

PRELIMINARY STORMWATER ANALYSIS, DESIGN, AND REPORT

FOR

SJB BUILDING

BLUDORN BUILDERS, LLC
23-142

January 2024


PREPARED BY:



www.starkengineer.com
320-249-2611
Sauk Rapids, Minnesota

Civil Engineering
Site Planning
Sustainable Design

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly licensed Professional Engineer under the laws of the State of Minnesota.


Wayne C.B. Stark, P.E.
Registration Number 26093

Date: _____

1/5/24

PROJECT INFORMATION

The project site is located at the northwest corner of westerly terminus of Energy Drive in Montrose, Minnesota. The 8.355-acre project site is bounded by a farm field on the south side, a mobile home park on the west side, Burlington Northern Railroad right-of-way on the north side and an existing commercial building site on the east side. The majority of the site is agricultural land with no existing impervious surface area.

According to the Web Soil Survey, the existing soils on this site are Cordova clay loam (109) and Angus-Le Sueur complex (1901B) which are classified as hydrologic soil group C/D and C, respectively. Site specific borings have not been completed at this time.

The proposed improvements include a 27,840 square foot (SF) commercial building with paved parking and gravel storage areas. This will result in a proposed impervious surface area of 2.813 acres or 31.5%. The existing stormwater wet pond to the northeast of the project site will be expanded to treat and detain the stormwater runoff from the proposed improvements.

RECOMMENDATIONS

The stormwater analysis and design for this site is presented for review and comment along with the preliminary plans. Due to the existing sandy lean clays, the site has been determined to be unsuitable for infiltration. Therefore, the existing stormwater wet pond will be expanded to meet the rate control and the water quality requirements for the site improvements.

ANALYSIS AND DESIGN

Procedurally, the surface water hydrological conditions for the existing and proposed conditions on the site were analyzed for each of the statistical rainfall events included. The events analyzed use Atlas 14 rainfall intensity frequencies and MSE rainfall distributions as follows:

- 2-year, 24-hour rainfall of 2.84 inches
- 10-year, 24-hour rainfall of 4.22 inches
- 100-year, 24-hour rainfall of 7.12 inches

The analysis is accomplished using the HydroCAD, Version 10.0, Stormwater Modeling System software by HydroCAD Software Solutions, LLC. Within the software, the user selects certain methods and techniques that are dependent upon the user preferences and the application. For the design of the proposed post-development systems, the following methods and preferences are used:

Site Specific Soil/Surface Cover Conditions: SCS* TR-20 Methods

Time of Concentration: SCS TR-55 Methods
Unit Hydrograph: SCS TR-20 Methods
Reach Routing / Pond Routing: Storage-Indication Method

*SCS (Soil Conservation Service) is now known as NRCS (Natural Resources Conservation Service).

Each of these methods or techniques is explained in detail in the National Engineering Handbook: Section 4 - Hydrology, as well as several additional references.

EXISTING SITE DRAINAGE

With the existing site conditions, three (3) drainage areas were determined as follows:

- 1E – This 5.45-acre area flows overland to the northeast towards to the existing stormwater pond. It is agricultural area with an impervious surface area of 2.3% from the existing paved turnaround.
- 2E – This area flows overland to the north and is farm field. It is 2.40 acres in size and has no impervious surface area.
- 3E – This 1.06-acre area flows overland to the south. It is agricultural area with no impervious surface area.

An analysis of the runoff rates and volumes from this drainage area for the design rainfall events was completed using the HydroCAD model. This analysis indicated that the peak stormwater runoff rates from this site are as follows:

- 2-year, 24-hour rainfall = 6.00 cfs
- 10-year, 24-hour rainfall = 13.67 cfs
- 100-year, 24-hour rainfall = 32.38 cfs

A copy of the Existing Conditions Summary Output is attached.

