Attachment 3

Memorandum

SRF No. 18244

To: Brian Olsen, Environmental Resource Specialist
Ramsey County Parks & Recreation

Cc: Connie Taillon, City of White Bear Lake
Lauren Sampedro, VLAWMO

From: Leah Gifford, PE, Sr. Project Manager
Kyra Hauser, Engineer III
Claire Matrisciano, Engineer I

Date: November 11, 2024

Subject: White Bear Lake Sports Center Stormwater Retrofit Feasibility Study – Conceptual Design

Project Summary

SRF Consulting Group, Inc. was commissioned by Ramsey County to provide engineering services for a retrofit of the stormwater swale adjacent to the White Bear Lake Sports Center Parking Lot at Birch Lake Boulevard to improve water quality to Birch Lake and its many downstream lakes. The primary goal of the project is to assess potential stormwater BMP retrofits to improve water quality, stabilize the channel, and promote volume reduction. This project is a partnered effort between Ramsey County, City of White Bear Lake, and Vadnais Lake Area Watershed Management Organization (VLAWMO).

The major project phases can be described as:

- Data Collection
- Conceptual Designs of Projects
- Draft and Final Construction Documents

This memorandum will focus on data collection and the conceptual design of the BMPs. If approved by partners, the design will advance to construction documents.

Data Collection

Online and Provided Data

Data collection began with a desktop review of existing conditions data including:

- MnDNR LiDAR data,
- As-built plans for South Birch Lake Road, and

- Information provided from the completion of a Gopher State One Call to obtain utility location information for the project area.

Field Data Collection

- Gale-Tec Engineering (GTE) collected soil borings on September 11, 2024. The Geotechnical Report will be provided once complete.
- On September 23 and October 9, 2024, survey staff from SRF collected topographic data at the project site. The survey included the following: channel flow line and sides, pipe inverts and sizes in the catch basin along South Birch Lake Road, and the pipe invert and size of the culvert under the pedestrian walkway. Data was collected using survey grade GPS and imported into CAD for use in design.

Conceptual Design

The concept design will consider a bioretention swale with several ditch blocks to replace the existing stormwater swale adjacent to the parking lot as well as two water quality structures, see Attachment A. The geotechnical study indicated a clayey soils with low infiltration potential. Therefore, the design incorporated drain tile under the bioretention media to ensure adequate drainage. The pretreatment included in the design include a Rain Guardian curb inlet and a sumped manhole with a SAFL Baffle. The Rain Guardian will be placed at the parking lot outlet to capture sediment and silt before runoff enters the bioretention swale. The sumped manhole with a baffle will pretreat the road and neighborhood runoff downstream of the catch basin along South Birch Lake Road and before draining into the bioretention swale. Due to space constraints near South Birch Lake Road, structural pretreatment was identified as the best option when compared to a wet forebay. A baffle was chosen instead of other structural devices because it is more cost-effective for this location, provides good TSS capture when cleaned regularly, and the maintenance is familiar to the City's Public Works staff.

Modeling Approach

Hydraulic Modeling

HydroCAD was used to model the watershed hydrology and calculate the flow rates to the stormwater swale. The swale sections and information, including manning's values, slopes, and flow rates from HydroCAD, were added to the FHWA's Hydraulic Toolbox to gather information on the shear stresses. The flow results from the HydroCAD model for the 2-year, 10-year, 50-year, and 100-year, 24-hour storm events are provided in Table 1. See Attachment B for the HydroCAD model output.

Table 1: Flow Rates through the Swale

	2 YR Flow Rate (cfs)	10 YR Flow Rate (cfs)	50 YR Flow Rate (cfs)	100 YR Flow Rate (cfs)
Swale	6.9 – 7.4	15.7 – 16.7	31.0 – 32.7	39.5 – 41.5

With the proposed improvements, the stormwater swale will allow filtration through the filter media, which will slow down runoff to the wetland. The culvert underneath the pedestrian walk will be upsized and will allow more flow under the walk compared to existing conditions, which should reduce to an extent the amount of overtopping in larger storm events.

Existing cross sections from the surveyed topography were then added to the FHWA's Hydraulic Toolbox version 5.4 to understand the shear stresses and velocities at various locations in the channel as well as the flow depth of 100-year flow within the existing channel. Flow depths range from 1.0-2.1 ft in the 100-year flow, velocities from 2.0-4.2 fps, and maximum shear stresses of 0.25-3.5 lb/sq ft. The highest of which was where erosion is most evident, from stations 3+25 to 4+50.

A proposed cross section with a 10 foot bottom and 1V:3H side slopes was then modeled to understand the proposed shear stresses. The maximum shear stresses were found to be approximately 0.40 lb/sq ft within a typical channel slope and should be stable when lined with vegetation. The design will propose temporary natural netting blanket as the vegetation establishes. To stabilize the channel just downstream of the ditch checks, we recommend Class II rounded random riprap on the back slope of each ditch check to provide a "riffle" design to slow and protect from erosion.

Water Quality Modeling

Phosphorus and TSS loading were modeled utilizing the Minimal Impact Design Standards (MIDS) software (Attachment C). The bioretention swale was modeled directly in the MIDS software. The Rain Guardian was assumed to have the TSS removal as noted in the product design documentation.

For conceptual level design, the SAFL Baffle was modeled in SHSAM using the MnDOT road sand particle size distribution to get an estimated TSS removal. The TSS removal rate was added to the MIDS model. The particulate phosphorous removal rate was assumed to be equivalent to TSS removal at 54% and the dissolved phosphorous was assumed to be 0%.

The annual volume of runoff removed by the BMPs was 2.3 ac-ft. The annual total phosphorus removal was 7.4 lbs, which consisted of 5.6 lbs of particulate phosphorus and 1.8 lbs of dissolved phosphorus. The annual TSS removed was 2,100 lbs.

Table 2: BMP Summary

BMP	TSS Removal (lb/yr)	TP removal (lb/yr)	Volume Reduction (ac-ft/yr)
Bioretention Swale	862	3.6	2.3

Baffle and Sump Structure	1,103	3.3	0
Rain Guardian	135	0.4	0
Total	2,100	7.3	2.3

Cost Estimate

Table 3: Conceptual Cost Estimate

Item	Estimated Percentage Assumption	Estimated Total Cost
Construction Subtotal	-	$136,600
Erosion Control And Turf Establishment	8%	$10,900
Contingency	30%	$41,000
Administration	10%	$18,800
Total		**$207,300**

Attachments

Attachment A – White Bear Lake Sports Center Conceptual Design (Plan, Profile and Details)

Attachment B – Drainage Map and HydroCAD Model Output

Attachment C – Water Quality Outputs

Attachment D – Geotechnical Report

SWALE OVERVIEW MAP

WHITE BEAR LAKE SPORTS CENTER
CONCEPTUAL DESIGN

WHITE BEAR LAKE, MN

ATTACHMENT A

OVERFLOW PARKING AREA

R/W

EXISTING 24" RCP @ 0.7%
APRON INV ELEV 926.61

CONSTRUCTION LIMITS

REPLACE GRAVEL
RAISE TRAIL 0.5' AND GRADE
AT 5% ON BOTH SIDES

INV ELEV 926.0'

INV ELEV 925.87'

DITCH BOTTOM ELEV 925.9'

GRAVEL PEDESTRIAN
WALK

DRAIN TILE OUTLET
INV ELEV 921.0'

0+00

1+00

2+00

3+00

4+00

5+00

5+98

REMOVE AND
REPLACE 16 LF
24" RCP PIPE

PROPOSED SWALE
0.7% SLOPE

GRAVEL PEDESTRIAN WALK CROSSING
REMOVE EXISTING 12" CMP PIPE
INSTALL 10' OF 15" CMP CULVERT 1'
ABOVE THE DITCH BOTTOM TO
ENCOURAGE FILTRATION.

REMOVE CONCRETE FLUME
AND REPLACE WITH WATER
QUALITY PRETREATMENT
STRUCTURE

WATER QUALITY
STRUCTURE WITH
SUMP AND BAFFLE

S BIRCH LAKE BLVD

BIRCH LAKE

WHITE BEAR LAKE SPORTS CENTER

0 25 50
SCALE IN FEET

LEGEND

- CATCH BASIN EXISTING/PROPOSED
- MANHOLE EXISTING/PROPOSED
- APRON EXISTING/PROPOSED
- PROPOSED STORM SEWER
- EXISTING STORM SEWER
- RIPRAP
- SURFACE FLOW ARROW
- DITCH CHECK
- PROPOSED DITCH LINE

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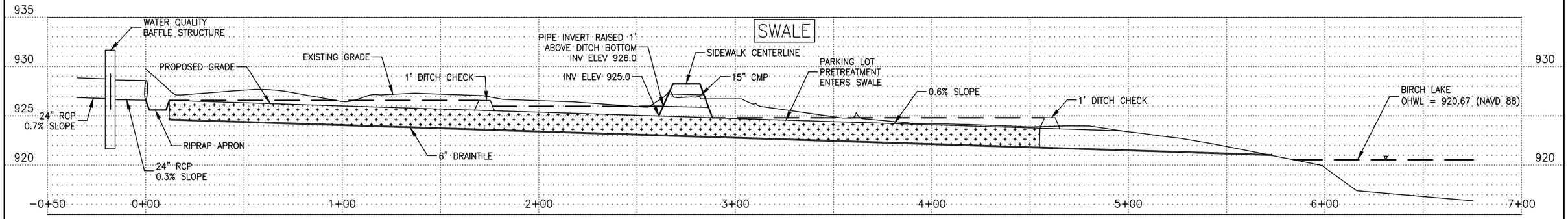

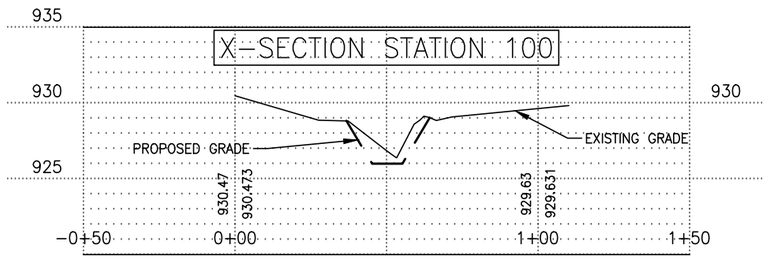

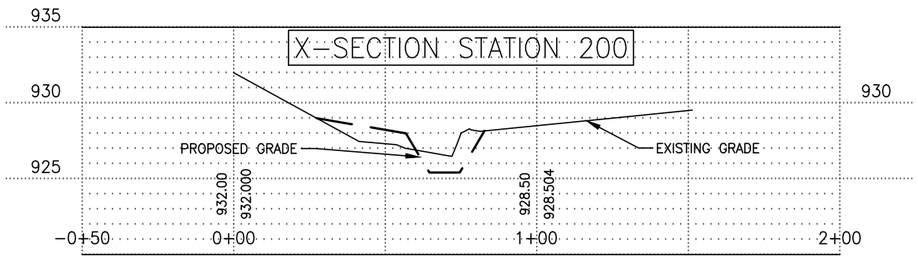

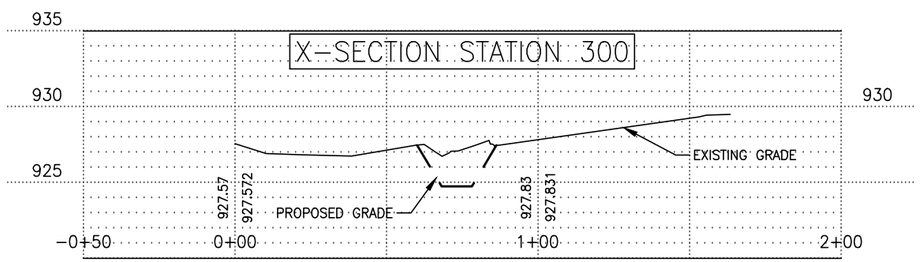

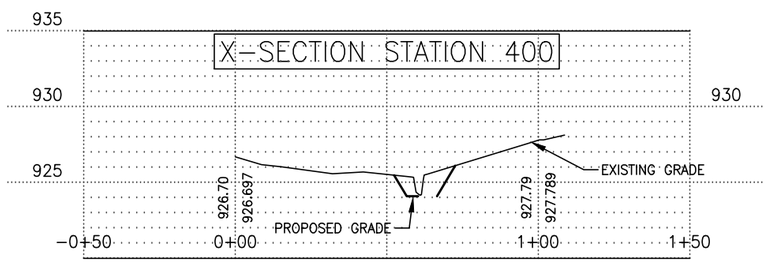

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SRF

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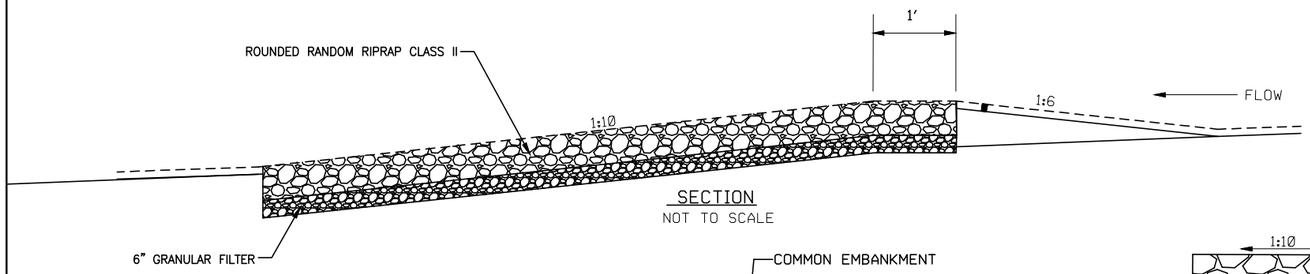
SWALE PROFILE AND CROSS SECTIONS

