SAINT PAUL
MINNESOTA

2020 STORMWATER QUALITY AND QUANTITY MONITORING PROGRAM

CITY OF ST. PAUL

MARCH 30, 2020

Prepared for:
City of St. Paul
15 Kellogg Blvd West
St. Paul, MN 55102

WSB PROJECT NO. 015938

wsb

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LIST OF ABBREVIATIONS

BMP	Best Management Practices
CCB	Capital City Bikeway
CRWD	Capital Region Watershed District
Cu-ft	Cubic feet
DP	Dissolved phosphorus
EMC	Event mean concentration
FT	Feet
FWA	Flow-weighted average
HDPE	High-density polyethylene
In/hr	Inches per hour
IR	In-rock
lbs	Pounds
mg/L	Milligrams per liter
MS4	Municipal Separate Storm Sewer System
MSWM	Minnesota Stormwater Manual
MPCA	Minnesota Pollution Control Agency
MPN	Most probable number
MnDOT	Minnesota Department of Transportation
NPDES	National Pollutant Discharge Elimination System
OCS	Outlet control structure
SP	Poorly graded sand
SPCD	Saint Paul City Datum
SRP	Soluble reactive phosphorus
TP	Total phosphorus
TSS	Total suspended solids

1. Introduction

The purpose of this report is to present the findings of the City of Saint Paul's (City) 2020 Stormwater Monitoring Program. The monitoring was conducted to fulfill requirements of the City's National Pollutant Discharge Elimination System (NPDES) MS4 Phase I Permit. Data collected and analyzed is used to quantify stormwater volumes and loads from the Municipal Separate Storm Sewer System (MS4) and assist in the assessment of effectiveness of the City's Stormwater Management Program.

Since 2006, the City has been required by the Minnesota Pollution Control Agency (MPCA) to construct stormwater volume reduction Best Management Practices (BMPs) concurrent with City projects that generate or reconstruct impervious surfaces. The MPCA requirements stipulate that these BMPs must provide volume reduction for the runoff from a one-inch rainfall event over the impervious surfaces of the project. In 2015, the watershed updated their standard to require that the BMP provide volume reduction for the runoff from a 1.1-inch rainfall event over the impervious surface of the project. The City has typically achieved this by constructing infiltration BMPs.

The focus of the City's stormwater monitoring program has been to monitor the effectiveness and maintenance needs of stormwater BMPs. Outfall monitoring data, collected by Capitol Region Watershed District (CRWD), is used to evaluate pollutant loading from major sub-watersheds and to estimate City-wide pollutant loading from the MS4.

Four BMPs and two drainage areas monitored via storm pipe were monitored in 2020 to quantify progress toward meeting the City's stormwater management goals and to refine current design and maintenance practices. Rainfall was also measured at four locations in the City. The 2020 monitoring sites are shown on **Figure 1-1** and listed in **Table 1-1**. This effort focused on evaluating four major parameters during the monitoring period:

- Water level/infiltration rate
- Volume reduction
- Pollutant capture
- BMP maintenance

To evaluate these parameters, electronic monitoring equipment was used to continuously measure system water levels, inflow/outflow volumes, and rainfall amounts. In addition, visual inspections and measurements of sediment accumulation were conducted periodically for each system to assess maintenance needs.

Three of the monitored BMPs are pervious pavement sites, evaluated for infiltration performance. Long-term monitoring at these sites is completed to research the benefits, feasibility, and sustainability of pervious surface parking lanes, alleyways, and bike trails in the City.

This report describes the procedures and methods used to collect water quality and quantity data, provides background information for each site monitored, and presents the results of the monitoring that was completed.

Table 1-1: 2020 City of Saint Paul Monitoring Site Summary

BMP/Site Name	BMP/Site Type	Monitored Parameters[1]
Beacon Bluff	Underground Infiltration Gallery & Rain Garden	WL, Q, WQ, GW
St. Albans Street	Underground Infiltration Gallery	WL, Q, WQ
Hampden Park	Underground Infiltration Gallery	WL, Q, WQ, GW
Victoria Street	Pervious Pavers & Underground Infiltration Gallery	WL, Q, WQ, Infiltration
Battle Creek	Storm Pipe/Creek	WL, Q, WQ
Sackett Park	Storm Pipe/Flood Plain	WL, Q, WQ
Jackson Street Pervious Bike Path	Pervious Asphalt	Infiltration
Hamline Midway Library Pervious Alleyway	Pervious Asphalt	Infiltration
Wilder Foundation	Rainfall Monitoring Location	R
Fire Station 18	Rainfall Monitoring Location	R
Frost Elementary School	Rainfall Monitoring Location	R
Edgcumbe Recreation Center	Rainfall Monitoring Location	R

1 WL- Water Level, Q – Flow Rate, WQ – Water Quality, GW – Groundwater, R – Rainfall

2. Procedures and Methodology

This section outlines the procedures and methods followed to perform monitoring and data analysis. For more detailed information related to equipment use monitoring protocols that were followed for this monitoring program, see the 2020 Stormwater Monitoring Protocols document located in **Appendix F**.

2.1. Infiltration Rate

The infiltration rate was measured at applicable locations by collecting water level data on a continual basis. The data was then analyzed to estimate the average infiltration rates observed during the monitoring period. The following provides a detailed description of how this was completed. The water level data collected at those sites was reviewed to determine level fluctuation over the monitoring period and to compare against normal and high-water elevations.

2.1.1 Data Collection

Water levels were monitored using electronic level loggers. The loggers were configured at each site to log data at a minimum of one reading per hour for groundwater and once every 15 minutes for BMPs.

Enclosures for the infiltration gallery level loggers were installed at Beacon Bluff, St. Albans Street, and Hampden Park. These consisted of three-inch-diameter PVC pipes with four rows of half-inch-diameter holes drilled along the pipe achieving approximately twenty holes per foot. The enclosures were then wrapped with a highly permeable geotextile fabric and secured with zip ties to protect the instrument from fine sediment accumulation. Enclosures were secured to the system floor and to the access riser wall (**Photo 2-1**). Groundwater and rain garden locations were monitored from permanent monitoring wells (**Photo 2-2**).

Photo 2-1:
Infiltration Gallery Level Monitoring Enclosure

Photo 2-2:
Beacon Bluff Rain Garden and In-Rock Wells

2.1.2 Data Analysis

The data collected at each site reflected hydrograph-type curves resulting from the rise and fall of water within the systems during and after significant rainfall events. The data was analyzed in Microsoft Excel to develop stage/infiltration rate relationships for each system. Since the infiltration rates increase exponentially at higher depths in the systems, this relationship was developed by calculating the infiltration rate at each half foot height increment. These calculations also accounted for the volume of runoff entering the system while drawdown was occurring. Infiltration of water in the horizontal direction through the vertical surfaces of the trenches was not included in this analysis, as the policies of the watershed districts only recognize infiltration through the bottom horizontal surface. The infiltration rates calculated at each increment were averaged and plotted on a graph.

The following equation was used to perform these calculations at each half foot increment:

$$\boldsymbol{Infiltration\ Rate}\left(\frac{\boldsymbol{in}}{\boldsymbol{hr}}\right) = \frac{\mathbf{0.5}\ \boldsymbol{ft} + \frac{\mathbf{V_{in}}}{\mathbf{WHSA}}}{\boldsymbol{\Delta t}}$$

where:

V_{in} = Inflow Volume (cu-ft)
WHSA = Wetted Horizontal Surface Area (sq-ft)
Δt = Time it takes for water level to drop by 0.5 ft

Monitored Infiltration rates were evaluated against design infiltration rates as described in the Minnesota Stormwater Manual (MPCA, 2008) and infiltration rates observed during pre-construction field testing.

2.2. Flow & Volume Reduction

Stormwater runoff volume was measured at Beacon Bluff, Victoria Street, St. Albans Street, Hampden Park, Sackett Park, and Battle Creek using continuous flow monitoring equipment. At BMP Sites, the data was utilized to determine the total volume of water draining to and captured by each system. Collected data was analyzed using Flowlink software and Microsoft Excel to quantify the volumes measured during each discrete rainfall event recorded during the monitoring periods. The following section provides brief descriptions of the methods and procedures used to quantify flow at each system.

2.2.1 Data Collection

Teledyne ISCO 2150 area velocity flow modules and sensors were used to monitor runoff volumes. These devices measure water level and flow velocity. Combining this information with a known conduit shape, the flow rate, and flow volume through the conduit were calculated. Each of the monitored systems received stormwater runoff from a diversion structure located along the storm sewer system. The 2150 flow sensors were positioned at the upstream and downstream pipes in these structures to measure the total volume draining to each BMP and the total volume that bypassed each BMP. **Photos 2-3** and **2-4** show the flow meters installation in Battle Creek and Sackett Park, respectively.

The flow modules were configured at each site to log data at one-minute intervals once the water level in the upstream pipe was greater than one-inch above the pipe invert to increase the resolution of the flow data.

Photo 2-3: Flow Monitoring Module Install Process

Photo 2-4: Flow Sensor in Downstream Pipe in Victoria Diversion Structure

2.2.2 Data Analysis

Flow data was regularly imported into Flowlink 5.1 for storage and analysis. Data was analyzed and validated using built-in velocity error checking parameters. The flow level and velocity data were converted to total flow volumes and exported to a Microsoft Excel spreadsheet for further analysis. Each rainfall event and associated inflow and outflow volumes were tabulated.

For the Beacon Bluff, Saint Albans Street, and Hampden Park BMPs, runoff volume was estimated for un-monitored system inlets by taking the monitored flow data and multiplying by the ratio of the respective drainage areas.

2.3. Water Quality

Water quality was monitored at the Beacon Bluff BMP, Victoria Street BMP, Battle Creek, Hampden Park, Sackett Park, and St. Albans Street. The following section provides a summary of the methods and procedures used to collect and test water quality samples and analyze the data.

2.3.1 Data Collection

Photo 2-5:
ISCO 6712 Sampler at Battle Creek

Photo 2-6:
ISCO Bottle Configuration

ISCO 6712 automatic samplers were installed at all water quality locations. (**Photos 2-5** and **2-6**).

The automatic samplers were configured to collect 250 mL samples at constant volume intervals. The flow pacing intervals were initially estimated for each site to provide a minimum of six samples during a quarter-inch storm, but less than 120 samples for the three-inch storm. Flow pacing was refined during the monitoring period to achieve this objective.

Samples from sufficiently sized rainfall events were submitted to the Metropolitan Council Environmental Services (MCES) Laboratory for analysis. The samples were composited using a batch mixing technique to create one sample for the event. All water quality monitoring site composite samples were analyzed for the parameters listed in the **Table 2-1** as volumes allowed, in accordance with the City's NPDES Permit. Grab samples were also collected during select storm events and analyzed for *E. Coli* and grease. The most probable number (MPN) procedure was used to determine the concentration of *E. Coli* in the stormwater runoff.

Table 2-1: Water Quality Parameters

Monitoring Parameters			
Parameters	**Method**	**Sample Type**	**Frequency**
Oil and Grease	SM 5210B	Grab	Quarterly
Chloride, Total	SM4500	Composite	10/year
Copper, Total (as Cu)	EPA 200.7	Composite	10/year
E. coli	MPN	Grab	Quarterly
Flow	NA	Measurement	NA
Hardness, Carbonate (as CaCo3)	SM 2340B	Composite	10/year
Lead, Total (as Pb)	EPA 200.7	Composite	10/year
Nitrite Plus Nitrate, Total (asN)	SM4500/NO3F	Composite	10/year
Nitrogen, Ammonia, Un-ionized (as N)	EPA 350.1	Composite	10/year
Nitrogen, Kjeldahl, Total	EPA 351.2	Composite	10/year
pH	EPA 9045D	Grab	Quarterly
Phosphate, total Dissolved or Ortho	EPA 365.1	Composite	10/year
Phosphorus, Total as P	EPA 365.1	Composite	10/year
Precipitation	NA	Measurement	1 x Day
Solids, Total Dissolved (TDS)	SM2540 C-97	Composite	10/year
Solids, Total Suspended (TSS)	ASTM D3977-97	Composite	10/year
Chemical Oxygen Demand (COD)	EPA 9056A	Composite	10/year
Organic Dissolved Carbon	EPA 9060A	Composite	10/year
Volatile Suspended Soilds (VSS)	EPA 160.4	Composite	10/year
Zinc, Total (as Zn)	EPA 200.7	Composite	10/year

2.3.2 Data Analysis

The event mean concentrations (EMCs) derived from sampling events were multiplied by the corresponding volume measurements taken at each site for every rainfall event sampled. For storm events with no sampling data, a flow weighted EMC concentration from that site's entire monitoring period was used. This information was tabulated and summed to determine the total amount of pollutants generated in the contributing drainage areas and the number of pollutants captured by the BMP, at applicable sites.

2.4. Maintenance Inspections

BMP inspections were conducted at Beacon Bluff, St. Albans Street, Hampden Park, and Victoria Street sites periodically during the monitoring period. Pre-treatment structures were inspected for accumulated sediment depth and floatable debris. Underground chambers were inspected from the level monitoring location for accumulation of sediment, debris, and standing water. Inspection photos are included in the photo log (**Appendix E**).

2.5. Pervious Surface Infiltration Rate

The infiltration rate of the permeable surfaces was measured at the Victoria Street, Hamline Midway Library, and Jackson Street pervious pavement sites following the protocols outlined in ASTM method C1701 (**Appendix G**). The following section provides a summary of those methods.

2.5.1 Data Collection

Infiltration tests were conducted according to the modified ASTM C1701 methods for measuring infiltration rates (**Photo 2-7**). Five locations at Victoria Street, 18 locations at Jackson Street, and nine locations at Hamline Midway Library were evaluated to develop an average infiltration rate measurement for each site. Tests were taken at locations that remained consistent year to year and included a combination of high and low traffic areas. At each test location, a pre-wet test was conducted, followed by two infiltration tests. The two infiltration tests were averaged to generate the infiltration rate for each location. If after 15 minutes of monitoring during a pre-wet test no infiltration was observed, the test was concluded, and no subsequent tests were completed.

Photo 2-7: Permeable Pavement Infiltration Test

3. Precipitation Summary

As part of the City's stormwater monitoring program, seasonal precipitation monitoring is conducted at the following locations: Saint Paul Fire House 18, Wilder Foundation, Edgcumbe Recreation Center and Frost Lake Elementary School (**Figure 1-1**). The precipitation data collected at these locations provides localized rainfall totals which are utilized for calculating rainfall intensity and runoff yield at monitored BMP sites. Each station is equipped with an automated tipping bucket that records continuously throughout the season.

Precipitation data collected by MCES, Minnesota Climatology Working Group (MCWG), and the National Weather Service (NWS) is used to supplement the City's data as needed. This includes any data gaps in seasonally monitored stations as well as parameters, such as snowfall and snowpack depth, which exceed the limitations of the City's monitoring equipment. These stations also provide a longer period of record which is valuable for analyzing rainfall trends. Data collected by MCWG and NWS is accessible through the Midwest Regional Climate Center online database (MCWG, 2019).

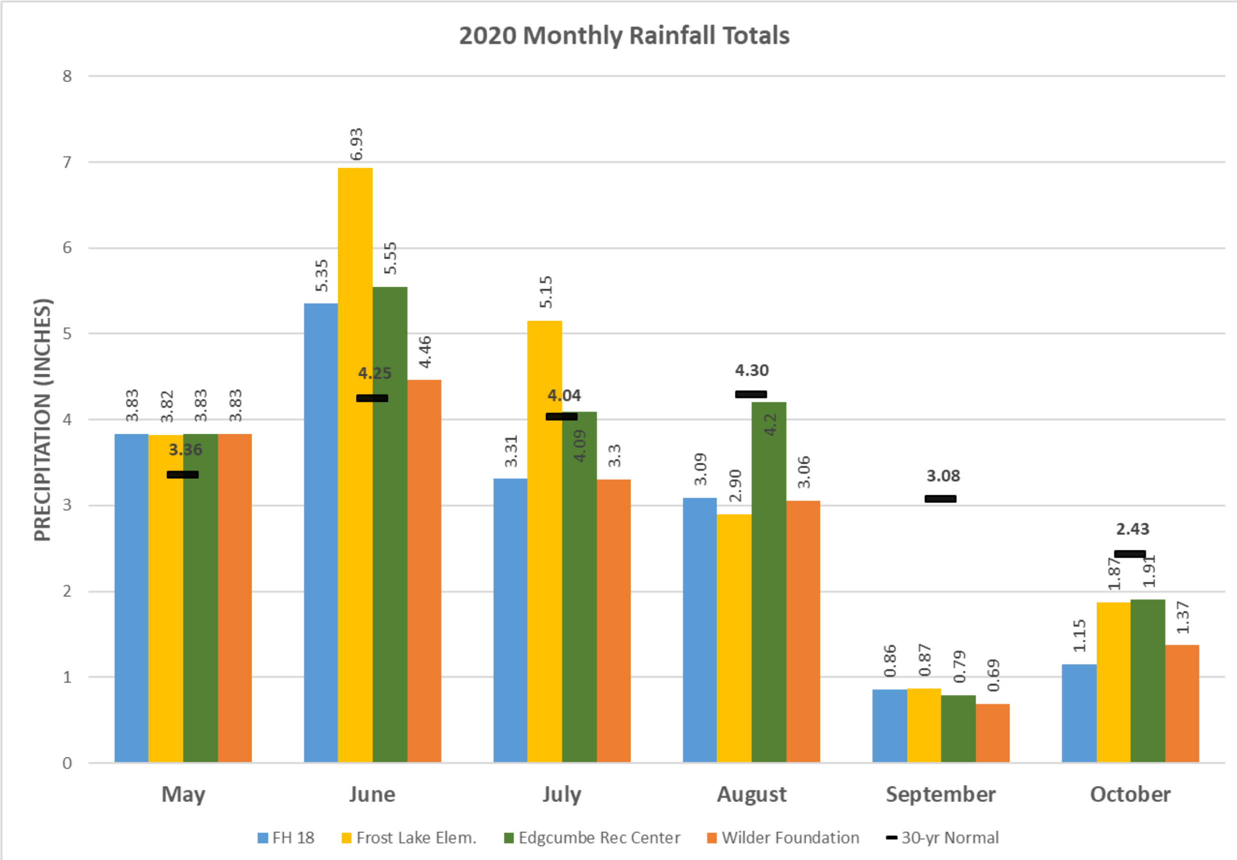
Table 3-1 and **Chart 3-1** show 2020 monthly precipitation totals for seasonally monitored sites compared to the 30-year normal. The 30-year normal reflect data collected from 1981-2010 and are updated every ten years, with the most recent update being in 2010.

May through October rainfall ranged from 16.71 inches at the Wilder Foundation to 21.54 inches at Frost Lake Elementary. The City-wide average for those months was 19.05 inches which is 2.41 inches less than the 30-year normal. The greatest variability between stations was observed during the month of June with 2.47 inches more rainfall recorded at Frost Lake Elementary than Wilder Foundation. The month of September saw the greatest departure from the 30-year normal (-2.28 inches).

Table 3-1: 2020 Seasonal Precipitation Summary

Month	FH 18	Frost Lake Elem.	Edgcumbe Rec Center	Wilder Foundation	City-Wide Average	30-yr Normal	Departure from 30-yr Normal
May	3.83	3.82	3.83	3.83	3.83	3.36	0.47
June	5.35	6.93	5.55	4.46	5.57	4.25	1.32
July	3.31	5.15	4.09	3.3	3.96	4.04	-0.08
August	3.09	2.90	4.2	3.06	3.31	4.30	-0.99
September	0.86	0.87	0.79	0.69	0.80	3.08	-2.28
October	1.15	1.87	1.91	1.37	1.58	2.43	-0.86
Seasonal Total	**17.59**	**21.54**	**20.37**	**16.71**	**19.05**	**21.46**	**-2.41**

Chart 3-1


2020 Monthly Rainfall Totals
PRECIPITATION (INCHES)
0
1
2
3
4
5
6
7
8
May
June
July
August
September
October
3.83
3.82
3.83
3.83
3.36
5.35
6.93
5.55
4.46
4.25
3.31
5.15
4.09
3.3
4.04
3.09
2.90
4.2
3.06
4.30
0.86
0.87
0.79
0.69
3.08
1.15
1.87
1.91
1.37
2.43
FH 18
Frost Lake Elem.
Edgcumbe Rec Center
Wilder Foundation
30-yr Normal

Major rainfall events in 2020 are provided in **Table 3-2** below:

Table 3-2: 2020 Significant Rainfall Events

Date	Rainfall Total (in)[1]	Duration (hr)	Intensity (in/hr)
5/16/20-5/17/20	2.61	23.5	0.11
6/28/20-6/29/20	4.51	16	0.28
7/5/2020	1.99	1.5	1.33
7/25/20-7/26/20	1.31	9.25	0.14

1 - Rainfall event totals may not reflect total daily rainfall.

Table 3-3 below provides a five-year monthly precipitation summary as recorded at the University of Minnesota Saint Paul Campus. Annual precipitation has exceeded the 30-year normal every year in the last five years, except for this year (2020). Total precipitation in 2020 was 25.80 inches, 4.81 inches below normal. Most months saw below average rainfall amounts with September seeing the greatest difference from the 30-year normal at 2.03 inches below and accumulating only 1.05 inches of precipitation.

Table 3-3: 5-year Precipitation Summary (UMN – Saint Paul Campus)

Month	2016	2017	2018	2019	2020	30-yr Normal
January	0.28	0.93	1.07	0.36	0.81	0.90
February	0.79	0.70	1.24	2.31	0.53	0.77
March	2.15	0.58	1.38	2.09	2.76	1.89
April	3.66	3.68	2.37	3.37	1.67	2.66
May	2.05	6.54	3.52	6.44	4.43	3.36
June	3.65	3.16	4.64	2.85	4.15	4.25
July	5.97	2.45	4.07	4.75	2.20	4.04
August	9.90	8.89	2.91	6.88	3.70	4.30
September	5.19	1.25	7.19	4.88	1.05	3.08
October	3.32	4.84	3.4	4.93	2.25	2.43
November	2.70	0.42	1.41	1.67	1.37	1.77
December	2.01	0.62	1.32	2.42	0.88	1.16
Total	**41.67**	**34.06**	**34.52**	**42.95**	**25.80**	**30.61**
Departure from 30-yr Normal	**+11.06**	**+3.45**	**+3.91**	**+12.34**	**-4.81**	**N/A**

4. Beacon Bluff

This system, shown in **Figure 4-1**, is owned and operated by the City. The Saint Paul Port Authority contributed financially to the project and oversaw its construction. Volume reduction credits were split between the City and the Saint Paul Port Authority based on the respective financial contribution. Performance monitoring of the system has been conducted since 2012 and rainfall monitoring for the site is conducted at Frost Lake Elementary, located 1.8 miles to the northwest. The BMP system details are provided in **Table 4-1**.

The system is comprised of three connected stormwater treatment structures, which include a stormwater pond west of the Duchess Street cul-de-sac (west pond), an infiltration basin east of the cul-de-sac (rain garden) (**Photo 4-1**), and an underground infiltration chamber (**Photo 4-2**) constructed directly beneath the rain garden. The underground chamber consists of three, parallel, 215-foot-long, ten-foot-diameter perforated metal pipes for infiltration.

The Beacon Bluff system has a total drainage area of 143.6 acres, which consists of three subwatersheds. Stormwater from a 136.8-acre drainage area is routed to a diversion structure in the storm sewer along Duchess Street (MH7). The diverted stormwater passes through a manhole equipped with a SAFL Baffle pre-treatment system for particle settling, and then discharges to the rain garden. Two inlets on the eastern side of the rain garden discharge stormwater from a 4.7-acre drainage area immediately surrounding the BMP. Stormwater from a 2.1-acre drainage area discharges to the west pond, which outlets directly to the underground chamber.

Overflow grates within the rain garden allow stormwater to spill from the rain garden, directly into the underground chamber. When the underground chamber reaches capacity, stormwater discharges from the underground system, through an outlet control structure, back to the main storm sewer line.

Table 4-1: Beacon Bluff BMP Details

Total Drainage Area to BMP	143.6 acres
Sub-watershed to Diversion Structure (discharge to rain garden)	*136.8 acres*
Sub-watershed to Eastern Inlet Pipes (discharge to rain garden)	*4.7 acres*
Sub-watershed to West Pond (discharge from west pond to underground chamber)	*2.1 acres*
Year Constructed	2011
Total Construction Cost	$980,000
Storage Volume[1]	159,350 cu-ft
Volume Reduction Credit Received by the City of Saint Paul	116,435 cu-ft
Volume Reduction Credit Received by Saint Paul Port Authority	42,925 cu-ft

Photo 4-1: Underground Infiltration Chamber (Facing West)

Photo 4-2: Rain Garden Located above Infiltration Chambers (Facing East)

4.1. Water Level and Infiltration Rate Monitoring

Water level was monitored by a logger placed directly in the BMP Pipe. Water level in the rain garden was not measured in 2020 due to piezometer damage following a dredge in the Spring of 2019. An additional logger was installed within the outlet control structure of the system to confirm when flow was being conveyed back to the storm sewer from the underground chamber. Groundwater elevation was also measured in two locations at the site. Water level elevations within the system and groundwater, and daily rainfall totals are presented on **Chart A.1** and **A.2** of **Appendix A**.

Photo 4-3: Water being conveyed back to the storm sewer from the underground chamber in the outlet control structure.

Overflow in the outlet control structure to the storm sewer, (**Photo 4-3**), occurred during eight treatment events. The 2020 rain garden infiltration rate and infiltration rate trends are provided on **Charts A.3** and **A.5** of **Appendix A**, respectively. The 2020 average infiltration rate for the BMP Pipe was 0.12 inches per hour (in/hr), which is less than the Minnesota Stormwater Manual (MSWM) recommended infiltration rate for SP (poorly graded sand) soils of 0.80 in/hr. This is the same as the rates observed in 2019 (0.12 in/hr) and 2018 (0.12 in/hr) (**Table 4-2**). Sediment accumulation has been observed ranging from 0.5 ft to 1.5 ft of depth, across the basin. The 141.5-acre drainage area discharging directly to the pond conveys a significant amount of sediment and debris, which has accumulated primarily around the diversion inlet pipe. Dredge maintenance was completed on the rain garden over the Spring of 2019.

Table 4-2: Beacon Bluff Infiltration Rates

Location	Average Infiltration Rate (in/hr)								
	2012	2013	2014	2015	2016	2017	2018	2019	2020
Beacon Bluff Rain Garden (IR-31)	2.9	0.85	0.70	0.29	0.43	0.50	0.40	NA	NA
Beacon Bluff Underground System (IR-32)	2.6	0.57	0.64	0.30	0.15	0.11	0.12	0.12	0.12

Water level in the underground system ranged from 8.3 ft to 21.0 ft deep. Depths greater than 10 feet indicate the water is rising into the substrate above the 10-ft diameter corrugated metal infiltration pipes. The data indicates that the system did not drain to empty during the 2020 monitoring period, including over the winter months. The underground system discharged back to the storm sewer (system outflow) during 7 storm events in 2020. Discharge events occurred 2015 (five), 2016 (nine), 2017 (ten) 2018 (fourteen), and 2019 (fifteen). The decrease in 2020 from previous years can be attributed to less precipitation and less water entering the system. The overall increased frequency of system discharge events is a result of the standing water in the underground system and the capacity it utilizes. Groundwater elevations at the site were a minimum of 10 ft below the bottom of the underground chamber, which suggests that groundwater mounding is not the cause of standing water in the system.

The 2020 underground chamber infiltration rate and infiltration rate trends are provided on **Charts A.4** and **A.6** of **Appendix A**. From 2012 to 2020, the infiltration rate has decreased from 2.6 in/hr to 0.12 in/hr, with the largest decline following the first year of monitoring in 2012. As mentioned above, standing water in the underground system has resulted in a decrease in infiltration rates each year.

4.2. Volume Reduction Monitoring

Stormwater flowing into the BMP was measured in the Duchess Street diversion structure and at the outlet of the west pond, which discharges directly to the underground chamber. Volume that bypassed the system was measured with a flow meter downstream of the Duchess Street diversion structure. Inflow volume from the inlets discharging into the eastern side of the rain garden was modeled using the Duchess upstream flow data and the ratio of drainage areas. Level logger data from within outlet control structure was used to identify when the underground system was at capacity, and estimate the volume being conveyed back to the storm sewer system from the BMP. Flow rates and daily rainfall are depicted on **Chart B.1** of **Appendix B**. An event-based volume reduction summary is provided with the pollutant loading data in **Table C.2** of **Appendix C**. A summary of the 2020 Beacon Bluff Volume Reduction is included in **Table 4-3** below.

In 2020, total runoff to the Beacon Bluff system was 1,500,588 cubic feet (cu-ft). Of that volume, 917,092 cu-ft was captured by the system, resulting in a 61.1% volume reduction. The total flow conveyed back to the storm sewer from the underground system was 502,547 cu-ft. For the 143.6-acre drainage area to the diversion structure, the total water yield was 10,450 cu-ft/acre which is equivalent to 2.88 inches of runoff as a result of 18.6 inches of rain (15%). The greatest volume captured by the BMP was 111,128 cu-ft on May 16th, 2020. This volume represents 69.7% of the total storage capacity of the system.

Table 4-3: Beacon Bluff Volume Reduction

Monitoring Period	4/29/2020 – 10/12/2020		
Total Rainfall		18.6	in.
Diversion Structure Water Balance			
Runoff Volume:		1,405,133	cu-ft
Runoff Yield:		2.88	in/acre
Bypassed Volume:		68,676	cu-ft
Volume Diverted into BMP:		1,336,457	cu-ft
Beacon Bluff Rain Garden and Infiltration Gallery Inputs			
Inflow Volume from Diversion Structure:	SubWSHD A	1,336,457	cu-ft
Inflow Volume from West Pond:	SubWSHD B	16,064	cu-ft
Inflow Volume from Eastern Inlets:	SubWSHD C	67,118	cu-ft
System Discharge (conveyed back to storm sewer from OCS):		502,547	cu-ft
Beacon Bluff System Performance			
Total Runoff Volume:		1,500,588	cu-ft
Total Runoff Volume Captured:		917,092	cu-ft
Percent of Total Runoff Volume Captured:		61.1	%
Maximum Percentage of Storage: Volume Utilized [1]		69.7	%

1- This is the maximum volume infiltrated by the BMP for a treatment event as a percentage of the total storage volume. The system exceeded 100% capacity on several occasions, but only a portion of the total capacity was available for infiltration due to standing water in the BMP.

4.3. Pollutant Removal Monitoring

A water quality sampler was placed in the Duchess Street diversion structure to collect samples during runoff events. The sampler was paced to collect samples at equal volume intervals to provide a representative sampling of each storm event. Samples for each event were tested as a composite to provide EMC during each event for each parameter analyzed. Grab samples were collected in the diversions structure near the automated sampler quarterly and tested for *E. Coli*. See **Charts C.1** and **C.2** of **Appendix C** for the complete water quality summary and pollutant loading calculations.

Table 4-4 below provides a load reduction summary for the loading parameters defined in NPDES Permit issued to the City in addition to ortho-phosphate. During the monitoring period, 3,191 pounds of TSS and 17.6 pounds of TP were captured by the system. Over the past eight years of monitoring, 102,928 pounds of TSS and 384 pounds of TP have been captured at the Beacon Bluff Site.

Table 4-4: Beacon Bluff Load/Capture Summary

Monitoring Period		5/9/2020 – 10/12/2020		
Total Rain		18.6		
Water Quality Parameter	**Flow Weighted Average (mg/L)**	**Total Pollutant Load (lbs)**	**Load Captured (lbs)**	**Percent Reduction %**
Total Suspended Solids	59	5,147	3,191	62
Volatile Suspended Solids	23.7	2,200	1,365	62
Inorganic Suspended Solids	61.5	5,716	3,558	62
Total Phosphorus	0.29	27.8	17.6	63
Ortho-phosphate	0.086	8.21	5.16	63
Chloride	4.35	404.5	255.0	63
Total Kjeldahl Nitrogen	1.75	162.7	101.5	62
Nitrate + Nitrite as N	0.410	38.1	23.5	62

4.4. Maintenance Inspection

Visual inspections of the pretreatment structure, rain garden, and underground system were completed during site visits to determine performance and maintenance needs. As shown in **Table 4-5**, sediment depths in the pretreatment device were approximately 0.1 ft to 0.4 ft throughout the 2020 season. Floatables were observed in the pretreatment structure during all visits and within the rain garden.

Standing water was observed in the underground system on all visits, as discussed in **Section 4.1**. The last chamber inspection was completed in November 2014 when the system was mostly empty. At that time, roughly 0.25 ft of sediment was observed within the grooves of the corrugated pipe, along the bottom. See **Appendix E** for photos of the BMP inspections.

Table 4-5: Beacon Bluff Maintenance Inspections

Date	Sediment Depth in Pre-treatment (ft)	Sediment Depth in Infiltration Gallery (ft)[1]	Standing Water in Infiltration Gallery?	Observations
Pre-Treatment Chamber Cleaned on May 18, 2020				
June 12, 2020	0.1	NM	Y	Trash in pretreatment
July 16, 2020	0.2	NM	Y	Trash in pretreatment
August 18, 2020	0.1	NM	Y	Trash in pretreatment
October 5, 2020	0.4	NM	Y	Trash in pretreatment

1-Not Measured – Sediment levels could not be evaluated in the infiltration galley due to the depth of standing water and the total depth of the system.

5. St. Albans Street

This system, shown in **Figure 5-1**, was constructed in 2010 to provide volume reduction along the Central Corridor light rail transit way. Volume and flow have been monitored at the site since 2012, with water quality monitored in 2014, 2015, 2019, and 2020.

A manhole structure positioned along the main storm sewer under Aurora Avenue diverts stormwater into the underground infiltration system (**Photo 5-1**) via a 30-inch elliptical pipe. The system is also connected to the University Avenue storm sewer system. Any runoff that does not get treated by infiltration trenches and tree planters along University Avenue is directed to this system (**Photo 5-1**). When the system reaches its storage capacity, water flows west through the existing storm sewer system. The system includes a pretreatment structure comprised of a grit chamber and baffled weir to provide settling for sediment and skimming. Rainfall monitoring for the site is conducted on the roof of Fire Station 18, located across the street from the BMP. The BMP system details are provided in **Table 5-1**.

Table 5-1: St. Albans Street BMP Details

Total Drainage Area to BMP	25.2 acres
Year Constructed	2010
Total Construction Cost	$381,903
Storage Volume	31,189 cu-ft
Volume Reduction Credit Received by the City of Saint Paul	31,189 cu-ft

Photo 5-1: St. Albans 48" Perforated HDPE Installation

5.1. Water Level and Infiltration Rate Monitoring

BMP water level was monitored in the access manhole at the northwest corner of the system. The 2020 water elevations and daily rainfall is provided on **Chart A.11** of **Appendix A**. Water level monitoring indicated that the infiltration gallery reached 100% capacity only 2 times in 2020. Every treatment event monitored in 2020 resulted in the infiltration gallery drawing down to empty in less than a 24-hour period.

Infiltration rates are presented on **Chart A.12** of **Appendix A**. In 2020, the average infiltration rate of the BMP pipe was 9.9 in/hr (**Table 5-2**), which is above the MSWM recommended infiltration rate for SP soils of 0.8 in/hr, but below the design infiltration rate of 26.0 in/hr. Infiltration rate trends for the St. Albans Street BMP pipe are depicted on **Chart A.13**.

Table 5-2: St. Albans Infiltration Rate

Location	Average Infiltration Rate (in/hr)								
	2012	2013	2014	2015	2016	2017	2018	2019	2020
St. Albans Street BMP Pipe	38.5	35.7	64.8	55.3	36.2	20.6	21.3	9.6	9.9

5.2. Volume Reduction Monitoring

Two flow meters were installed in the storm sewer diversion manhole located in the intersection of St. Albans Street and Aurora Avenue. One meter was installed in the elliptical pipe to capture flows into the system from the south, and the other was installed in the downstream pipe to measure flows bypassing the system to the west. The difference in volume recorded by the two meters is assumed to be diverted into, and infiltrated by, the BMP. An additional flow meter was installed in the 30-inch pipe at the corner of St. Albans Street and University Avenue to capture flows into the system from along University Avenue. Flow rates and daily rainfall are depicted on **Chart B.3** of **Appendix B**.

In 2020, total runoff for the St. Albans Street system was 227,611 cu-ft. Of that volume, 219,920 cu-ft was captured and infiltrated by the system, resulting in a volume reduction of 97% (**Table 5-3**). On average, 40% of the total volume of flow diverted into the BMP was from the University Avenue inlet pipe. The total water yield for the 25.2-acre drainage area is 9,032 cu-ft/acre which is equivalent to 2.49 inches of runoff resulting from 10.8 inches of rain (23%). The greatest volume infiltrated by the BMP was 51,270 cu-ft, which represents 164% of the total storage capacity of the system. Storm-specific rainfall and volume reduction data is provided on **Chart B.4** of **Appendix B**.

