the stormwater system:

Frequency	Action
Monthly in first year	Check inlets and outlets for clogging and remove any debris, as required.
Spring and Fall	Check inlets and outlets for clogging and remove any debris, as required.
One year after commissioning and every third year following	Check inlets and outlets for clogging and remove any debris, as required.

### B. Major Maintenance

The following suggested maintenance schedule shall be followed to maintain the performance of the CULTEC stormwater management chambers. Additional work may be necessary due to insufficient performance and other issues that might be found during the inspection of the stormwater management chambers. (See table on next page)

	Frequency	Action
Inlets and Outlets	Every 3 years	<ul style="list-style-type: none"> <li>Obtain documentation that the inlets, outlets and vents have been cleaned and will function as intended.</li> </ul>
	Spring and Fall	<ul style="list-style-type: none"> <li>Check inlet and outlets for clogging and remove any debris as required.</li> </ul>
CULTEC Stormwater Chambers	2 years after commissioning	<ul style="list-style-type: none"> <li>Inspect the interior of the stormwater management chambers through inspection port for deficiencies using CCTV or comparable technique.</li> <li>Obtain documentation that the stormwater management chambers and feed connectors will function as anticipated.</li> </ul>
	9 years after commissioning every 9 years following	<ul style="list-style-type: none"> <li>Clean stormwater management chambers and feed connectors of any debris.</li> <li>Inspect the interior of the stormwater management structures for deficiencies using CCTV or comparable technique.</li> <li>Obtain documentation that the stormwater management chambers and feed connectors have been cleaned and will function as intended.</li> </ul>
	45 years after commissioning	<ul style="list-style-type: none"> <li>Clean stormwater management chambers and feed connectors of any debris.</li> <li>Determine the remaining life expectancy of the stormwater management chambers and recommended schedule and actions to rehabilitate the stormwater management chambers as required.</li> <li>Inspect the interior of the stormwater management chambers for deficiencies using CCTV or comparable technique.</li> <li>Replace or restore the stormwater management chambers in accordance with the schedule determined at the 45-year inspection.</li> <li>Attain the appropriate approvals as required.</li> <li>Establish a new operation and maintenance schedule.</li> </ul>
Surrounding Site	Monthly in 1 <sup>st</sup> year	<ul style="list-style-type: none"> <li>Check for depressions in areas over and surrounding the stormwater management system.</li> </ul>
	Spring and Fall	<ul style="list-style-type: none"> <li>Check for depressions in areas over and surrounding the stormwater management system.</li> </ul>
	Yearly	<ul style="list-style-type: none"> <li>Confirm that no unauthorized modifications have been performed to the site.</li> </ul>

For additional information concerning the maintenance of CULTEC Subsurface Stormwater Management Chambers, please contact CULTEC, Inc. at 1-800-428-5832.

# WQMP Operation & Maintenance (O&M) Plan

Project Name: \_\_\_\_\_

## Prepared for:

Project Name: \_\_\_\_\_

Address: \_\_\_\_\_

City, State Zip: \_\_\_\_\_

## Prepared on:

Date: \_\_\_\_\_



This O&M Plan describes the designated responsible party for implementation of this WQMP, including: operation and maintenance of all the structural BMP(s), conducting the training/educational program and duties, and any other necessary activities. The O&M Plan includes detailed inspection and maintenance requirements for all structural BMPs, including copies of any maintenance contract agreements, manufacturer’s maintenance requirements, permits, etc.

### 8.1.1 Project Information

Project name	
Address	
City, State Zip	
Site size	
List of structural BMPs, number of each	
Other notes	

### 8.1.2 Responsible Party

The responsible party for implementation of this WQMP is:

Name of Person or HOA Property Manager	
Address	
City, State Zip	
Phone number	
24-Hour Emergency Contact number	
Email	

### 8.1.3 Record Keeping

Parties responsible for the O&M plan shall retain records for at least 5 years.

All training and educational activities and BMP operation and maintenance shall be documented to verify compliance with this O&M Plan. A sample Training Log and Inspection and Maintenance Log are included in this document.

### 8.1.4 Electronic Data Submittal

This document along with the Site Plan and Attachments shall be provided in PDF format. AutoCAD files and/or GIS coordinates of BMPs shall also be submitted to the City.

## Appendix \_\_\_\_

### **BMP SITE PLAN**

Site plan is preferred on minimum 11" by 17" colored sheets, as long as legible.



## Minor Maintenance

Frequency		Action
<b>Monthly in first year</b>		Check inlets and outlets for clogging and remove any debris, as required.
		Notes
<input type="checkbox"/> Month 1	Date:	
<input type="checkbox"/> Month 2	Date:	
<input type="checkbox"/> Month 3	Date:	
<input type="checkbox"/> Month 4	Date:	
<input type="checkbox"/> Month 5	Date:	
<input type="checkbox"/> Month 6	Date:	
<input type="checkbox"/> Month 7	Date:	
<input type="checkbox"/> Month 8	Date:	
<input type="checkbox"/> Month 9	Date:	
<input type="checkbox"/> Month 10	Date:	
<input type="checkbox"/> Month 11	Date:	
<input type="checkbox"/> Month 12	Date:	
<b>Spring and Fall</b>		Check inlets and outlets for clogging and remove any debris, as required.
		Notes
<input type="checkbox"/> Spring	Date:	
<input type="checkbox"/> Fall	Date:	
<input type="checkbox"/> Spring	Date:	
<input type="checkbox"/> Fall	Date:	
<input type="checkbox"/> Spring	Date:	
<input type="checkbox"/> Fall	Date:	
<input type="checkbox"/> Spring	Date:	
<input type="checkbox"/> Fall	Date:	
<input type="checkbox"/> Spring	Date:	
<input type="checkbox"/> Fall	Date:	
<input type="checkbox"/> Spring	Date:	
<input type="checkbox"/> Fall	Date:	
<b>One year after commissioning and every third year following</b>		Check inlets and outlets for clogging and remove any debris, as required.
		Notes
<input type="checkbox"/> Year 1	Date:	
<input type="checkbox"/> Year 4	Date:	
<input type="checkbox"/> Year 7	Date:	
<input type="checkbox"/> Year 10	Date:	
<input type="checkbox"/> Year 13	Date:	
<input type="checkbox"/> Year 16	Date:	
<input type="checkbox"/> Year 19	Date:	
<input type="checkbox"/> Year 22	Date:	