WHITE BEAR LAKE SPORTS CENTER CONCEPTUAL DESIGN
WHITE BEAR LAKE, MN

ATTACHMENT A



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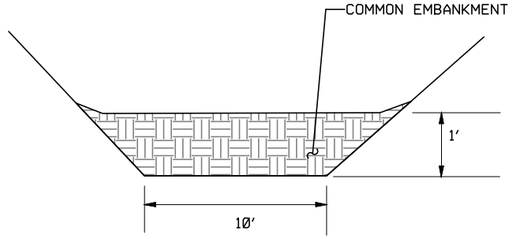

CROSS SECTION AT CREST
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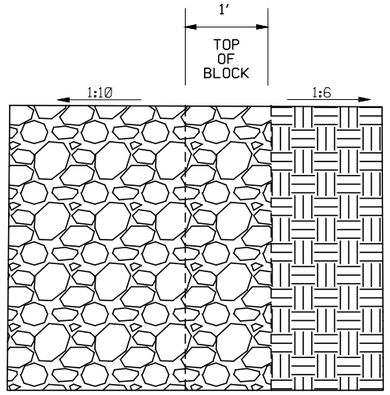
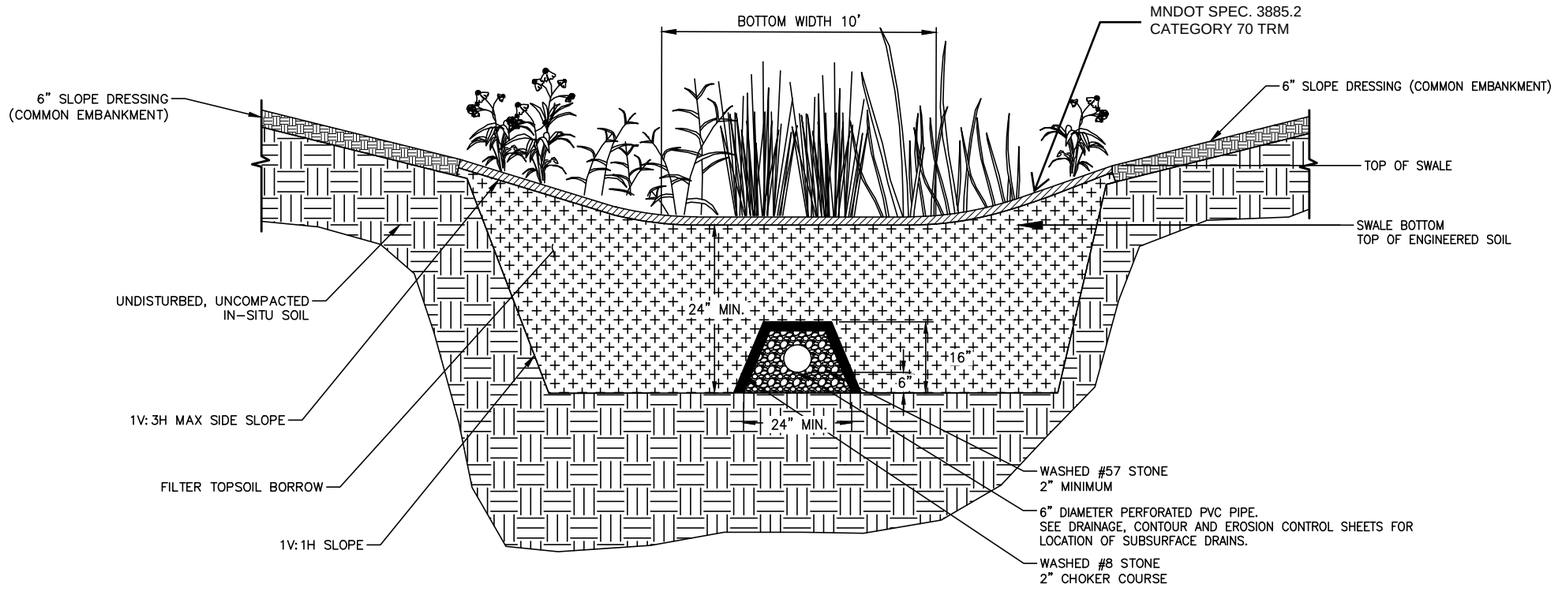


PLAN VIEW
NOT TO SCALE

DITCH CHECK
NOT TO SCALE



FILTRATION SWALE TYPICAL SECTION
NOT TO SCALE

DRAINAGE DETAILS

WHITE BEAR LAKE SPORTS CENTER
CONCEPTUAL DESIGN

WHITE BEAR LAKE, MN

ATTACHMENT A

SRF

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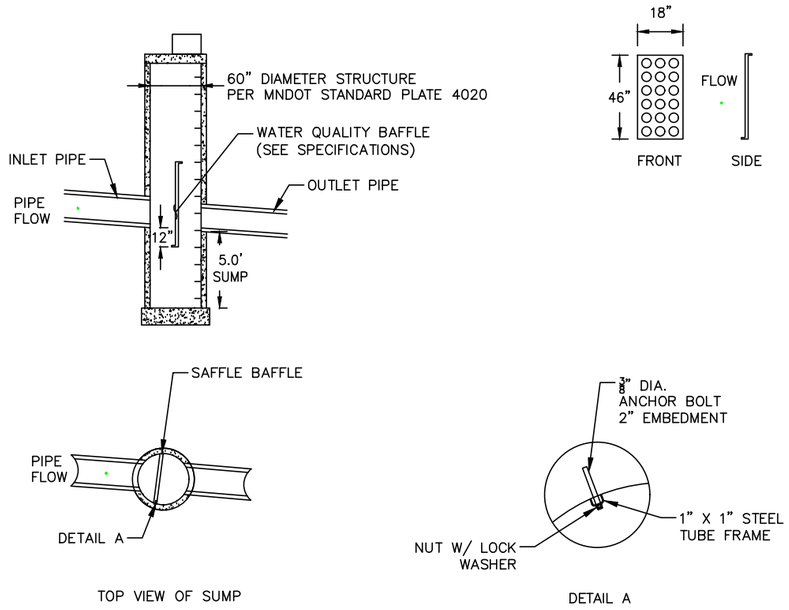
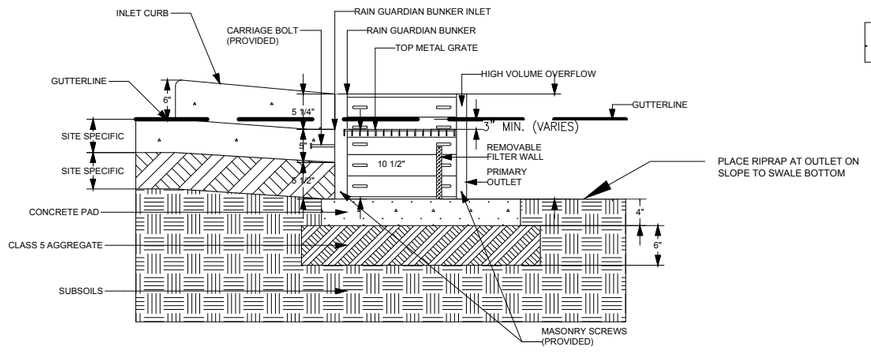


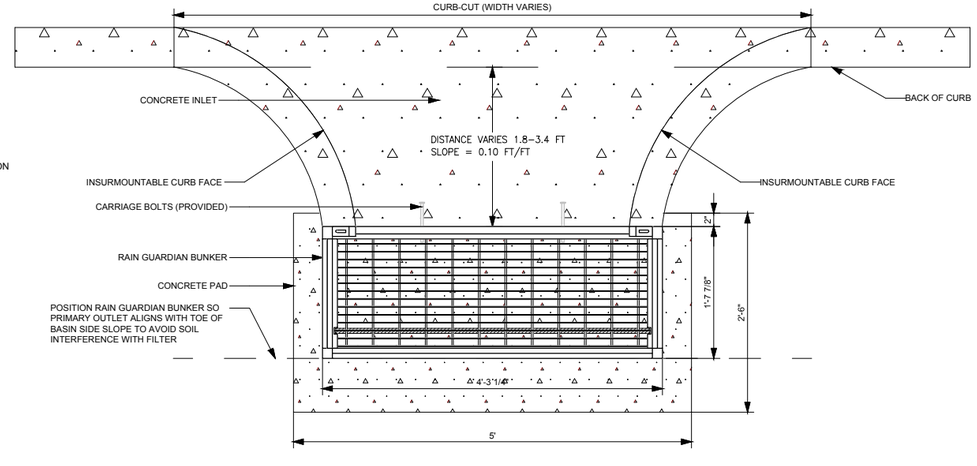
WATER QUALITY BAFFLE STRUCTURE ("SAFL" BAFFLE)

NOT TO SCALE

RAIN GUARDIAN BUNKER CROSS-SECTION VIEW
U.S. PATENT 8,501,016



RAIN GUARDIAN BUNKER PLAN VIEW
U.S. PATENT 8,501,016



PRETREATMENT STRUCTURE

NOT TO SCALE

DRAINAGE DETAILS

WHITE BEAR LAKE SPORTS CENTER
CONCEPTUAL DESIGN

WHITE BEAR LAKE, MN

ATTACHMENT A

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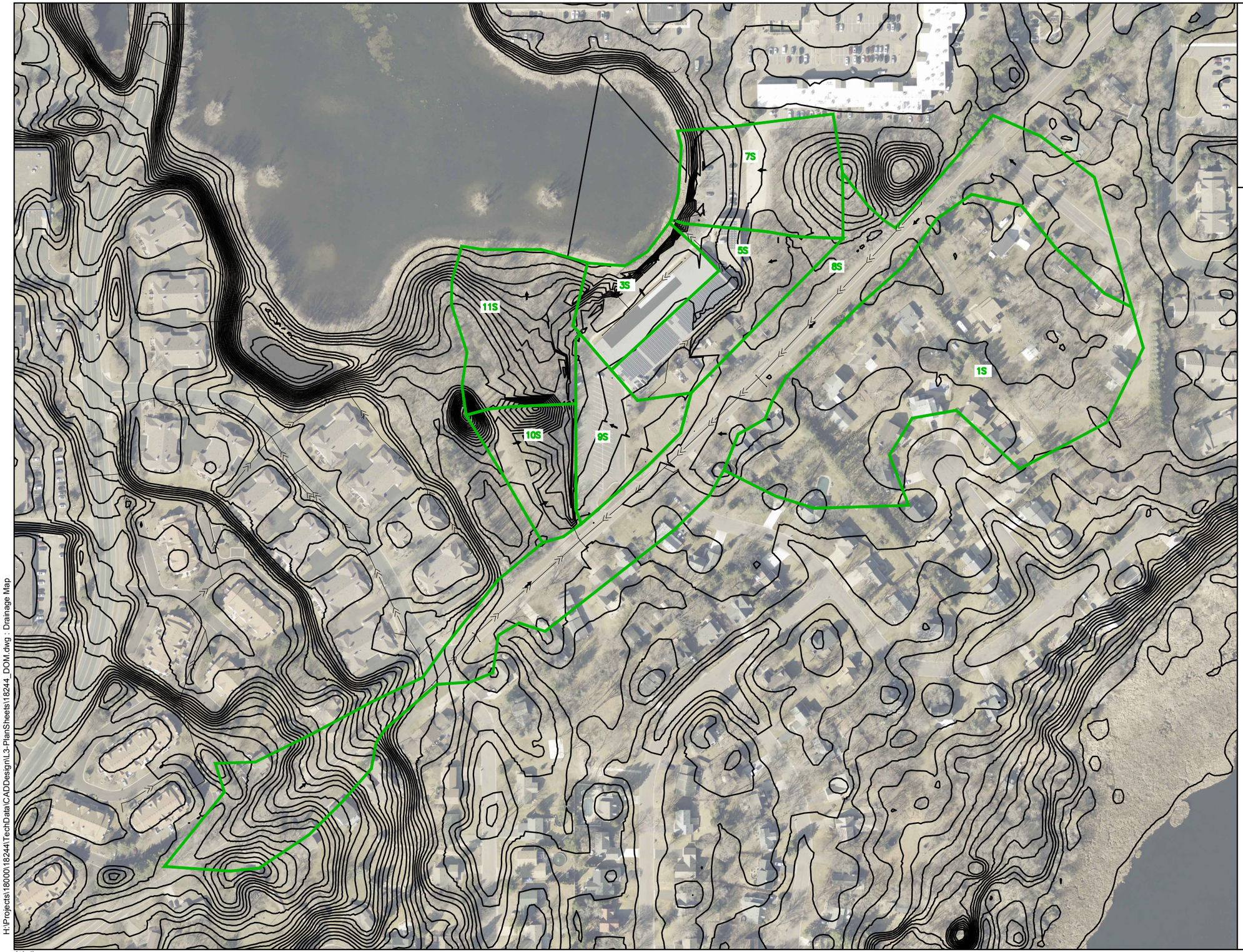