Table 5-3: St. Albans Street Volume Reduction

Monitoring Period	6/21/2020 – 10/12/2020	
Total Rainfall	10.8 in	
	System Water Balance	
Aurora Runoff Volume:	136,294	cu-ft
Aurora Bypassed Volume:	7,691	cu-ft
St. Albans and University Volume	91,317	cu-ft
	St. Albans System Performance	
Total Runoff Volume	227,611	cu-ft
Runoff Yield	2.49	in/acre
Total Runoff Volume Captured	219,920	cu-ft
Percent of Runoff Volume Captured:	97	%
Maximum Volume Discharge to BMP	51,270	cu-ft
Maximum Percentage of Storage Volume Utilized[1]	164	%

1- This is the maximum volume infiltrated by the BMP for a treatment event as a percentage of the total storage volume.

5.3. Pollutant Removal Monitoring

A water quality sampler was placed in the diversion structure at the intersection of St. Albans and Aurora Ave. to collect samples during runoff events. The sampler was paced to collect samples at equal volume intervals to provide a representative sampling of each storm event. Samples for each event were tested as a composite to provide EMC during each event for each parameter analyzed. Grab samples were collected in the diversions structure near the automated sampler quarterly and tested for *E. Coli*. See **Charts C.1** and **C.2** of **Appendix C** for the complete water quality summary and pollutant loading calculations.

Table 5-4 below provides a load reduction summary for the loading parameters defined in NPDES Permit issued to the City in addition to ortho-phosphate. During the monitoring period, 3,104 pounds of TSS and 6.1 pounds of TP were captured by the system. Percent captured for all parameters were above 92% in 2020.

Table 5-4: St. Albans Load/Capture Summary

Monitoring Period		6/21/2020 – 10/12/2020		
Total Rain		10.8		
Water Quality Parameter	**Flow Weighted Average (mg/L)**	**Total Pollutant Load (lbs)**	**Load Captured (lbs)**	**Percent Reduction %**
Total Suspended Solids	227.8	3,369	3,104	92
Volatile Suspended Solids	50.7	750	691	92
Inorganic Suspended Solids	80.3	1,207	1,127	93
Total Phosphorus	0.45	6.5	6.1	94
Ortho-phosphate	0.072	1.05	0.99	96
Chloride	7.6	112	105	94
Total Kjeldahl Nitrogen	1.68	24.7	23.1	93
Nitrate + Nitrite as N	0.41	6.1	5.7	94

5.4. Maintenance Inspection

The pretreatment device and the underground infiltration system were inspected during site visits to evaluate maintenance needs of the BMP. As shown in **Table 5-5**, minimal sediment was observed in both the pretreatment device and the infiltration gallery. Garbage was observed in the pretreatment and infiltration gallery. Water level monitoring in the infiltration gallery confirms that the system is regularly drawing down to empty, which is consistent with no standing water observed during most BMP inspection visits. See **Appendix E** for the **Photolog**.

Table 5-5: St. Albans Maintenance Inspections

Date	Sediment Depth in Pre-treatment (ft)	Sediment Depth in Infiltration Gallery (ft)	Standing Water in Infiltration Gallery?	Observations
Pre-treatment Chamber cleaned on May 19, 2020				
June 12, 2020	0.1	0.1	Y	Algal scum on surface of water in pretreatment
July 16, 2020	0.1	0.1	Y	Trash in pretreatment and BMP
August 18, 2020	0.1	0.1	Y	Algal scum on surface of water in pretreatment
October 5, 2020	0.1	0.1	Y	Minimal water in BMP, trash in BMP and pre-treatment chamber

6. Hampden Park

The Hampden Park infiltration gallery, shown in **Figure 6-1,** was constructed in 2014. The system consists of eight parallel perforated pipes that are 5 ft in diameter, and range in length from 40 to 100 ft. Runoff is routed to the system via a 24-inch RCP from the storm sewer line near Hampden and Raymond Avenues. Prior to entering the infiltration gallery, stormwater passes through a Vortechs pre-treatment chamber for particle settling. The infiltration gallery receives flow from a second inlet location along Hampden Avenue, farther to the north. When the system reaches full capacity, stormwater is routed back to the storm sewer via a 24-inch pipe from the southeast side of the system. Rainfall monitoring is conducted on top of the Hampden Park Co-Op across the street from the park. Monitoring has been conducted at the site since 2014. The BMP system details are provided in **Table 6-1** below.

Photo 6-1: Hampden Park BMP Construction

Table 6-1 Hampden Park BMP Details

Total Drainage Area to BMP	7.8 acres
Year Constructed	2014
Total Construction Cost	$687,132
Total Storage Volume	31,808 cu-ft
Volume Reduction Credit Received by the City of Saint Paul – Public Works	24,908 cu-ft
Volume Reduction Credit Received by the City of Saint Paul – Parks and Recreation	6,900 cu-ft

6.1. Water Level and Infiltration Rate Monitoring

Water levels were monitored within the underground infiltration system and groundwater (P2), using electronic water level loggers. Water levels and daily rainfall for 2020 are provided on **Chart A.14** and **A.15** of **Appendix A**. Water level within the BMP, ranged from 0 to 1.6 ft. The BMP water level must exceed 6.5 ft for the system to reach capacity and for water to be conveyed back to the sewer system. Based on the 2020 level data, no flow discharged back to the sewer system. The system saw less rainfall, infiltration rates may be higher due to less events and lower volumes moving through the system. Groundwater monitoring data showed that groundwater elevation fluctuated by 1.4 ft in 2020 with a minimum separation of 16.5 ft from the bottom of the BMP.

The 2020 infiltration rates are presented on **Chart A.16** of **Appendix A** and are adjusted for incremental volume flow. The adjusted average infiltration rate for the BMP was 41.09 in/hr, which is greater than the MSWM recommended infiltration rate for SP soils of 0.8 in/hr and the design infiltration rate of 1.8 in/hr. Infiltration rates at the base of site during construction were calculated to be, on average, 60 in/hr using a Double Ring Infiltrometer (DRI). Infiltration rate trends are depicted on **Chart A.17**. Water level data shows that all 2020 events were infiltrated within 24 hours of a treatment event.

Table 6-2: Hampden Park Infiltration Rate

Location	Average Infiltration Rate (in/hr)				
	2016	2017	2018	2019	2020
Hampden Park BMP	14.38	8.30	11.19	11.57	41.09

6.2. Volume Reduction Monitoring

One flow meter was installed within the 24-inch RCP diverting flow from the storm sewer to the BMP from the intersection of Hampden and Raymond Avenues. The metered drainage area consists of 6.7 acres of the total 7.8-acre drainage area to the BMP. The 2020 flow rates and daily rainfall are depicted on **Chart B.6** of **Appendix B**. No discharge was observed at the system outlet therefore that data is not plotted.

In 2020, the total runoff was 167,295 cu-ft. Since monitored level within the BMP did not reach the discharge outlet, 100% of the runoff was infiltrated by the system (**Table 6-3**). The total water yield for the 7.8-acre drainage area is 21,448 cu-ft/acre which is equivalent to 5.91 inches of runoff as a result of 15.12 inches of rain (39%). The greatest volume received by the BMP was 25,580 cu-ft as a result of a 2.51-inch rain event on May 16th to May 17th, 2020. This volume represents 80% of the total storage capacity of the system. Storm-specific rainfall and volume reduction data is provided on **Chart B.5** of **Appendix B**.

Table 6-3: Hampden Park Volume Reduction

Monitoring Period	5/9/2020 – 10/10/2020	
Total Rainfall	15.12	in
Hampden Park Water Balance		
Raymond/Hampden Runoff Volume	167,295	cu-ft
System Bypass Volume	0	cu-ft
Hampden Park System Performance		
Total Runoff Volume	167,295	cu-ft
Runoff Yield	5.91	in/acre
Total Runoff Volume Captured	167,295	cu-ft
Percent of Runoff Volume Captured	100	%
Maximum Event Volume Captured by BMP	25,580	cu-ft
Maximum Percentage of Storage Volume Utilized[2]	80	%

1 – The second system inlet along Hampden Avenue is not monitored, and the volume discharged to the system from that location is estimated based on monitored data at Hampden/Raymond and the ratio of the drainage areas.
2- This is the maximum volume infiltrated by the BMP for a treatment event as a percentage of the total storage volume.

6.3. Pollutant Removal Monitoring

A water quality sampler was placed at the intersection of Hampden and Raymond Avenues to collect samples during runoff events. The sampler was paced to collect samples at equal volume intervals to provide a representative sampling of each storm event. Samples for each event were tested as a composite to provide EMC during each event for each parameter analyzed. Grab samples were collected in the 24 in RCP near the automated sampler quarterly and tested for *E. Coli*. See **Charts C.1** and **C.2** of **Appendix C** for the complete water quality summary and pollutant loading calculations.

Table 6-4 below provides a load reduction summary for the loading parameters defined in NPDES Permit issued to the City in addition to ortho-phosphate. During the monitoring period, 498 pounds of TSS and 1.5 pounds of TP were captured by the system. Percent captured for all parameters were 100% in 2020.

Table 6-4: St. Albans Load/Capture Summary

Monitoring Period		5/9/2020 – 10/10/2020		
Total Rain		15.12		
Water Quality Parameter	**Flow Weighted Average (mg/L)**	**Total Pollutant Load (lbs)**	**Load Captured (lbs)**	**Percent Reduction %**
Total Suspended Solids	47.7	498	498	100
Volatile Suspended Solids	16.5	172	172	100
Inorganic Suspended Solids	46.0	481	481	100
Total Phosphorus	0.14	1.49	1.49	100
Ortho-phosphate	0.024	0.26	0.26	100
Chloride	4.07	42.5	42.5	100
Total Kjeldahl Nitrogen	1.12	11.7	11.7	100
Nitrate + Nitrite as N	0.39	4.0	4.0	100

6.4. Maintenance Inspection

Sediment depths in the pretreatment structure and in the underground infiltration system were measured during site visits to determine performance and maintenance needs. As shown in **Table 6-5**, minimal sediment was observed in both the pretreatment device and infiltration gallery.

Table 6-5: Hampden Park BMP Maintenance Inspection

Date	Sediment Depth in Pre-treatment (ft)	Sediment Depth in Infiltration Gallery (ft)[1]	Standing water in Infiltration Gallery?	Observations
Pre-treatment Chamber Cleaned April 29, 2020				
June 12, 2020	0.1	0.2	N	Some bottles in pre-treatment chamber
July 16, 2020	0.1	0.2	N	Trash in pre-treatment chamber
August 18, 2020	0.1	0.2	N	Trash in pre-treatment chamber
October 5, 2020	0.1	0.2	N	Leaves in pre-treatment chamber

7. Victoria Street

Victoria Street monitoring site is located just East of Orchard Recreation Center and includes a permeable paver parking lane. Stormwater runoff within the 19.1 acre subwatershed is diverted from the main storm sewer to the underground system. When the system has reached its storage capacity, runoff continues to flow downstream through the storm sewer. The system includes a pretreatment structure. consisting of a grit chamber for sediment capture and a baffled weir for skimming. In addition, the runoff from Victoria Street flows to the permeable paver parking lane, passes through a layer of stone aggregate below the pavers and is collected by a drain tile pipe. The drain tile discharges the runoff into the underground infiltration system. Rainfall monitoring is conducted on top of the Fire Station 18. The BMP system details are provided in **Table 7-1** below.

Table 7-1 Victoria Street BMP Details

Total Drainage Area to BMP	19.1 acres
Year Constructed	2010
Total Construction Cost	$174,000
Total Storage Volume	16,714 cu-ft
Volume Reduction Credit Received by the City of Saint Paul – Public Works	16,714 cu-ft
Volume Reduction Credit Received by the City of Saint Paul – Parks and Recreation	

This system consists of one 384-foot-long, 60-inch-diameter perforated HDPE pipe located below a permeable paver parking lane. It was constructed to meet the volume reduction requirements for the Front/Victoria Residential Street Vitality Program (RSVP) project.

7.1. Water Level and Infiltration Rate Monitoring

In 2020, water levels were monitored continuously in the access manhole at the north end of the underground system along Victoria Street. Water levels were monitored within the underground infiltration using an electronic water level logger. Water levels and daily rainfall for 2020 are provided on **Chart A.14** and **A.15** of **Appendix A**. Water level within the BMP, ranged from 0 to 4.6ft. The BMP water level must exceed 5 ft for the system to reach capacity and for water to flow to the sewer system. Based on the 2020 level data, the system did not reach capacity.

The 2020 infiltration rates are presented on **Chart A.16** of **Appendix A** and are adjusted for incremental volume flow. The adjusted average infiltration rate for the BMP was 43.94 in/hr, which is greater than the MSWM recommended infiltration rate for SP soils of 0.8 in/hr and the design infiltration rate of 12.8 in/hr. Infiltration rates at the base of site during construction were calculated to be, on average, 95.9 in/hr using a Double Ring Infiltrometer (DRI). Infiltration rate trends are depicted on **Chart A17**. Water level data shows that all 2020 events were infiltrated within 24 hours of a treatment event.

Table 7-2: Victoria Street Infiltration Rate

Location	Average Infiltration Rate (in/hr)			
	2012	2013	2019	2020
Victoria Street BMP	46.56	48.04	21.08	43.94

7.2. Volume Reduction Monitoring

One flow meter was installed upstream of the system and one flow meter downstream of the diversion structure located near the intersection of Victoria Street and Orchard Avenue. The metered drainage area consists of 19.1 acres and drains to the BMP. The 2020 flow rates and daily rainfall are depicted on **Chart B.6** of **Appendix B**. Minimal discharge was observed during a single event at the system outlet therefore that data is not plotted.

In 2020, the total run off to the Victoria Street system was 258,999 cu-ft. The system captured 99.8% of that volume (**Table 7-3**). The total water yield for the 19.1-acre drainage area is 13,560 cu-ft/acre which is equivalent to 3.73 inches of runoff as a result of 16.17 inches of rain (23%). The greatest volume received by the BMP was 49,254 cu-ft as a result of a 2.5-inch rain event on May17th, 2020. This volume represents 294% of the total storage capacity of the system. Storm-specific rainfall and volume reduction data is provided on **Chart B.5** of **Appendix B**.

Table 7-3: Victoria Street Volume Reduction

Monitoring Period	5/9/2020 – 10/12/2020	
Total Rainfall	16.17	in
Victoria Street Water Balance		
Runoff Volume	258,999	
System Bypass Volume	602	
Victoria Street System Performance		
Total Runoff Volume	258,999	cu-ft
Runoff Yield	3.73	in/acre
Total Runoff Volume Captured	258,395	cu-ft
Percent of Runoff Volume Captured	99.8	%
Maximum Event Volume Captured by BMP	49,254	cu-ft
Maximum Percentage of Storage Volume Utilized[1]	294	%

1- This is the maximum volume infiltrated by the BMP for a treatment event as a percentage of the total storage volume.

7.3. Pollutant Removal Monitoring

A water quality sampler was placed in the diversion structure to collect samples during runoff events. The sampler was paced to collect samples at equal volume intervals to provide a representative sampling of each storm event. Samples for each event were tested as a composite to provide EMC's for each event for each parameter analyzed. Grab samples were also collected in the diversion manhole near the automated sampler quarterly and tested for *E. Coli*. See **Charts C.1** and **C.2** of **Appendix C** for the complete water quality summary and pollutant loading calculations.

Table 7-4 below provides a load reduction summary for the loading parameters defined in NPDES Permit issued to the City in addition to ortho-phosphate. During the monitoring period, 952 pounds of TSS and 15.7 pounds of TP were captured by the system. Percent captured for all parameters was above 99.8% in 2020.

Table 7-4: Victoria Street Load/Capture Summary

Monitoring Period		5/9/2020 – 10/12/2020		
Total Rain		16.17		
Water Quality Parameter	**Flow Weighted Average (mg/L)**	**Total Pollutant Load (lbs)**	**Load Captured (lbs)**	**Percent Reduction %**
Total Suspended Solids	59.0	954	952	99.8
Volatile Suspended Solids	33.5	542	541	99.8
Inorganic Suspended Solids	123.4	1996	1991	99.8
Total Phosphorus	0.98	15.8	15.7	99.8
Ortho-phosphate	0.474	7.67	7.65	99.8
Chloride	10.2	165.6	165.2	99.8
Total Kjeldahl Nitrogen	3.17	51.3	51.2	99.8
Nitrate + Nitrite as N	0.44	7.05	7.00	99.8

7.4. Maintenance Inspection

Sediment depths in the pretreatment structure and in the underground infiltration system were measured during site visits to determine performance and maintenance needs. As shown in **Table 7-5**, minimal sediment was observed in both the pretreatment device and infiltration gallery.

Table 7-5: Victoria Street BMP Maintenance Inspection

Date	Sediment Depth in Pre-treatment (ft)	Sediment Depth in Infiltration Gallery (ft)[1]	Standing water in Infiltration Gallery?	Observations
Pre-Treatment Chamber Cleaned May 26, 2020				
June 12, 2020	0.2	0.6	N	Sludge on top of water in pre-tretment chamber
July 16, 2020	0.5	0.8	N	Pre-treat sediment concentrated at inlet
August 18, 2020	0.1	1.0	N	Minimal sediment in pre-treatment chamber
October 5, 2020	0.1	1.0	N	

8. Battle Creek

The Battle Creek monitoring location is on the eastern edge of St. Paul and provides upstream data of water flowing west from Maplewood into St. Paul. The monitoring location is positioned in a sizeable greenspace on Battle Creek in a tunnel that connects the creek underneath McKnight Road N. Monitoring at this site was initiated in 2019.

8.1. Water Level Monitoring

A level logger was installed in the creek near the inlet into the 72-inch arch pipe and configured to record water elevations once every 10 minutes. Water elevations and rainfall are presented on **Chart A.22** of **Appendix A.** A summary of select runoff events from 2020 is presented in **Table 8-1** below.

Table 8-1: Battle Creek Water Level Summary (Select Flow Events)

Date	Rainfall (in)	Rainfall Intensity (in/hr)	Level Increase (ft)	Peak Water Elevation (ft SPCD)
5/26/20 – 5/27/20	0.80	0.15	4.3	204.5
6/28/20 – 6/29/20	4.51	0.30	11.7	211.5
7/25/20 – 7/26/20	1.31	0.09	1.5	201.7

Photo 8-1: Battle Creek pipe clogged, and surrounding area flooded. (6/29/20)

In 2020, water levels ranged from 199.7 ft SPCD on October 2, 2020 to 211.5 ft SPCD on June 30, 2020. The maximum level occurred as a result of 4.51 inches of rain on June 28 and 29, 2020, which increased the level by 11.7 ft. The inlet grate into 72- inch arch pipe was often blocked with debris, possibly causing a longer time for the level to drop and delays in flow following a rain event. Although flow was continuous throughout the year, base flow within the pipe could not be determined due to debris and timing of water flowing through the entire Battle Creek system of ponds.

8.2. Volume Monitoring

One flow meter was installed on the bottom of the pipe where Battle Creek crosses underneath McKnight Road N. The metered drainage area consists of 19.1 acres of Maplewood and drains into St. Paul. The 2020 flow rates and daily rainfall are depicted on **Chart B.6** of **Appendix B**.

During the 2020 monitoring period, the total volume moving through the system into St. Paul was 90,289,600 cu-ft and total event-based volume moving through the system was 22,958,139 cu-ft (**Table 8-2**). The total water yield for the 662-acre drainage area is 34,680 cu-ft/acre. The greatest event-based volume moving through the system was 10,540,415 cu-ft as a result of a 4.27-inch rain event on June 28th and 29th, 2020.

Table 8-2: Battle Creek Volume Summary

Monitoring Period	6/18/2020 – 10/12/2020	
Total Rainfall	13.52	in
Battle Creek Water Balance		
Total Volume	90,289,600	cu-ft
Maximum Event Volume	10,510,415	cu-ft

8.3. Pollutant Monitoring

A water quality sampler was placed in the structure to collect samples during high flow/rain events. The sampler was paced to collect samples at equal volume intervals to provide a representative sampling of each storm event. Samples for each event were tested as a composite to provide EMC's for each event for each parameter analyzed. Grab samples were also collected in the stream, near the automated sampler and tested for *E. Coli*. See **Charts C.1** and **C.2** of **Appendix C** for the complete water quality summary and pollutant loading calculations.

Table 8-3 below provides a load summary for flow weighted averages of pollutants entering the city defined in NPDES Permit issued to the City in addition to ortho-phosphate.

Table 8-3: Battle Creek Pollutant Load Summary

Monitoring Period	
Total Rain	
Water Quality Parameter	**Flow Weighted Average (mg/L)**
Total Suspended Solids	31.9
Volatile Suspended Solids	7.7
Inorganic Suspended Solids	251.0
Total Phosphorus	0.10
Ortho-phosphate	0.008
Chloride	90.9
Total Kjeldahl Nitrogen	0.73
Nitrate + Nitrite as N	0.27

9. Sackett Park Pond

The Sackett Park Pond is situated in a wooded area between the Boys and Girls Club and the Chicago Northwestern Railroad on St. Paul's East Side. The basin receives runoff from the east via a storm sewer inlet pipe. The runoff flows northwest through a shallow channel, until it reaches an outlet control structure that conveys water away from the site through a 42-inch RCP pipe (**Photo 9-1**). When runoff exceeds the banks of the channel, it spills into the surrounding flood plain (**Photo 9-2**). Water elevations were monitored within the Sackett Park Pond to evaluate water level fluctuation in the basin, and to provide hydrologic data for future improvements at that location. The pond location is provided as **Figure 9-1**.

Photo 9-1: Level Logger Configuration and Outlet Control Structure

9.1. Water Level Monitoring

A level logger was installed near the pond outlet control structure and configured to record water elevations once every 8 minutes. Water elevations and rainfall are presented on **Chart A.22** of **Appendix A**. A summary of select runoff events from 2020 is presented in **Table 9-1** below. The elevation of the top of the outlet control structure is 194 ft SPCD. Groundwater monitoring was conducted during the 2015 monitoring season and those results indicated that a continuous artesian condition was present at the site. Groundwater has not been monitored since the 2015 season.

Table 9-1: Sackett Park Pond Water Level Summary (Select Flow Events)

Date	Rainfall (in)	Rainfall Intensity (in/hr)	Level Increase (ft)	Peak Water Elevation (ft SPCD)	Depth above OCS (ft)	Duration of time above OCS (hr)
5/16/20 - 5/17/20	2.51	0.11	0.2	193.6	NA	NA
5/26/20 – 5/27/20	0.79	0.14	1.0	194.3	0.3	0.7
6/28/20 – 6/29/20	4.51	0.29	1.9	195.2	1.2	3.5
7/25/20 – 7/26/20	1.31	0.15	1.9	194.6	0.6	0.7

In 2020, water levels ranged from 192.6 ft SPCD on April 20, 2020 to 195.2 ft SPCD on June 29, 2020. The maximum level occurred as a result of 4.51 inches of rain on June 28 and 29, 2020, which increased the level by 1.9 ft. In 2020, 13 rain events ranging from 0.08 inches to 4.51 inches resulted in water level elevations that exceeded the top of the outlet control structure, a decrease from 26 in 2019. Outlet control structure was often blocked with debris, although it appears maintenance may have been performed in late September.

Photo 9-2: Water level even with Sackett Park Pond outlet control structure. (3/4/2020)

Photos 9-3: Path of water overflow across ball fields from flood plain. (6/28/2020)

9.2. Volume Monitoring

One flow meter was installed inside of the 42-inch RCP pipe downstream of the pond. The metered drainage area consists of 19.1 acres of. The 2020 flow rates and daily rainfall are depicted on **Chart B.6** of **Appendix B**.

During the 2020 monitoring period, flow through the system was continuous although minimal and baseflow could be predicted to be less than 0.3 cu-ft/sec. The total event volume moving through the system was 1,403,285 cu-ft (**Table 9-2**). The total water yield for the 19.1-acre drainage area is 73,470 cu-ft/acre. The greatest event-based volume moving through the system was 281,713 cu-ft as a result of a 2.51-inch rain event on May 16th and 17th, 2020.

Table 9-2: Sackett Park Volume Summary

Monitoring Period	5/9/2020 – 10/12/2020	
Total Rainfall	20.04 in	
Sackett Park Water Balance		
Total Volume	1,403,285	cu-ft
Maximum Event Volume	281,713	cu-ft

9.3. Pollutant Monitoring

A water quality sampler was placed inside of the 42-inch RCP pipe downstream of the pond near the flow meter to collect samples during high flow/rain events. The sampler was paced to collect samples at equal volume intervals to provide a representative sampling of each storm event. Samples for each event were tested as a composite to provide EMC's for each event for each parameter analyzed.

Grab samples were also collected in the stream, near the automated sampler and tested for *E. Coli*. See **Charts C.1** and **C.2** of **Appendix C** for the complete water quality summary and pollutant loading calculations.

Table 9-3 below provides a pollutant load summary for the loading parameters defined in NPDES Permit issued to the City in addition to ortho-phosphate. During the monitoring period 21,416 pounds of TSS and 65.3 pounds of TP passed through the monitored area during storm events.

Table 9-3: Sackett Park Pollutant Load Summary

Monitoring Period		
Total Rain		
Water Quality Parameter	**Flow Weighted Average (mg/L)**	**Total Pollutant Load (lbs)**
Total Suspended Solids	244.5	21,416
Volatile Suspended Solids	72.7	6,372
Inorganic Suspended Solids	130.0	11,391
Total Phosphorus	0.75	65.3
Ortho-phosphate	0.055	4.83
Chloride	22.4	1,961.0
Total Kjeldahl Nitrogen	2.92	255.5
Nitrate + Nitrite as N	0.59	51.8

10. River Level Monitoring

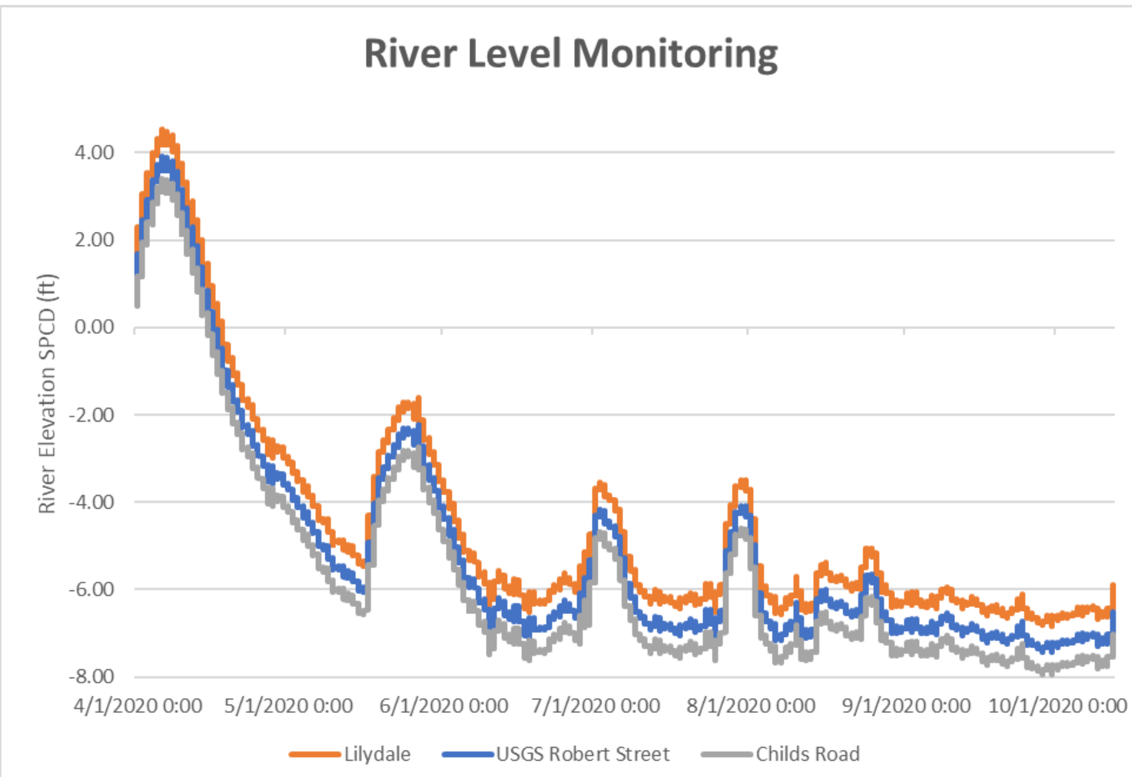
To determine elevations of the Mississippi River in relation to the United States Geological Survey (USGS) monitoring station at the Robert Street Bridge, two water level loggers were installed in storm water structures near the river and one in storm water pond. Due to low water levels throughout the monitoring season and uncertainties within the storm sewer, a correlation between the level logger data and USGS monitoring station could not be determined.

Table 10-1 depicts the difference between river monitoring locations as well as their approximate river mile location. **Chart 10-1** shows and estimation of river level based off of manual water level measurements and compared to the continuous USGS monitoring station near Robert Street Bridge. For a full chart showing level logger data, USGS data, and rainfall see **Chart A.17** within **Appendix A**.

Table 10-1

	Lilydale	USGS	Childs Road
Approximate River Mile	841.5	839.25	837.5
Mile Difference from USGS	Upstream 2.25 miles		Downstream 1.75 miles
Difference from USGS	0.61		-0.51

Chart 10-1



11. Pervious Surface Infiltration Assessment

The City has been monitoring the performance of pervious pavement BMPs constructed in the City since 2012. Pervious pavement is constructed with substantial void space to allow for infiltration or filtration of stormwater through the pavement surface as a means of stormwater management. Pervious pavement BMPs monitored in the City include porous asphalt and permeable interlocking concrete pavers. The purpose of the infiltration testing is to monitor the change in site conditions and infiltration capability of the BMPs overtime. Pavement maintenance is also monitored to study the effect of routine and rehabilitative maintenance on these BMPs.

Infiltration testing was completed at the Jackson Street Pervious Bike Path BMP and the Victoria Street pervious pavement BMP in July and November 2020. Testing was also completed at the Hamline Midway Library pervious pavement in November 2020. This section presents the results of the 2020 infiltration testing. The Infiltration testing methodologies are described in **Section 2.5.** A photolog of infiltration testing is provided in **Appendix E**.

11.1. Victoria Street

The Victoria Street pervious surface consists of a parking area completed with permeable concrete pavers designed to receive stormwater runoff from Victoria Street and the properties adjacent to it. The pavers themselves are non-permeable and they are separated with aggregate fill (**Photo 11-1** and **11-2**). The spaces between the pavers allow stormwater runoff to infiltrate into the parking surface instead of running off and being collected by the storm sewer system. The pavers were installed in 2011 and infiltration rates have been monitored annually since 2012. The site and the infiltration test locations are provided on **Figure 11-1**.

Photo 11-1: Victoria Street Pavers

Photo 11-2: Victoria Street Infiltration Testing

Infiltration Test Results and Observations

Five locations were tested for infiltration at the Victoria Street site. In 2015, the exact test locations from 2014 could not be located, so new locations were established in the immediate area and identified as A-E (these locations were used since 2016). Those locations are depicted on **Figure 10-1** and the results of the testing are presented in **Table 11-1** and **Chart D.1** in **Appendix D**.

A summary of the 2020 infiltration test results is provided below:

Table 11-1: Victoria Street Infiltration Rate Summary

Infiltration Ring Location	2012 Infiltration Rate (in/hr)	2013 Infiltration Rate (in/hr)	2014 Infiltration Rate (in/hr)	2015 Infiltration Rate (in/hr)		2016 Infiltration Rate (in/hr)		2017 Infiltration Rate (in/hr)		2018 Infiltration Rate (in/hr)		2019 Infiltration Rate (in/hr)		2020 Infiltration Rate (in/hr)	
IR-1	168.60	18.10	0.00	E	15.11	E	17.77	E	3.41	E	14.51	E	15.89	E	4.94
IR-2	266.60	75.70	12.93	A	0.00	A	19.38	A	3.78	A	11.47	A	4.06	A	4.68
IR-3	271.10	92.20	18.56	B	3.44	B	22.97	B	10.05	B	16.92	B	4.35	B	9.39
IR-4	69.10	24.00	9.72	C	0.00	C	6.55	C	28.91	C	6.25	C	4.03	C	3.65
IR-5	149.80	49.20	30.81	D	0.00	D	0.00	D	0.00	D	1.92	D	4.21	D	6.56
Average	185.04	51.84	14.40	3.71		13.33		9.23		10.21		6.51		5.84	

- In 2020 (5.84 in/hr) compared to 2019 (6.51 in/hr) and 2018 (10.21 in/hr).
- The 2020 (5.84 in/hr) infiltration rates were, on average, less than 4 percent of 2012 (185.04 in/hr) infiltration rates.
- Infiltration rates have been decreasing the last 2 years and 2020 (5.84 in/hr) infiltration rates were, on average, 57 percent of 2018 (10.21 in/hr) infiltration rates.
- Infiltration rates at Locations A, B, and D were greater in 2020, compared to 2019, while infiltration rates at Locations E and C were less in 2020 than 2019.

Photo 11-3: Location D Pre-Test

Photo 11-4: Location D Infiltration Test

11.2. Jackson Street

The Jackson Street BMP (**Photo 11-5** and **11-6**) is a designated bike path constructed of pervious asphalt. It is a section of the Capital City Bikeway (CCB), a system of off-street bicycle trails in downtown Saint Paul. The BMP is eight blocks long, stretching from Kellogg Street to 11th Street, and consists of 2,750 square yards of pervious asphalt. Stormwater runoff filters through the asphalt and underlying media and is then conveyed to the storm sewer system via drain tile.

Monitoring locations JS-1 through JS-11 were established In November 2016 upon completion of the four-block stretch from Kellogg Boulevard to 7th Place East. Monitoring locations JS-12 through JS-18 were established in November 2017 upon completion of the four-block stretch from 7th Place East to 11th street. The monitoring locations were carefully selected to evaluate sediment loading and asphalt compaction from varying levels of pedestrian and vehicular traffic. Each site was characterized into one of three groups, identified in **Table 11-2**, based on their location and surroundings. The site and infiltration test locations are depicted on **Figure 11-2**. Site photos are provided in **Appendix E**.

Table 11-2: Monitoring Site Traffic Characterization

Site Traffic Characterization
Low: No driving and minimal foot traffic area. Adjacent to planter or minimal impervious surface.
Medium: Pedestrian cross walks or adjacent to large areas of impervious surface.
High: Driveways for parking or businesses, heavy vehicular traffic.

Photo 11-5: Capital City Bikeway (CCB) – Jackson Street/Kellogg Avenue

Photo 11-6: Jackson Street Infiltration Test

<u>Infiltration Test Results and Observations</u>

The site was tested for infiltration in July 2020 and November 2020. The infiltration test results from the 18 locations are summarized in **Table 11-3** and **Chart D.2** in **Appendix D**, which includes all infiltration test results completed to-date. **Table 11-3** is color coded to identify the site traffic characterizations described above. The infiltration tests results are also summarized in **Table 11-4**, which presents an average infiltration rate based on the monitoring location traffic characterization. The infiltration test locations are depicted on **Figure 11-2**.

Table 11-3: Jackson Street Infiltration Rate Summary (in/hr)

Location	Test Location Description	Nov 2016 Infiltr. Rate	Jun 2017 Infiltr. Rate	Nov 2017 Infiltr. Rate	Jul 2018 Infiltr. Rate	Oct 2018 Infiltr. Rate	Jul 2019 Infiltr. Rate	Oct 2019 Infiltr. Rate	Jul 2020 Infiltr. Rate	Nov 2020 Infiltr. Rate
JS-1	Northern half of Securian ramp entrance. Non-painted surface east of path center line.	572.6	9.3	3.9	0	0	0	0	0	0
JS-2	Midline of Securian ramp entrance. Non-painted surface east of path center line.	750.4	6.3	0	0	0	0	0	0	0
JS-3	Jackson Street pedestrian cross south of 6th Street. Near midline of bike path.	1282.1	1069.0	793.8	642.2	247.1	67.1	30.4	7.0	0.0
JS-4	Midblock between 6th & 5th Street. North of skyway. Near midline of bike path.	2122.2	1520.1	1372.0	1026.7	733.7	1050.1	764.4	516.3	299.9
JS-5	345 parking ramp entrance. Non-painted surface just north of the midline of the entrance. Midline of bike path.	385.9	4.5	0	0	0	0	0	0	0
JS-6	345 parking ramp entrance. Green painted stripe farthest south. West side of bike path.	118.7	12.1	0	0	0	0	0	0	0
JS-7	Jackson Street pedestrian cross north of 4th Street. Near midline of bike path.	533.7	353.9	181.7	73.7	29.4	0	0	0	0
JS-8	Midblock between 4th & Kellogg. Western edge of bike path (adjacent to concrete).	177.5	275.3	90.8	0	0	0	0	0	0
JS-9	Midblock between 4th & Kellogg. Eastern side of bike path.	277.9	56.1	2.4	0	0	0	0	0	0
JS-10	In line with the southern wall of the US Courthouse (facing Kellogg). Western edge of bike path adjacent to concrete.	557.9	125.5	2.1	0	0	0	0	0	0
JS-11	In line with the southern wall of the US Courthouse (facing Kellogg). Eastern side of the bike path.	471.5	125.4	35.5	0	0	0	0	0	0
JS-12	N of Credit Union Driveway between 11th St. and 10th St Midline of bike path, next to a planter.	NE	NE	843.3	827.2	877.1	710.5	633.3	620.4	572.0
JS-13	In front of Child Care Center between 11th St. and 10th St. Western edge of bike path, next to a planter.	NE	NE	1246.7	1696.9	1179.2	889.5	809.6	608.6	839.8
JS-14	S of 10th St. Adjacent to planter (2nd weir). Between Western edge and bike path midline.	NE	NE	464.4	575.1	447.5	323.3	211.4	207.8	195.4
JS-15	Firestone driveway, N of 2nd stripe from the S.	NE	NE	100.0	0	0	0	0	0	0
JS-16	Pedestrian cross, SW intersection of Jackson and 9th.	NE	NE	1104.4	190.1	9.0	0	0	0	0
JS-17	Mid-block of 9th St. and 7th St. Adjacent to planter (southern-most tree). Just W of bike path midline.	NE	NE	1670.0	1605.0	1369.7	1329.5	1082.1	1343.2	640.1
JS-18	Pedestrian cross, NW intersection of Jackson and 7th Pl. Adjacent to large concrete area.	NE	NE	665.4	589.6	521.5	215.7	327.7	160.4	115.5
Site Average:		659.1	323.4	476.5	401.5	300.8	254.8	214.4	192.4	147.9
Average of Sites JS-1 through JS-11 (established Nov 2016):				225.6	158.4	91.8	558.6	72.3	47.6	27.3
Average of Sites JS-12 through JS-18 (established Nov 2017):				870.6	783.4	629.1	693.7	437.7	420.1	337.5

NM – Not Measured

Table 11-4: Jackson Street Infiltration Summary by Site Traffic Characterization

Site Traffic Characterization	Nov 2016	Jun 2017	Nov 2017	Jul 2018	Oct 2018	Jul 2019	Oct 2019	Jul 2020	Nov 2020
Low: No driving and minimal foot traffic area. Adjacent to planter or minimal impervious surface.	2122.2	1520.1	1119.3	1146.2	921.4	860.6	700.2	659.3	509.4
Medium: Pedestrian cross walks or adjacent to large areas of impervious surface.	550.1	334.2	359.5	187.0	100.9	35.3	44.8	20.9	14.4
High: Driveways for parking or businesses, heavy vehicular traffic.	456.9	8.0	20.8[1]	0.0	0.0	0.0	0.0	0.0	0.0

1 - The increase in the site average for high traffic areas from June 2017 to November 2017 is a result of a new location added in November 2017.