Major Maintenance

Frequency		Action
<b>Inlets and Outlets</b>	<b>Every 3 years</b>	
	Notes	
	<input type="checkbox"/> Year 1	Date:
	<input type="checkbox"/> Year 4	Date:
	<input type="checkbox"/> Year 7	Date:
	<input type="checkbox"/> Year 10	Date:
	<input type="checkbox"/> Year 13	Date:
	<input type="checkbox"/> Year 16	Date:
	<input type="checkbox"/> Year 19	Date:
	<input type="checkbox"/> Year 22	Date:
	<b>Spring and Fall</b>	
	Notes	
	<input type="checkbox"/> Spring	Date:
	<input type="checkbox"/> Fall	Date:
	<input type="checkbox"/> Spring	Date:
	<input type="checkbox"/> Fall	Date:
<input type="checkbox"/> Spring	Date:	
<input type="checkbox"/> Fall	Date:	
<input type="checkbox"/> Spring	Date:	
<input type="checkbox"/> Fall	Date:	
<input type="checkbox"/> Spring	Date:	
<input type="checkbox"/> Fall	Date:	
<b>CULTEC Stormwater Chambers</b>	<b>2 years after commissioning</b>	
Notes		
<input type="checkbox"/> Year 2	Date:	

## Major Maintenance

Frequency		Action
<b>CULTEC Stormwater Chambers</b>	<b>9 years after commissioning every 9 years following</b>	
	<ul style="list-style-type: none"> <li><input type="checkbox"/> Clean stormwater management chambers and feed connectors of any debris.</li> <li><input type="checkbox"/> Inspect the interior of the stormwater management structures for deficiencies using CCTV or comparable technique.</li> <li><input type="checkbox"/> Obtain documentation that the stormwater management chambers and feed connectors have been cleaned and will function as intended.</li> </ul>	
	Notes	
	<input type="checkbox"/> Year 9	Date:
	<input type="checkbox"/> Year 18	Date:
	<input type="checkbox"/> Year 27	Date:
	<input type="checkbox"/> Year 36	Date:
<b>45 years after commissioning</b>		
<ul style="list-style-type: none"> <li><input type="checkbox"/> Clean stormwater management chambers and feed connectors of any debris.</li> <li><input type="checkbox"/> Determine the remaining life expectancy of the stormwater management chambers and recommended schedule and actions to rehabilitate the stormwater management chambers as required.</li> <li><input type="checkbox"/> Inspect the interior of the stormwater management chambers for deficiencies using CCTV or comparable technique.</li> <li><input type="checkbox"/> Replace or restore the stormwater management chambers in accordance with the schedule determined at the 45-year inspection.</li> <li><input type="checkbox"/> Attain the appropriate approvals as required.</li> <li><input type="checkbox"/> Establish a new operation and maintenance schedule.</li> </ul>		
Notes		
<input type="checkbox"/> Year 45	Date:	

Major Maintenance

Frequency		Action	
<b>Surrounding Site</b>	<b>Monthly in 1<sup>st</sup> year</b>		
	<input type="checkbox"/> Check for depressions in areas over and surrounding the stormwater management system.		
	Notes		
	<input type="checkbox"/> Month 1	Date:	
	<input type="checkbox"/> Month 2	Date:	
	<input type="checkbox"/> Month 3	Date:	
	<input type="checkbox"/> Month 4	Date:	
	<input type="checkbox"/> Month 5	Date:	
	<input type="checkbox"/> Month 6	Date:	
	<input type="checkbox"/> Month 7	Date:	
	<input type="checkbox"/> Month 8	Date:	
	<input type="checkbox"/> Month 9	Date:	
	<input type="checkbox"/> Month 10	Date:	
	<input type="checkbox"/> Month 11	Date:	
	<input type="checkbox"/> Month 12	Date:	
	<b>Spring and Fall</b>		
	<input type="checkbox"/> Check for depressions in areas over and surrounding the stormwater management system.		
	Notes		
	<input type="checkbox"/> Spring	Date:	
	<input type="checkbox"/> Fall	Date:	
	<input type="checkbox"/> Spring	Date:	
	<input type="checkbox"/> Fall	Date:	
	<input type="checkbox"/> Spring	Date:	
	<input type="checkbox"/> Fall	Date:	
	<input type="checkbox"/> Spring	Date:	
	<input type="checkbox"/> Fall	Date:	
	<input type="checkbox"/> Spring	Date:	
	<input type="checkbox"/> Fall	Date:	
	<input type="checkbox"/> Spring	Date:	
	<input type="checkbox"/> Fall	Date:	
	<b>Yearly</b>		
	<input type="checkbox"/> Confirm that no unauthorized modifications have been performed to the site.		
Notes			
<input type="checkbox"/> Year 1	Date:		
<input type="checkbox"/> Year 2	Date:		
<input type="checkbox"/> Year 3	Date:		
<input type="checkbox"/> Year 4	Date:		
<input type="checkbox"/> Year 5	Date:		
<input type="checkbox"/> Year 6	Date:		
<input type="checkbox"/> Year 7	Date:		



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