DRAINAGE OVERVIEW MAP

WHITE BEAR LAKE SPORTS CENTER
CONCEPTUAL DESIGN

WHTIE BEAR LAKE, MN

ATTACHMENT B

0 100 200
SCALE IN FEET

SRF

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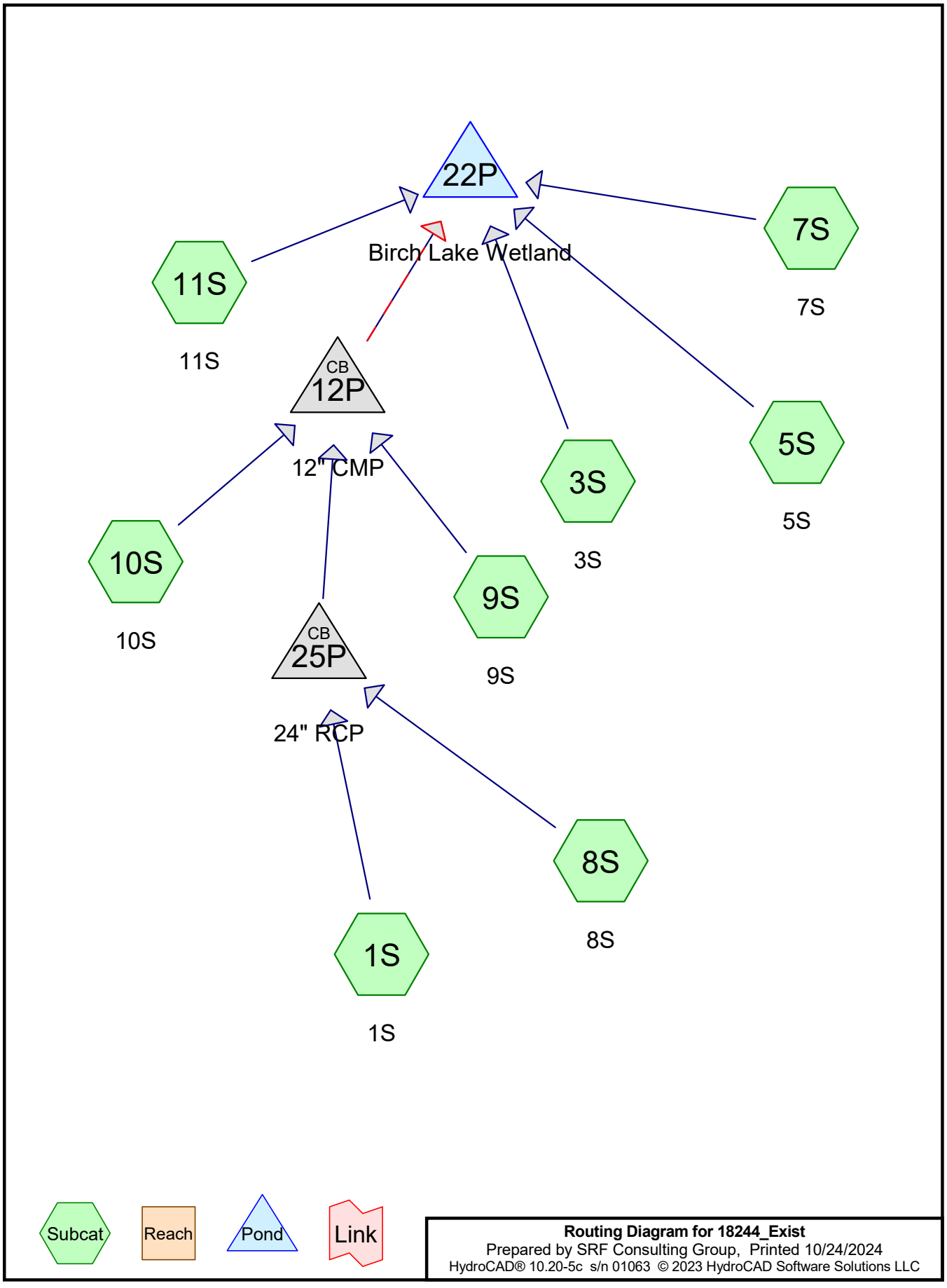


Routing Diagram for 18244_Exist
Prepared by SRF Consulting Group, Printed 10/24/2024

Project Notes

Rainfall events imported from "NRCS2-Rain.txt" for 471 MN Ramsey

Rainfall Events Listing (selected events)

Event#	Event Name	Storm Type	Curve	Mode	Duration (hours)	B/B	Depth (inches)	AMC
1	2-Year	MSE 24-hr	3	Default	24.00	1	2.81	2
2	10-Year	MSE 24-hr	3	Default	24.00	1	4.19	2
3	50-Year	MSE 24-hr	3	Default	24.00	1	6.27	2
4	100-Year	MSE 24-hr	3	Default	24.00	1	7.36	2

Area Listing (selected nodes)

Area (acres)	CN	Description (subcatchment-numbers)
17.204	69	50-75% Grass cover, Fair, HSG B (1S, 3S, 5S, 7S, 8S, 9S, 10S, 11S)
6.135	98	Paved parking, HSG B (1S, 3S, 5S, 7S, 8S, 9S, 10S)
23.339	**77**	**TOTAL AREA**

Soil Listing (selected nodes)

Area (acres)	Soil Group	Subcatchment Numbers
0.000	HSG A	
23.339	HSG B	1S, 3S, 5S, 7S, 8S, 9S, 10S, 11S
0.000	HSG C	
0.000	HSG D	
0.000	Other	
23.339		**TOTAL AREA**

Ground Covers (selected nodes)

HSG-A (acres)	HSG-B (acres)	HSG-C (acres)	HSG-D (acres)	Other (acres)	Total (acres)	Ground Cover	Subcatchment Numbers
0.000	17.204	0.000	0.000	0.000	17.204	50-75% Grass cover, Fair	1S, 3S, 5S, 7S, 8S, 9S, 10S, 11S
0.000	6.135	0.000	0.000	0.000	6.135	Paved parking	1S, 3S, 5S, 7S, 8S, 9S, 10S
0.000	**23.339**	**0.000**	**0.000**	**0.000**	**23.339**	**TOTAL AREA**	

Pipe Listing (selected nodes)

Line#	Node Number	In-Invert (feet)	Out-Invert (feet)	Length (feet)	Slope (ft/ft)	n	Width (inches)	Diam/Height (inches)	Inside-Fill (inches)	Node Name
1	8S	0.00	0.00	1,010.0	0.0050	0.012	0.0	24.0	0.0	
2	12P	926.87	926.80	30.0	0.0023	0.024	0.0	12.0	0.0	
3	25P	926.82	926.61	30.0	0.0070	0.012	0.0	24.0	0.0	

Time span=0.00-48.00 hrs, dt=0.01 hrs, 4801 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 1S: 1S Runoff Area=7.165 ac 9.99% Impervious Runoff Depth=0.70"
Flow Length=740' Tc=61.9 min CN=72 Runoff=2.49 cfs 0.416 af

Subcatchment 3S: 3S Runoff Area=1.066 ac 80.30% Impervious Runoff Depth=1.98"
Tc=12.0 min CN=92 Runoff=2.97 cfs 0.176 af

Subcatchment 5S: 5S Runoff Area=1.735 ac 30.03% Impervious Runoff Depth=1.00"
Tc=12.0 min CN=78 Runoff=2.44 cfs 0.144 af

Subcatchment 7S: 7S Runoff Area=1.804 ac 50.00% Impervious Runoff Depth=1.36"
Tc=12.0 min CN=84 Runoff=3.54 cfs 0.205 af

Subcatchment 8S: 8S Runoff Area=7.532 ac 30.01% Impervious Runoff Depth=1.00"
Flow Length=1,610' Tc=51.9 min CN=78 Runoff=4.59 cfs 0.625 af

Subcatchment 9S: 9S Runoff Area=1.131 ac 60.04% Impervious Runoff Depth=1.50"
Tc=12.0 min CN=86 Runoff=2.45 cfs 0.141 af

Subcatchment 10S: 10S Runoff Area=1.003 ac 20.04% Impervious Runoff Depth=0.84"
Tc=12.0 min CN=75 Runoff=1.16 cfs 0.070 af

Subcatchment 11S: 11S Runoff Area=1.903 ac 0.00% Impervious Runoff Depth=0.57"
Tc=12.0 min CN=69 Runoff=1.34 cfs 0.090 af

Pond 12P: 12" CMP Peak Elev=928.12' Inflow=7.42 cfs 1.253 af
Primary=1.87 cfs 0.720 af Secondary=5.56 cfs 0.533 af Outflow=7.42 cfs 1.253 af

Pond 22P: Birch Lake Wetland Peak Elev=920.13' Storage=1.868 af Inflow=14.89 cfs 1.868 af
Outflow=0.00 cfs 0.000 af

Pond 25P: 24" RCP Peak Elev=928.45' Inflow=6.92 cfs 1.041 af
24.0" Round Culvert n=0.012 L=30.0' S=0.0070 '/' Outflow=6.92 cfs 1.041 af

Total Runoff Area = 23.339 ac Runoff Volume = 1.868 af Average Runoff Depth = 0.96"
73.71% Pervious = 17.204 ac 26.29% Impervious = 6.135 ac

Summary for Subcatchment 1S: 1S

Runoff = 2.49 cfs @ 12.93 hrs, Volume= 0.416 af, Depth= 0.70"
Routed to Pond 25P : 24" RCP

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 2-Year Rainfall=2.81"

Area (ac)	CN	Description
6.449	69	50-75% Grass cover, Fair, HSG B
0.716	98	Paved parking, HSG B
7.165	72	Weighted Average
6.449		90.01% Pervious Area
0.716		9.99% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.7	100	0.0100	0.12		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.85"
48.2	640	0.0010	0.22		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
61.9	740	Total			

Summary for Subcatchment 3S: 3S

Runoff = 2.97 cfs @ 12.20 hrs, Volume= 0.176 af, Depth= 1.98"
Routed to Pond 22P : Birch Lake Wetland

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 2-Year Rainfall=2.81"

Area (ac)	CN	Description
0.856	98	Paved parking, HSG B
0.210	69	50-75% Grass cover, Fair, HSG B
1.066	92	Weighted Average
0.210		19.70% Pervious Area
0.856		80.30% Impervious Area

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

Summary for Subcatchment 5S: 5S

Runoff = 2.44 cfs @ 12.21 hrs, Volume= 0.144 af, Depth= 1.00"
Routed to Pond 22P : Birch Lake Wetland

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 2-Year Rainfall=2.81"

Area (ac)	CN	Description
1.214	69	50-75% Grass cover, Fair, HSG B
0.521	98	Paved parking, HSG B
1.735	78	Weighted Average
1.214		69.97% Pervious Area
0.521		30.03% Impervious Area

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

Summary for Subcatchment 7S: 7S

Runoff = 3.54 cfs @ 12.20 hrs, Volume= 0.205 af, Depth= 1.36"
Routed to Pond 22P : Birch Lake Wetland

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 2-Year Rainfall=2.81"

Area (ac)	CN	Description
0.902	69	50-75% Grass cover, Fair, HSG B
0.902	98	Paved parking, HSG B
1.804	84	Weighted Average
0.902		50.00% Pervious Area
0.902		50.00% Impervious Area

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

Summary for Subcatchment 8S: 8S

Runoff = 4.59 cfs @ 12.75 hrs, Volume= 0.625 af, Depth= 1.00"
Routed to Pond 25P : 24" RCP

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 2-Year Rainfall=2.81"

Area (ac)	CN	Description
5.272	69	50-75% Grass cover, Fair, HSG B
2.260	98	Paved parking, HSG B
7.532	78	Weighted Average
5.272		69.99% Pervious Area
2.260		30.01% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.6	40	0.0100	0.10		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.85"
42.2	560	0.0010	0.22		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
3.1	1,010	0.0050	5.52	17.33	**Pipe Channel, Stormsewer** 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.012 Concrete pipe, finished
51.9	1,610	Total			

Summary for Subcatchment 9S: 9S

Runoff = 2.45 cfs @ 12.20 hrs, Volume= 0.141 af, Depth= 1.50"
Routed to Pond 12P : 12" CMP

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 2-Year Rainfall=2.81"

Area (ac)	CN	Description
0.452	69	50-75% Grass cover, Fair, HSG B
0.679	98	Paved parking, HSG B
1.131	86	Weighted Average
0.452		39.96% Pervious Area
0.679		60.04% Impervious Area

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

Summary for Subcatchment 10S: 10S

Runoff = 1.16 cfs @ 12.21 hrs, Volume= 0.070 af, Depth= 0.84"
Routed to Pond 12P : 12" CMP

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 2-Year Rainfall=2.81"

Area (ac)	CN	Description
0.802	69	50-75% Grass cover, Fair, HSG B
0.201	98	Paved parking, HSG B
1.003	75	Weighted Average
0.802		79.96% Pervious Area
0.201		20.04% Impervious Area

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

Summary for Subcatchment 11S: 11S

Runoff = 1.34 cfs @ 12.22 hrs, Volume= 0.090 af, Depth= 0.57"
Routed to Pond 22P : Birch Lake Wetland

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 2-Year Rainfall=2.81"

Area (ac)	CN	Description
1.903	69	50-75% Grass cover, Fair, HSG B
1.903		100.00% Pervious Area

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

Summary for Pond 12P: 12" CMP

Inflow Area = 16.831 ac, 22.91% Impervious, Inflow Depth = 0.89" for 2-Year event
Inflow = 7.42 cfs @ 12.80 hrs, Volume= 1.253 af
Outflow = 7.42 cfs @ 12.80 hrs, Volume= 1.253 af, Atten= 0%, Lag= 0.0 min
Primary = 1.87 cfs @ 12.80 hrs, Volume= 0.720 af
Routed to Pond 22P : Birch Lake Wetland
Secondary = 5.56 cfs @ 12.80 hrs, Volume= 0.533 af
Routed to Pond 22P : Birch Lake Wetland

Routing by Dyn-Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Peak Elev= 928.12' @ 12.80 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	926.87'	**12.0" Round Ped Path Culvert** L= 30.0' CMP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 926.87' / 926.80' S= 0.0023 '/' Cc= 0.900 n= 0.024, Flow Area= 0.79 sf
#2	Secondary	927.75'	**10.0' long x 5.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.34 2.50 2.70 2.68 2.68 2.66 2.65 2.65 2.65 2.65 2.67 2.66 2.68 2.70 2.74 2.79 2.88

Primary OutFlow Max=1.87 cfs @ 12.80 hrs HW=928.12' TW=920.05' (Dynamic Tailwater)
↑—**1=Ped Path Culvert** (Barrel Controls 1.87 cfs @ 2.44 fps)

Secondary OutFlow Max=5.56 cfs @ 12.80 hrs HW=928.12' TW=920.05' (Dynamic Tailwater)
↑—**2=Broad-Crested Rectangular Weir** (Weir Controls 5.56 cfs @ 1.50 fps)

Summary for Pond 22P: Birch Lake Wetland

Inflow Area = 23.339 ac, 26.29% Impervious, Inflow Depth = 0.96" for 2-Year event
Inflow = 14.89 cfs @ 12.21 hrs, Volume= 1.868 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Dyn-Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Peak Elev= 920.13' @ 27.53 hrs Surf.Area= 13.895 ac Storage= 1.868 af

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

Volume	Invert	Avail.Storage	Storage Description
#1	920.00'	60.781 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
920.00	13.807	0.000	0.000
922.00	15.109	28.916	28.916
924.00	16.756	31.865	60.781