A summary of the 2020 infiltration testing completed at the Jackson Street Pervious Pavement Site is provided below:

- The overall site infiltration rate was 192.4 inches per hour (in/hr) in July 2020 and 147.9 in/hr in November 2020.
  - 11 of 18 locations showed no infiltration during July and 12 of 18 locations showed no infiltration in November testing events.
  - Of the remaining six locations where infiltration occurred, November 2020 infiltrations rates ranged from 115.5 in/hr to 839.8 in/hr.
- Low traffic areas had an average infiltration rate of 659.3 in/hr in July 2020 and 509.4 in/hr in November 2020.
  - All five monitoring locations exhibited infiltration ranging from 195.4 in/hr to 839.8 in/hr in November 2020.
  - Four of the five low traffic testing locations were established in November 2017. The average infiltration rate in November 2020 was 45% of the infiltration rate observed in November 2017 at those locations.
- Medium traffic areas had an average infiltration rate of 20.9 in/hr in July 2020 and 14.4 in/hr in November 2020.
  - Seven of eight monitoring locations showed no infiltration during November 2020 testing.
  - Locations JS-7 through JS-11 are within the first constructed section of the pervious pavement near the Jackson Street and Kellogg Boulevard intersection. These locations have not shown any infiltration since October 2018.
- High traffic areas had an average infiltration rate of 0.0 in/hr in 2020 testing events.
  - No infiltration was observed at all five high traffic monitoring locations in July and October 2020.
  - High traffic locations have not shown any infiltration since November 2017.

Photo 11-7: Test Locations JS-1 and JS-2 (high traffic)

11.3. Hamline Midway Library

The Hamline Midway Library pervious surface consists of 920 square yards of porous asphalt within the two alleyways adjacent to the Hamline Midway Library and the center alleyway connecting the sections. The asphalt content of the mix is 6.3 percent, and the specific voids ratio is 18 percent. Prior to construction, the sub-surface soil infiltration rate was determined to be 29.0 inches per hour (in/hr) and 59.1 in/hr using a double ring infiltrometer. The asphalt was installed in 2012 and infiltration rate monitoring has been conducted from 2013 through 2020. After installation of the pavement, infiltration rates from 2013 to 2014 severely diminished at the site, with only two of nine locations exhibiting any infiltration. Photo documentation at the site confirmed areas with significant sediment accumulation within the pore space of the asphalt. Maintenance treatments were completed with the objective of determining if the pervious pavement could be restored. This years and prior years test results are shown in **Table 11-5**.

Table 11-5: Hamline Midway Library Infiltration Rate Summary

Infiltration Ring Location	2013 Infiltration Rate (in/hr)	2014 Infiltration Rate (in/hr)[1]	2015 Infiltration Rate (in/hr)[1]	2019 Infiltration Rate (in/hr)[1]	2020 Infiltration Rate (in/hr)[1]
IR-1	102.4	0.0	0	0	0
IR-2	14.9	0.0	0	0	0
IR-3	11.4	0.0	0	0	0
IR-4	172.7	0.0	0	0	0
IR-5	0.0	0.0	605.97	218.96	177.48
IR-6	1125.3	206.4	502.41	10.30	0
IR-7	290.2	73.1	0	0	0
IR-8	28.4	0.0	0	0	0
IR-9	115.6	0.0	0	0	0
Average	**206.8**	**31.1**	**123.15**	**25.47**	**19.72**

1 - Locations were monitored for a maximum of 25 minutes during the pre-wet test. If no infiltration was observed, no subsequent tests were completed, and infiltrations rates were documented to be 0.0 in/hr.
BLUE – Dry sweep maintenance
RED – Wet sweep maintenance
GREY– Power wash and vacuum sweep

Photo 11-8: Recently Constructed Hamline Midway Library Porous Asphalt (2012)

Photo 11-9: Hamline Midway Library Asphalt

12. City-wide Loading Assessment

12.1. 2020 Pollutant Loading Calculations

Monitoring of major outfalls within the City of Saint Paul was completed by Capitol Region Watershed District (CRWD) in 2020. Annual and seasonal pollutant loads were estimated for each subwatershed within the City for the loading parameters identified in the City's MS4 permit which include chloride (Cl), total kjeldahl nitrogen (TKN), total phosphorus (TP), nitrate plus nitrite (NO3 +NO2), total suspended solids (TSS), and volatile suspended solids (VSS). The subwatersheds within the City are included in **Table 12-1** below.

Monitoring data collected by CRWD from the following subwatersheds was utilized for this assessment: East Kittsondale, St. Anthony Park, Trout Brook, Phalen Creek, and Hidden Falls. Monitoring of each subwatershed was completed at or near the outfall. The stations were configured to collect continuous flow measurements, and water quality, in accordance with the City's MS4 Permit.

Table 12-1 Watershed Inventory

Watershed	Area [acre]	Runoff Coefficient [.]	Rainfall Station
Battle Creek	1106	0.54	Wilder
Beaver Lake	192	0.33	Wilder
Belt Line	3014	0.55	Wilder
Crosby	1679	0.45	Hampden Park Co-op
Davern	1302	0.55	Hampden Park Co-op
Downtown	550	0.75	Engine House 18
East Kittsondale	1872	0.62	Engine House 18
Fish Creek	46	0.52	Wilder
Goodrich/Western	424	0.63	Engine House 18
Griffith/Pt. Douglas	460	0.61	Wilder
Hidden Falls	313	0.55	Hampden Park Co-op
Highwood	1123	0.50	Wilder
Lake Como	1294	0.47	Hampden Park Co-op
Lake Phalen	1013	0.42	Wilder
Mississippi River Blvd.	2391	0.58	Hampden Park Co-op
MRWMO	135	0.70	Hampden Park Co-op
Phalen Creek	1405	0.62	Wilder
Pigs Eye	3001	0.40	Wilder
Riverview	1017	0.57	Wilder
St. Anthony Hill	2651	0.64	Engine House 18
St. Anthony Park	2481	0.68	Hampden Park Co-op
Trout Brook	3963	0.62	Wilder
Urban	327	0.57	Wilder
West Kittsondale	1042	0.67	Hampden Park Co-op
West Seventh	451	0.60	Fire House 18

Monitored Subwatershed

Annual and seasonal city-wide flow-weighted averages were calculated for each of the loading pollutants from the monitored outfall data. TKN, TP, TSS and VSS loads were generated by CRWD in the WISKI data management program. This allowed for the extraction of baseflow and the associated load from the event load for those parameters. Cl and NO_2+NO_3 loads were calculated for the event-based volume (baseflow volume extracted), although the base flow loading for those parameters was not extracted. The following formula was used to calculate the annual/seasonal flow weighted mean concentrations (**Table 12-2**):

$$C = \frac{\sum(F_i \times C_i)}{\sum(F_i)}$$

C = annual/seasonal flow weighted mean concentration [mg/L]*
F_i = the event based flow for an individual event [cf]
C_i = the pollutant concentration for an individual event [mg/L]

*As described above, the flow-weighted mean concentration for TKN, TP, TSS, and VSS, was calculated from loads generated in the WISKI program, which extracted baseflow loading (not reflected in the formula above)

Table 12-2: City-wide Annual and Seasonal Flow-weighted Mean Concentrations

Parameter	Cl	TKN	TP	NO_2+NO_3	TSS	VSS
Units	**[mg/L]**	**[mg/L]**	**[mg/L]**	**[mg/L]**	**[mg/L]**	**[mg/L]**
Annual	88.2	2.5	0.46	0.46	193.8	63.8
Q1 (Jan-Mar)	411.1	4.9	0.64	0.79	171.1	48.7
Q2 (Apr-Jun)	31.3	2.4	0.43	0.42	215.2	73.5
Q3 (Jul-Sep)	19.3	1.7	0.42	0.40	191.2	61.6
Q4 (Oct-Dec)	31.1	1.4	0.47	0.33	122.6	44.6

Based on these calculated flow-weighted mean concentrations, the Simple Method was used to calculate each subwatershed's pollutant loading. Loads for the four monitored subwatersheds were generated using actual monitored loads. The Simple Method is show below:

$$L = 2.72\left(\frac{PP_jR_v}{12}\right)(CA)$$

L = pollutant loading for the year/season [lb]
P = rainfall depth for the year/season [in]
P_j = correction factor for storms that produce no runoff [.]
R_v = runoff coefficient [.]
C = flow-weighted mean concentration [mg/L]
A = area of the watershed [acre]

Values used in loading calculations:
R_v and A = Table 1
C = Table 2
P = Table 3
P_j = 0.85

The annual/seasonal precipitation totals for four different rainfall monitoring locations in St. Paul are provided in **Section 3** the **Table 3-1**. Each subwatershed was assigned precipitation data from the nearest precipitation monitoring site (see **Table 12-1** for assignments). The rainfall data was used as an input to the Simple Method for load calculations, as described above. Rain data outside the seasonal monitoring period was supplemented with data from the University of Minnesota – St. Paul.

The annual and seasonal pollutant loads for each of the City's subwatersheds are presented in **Tables 12-3 – 12-7**. Loads for the five monitored sites are actual totals calculated for each station. Those sites are highlighted blue.

Table 12-3. Annual Pollutant Loadings (lbs)

Subwatershed	Cl	TKN	Total P	NO2+NO3	TSS	VSS
Battle Creek	442193	8240	1635	1799	571865	200970
Beaver Lake	48931	912	181	199	63280	22238
Belt Line	1280187	23855	4734	5209	1655598	581825
Crosby	571221	10644	2112	2324	738730	259611
Davern	541396	10088	2002	2203	700159	246056
Downtown	312436	5822	1155	1271	404056	141997
East Kittsondale	407848	8586	1374	1505	444016	173126
Fish Creek	17710	330	65	72	22904	8049
Goodrich/Western	202322	3770	748	823	261652	91952
Griffith/Pt. Douglas	207755	3871	768	845	268678	94421
Hidden Falls	130151	2425	481	530	168318	59152
Highwood	415731	7747	1537	1692	537644	188944
Lake Como	459805	8568	1700	1871	594641	208974
Lake Phalen	328569	6123	1215	1337	424921	149329
Mississippi River Blvd.	1048452	19537	3877	4266	1355908	476506
MRWMO	71445	1331	264	291	92396	32471
Phalen Creek	644958	12018	2385	2624	834090	293123
Pigs Eye	888769	16561	3287	3617	1149399	403932
Riverview	429199	7998	1587	1747	555061	195064
St. Anthony Hill	1285068	23946	4752	5229	1661911	584044
St. Anthony Park	619683	8495	1559	2354	590036	210466
Trout Brook	355203	7813	1993	1540	675781	219525
Urban	138002	2572	510	562	178471	62720
West Kittsondale	527817	9835	1952	2148	682598	239885
West Seventh	204958	3819	758	834	265061	93150

Monitored Locations

Table 12-4: Q1 (Jan-Mar) Pollutant Loading (lbs)

Subwatershed	Cl	TKN	Total P	NO2+NO3	TSS	VSS
Battle Creek	193944	2311	302	374	80706	22994
Beaver Lake	20575	245	32	40	8562	2439
Belt Line	538312	6415	840	1037	224007	63821
Crosby	245353	2924	383	473	102098	29088
Davern	232542	2771	363	448	96767	27570
Downtown	133953	1596	209	258	55742	15881
East Kittsondale	361825	3427	431	436	72035	32670
Fish Creek	7768	93	12	15	3232	921
Goodrich/Western	86743	1034	135	167	36096	10284
Griffith/Pt. Douglas	91120	1086	142	176	37918	10803
Hidden Falls	55903	666	87	108	23263	6628
Highwood	182338	2173	284	351	75876	21618
Lake Como	197497	2354	308	380	82184	23415
Lake Phalen	138161	1647	215	266	57493	16380
Mississippi River Blvd.	450335	5367	702	867	187397	53391
MRWMO	30687	366	48	59	12770	3638
Phalen Creek	282876	3371	441	545	117713	33537
Pigs Eye	389811	4646	608	751	162211	46215
Riverview	188245	2243	294	363	78334	22318
St. Anthony Hill	550957	6566	859	1061	229269	65320
St. Anthony Park	508001	3947	555	959	148243	40555
Trout Brook	159507	2492	280	220	35454	10534
Urban	60527	721	94	117	25187	7176
West Kittsondale	226710	2702	354	437	94340	26878
West Seventh	87873	1047	137	169	36566	10418

Monitored Locations

Table 12-5: Q2 (Apr-Jun) Pollutant Loading (lbs)

Subwatershed	Cl	TKN	Total P	NO2+NO3	TSS	VSS
Battle Creek	44782	3475	609	595	308340	105284
Beaver Lake	4751	369	65	63	32711	11169
Belt Line	124296	9645	1691	1652	855830	292226
Crosby	49371	3831	672	656	339942	116074
Davern	46794	3631	636	622	322193	110014
Downtown	26955	2092	367	358	185595	63372
East Kittsondale	20551	2336	384	425	149261	63163
Fish Creek	1794	139	24	24	12349	4217
Goodrich/Western	17455	1354	237	232	120184	41037
Griffith/Pt. Douglas	21040	1633	286	280	144867	49465
Hidden Falls	1276	83	17	14	11351	2033
Highwood	42102	3267	573	560	289889	98983
Lake Como	39742	3084	541	528	273637	93434
Lake Phalen	31901	2475	434	424	219655	75002
Mississippi River Blvd.	90619	7032	1233	1204	623950	213050
MRWMO	5669	440	77	75	39030	13327
Phalen Creek	65316	5068	888	868	449728	153561
Pigs Eye	90007	6984	1224	1196	619737	211611
Riverview	37880	2939	515	503	260818	89057
St. Anthony Hill	110867	8603	1508	1473	763364	260653
St. Anthony Park	22647	1309	228	290	130690	58129
Trout Brook	98678	2279	611	494	254158	95978
Urban	13976	1084	190	186	96229	32858
West Kittsondale	41878	3250	570	557	288346	98457
West Seventh	17682	1372	241	235	121750	41572

Monitored Locations

Table 12-6: Q3 (Jul-Sep) Pollutant Loading

Subwatershed	Cl	TKN	Total P	NO2+NO3	TSS	VSS
Battle Creek	19799	1786	429	405	195819	63079
Beaver Lake	2100	189	46	43	20774	6692
Belt Line	54955	4958	1191	1124	543516	175081
Crosby	20432	1843	443	418	202077	65094
Davern	19365	1747	420	396	191526	61696
Downtown	11155	1006	242	228	110326	35539
East Kittsondale	13897	2298	416	487	186182	64271
Fish Creek	793	72	17	16	7843	2526
Goodrich/Western	7224	652	157	148	71443	23014
Griffith/Pt. Douglas	9302	839	202	190	92001	29636
Hidden Falls	1307	136	27	33	14797	3074
Highwood	18614	1679	404	381	184101	59304
Lake Como	16447	1484	357	336	162662	52398
Lake Phalen	14104	1272	306	289	139497	44936
Mississippi River Blvd.	37502	3383	813	767	370903	119478
MRWMO	2482	224	54	51	24544	7906
Phalen Creek	5925	1365	319	266	172293	137370
Pigs Eye	39795	3590	863	814	393579	126783
Riverview	15676	1414	340	321	155042	49943
St. Anthony Hill	45881	4139	995	939	453777	146174
St. Anthony Park	29336	2520	467	660	227756	83092
Trout Brook	62810	2548	860	615	340515	96956
Urban	6179	557	134	126	61112	19686
West Kittsondale	18333	1654	397	375	181321	58408
West Seventh	7318	660	159	150	72374	23314

Monitored Locations

Table 12-7: Q4 (Oct-Dec) Pollutant Loading (lbs)

Subwatershed	Cl	TKN	Total P	NO2+NO3	TSS	VSS
Battle Creek	14617	672	220	156	57680	21002
Beaver Lake	1551	71	23	17	6119	2228
Belt Line	40571	1864	610	433	160098	58293
Crosby	19758	908	297	211	77965	28388
Davern	18726	860	282	200	73894	26906
Downtown	10787	496	162	115	42566	15499
East Kittsondale	577	15	4	7	963	254
Fish Creek	585	27	9	6	2310	841
Goodrich/Western	6985	321	105	74	27564	10036
Griffith/Pt. Douglas	6868	316	103	73	27100	9867
Hidden Falls	1307	136	27	33	14797	3074
Highwood	13742	631	207	147	54229	19745
Lake Como	15904	731	239	170	62758	22851
Lake Phalen	10900	900	191	231	69455	26343
Mississippi River Blvd.	36264	1666	545	387	143102	52105
MRWMO	2047	94	31	22	8078	2941
Phalen Creek	7745	961	260	66	45183	25459
Pigs Eye	29379	1350	442	313	115933	42212
Riverview	15159	696	228	162	59818	21780
St. Anthony Hill	44367	2038	667	473	175076	63747
St. Anthony Park	59699	719	309	445	83347	28690
Trout Brook	35957	577	257	222	50408	17698
Urban	4562	210	69	49	18001	6554
West Kittsondale	15123	695	227	161	59677	21729
West Seventh	7076	325	106	75	27923	10167

Monitored Locations

13. 2020 Summary

In 2020, seven (7) stormwater BMPs were monitored along with two (2) locations that provide upstream stormwater data. All locations were evaluated for performance in 2020 to help the City meet its Phase I MS4 Permit monitoring requirements. The BMP systems that were monitored include underground infiltration systems, a rain garden, and pervious pavement. The systems were monitored to evaluate infiltration rates, volume reduction, and pollutant removal efficiencies. Long-term monitoring data has shown how the effectiveness of these systems change over time.

13.1. Underground Infiltration Systems/Outfall

Four underground infiltration BMPs (Beacon Bluff, St. Albans, Hampden Park, and Victoria Street) were monitored for flow to evaluate runoff and volume reduction at BMP Sites. The runoff data for each site was normalized over the individual drainage areas to evaluate drainage characteristics that contribute to each Site. A summary of runoff and volume reduction data is presented in **Table 13-1** below.

Table 13-1: Runoff Summary

BMP Site	Drainage Area (acres)[1]	Total Monitored Runoff (cf)	% Runoff Captured	Water Yield (in/acre)[1]	Water Yield (cu-ft/acre)[1]	Rainfall/Runoff Coefficient
Beacon Bluff	143.6	1,500,588	61.1	2.88	10,450	0.15
St. Albans	25.2	227,611	97	2.49	9,032	0.23
Hampden Park	7.8	167,295	100	5.91	21,448	0.39
Victoria Street	19.1	258,999	99.8	3.73	13,560	0.23

1-For the Beacon Bluff and Hampden Park Sites, the drainage area and total runoff presented in the table includes the total for the BMP system. The water yield calculations were generated from the monitored/modeled runoff volume and the corresponding drainage area

Of the four sites, the Hampden Park site received the greatest amount of runoff per drainage acre, resulting in a rainfall to runoff coefficient of 0.39. Beacon Bluff's drainage area showed the least amount of runoff, having a coefficient of 0.15.

TSS and TP loads captured by the monitored BMPs are summarized in **Table 12-2**. TSS and TP loads were calculated using 2020 flow data and flow-weighted averages. Beacon Bluff takes in the largest runoff volume and also captured the largest amount of TSS and TP. The total TSS load and TP load captured by the four systems was 7,745 pounds and 40.89 pounds, respectively.

Table 13-2: Underground Infiltration System Pollutant Capture Summary

BMP Site	TSS Captured (pounds)	TP Captured (pounds)
Beacon Bluff	3,191	17.6
St. Albans	3,104	6.1
Hampden Park	498	1.49
Victoria Street	952	15.7
Total	**7,745**	**40.89**

A summary of the 2020 infiltration rates for the underground infiltration systems is provided below.

- The infiltration rate for the Beacon Bluff underground system was 0.09 in/hr, which is 3.5% of the post-construction infiltration rate. The underground system no longer drains to empty, and groundwater mounding does not appear to be the cause of standing water, based on groundwater elevation data. Even with standing water observed in the BMP and an increase in system discharge events, the BMP infiltrated 61.1% of the total volume monitored.
- The 2020, St. Albans infiltration rate of 9.9 in/hr is greater than the MSWM infiltration rate, but less than design rate of 26.0 in/hr. The St. Albans BMP system regularly drained to empty within 24 hours of a runoff event.
- The infiltration rate for the Hampden Park BMP was 41 in/hr, which exceeded the design rate of 1.8 in/hr and is much greater than the 2019 infiltration rate. Possibly due to low rain fall totals and less water moving through the pipe. No overflow bypass was observed, therefor 100% of the volume received by the BMP was infiltrated.
- The infiltration rate for the Victoria Street BMP was 43.9 in/hr, which saw an increase compared to 2019, and was 94% of the post-construction infiltration rate. The Victoria Street BMP regularly drained to empty with 24 hours of a runoff event.

13.2. Pervious Pavement

Infiltration testing was conducted at the Victoria Street permeable pavers, Jackson Street pervious asphalt, and Hamline Midway Library pervious asphalt sites in 2020. The Victoria Street 2020 average infiltration rate of 5.8 in/hr is less than 4% of post-construction monitored infiltration rate.

The November 2020 infiltration rate at the Jackson Street Site was 147.9 in/hr, which is 22.4% of the infiltration rate observed during the first year of monitoring (2016). Low traffic areas were observed to have a significantly greater infiltration rates on average (509.4 in/hr) than medium traffic (14.4 in/hr) and high traffic (0.0 in/hr) areas.

13.3. 2020 Recommendations

The recommendations for the 2021 Monitoring Program include:

- Continue to perform inspections and regular maintenance on BMP pre-treatment systems and infiltration galleries.
- Continue to notify of potential illicit discharges observed at flow monitoring locations.
- Stop monitoring at Sackett Park and start at new location as construction is on hold at Sackett Park.
- Complete additional infiltration testing at Jackson Street Pervious Bike Path to further evaluate changes in pervious surface performance with respect to pavement traffic.
- Adjust river level monitoring to be within the Mississippi River in protected areas for more accurate results.

14. References

City of Saint Paul, 2018. 2017 Water Quality and Quantity Monitoring Report. Saint Paul, MN.

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Minnesota Department of Transportation, 2015. Study: “Permeable Pavements in Cold Climates: State of the Art and Cold Climate Case Studies”. Accessed 2017. https://lrrb.org/pdf/201530.pdf.

Figures

Appendix A – Infiltration/Water Level Charts

Appendix B – Flow Rate Charts

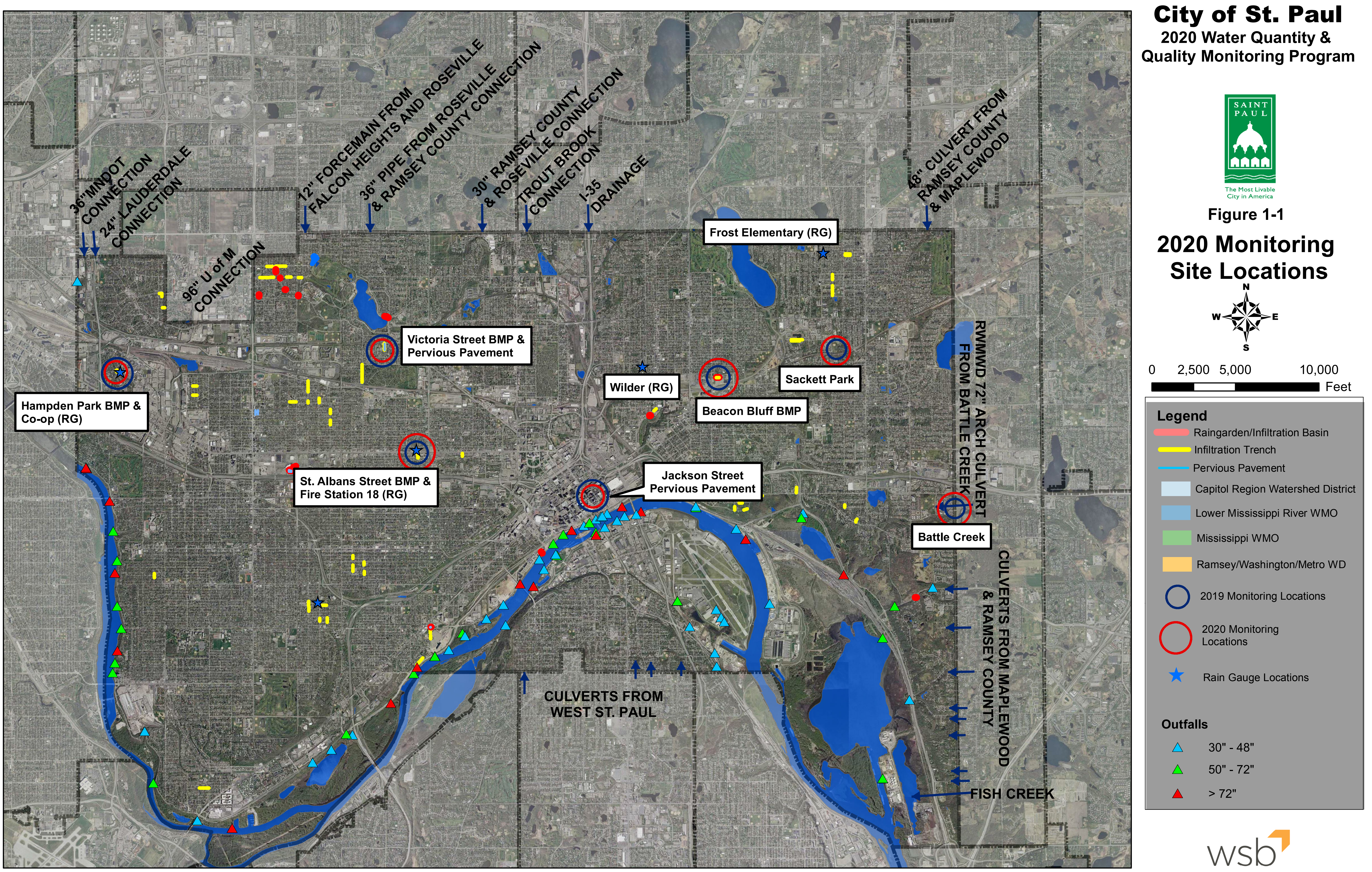
Appendix C – Water Quality Summary and Pollutant Load Calculations

Appendix D – Pervious Pavement Infiltration Charts

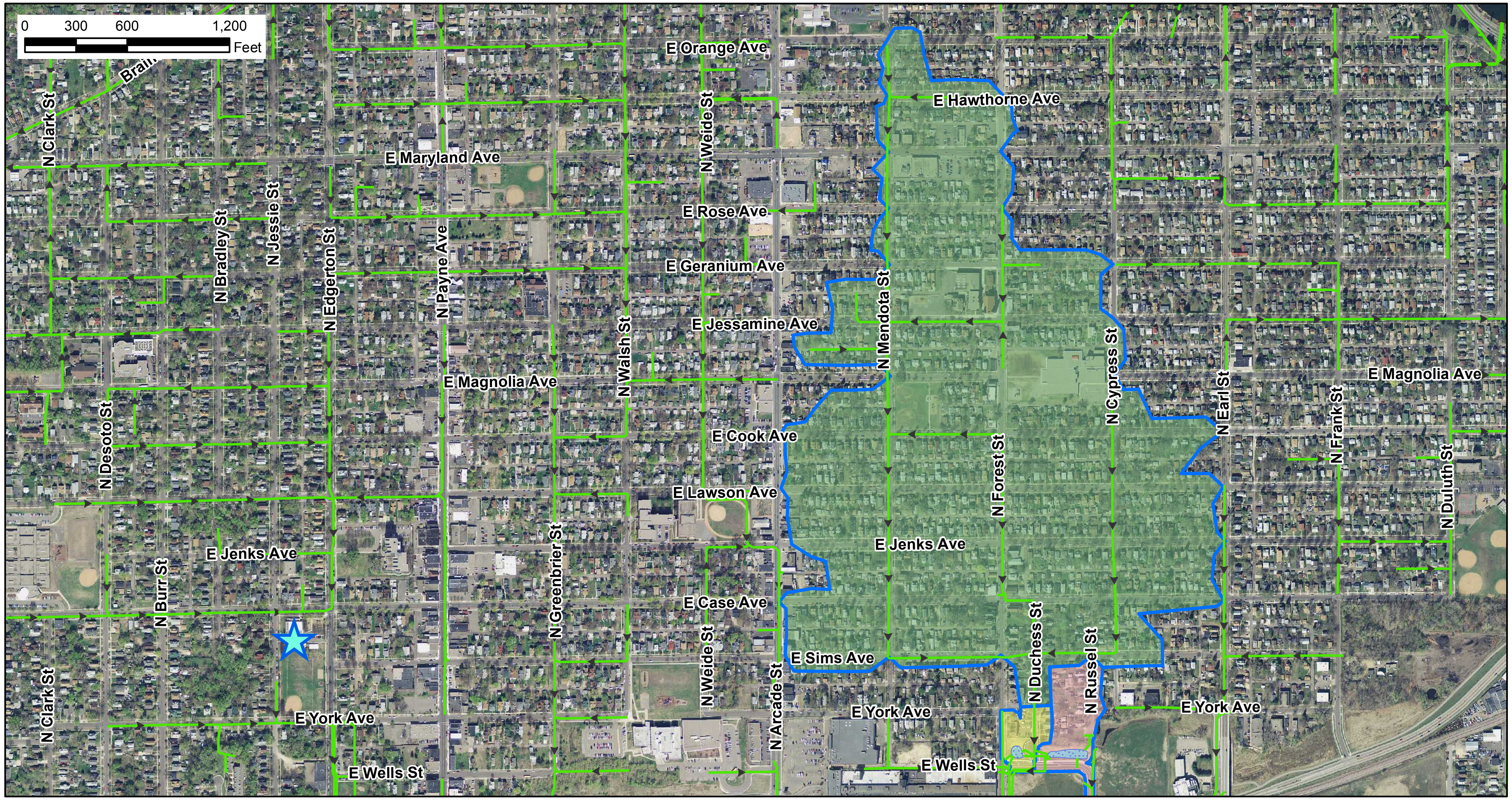
Appendix E – Photolog

Appendix F – 2017 Monitoring Protocols

Appendix G – ASTM C1701 Procedures



City of St. Paul
2020 Water Quantity & Quality Monitoring Program
Figure 1-1
2020 Monitoring Site Locations
N
S
W
E
0 2,500 5,000 10,000 Feet
Legend
Raingarden/Infiltration Basin
Infiltration Trench
Pervious Pavement
Capitol Region Watershed District
Lower Mississippi River WMO
Mississippi WMO
Ramsey/Washington/Metro WD
2019 Monitoring Locations
2020 Monitoring Locations
Rain Gauge Locations
Outfalls
30" - 48"
50" - 72"
> 72"
36" MNDOT CONNECTION
24" LAUDERDALE CONNECTION
96" U of M CONNECTION
12" FORCEMAIN FROM FALCON HEIGHTS AND ROSEVILLE
36" PIPE FROM ROSEVILLE & RAMSEY COUNTY CONNECTION
30" RAMSEY COUNTY & ROSEVILLE CONNECTION
TROUT BROOK CONNECTION
I-35 DRAINAGE
48" CULVERT FROM RAMSEY COUNTY & MAPLEWOOD
RWMWD 72" ARCH CULVERT FROM BATTLE CREEK
CULVERTS FROM MAPLEWOOD & RAMSEY COUNTY
CULVERTS FROM WEST ST. PAUL
FISH CREEK
Frost Elementary (RG)
Victoria Street BMP & Pervious Pavement
Hampden Park BMP & Co-op (RG)
Wilder (RG)
Beacon Bluff BMP
Sackett Park
St. Albans Street BMP & Fire Station 18 (RG)
Jackson Street Pervious Pavement
Battle Creek
wsb



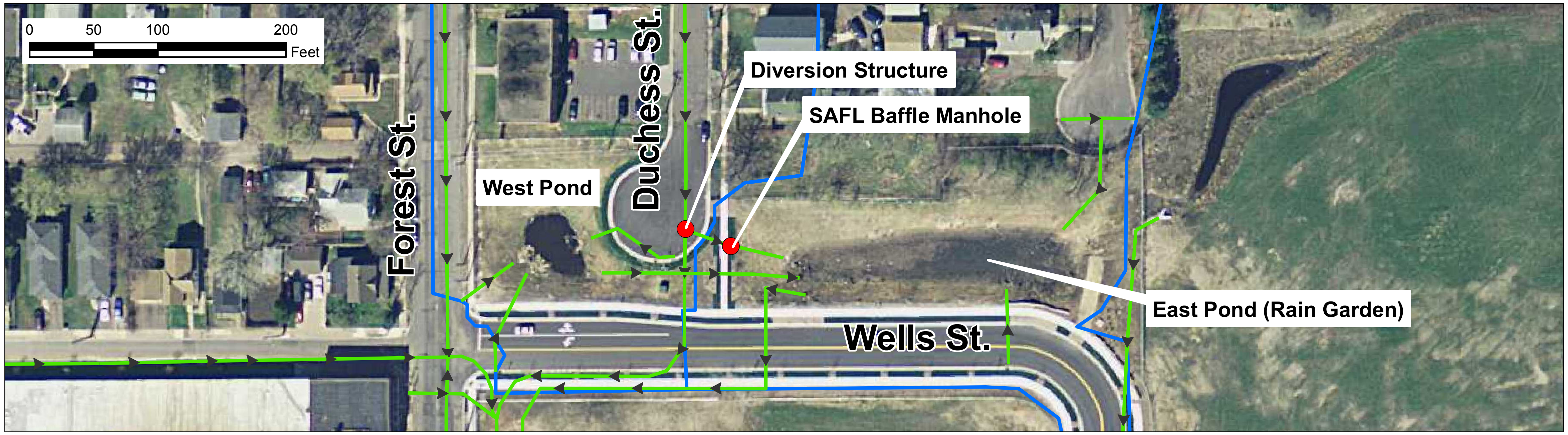


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FIGURE 4-1
Beacon Bluff Infiltration BMP Drainage Areas