POST-DEVELOPMENT SITE DRAINAGE

With the previously described improvements on the project site, there are three (3) proposed drainage areas described as follows:

- S1 – This 5.45-acre area flows overland and via proposed storm sewer to the northeast stormwater wet pond. It includes all of the proposed building roof areas as well as the paved and gravel areas for an impervious surface area of 51.6%.
- S2 – This area is existing drainage area E2 and remains unchanged.
- S3 – This area is existing drainage area E3 and remains unchanged.

The expanded stormwater wet pond will have 3:1 side slopes, a bottom elevation of 980.0, a 10:1 safety bench and NWL at an elevation of 985.5 and a top elevation of 990.0. The pond will utilize the existing outlet structure with a rim elevation of 988.00 and an invert elevation of 985.50. The outlet structure discharges to the east via a 15" concrete pipe. The existing EOF is at elevation 989.10 for this pond.

Analysis of the runoff rates for the design rainfall events were completed using the HydroCAD model. This analysis indicated that the peak stormwater runoff rates from the site are as follows:

- 2-year, 24-hour rainfall = 5.28 cfs
- 10-year, 24-hour rainfall = 9.61 cfs
- 100-year, 24-hour rainfall = 27.73 cfs

The permanent pool within the expanded stormwater pond has been designed to treat the stormwater runoff volume for a 1" rainfall over the proposed impervious surface area or 10,108 CF. The expanded permanent pool volume is 32,424 CF. Therefore, the City's stormwater quality requirement is met.

For each of the three design rainfall events analyzed, the peak runoff rates from the proposed conditions are less than the existing conditions and the City's rate control requirements are met.

A copy of the Post-Development Summary Output is attached.

**EXISTING CONDITIONS
SUMMARY OUTPUT**



BURLINGTON NORTHERN RAILROAD

2E

To North

1E

To NE

3E

To South

Subcat

Reach

Pond

Link

Routing Diagram for 23-142 Existing
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23-142 Existing

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MSE 24-hr 3 2-Year Rainfall=2.84"

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Summary for Subcatchment 1E: To NE

Runoff = 4.04 cfs @ 12.44 hrs, Volume= 16,977 cf, Depth= 0.86"
 Routed to nonexistent node SWP

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs
 MSE 24-hr 3 2-Year Rainfall=2.84"

Area (sf)	CN	Description
* 5,521	98	Pavement
231,986	74	Pasture/grassland/range, Good, HSG C
237,507	75	Weighted Average
231,986	74	97.68% Pervious Area
5,521	98	2.32% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
23.8	150	0.0180	0.11		Sheet Flow, HP to SCF Grass: Dense n= 0.240 P2= 2.40"
4.5	404	0.0099	1.49		Shallow Concentrated Flow, SF to LP Grassed Waterway Kv= 15.0 fps
28.3	554	Total			

Summary for Subcatchment 2E: To North

Runoff = 1.32 cfs @ 12.63 hrs, Volume= 7,056 cf, Depth= 0.81"
 Routed to nonexistent node 2P

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs
 MSE 24-hr 3 2-Year Rainfall=2.84"

Area (sf)	CN	Description
104,740	74	Pasture/grassland/range, Good, HSG C
104,740	74	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
38.8	150	0.0053	0.06		Sheet Flow, HP to SCF Grass: Dense n= 0.240 P2= 2.40"
2.3	207	0.0101	1.51		Shallow Concentrated Flow, SF to LP Grassed Waterway Kv= 15.0 fps
41.1	357	Total			

Summary for Subcatchment 3E: To South

Runoff = 0.64 cfs @ 12.55 hrs, Volume= 3,119 cf, Depth= 0.81"
 Routed to nonexistent node 2P

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs
 MSE 24-hr 3 2-Year Rainfall=2.84"

23-142 Existing

MSE 24-hr 3 2-Year Rainfall=2.84"

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Area (sf)	CN	Description			
46,303	74	Pasture/grassland/range, Good, HSG C			
46,303	74	100.00% Pervious Area			