Summary for Pond 25P: 24" RCP

Inflow Area = 14.697 ac, 20.25% Impervious, Inflow Depth = 0.85" for 2-Year event
Inflow = 6.92 cfs @ 12.80 hrs, Volume= 1.041 af
Outflow = 6.92 cfs @ 12.80 hrs, Volume= 1.041 af, Atten= 0%, Lag= 0.0 min
Primary = 6.92 cfs @ 12.80 hrs, Volume= 1.041 af
Routed to Pond 12P : 12" CMP

Routing by Dyn-Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Peak Elev= 928.45' @ 12.80 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	926.82'	**24.0" Round Culvert** L= 30.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 926.82' / 926.61' S= 0.0070 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished, Flow Area= 3.14 sf

Primary OutFlow Max=6.92 cfs @ 12.80 hrs HW=928.45' TW=928.12' (Dynamic Tailwater)
↑—**1=Culvert** (Outlet Controls 6.92 cfs @ 3.45 fps)

Time span=0.00-48.00 hrs, dt=0.01 hrs, 4801 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 1S: 1S Runoff Area=7.165 ac 9.99% Impervious Runoff Depth=1.59"
Flow Length=740' Tc=61.9 min CN=72 Runoff=6.27 cfs 0.952 af

Subcatchment 3S: 3S Runoff Area=1.066 ac 80.30% Impervious Runoff Depth=3.30"
Tc=12.0 min CN=92 Runoff=4.82 cfs 0.293 af

Subcatchment 5S: 5S Runoff Area=1.735 ac 30.03% Impervious Runoff Depth=2.04"
Tc=12.0 min CN=78 Runoff=5.10 cfs 0.295 af

Subcatchment 7S: 7S Runoff Area=1.804 ac 50.00% Impervious Runoff Depth=2.54"
Tc=12.0 min CN=84 Runoff=6.57 cfs 0.382 af

Subcatchment 8S: 8S Runoff Area=7.532 ac 30.01% Impervious Runoff Depth=2.04"
Flow Length=1,610' Tc=51.9 min CN=78 Runoff=9.78 cfs 1.280 af

Subcatchment 9S: 9S Runoff Area=1.131 ac 60.04% Impervious Runoff Depth=2.72"
Tc=12.0 min CN=86 Runoff=4.38 cfs 0.256 af

Subcatchment 10S: 10S Runoff Area=1.003 ac 20.04% Impervious Runoff Depth=1.81"
Tc=12.0 min CN=75 Runoff=2.61 cfs 0.151 af

Subcatchment 11S: 11S Runoff Area=1.903 ac 0.00% Impervious Runoff Depth=1.39"
Tc=12.0 min CN=69 Runoff=3.70 cfs 0.221 af

Pond 12P: 12" CMP Peak Elev=928.41' Inflow=16.70 cfs 2.640 af
Primary=2.27 cfs 1.072 af Secondary=14.43 cfs 1.568 af Outflow=16.70 cfs 2.640 af

Pond 22P: Birch Lake Wetland Peak Elev=920.28' Storage=3.830 af Inflow=30.57 cfs 3.830 af
Outflow=0.00 cfs 0.000 af

Pond 25P: 24" RCP Peak Elev=929.49' Inflow=15.73 cfs 2.232 af
24.0" Round Culvert n=0.012 L=30.0' S=0.0070 '/' Outflow=15.73 cfs 2.232 af

Total Runoff Area = 23.339 ac Runoff Volume = 3.830 af Average Runoff Depth = 1.97"
73.71% Pervious = 17.204 ac 26.29% Impervious = 6.135 ac

Summary for Subcatchment 1S: 1S

Runoff = 6.27 cfs @ 12.86 hrs, Volume= 0.952 af, Depth= 1.59"
Routed to Pond 25P : 24" RCP

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 10-Year Rainfall=4.19"

Area (ac)	CN	Description
6.449	69	50-75% Grass cover, Fair, HSG B
0.716	98	Paved parking, HSG B
7.165	72	Weighted Average
6.449		90.01% Pervious Area
0.716		9.99% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.7	100	0.0100	0.12		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.85"
48.2	640	0.0010	0.22		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
61.9	740	Total			

Summary for Subcatchment 3S: 3S

Runoff = 4.82 cfs @ 12.20 hrs, Volume= 0.293 af, Depth= 3.30"
Routed to Pond 22P : Birch Lake Wetland

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 10-Year Rainfall=4.19"

Area (ac)	CN	Description
0.856	98	Paved parking, HSG B
0.210	69	50-75% Grass cover, Fair, HSG B
1.066	92	Weighted Average
0.210		19.70% Pervious Area
0.856		80.30% Impervious Area

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

Summary for Subcatchment 5S: 5S

Runoff = 5.10 cfs @ 12.20 hrs, Volume= 0.295 af, Depth= 2.04"
Routed to Pond 22P : Birch Lake Wetland

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 10-Year Rainfall=4.19"

Area (ac)	CN	Description
1.214	69	50-75% Grass cover, Fair, HSG B
0.521	98	Paved parking, HSG B
1.735	78	Weighted Average
1.214		69.97% Pervious Area
0.521		30.03% Impervious Area

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

Summary for Subcatchment 7S: 7S

Runoff = 6.57 cfs @ 12.20 hrs, Volume= 0.382 af, Depth= 2.54"
Routed to Pond 22P : Birch Lake Wetland

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 10-Year Rainfall=4.19"

Area (ac)	CN	Description
0.902	69	50-75% Grass cover, Fair, HSG B
0.902	98	Paved parking, HSG B
1.804	84	Weighted Average
0.902		50.00% Pervious Area
0.902		50.00% Impervious Area

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

Summary for Subcatchment 8S: 8S

Runoff = 9.78 cfs @ 12.74 hrs, Volume= 1.280 af, Depth= 2.04"
Routed to Pond 25P : 24" RCP

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 10-Year Rainfall=4.19"

Area (ac)	CN	Description
5.272	69	50-75% Grass cover, Fair, HSG B
2.260	98	Paved parking, HSG B
7.532	78	Weighted Average
5.272		69.99% Pervious Area
2.260		30.01% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.6	40	0.0100	0.10		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.85"
42.2	560	0.0010	0.22		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
3.1	1,010	0.0050	5.52	17.33	**Pipe Channel, Stormsewer** 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.012 Concrete pipe, finished
51.9	1,610	Total			

Summary for Subcatchment 9S: 9S

Runoff = 4.38 cfs @ 12.20 hrs, Volume= 0.256 af, Depth= 2.72"
Routed to Pond 12P : 12" CMP

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 10-Year Rainfall=4.19"

Area (ac)	CN	Description
0.452	69	50-75% Grass cover, Fair, HSG B
0.679	98	Paved parking, HSG B
1.131	86	Weighted Average
0.452		39.96% Pervious Area
0.679		60.04% Impervious Area

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

Summary for Subcatchment 10S: 10S

Runoff = 2.61 cfs @ 12.20 hrs, Volume= 0.151 af, Depth= 1.81"
Routed to Pond 12P : 12" CMP

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 10-Year Rainfall=4.19"

Area (ac)	CN	Description
0.802	69	50-75% Grass cover, Fair, HSG B
0.201	98	Paved parking, HSG B
1.003	75	Weighted Average
0.802		79.96% Pervious Area
0.201		20.04% Impervious Area

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

Summary for Subcatchment 11S: 11S

Runoff = 3.70 cfs @ 12.21 hrs, Volume= 0.221 af, Depth= 1.39"
Routed to Pond 22P : Birch Lake Wetland

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 10-Year Rainfall=4.19"

Area (ac)	CN	Description
1.903	69	50-75% Grass cover, Fair, HSG B
1.903		100.00% Pervious Area

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

Summary for Pond 12P: 12" CMP

Inflow Area = 16.831 ac, 22.91% Impervious, Inflow Depth = 1.88" for 10-Year event
Inflow = 16.70 cfs @ 12.75 hrs, Volume= 2.640 af
Outflow = 16.70 cfs @ 12.75 hrs, Volume= 2.640 af, Atten= 0%, Lag= 0.0 min
Primary = 2.27 cfs @ 12.75 hrs, Volume= 1.072 af
Routed to Pond 22P : Birch Lake Wetland
Secondary = 14.43 cfs @ 12.75 hrs, Volume= 1.568 af
Routed to Pond 22P : Birch Lake Wetland

Routing by Dyn-Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Peak Elev= 928.41' @ 12.75 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	926.87'	**12.0" Round Ped Path Culvert** L= 30.0' CMP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 926.87' / 926.80' S= 0.0023 '/' Cc= 0.900 n= 0.024, Flow Area= 0.79 sf
#2	Secondary	927.75'	**10.0' long x 5.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.34 2.50 2.70 2.68 2.68 2.66 2.65 2.65 2.65 2.65 2.67 2.66 2.68 2.70 2.74 2.79 2.88

Primary OutFlow Max=2.27 cfs @ 12.75 hrs HW=928.41' TW=920.11' (Dynamic Tailwater)
↑—**1=Ped Path Culvert** (Barrel Controls 2.27 cfs @ 2.89 fps)

Secondary OutFlow Max=14.43 cfs @ 12.75 hrs HW=928.41' TW=920.11' (Dynamic Tailwater)
↑—**2=Broad-Crested Rectangular Weir** (Weir Controls 14.43 cfs @ 2.19 fps)

Summary for Pond 22P: Birch Lake Wetland

Inflow Area = 23.339 ac, 26.29% Impervious, Inflow Depth = 1.97" for 10-Year event
Inflow = 30.57 cfs @ 12.21 hrs, Volume= 3.830 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Dyn-Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Peak Elev= 920.28' @ 27.53 hrs Surf.Area= 13.986 ac Storage= 3.830 af

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

Volume	Invert	Avail.Storage	Storage Description
#1	920.00'	60.781 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
920.00	13.807	0.000	0.000
922.00	15.109	28.916	28.916
924.00	16.756	31.865	60.781

Summary for Pond 25P: 24" RCP

Inflow Area = 14.697 ac, 20.25% Impervious, Inflow Depth = 1.82" for 10-Year event
Inflow = 15.73 cfs @ 12.75 hrs, Volume= 2.232 af
Outflow = 15.73 cfs @ 12.75 hrs, Volume= 2.232 af, Atten= 0%, Lag= 0.0 min
Primary = 15.73 cfs @ 12.75 hrs, Volume= 2.232 af
Routed to Pond 12P : 12" CMP

Routing by Dyn-Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Peak Elev= 929.49' @ 12.75 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	926.82'	**24.0" Round Culvert** L= 30.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 926.82' / 926.61' S= 0.0070 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished, Flow Area= 3.14 sf

Primary OutFlow Max=15.73 cfs @ 12.75 hrs HW=929.49' TW=928.41' (Dynamic Tailwater)
↑—**1=Culvert** (Inlet Controls 15.73 cfs @ 5.01 fps)

Time span=0.00-48.00 hrs, dt=0.01 hrs, 4801 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 1S: 1S Runoff Area=7.165 ac 9.99% Impervious Runoff Depth=3.22"
Flow Length=740' Tc=61.9 min CN=72 Runoff=13.07 cfs 1.920 af

Subcatchment 3S: 3S Runoff Area=1.066 ac 80.30% Impervious Runoff Depth=5.34"
Tc=12.0 min CN=92 Runoff=7.57 cfs 0.474 af

Subcatchment 5S: 5S Runoff Area=1.735 ac 30.03% Impervious Runoff Depth=3.82"
Tc=12.0 min CN=78 Runoff=9.50 cfs 0.552 af

Subcatchment 7S: 7S Runoff Area=1.804 ac 50.00% Impervious Runoff Depth=4.45"
Tc=12.0 min CN=84 Runoff=11.28 cfs 0.669 af

Subcatchment 8S: 8S Runoff Area=7.532 ac 30.01% Impervious Runoff Depth=3.82"
Flow Length=1,610' Tc=51.9 min CN=78 Runoff=18.41 cfs 2.397 af

Subcatchment 9S: 9S Runoff Area=1.131 ac 60.04% Impervious Runoff Depth=4.67"
Tc=12.0 min CN=86 Runoff=7.34 cfs 0.440 af

Subcatchment 10S: 10S Runoff Area=1.003 ac 20.04% Impervious Runoff Depth=3.51"
Tc=12.0 min CN=75 Runoff=5.08 cfs 0.294 af

Subcatchment 11S: 11S Runoff Area=1.903 ac 0.00% Impervious Runoff Depth=2.92"
Tc=12.0 min CN=69 Runoff=8.02 cfs 0.464 af

Pond 12P: 12" CMP Peak Elev=928.82' Inflow=32.68 cfs 5.050 af
Primary=2.94 cfs 1.519 af Secondary=29.75 cfs 3.531 af Outflow=32.68 cfs 5.050 af

Pond 22P: Birch Lake Wetland Peak Elev=920.52' Storage=7.209 af Inflow=57.06 cfs 7.209 af
Outflow=0.00 cfs 0.000 af

Pond 25P: 24" RCP Peak Elev=933.03' Inflow=31.04 cfs 4.317 af
24.0" Round Culvert n=0.012 L=30.0' S=0.0070 '/' Outflow=31.04 cfs 4.317 af

Total Runoff Area = 23.339 ac Runoff Volume = 7.209 af Average Runoff Depth = 3.71"
73.71% Pervious = 17.204 ac 26.29% Impervious = 6.135 ac

Summary for Subcatchment 1S: 1S

Runoff = 13.07 cfs @ 12.86 hrs, Volume= 1.920 af, Depth= 3.22"
Routed to Pond 25P : 24" RCP

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 50-Year Rainfall=6.27"

Area (ac)	CN	Description
6.449	69	50-75% Grass cover, Fair, HSG B
0.716	98	Paved parking, HSG B
7.165	72	Weighted Average
6.449		90.01% Pervious Area
0.716		9.99% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.7	100	0.0100	0.12		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.85"
48.2	640	0.0010	0.22		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
61.9	740	Total			