N W E S

Legend

- Underground Chamber
- Storm Pipe
- Rain Gauge Location

Drainage Areas

- Subwatershed A - Diversion Structure (136.8 ac)
- Suwatershed B - East Pond (4.7 ac)
- Subwatershed C - West Pond (2.1 ac)

wsb

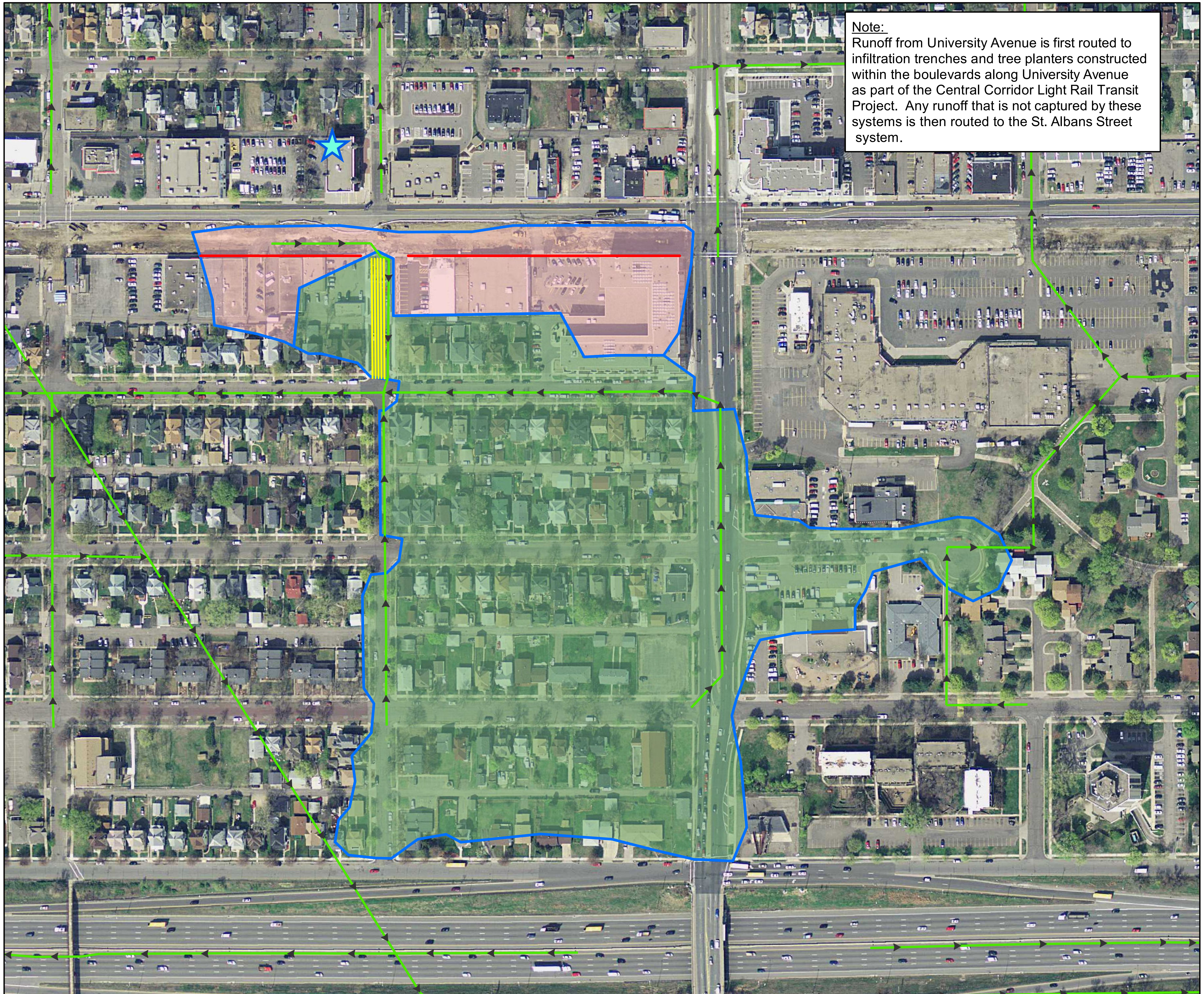

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FIGURE 5-1

St. Albans Street Infiltration BMP Drainage Areas

N
W E
S

0 100 200 400 Feet

Legend

- Infiltration Trench
- CCLRT Infiltration Trench (Not monitored)
- Storm Pipe
- Rain Gauge Location

Drainage Areas

- St. Albans Infiltration System (20.3 ac)
- CCLRT Infiltration Trenches (4.9 acres)

wsb

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FIGURE 6-1
Hampden Park Infiltration BMP Drainage Area

N
W E
S

0 50 100 200 300 400
Feet

Legend

- Storm Pipe
- Rain Gauge Location
- Hampden Park BMP
- Hampden Park BMP Drainage Area

wsb

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FIGURE 7-1
Victoria Street Infiltration BMP Drainage Areas

Legend

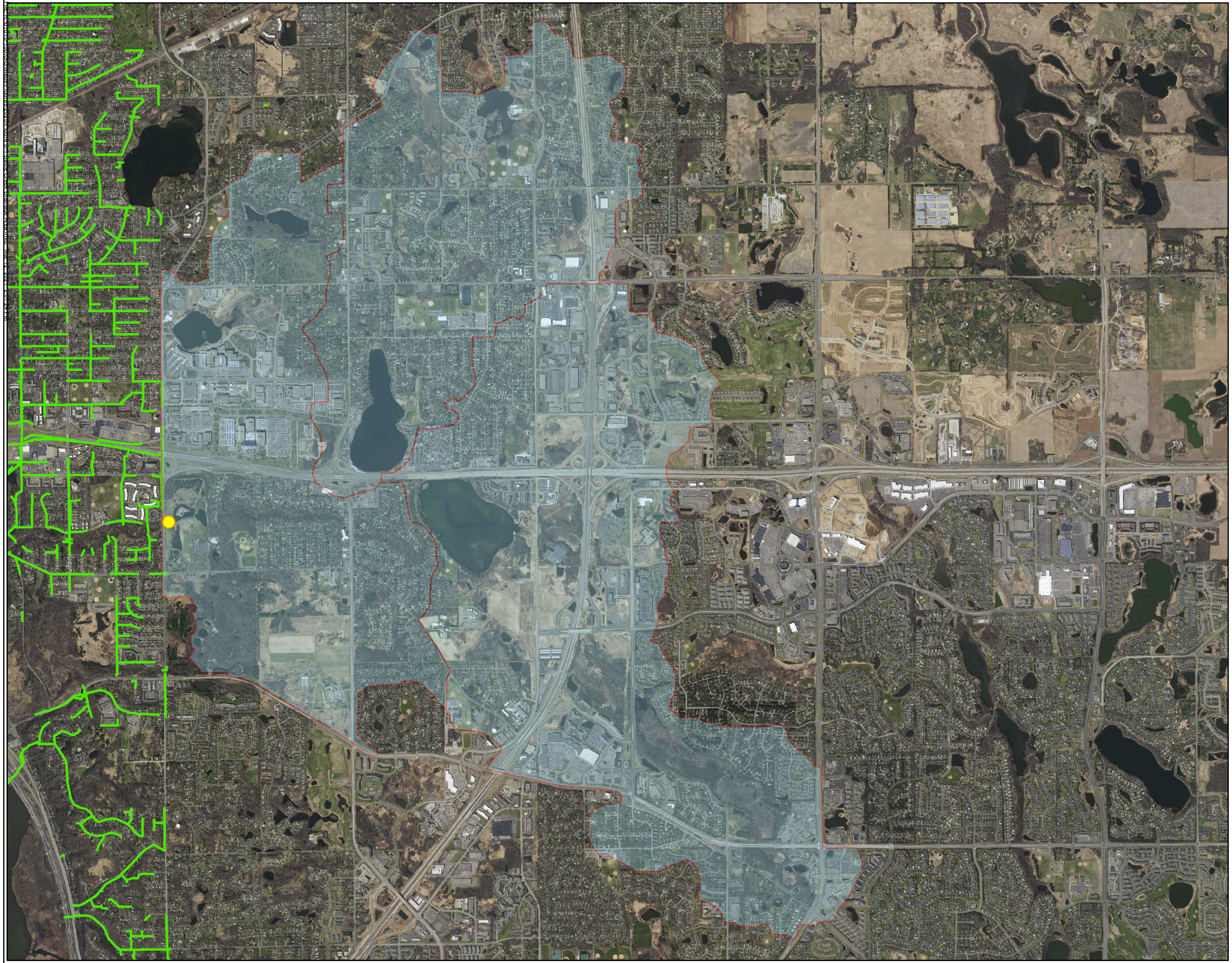
Infiltration BMPs

- Infiltration Trench
- Pervious Pavement
- Storm Pipe
- Rain Gauge Location

Drainage Areas

- Infiltration Trench (19.1 ac)
- Pervious Pavement (1.0 ac)

wsb



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N
W E
S

Figure 8-1

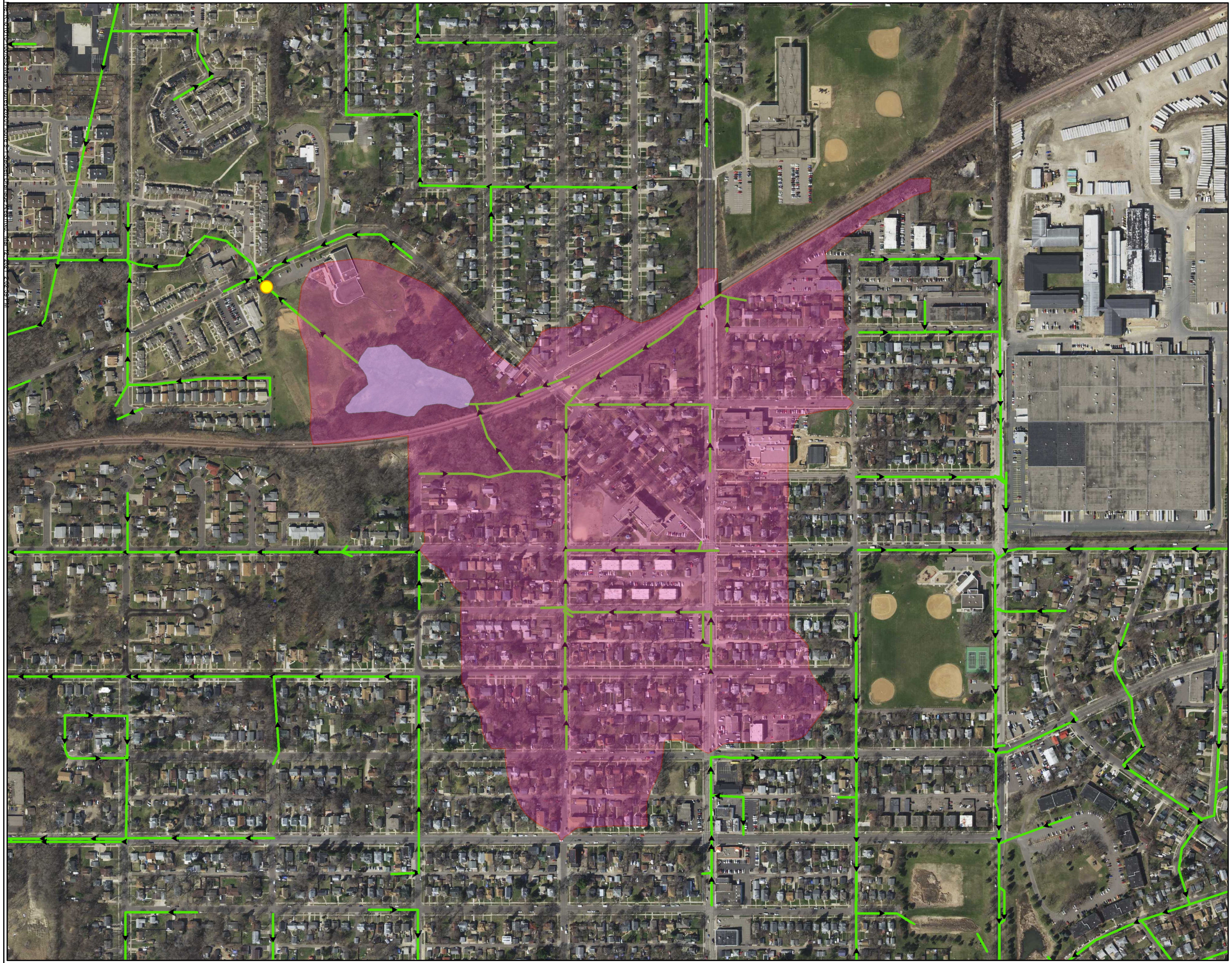
Battle Creek Monitoring Location
Drainage Area:661.7 acres

Rain Gauge Location -
Frost Lake Elementary
1505 Hoyt Ave E

Monitoring Locations
Sackett Park Drainage Area
Battle Creek Drainage Area
BMP Location
Storm Pipe

0 1,300 2,600 5,200 Feet

wsb



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N
W E
S

Figure 9-1

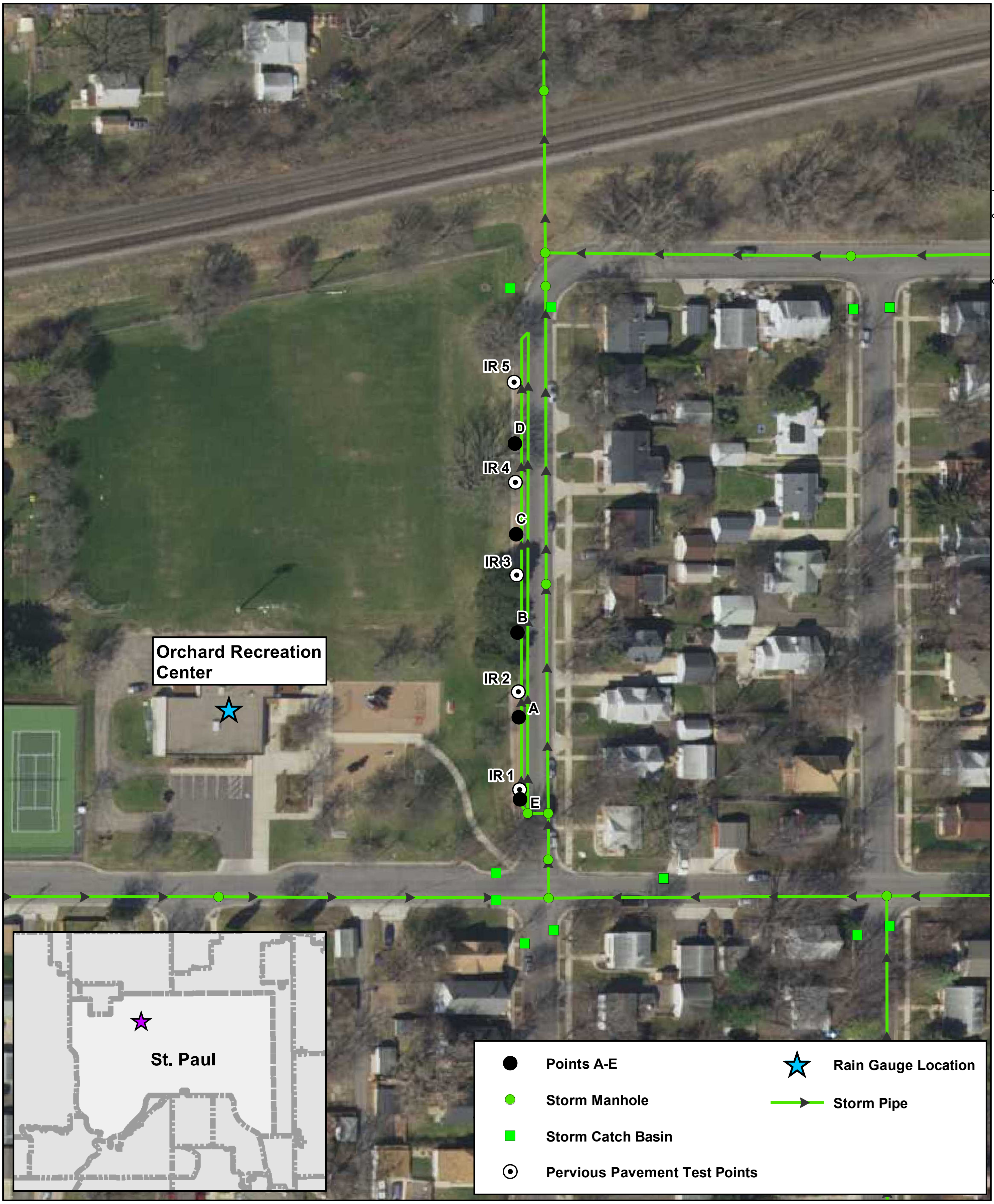
Sackett Park Monitoring Location
Drainage Area:93.3 acres

Rain Gauge Location -
Frost Lake Elementary
1505 Hoyt Ave E

Monitoring Locations
Sackett Park Drainage Area
Battle Creek Drainage Area
BMP Location
Storm Pipe

0 215 430 860
Feet

wsb



Document Path: K:\01610-100\GIS\Maps\Figures\2020\Figure 10-1 Victoria StreetPP.mxd Date Saved: 2/26/2020 12:06:13 PM

Figure 10-1 - Victoria Street
Pervious Pavement Test Locations

2020 Water Quantity and Quality Monitoring Program
City of St Paul, MN

N

0 30 60 120 Feet

wsb

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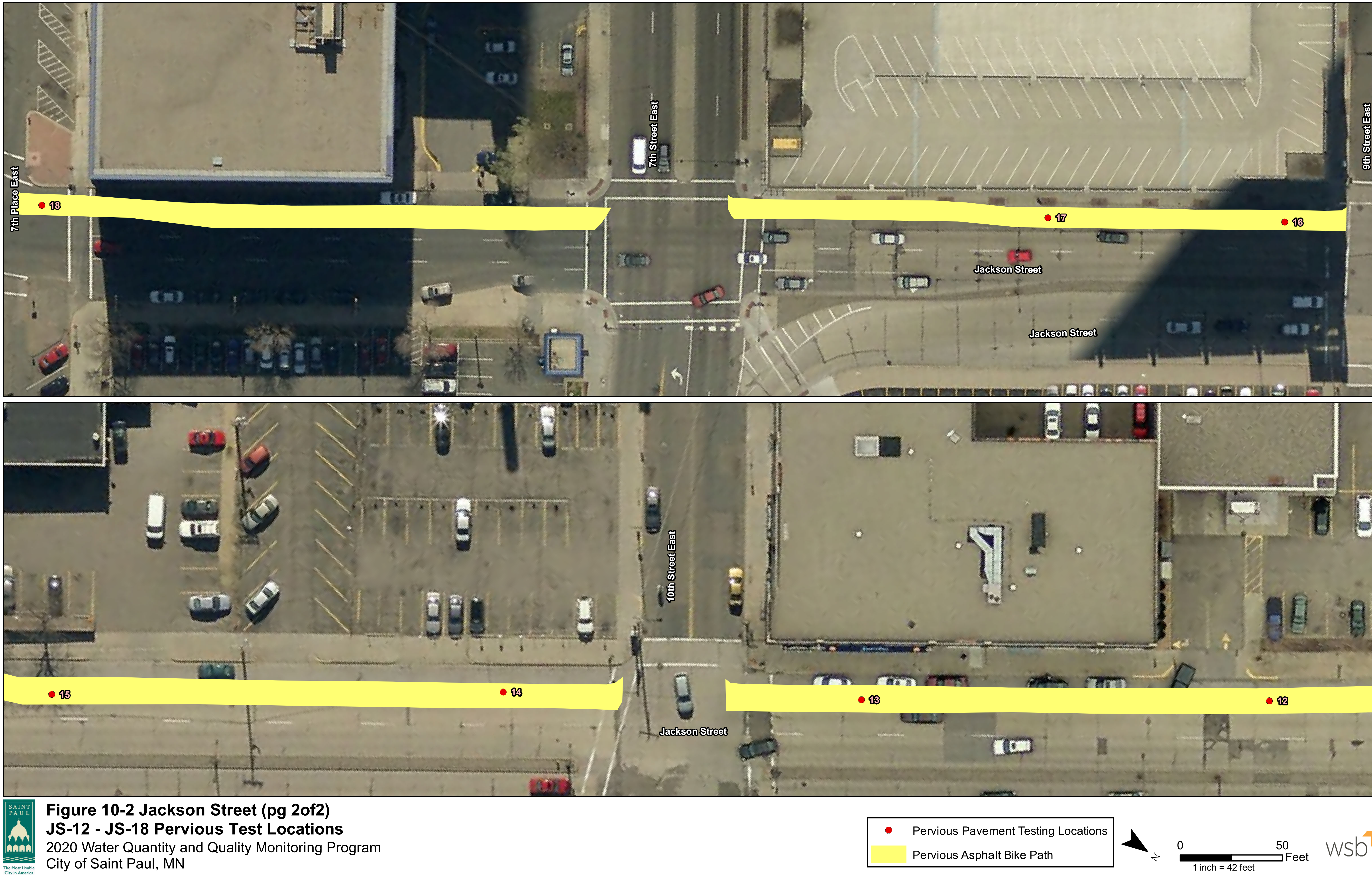

Figure 10-2 Jackson Street (pg 2of2)
JS-12 - JS-18 Pervious Test Locations
2020 Water Quantity and Quality Monitoring Program
City of Saint Paul, MN

Figure 10-2 Jackson Street (pg 1of2)
JS-1 - JS-11 Pervious Test Locations
2020 Water Quantity and Quality Monitoring Program
City of Saint Paul, MN

- Pervious Pavement Testing Locations
- Pervious Asphalt Bike Path

N

0 50 Feet
1 inch = 42 feet

Document Path: K:\01610-100\GIS\Maps\Figures2020\Figure 10-2 JacksonStPerviousPavement.mxd Date Saved: 2/26/2020 12:08:05 PM

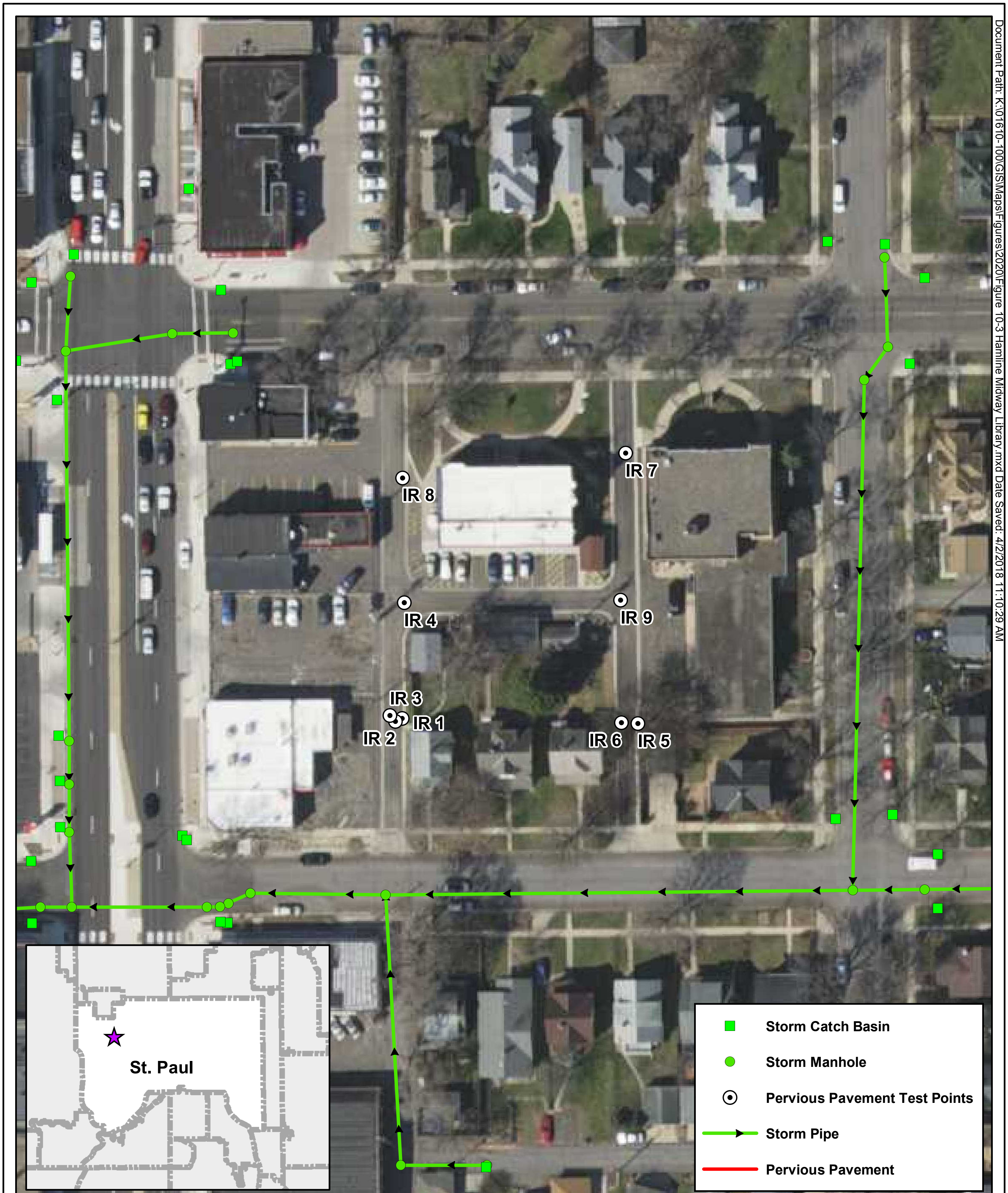

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Figure 10-3 - Hamline Midway Library Pervious Pavement Test Locations

2019 Water Quantity and Quality Monitoring Program
City of St Paul, MN

wsb

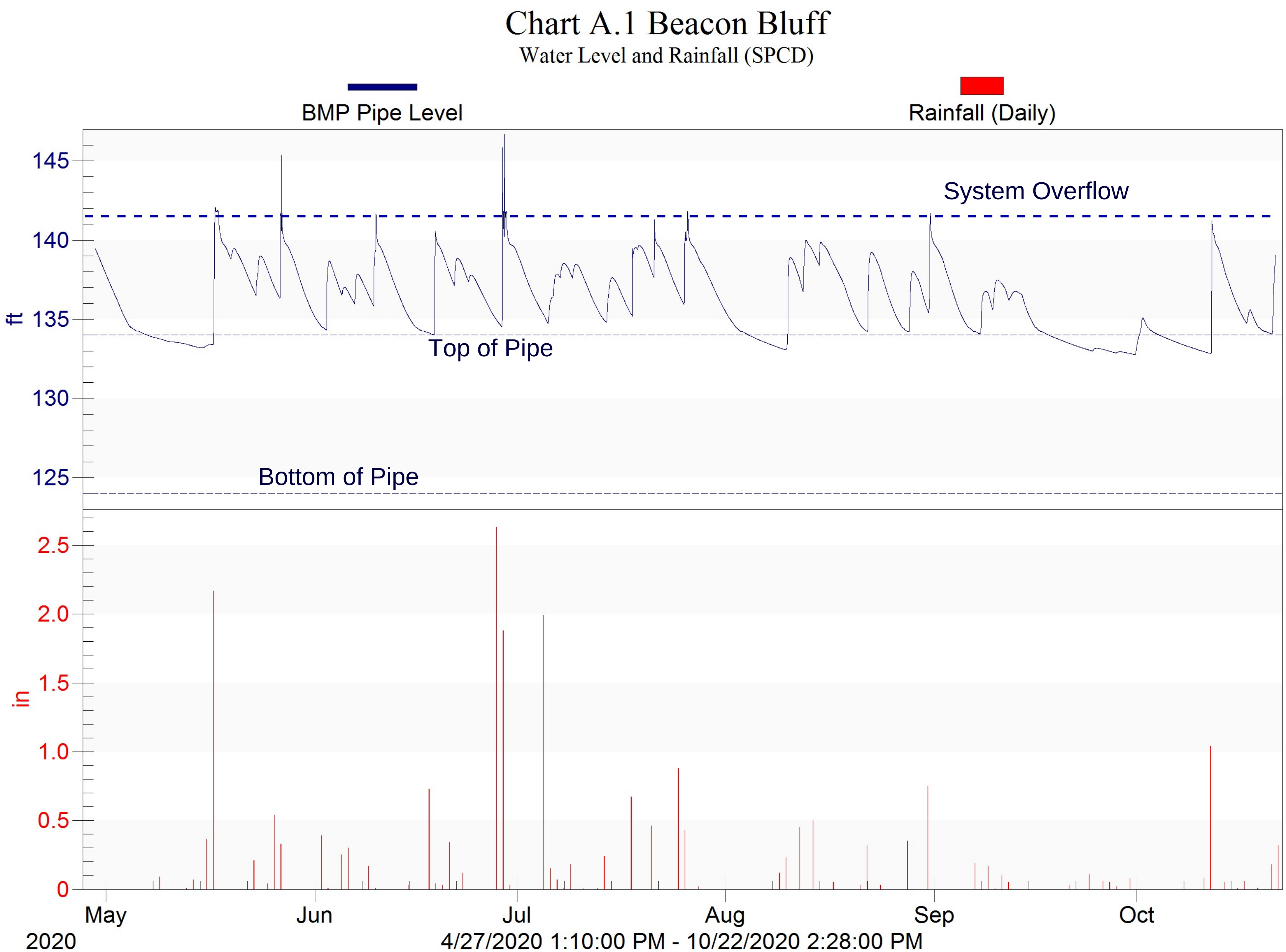
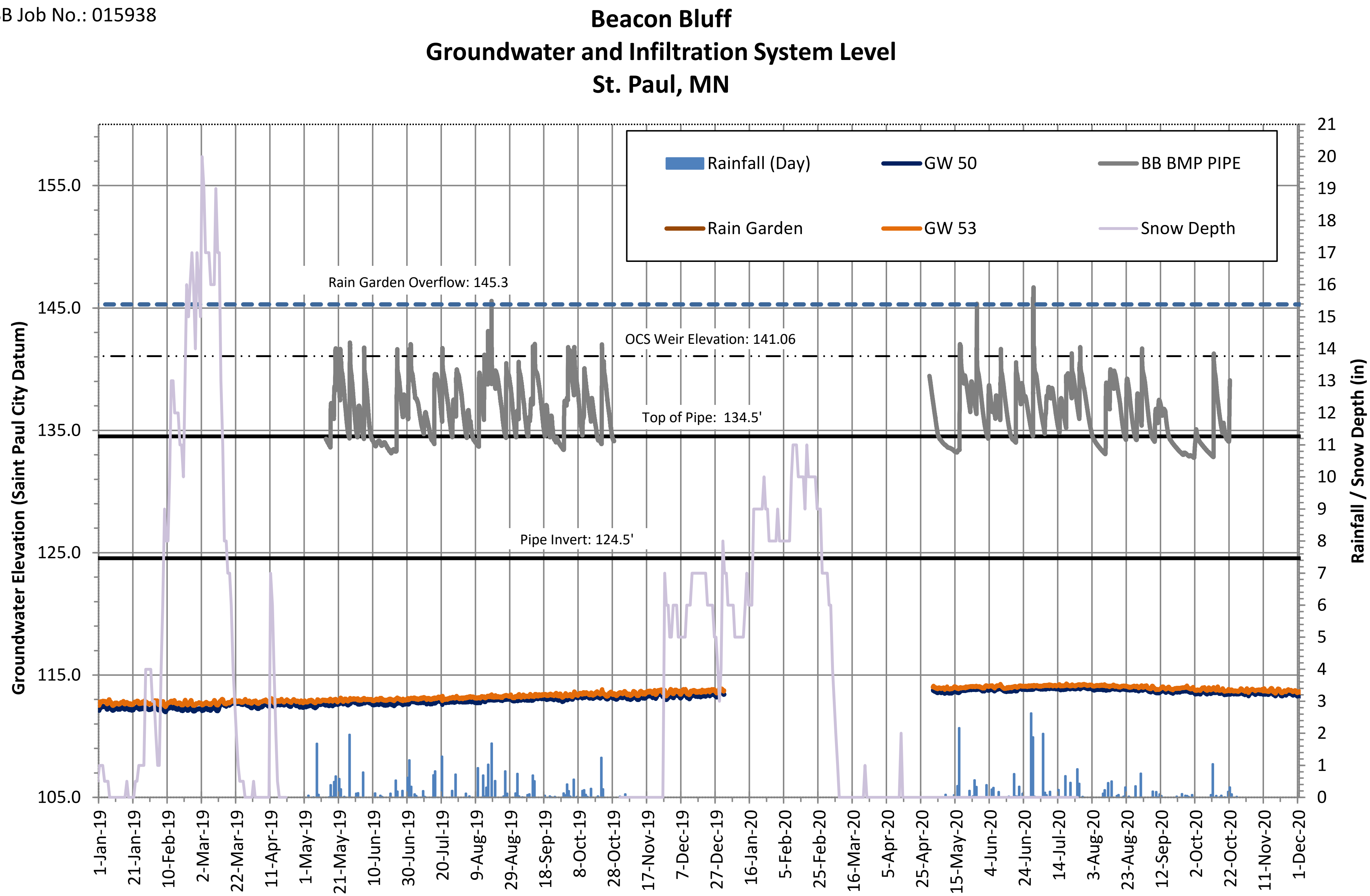
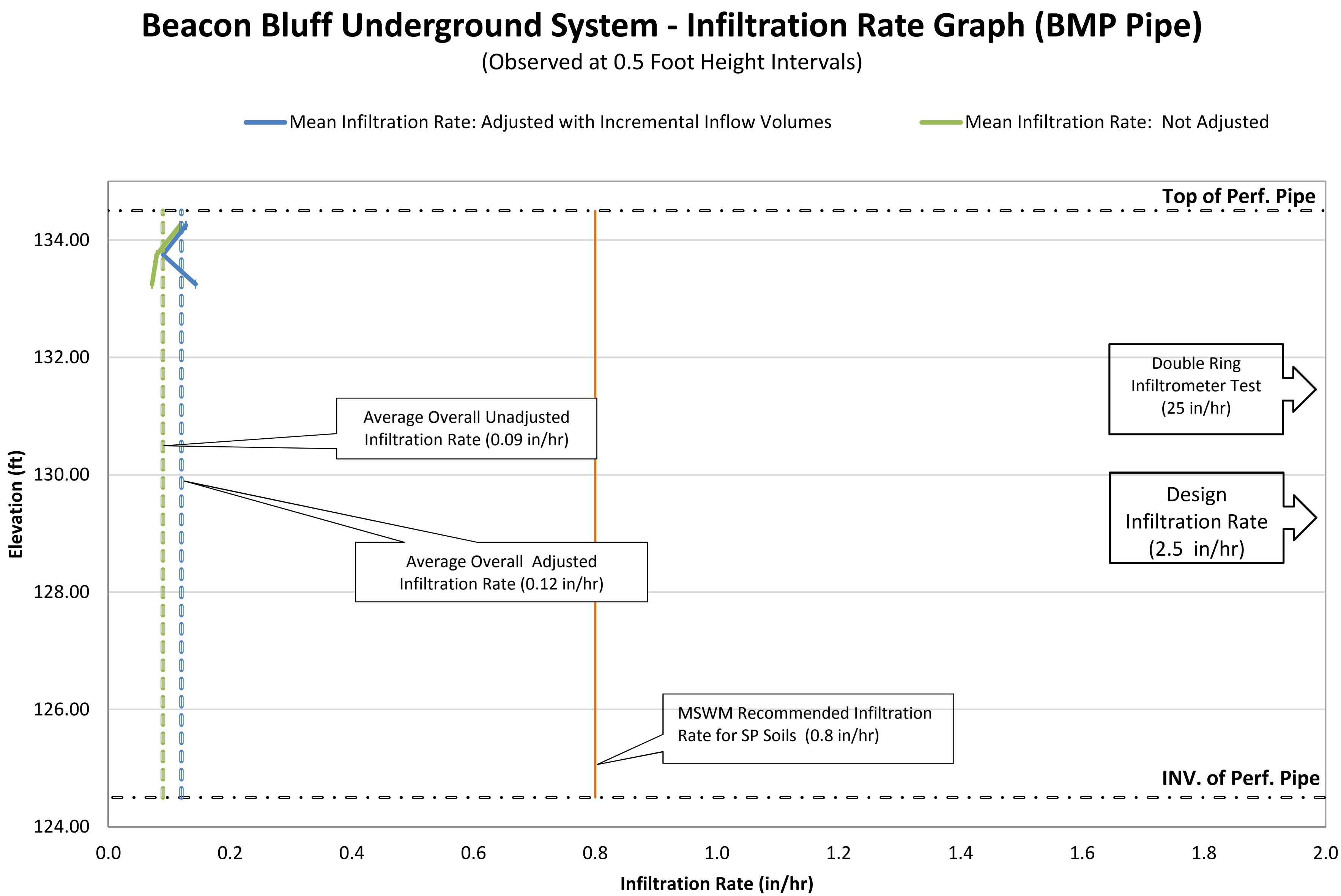


Chart A.1 Beacon Bluff
Water Level and Rainfall (SPCD)
BMP Pipe Level
Rainfall (Daily)
System Overflow
Top of Pipe
Bottom of Pipe
ft
145
140
135
130
125
in
2.5
2.0
1.5
1.0
0.5
0
May
Jun
Jul
Aug
Sep
Oct
2020
4/27/2020 1:10:00 PM - 10/22/2020 2:28:00 PM