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
35.3	150	0.0067	0.07		Sheet Flow, HP to SCF
					Grass: Dense n= 0.240 P2= 2.40"
0.3	26	0.0115	1.61		Shallow Concentrated Flow, SF to LP
					Grassed Waterway Kv= 15.0 fps
35.6	176	Total			

23-142 Existing

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MSE 24-hr 3 10-Year Rainfall=4.22"

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Summary for Subcatchment 1E: To NE

Runoff = 9.13 cfs @ 12.42 hrs, Volume= 36,288 cf, Depth= 1.83"
 Routed to nonexistent node SWP

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs
 MSE 24-hr 3 10-Year Rainfall=4.22"

Area (sf)	CN	Description
* 5,521	98	Pavement
231,986	74	Pasture/grassland/range, Good, HSG C
237,507	75	Weighted Average
231,986	74	97.68% Pervious Area
5,521	98	2.32% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
23.8	150	0.0180	0.11		Sheet Flow, HP to SCF Grass: Dense n= 0.240 P2= 2.40"
4.5	404	0.0099	1.49		Shallow Concentrated Flow, SF to LP Grassed Waterway Kv= 15.0 fps
28.3	554	Total			

Summary for Subcatchment 2E: To North

Runoff = 3.06 cfs @ 12.60 hrs, Volume= 15,358 cf, Depth= 1.76"
 Routed to nonexistent node 2P

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs
 MSE 24-hr 3 10-Year Rainfall=4.22"

Area (sf)	CN	Description
104,740	74	Pasture/grassland/range, Good, HSG C
104,740	74	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
38.8	150	0.0053	0.06		Sheet Flow, HP to SCF Grass: Dense n= 0.240 P2= 2.40"
2.3	207	0.0101	1.51		Shallow Concentrated Flow, SF to LP Grassed Waterway Kv= 15.0 fps
41.1	357	Total			

Summary for Subcatchment 3E: To South

Runoff = 1.48 cfs @ 12.52 hrs, Volume= 6,790 cf, Depth= 1.76"
 Routed to nonexistent node 2P

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs
 MSE 24-hr 3 10-Year Rainfall=4.22"

23-142 Existing

MSE 24-hr 3 10-Year Rainfall=4.22"

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Area (sf)	CN	Description			
46,303	74	Pasture/grassland/range, Good, HSG C			
46,303	74	100.00% Pervious Area			

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
35.3	150	0.0067	0.07		Sheet Flow, HP to SCF Grass: Dense n= 0.240 P2= 2.40"
0.3	26	0.0115	1.61		Shallow Concentrated Flow, SF to LP Grassed Waterway Kv= 15.0 fps
35.6	176	Total			

23-142 Existing

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MSE 24-hr 3 100-Year Rainfall=7.12"

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Summary for Subcatchment 1E: To NE

Runoff = 21.44 cfs @ 12.40 hrs, Volume= 84,223 cf, Depth= 4.26"
 Routed to nonexistent node SWP

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs
 MSE 24-hr 3 100-Year Rainfall=7.12"

Area (sf)	CN	Description
* 5,521	98	Pavement
231,986	74	Pasture/grassland/range, Good, HSG C
237,507	75	Weighted Average
231,986	74	97.68% Pervious Area
5,521	98	2.32% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
23.8	150	0.0180	0.11		Sheet Flow, HP to SCF Grass: Dense n= 0.240 P2= 2.40"
4.5	404	0.0099	1.49		Shallow Concentrated Flow, SF to LP Grassed Waterway Kv= 15.0 fps
28.3	554	Total			

Summary for Subcatchment 2E: To North

Runoff = 7.38 cfs @ 12.57 hrs, Volume= 36,195 cf, Depth= 4.15"
 Routed to nonexistent node 2P

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs
 MSE 24-hr 3 100-Year Rainfall=7.12"