Summary for Subcatchment 3S: 3S

Runoff = 7.57 cfs @ 12.19 hrs, Volume= 0.474 af, Depth= 5.34"
Routed to Pond 22P : Birch Lake Wetland

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 50-Year Rainfall=6.27"

Area (ac)	CN	Description
0.856	98	Paved parking, HSG B
0.210	69	50-75% Grass cover, Fair, HSG B
1.066	92	Weighted Average
0.210		19.70% Pervious Area
0.856		80.30% Impervious Area

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

Summary for Subcatchment 5S: 5S

Runoff = 9.50 cfs @ 12.20 hrs, Volume= 0.552 af, Depth= 3.82"
Routed to Pond 22P : Birch Lake Wetland

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 50-Year Rainfall=6.27"

Area (ac)	CN	Description
1.214	69	50-75% Grass cover, Fair, HSG B
0.521	98	Paved parking, HSG B
1.735	78	Weighted Average
1.214		69.97% Pervious Area
0.521		30.03% Impervious Area

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

Summary for Subcatchment 7S: 7S

Runoff = 11.28 cfs @ 12.20 hrs, Volume= 0.669 af, Depth= 4.45"
Routed to Pond 22P : Birch Lake Wetland

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 50-Year Rainfall=6.27"

Area (ac)	CN	Description
0.902	69	50-75% Grass cover, Fair, HSG B
0.902	98	Paved parking, HSG B
1.804	84	Weighted Average
0.902		50.00% Pervious Area
0.902		50.00% Impervious Area

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

Summary for Subcatchment 8S: 8S

Runoff = 18.41 cfs @ 12.74 hrs, Volume= 2.397 af, Depth= 3.82"
Routed to Pond 25P : 24" RCP

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 50-Year Rainfall=6.27"

Area (ac)	CN	Description
5.272	69	50-75% Grass cover, Fair, HSG B
2.260	98	Paved parking, HSG B
7.532	78	Weighted Average
5.272		69.99% Pervious Area
2.260		30.01% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.6	40	0.0100	0.10		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.85"
42.2	560	0.0010	0.22		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
3.1	1,010	0.0050	5.52	17.33	**Pipe Channel, Stormsewer** 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.012 Concrete pipe, finished
51.9	1,610	Total			

Summary for Subcatchment 9S: 9S

Runoff = 7.34 cfs @ 12.20 hrs, Volume= 0.440 af, Depth= 4.67"
Routed to Pond 12P : 12" CMP

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 50-Year Rainfall=6.27"

Area (ac)	CN	Description
0.452	69	50-75% Grass cover, Fair, HSG B
0.679	98	Paved parking, HSG B
1.131	86	Weighted Average
0.452		39.96% Pervious Area
0.679		60.04% Impervious Area

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

Summary for Subcatchment 10S: 10S

Runoff = 5.08 cfs @ 12.20 hrs, Volume= 0.294 af, Depth= 3.51"
Routed to Pond 12P : 12" CMP

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 50-Year Rainfall=6.27"

Area (ac)	CN	Description
0.802	69	50-75% Grass cover, Fair, HSG B
0.201	98	Paved parking, HSG B
1.003	75	Weighted Average
0.802		79.96% Pervious Area
0.201		20.04% Impervious Area

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

Summary for Subcatchment 11S: 11S

Runoff = 8.02 cfs @ 12.20 hrs, Volume= 0.464 af, Depth= 2.92"
Routed to Pond 22P : Birch Lake Wetland

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 50-Year Rainfall=6.27"

Area (ac)	CN	Description
1.903	69	50-75% Grass cover, Fair, HSG B
1.903		100.00% Pervious Area

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

Summary for Pond 12P: 12" CMP

Inflow Area = 16.831 ac, 22.91% Impervious, Inflow Depth = 3.60" for 50-Year event
Inflow = 32.68 cfs @ 12.74 hrs, Volume= 5.050 af
Outflow = 32.68 cfs @ 12.74 hrs, Volume= 5.050 af, Atten= 0%, Lag= 0.0 min
Primary = 2.94 cfs @ 12.74 hrs, Volume= 1.519 af
Routed to Pond 22P : Birch Lake Wetland
Secondary = 29.75 cfs @ 12.74 hrs, Volume= 3.531 af
Routed to Pond 22P : Birch Lake Wetland

Routing by Dyn-Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Peak Elev= 928.82' @ 12.74 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	926.87'	**12.0" Round Ped Path Culvert** L= 30.0' CMP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 926.87' / 926.80' S= 0.0023 '/' Cc= 0.900 n= 0.024, Flow Area= 0.79 sf
#2	Secondary	927.75'	**10.0' long x 5.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.34 2.50 2.70 2.68 2.68 2.66 2.65 2.65 2.65 2.65 2.67 2.66 2.68 2.70 2.74 2.79 2.88

Primary OutFlow Max=2.94 cfs @ 12.74 hrs HW=928.82' TW=920.23' (Dynamic Tailwater)
↑—**1=Ped Path Culvert** (Barrel Controls 2.94 cfs @ 3.74 fps)

Secondary OutFlow Max=29.74 cfs @ 12.74 hrs HW=928.82' TW=920.23' (Dynamic Tailwater)
↑—**2=Broad-Crested Rectangular Weir** (Weir Controls 29.74 cfs @ 2.77 fps)

Summary for Pond 22P: Birch Lake Wetland

Inflow Area = 23.339 ac, 26.29% Impervious, Inflow Depth = 3.71" for 50-Year event
Inflow = 57.06 cfs @ 12.20 hrs, Volume= 7.209 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Dyn-Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Peak Elev= 920.52' @ 27.53 hrs Surf.Area= 14.143 ac Storage= 7.209 af

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

Volume	Invert	Avail.Storage	Storage Description
#1	920.00'	60.781 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
920.00	13.807	0.000	0.000
922.00	15.109	28.916	28.916
924.00	16.756	31.865	60.781

Summary for Pond 25P: 24" RCP

Inflow Area = 14.697 ac, 20.25% Impervious, Inflow Depth = 3.52" for 50-Year event
Inflow = 31.04 cfs @ 12.75 hrs, Volume= 4.317 af
Outflow = 31.04 cfs @ 12.75 hrs, Volume= 4.317 af, Atten= 0%, Lag= 0.0 min
Primary = 31.04 cfs @ 12.75 hrs, Volume= 4.317 af
Routed to Pond 12P : 12" CMP

Routing by Dyn-Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Peak Elev= 933.03' @ 12.75 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	926.82'	**24.0" Round Culvert** L= 30.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 926.82' / 926.61' S= 0.0070 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished, Flow Area= 3.14 sf

Primary OutFlow Max=31.03 cfs @ 12.75 hrs HW=933.03' TW=928.82' (Dynamic Tailwater)
1=Culvert (Inlet Controls 31.03 cfs @ 9.88 fps)

Time span=0.00-48.00 hrs, dt=0.01 hrs, 4801 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 1S: 1S Runoff Area=7.165 ac 9.99% Impervious Runoff Depth=4.14"
Flow Length=740' Tc=61.9 min CN=72 Runoff=16.89 cfs 2.471 af

Subcatchment 3S: 3S Runoff Area=1.066 ac 80.30% Impervious Runoff Depth=6.41"
Tc=12.0 min CN=92 Runoff=9.00 cfs 0.569 af

Subcatchment 5S: 5S Runoff Area=1.735 ac 30.03% Impervious Runoff Depth=4.80"
Tc=12.0 min CN=78 Runoff=11.86 cfs 0.694 af

Subcatchment 7S: 7S Runoff Area=1.804 ac 50.00% Impervious Runoff Depth=5.48"
Tc=12.0 min CN=84 Runoff=13.76 cfs 0.824 af

Subcatchment 8S: 8S Runoff Area=7.532 ac 30.01% Impervious Runoff Depth=4.80"
Flow Length=1,610' Tc=51.9 min CN=78 Runoff=23.11 cfs 3.014 af

Subcatchment 9S: 9S Runoff Area=1.131 ac 60.04% Impervious Runoff Depth=5.71"
Tc=12.0 min CN=86 Runoff=8.89 cfs 0.538 af

Subcatchment 10S: 10S Runoff Area=1.003 ac 20.04% Impervious Runoff Depth=4.47"
Tc=12.0 min CN=75 Runoff=6.43 cfs 0.373 af

Subcatchment 11S: 11S Runoff Area=1.903 ac 0.00% Impervious Runoff Depth=3.81"
Tc=12.0 min CN=69 Runoff=10.47 cfs 0.604 af

Pond 12P: 12" CMP Peak Elev=929.03' Inflow=41.49 cfs 6.397 af
Primary=3.22 cfs 1.702 af Secondary=38.27 cfs 4.695 af Outflow=41.49 cfs 6.397 af

Pond 22P: Birch Lake Wetland Peak Elev=920.65' Storage=9.089 af Inflow=71.53 cfs 9.089 af
Outflow=0.00 cfs 0.000 af

Pond 25P: 24" RCP Peak Elev=935.84' Inflow=39.49 cfs 5.485 af
24.0" Round Culvert n=0.012 L=30.0' S=0.0070 '/' Outflow=39.49 cfs 5.485 af

Total Runoff Area = 23.339 ac Runoff Volume = 9.089 af Average Runoff Depth = 4.67"
73.71% Pervious = 17.204 ac 26.29% Impervious = 6.135 ac

Summary for Subcatchment 1S: 1S

Runoff = 16.89 cfs @ 12.86 hrs, Volume= 2.471 af, Depth= 4.14"
Routed to Pond 25P : 24" RCP

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-Year Rainfall=7.36"

Area (ac)	CN	Description
6.449	69	50-75% Grass cover, Fair, HSG B
0.716	98	Paved parking, HSG B
7.165	72	Weighted Average
6.449		90.01% Pervious Area
0.716		9.99% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.7	100	0.0100	0.12		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.85"
48.2	640	0.0010	0.22		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
61.9	740	Total			

Summary for Subcatchment 3S: 3S

Runoff = 9.00 cfs @ 12.19 hrs, Volume= 0.569 af, Depth= 6.41"
Routed to Pond 22P : Birch Lake Wetland

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-Year Rainfall=7.36"

Area (ac)	CN	Description
0.856	98	Paved parking, HSG B
0.210	69	50-75% Grass cover, Fair, HSG B
1.066	92	Weighted Average
0.210		19.70% Pervious Area
0.856		80.30% Impervious Area

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

Summary for Subcatchment 5S: 5S

Runoff = 11.86 cfs @ 12.20 hrs, Volume= 0.694 af, Depth= 4.80"
Routed to Pond 22P : Birch Lake Wetland

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-Year Rainfall=7.36"

Area (ac)	CN	Description
1.214	69	50-75% Grass cover, Fair, HSG B
0.521	98	Paved parking, HSG B
1.735	78	Weighted Average
1.214		69.97% Pervious Area
0.521		30.03% Impervious Area

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

Summary for Subcatchment 7S: 7S

Runoff = 13.76 cfs @ 12.20 hrs, Volume= 0.824 af, Depth= 5.48"
Routed to Pond 22P : Birch Lake Wetland

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-Year Rainfall=7.36"

Area (ac)	CN	Description
0.902	69	50-75% Grass cover, Fair, HSG B
0.902	98	Paved parking, HSG B
1.804	84	Weighted Average
0.902		50.00% Pervious Area
0.902		50.00% Impervious Area

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

Summary for Subcatchment 8S: 8S

Runoff = 23.11 cfs @ 12.69 hrs, Volume= 3.014 af, Depth= 4.80"
Routed to Pond 25P : 24" RCP

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-Year Rainfall=7.36"

Area (ac)	CN	Description
5.272	69	50-75% Grass cover, Fair, HSG B
2.260	98	Paved parking, HSG B
7.532	78	Weighted Average
5.272		69.99% Pervious Area
2.260		30.01% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.6	40	0.0100	0.10		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.85"
42.2	560	0.0010	0.22		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
3.1	1,010	0.0050	5.52	17.33	**Pipe Channel, Stormsewer** 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.012 Concrete pipe, finished
51.9	1,610	Total			

Summary for Subcatchment 9S: 9S

Runoff = 8.89 cfs @ 12.20 hrs, Volume= 0.538 af, Depth= 5.71"
Routed to Pond 12P : 12" CMP

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-Year Rainfall=7.36"

Area (ac)	CN	Description
0.452	69	50-75% Grass cover, Fair, HSG B
0.679	98	Paved parking, HSG B
1.131	86	Weighted Average
0.452		39.96% Pervious Area
0.679		60.04% Impervious Area

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

Summary for Subcatchment 10S: 10S

Runoff = 6.43 cfs @ 12.20 hrs, Volume= 0.373 af, Depth= 4.47"
Routed to Pond 12P : 12" CMP

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-Year Rainfall=7.36"

Area (ac)	CN	Description
0.802	69	50-75% Grass cover, Fair, HSG B
0.201	98	Paved parking, HSG B
1.003	75	Weighted Average
0.802		79.96% Pervious Area
0.201		20.04% Impervious Area

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

Summary for Subcatchment 11S: 11S

Runoff = 10.47 cfs @ 12.20 hrs, Volume= 0.604 af, Depth= 3.81"
Routed to Pond 22P : Birch Lake Wetland

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-Year Rainfall=7.36"

Area (ac)	CN	Description
1.903	69	50-75% Grass cover, Fair, HSG B
1.903		100.00% Pervious Area

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

Summary for Pond 12P: 12" CMP

Inflow Area = 16.831 ac, 22.91% Impervious, Inflow Depth = 4.56" for 100-Year event
Inflow = 41.49 cfs @ 12.74 hrs, Volume= 6.397 af
Outflow = 41.49 cfs @ 12.74 hrs, Volume= 6.397 af, Atten= 0%, Lag= 0.0 min
Primary = 3.22 cfs @ 12.74 hrs, Volume= 1.702 af
Routed to Pond 22P : Birch Lake Wetland
Secondary = 38.27 cfs @ 12.74 hrs, Volume= 4.695 af
Routed to Pond 22P : Birch Lake Wetland