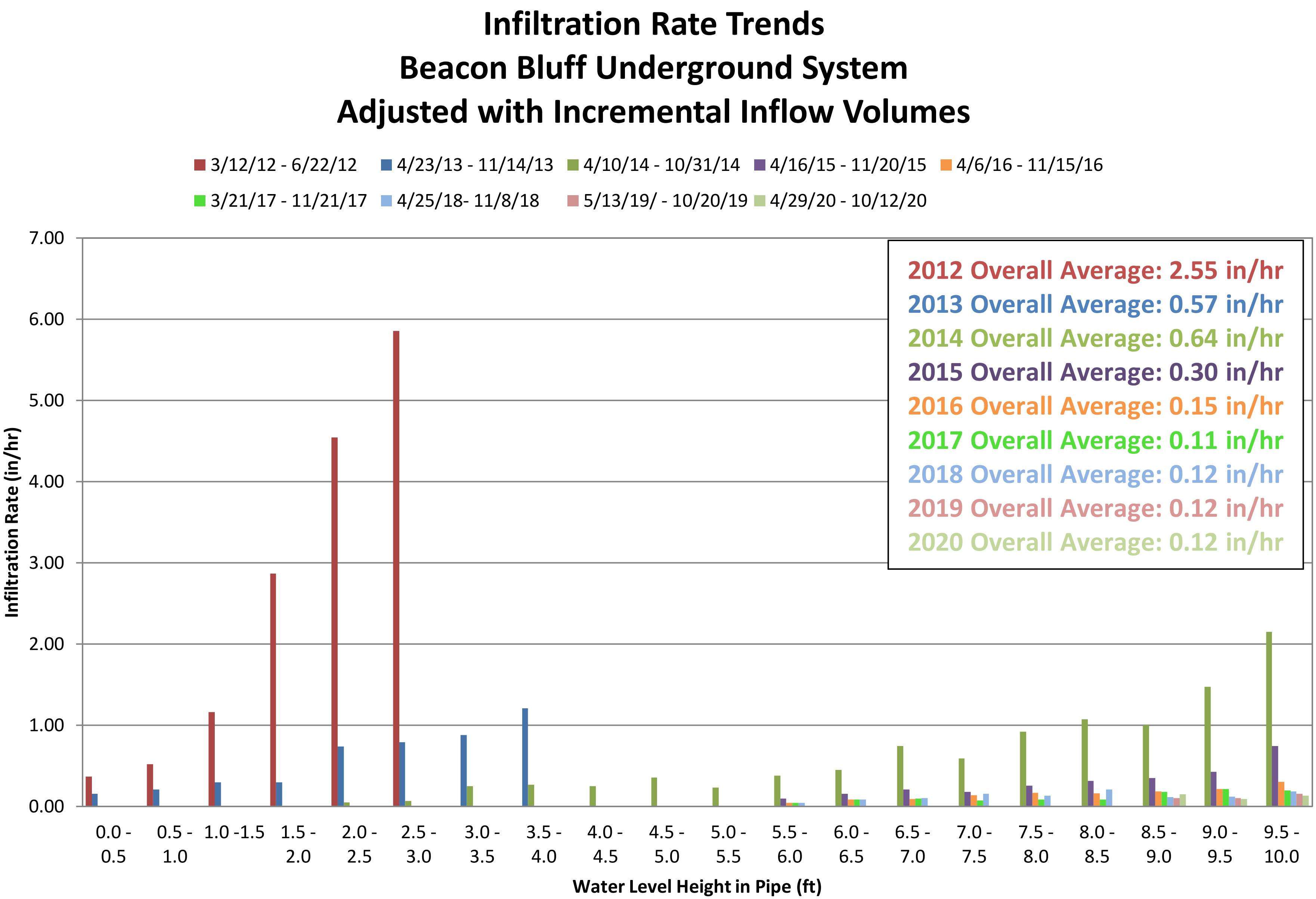
City of Saint Paul
2020 Beacon Bluff Groundwater and System Level
Chart A.2
WSB Job No.: 015938



City of Saint Paul
2020 Water Quality and Quantity Report
Chart A.3
WSB Project No.: 015938



Note: Pipe Invert is 124.5'
Pipe perforated around circumference of pipe


Infiltration Rate Trends
Beacon Bluff Underground System
Adjusted with Incremental Inflow Volumes
3/12/12 - 6/22/12
4/23/13 - 11/14/13
4/10/14 - 10/31/14
4/16/15 - 11/20/15
4/6/16 - 11/15/16
3/21/17 - 11/21/17
4/25/18- 11/8/18
5/13/19/ - 10/20/19
4/29/20 - 10/12/20
2012 Overall Average: 2.55 in/hr
2013 Overall Average: 0.57 in/hr
2014 Overall Average: 0.64 in/hr
2015 Overall Average: 0.30 in/hr
2016 Overall Average: 0.15 in/hr
2017 Overall Average: 0.11 in/hr
2018 Overall Average: 0.12 in/hr
2019 Overall Average: 0.12 in/hr
2020 Overall Average: 0.12 in/hr
Infiltration Rate (in/hr)
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
0.0 - 0.5
0.5 - 1.0
1.0 -1.5
1.5 - 2.0
2.0 - 2.5
2.5 - 3.0
3.0 - 3.5
3.5 - 4.0
4.0 - 4.5
4.5 - 5.0
5.0 - 5.5
5.5 - 6.0
6.0 - 6.5
6.5 - 7.0
7.0 - 7.5
7.5 - 8.0
8.0 - 8.5
8.5 - 9.0
9.0 - 9.5
9.5 - 10.0
Water Level Height in Pipe (ft)

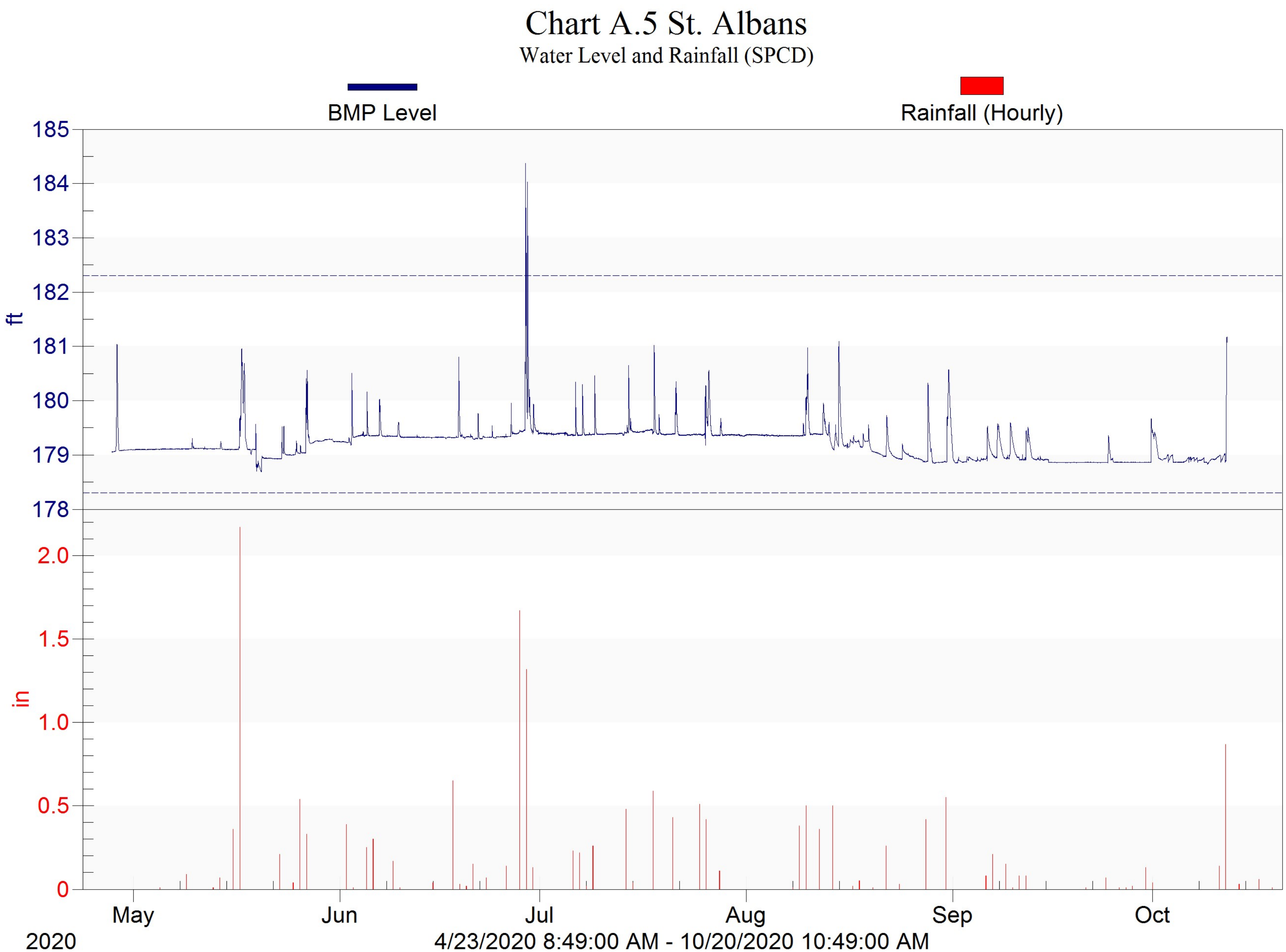
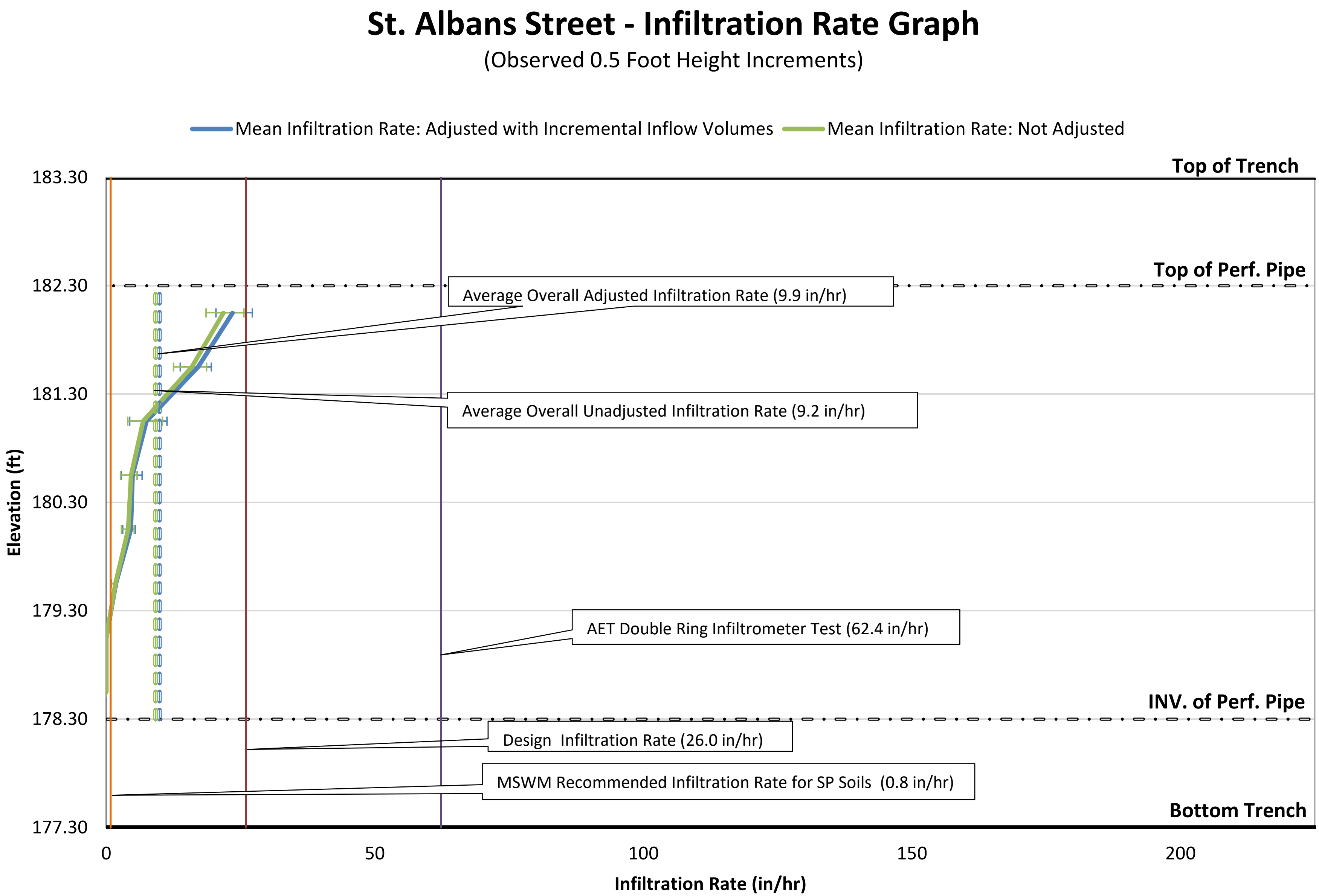


Chart A.5 St. Albans
Water Level and Rainfall (SPCD)
BMP Level
Rainfall (Hourly)
185
184
183
182
181
180
179
178
ft
2.0
1.5
1.0
0.5
0
in
May
Jun
Jul
Aug
Sep
Oct
2020
4/23/2020 8:49:00 AM - 10/20/2020 10:49:00 AM

City of Saint Paul
2020 Water Quality and Quantity Report
Chart A.6
WSB Job No.: 015938



Note: Pipe Invert is 178.3'
Error Bars Represent 25th and 75th Percentiles
Pipe perforated w/ 2 rows of holes at Elev: 178.9' and 179.2'

City of Saint Paul
2020 Water Quality and Quantity Report
Chart A.7
WSB Project No.: 015938

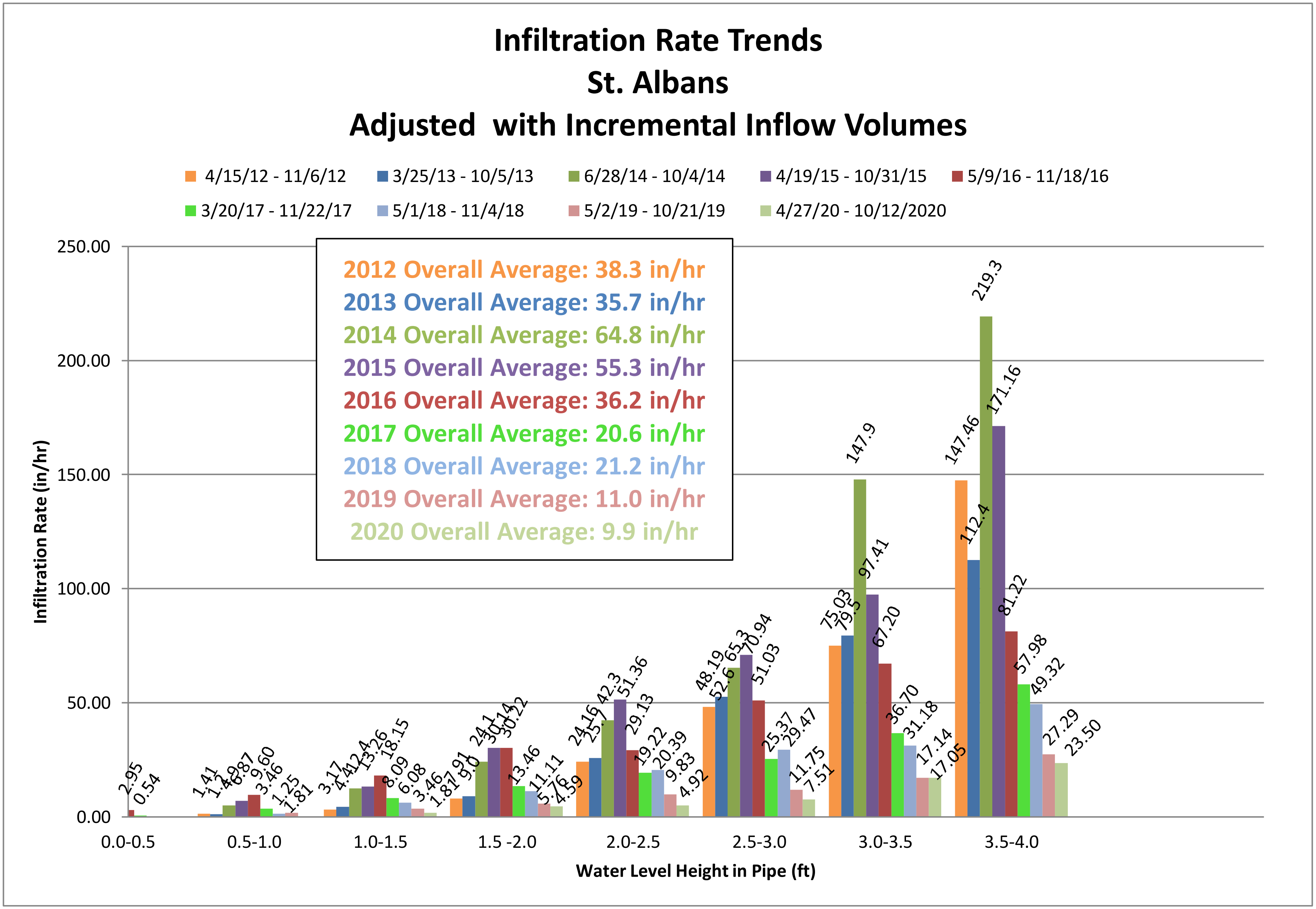
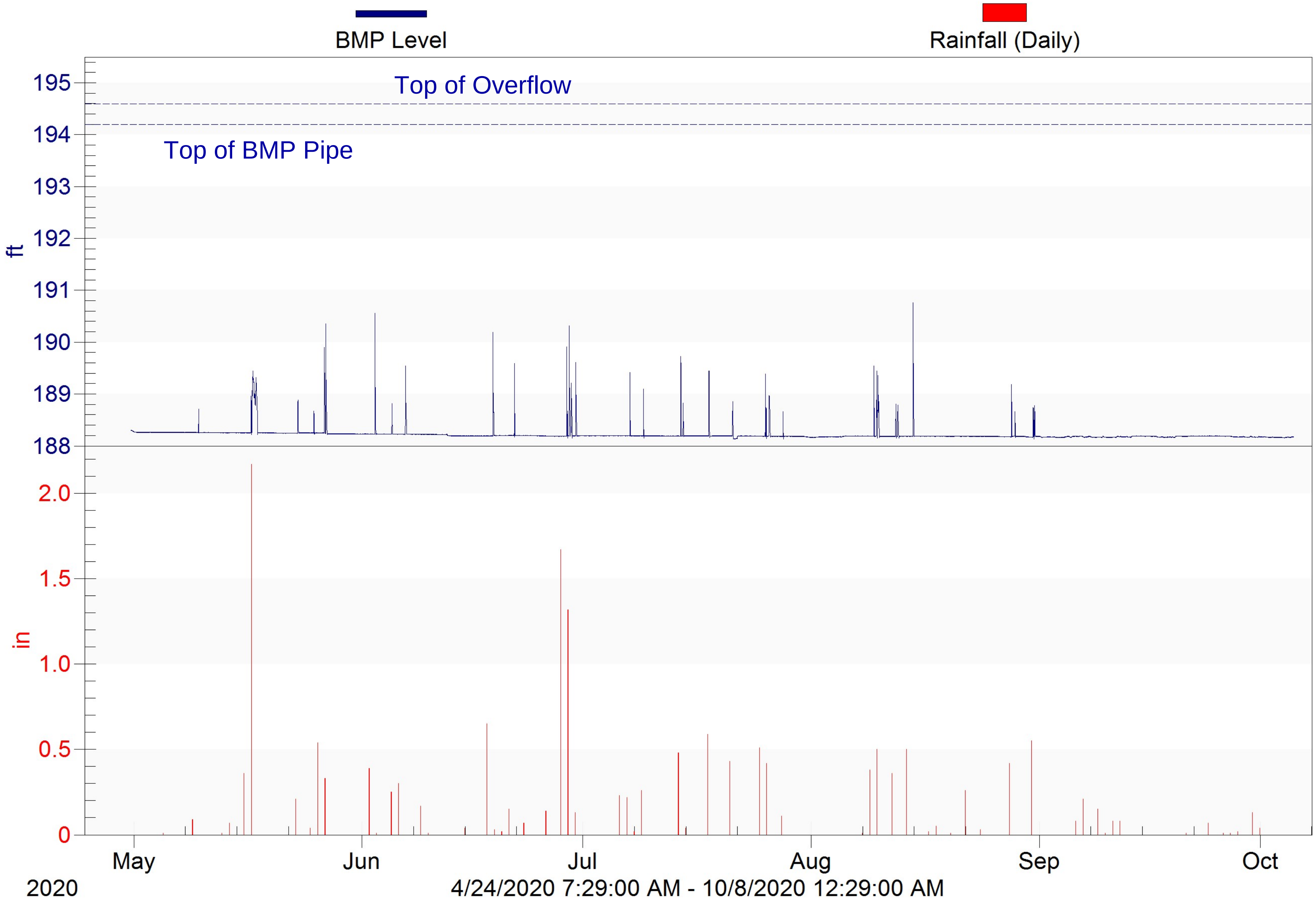
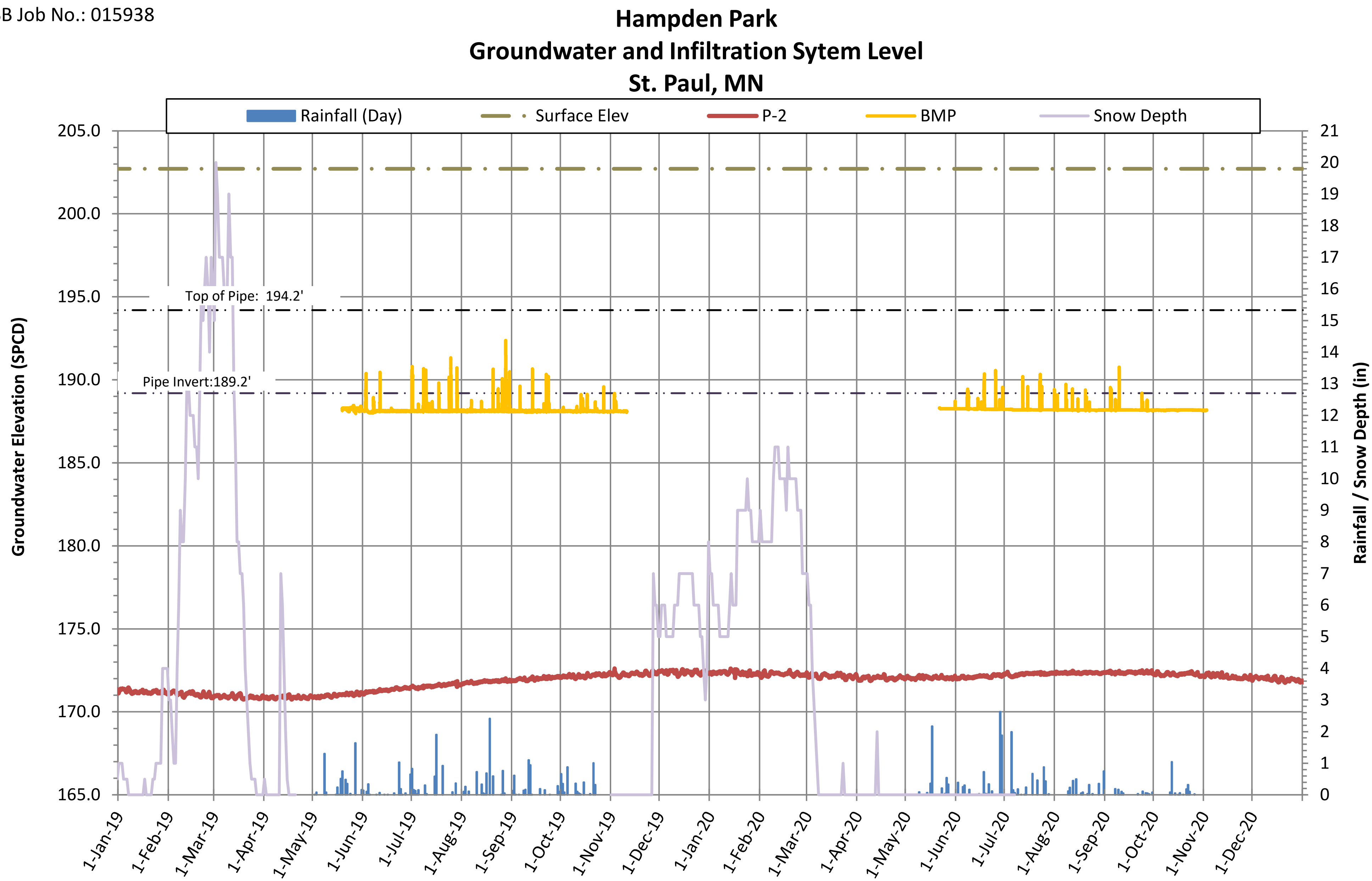


Chart A.8 Hampden Park

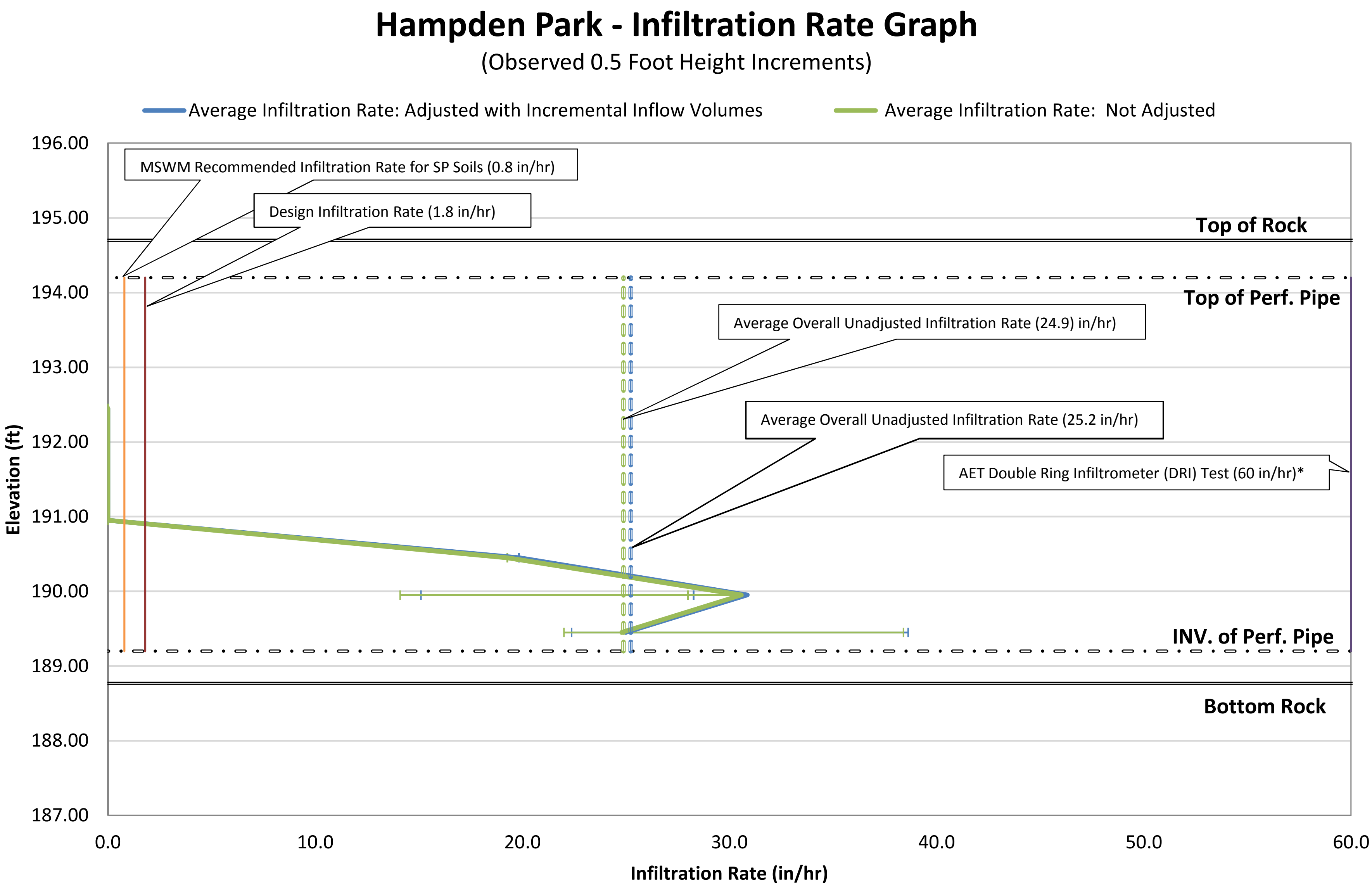
BMP Water Level and Rainfall



City of Saint Paul
2020 Water Quality and Quantity Report
Chart A.9
WSB Job No.: 015938



City of Saint Paul
2020 Water Quality and Quantity Monitoring
Chart A.10
WSB Job No.: 015938



Note: Pipe Invert is 189.2'
Error Bars Represent 25th and 75th Percentiles
* The DRI testing was completed on top of a 5 ft layer of fine filter aggregate that was constructed above the native soils, per the design.

City of Saint Paul
2020 Water Quality and Quantity Report
Chart A.11
WSB Job No.: 015938

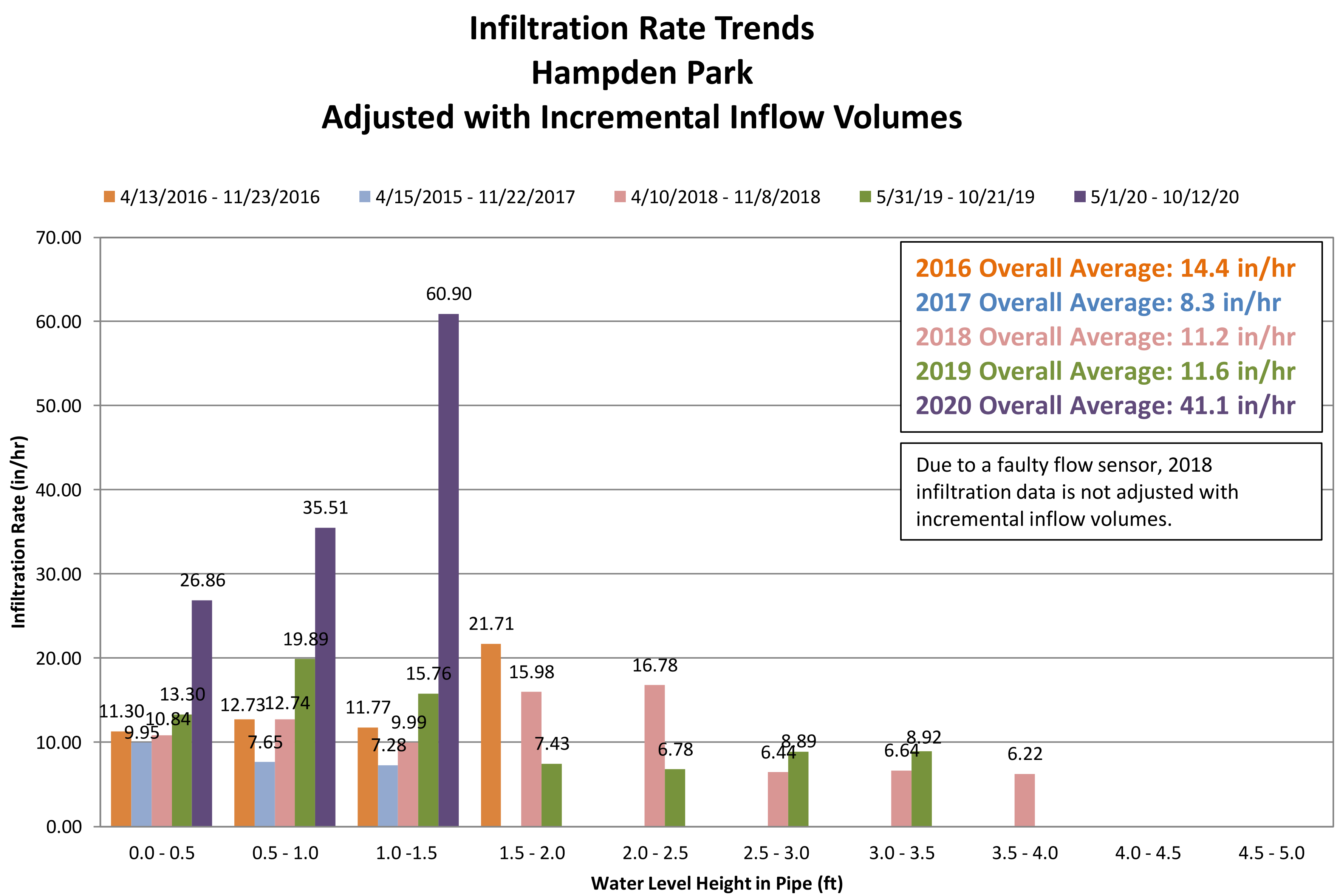
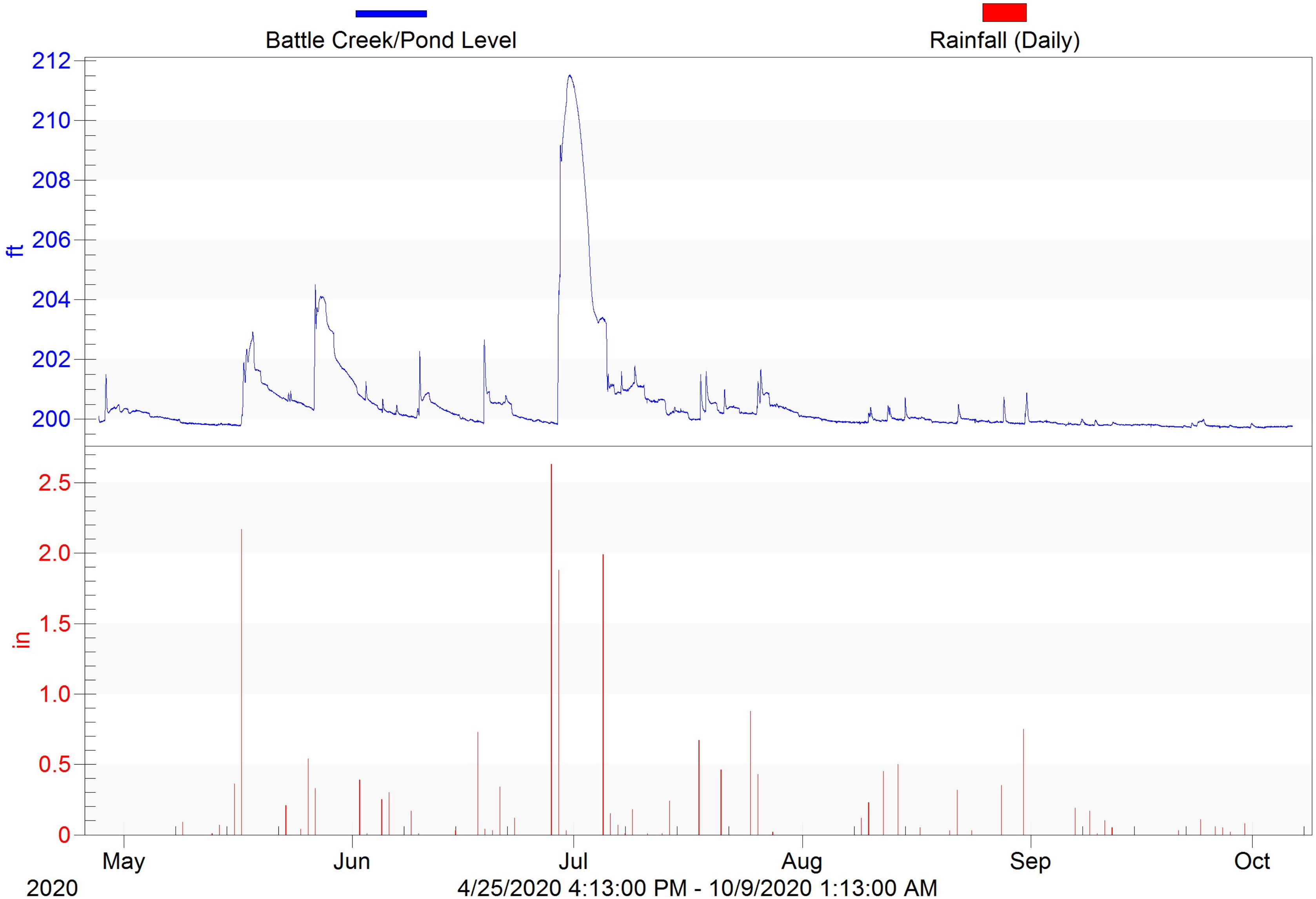


Chart A.12 Battle Creek

Creek Level and Rainfall (SPCD)