Area (sf)	CN	Description
104,740	74	Pasture/grassland/range, Good, HSG C
104,740	74	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
38.8	150	0.0053	0.06		Sheet Flow, HP to SCF Grass: Dense n= 0.240 P2= 2.40"
2.3	207	0.0101	1.51		Shallow Concentrated Flow, SF to LP Grassed Waterway Kv= 15.0 fps
41.1	357	Total			

Summary for Subcatchment 3E: To South

Runoff = 3.56 cfs @ 12.50 hrs, Volume= 16,001 cf, Depth= 4.15"
 Routed to nonexistent node 2P

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs
 MSE 24-hr 3 100-Year Rainfall=7.12"

23-142 Existing

MSE 24-hr 3 100-Year Rainfall=7.12"

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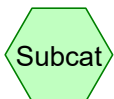
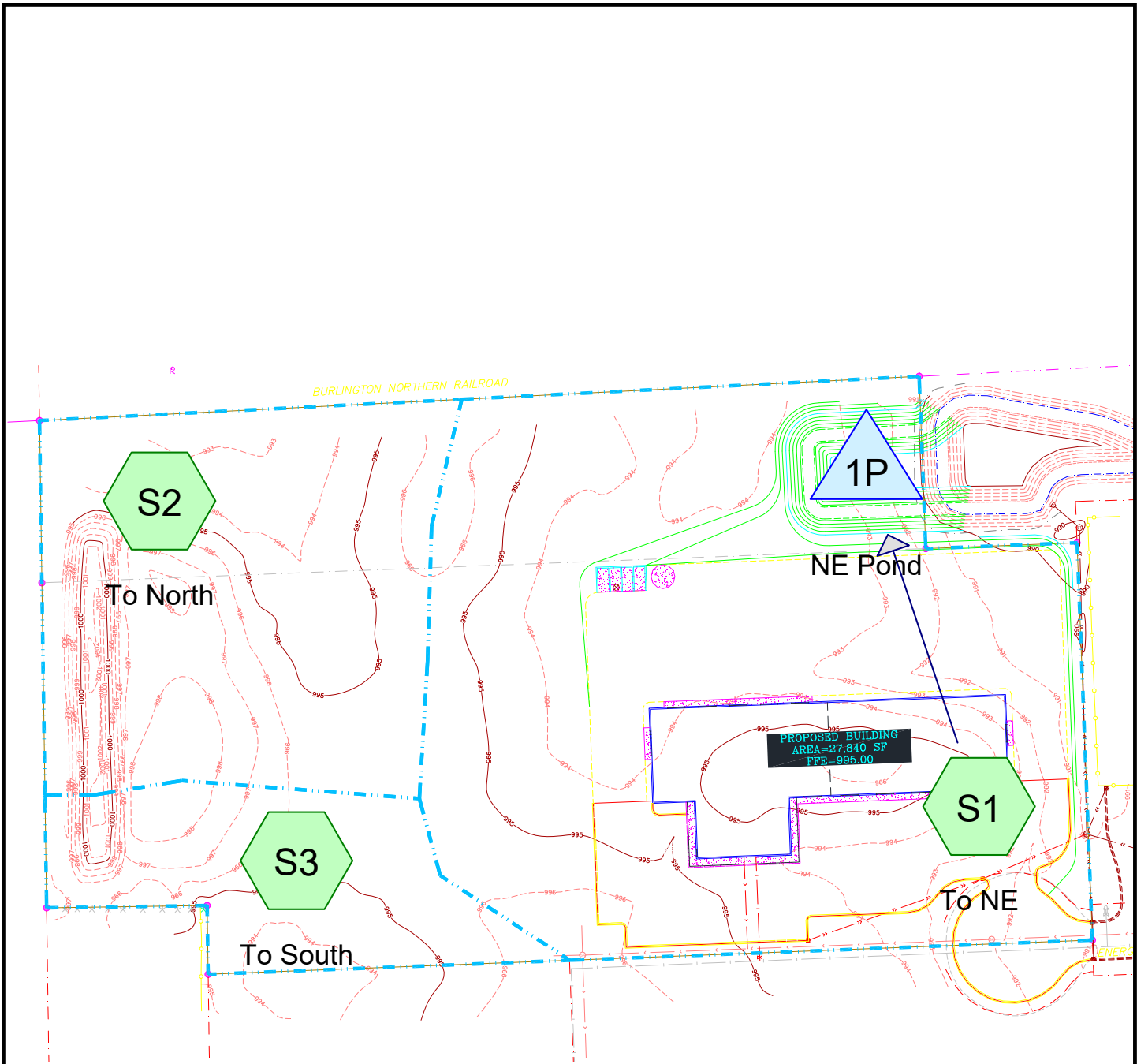
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Area (sf)	CN	Description			
46,303	74	Pasture/grassland/range, Good, HSG C			
46,303	74	100.00% Pervious Area			