Routing by Dyn-Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Peak Elev= 929.03' @ 12.74 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	926.87'	**12.0" Round Ped Path Culvert** L= 30.0' CMP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 926.87' / 926.80' S= 0.0023 '/' Cc= 0.900 n= 0.024, Flow Area= 0.79 sf
#2	Secondary	927.75'	**10.0' long x 5.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.34 2.50 2.70 2.68 2.68 2.66 2.65 2.65 2.65 2.65 2.67 2.66 2.68 2.70 2.74 2.79 2.88

Primary OutFlow Max=3.22 cfs @ 12.74 hrs HW=929.03' TW=920.29' (Dynamic Tailwater)
↑—**1=Ped Path Culvert** (Barrel Controls 3.22 cfs @ 4.09 fps)

Secondary OutFlow Max=38.27 cfs @ 12.74 hrs HW=929.03' TW=920.29' (Dynamic Tailwater)
↑—**2=Broad-Crested Rectangular Weir** (Weir Controls 38.27 cfs @ 3.00 fps)

Summary for Pond 22P: Birch Lake Wetland

Inflow Area = 23.339 ac, 26.29% Impervious, Inflow Depth = 4.67" for 100-Year event
Inflow = 71.53 cfs @ 12.20 hrs, Volume= 9.089 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Dyn-Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Peak Elev= 920.65' @ 27.52 hrs Surf.Area= 14.229 ac Storage= 9.089 af

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

Volume	Invert	Avail.Storage	Storage Description
#1	920.00'	60.781 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
920.00	13.807	0.000	0.000
922.00	15.109	28.916	28.916
924.00	16.756	31.865	60.781

Summary for Pond 25P: 24" RCP

Inflow Area = 14.697 ac, 20.25% Impervious, Inflow Depth = 4.48" for 100-Year event
Inflow = 39.49 cfs @ 12.74 hrs, Volume= 5.485 af
Outflow = 39.49 cfs @ 12.74 hrs, Volume= 5.485 af, Atten= 0%, Lag= 0.0 min
Primary = 39.49 cfs @ 12.74 hrs, Volume= 5.485 af
Routed to Pond 12P : 12" CMP

Routing by Dyn-Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Peak Elev= 935.84' @ 12.74 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	926.82'	**24.0" Round Culvert** L= 30.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 926.82' / 926.61' S= 0.0070 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished, Flow Area= 3.14 sf

Primary OutFlow Max=39.48 cfs @ 12.74 hrs HW=935.84' TW=929.03' (Dynamic Tailwater)
↑—**1=Culvert** (Inlet Controls 39.48 cfs @ 12.57 fps)

Project Information

Calculator Version:	Version 4: July 2020
Project Name:	White Bear Lake Sports Center
User Name / Company Name:	SRF Consulting
Date:	10/4/2024
Project Description:	Retrofit of the stormwate swale adjacent to the White Bear Lake Sports Center parking lot at Birch Lake Boulevard with the goal of improving water quality to Birch Lake and its many downstream lakes
Construction Permit?:	No

Site Information

Retention Requirement (inches):	1.1
Site's Zip Code:	55110
Annual Rainfall (inches):	31.8
Phosphorus EMC (mg/l):	0.3
TSS EMC (mg/l):	54.5

Total Site Area

Land Cover	A Soils (acres)	B Soils (acres)	C Soils (acres)	D Soils (acres)	Total (acres)
Forest/Open Space - Undisturbed, protected forest/open space or reforested land				2.7	2.7
Managed Turf - disturbed, graded for yards or other turf to be mowed/managed				12.1	12.1
			Impervious Area (acres)		3.9
				Total Area (acres)	18.7

Site Areas Routed to BMPs

Land Cover	A Soils (acres)	B Soils (acres)	C Soils (acres)	D Soils (acres)	Total (acres)
Forest/Open Space - Undisturbed, protected forest/open space or reforested land				2.7	2.7
Managed Turf - disturbed, graded for yards or other turf to be mowed/managed				12.1	12.1
			Impervious Area (acres)		3.9
				Total Area (acres)	18.7

Summary Information

Performance Goal Requirement

Performance goal volume retention requirement:	15573	ft3
Volume removed by BMPs towards performance goal:	3814	ft^3
Percent volume removed towards performance goal	**24**	**%**

Annual Volume and Pollutant Load Reductions

Post development annual runoff volume	16.373	acre-ft
Annual runoff volume removed by BMPs:	2.2884	acre-ft
Percent annual runoff volume removed:	**14**	**%**
Post development annual particulate P load:	7.3482	lbs
Annual particulate P removed by BMPs:	5.645	lbs
Post development annual dissolved P load:	6.012	lbs
Annual dissolved P removed by BMPs:	1.75	lbs
Total P removed by BMPs	7.395	lbs
Percent annual total phosphorus removed:	**55**	**%**
Post development annual TSS load:	2427.1	lbs
Annual TSS removed by BMPs:	2099.7	lbs
Percent annual TSS removed:	**87**	**%**

BMP Summary

Performance Goal Summary

BMP Name	BMP Volume Capacity (ft3)	Volume Recieved (ft3)	Volume Retained (ft3)	Volume Outflow (ft3)	Percent Retained (%)
1 - Swale main channel (with underdrain)	3814	15573	3814	11758	24
2 - SAFL Baffle	0	11979	0	11979	0
3 - Rain Guardian	0	2795	0	2795	0

Annual Volume Summary

BMP Name	Volume From Direct Watershed (acre-ft)	Volume From Upstream BMPs (acre-ft)	Volume Retained (acre-ft)	Volume outflow (acre-ft)	Percent Retained (%)
1 - Swale main channel (with underdrain)	0.7751	15.5979	2.2884	14.0846	14
2 - SAFL Baffle	13.7734	0	0	13.7734	0
3 - Rain Guardian	1.8245	0	0	1.8245	0

Particulate Phosphorus Summary

BMP Name	Load From Direct Watershed (lbs)	Load From Upstream BMPs (lbs)	Load Retained (lbs)	Outflow Load (lbs)	Percent Retained (%)
1 - Swale main channel (with underdrain)	0.3479	3.2529	1.8972	1.7036	53
2 - SAFL Baffle	6.1815	0	3.338	2.8435	54
3 - Rain Guardian	0.8188	0	0.4094	0.4094	50

Dissolved Phosphorus Summary

BMP Name	Load From Direct Watershed (lbs)	Load From Upstream BMPs (lbs)	Load Retained (lbs)	Outflow Load (lbs)	Percent Retained (%)
1 - Swale main channel (with underdrain)	0.2846	5.7276	1.7505	4.2617	29
2 - SAFL Baffle	5.0576	0	0	5.0576	0
3 - Rain Guardian	0.67	0	0	0.67	0

Total Phosphorus Summary

BMP Name	Load From Direct Watershed (lbs)	Load From Upstream BMPs (lbs)	Load Retained (lbs)	Outflow Load (lbs)	Percent Retained (%)
1 - Swale main channel (with underdrain)	0.6325	8.9805	3.6477	5.9653	41
2 - SAFL Baffle	11.2391	0	3.338	7.9011	27
3 - Rain Guardian	1.4888	0	0.4094	1.0794	25

TSS Summary

BMP Name	Load From Direct Watershed (lbs)	Load From Upstream BMPs (lbs)	Load Retained (lbs)	Outflow Load (lbs)	Percent Retained (%)
1 - Swale main channel (with underdrain)	114.9	1074.44	861.94	327.4	72
2 - SAFL Baffle	2041.77	0	1102.56	939.21	54
3 - Rain Guardian	270.47	0	135.24	135.23	50

BMP Schematic

GALE-TEC ENGINEERING, INC.

801 TWELVE OAKS CENTER DRIVE, SUITE 832
WAYZATA, MN 55391
TELEPHONE (952) 473-7193 FAX (952) 473-1492
www.gale-tec.com

October 30, 2024

Ms. Leah Gifford, P.E./Mr. Andrew Toay, P.E.
SRF Consulting Group, Inc.
Via email

GTE Project No. 95688

RE: Subsurface Exploration and Geotechnical Engineering Services
Related to the White Bear Lake Sports Center Stormwater Swale Reconstruction
in White Bear Lake, MN

Dear Ms. Gifford:

We are pleased to have completed our geotechnical investigation and report for the White Bear Lake Sportscenter channel reconstruction project.

If you have any questions concerning the data or our recommendations, please do not hesitate to contact us.

Respectfully,

GALE-TEC ENGINEERING, INC.

Nathan M. Lichty, P.E.
Sr. Project Engineer

Stephan M. Gale, P.E.
Principal Engineer

NML/SMG/pjk

I hereby certify that this plan, specification, calculation, or report was prepared by me or under my direct supervision and that I am a Registered Professional Engineer under Minnesota Statute, Sections 326.02 to 326.15.

Nathan Lichty

Date: 10/30/2024 Reg. No. 51331

Geotechnical Engineering Services Related to White Bear Lake Sportscenter Drainage Channel Reconstruction, White Bear Lake, MN

1.0 INTRODUCTION

Stormwater treatment improvements have been proposed for the parking lot associated with the White Bear Lake Sports Center. We understand the project stakeholders, including Ramsey County SWCD, Vadnais Lake Area Water Management Organization (VLAWMO) and the City of White Bear Lake, are proposing to retrofit an existing swale located on the north side of the parking lot, which is adjacent to the sports center facility. The swale collects stormwater from the parking lot and adjacent residential area and drains to an adjacent wetland. The goal of the project is to retrofit the existing swale to reduce erosion potential and improve the stormwater run-off quality.

You have requested two (2) geotechnical soil borings drilled from the parking lot adjacent to the swale to assess soil conditions within the existing channel. The results of the soil borings were used to provide recommendations for soil infiltration rates and channel stabilization measures to reduce instability and erosion potential. Our work was performed in substantial accordance with our subconsultant agreement dated August 19, 2024. We were issued a Notice to Proceed for the project by the SRF Consulting Group, Inc. Project Manager on August 29, 2024.

2.0 SUBSURFACE EXPLORATION AND LABORATORY TESTING

The subsurface exploration consisted of two (2) SPT soil borings performed from just off of the northwest portion of existing Sportscenter bituminous parking lot where it is located adjacent to the existing drainage channel. One (1) SPT soil boring was performed along the northern portion of the parking lot, at the location where an existing trail connects the parking lot to an overflow lot located to the west of the sportscenter. The second SPT soil boring was performed along the southwest portion of the parking lot, adjacent to the drainage swale. Table No. 1 indicates the soil boring locations and surface elevations. A location diagram and soil borings logs are included in the Appendix.

Table No. 1: Boring Locations

Soil Boring	Northing*	Easting*	Surface Elevation* (ft)
B-1	152848.710	437083.649	950.851
B-2	153099.865	437286.977	943.574

* Northing/Easting and Surface Elevations obtained by SRF Consulting Group Inc Surveyor

2.1 Drilling

The two (2) 14ft deep SPT soil borings were drilled on September 11, 2024. Gopher State One Call was contacted to check for public underground utilities; additionally a Private Utility locate was performed in the parking lot near the soil boring location to mark existing buried electrical wiring.

All SPT soil borings were drilled with a truck mounted CME 75HT rig to a depth of 14ft. The SPT soil borings were advanced with a hollow stem auger with split spoon sampling methods. Split-spoon samples were collected at 2½ ft. intervals in the upper 10 ft. and then 5 ft. intervals. In the split spoon sampling method the number of blows required to drive the split-spoon sampler into the ground in 6-inch increments is recorded. The sampling spoon is driven into the ground with a 140-pound hammer falling a distance of 30 inches. The number of blows required to drive the sampler 12 inches is recorded on the boring logs as the N-value (reported in blows per foot). The N-value obtained from this test is an index of the relative density/consistency of the soils.

The depths at which groundwater was encountered was recorded during drilling operations and the borings were then backfilled. Boreholes were backfilled with soil in accordance with Minnesota Department of Health requirements. After drilling, the ground surface elevations and location coordinates at the borehole locations were obtained by SRF.

2.2 Laboratory Testing

Soil laboratory testing consisted of classification of all soil samples. Moisture content (w/c), and percent passing the U.S. No. 200 Sieve (P200) was performed on select soil samples. All geotechnical laboratory test results are included in the boring logs in the Appendix.

3.0 SITE, SOIL & GROUNDWATER CONDITIONS

3.1 Site Conditions

The White Bear Lake Sportscenter is located at 1328 Hwy 96, just to the east of the I-35E/TH 96 intersection. The proposed drainage swale is located to the west of the Sportscenter parking lot, located on the southwestern portion of the property. The drainage swale is approximately 600ft in length and extends from S. Birch Lake Blvd to a large retention pond located to the northwest of the Sportscenter. The drainage channel is located between the Sportscenter parking lot and an adjacent wooded property. The drainage channel appears to drain stormwater from a residential subdivision located to the south of the Sportscenter property, as well as the Sportscenter parking lot.

The existing drainage channel is approximately 8ft wide by 1-2ft deep along the southern portion of the drainage channel. This portion of the drainage channel contained standing water at the time the borings were drilled. The northern portion of the channel is 2-3ft wide

and shallower than the southern portion. The two channel segments are separated by a small CMP culvert that carries a walking trail from the adjacent parking lot over the existing drainage channel.

3.2 Soil Conditions

Soil conditions at the site consisted of approximately 2ft of topsoil fill over approximately 8ft of very soft to soft clay. The topsoil consisted of a slightly organic silty sand that extended from the ground surface to a depth of 2ft below the ground surface.

Beneath the topsoil fill layer, the native soil consisted of an approximately 8ft thick layer of very soft silty clay that was encountered to a depth of approximately 10ft below the parking lot grade. Beneath the very soft clay, a medium stiff to stiff clay layer was encountered from a depth of 10ft to the 14ft termination depth of the soil borings.

3.3 Groundwater Conditions

Groundwater was encountered a depth of 7ft at soil boring B-1 during drilling operations, but at the conclusion of drilling the boring, the borehole was dry. Groundwater was not encountered at soil boring B-2, either during or post drilling operations.