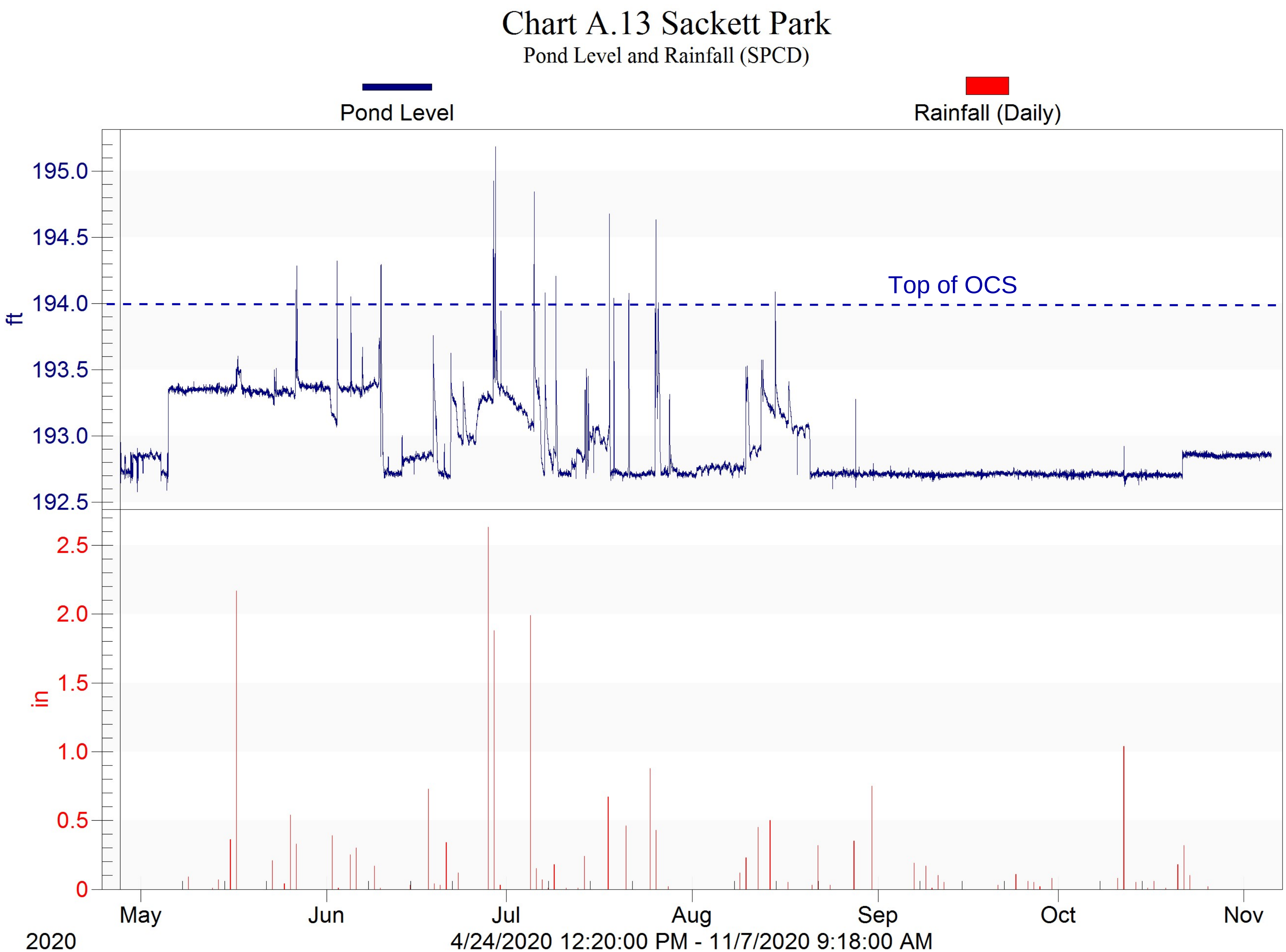


Chart A.13 Sackett Park
Pond Level and Rainfall (SPCD)
Pond Level
Rainfall (Daily)
195.0
194.5
194.0
193.5
193.0
192.5
ft
Top of OCS
2.5
2.0
1.5
1.0
0.5
0
in
May
Jun
Jul
Aug
Sep
Oct
Nov
2020
4/24/2020 12:20:00 PM - 11/7/2020 9:18:00 AM

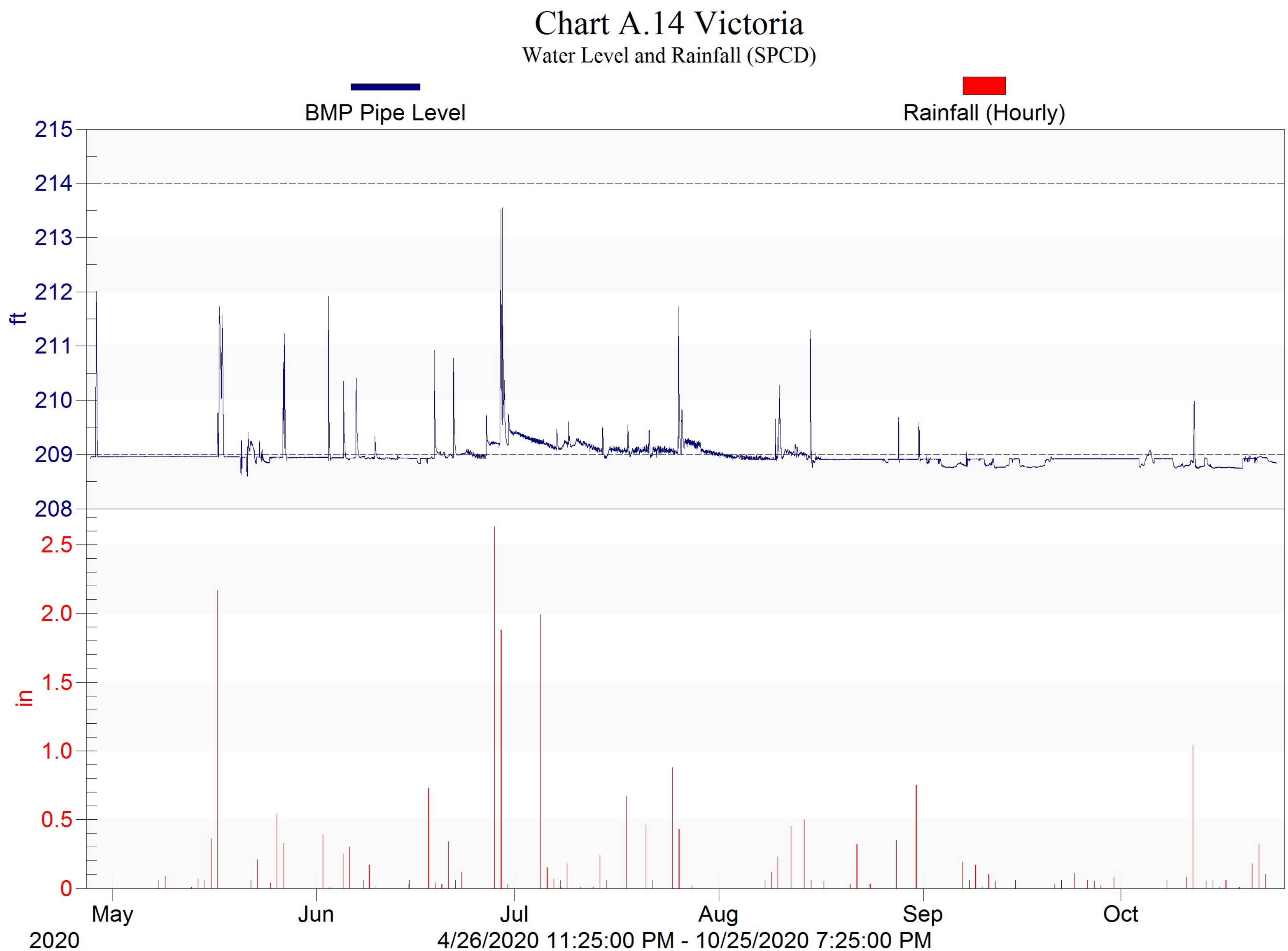
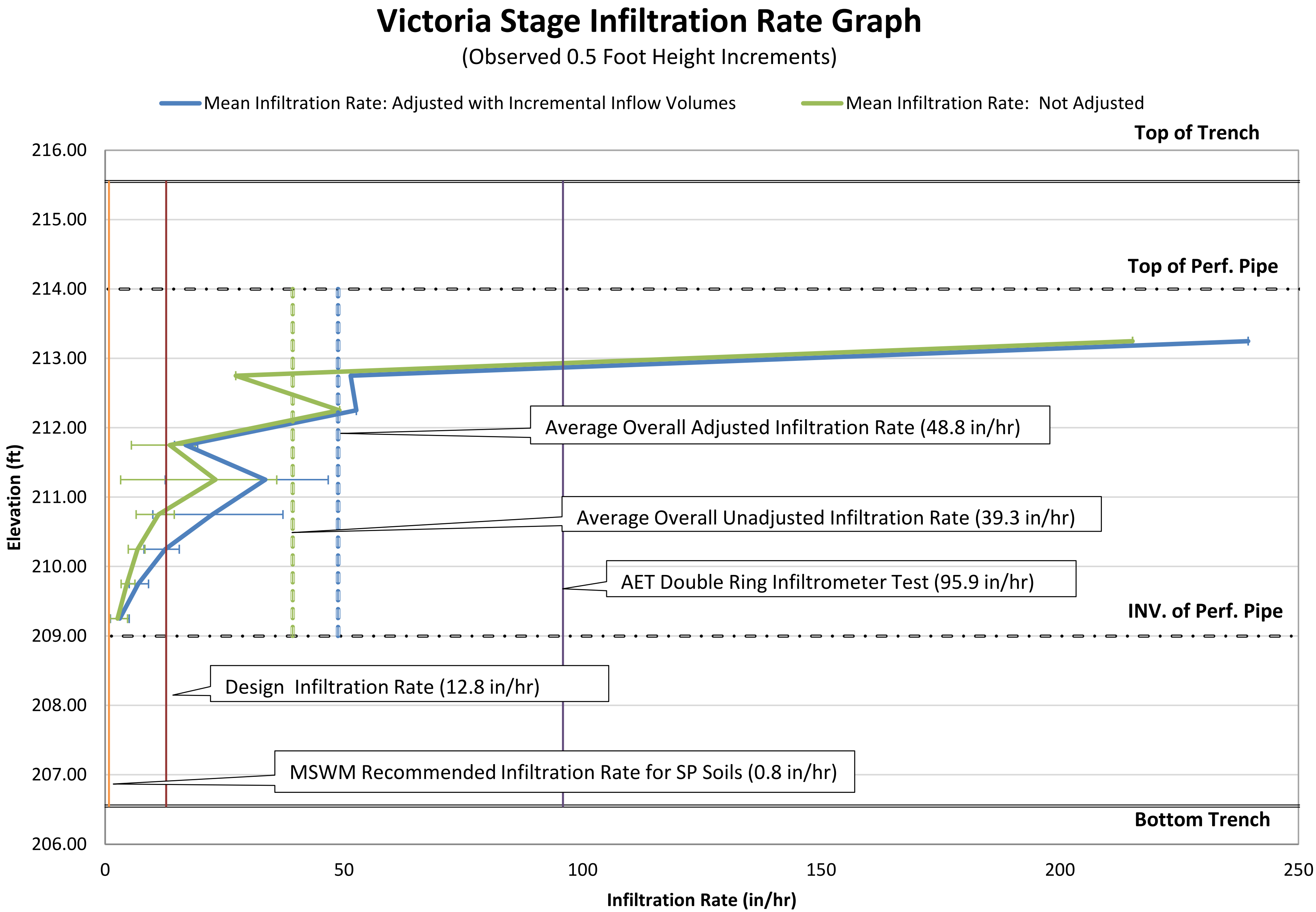
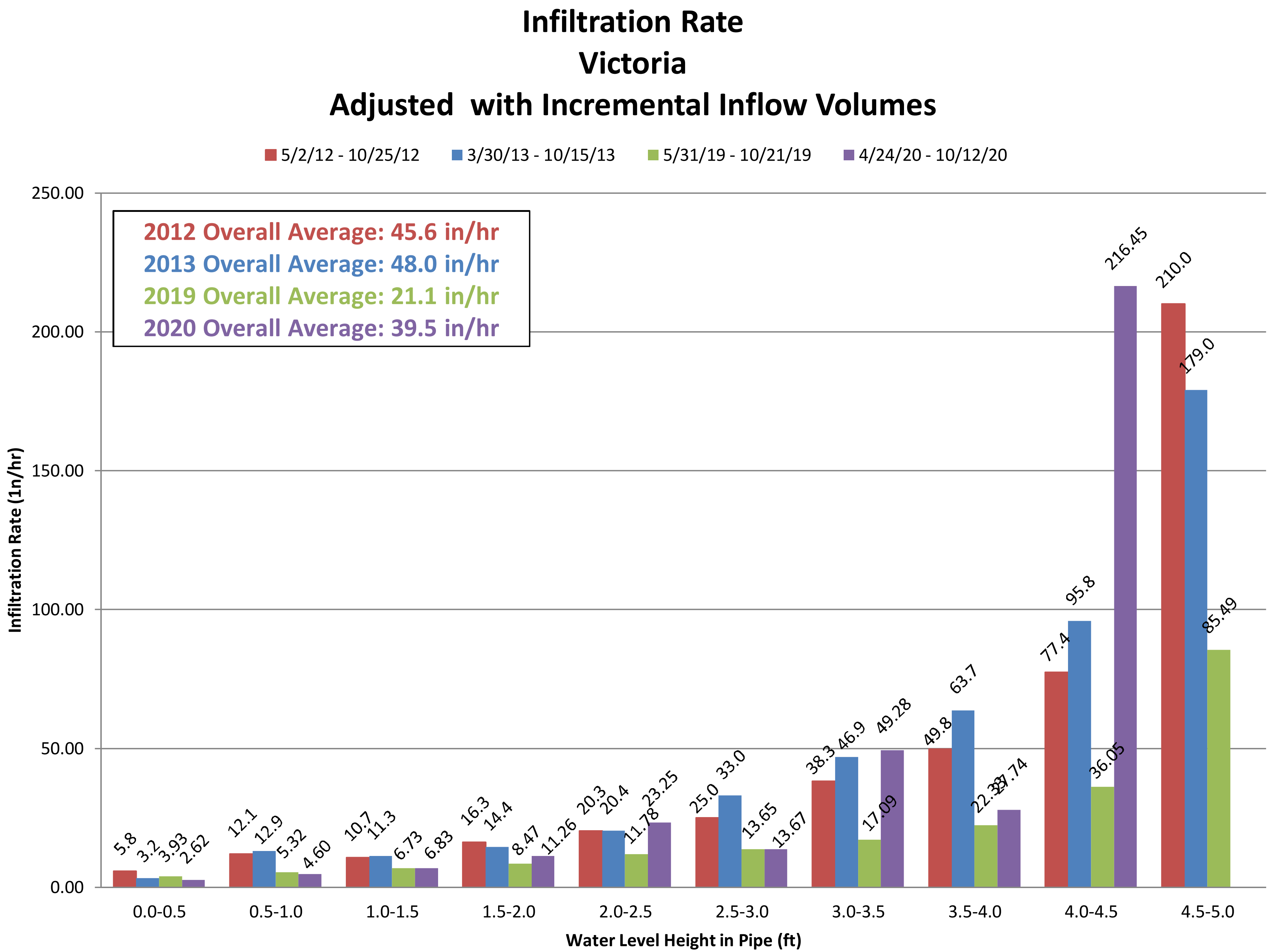


Chart A.14 Victoria
Water Level and Rainfall (SPCD)
BMP Pipe Level
Rainfall (Hourly)
215
214
213
212
211
210
209
208
ft
2.5
2.0
1.5
1.0
0.5
0
in
May
Jun
Jul
Aug
Sep
Oct
2020
4/26/2020 11:25:00 PM - 10/25/2020 7:25:00 PM

City of Saint Paul
2020 Water Quality and Quantity Report
Chart A.15
WSB Job No.: 015938



Pipe Invert is 209
Error Bars Represent 25th and 75th Percentiles


Infiltration Rate
Victoria
Adjusted with Incremental Inflow Volumes
5/2/12 - 10/25/12
3/30/13 - 10/15/13
5/31/19 - 10/21/19
4/24/20 - 10/12/20
2012 Overall Average: 45.6 in/hr
2013 Overall Average: 48.0 in/hr
2019 Overall Average: 21.1 in/hr
2020 Overall Average: 39.5 in/hr
Infiltration Rate (1n/hr)
Water Level Height in Pipe (ft)
250.00
200.00
150.00
100.00
50.00
0.00
0.0-0.5
0.5-1.0
1.0-1.5
1.5-2.0
2.0-2.5
2.5-3.0
3.0-3.5
3.5-4.0
4.0-4.5
4.5-5.0
5.8
3.2
3.93
2.62
12.1
12.9
5.32
4.60
10.7
11.3
6.73
6.83
16.3
14.4
8.47
11.26
20.3
20.4
11.78
23.25
25.0
33.0
13.65
13.67
38.3
46.9
17.09
49.28
49.8
63.7
22.32
27.74
77.4
95.8
36.05
216.45
210.0
179.0
85.49

City of Saint Paul
2020 River Level Monitoring
Chart A.17
WSB Job No.: 015938

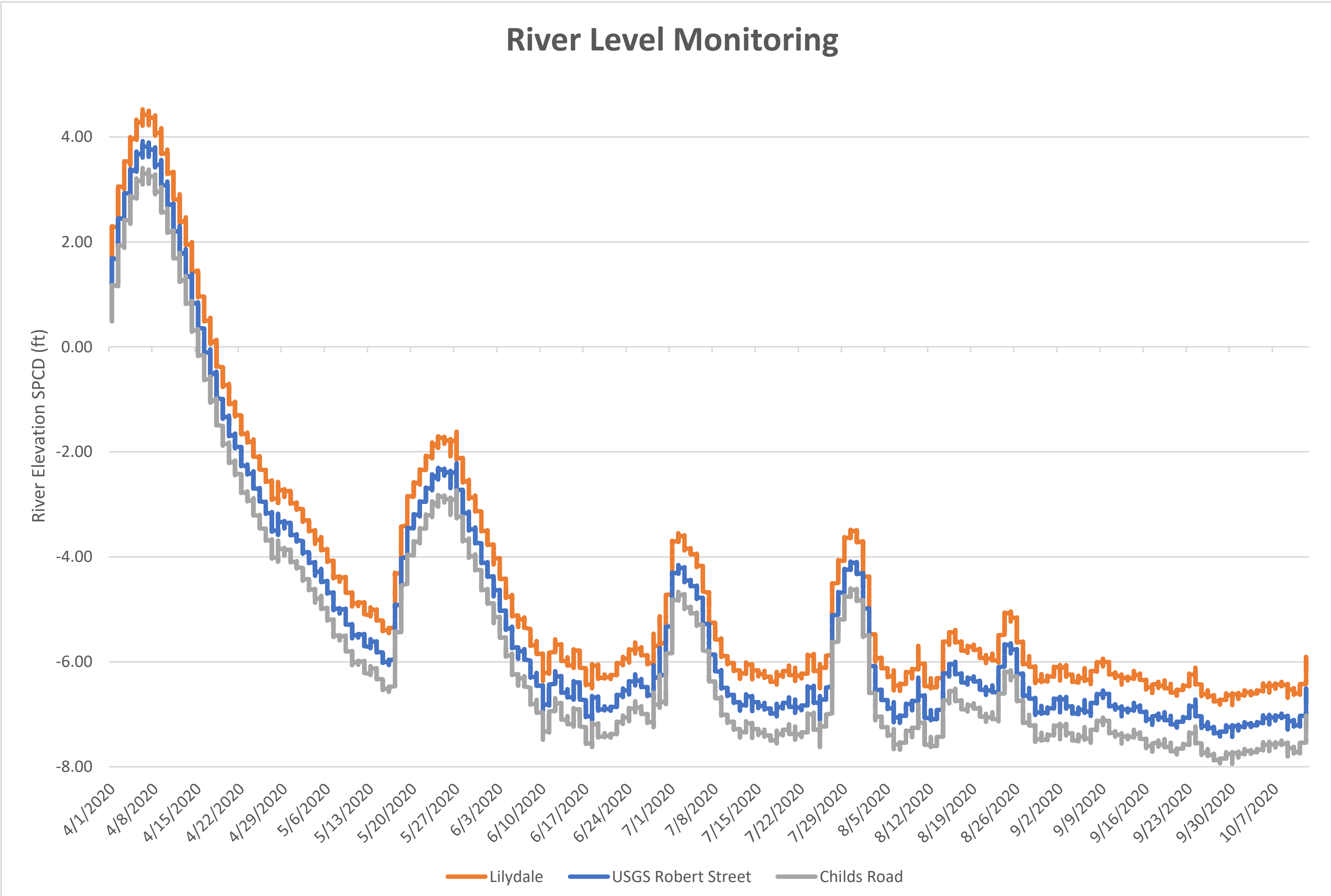


Chart B.1 Beacon Bluff

Flow Rates and Rainfall

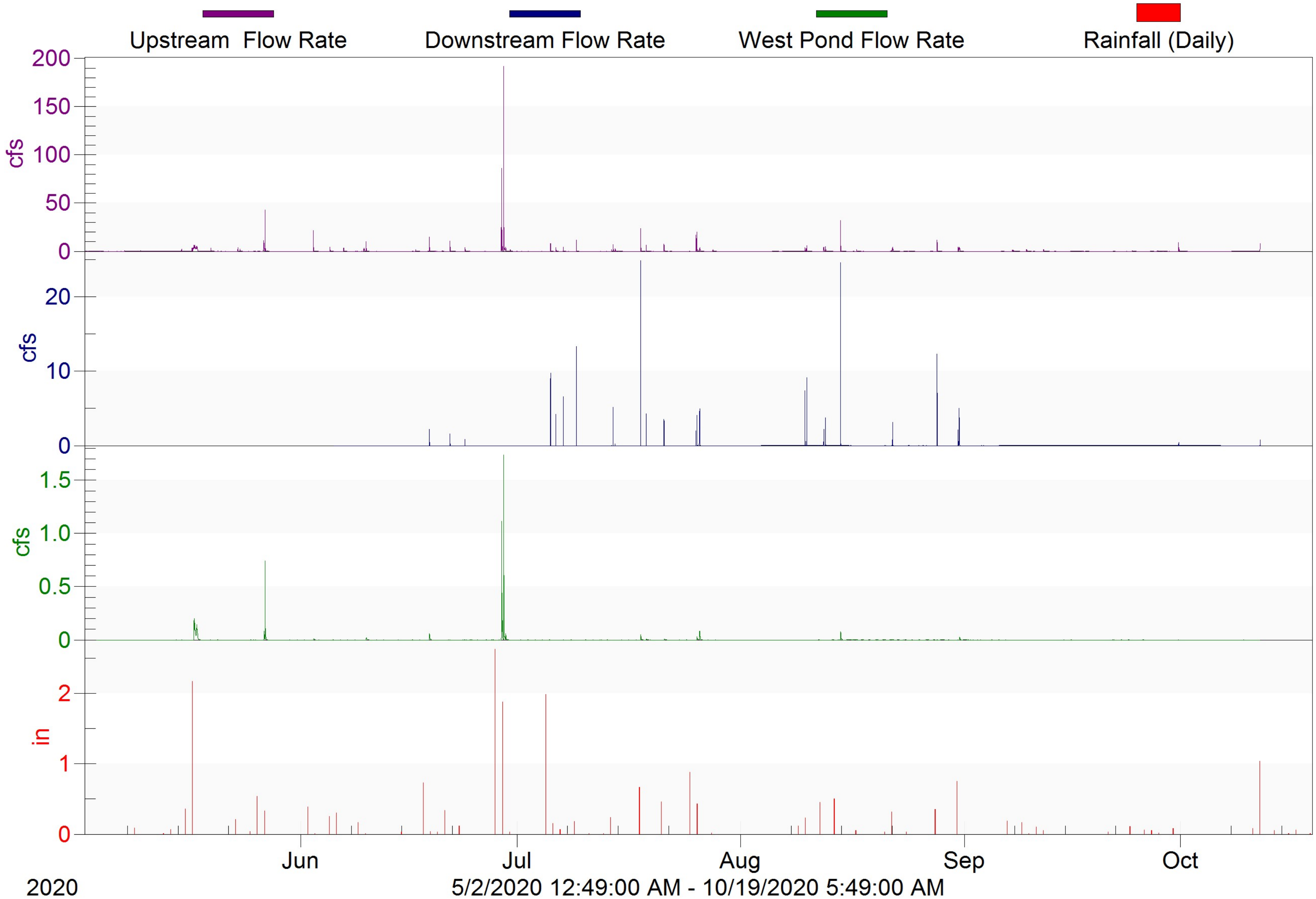


Chart B.2 St. Albans

Flow Rates and Rainfall

Chart B.3 Hampden Park

Flow Rates and Rainfall

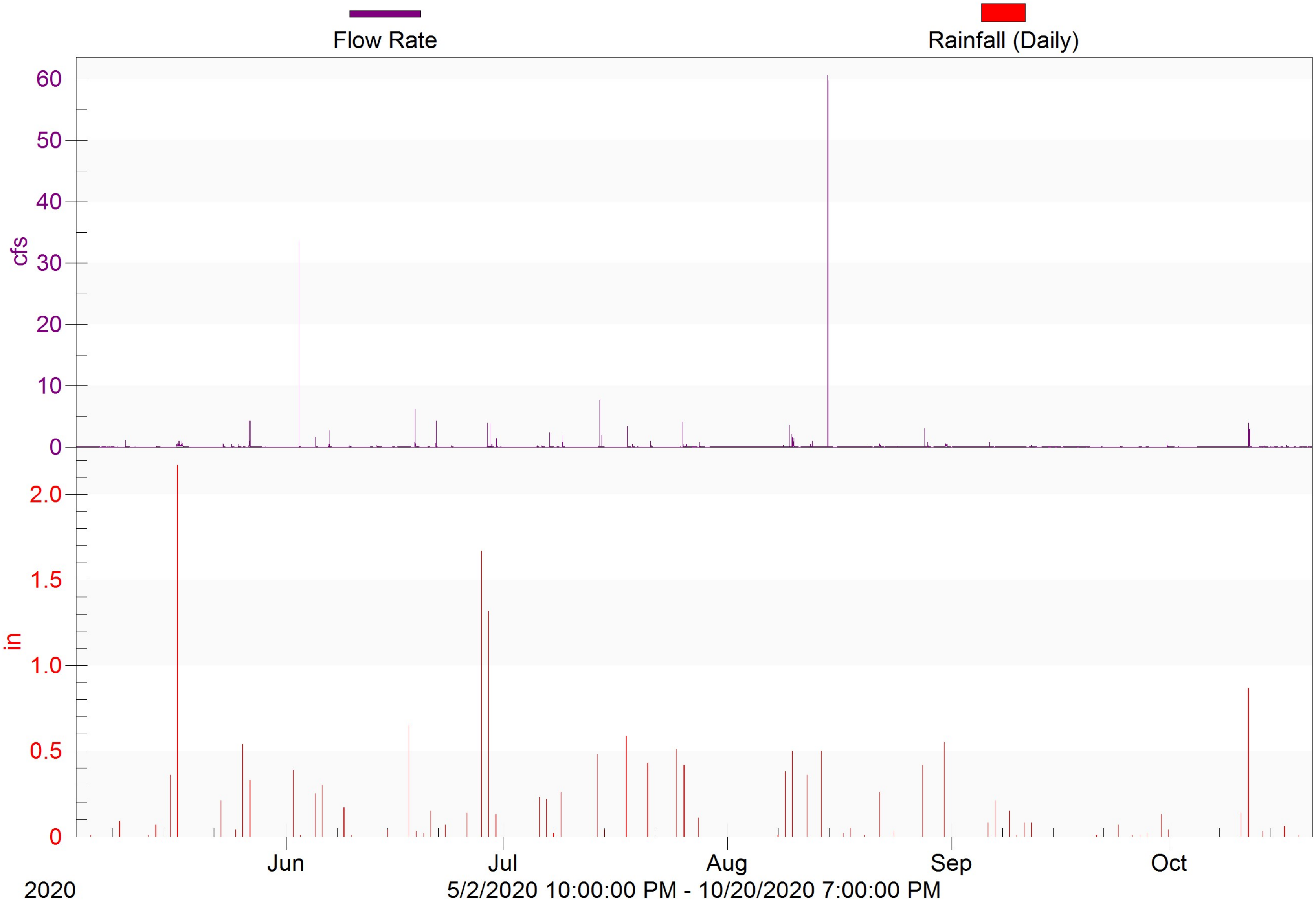


Chart B.4 Victoria

Flow Rates and Rainfall

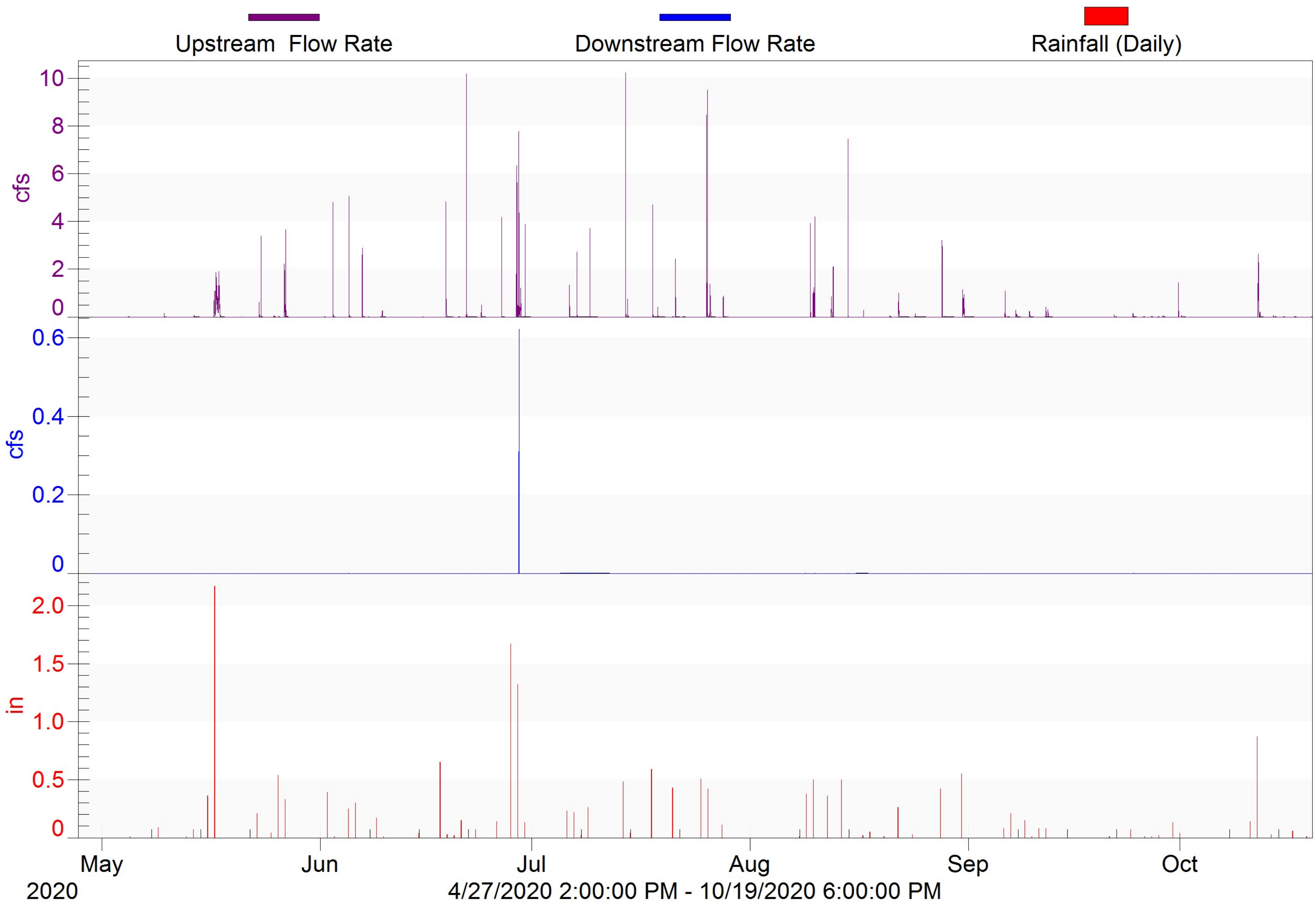
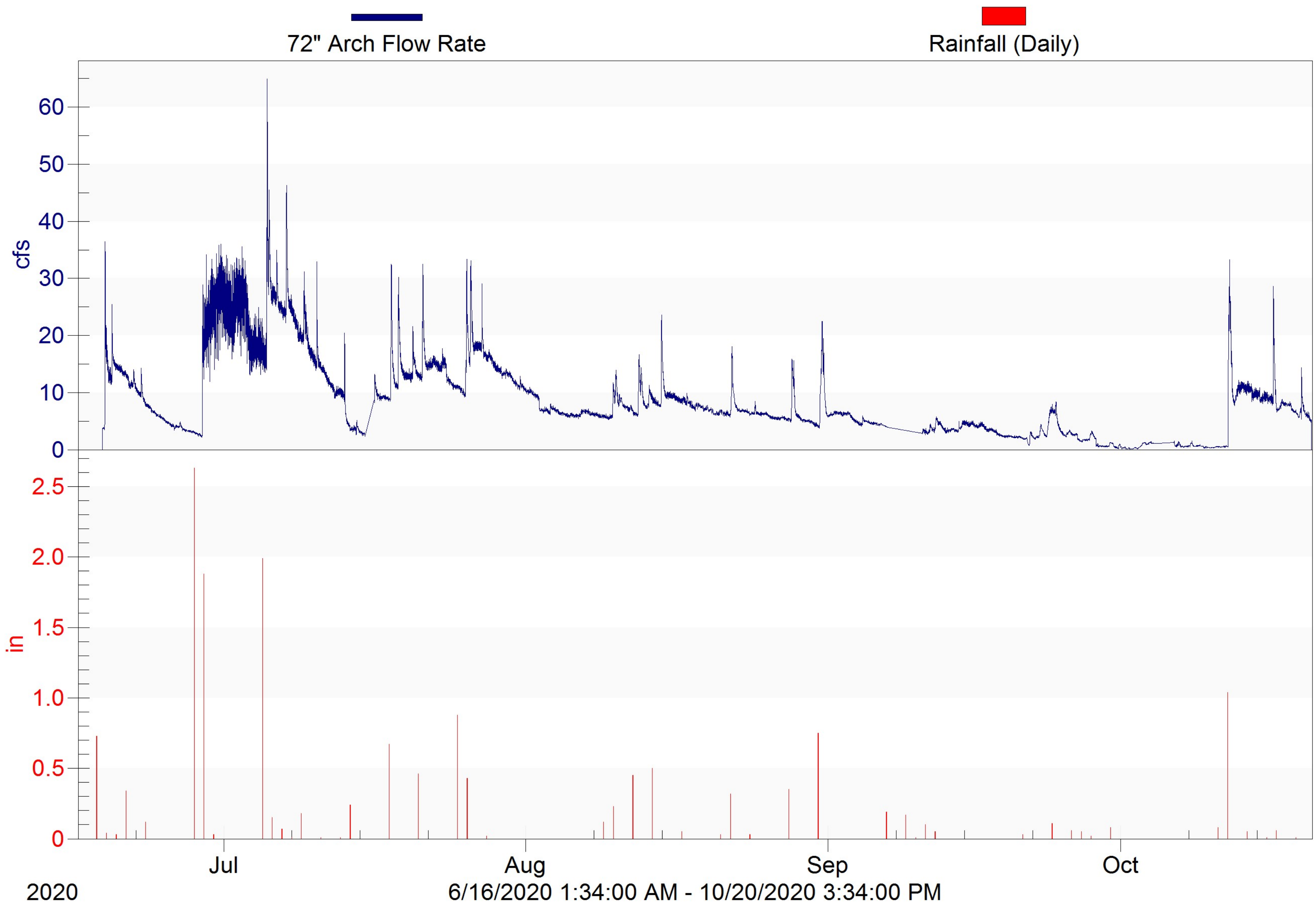


Chart B.5 Battle Creek

Flow Rates and Rainfall



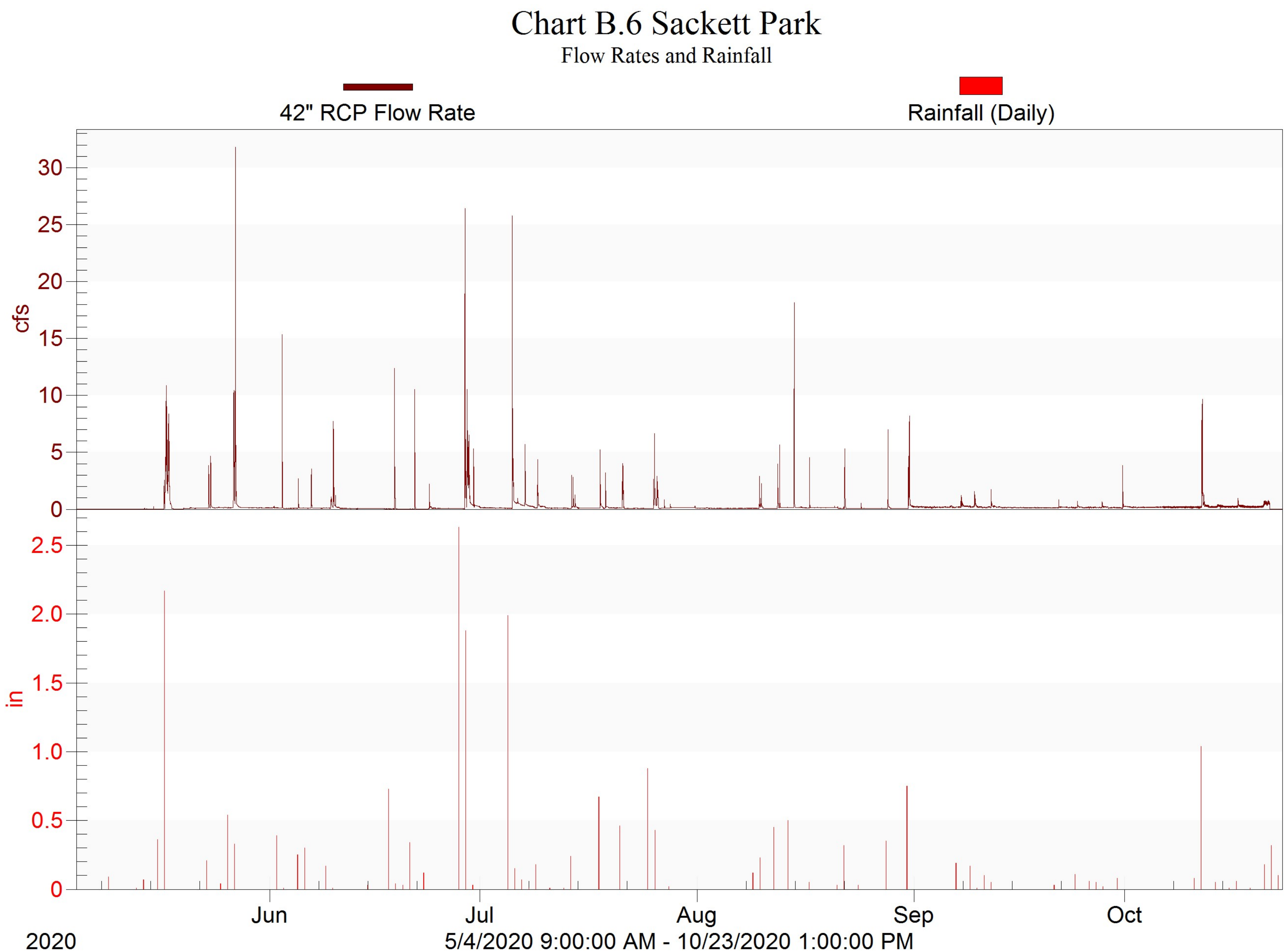


Chart B.6 Sackett Park
Flow Rates and Rainfall
42" RCP Flow Rate
Rainfall (Daily)
cfs
30
25
20
15
10
5
0
in
2.5
2.0
1.5
1.0
0.5
0
Jun
Jul
Aug
Sep
Oct
2020
5/4/2020 9:00:00 AM - 10/23/2020 1:00:00 PM