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
35.3	150	0.0067	0.07		Sheet Flow, HP to SCF Grass: Dense n= 0.240 P2= 2.40"
0.3	26	0.0115	1.61		Shallow Concentrated Flow, SF to LP Grassed Waterway Kv= 15.0 fps
35.6	176	Total			

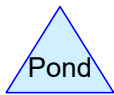
**POST-DEVELOPMENT
SUMMARY OUTPUT**



Subcat



Reach



Pond



Link

Routing Diagram for 23-142 Proposed
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MSE 24-hr 3 2-Year Rainfall=2.84"

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Summary for Subcatchment S1: To NE

Runoff = 12.62 cfs @ 12.18 hrs, Volume= 30,208 cf, Depth= 1.53"
Routed to Pond 1P : NE Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs
MSE 24-hr 3 2-Year Rainfall=2.84"

	Area (sf)	CN	Description
*	27,840	98	Building roof
*	42,565	98	Pavement
	52,121	96	Gravel surface
	114,981	74	>75% Grass cover, Good, HSG C
	237,507	86	Weighted Average
	167,102	81	70.36% Pervious Area
	70,405	98	29.64% Impervious Area

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

Summary for Subcatchment S2: To North

Runoff = 1.32 cfs @ 12.63 hrs, Volume= 7,056 cf, Depth= 0.81"
Routed to nonexistent node 2P

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs
MSE 24-hr 3 2-Year Rainfall=2.84"

	Area (sf)	CN	Description
	104,740	74	Pasture/grassland/range, Good, HSG C
	104,740	74	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
38.8	150	0.0053	0.06		Sheet Flow, HP to SCF
					Grass: Dense n= 0.240 P2= 2.40"
2.3	207	0.0101	1.51		Shallow Concentrated Flow, SF to LP
					Grassed Waterway Kv= 15.0 fps
41.1	357	Total			

Summary for Subcatchment S3: To South

Runoff = 0.64 cfs @ 12.55 hrs, Volume= 3,119 cf, Depth= 0.81"
Routed to nonexistent node 2P

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs
MSE 24-hr 3 2-Year Rainfall=2.84"

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MSE 24-hr 3 2-Year Rainfall=2.84"

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Area (sf)	CN	Description
46,303	74	Pasture/grassland/range, Good, HSG C
46,303	74	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
35.3	150	0.0067	0.07		Sheet Flow, HP to SCF Grass: Dense n= 0.240 P2= 2.40"
0.3	26	0.0115	1.61		Shallow Concentrated Flow, SF to LP Grassed Waterway Kv= 15.0 fps
35.6	176	Total			

Summary for Pond 1P: NE Pond

Inflow Area = 237,507 sf, 29.64% Impervious, Inflow Depth = 1.53" for 2-Year event
 Inflow = 12.62 cfs @ 12.18 hrs, Volume= 30,208 cf
 Outflow = 3.32 cfs @ 12.49 hrs, Volume= 30,026 cf, Atten= 74%, Lag= 18.6 min
 Primary = 3.32 cfs @ 12.49 hrs, Volume= 30,026 cf
 Secondary = 0.00 cfs @ 1.00 hrs, Volume= 0 cf