In cohesive type soils that exist on this site, a relatively long period of time is required for the groundwater table to attain an equilibrium position within the borehole. In order to obtain a depiction of the water table in clay soils, open-pipe piezometers should be installed and monitored over a period of months. In any event, the water table is likely at or near the elevation of the adjacent wetland.

4.0 RECOMMENDATIONS

4.1 Drainage Channel

Soils within the existing drainage channel consist of silty clay soils. This soil type is susceptible to erosion when exposed to flowing water, whether on an exposed slope face on within a channel. This soil contains a relatively low shear strength, especially at low confining pressures near the ground surface.

With respect to channel sideslope stability, stormwater infiltration into the near surface soils can result in seepage pressure build-up and a lowered soil shear strength when the channel water surface drops/changes. When the soil's shear strength lowers to a value less than the downslope gravitation force, the near surface soils will slough off of the slope face. The sloughing can then progress further back into the slope with subsequent rainfall events and channel fluctuations.

Channel sideslope instability can also occur due to slope toe erosion and undermining at the base, resulting in undermining and channel sideslope sloughing. Both of these factors,

erosion and surface sloughing of the fine grained soils, have likely combined to create the current channel sideslope distress/instability.

4.1.1 Potential Stabilization Measures

Drainage channel sideslope stabilization could consist of 1) sizing the channel base and sideslopes back to a stable slope angle and channel width such that lower water velocities and flow rates will results, and 2) installing erosion protection within the channel base and over the sideslopes.

The results of the soil borings indicate that the channel sideslopes and base consist of a silty clay soil. We estimate the current channel sideslopes range in height from 1 - 2ft along the channel alignment. SRF Water Resources Unit has indicated that a required channel base may be up to 10ft in width. Based on these soil conditions, channel water level and channel sideslope heights, we recommend that the channel sideslopes be excavated back to a slope angle no steeper than 3H:1V. Channel sideslopes excavated back to this slope angle are likely to remain stable over the long term, even with varying water elevations within the channel and potential seepage pressure development, provided sufficient surface erosion protection is placed.

A hydraulic analysis performed by SRF Water Resources has indicated that the channel will be designed for flowrates of 39.5 ft^3/s, which results in water velocities of 1.5 – 4.1 ft/s and shear stresses of 0.3 – 1.1 lbs/ft^2, and up to 3.5 lbs/ft^2 induced on the channel sideslope and base due water flow.

Based on these channel flow rates and shear stresses, channel base and sideslope surface erosion protection could consist of either: 1) a Turf Reinforcement Mat (TRM) infilled with topsoil, seed and fertilizer to establish long term vegetation, 2) geocells infilled with gravel at the channel base and topsoil/seed/fertilizer on the sideslopes 3) Erosion Control Blanket (ECB) encapsulated soil lifts or 4) riprap options.

Erosion Mitigation Option 1 – TRM Lined Channel: A Turf Reinforcement Mat (TRM) is a permanent rolled erosion control product that consists of woven synthetic fibers alignment to form a three (3) dimension product that holds topsoil and seed. TRM products vary in tensile strength and fiber orientation, with the TRM type selected based on the shear stresses induced on the installed TRM within the channel. For these channel flowrates, we recommend a MnDOT Spec. 3885.2 Category 70 TRM be used.

The TRM should be deployed longitudinally along the channel alignment, with adjacent TRM panels overlapped at least 6 inches. The TRM should be connected to the graded channel with 18 inch long, hooked No. 4 rebar, helical twist metal anchors or other approved anchor types. The anchors should be placed in a triangular pattern at a 3ft by 3ft horizontal and vertical spacing, resulting in 1.5 anchors placed per square yard of TRM face.

The TRM should be infilled with a 1-2 inch thick layer of Sandy Clay Loam Topsoil (MnDOT Spec. 3877.2.C) premixed with an appropriate seed/fertilizer mix to promote rapid vegetation development. A MnDOT Category 30 Erosion Control Blanket should then be placed above the topsoil infilled TRM to provide temporary erosion protection.

The TRM should be "keyed into" the channel crests using a small anchor trench constructed at either side of the channel. The anchor trench should be constructed as a triangular or wedge shape to reduce the potential for TRM undermining on the channel sideslope face.

Erosion Mitigation Option 2 – Geocell Infilled with Gravel/Topsoil Covered Sideslope:
We recommend a geocell, such as a Presto Geoweb® GW20V4 or Envirogrid EGA 20, be deployed along the channel base and sideslopes. A geocell consists of a series of perforated polyethylene sheets seamed together in a honeycomb pattern to create a three-dimensional network for channel protection. The geocell should be deployed on a prepared slope and then each confining cell filled with gravel in the channel and topsoil on the sideslopes. The geocells should be 4 inches in height and contain an individual opening area of at least 80 square inches.

The geocells deployed on the sideslopes could be infilled with a Sandy Clay Loam Topsoil/seed/fertilizer mix, the same as recommended for Erosion Mitigation Option 1. A MnDOT Category 30 Rolled Erosion Prevention Product should be placed over the topsoil/seed mix deployed within the geocells.

The geocells deployed within the channel base could be infilled with a gravel, such as a Coarse Filter Aggregate (MnDOT Spec. 3149.2.H). This gravel fill confined by the geocells could be used to replace a larger diameter Class 2 or Class 3 riprap, if no geocell was used. Previous studies conducted by the Geocell manufacturers have indicated that a geocell infilled with gravel can resist an maximum permissible shear stress of 8 lbs/ft^2.

A longitudinal anchor trench would need to be constructed just behind the crest of both channel sideslopes to "key" in the geocell into the channel. The geocells will also have to be anchored into the prepared sideslopes with stakes. The staking alignment should be consistent with the manufacturers' recommendations. Adjacent geocell panels should be mechanically connected with zip ties or other approved connection devices.

Erosion Mitigation Option 3 – Fabric (Erosion Control Blanket – ECB) Encapsulated Soil Lifts: This "natural" stream stabilization option includes reconstructing the channel sideslopes using a series of erosion control blanket wraps for short-term stabilization, with live stake branches placed between soil lifts to provide longer term channel reinforcement. A layer of topsoil premixed with seed and fertilizer should be placed on the slope face behind the ECB wrap to promote vegetation establishment and long term erosion protection.

Individual ECB wraps should be placed in 1ft vertical wraps and include at least a 3ft wrap back on both the top and bottom of each 1ft tall wrap. Each wrap could be horizontally

offset 3ft to form an overall 3H:1V channel sideslope. We understand that the client may choose to use a biodegradable product as the wrap with a life expectancy of only a few years. Such biodgradable erosion control products include Western Green Bionet C125BN, or Western Excelsior Excel CC-4 All Natural, which contains 100% Coir or Hemp Fabric and a maximum permissible shear stress of up to 2.5 lbs/ft^2. We understand that the 2.5 lbs/ft^2 value provides slope face erosion protection for the majority of the channel.

These products are reported to have a functional design life of up 36 months, so long term erosion protection will be dependent on vegetation establishment at the slope face. As such we recommend at least a 6 inch thick layer of Sandy Clay Loam Topsoil (MnDOT Spec. 3877.2.C) be placed on the slope face behind ECB wraps. An appropriate seed and fertilizer should be premixed into the topsoil prior to placement on the channel. A watering specification, requiring periodic water during and post construction should be implemented.

Behind the Topsoil Layer, the excavated, native silty clay soils could be replaced and compacted in 1ft lifts to match the ECB wrap heights. The backfill material should be placed and compacted to 95% of the Maximum Standard Proctor Dry Density.

Additionally, live branches could be placed in the slope face to provide additional reinforcement against channel sideslope instability. The branches should be 3-6ft long and contain a maximum diameter of ½ inch. The branches should be placed at a 5-6ft horizontal offset in a triangular pattern on the slope face.

The ECBs discussed herein are proposed to form the encapsulated soil lifts, but will biodegrade after several years. Long term erosion protection of this system is dependent on widespread vegetation establishment within the channel. Long-term maintenance including continued watering and potential reseeding, via hydroseeding, within the channel may be required.

Erosion Mitigation Option 4 – Riprap: An alternative to a Geosynthetic Lined Channel could be a conventional riprap lined channel. The riprap class selected should be based on the hydraulic analysis, but we estimate that a Class 2 or Class 3 riprap (MnDOT Spec. 3601.2) would be required. Regardless of the riprap size selected, the riprap would need to be underlain by a MnDOT Spec. 3733.2 Type 4 geotextile or appropriate filter layers.

4.2 Soil Infiltration Rate

We understand that SRF/City of White Bear Lake is considering installing stormwater infiltration structures along the channel alignment. The results of the subsurface exploration indicate that the underlying native soils consist of a very soft to medium stiff silty clay (CL) that extend to a depth of at least 15ft below the site grade.

The Minnesota Stormwater Manual, published by the Minnesota Pollution Control Agency, indicates that USCS symbols of CL fall within hydrologic soil group “D”. This

soil is reported to have an infiltration rate of approximately 0.06 inches per hour. We recommend that this infiltration rate be used in the design of stormwater BMPs used for this project.

5.0 GENERAL QUALIFICATIONS

This report has been prepared in order to aid in the evaluation of proposed channel improvement and to assist the Consultant in the design of the project. The scope is limited to the specific project and location described herein, and our description of the project represents our understanding of the significant aspects relevant to soil and foundation characteristics. In the event that any changes in the design, as outlined in this report, are planned. We should be informed so that changes can be reviewed and the conclusion of this report modified or approved in writing. As a check, we recommend that we be authorized to review project plans and specifications to confirm that our report recommendations have been interpreted in accordance with our intent. Without this review, we will not be responsible for misinterpretations of our data, or analysis and/or our recommendations nor how these are incorporated into the final design.

The analysis and recommendations are based on the data obtained from two (2) soil borings performed at the locations indicated in this report. This report does not reflect any variations which may occur between these locations. In the performance of subsurface explorations, specific information is obtained at specific locations and at specific times. It is a well-known fact that variations in soil conditions occur at most sites between boring locations. The nature and extent of the variation may not become evident until the course of construction. If variations appear event during embankment construction, it will be necessary for a re-evaluation of the recommendations of this report after performing on-site observations during the construction period and noting the characteristics of any variations.