City of Saint Paul
2020 Water Quality and Quantity Report
Table C.1
WSB Project Number: 015938

BEACON BLUFF WATER QUALITY SUMMARY

LAB ID	Date Composite Sampling Started	Date Composite Sampling Ended	TSS (mg/L)	TDS (mg/L)	VSS (mg/L)	TP (mg/L)	Ortho-P (mg/L)	Chloride (mg/L)	Ammonia as N (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Nitrate + Nitrite as N (mg/L)	Hardness as CaCO3 (mg/L)	Copper (mg/L)	Lead (mg/L)	Zinc (mg/L)	Total Organic Carbon (mg/L)	Sulfate (mg/L)	pH	COD (mg/L)	E. Coli (MPN/ 100 mL)
2843362	2/3/2020 12:28	2/3/2020 12:28	7.0	4204.0	5.0	0.12	0.039	2436.4	0.97	2.87	0.637	168	0.0073	0.0016 J	0.05650	12.0000		7.2	140.0	
2850505	3/4/2020 11:49	3/4/2020 11:49	28.0	4128.0	14.0	0.53	0.276	4792.1	0.84	2.86	0.426	170	0.0100	0.0107	0.04860	3.9000			111.0	1267
2873900	6/9/2020 15:59	6/10/2020 1:35	87.0	99.0	48.0	0.67	0.112	5.6	0.06 <	3.35	0.260 <	45 <	0.0189	0.0152	0.08780	22.7000			162.0	
2876240	6/18/2020 18:59	6/18/2020 22:35	51.0	46.0	21.0	0.28	0.115	3.1	0.06 <	1.32	0.333	45 <	0.0094	0.0098	0.04800	11.6000			65.0	
2877170	6/21/2020 16:49	6/21/2020 18:35	87.0	62.0	29.0	0.49	0.108	3.6	0.37	2.43	0.512	45 <	0.0134	0.0164	0.06820	11.8000			96.0	
2878729	6/29/2020 9:42	6/29/2020 9:42																		10900
2881124	7/6/2020 8:19	7/6/2020 11:56	35.0	81.0	16.0	0.33	0.112	6.2	0.24	1.88	0.591	45 <	0.0136	0.0079	0.04020	16.5000			79.0	
2883107	7/14/2020 9:43	7/14/2020 9:43																		2420 >
2883792	7/14/2020 2:24	7/14/2020 15:35	60.0	87.0	27.0	0.44	0.117	7.4	0.24	2.76	0.260 <	45 <	0.0184	0.0120	0.06910	20.3000			129.0	
2885361	7/21/2020 7:44	7/21/2020 11:05	25.0	52.0	12.0	0.20	0.072	2.0 <	0.23	1.23	0.440 <	45 <	0.0074	0.0055	0.02870	9.2000			47.0	
2886836	7/25/2020 18:50	7/26/2020 10:05	76.0	44.0	24.0	0.26	0.084	2.0 <	0.14	1.22	0.394 <	45 <	0.0113	0.0162	0.04680	7.8000			52.0	
2890621	8/9/2020 14:05	8/10/2020 5:05	64.0	108.0	32.0	0.47	0.123	8.4	0.06 <	2.99	0.653	45 <	0.0167	0.0106	0.06080	21.4000			123.0	
2891767	8/12/2020 11:05	8/12/2020 14:35	24.0	51.0	11.0	0.20	0.091	5.0 <	0.06	1.16	0.394 <	45 <	0.0105	0.0061	0.03650	11.6000			59.0	
2892789	8/14/2020 20:25	8/14/2020 23:20	108.0	37.0	31.0	0.35		5.0 <	0.17	1.30		45 <	0.0130	0.0234	0.06100	4.4000			55.0	
2900269	9/9/2020 14:50	9/9/2020 15:50	20.0		13.0	0.25	0.082	5.1	0.06 <	1.38	0.260 <	45 <	0.0086	0.0051	0.03630	13.8000			68.0	
2901196	9/11/2020 23:25	9/12/2020 8:20	16.0	76.0	10.0	0.34	0.112	6.2	0.16	1.38	0.299 <	45 <	8.2000	3.4000	30.70000	14.8000			64.0	
2908773	10/12/2020 0:00	10/12/2020 3:22	75.0	117.0	41.0	1.25	0.627	7.1	0.06 <	3.34	0.260 <	45 <	22.3000	14.9000	83.50000	44.8000			221.0	
2908775	10/12/2020 13:05	10/12/2020 13:05																7.7		18300
MINIMUM			**7.0**	**37.0**	**5.0**	**0.1**	**0.0**	**2.0**	**0.1**	**1.2**	**0.3**	**45.0**	**0.0**	**0.0**	**0.0**	**3.9**	**0.0**	**7.2**	**47.0**	**1266.8**
AVERAGE			**50.9**	**656.6**	**22.3**	**0.4**	**0.1**	**486.3**	**0.2**	**2.1**	**0.4**	**61.5**	**2.0**	**1.2**	**7.7**	**15.1**	**#DIV/0!**	**7.4**	**98.1**	**8221.7**
MEDIAN			**51.0**	**78.5**	**21.0**	**0.3**	**0.1**	**5.6**	**0.2**	**1.9**	**0.4**	**45.0**	**0.0**	**0.0**	**0.1**	**12.0**	**#NUM!**	**7.4**	**79.0**	**6660.0**
MAXIMUM			**108.0**	**4204.0**	**48.0**	**1.3**	**0.6**	**4792.1**	**1.0**	**3.3**	**0.7**	**170.5**	**22.3**	**14.9**	**83.5**	**44.8**	**0.0**	**7.7**	**221.0**	**18300.0**

Laboratory analysis was completed by Metroplian Council Environmental Services
Grab Sample | Duplicate
< - Analyte not detected above the Method Detection Limit (MDL), MDL value reported
J - Result reported as estimated between the MDL and Reporting Limit (RL)
> - Analyte exceeded the maximum dection level (was not fully diluted prior to analysis)

City of Saint Paul
2020 Beacon Bluff Pollutant Loading
Table C.2
WSB Job No.: 015938

BEACON BLUFF VOLUME AND POLLUTANT REDUCTION SUMMARY

Event Time Interval		Sampling Data									Event Loading and Volume Data[1]																
		TSS	TDS	VSS	TP	Ortho-P	Chloride	Ammonia as N	Total Kjeldahl Nitrogen	Nitrate + Nitrite as N	Interval Rain	sion Structure on Duchess Volume Directed from Diversion Structure into Surface Basin (1)	Inflow Volume from West Pond (Subwatershed B - Discharges to Underground System) (2)	Inflow Volume from Eastern Inlet (Subwatershed C - Discharges to Surface Basin)[3] (3)	Underground System Discharged Volume (4)	Volume Captured by BMP (1+2+3)-4	% of Total Inflow to BMP from Diversion Structure	Overall Volume reduction	Captured TSS	Captured TDS	Captured VSS	Captured TP	Captured Ortho-P	Captured Chloride	Captured Ammonia as N	Captured Total Kjeldahl Nitrogen	Captured Nitrate + Nitrite as N
Start		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	In.	cf	cf	cf	cf	cf			lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
5/9/2020 18:45	5/9/2020 20:43	54	62	24	0.3	0.09	4	0.1	1.8	0.41	0.07	1629	0	78	0	1707	95.4%	100.0%	5.8	6.6	2.5	0.03	0.01	0.5	0.01	0.19	0.04
5/14/2020 0:15	5/14/2020 5:30	54	62	24	0.3	0.09	4	0.1	1.8	0.41	0.08	2332	0	111	0	2443	95.4%	100.0%	8.3	9.4	3.6	0.04	0.01	0.7	0.02	0.27	0.06
5/16/2020 19:45	5/17/2020 23:08	54	62	24	0.3	0.09	4	0.1	1.8	0.41	2.51	240931	4960	11508	146272	111128	93.5%	43.2%	377.5	426.9	164.2	2.01	0.59	30.2	0.95	12.15	2.85
5/23/2020 5:59	5/23/2020 9:26	54	62	24	0.3	0.09	4	0.1	1.8	0.41	0.13	14802	0	707	0	15509	95.4%	100.0%	52.7	59.6	22.9	0.28	0.08	4.2	0.13	1.70	0.40
5/23/2020 13:19	5/23/2020 16:11	54	62	24	0.3	0.09	4	0.1	1.8	0.41	0.08	7597	0	363	0	7960	95.4%	100.0%	27.0	30.6	11.8	0.14	0.04	2.2	0.07	0.87	0.20
5/25/2020 11:00	5/25/2020 12:43	54	62	24	0.3	0.09	4	0.1	1.8	0.41	0.04	486	0	23	0	509	95.4%	100.0%	1.7	2.0	0.8	0.01	0.00	0.1	0.00	0.06	0.01
5/26/2020 19:00	5/27/2020 4:28	54	62	24	0.3	0.09	4	0.1	1.8	0.41	0.78	108097	1997	5163	28703	86554	93.7%	75.1%	294.0	332.5	127.9	1.57	0.46	23.5	0.74	9.47	2.22
6/2/2020 18:00	6/2/2020 20:47	54	62	24	0.3	0.09	4	0.1	1.8	0.41	0.37	20776	65	992	0	21834	95.1%	100.0%	74.2	83.9	32.3	0.39	0.12	5.9	0.19	2.39	0.56
6/5/2020 1:00	6/5/2020 3:14	54	62	24	0.3	0.09	4	0.1	1.8	0.41	0.24	7320	0	350	0	7669	95.4%	100.0%	26.1	29.5	11.3	0.14	0.04	2.1	0.07	0.84	0.20
6/6/2020 21:20	6/7/2020 1:13	54	62	24	0.3	0.09	4	0.1	1.8	0.41	0.28	12734	0	608	0	13343	95.4%	100.0%	45.3	51.3	19.7	0.24	0.07	3.6	0.11	1.46	0.34
6/9/2020 15:45	6/9/2020 21:30	**87**	**99**	**48**	**0.7**	**0.11**	**5.6**	**0.1** <	**3.3**	**0.26** <	0.17	25498	0	1218	0	26716	95.4%	100.0%	145.1	165.1	80.1	1.11	0.19	9.4	0.10	5.58	0.43
6/10/2020 1:10	6/10/2020 4:20	54	62	24	0.3	0.09	4	0.1	1.8	0.41	0.01	10563	126	505	3228	7965	94.3%	71.2%	27.1	30.6	11.8	0.14	0.04	2.2	0.07	0.87	0.20
6/18/2020 18:55	6/18/2020 23:49	**51**	**46**	**21**	**0.3**	**0.12**	**3.1**	**0.1** <	**1.3**	**0.33**	0.68	40637	486	2016	0	43139	94.1%	96.5%	137.3	123.9	56.6	0.75	0.31	8.5	0.16	3.54	0.90
6/20/2020 14:00	6/20/2020 15:41	54	62	24	0.3	0.09	4	0.1	1.8	0.41	0.03	1086	0	52	0	1138	95.4%	100.0%	3.9	4.4	1.7	0.02	0.01	0.3	0.01	0.12	0.03
6/21/2020 16:44	6/21/2020 19:33	**87**	**62**	**29**	**0.5**	**0.11**	**3.6**	**0.4**	**2.4**	**0.51**	0.27	17127	0	840	0	17966	95.3%	97.6%	97.6	69.5	32.5	0.55	0.12	4.0	0.42	2.72	0.57
6/23/2020 18:41	6/23/2020 21:02	54	62	24	0.3	0.09	4	0.1	1.8	0.41	0.11	8848	0	433	0	9281	95.3%	97.7%	31.5	35.7	13.7	0.17	0.05	2.5	0.08	1.02	0.24
6/28/2020 19:05	6/29/2020 0:49	54	62	24	0.3	0.09	4	0.1	1.8	0.41	2.31	170978	3681	8167	139628	43198	93.4%	23.6%	146.7	165.9	63.8	0.78	0.23	11.7	0.37	4.72	1.11
6/29/2020 3:08	6/29/2020 12:58	54	62	24	0.3	0.09	4	0.1	1.8	0.41	1.82	208139	3088	9942	148846	72324	94.0%	32.7%	245.7	277.8	106.9	1.31	0.39	19.7	0.62	7.91	1.85
6/30/2020 1:10	6/30/2020 2:49	54	62	24	0.3	0.09	4	0.1	1.8	0.41	0.03	3088	0	148	0	3235	95.4%	100.0%	11.0	12.4	4.8	0.06	0.02	0.9	0.03	0.35	0.08
7/5/2020 15:00	7/5/2020 17:00	54	62	24	0.3	0.09	4	0.1	1.8	0.41	1.93	5011	0	489	0	5500	91.1%	51.3%	18.7	21.1	8.1	0.10	0.03	1.5	0.05	0.60	0.14
7/6/2020 8:14	7/6/2020 11:13	**35**	**81**	**16**	**0.3**	**0.11**	**6.2**	**0.2**	**1.9**	**0.59**	0.15	10317	0	555	0	10872	94.9%	89.3%	23.8	55.0	10.9	0.22	0.08	4.2	0.16	1.28	0.40
7/7/2020 9:21	7/7/2020 11:43	54	62	24	0.3	0.09	4	0.1	1.8	0.41	0.07	5708	0	435	0	6143	92.9%	64.3%	20.9	23.6	9.1	0.11	0.03	1.7	0.05	0.67	0.16
7/9/2020 5:11	7/9/2020 7:15	54	62	24	0.3	0.09	4	0.1	1.8	0.41	0.16	5825	0	630	0	6455	90.2%	46.7%	21.9	24.8	9.5	0.12	0.03	1.8	0.06	0.71	0.17
7/14/2020 7:20	7/14/2020 10:08	**60**	**87**	**27**	**0.4**	**0.12**	**7**	**0.2**	**2.8**	**0.26** <	0.16	8123	0	513	0	8637	94.1%	76.7%	32.4	46.9	14.6	0.24	0.06	4.0	0.13	1.49	0.14
7/14/2020 14:15	7/14/2020 16:25	54	62	24	0.3	0.09	4	0.1	1.8	0.41	0.05	4377	0	217	0	4594	95.3%	96.5%	15.6	17.6	6.8	0.08	0.02	1.2	0.04	0.50	0.12
7/18/2020 2:59	7/18/2020 6:18	54	62	24	0.3	0.09	4	0.1	1.8	0.41	0.53	16555	243	1324	0	18122	91.2%	61.9%	61.6	69.6	26.8	0.33	0.10	4.9	0.16	1.98	0.46
7/18/2020 21:10	7/18/2020 23:25	54	62	24	0.3	0.09	4	0.1	1.8	0.41	0.08	6241	43	469	0	6753	92.4%	65.4%	22.9	25.9	10.0	0.12	0.04	1.8	0.06	0.74	0.17
7/21/2020 7:39	7/21/2020 11:44	**25**	**52**	**12**	**0.2**	**0.07**	**2.0** <	**0.2**	**1.2**	**0.44** <	0.45	25143	48	1826	0	27017	93.1%	67.4%	42.2	87.7	20.2	0.33	0.12	3.4	0.39	2.08	0.74
7/25/2020 18:45	7/26/2020 3:05	**76**	**44**	**24**	**0.3**	**0.08**	**2.0** <	**0.1**	**1.2**	**0.39** <	0.82	44322	257	2236	26911	19904	94.6%	40.4%	94.4	54.7	29.8	0.33	0.10	2.5	0.18	1.52	0.49
7/26/2020 5:56	7/26/2020 11:25	54	62	24	0.3	0.09	4	0.1	1.8	0.41	0.37	15470	638	1505	0	17613	87.4%	52.3%	59.8	67.7	26.0	0.32	0.09	4.8	0.15	1.93	0.45
8/9/2020 21:05	8/10/2020 5:25	**64**	**108**	**32**	**0.5**	**0.12**	**8**	**0.1** <	**3.0**	**0.65**	0.31	30087	0	1437	0	31524	95.4%	100.0%	126.0	212.5	63.0	0.92	0.24	16.5	0.12	5.88	1.29
8/12/2020 11:00	8/12/2020 16:17	**24**	**51**	**11**	**0.2**	**0.09**	**5.0** <	**0.1**	**1.2**	**0.39** <	0.36	31616	0	1510	0	33126	95.4%	100.0%	49.6	105.5	22.7	0.41	0.19	10.3	0.13	2.41	0.81
8/12/2020 18:20	8/12/2020 20:40	54	62	24	0.3	0.09	4	0.1	1.8	0.41	0.09	8663	0	414	0	9077	95.4%	100.0%	30.8	34.9	13.4	0.16	0.05	2.5	0.08	0.99	0.23
8/14/2020 20:20	8/14/2020 23:33	**108**	**37**	**31**	**0.4**	0.09	**5.0** <	**0.2**	**1.3**	0.41	0.45	30964	268	1479	0	32712	94.6%	100.0%	220.5	75.6	63.3	0.72	0.18	10.2	0.36	2.65	0.84
8/17/2020 1:25	8/17/2020 3:04	54	62	24	0.3	0.09	4	0.1	1.8	0.41	0.05	3172	0	152	0	3324	95.4%	100.0%	11.3	12.8	4.9	0.06	0.02	0.9	0.03	0.36	0.09
8/22/2020 0:16	8/22/2020 5:11	54	62	24	0.3	0.09	4	0.1	1.8	0.41	0.32	28199	0	1347	0	29547	95.4%	100.0%	100.4	113.5	43.7	0.53	0.16	8.0	0.25	3.23	0.76
8/28/2020 5:29	8/28/2020 8:11	54	62	24	0.3	0.09	4	0.1	1.8	0.41	0.35	20700	1	989	0	21690	95.4%	100.0%	73.7	83.3	32.1	0.39	0.12	5.9	0.19	2.37	0.56
8/31/2020 2:35	8/31/2020 11:02	54	62	24	0.3	0.09	4	0.1	1.8	0.41	0.75	59704	162	2852	8959	53759	95.2%	85.7%	182.6	206.5	79.5	0.97	0.29	14.6	0.46	5.88	1.38
9/7/2020 15:30	9/7/2020 22:41	54	62	24	0.3	0.09	4	0.1	1.8	0.41	0.18	13442	0	642	0	14084	95.4%	100.0%	47.8	54.1	20.8	0.25	0.08	3.8	0.12	1.54	0.36
9/9/2020 13:45	9/9/2020 19:26	**20**	62	**13**	**0.2**	**0.08**	**5.1**	**0.1** <	**1.4**	**0.26** <	0.17	11678	0	558	0	12236	95.4%	100.0%	15.3	47.0	9.9	0.19	0.06	3.9	0.05	1.05	0.20
9/11/2020 23:15	9/12/2020 2:26	**16**	**76**	**10**	**0.3**	**0.11**	**6.2**	**0.2**	**1.4**	**0.30** <	0.10	5010	0	239	0	5250	95.4%	100.0%	5.2	24.9	3.3	0.11	0.04	2.0	0.05	0.45	0.10
9/24/2020 6:55	9/24/2020 10:19	54	62	24	0.3	0.09	4	0.1	1.8	0.41	0.10	2473	0	118	0	2592	95.4%	100.0%	8.8	10.0	3.8	0.05	0.01	0.7	0.02	0.28	0.07
9/27/2020 19:10	9/27/2020 21:30	54	62	24	0.3	0.09	4	0.1	1.8	0.41	0.05	1599	0	76	0	1676	95.4%	100.0%	5.7	6.4	2.5	0.03	0.01	0.5	0.01	0.18	0.04
9/30/2020 17:05	9/30/2020 21:18	54	62	24	0.3	0.09	4	0.1	1.8	0.41	0.07	13082	0	625	0	13707	95.4%	100.0%	46.6	52.7	20.3	0.25	0.07	3.7	0.12	1.50	0.35
10/11/2020 23:55	10/12/2020 1:22	54	62	24	0.3	0.09	4	0.1	1.8	0.41	0.45	26303	0	1256	0	27559	95.4%	100.0%	93.6	105.9	40.7	0.50	0.15	7.5	0.24	3.01	0.71
Sum											18.58	1,336,457	16,064	67,118	502,547	**917,092**			**3,191**	**3,558**	**1,365**	**17.6**	**5.16**	**255.0**	**7.8**	**101.5**	**23.5**
Average		54.4	67.5	22.8	0.36	0.103	4.97	0.15	1.87	0.400	0.41	29,699	357	58	11,168	20,380			71	79	30	0.39	0.11	5.7	0.2	2.3	0.5
Weighted Ave		59.0	61.5	23.7	0.29	0.086	4.35	0.14	1.75	0.410																	
STDEV		30.8	24.0	11.3	0.14	0.017	2.00	0.10	0.80	0.137																	
Median		55.5	62.0	22.5	0.33	0.112	5.04	0.15	1.38	0.394																	
Min		16.0	37.0	10.0	0.20	0.072	2.00	0.06	1.16	0.260									5147	5716.26	2199.7	27.84	8.21	404.5	12.80	162.74	38.13
Max		108.0	108.0	48.0	0.67	0.123	8.36	0.37	3.35	0.653																	
Percent Capture of Total Runoff																**61.6%**			**62%**	**62%**	**62%**	**63%**	**63%**	**63%**	**61%**	**62%**	**62%**

< Sample Was not detected above the method detection limit (MDL) - MDL is reported
J Result reported as estimated between the MDL and the Reporting Limit (RL)
BOLD Sampled Event
GREY Events with no sampling data (weighted average used)
1 See Figure 2 for Locations of Subwatersheds
2 Erroneous flow data was recorded at the diversion upstream, on occasion, as a result of turbulent and high velocity flow. Runoff to the diversion was modeled for those events using a rainfall to runoff ratio developed using historical monitoring data. The events are shaded brown.
3 Volume calculated based on ratio of Subwatershed C area to Subwatershed A area- (4.66 ac)/(136.77 ac)*(Upstream Volume)
* Flow events under 1000 cf runoff volume without samples are hidden from chart, but included in totals

City of Saint Paul
2020 Water Quality and Quantity Report
Table C.3
WSB Project Number: 015938

SAINT ALBANS WATER QUALITY SUMMARY

LAB ID	Date Composite Sampling Started	Date Composite Sampling Ended	TSS (mg/L)	TDS (mg/L)	VSS (mg/L)	TP (mg/L)	Ortho-P (mg/L)	Chloride (mg/L)	Ammonia as N (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Nitrate + Nitrite as N (mg/L)	Hardness as CaCO3 (mg/L)	Copper (mg/L)	Lead (mg/L)	Zinc (mg/L)	Total Organic Carbon (mg/L)	Sulfate (mg/L)	pH	COD (mg/L)	E. Coli (MPN/ 100 mL)
2843370	2/3/2020 14:14	2/3/2020 14:14	710.0	5456.0	410.0	1.10	0.050	3799.7	2.03	10.40	1.343	317	0.1480	0.0976	1.15000	11.7000			1430.0	
2850501	3/4/2020 12:12	3/4/2020 12:12	49.0	672.0	30.0	0.61	0.314	379.0	0.95	3.72	0.288 <	56	0.0159	0.0074	0.07740	21.2000			176.0	27
2878728	6/29/2020 9:23	6/29/2020 9:23																		90800
2879137	6/28/2020 19:17	6/28/2020 21:14	307.0	72.0	69.0	0.42	0.045	6.7	0.06 <	1.77	0.376 <	45 <	0.0258	0.0499	0.10900	5.9000			87.0	
2881128	7/6/2020 7:52	7/6/2020 9:01	60.0	84.0	21.0	0.31	0.063	11.2	0.19	2.10	0.461	45 <	0.0201	0.0157	0.08230	12.5000			82.0	
2881130	7/7/2020 9:17	7/7/2020 10:21	99.0	73.0	27.0	0.24	0.073	12.3	0.55	2.00	0.555	45 <	0.0212	0.0235	0.09110	12.1000			113.0	
2883110	7/14/2020 9:02	7/14/2020 9:02																		2420 >
2883802	7/14/2020 7:22	7/14/2020 14:37	136.0	76.0	30.0	0.33	0.057	8.5	0.30	1.61	0.625	45 <	0.0214	0.0528	0.08570	12.1000			88.0	
2885359	7/21/2020 7:47	7/21/2020 10:07	26.0	64.0	10.0	0.13	0.156	7.4	0.22	1.16	0.442	45 <	0.0088	0.0066	0.03480				53.0	
2886833	7/25/2020 18:42	7/26/2020 9:37	40.0	82.0	12.0	0.16		9.8	0.09	1.31		50	0.0122	0.0164	0.04480	9.9000			57.0	
2890627	8/9/2020 21:12	8/10/2020 4:37	82.0	67.0	26.0	0.37	0.033	5.0 <	0.22	1.90	0.800	45 <	0.0165	0.0183	0.06390	8.6000			78.0	
2892787	8/14/2020 20:26	8/14/2020 22:06	438.0	129.0	85.0	0.92		6.3	0.09	2.38		45 <	0.0474	0.0848	0.13100	6.5000			139.0	
2896363	8/28/2020 5:31	8/28/2020 7:51	546.0	140.0	89.0	1.21	0.179	5.0 <	0.46	3.37	0.977	58	0.0542	0.1120	0.15900	18.1000			159.0	
2908793	10/12/2020 0:01	10/12/2020 3:07	54.0	111.0	26.0	0.67	0.126	7.6	0.06 <	2.73	0.260 <	45 <	24.0000	11.5000	70.40000	28.1000			142.0	
2916616	11/9/2020 12:31	11/9/2020 12:31	47.0	246.0	31.0	0.70	0.375	43.6	0.17	2.87	0.595	58	19.9000	13.0000	83.40000	66.8000			557.7	
2916618	11/9/2020 12:22	11/9/2020 12:22																		201
MINIMUM			**26.0**	**64.0**	**10.0**	**0.1**	**0.0**	**5.0**	**0.1**	**1.2**	**0.3**	**45.0**	**0.0**	**0.0**	**0.0**	**5.9**	**0.0**	**0.0**	**53.0**	**27**
AVERAGE			**199.5**	**559.4**	**66.6**	**0.6**	**0.1**	**330.9**	**0.4**	**2.9**	**0.6**	**69.1**	**3.4**	**1.9**	**12.0**	**17.8**	**#DIV/0!**	**#DIV/0!**	**243.2**	**23362**
MEDIAN			**82.0**	**84.0**	**30.0**	**0.4**	**0.1**	**8.5**	**0.2**	**2.1**	**0.6**	**45.0**	**0.0**	**0.0**	**0.1**	**12.1**	**#NUM!**	**#NUM!**	**113.0**	**1311**
MAXIMUM			**710.0**	**5456.0**	**410.0**	**1.2**	**0.4**	**3799.7**	**2.0**	**10.4**	**1.3**	**316.9**	**24.0**	**13.0**	**83.4**	**66.8**	**0.0**	**0.0**	**1430.0**	**90800**

Laboratory analysis was completed by Metroplian Council Environmental Services

Grab Sample | Duplicate

< - Analyte not detected above the Method Detection Limit (MDL), MDL value reported

J - Result reported as estimated between the MDL and Reporting Limit (RL)

> - Analyte exceeded the maximum dection level (was not fully diluted prior to analysis)

City of Saint Paul
2020 St. Albans Volume Reduction Pollutant Loading
Table C.4
WSB Project No.: 015938

SAINT ALBANS INFILTRATION SYSTEM VOLUME REDUCTION AND POLLUTANT LOADING

Sampling Data

Event Time Interval Start	Event Time Interval End	TSS	TDS	VSS	TP	Ortho-P	Chloride	Ammonia as N	Total Kjeldahl Nitrogen	Nitrate + Nitrite as N
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
6/21/20 16:40	6/21/20 19:30	228	80	50.7	0.4	0.07	8	0.1	1.7	0.4
6/23/20 19:29	6/23/20 20:15	228	80	50.7	0.4	0.07	8	0.1	1.7	0.4
6/26/20 16:10	6/26/20 17:15	228	80	50.7	0.4	0.07	8	0.1	1.7	0.4
6/28/20 19:00	6/28/20 23:36	**307.0**	**72.0**	**69.0**	**0.42**	**0.045**	**6.7**	**0.06** <	**1.77**	**0.38** <
6/29/20 2:58	6/29/20 7:30	228	80	50.7	0.4	0.07	8	0.1	1.7	0.4
6/29/20 8:55	6/29/20 11:31	228	80	50.7	0.4	0.07	8	0.1	1.7	0.4
6/30/20 1:00	6/30/20 2:00	228	80	50.7	0.4	0.07	8	0.1	1.7	0.4
7/6/20 7:45	7/6/20 9:16	**60.0**	**84.0**	**21.0**	**0.31**	**0.063**	**11.2**	**0.19**	**2.10**	**0.46**
7/7/20 9:11	7/7/20 10:30	**99.0**	**73.0**	**27.0**	**0.24**	**0.073**	**12.3**	**0.55**	**2.00**	**0.56**
7/9/20 5:06	7/9/20 6:01	228	80	51	0.4	0.07	8	0.1	1.7	0.4
7/14/20 7:15	7/14/20 8:27	**136.0**	**76.0**	**30.0**	**0.33**	**0.057**	**8.5**	**0.3**	**1.61**	**0.63**
7/14/20 14:20	7/14/20 15:00	228	80	50.7	0.4	0.07	8	0.1	1.7	0.4
7/18/20 2:56	7/18/20 4:45	228	80	50.7	0.4	0.07	8	0.1	1.7	0.4
7/18/20 21:15	7/18/20 22:15	228	80	50.7	0.4	0.07	8	0.1	1.7	0.4
7/21/20 7:37	7/21/20 12:30	**26.0**	**64.0**	**10.0**	**0.13**	**0.156**	**7.4**	**0.22**	**1.16**	**0.44**
7/25/20 18:36	7/26/20 11:30	**40.0**	**82.0**	**12.0**	**0.16**	0.07	**9.8**	**0.09**	**1.31**	0.4
7/28/20 2:40	7/28/20 4:33	228	80	50.7	0.4	0.07	8	0.1	1.7	0.4
8/9/20 13:02	8/9/20 13:45	**82.0**	**67.0**	**26.0**	**0.37**	**0.033**	**5.0** <	**0.22**	**1.90**	**0.80**
8/9/20 21:04	8/9/20 23:45	228	80	50.7	0.4	0.07	8	0.1	1.7	0.4
8/10/20 0:30	8/10/20 5:16	228	80	50.7	0.4	0.07	8	0.1	1.7	0.4
8/12/20 11:13	8/12/20 14:30	228	80	50.7	0.4	0.07	8	0.1	1.7	0.4
8/14/20 20:20	8/14/20 23:33	**438.0**	**129.0**	**85.0**	**0.92**	0.07	**6.3**	**0.09**	**2.38**	0.4
8/22/20 0:45	8/22/20 3:30	228	80	50.7	0.4	0.07	8	0.1	1.7	0.5
8/28/20 5:26	8/28/20 7:21	**546.0**	**140.0**	**89.0**	**1.21**	**0.179**	**5.0** <	**0.46**	**3.37**	**0.98**
8/31/20 2:34	8/31/20 10:23	228	80	50.7	0.4	0.07	8	0.1	1.7	0.4
9/6/20 2:56	9/6/20 5:15	228	80	51	0.4	0.07	8	0.1	1.7	0.4
9/7/20 15:58	9/7/20 17:44	228	80	51	0.4	0.07	8	0.1	1.7	0.4
9/9/20 14:00	9/9/20 18:46	228	80	51	0.4	0.07	8	0.1	1.7	0.4
9/11/20 22:57	9/12/20 0:57	228	80	51	0.4	0.07	8	0.1	1.7	0.4
9/12/20 6:00	9/12/20 7:03	228	80	51	0.4	0.07	8	0.1	1.7	0.4
9/24/20 7:00	9/24/20 8:45	228	80	51	0.4	0.07	8	0.1	1.7	0.4
9/30/20 18:25	9/30/20 19:22	228	80	51	0.4	0.07	8	0.1	1.7	0.4
10/11/20 23:56	10/12/20 5:30	**54.0**	**111.0**	**26.0**	**0.67**	**0.126**	**7.6**	**0.06 <**	**2.734**	**0.26 <**
Sum										
Average		178.8	89.8	39.5	0.48	0.092	8.0	0.22	2.03	0.56
Weighted Avg		227.8	80.3	50.7	0.45	0.072	7.6	0.13	1.68	0.41
STDEV		185.1	27.0	29.8	0.35	0.055	2.5	0.17	0.66	0.23
Min		26.0	64.0	10.0	0.13	0.033	5.0	0.06	1.16	0.26
Max		546.0	140.0	89.0	1.21	0.179	12.3	0.55	3.37	0.98
Percent Capture										

Event Loading and Volume Data

Event Time Interval Start	Event Time Interval End	Interval Rain	Eliptical Volume (1)	University 1 Volume (2)	Bypass Volume (3)	Volume Captured by BMP (1+2-3)	Captured TSS	Captured TDS	Captured VSS	Captured TP	Captured Ortho-P	Captured Chloride	Captured Ammonia as N	Captured Total Kjeldahl Nitrogen	Captured Nitrate + Nitrite as N
		In.	cu-ft	cu-ft	cu-ft	cu-ft	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
6/21/20 16:40	6/21/20 19:30	0.14	880.9	590	0	1471.0	20.9	ND	4.7	0.04	0.007	0.7	0.0	0.2	0.0
6/23/20 19:29	6/23/20 20:15	0.07	134.1	90	0	223.9	3.2	1.1	0.7	0.01	0.001	0.1	0.0	0.0	0.0
6/26/20 16:10	6/26/20 17:15	0.14	1221.6	818	0	2040.1	29.0	10.2	6.5	0.06	0.009	1.0	0.0	0.2	0.1
6/28/20 19:00	6/28/20 23:36	1.63	33496.9	22443	4670	51269.9	982.6	230.4	220.8	1.35	0.144	21.3	0.2	5.7	1.2
6/29/20 2:58	6/29/20 7:30	1	31923.0	21388	3021	50290.4	715.1	252.2	159.2	1.40	0.225	23.9	0.4	5.3	1.3
6/29/20 8:55	6/29/20 11:31	0.25	1989.5	1333	0	3322.4	47.2	16.7	10.5	0.09	0.015	1.6	0.0	0.3	0.1
6/30/20 1:00	6/30/20 2:00	0.11	1000.2	670	0	1670.4	23.7	8.4	5.3	0.05	0.007	0.8	0.0	0.2	0.0
7/6/20 7:45	7/6/20 9:16	0.21	3254.4	2180	0	5434.8	20.4	28.5	7.1	0.11	0.021	3.8	0.1	0.7	0.2
7/7/20 9:11	7/7/20 10:30	0.22	2653.4	1778	0	4431.2	27.4	20.2	7.5	0.07	0.020	3.4	0.2	0.6	0.2
7/9/20 5:06	7/9/20 6:01	0.26	3421.8	2293	0	5714.3	81.2	28.7	18.1	0.16	0.026	2.7	0.0	0.6	0.1
7/14/20 7:15	7/14/20 8:27	0.37	4230.0	2834	0	7064.1	60.0	33.5	13.2	0.14	0.025	3.8	0.1	0.7	0.3
7/14/20 14:20	7/14/20 15:00	0.06	260.0	174	0	434.1	6.2	2.2	1.4	0.01	0.002	0.2	0.0	0.0	0.0
7/18/20 2:56	7/18/20 4:45	0.46	5772.2	3867	0	9639.6	137.1	48.3	30.5	0.27	0.043	4.6	0.1	1.0	0.2
7/18/20 21:15	7/18/20 22:15	0.06	664.5	445	0	1109.7	15.8	5.6	3.5	0.03	0.005	0.5	0.0	0.1	0.0
7/21/20 7:37	7/21/20 12:30	0.43	4161.1	2788	0	6949.1	11.3	27.8	4.3	0.06	0.068	3.2	0.1	0.5	0.2
7/25/20 18:36	7/26/20 11:30	0.93	10080.4	6754	0	16834.2	42.0	86.2	12.6	0.17	0.075	10.3	0.1	1.4	0.4
7/28/20 2:40	7/28/20 4:33	0.1	484.8	325	0	809.6	11.5	4.1	2.6	0.02	0.004	0.4	0.0	0.1	0.0
8/9/20 13:02	8/9/20 13:45	0.07	149.1	100	0	249.0	1.3	1.0	0.4	0.01	0.001	0.1	0.0	0.0	0.0
8/9/20 21:04	8/9/20 23:45	0.3	2227.3	1492	0	3719.6	52.9	18.7	11.8	0.10	0.017	1.8	0.0	0.4	0.1
8/10/20 0:30	8/10/20 5:16	0.47	4957.4	3321	0	8278.9	117.7	41.5	26.2	0.23	0.037	3.9	0.1	0.9	0.2
8/12/20 11:13	8/12/20 14:30	0.31	1327.4	889	0	2216.8	31.5	11.1	7.0	0.06	0.010	1.1	0.0	0.2	0.1
8/14/20 20:20	8/14/20 23:33	0.49	5811.6	3894	0	9705.3	265.4	78.2	51.5	0.56	0.043	3.8	0.1	1.4	0.3
8/22/20 0:45	8/22/20 3:30	0.25	1178.9	790	0	1968.7	28.0	9.9	6.2	0.05	0.009	0.9	0.0	0.2	0.1
8/28/20 5:26	8/28/20 7:21	0.4	3318.0	2223	0	5541.1	188.9	48.4	30.8	0.42	0.062	1.7	0.2	1.2	0.3
8/31/20 2:34	8/31/20 10:23	0.54	4046.4	2711	0	6757.5	96.1	33.9	21.4	0.19	0.030	3.2	0.1	0.7	0.2
9/6/20 2:56	9/6/20 5:15	0.08	280.1	188	0	467.8	6.7	2.3	1.5	0.01	0.002	0.2	0.0	0.0	0.0
9/7/20 15:58	9/7/20 17:44	0.11	324.2	217	0	541.3	7.7	2.7	1.7	0.02	0.002	0.3	0.0	0.1	0.0
9/9/20 14:00	9/9/20 18:46	0.15	685.2	459	0	1144.3	16.3	5.7	3.6	0.03	0.005	0.5	0.0	0.1	0.0
9/11/20 22:57	9/12/20 0:57	0.07	302.1	202	0	504.5	7.2	2.5	1.6	0.01	0.002	0.2	0.0	0.1	0.0
9/12/20 6:00	9/12/20 7:03	0.05	275.8	185	0	460.6	6.5	2.3	1.5	0.01	0.002	0.2	0.0	0.0	0.0
9/24/20 7:00	9/24/20 8:45	0.07	216.3	145	0	361.3	5.1	1.8	1.1	0.01	0.002	0.2	0.0	0.0	0.0
9/30/20 18:25	9/30/20 19:22	0.09	371.9	249	0	621.1	8.8	3.1	2.0	0.02	0.003	0.3	0.0	0.1	0.0
10/11/20 23:56	10/12/20 5:30	0.91	5193.6	3480	0	8673.3	29.2	60.1	14.1	0.36	0.068	4.1	ND	ND	ND
Sum		10.8	136294	91317	7691	**219920**	3104	1127	691	6.1	0.99	104.7	1.8	23.1	5.7
Average		0.33	4130	2767	233	6664	94	35	21	0.2	0.03	3.2	0.1	0.7	0.2
Weighted Avg															
STDEV															
Min															
Max															
Percent Capture						**97%**	**92%**	**93%**	**92%**	**94%**	**95%**	**94%**	**96%**	**93%**	**94%**