Routing by Dyn-Stor-Ind method, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs
 Peak Elev= 986.77' @ 12.49 hrs Surf.Area= 10,676 sf Storage= 12,926 cf

Plug-Flow detention time= 123.7 min calculated for 30,026 cf (99% of inflow)
 Center-of-Mass det. time= 120.0 min (927.5 - 807.5)

Volume #1	Invert 985.50'	Avail.Storage 51,686 cf	Storage Description
Custom Stage Data (Prismatic) Listed below (Recalc)			
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
985.50	9,660	0	0
986.00	10,054	4,929	4,929
987.00	10,860	10,457	15,386
988.00	11,676	11,268	26,654
989.00	12,520	12,098	38,752
990.00	13,349	12,935	51,686

Device	Routing	Invert	Outlet Devices
#1	Primary	985.50'	15.0" Round Culvert L= 27.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 985.50' / 985.40' S= 0.0037 ' / ' Cc= 0.900 n= 0.012 Concrete pipe, finished, Flow Area= 1.23 sf
#2	Device 1	985.50'	12.0" Vert. Orifice/Grate C= 0.600 Limited to weir flow at low heads
#3	Device 1	988.00'	48.0" Horiz. Orifice/Grate C= 0.600 Limited to weir flow at low heads
#4	Secondary	989.10'	15.0' long + 1.0 ' / SideZ x 10.0' breadth Broad-Crested Rectangular Weir Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64

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MSE 24-hr 3 2-Year Rainfall=2.84"

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Primary OutFlow Max=3.32 cfs @ 12.49 hrs HW=986.77' (Free Discharge)

↑1=Culvert (Passes 3.32 cfs of 3.76 cfs potential flow)

↑2=Orifice/Grate (Orifice Controls 3.32 cfs @ 4.23 fps)

↑3=Orifice/Grate (Controls 0.00 cfs)

Secondary OutFlow Max=0.00 cfs @ 1.00 hrs HW=985.50' (Free Discharge)

↑4=Broad-Crested Rectangular Weir (Controls 0.00 cfs)

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MSE 24-hr 3 10-Year Rainfall=4.22"

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Summary for Subcatchment S1: To NE

Runoff = 22.43 cfs @ 12.17 hrs, Volume= 54,357 cf, Depth= 2.75"
 Routed to Pond 1P : NE Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs
 MSE 24-hr 3 10-Year Rainfall=4.22"

	Area (sf)	CN	Description
*	27,840	98	Building roof
*	42,565	98	Pavement
	52,121	96	Gravel surface
	114,981	74	>75% Grass cover, Good, HSG C
	237,507	86	Weighted Average
	167,102	81	70.36% Pervious Area
	70,405	98	29.64% Impervious Area

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

Summary for Subcatchment S2: To North

Runoff = 3.06 cfs @ 12.60 hrs, Volume= 15,358 cf, Depth= 1.76"
 Routed to nonexistent node 2P

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs
 MSE 24-hr 3 10-Year Rainfall=4.22"

	Area (sf)	CN	Description
	104,740	74	Pasture/grassland/range, Good, HSG C
	104,740	74	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
38.8	150	0.0053	0.06		Sheet Flow, HP to SCF
					Grass: Dense n= 0.240 P2= 2.40"
2.3	207	0.0101	1.51		Shallow Concentrated Flow, SF to LP
					Grassed Waterway Kv= 15.0 fps
41.1	357	Total			

Summary for Subcatchment S3: To South

Runoff = 1.48 cfs @ 12.52 hrs, Volume= 6,790 cf, Depth= 1.76"
 Routed to nonexistent node 2P

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs
 MSE 24-hr 3 10-Year Rainfall=4.22"