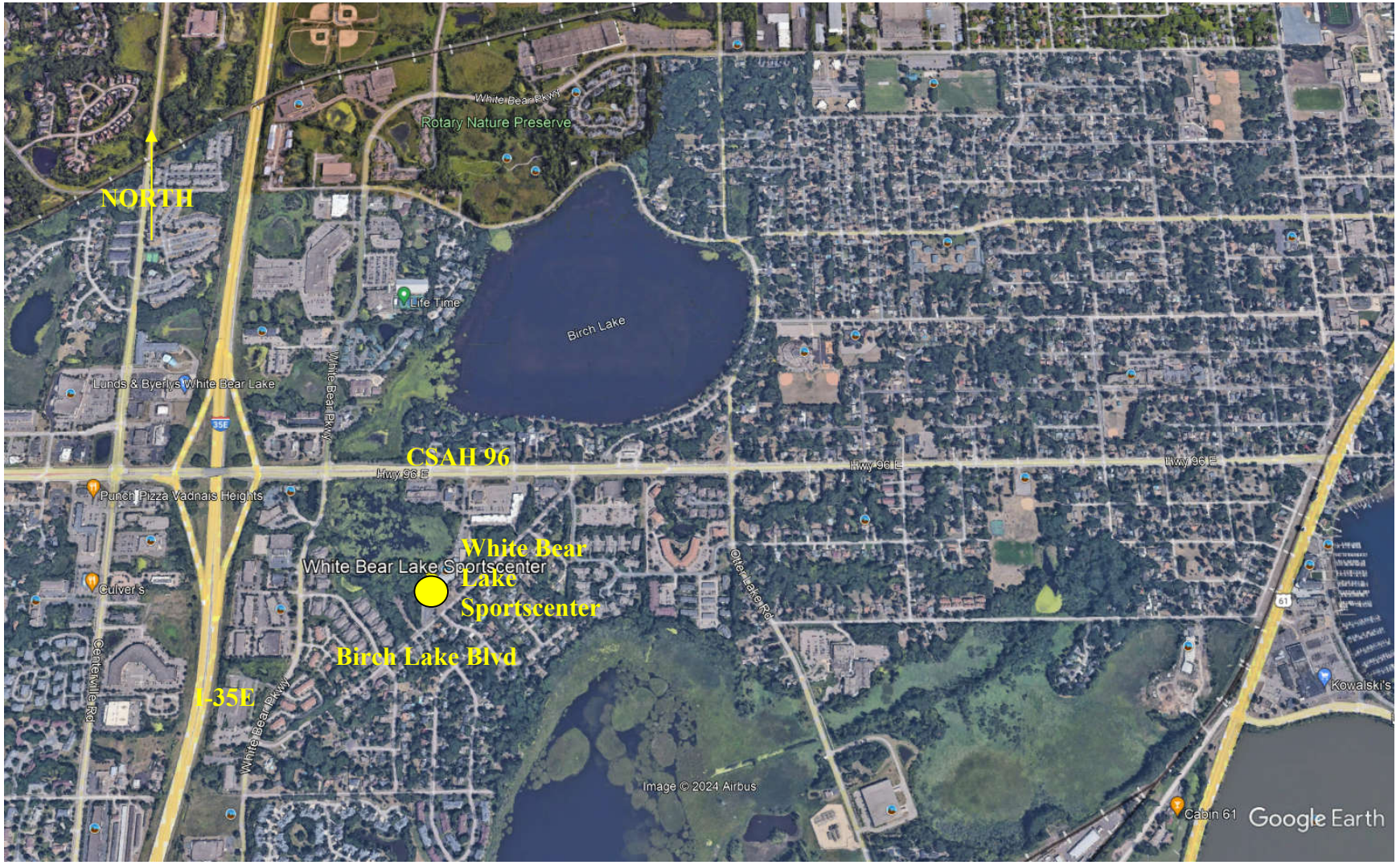
APPENDIX

1. Soil Boring Location Diagram

2. Soil Boring Logs

3. General Notes
   Classification of Soils for Engineering Purposes

1. Soil Boring Location Diagram



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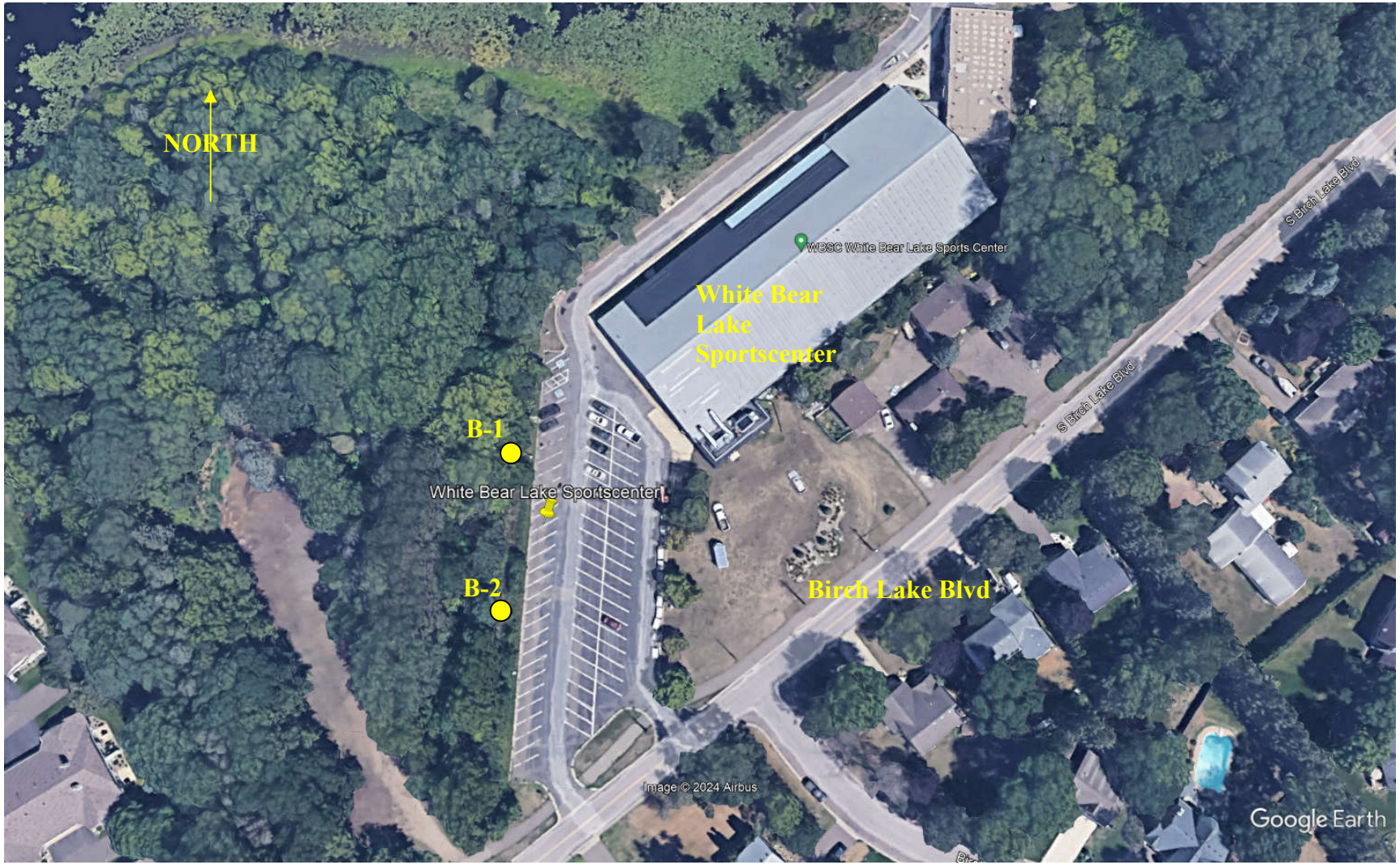
Site Location Diagram
White Bear Lake Parking Lot Improvements



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Soil Boring Location Diagram
White Bear Lake Parking Lot Improvements
Page 2 of 2

2. Soil Boring Logs

BORING NO. B-1

PROJECT:	CLIENT:
White Bear Lake Sportscenter Drainage Channel	SRF Consulting Group, Inc.
LOCATION: White Bear Lake, MN Northing: 152848.71, Easting: 437083.65	**ARCHITECT - ENGINEER:** SRF Consulting Group, Inc.

DEPTH IN FEET	SAMPLE NO.	SAMPLE TYPE	SOIL DESCRIPTION SURFACE ELEVATION: 950.85	N-VALUE IN BLOWS/FT.	% REC.	LABORATORY TESTS Qp (tsf)
	7	SS	Silty Sand, very fine to fine grained, dark brown-black, loose, moist, Topsoil Fill (SM)	4	83	
	8	SS	Silty Clay with little sand, medium stiff, brown-gray mottled, Fill (CL)	3	33	1.3
5	9	SS		3	44	0.3
	10	SS	Clayey Silt to Silty Clay, soft to medium stiff, brown (ML-CL)	2	44	0.3
10	11	SS		4	56	0.5
	12	SS		4	72	0.5
			Soil Boring Termination Depth = 14.5ft Soil Boring Drilled with Hollow Stem Auger Soil Boring Backfill with Soil upon Completion			

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS			
WL	7 ft, WD	BORING STARTED 9-11-24	
WL	Dry, AD	BORING COMPLETED 9-11-24	
CAVE IN DEPTH	3ft	RIG CME 75 HT	FOREMAN br
		DRAWN nl	JOB# 95688

GTE
GALE-TEC ENGINEERING, INC.

BORING LOG W/P200 WHITE BEAR LAKE SPORTSCENTER PARKING LOT.GPJ UNITWT.GDT 10/30/24

BORING NO. B-2

PROJECT:	CLIENT:
White Bear Lake Sportscenter Drainage Channel	SRF Consulting Group, Inc.
LOCATION: White Bear Lake, MN Northing: 153099.87, Easting: 437286.98	**ARCHITECT - ENGINEER:** SRF Consulting Group, Inc.

DEPTH IN FEET	SAMPLE NO.	SAMPLE TYPE	SOIL DESCRIPTION SURFACE ELEVATION: 943.57	N-VALUE IN BLOWS/FT.	% REC.	LABORATORY TESTS Qp (tsf)
	1	SS	Silty Sand, very fine to fine grained, dark brown-black, loose, moist, Topsoil Fill (SM)	6	83	
	2	SS	Silty Clay with little sand, medium stiff, brown-gray mottled, Fill (CL)	3	83	1.3
5	3	SS		3	78	0.3
	4	SS	Clayey Silt to Silty Clay, soft to medium stiff, brown (ML-CL)	2	78	0.3
10	5	SS		3	78	0.5
	6	SS		4	72	0.5
			Soil Boring Termination Depth = 14.5ft Soil Boring Drilled with Hollow Stem Auger Soil Boring Backfill with Soil upon Completion			

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS		GTE GALE-TEC ENGINEERING, INC.	BORING STARTED 9-11-24	
WL	Dry, WD		BORING COMPLETED 9-11-24	
WL	Dry, AD		RIG CME 75 HT	FOREMAN br
CAVE IN DEPTH	3ft		DRAWN nl	JOB# 95688

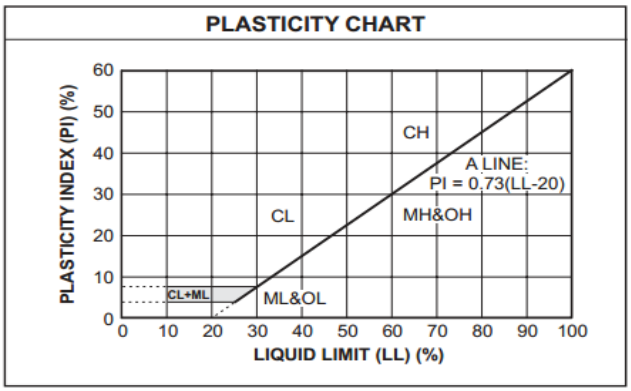
BORING LOG W/P200 WHITE BEAR LAKE SPORTSCENTER PARKING LOT.GPJ UNITWT.GDT 10/30/24

3. General Notes
Classification of Soils for Engineering Purposes

CLASSIFICATION OF SOILS FOR ENGINEERING PURPOSES

(ASTM: D 2487 and 2488)

Major Divisions			Group Symbols	Typical Names	Laboratory Classification Criteria		
Coarse-grained soils (More than half of material is *larger* than No. 200 sieve size)	**Gravels** (More than half of coarse fraction is *larger* than No. 4 sieve size)	**Clean Gravels** (Little or no fines)	**GW**	Well-graded gravels, gravel-sand mixtures, little or no fines	Determine percentages of sand and gravel from grain-size cuve. Depending on percentage of lines (fraction smaller than No. 200 sieve size), coarse-grained soils are classified as follows: Less than 5% ----------GW,GP,SW,SP More than 12%----------GM,MG,SM,SC 5 to 12%----------*Borderline* cases requiring dual symbols	$C_u = \frac{D_{60}}{D_{10}}$ greater than 4; $C_c = \frac{(D_{30})^2}{(D_{10})(D_{60})}$ between 1 and 3	
			GP	Poorly graded gravels, gravel-sand mixtures, little or no fines		Not meeting all gradation requirements for GW	
		Gravels w/ Fines (Appreciable amount of fines)	**GM** d / u	Silty gravels, gravel-sand-silt mixtures		Atterberg Limits below "A" line or P.I. less than 4	Above "A" line with P.I. between 4 and 7 are *borderline* cases requiring use of dual symbols
			GC	Clayey gravels, gravel-sand-silt mixtures		Atterberg Limits below "A" line or P.I. greater than 7	
	Sands (More than half of coarse fraction is *smaller* than No. 4 sieve size)	**Clean Sands** (Little or no fines)	**SW**	Well-graded sands, gravelly sands, little or no fines		$C_u = \frac{D_{60}}{D_{10}}$ greater than 4; $C_c = \frac{(D_{30})^2}{(D_{10})(D_{60})}$ between 1 and 3	
			SP	Poorly graded sands, gravelly sands, little or no fines		Not meeting all gradation requirements for SW	
		Sands w/ Fines (Appreciable amount of fines)	**SM** d / u	Silty sands, sand-silt mixtures		Atterberg Limits below "A" line or P.I. less than 4	Limits plotting in hatched zone with P.I. between 4 and 7 are *borderline* cases requiring use of dual symbols
			SC	Clayey sands, sand-clay mixtures		Atterberg Limits below "A" line or P.I. greater than 7	
Fine-grained soils (More than half of material is *smaller* than No. 200 sieve size)	**Silts and Clays** (Liquid limit *less* than 50)		**ML**	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or slayey silts with slight plasticity	For classification of fine-grained soils and fine fraction of coarse-grained soils. Atterberg Limits plotting in (CL+ML) area are borderline classifications requiring use of dual symbols.		
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays			
			OL	Organic silts and organic silty clays of low plasticity			
	Silts and Clays (Liquid limit *greater* than 50)		**MH**	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic soils			
			CH	Inorganic clays of high plasticity, fat clay			
			OH	Organic clays of medium to high plasticity, organic silts			
	Higly Organic Soils		**Pt**	Peat and other highly organic soils			



GALE-TEC ENGINEERING, INC.

GENERAL NOTES

DRILLING & SAMPLING SYMBOLS:

SL : SS with Liner
SS : Split Spoon – 1 3/8" I.D., 2" O.D., unless otherwise noted
ST : Shelby Tube – 2" O.D., unless otherwise noted
PA : Power Auger
DB : Diamond Bit – NX: BX: AX
AS : Auger Sample
JS : Jar Sample
VS : Vane Shear
OS : Osterberg Sampler – 3" Shelby Tube
HS : Hollow Stem Auger
WS : Wash Sample
FT : Fish Trail
RB : Rock Bit
BS : Bulk Sample
PM : Pressuremeter test – in situ

Standard "N" Penetration: Blows per foot of a 140 pound hammer falling 30 inches on a 2 inch OD split spoon, except where noted.

WATER LEVEL MEASUREMENT SYMBOLS:

WL : Water Level
WCL : Wet Cave In
DCL : Dry Cave In
WS : While Sampling
WD : While Drilling
BCR : Before Casing Removal
ACR : After Casing Removal
AB : After Boring

Water levels indicated on the boring logs are the levels measured in the boring at the times indicated. In pervious soils, the indicated elevations are considered reliable ground water levels. In impervious soils, the accurate determination of ground water elevations is not possible in even several days of observation, and additional evidence of ground water elevations must be sought.

GRADATION DESCRIPTION & TERMINOLOGY

Coarse Grained or Granular Soils have more than 50% of their dry weight retained on a #200 sieve; they are described as: clays or clayey silts if they are cohesive, and silts if they are non-cohesive. In addition to gradation, granular soils are defined on the basis of their relative in-place density and fine-grained soils on the basis of their strength or consistency, and their plasticity.

Major Component of Sample	Size Range	Descriptive Term(s) (Of Components Also Present in Sample)	Percent Dry Weight
Boulders	Over 8" (200mm)	Trace	1 – 9
Cobbles	8" to 3" (200mm to 75mm)	Little	10 – 19
Gravel	3" to #4 sieve (75mm to 2mm)	Some	20 – 34
Sand	#4 to #200 sieve (2mm to 0.074mm)	And	35 – 50
Silt	Passing #200 sieve (0.074mm to 0.005mm)		
Clay	Smaller than 0.005mm		

CONSISTENCY OF COHESIVE SOILS:

Unconfined Comp. Strength, Qu, tsf	Consistency
<0.25	Very Soft
0.25 – 0.49	Soft
0.50 – 0.99	Medium (Firm)
1.00 – 1.99	Stiff
2.00 – 3.99	Very Stiff
4.00 – 8.00	Hard
>8.00	Very Hard

RELATIVE DENSITY OF GRANULAR SOILS:

N – Blows / ft.	Relative Density
0 – 3	Very Loose
4 – 9	Loose
10 – 29	Medium Dense
30 – 49	Dense
50 – 80	Very Dense
80+	Extremely Dense