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MSE 24-hr 3 10-Year Rainfall=4.22"

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Area (sf)	CN	Description
46,303	74	Pasture/grassland/range, Good, HSG C
46,303	74	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
35.3	150	0.0067	0.07		Sheet Flow, HP to SCF Grass: Dense n= 0.240 P2= 2.40"
0.3	26	0.0115	1.61		Shallow Concentrated Flow, SF to LP Grassed Waterway Kv= 15.0 fps
35.6	176	Total			

Summary for Pond 1P: NE Pond

Inflow Area = 237,507 sf, 29.64% Impervious, Inflow Depth = 2.75" for 10-Year event
 Inflow = 22.43 cfs @ 12.17 hrs, Volume= 54,357 cf
 Outflow = 5.07 cfs @ 12.52 hrs, Volume= 54,172 cf, Atten= 77%, Lag= 20.5 min
 Primary = 5.07 cfs @ 12.52 hrs, Volume= 54,172 cf
 Secondary = 0.00 cfs @ 1.00 hrs, Volume= 0 cf

Routing by Dyn-Stor-Ind method, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs
 Peak Elev= 987.79' @ 12.52 hrs Surf.Area= 11,509 sf Storage= 24,275 cf

Plug-Flow detention time= 102.1 min calculated for 54,134 cf (100% of inflow)
 Center-of-Mass det. time= 101.8 min (897.4 - 795.7)

Volume #1	Invert	Avail.Storage	Storage Description
	985.50'	51,686 cf	Custom Stage Data (Prismatic) Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
985.50	9,660	0	0
986.00	10,054	4,929	4,929
987.00	10,860	10,457	15,386
988.00	11,676	11,268	26,654
989.00	12,520	12,098	38,752
990.00	13,349	12,935	51,686

Device	Routing	Invert	Outlet Devices
#1	Primary	985.50'	15.0" Round Culvert L= 27.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 985.50' / 985.40' S= 0.0037 ' / ' Cc= 0.900 n= 0.012 Concrete pipe, finished, Flow Area= 1.23 sf
#2	Device 1	985.50'	12.0" Vert. Orifice/Grate C= 0.600 Limited to weir flow at low heads
#3	Device 1	988.00'	48.0" Horiz. Orifice/Grate C= 0.600 Limited to weir flow at low heads
#4	Secondary	989.10'	15.0' long + 1.0 ' / SideZ x 10.0' breadth Broad-Crested Rectangular Weir Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64

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MSE 24-hr 3 10-Year Rainfall=4.22"

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Primary OutFlow Max=5.06 cfs @ 12.52 hrs HW=987.79' (Free Discharge)

↑1=Culvert (Passes 5.06 cfs of 7.38 cfs potential flow)

↑2=Orifice/Grate (Orifice Controls 5.06 cfs @ 6.45 fps)

↑3=Orifice/Grate (Controls 0.00 cfs)

Secondary OutFlow Max=0.00 cfs @ 1.00 hrs HW=985.50' (Free Discharge)

↑4=Broad-Crested Rectangular Weir (Controls 0.00 cfs)

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MSE 24-hr 3 100-Year Rainfall=7.12"

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Summary for Subcatchment S1: To NE

Runoff = 43.32 cfs @ 12.17 hrs, Volume= 108,485 cf, Depth= 5.48"
Routed to Pond 1P : NE Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs
MSE 24-hr 3 100-Year Rainfall=7.12"

	Area (sf)	CN	Description
*	27,840	98	Building roof
*	42,565	98	Pavement
	52,121	96	Gravel surface
	114,981	74	>75% Grass cover, Good, HSG C
	237,507	86	Weighted Average
	167,102	81	70.36% Pervious Area
	70,405	98	29.64% Impervious Area

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

Summary for Subcatchment S2: To North

Runoff = 7.38 cfs @ 12.57 hrs, Volume= 36,195 cf, Depth= 4.15"
Routed to nonexistent node 2P

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs
MSE 24-hr 3 100-Year Rainfall=7.12"

	Area (sf)	CN	Description
	104,740	74	Pasture/grassland/range, Good, HSG C
	104,740	74	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
38.8	150	0.0053	0.06		Sheet Flow, HP to SCF
					Grass: Dense n= 0.240 P2= 2.40"
2.3	207	0.0101	1.51		Shallow Concentrated Flow, SF to LP
					Grassed Waterway Kv= 15.0 fps
41.1	357	Total			

Summary for Subcatchment S3: To South

Runoff = 3.56 cfs @ 12.50 hrs, Volume= 16,001 cf, Depth= 4.15"
Routed to nonexistent node 2P

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs
MSE 24-hr 3 100-Year Rainfall=7.12"

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MSE 24-hr 3 100-Year Rainfall=7.12"

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Area (sf)	CN	Description
46,303	74	Pasture/grassland/range, Good, HSG C
46,303	74	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
35.3	150	0.0067	0.07		Sheet Flow, HP to SCF Grass: Dense n= 0.240 P2= 2.40"
0.3	26	0.0115	1.61		Shallow Concentrated Flow, SF to LP Grassed Waterway Kv= 15.0 fps
35.6	176	Total			

Summary for Pond 1P: NE Pond

Inflow Area = 237,507 sf, 29.64% Impervious, Inflow Depth = 5.48" for 100-Year event
 Inflow = 43.32 cfs @ 12.17 hrs, Volume= 108,485 cf
 Outflow = 16.79 cfs @ 12.37 hrs, Volume= 108,297 cf, Atten= 61%, Lag= 12.0 min
 Primary = 10.68 cfs @ 12.37 hrs, Volume= 103,666 cf
 Secondary = 6.11 cfs @ 12.37 hrs, Volume= 4,631 cf

Routing by Dyn-Stor-Ind method, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs
 Peak Elev= 989.39' @ 12.37 hrs Surf.Area= 12,847 sf Storage= 43,751 cf

Plug-Flow detention time= 82.6 min calculated for 108,297 cf (100% of inflow)
 Center-of-Mass det. time= 81.4 min (863.4 - 782.0)

Volume #1	Invert 985.50'	Avail.Storage 51,686 cf	Storage Description
Custom Stage Data (Prismatic) Listed below (Recalc)			
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
985.50	9,660	0	0
986.00	10,054	4,929	4,929
987.00	10,860	10,457	15,386
988.00	11,676	11,268	26,654
989.00	12,520	12,098	38,752
990.00	13,349	12,935	51,686

Device	Routing	Invert	Outlet Devices
#1	Primary	985.50'	15.0" Round Culvert L= 27.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 985.50' / 985.40' S= 0.0037 ' / ' Cc= 0.900 n= 0.012 Concrete pipe, finished, Flow Area= 1.23 sf
#2	Device 1	985.50'	12.0" Vert. Orifice/Grate C= 0.600 Limited to weir flow at low heads
#3	Device 1	988.00'	48.0" Horiz. Orifice/Grate C= 0.600 Limited to weir flow at low heads
#4	Secondary	989.10'	15.0' long + 1.0 ' SideZ x 10.0' breadth Broad-Crested Rectangular Weir Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64

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MSE 24-hr 3 100-Year Rainfall=7.12"

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Primary OutFlow Max=10.67 cfs @ 12.37 hrs HW=989.38' (Free Discharge)

↑1=Culvert (Inlet Controls 10.67 cfs @ 8.69 fps)

↑2=Orifice/Grate (Passes < 6.96 cfs potential flow)

↑3=Orifice/Grate (Passes < 66.91 cfs potential flow)

Secondary OutFlow Max=5.81 cfs @ 12.37 hrs HW=989.38' (Free Discharge)

↑4=Broad-Crested Rectangular Weir (Weir Controls 5.81 cfs @ 1.34 fps)