< Sample was not detected above the method detection limit (value reported)
GREY FONT Events with no sampling data (weighted average concentration used)
BOLD Sampling event Sampled Event
1 University Volumes after are estimated flow based on the relationship between the elipital and unvisity volumes for previous flow events

City of Saint Paul
2020 Water Quality and Quantity Report
Table C.5
WSB Project Number: 015938

HAMPDEN WATER QUALITY SUMMARY

LAB ID	Date Composite Sampling Started	Date Composite Sampling Ended	TSS (mg/L)	TDS (mg/L)	VSS (mg/L)	TP (mg/L)	Ortho-P (mg/L)	Chloride (mg/L)	Ammonia as N (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Nitrate + Nitrite as N (mg/L)	Hardness as CaCO3 (mg/L)	Copper (mg/L)	Lead (mg/L)	Zinc (mg/L)	Total Organic Carbon (mg/L)	pH	COD (mg/L)	E. Coli (MPN/ 100 mL)
2850503	3/4/2020 12:37	3/4/2020 12:37	15.0		11.0														579
2873902	6/9/2020 15:59	6/9/2020 19:48	53.0		27.0	0.32	0.009 J	20.7	0.12	2.66	0.304					26.8000			
2876242	6/18/2020 17:49	6/18/2020 22:04	46.0	53.5	17.0	0.17	0.041	3.8	0.17	1.35	0.313	45 <	0.0095	0.0050	0.05800	9.7000		55.0	
2877172	6/21/2020 15:39	6/21/2020 17:34	70.0	65.5	29.0	0.22	0.016	5.4	0.43	1.64	0.530	45 <	0.0097	0.0070	0.06550	9.9000		81.0	
2878723	6/29/2020 8:50	6/29/2020 8:50																	29200
2879133	6/28/2020 19:05	6/29/2020 3:50	41.0	37.0	14.0	0.12	0.016	2.2	0.06 <	0.74	0.365 <	45 <	0.0055	0.0047	0.03360	5.6000		25.0	
2883800	7/14/2020 7:20	7/14/2020 14:35	51.0	49.0	17.0	0.19	0.046	4.2	0.32	1.44	0.488 <	45 <	0.0137	0.0041	0.04840	9.2000		67.0	
2885363	7/21/2020 7:45	7/21/2020 9:49	36.0	53.5	15.0	0.09	0.015	2.0 <	0.33	1.12	0.394	45 <	0.0066	0.0028	0.05690	8.9000		53.0	
2885370	7/21/2020 9:36	7/21/2020 9:36																	517
2886840	7/25/2020 18:30	7/26/2020 9:04	37.0	43.0	13.0	0.12	0.029	2.2	0.23	0.99	0.440 <	45 <	0.0080	0.0041	0.04770	6.5000		43.0	
2890623	8/9/2020 21:15	8/10/2020 23:35	43.0	52.0	14.0	0.12	0.022	5.0 <	0.26	1.17	0.365 <	45 <	0.0081	0.0048	0.04420	6.4000		50.0	
2891769	8/12/2020 10:50	8/12/2020 13:20	43.0	57.5	18.0	0.10	0.010 <	5.0 <	0.09	1.00	0.276	45 <	0.0118	0.0047	0.08000	9.1000		64.0	
2892791	8/14/2020 20:15	8/14/2020 20:58	75.0	28.0	20.0	0.17		5.0 <	0.17	0.97		45 <	0.0099	0.0099	0.07240	4.7000		53.0	
2908776	10/11/2020 23:45	10/12/2020 3:50	73.0	66.0	28.0	0.45	0.042	5.0 <	0.06 <	1.77	0.260 <	45 <	11.5000	11.6000	90.20000	18.0000		87.0	
2908778	10/12/2020 10:15	10/12/2020 10:15															8.0		3100
MINIMUM			**15.0**	**28.0**	**11.0**	**0.1**	**0.0**	**2.0**	**0.1**	**0.7**	**0.3**	**45.0**	**0.0**	**0.0**	**0.0**	**4.7**	**8.0**	**25.0**	**517.2**
AVERAGE			**48.6**	**50.5**	**18.6**	**0.2**	**0.0**	**5.5**	**0.2**	**1.3**	**0.4**	**45.0**	**1.2**	**1.2**	**9.1**	**10.4**	**8.0**	**57.8**	**8349.2**
MEDIAN			**44.5**	**52.8**	**17.0**	**0.2**	**0.0**	**5.0**	**0.2**	**1.2**	**0.4**	**45.0**	**0.0**	**0.0**	**0.1**	**9.1**	**8.0**	**54.0**	**1839.7**
MAXIMUM			**75.0**	**66.0**	**29.0**	**0.4**	**0.0**	**20.7**	**0.4**	**2.7**	**0.5**	**45.0**	**11.5**	**11.6**	**90.2**	**26.8**	**8.0**	**87.0**	**29200.0**

Laboratory analysis was completed by Metroplian Council Environmental Services

Grab Sample | Duplicate

< - Analyte not detected above the Method Detection Limit (MDL), MDL value reported

J - Result reported as estimated between the MDL and Reporting Limit (RL)

> - Analyte exceeded the maximum dection level (was not fully diluted prior to analysis)

City of Saint Paul
2020 Water Quality and Quantity Report
Table C.6
WSB Project No.: 015938

HAMPDEN PARK VOLUME AND POLLUTANT REDUCTION SUMMARY

Sampling Data

Event Time Interval		TSS	TDS	VSS	TP	Ortho-P	Chloride	Ammonia as N	Total Kjeldahl Nitrogen	Nitrate + Nitrite as N
Start	End	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
5/9/20 17:11	5/9/20 19:56	48	46	16	0.14	0.02	4	0.2	1.1	0.4
5/13/20 23:56	5/14/20 5:45	48	46	16	0.14	0.02	4	0.2	1.1	0.4
5/16/20 18:39	5/17/20 22:16	48	46	16	0.14	0.02	4	0.2	1.1	0.4
5/23/20 6:00	5/23/20 8:30	48	46	16	0.14	0.02	4	0.2	1.1	0.4
5/25/20 7:21	5/25/20 12:00	48	46	16	0.14	0.02	4	0.2	1.1	0.4
5/26/20 20:16	5/27/20 3:30	48	46	16	0.14	0.02	4	0.2	1.1	0.4
6/2/20 17:45	6/2/20 19:36	48	46	16	0.14	0.02	4	0.2	1.1	0.4
6/5/20 0:51	6/5/20 2:15	48	46	16	0.14	0.02	4	0.2	1.1	0.4
6/6/20 18:45	6/7/20 0:15	48	46	16	0.14	0.02	4	0.2	1.1	0.4
6/9/20 15:57	6/9/20 20:15	**53**	46	**27**	**0.32**	**0.009** J	**20.74**	**0.12**	**2.66**	**0.30**
6/18/20 17:45	6/18/20 22:11	**46**	**54**	**17**	**0.17**	**0.041**	**3.8**	**0.17**	**1.35**	**0.31**
6/20/20 13:45	6/20/20 14:45	48	46	16	0.14	0.02	4	0.2	1.1	0.4
6/21/20 15:36	6/21/20 19:00	**70**	**66**	**29**	**0.22**	**0.016**	**5.40**	**0.43**	**1.64**	**0.53**
6/23/20 19:26	6/23/20 20:45	48	46	16	0.14	0.02	4	0.2	1.1	0.4
6/28/20 18:51	6/29/20 12:08	**41**	**37**	**14**	**0.12**	**0.016**	**2.2**	**0.06** <	**0.74**	**0.37** <
6/29/20 23:45	6/30/20 2:30	48	46	16	0.14	0.02	4	0.2	1.1	0.4
7/6/20 8:00	7/6/20 10:16	48	46	16	0.14	0.02	4	0.2	1.1	0.4
7/7/20 9:15	7/7/20 10:45	48	46	16	0.14	0.02	4	0.2	1.1	0.4
7/9/20 5:00	7/9/20 6:30	48	46	16	0.14	0.02	4	0.2	1.1	0.4
7/14/20 2:11	7/14/20 9:15	**51**	**49**	**17**	**0.19**	**0.046**	**4.2**	**0.32**	**1.44**	**0.49** <
7/14/20 13:56	7/14/20 15:15	48	46	16	0.14	0.02	4	0.2	1.1	0.4
7/18/20 2:56	7/18/20 22:00	48	46	16	0.14	0.02	4	0.2	1.1	0.4
7/21/20 7:30	7/21/20 10:30	**36**	**54**	**15**	**0.09**	**0.015**	**2.0** <	**0.33**	**1.12**	**0.39**
7/25/20 18:26	7/26/20 10:15	**37**	**43**	**13**	**0.12**	**0.029**	**2.2**	**0.23**	**0.99**	**0.44** <
7/28/20 2:36	7/28/20 5:15	48	46	16	0.14	0.02	4	0.2	1.1	0.4
8/9/20 12:51	8/10/20 5:30	**43**	**52**	**14**	**0.12**	**0.022**	**5.0** <	**0.26**	**1.17**	**0.37** <
8/12/20 10:45	8/12/20 15:15	**43**	**58**	**18**	**0.10**	**0.010** <	**5.0** <	**0.09**	**1.00**	**0.28**
8/12/20 18:11	8/12/20 19:30	48	46	16	0.14	0.02	4	0.2	1.1	0.4
8/14/20 20:11	8/14/20 22:15	**75**	**28**	**20**	**0.17**	0.02	**5.0** <	**0.17**	**0.97**	0.4
8/22/20 0:00	8/22/20 4:30	48	46	16	0.14	0.02	4	0.2	1.1	0.4
8/28/20 5:15	8/28/20 7:30	48	46	16	0.14	0.02	4	0.2	1.1	0.4
8/31/20 2:00	8/31/20 10:00	48	46	16	0.14	0.02	4	0.2	1.1	0.4
9/6/20 3:30	9/6/20 5:38	48	46	16	0.14	0.02	4	0.2	1.1	0.4
9/11/20 22:30	9/12/20 10:45	48	46	16	0.14	0.02	4	0.2	1.1	0.4
9/24/20 7:00	9/24/20 8:45	48	46	16	0.14	0.02	4	0.2	1.1	0.4
9/30/20 18:21	9/30/20 22:45	48	46	16	0.14	0.02	4	0.2	1.1	0.4
Sum										
Average		49.5	48.8	18.4	0.16	0.023	5.5	0.22	1.31	0.39
Weighted Avg		47.7	46.0	16.5	0.14	0.024	4.07	0.19	1.12	0.38
STDEV		12.7	11.3	5.5	0.07	0.013	5.5	0.12	0.54	0.09
Min		36.0	28.0	13.0	0.09	0.009	2.0	0.06	0.74	0.28
Max		75.0	65.5	29.0	0.32	0.046	20.7	0.43	2.66	0.53
Percent Capture										
		#REF!	#REF!							

Event Loading and Volume Data

Event Time Interval		Interval Rain	Hampden/Raymond Inflow Volume (1)	Eastern Hampden Modeled Inflow Volume[1] (2)	Bypass Volume2 (3)	Volume Captured by BMP (1+2-3)	Captured TSS	Captured TDS	Captured VSS	Captured TP	Captured Ortho-P	Captured Chloride	Captured Ammonia as N	Captured Total Kjeldahl Nitrogen	Captured Nitrate + Nitrite as N
Start	End	In.	cu-ft	cu-ft	cu-ft	cu-ft	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
5/9/20 17:11	5/9/20 19:56	0.07	1692.4	279	0	1971.7	5.9	5.7	2.0	0.02	0.003	0.50	0.02	0.14	0.05
5/13/20 23:56	5/14/20 5:45	0.08	1255.4	207	0	1462.6	4.4	4.2	1.5	0.01	0.002	0.37	0.02	0.10	0.03
5/16/20 18:39	5/17/20 22:16	2.51	21957.0	3623	0	25579.9	76.1	73.5	26.3	0.23	0.039	6.50	0.31	1.79	0.61
5/23/20 6:00	5/23/20 8:30	0.13	1305.2	215	0	1520.5	4.5	4.4	1.6	0.01	0.002	0.39	0.02	0.11	0.04
5/25/20 7:21	5/25/20 12:00	0.04	1602.7	264	0	1867.1	5.6	5.4	1.9	0.02	0.003	0.47	0.02	0.13	0.04
5/26/20 20:16	5/27/20 3:30	0.79	13172.2	2173	0	15345.6	45.7	44.1	15.8	0.14	0.023	3.90	0.19	1.07	0.36
6/2/20 17:45	6/2/20 19:36	0.37	12649.6	2087	0	14736.8	43.8	42.3	15.2	0.13	0.022	3.75	0.18	1.03	0.35
6/5/20 0:51	6/5/20 2:15	0.24	1104.0	182	0	1286.2	3.8	3.7	1.3	0.01	0.002	0.33	0.02	0.09	0.03
6/6/20 18:45	6/7/20 0:15	0.29	3285.9	542	0	3828.1	11.4	11.0	3.9	0.03	0.006	0.97	0.05	0.27	0.09
6/9/20 15:57	6/9/20 20:15	0.17	1266.8	209	0	1475.8	4.9	4.2	2.5	0.03	0.001	1.91	0.01	0.24	0.03
6/18/20 17:45	6/18/20 22:11	0.64	8090.9	1335	0	9425.9	27.1	31.5	10.0	0.10	0.024	2.21	0.10	0.79	0.18
6/20/20 13:45	6/20/20 14:45	0.02	254.9	42	0	297.0	0.9	0.9	0.3	0.00	0.000	0.08	0.00	0.02	0.01
6/21/20 15:36	6/21/20 19:00	0.14	2964.9	489	0	3454.1	15.1	14.1	6.3	0.05	0.003	1.16	0.09	0.35	0.11
6/23/20 19:26	6/23/20 20:45	0.07	484.0	80	0	563.9	1.7	1.6	0.6	0.01	0.001	0.14	0.01	0.04	0.01
6/28/20 18:51	6/29/20 12:08	2.95	12620.0	2082	0	14702.3	37.6	34.0	12.8	0.11	0.015	2.01	0.06	0.68	0.34
6/29/20 23:45	6/30/20 2:30	0.13	1957.4	323	0	2280.4	6.8	6.6	2.3	0.02	0.003	0.58	0.03	0.16	0.05
7/6/20 8:00	7/6/20 10:16	0.23	852.7	141	0	993.4	3.0	2.9	1.0	0.01	0.002	0.25	0.01	0.07	0.02
7/7/20 9:15	7/7/20 10:45	0.22	1690.3	279	0	1969.2	5.9	5.7	2.0	0.02	0.003	0.50	0.02	0.14	0.05
7/9/20 5:00	7/9/20 6:30	0.26	1400.9	231	0	1632.1	4.9	4.7	1.7	0.01	0.002	0.41	0.02	0.11	0.04
7/14/20 2:11	7/14/20 9:15	0.4	3824.1	631	0	4455.1	14.2	13.6	4.7	0.05	0.013	1.15	0.09	0.40	0.14
7/14/20 13:56	7/14/20 15:15	0.06	1363.1	225	0	1588.0	4.7	4.6	1.6	0.01	0.002	0.40	0.02	0.11	0.04
7/18/20 2:56	7/18/20 22:00	0.58	4085.6	674	0	4759.8	14.2	13.7	4.9	0.04	0.007	1.21	0.06	0.33	0.11
7/21/20 7:30	7/21/20 10:30	0.43	2597.0	429	0	3025.6	6.8	10.1	2.8	0.02	0.003	0.38	0.06	0.21	0.07
7/25/20 18:26	7/26/20 10:15	0.93	6331.8	1045	0	7376.5	17.0	19.8	6.0	0.06	0.013	1.01	0.11	0.45	0.20
7/28/20 2:36	7/28/20 5:15	0.1	1329.3	219	0	1548.6	4.6	4.4	1.6	0.01	0.002	0.39	0.02	0.11	0.04
8/9/20 12:51	8/10/20 5:30	0.84	10194.7	1682	0	11876.8	31.9	38.6	10.4	0.09	0.016	3.71	0.20	0.87	0.27
8/12/20 10:45	8/12/20 15:15	0.31	3100.0	511	0	3611.4	9.7	13.0	4.1	0.02	0.002	1.13	0.02	0.23	0.06
8/12/20 18:11	8/12/20 19:30	0.04	817.9	135	0	952.8	2.8	2.7	1.0	0.01	0.001	0.24	0.01	0.07	0.02
8/14/20 20:11	8/14/20 22:15	0.49	6277.1	1036	0	7312.8	34.2	12.8	9.1	0.08	0.011	2.28	0.08	0.44	0.17
8/22/20 0:00	8/22/20 4:30	0.25	2615.3	432	0	3046.9	9.1	8.8	3.1	0.03	0.005	0.77	0.04	0.21	0.07
8/28/20 5:15	8/28/20 7:30	0.4	2386.5	394	0	2780.3	8.3	8.0	2.9	0.02	0.004	0.71	0.03	0.19	0.07
8/31/20 2:00	8/31/20 10:00	0.54	5634.5	930	0	6564.2	19.5	18.9	6.8	0.06	0.010	1.67	0.08	0.46	0.16
9/6/20 3:30	9/6/20 5:38	0.06	975.7	161	0	1136.7	3.4	3.3	1.2	0.01	0.002	0.29	0.01	0.08	0.03
9/11/20 22:30	9/12/20 10:45	0.15	1316.5	217	0	1533.7	4.6	4.4	1.6	0.01	0.002	0.39	0.02	0.11	0.04
9/24/20 7:00	9/24/20 8:45	0.07	358.7	59	0	417.9	1.2	1.2	0.4	0.00	0.001	0.11	0.01	0.03	0.01
9/30/20 18:21	9/30/20 22:45	0.12	785.7	130	0	915.3	2.7	2.6	0.9	0.01	0.001	0.23	0.01	0.06	0.02
Sum		15.12	143601	23694	0	**167295**	498	481	172	1.49	0.26	42.5	2.0	11.7	4.0
Average		0.42	3989	658	0	4647	14	13	5	0.0	0.01	1.2	0.1	0.3	0.1
Weighted Avg															
STDEV															
Min															
Max						25580									
Percent Capture						**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

< Sample was not detected above the method detection limit (value reported)
GREY FONT Events with no sampling data (weighted average concentration used)
BOLD Sampling event
1 - Additional stormwater is conveyed to the system from the east via a pipe along Hampden Avenue. This flow is modeled using the monitored flow from the Hampden/Raymond location and the ratio of drainage areas.
2 - Water Levels in the BMP did not exceed the system outlet elevation
*Samples identified as outliers have been omitted from annual flow weighted averages

City of Saint Paul
2020 Water Quality and Quantity Report
Table C.7
WSB Project Number: 015938

VICTORIA WATER QUALITY SUMMARY

LAB ID	Date Composite Sampling Started	Date Composite Sampling Ended	TSS (mg/L)	TDS (mg/L)	VSS (mg/L)	TP (mg/L)	Ortho-P (mg/L)	Chloride (mg/L)	Ammonia as N (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Nitrate + Nitrite as N (mg/L)	Hardness as CaCO3 (mg/L)	Copper (mg/L)	Lead (mg/L)	Zinc (mg/L)	Total Organic Carbon (mg/L)	Sulfate (mg/L)	pH	COD (mg/L)	E. Coli (MPN/ 100 mL)
2843364	2/3/2020 12:07	2/3/2020 12:07	11.0	5596.0	6.0	0.25	0.222	3435.3	1.69	3.32	0.678	189	0.007	0.002 J	0.038	4.4000			100.0	2420 >
2873904	6/9/2020 16:43	6/9/2020 17:35	35.0	242.0	26.0	0.88	0.294	50.8	0.37	4.41	0.260 <	45 <	0.012	0.007	0.041	37.2000			179.0	
2876246	6/18/2020 18:48	6/18/2020 19:40	76.0	81.0	37.0	0.61	0.196	10.1	0.14	2.67	0.332	45 <	0.009	0.012	0.053	15.8000			115.0	
2878724	6/29/2020 9:09	6/29/2020 9:09																		12100
2881132	7/6/2020 8:03	7/6/2020 8:56	35.0	119.0	18.0	0.65	0.254	10.6	0.63	3.39	0.355 <	45 <	0.010	0.007	0.037	24.2000			118.0	
2883111	7/14/2020 9:20	7/14/2020 9:20																		2420 >
2883804	7/14/2020 7:13	7/14/2020 8:07	59.0	41.0	21.0	0.32	0.166	2.5	0.53	1.64	0.637	45 <	0.007	0.010	0.027	8.5000			50.0	
2885365	7/21/2020 7:38	7/21/2020 8:08	20.0	88.0	13.0	0.37	0.154	6.2	0.51	2.32	0.449	45 <	0.006	0.003	0.025	19.2000			82.0	
2891771	8/12/2020 11:03	8/12/2020 11:55	10.0	69.0	7.0	0.25	0.134	5.0 <	0.36	1.53	0.610 <	45 <	0.006	0.002	0.018	14.0000			57.0	
2892781	8/17/2020 1:18	8/17/2020 1:33	19.0	78.0	13.0	0.36	0.122	6.6	0.32	2.56	0.622	45	0.005	0.003	0.022	15.0000			81.0 #	
2896359	8/28/2020 5:18	8/28/2020 6:09	70.0	65.0	32.0	0.57	0.256	5.0 <	0.77	2.68	0.867 <	45 <	0.008	0.008	0.042	21.0000			103.0	
2900267	9/9/2020 14:50	9/9/2020 15:50	10.0		7.0	0.23	0.133	5.0 <	0.10	0.89	0.260 <	45 <	0.003	0.002	0.015	9.9000			45.0	
2908781	10/11/2020 23:54	10/12/2020 0:46	86.0	216.5	58.0	2.14	1.123	14.2	0.06 <	5.09	0.260 <	45 <	14.500	9.700	88.200	89.4000			351.0	
2908783	10/12/2020 10:55	10/12/2020 10:55																7.85		15600
MINIMUM			**10.0**	**41.0**	**6.0**	**0.2**	**0.1**	**2.5**	**0.1**	**0.9**	**0.3**	**45.0**	**0.0**	**0.0**	**0.0**	**4.4**	**0.0**	**7.9**	**45.0**	**2420.0**
AVERAGE			**39.2**	**659.6**	**21.6**	**0.6**	**0.3**	**322.8**	**0.5**	**2.8**	**0.5**	**58.1**	**1.3**	**0.9**	**8.0**	**23.5**	**#DIV/0!**	**7.9**	**116.5**	**8135.0**
MEDIAN			**35.0**	**84.5**	**18.0**	**0.4**	**0.2**	**6.6**	**0.4**	**2.7**	**0.4**	**45.0**	**0.0**	**0.0**	**0.0**	**15.8**	**#NUM!**	**7.9**	**100.0**	**7260.0**
MAXIMUM			**86.0**	**5596.0**	**58.0**	**2.1**	**1.1**	**3435.3**	**1.7**	**5.1**	**0.9**	**189.0**	**14.5**	**9.7**	**88.2**	**89.4**	**0.0**	**7.9**	**351.0**	**15600.0**

Laboratory analysis was completed by Metroplian Council Environmental Services

Grab Sample | Duplicate

< - Analyte not detected above the Method Detection Limit (MDL), MDL value reported

J - Result reported as estimated between the MDL and Reporting Limit (RL)

> - Analyte exceeded the maximum dection level (was not fully diluted prior to analysis)

City of Saint Paul
2020 Victoria Volume Reduction Pollutant Monitoring
Table C.8
WSB Project No.: 015938

VICTORIA VOLUME AND POLLUTANT REDUCTION SUMMARY

Sampling Data

Event Time Interval		TSS	TDS	VSS	TP	Ortho-P	Chloride		Ammonia as N		Total Kjeldahl Nitrogen	Nitrate + Nitrite as N	
Start	End	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L		mg/L		mg/L	mg/L	
5/9/2020 18:45	5/9/2020 19:48	59	123	34	1.0	0.47	10		0.3		3.2	0.4	
5/14/2020 0:15	5/14/2020 3:00	59	123	34	1.0	0.47	10		0.3		3.2	0.4	
5/16/2020 19:10	5/17/2020 23:45	59	123	34	1.0	0.47	10		0.3		3.2	0.4	
5/23/2020 6:18	5/23/2020 8:15	59	123	34	1.0	0.47	10		0.3		3.2	0.4	
5/23/2020 13:06	5/23/2020 14:45	59	123	34	1.0	0.47	10		0.3		3.2	0.4	
5/26/2020 20:24	5/27/2020 3:03	59	123	34	1.0	0.47	10		0.3		3.2	0.4	
6/2/2020 17:56	6/2/2020 19:24	59	123	34	1.0	0.47	10		0.3		3.2	0.4	
6/5/2020 0:56	6/5/2020 2:09	59	123	34	1.0	0.47	10		0.3		3.2	0.4	
6/6/2020 21:06	6/7/2020 0:13	59	123	34	1.0	0.47	10		0.3		3.2	0.4	
6/9/2020 15:42	6/9/2020 20:42	**35.0**	**242.0**	**26.0**	**0.88**	**0.294**	**50.8**		**0.37**		**4.41**	**0.26**	<
6/18/2020 18:51	6/18/2020 22:30	**76.0**	**81.0**	**37.0**	**0.61**	**0.196**	**10.1**		**0.14**		**2.67**	**0.33**	
6/21/2020 16:40	6/21/2020 18:49	59	123	34	1.0	0.47	10		0.3		3.2	0.4	
6/23/2020 19:11	6/23/2020 20:43	59	123	34	1.0	0.47	10		0.3		3.2	0.4	
6/26/2020 16:06	6/26/2020 17:15	59	123	34	1.0	0.47	10		0.3		3.2	0.4	
6/28/2020 19:05	6/28/2020 23:19	59	123	34	1.0	0.47	10		0.3		3.2	0.4	
6/29/2020 0:39	6/29/2020 1:21	59	123	34	1.0	0.47	10		0.3		3.2	0.4	
6/29/2020 2:45	6/29/2020 11:48	59	123	34	1.0	0.47	10		0.3		3.2	0.4	
6/30/2020 1:00	6/30/2020 2:30	59	123	34	1.0	0.47	10		0.3		3.2	0.4	
7/6/2020 8:06	7/6/2020 9:12	**35.0**	**119.0**	**18.0**	**0.65**	**0.254**	**10.6**		**0.63**		**3.39**	**0.35**	<
7/7/2020 9:11	7/7/2020 10:54	59	123	34	1.0	0.47	10		0.3		3.2	0.4	
7/9/2020 5:11	7/9/2020 6:54	59	123	34	1.0	0.47	10		0.3		3.2	0.4	
7/14/2020 7:14	7/14/2020 8:30	**59.0**	**41.0**	**21.0**	**0.3**	**0.166**	**2.5**		**0.53**		**1.64**	**0.64**	
7/14/2020 14:00	7/14/2020 14:52	59	123	34	1.0	0.47	10		0.3		3.2	0.4	
7/18/2020 2:56	7/18/2020 4:44	59	123	34	1.0	0.47	10		0.3		3.2	0.4	
7/18/2020 20:24	7/18/2020 22:18	59	123	34	1.0	0.47	10		0.3		3.2	0.4	
7/21/2020 7:41	7/21/2020 11:06	**20.0**	**88.0**	**13.0**	**0.4**	**0.154**	**6.2**		**0.51**		**2.32**	**0.4**	
7/25/2020 18:35	7/25/2020 22:48	59	123	34	1.0	0.47	10		0.3		3.2	0.4	
7/26/2020 4:11	7/26/2020 10:12	59	123	34	1.0	0.47	10		0.3		3.2	0.4	
7/28/2020 2:33	7/28/2020 4:36	59	123	34	1.0	0.47	10		0.3		3.2	0.4	
8/9/2020 13:00	8/9/2020 13:45	59	123	34	1.0	0.47	10		0.3		3.2	0.4	
8/9/2020 21:15	8/10/2020 4:30	59	123	34	1.0	0.47	10		0.3		3.2	0.4	
8/12/2020 11:00	8/12/2020 20:00	**10.0**	**69.0**	**7.0**	**0.25**	**0.134**	**5.0**	<	**0.36**		**1.53**	**0.61**	<
8/14/2020 20:21	8/14/2020 21:15	59	123	34	1.0	0.47	10		0.3		3.2	0.4	
8/17/2020 1:21	8/17/2020 2:36	**19.0**	**78.0**	**13.0**	**0.36**	**0.122**	**6.6**		**0.32**		**2.56**	**0.62**	
8/22/2020 0:21	8/22/2020 3:41	59	123	34	1.0	0.47	10		0.3		3.2	0.4	
8/28/2020 5:21	8/28/2020 7:08	**70.0**	**65.0**	**32**	**0.6**	**0.256**	**5.0**	<	**0.77**		**2.68**	**0.87**	<
8/31/2020 2:36	8/31/2020 9:32	59	123	34	1.0	0.47	10		0.3		3.2	0.4	
9/6/2020 4:08	9/6/2020 5:34	59	123	34	1.0	0.47	10		0.3		3.2	0.4	
9/7/2020 15:24	9/7/2020 23:06	59	123	34	1.0	0.47	10		0.3		3.2	0.4	
9/9/2020 14:00	9/9/2020 18:42	**10.0**	123	**7.0**	**0.23**	**0.133**	**5.0**	<	**0.10**		**0.9**	**0.26**	<
9/11/2020 23:00	9/12/2020 1:45	59	123	34	1.0	0.47	10		0.3		3.2	0.4	
9/24/2020 7:00	9/24/2020 9:18	59	123	34	1.0	0.47	10		0.3		3.2	0.4	
9/30/2020 18:21	9/30/2020 20:04	59	123	34	1.0	0.47	10		0.3		3.2	0.4	
10/11/2020 23:56	10/12/2020 6:30	**86.0**	**216.5**	**58**	**2.14**	**1.123**	**14.2**		**0.06**	<	**5.09**	**0.26**	<
Sum													
Average		42.0	111.1	23.2	0.64	0.283	11.6		0.38		2.72	0.47	
Weighted Ave		59.0	123.4	33.5	0.98	0.474	10.2		0.31		3.17	0.44	
STDEV		28.5	70.4	15.8	0.57	0.301	14.2		0.23		1.29	0.21	
Median		35.0	81.0	19.5	0.47	0.181	6.4		0.37		2.61	0.40	
Min		10.0	41.0	7.0	0.23	0.122	2.5		0.06		0.89	0.26	
Max		86.0	242.0	58.0	2.14	1.123	50.8		0.77		5.09	0.87	
Percent Capture													

Event Loading and Volume Data

Event Time Interval		Interval Rain	Runoff Volume (1)	Bypassed Volume (2)	Volume Captured by BMP (1-2)	Captured TSS	Captured TDS	Captured VSS	Captured TP	Captured Ortho-P	Captured Chloride	Captured Ammonia as N	Captured Total Kjeldahl Nitrogen	Captured Nitrate + Nitrite as N
Start	End	In.	cu-ft	cu-ft	cu-ft	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
5/9/2020 18:45	5/9/2020 19:48	0.06	239	0	239	0.9	1.8	0.5	0.0	0.007	0.2	0.00	0.0	0.0
5/14/2020 0:15	5/14/2020 3:00	0.07	274	0	274	1.0	2.1	0.6	0.0	0.008	0.2	0.01	0.1	0.0
5/16/2020 19:10	5/17/2020 23:45	2.50	49254	0	49254	181.4	379.6	103.1	3.0	1.459	31.5	0.95	9.8	1.3
5/23/2020 6:18	5/23/2020 8:15	0.12	1366	0	1366	5.0	10.5	2.9	0.1	0.040	0.9	0.03	0.3	0.0
5/23/2020 13:06	5/23/2020 14:45	0.08	3505	0	3505	12.9	27.0	7.3	0.2	0.104	2.2	0.07	0.7	0.1
5/26/2020 20:24	5/27/2020 3:03	0.79	15191	0	15191	55.9	117.1	31.8	0.9	0.450	9.7	0.29	3.0	0.4
6/2/2020 17:56	6/2/2020 19:24	0.37	5459	0	5459	20.1	42.1	11.4	0.3	0.162	3.5	0.11	1.1	0.1
6/5/2020 0:56	6/5/2020 2:09	0.24	2629	0	2629	9.7	20.3	5.5	0.2	0.078	1.7	0.05	0.5	0.1
6/6/2020 21:06	6/7/2020 0:13	0.28	4679	0	4679	17.2	36.1	9.8	0.3	0.139	3.0	0.09	0.9	0.1
6/9/2020 15:42	6/9/2020 20:42	0.17	1696	0	1696	3.7	25.6	2.8	0.1	0.031	5.4	0.04	0.5	0.0
6/18/2020 18:51	6/18/2020 22:30	0.63	8688	0	8688	41.2	43.9	20.1	0.3	0.106	5.5	0.08	1.4	0.2
6/21/2020 16:40	6/21/2020 18:49	0.13	5931	0	5931	21.8	45.7	12.4	0.4	0.176	3.8	0.11	1.2	0.2
6/23/2020 19:11	6/23/2020 20:43	0.07	828	0	828	3.0	6.4	1.7	0.1	0.025	0.5	0.02	0.2	0.0
6/26/2020 16:06	6/26/2020 17:15	0.14	2332	0	2332	8.6	18.0	4.9	0.1	0.069	1.5	0.04	0.5	0.1
6/28/2020 19:05	6/28/2020 23:19	1.64	20736	0	20736	76.4	159.8	43.4	1.3	0.614	13.3	0.40	4.1	0.6
6/29/2020 0:39	6/29/2020 1:21	0.04	466	0	466	1.7	3.6	1.0	0.0	0.014	0.3	0.01	0.1	0.0
6/29/2020 2:45	6/29/2020 11:48	1.26	19251	602	18649	68.7	143.7	39.0	1.1	0.552	11.9	0.36	3.7	0.5
6/30/2020 1:00	6/30/2020 2:30	0.13	2397	0	2397	8.8	18.5	5.0	0.1	0.071	1.5	0.05	0.5	0.1
7/6/2020 8:06	7/6/2020 9:12	0.21	1426	0	1425	3.1	10.6	1.6	0.1	0.023	0.9	0.06	0.3	0.0
7/7/2020 9:11	7/7/2020 10:54	0.22	3517	0	3517	13.0	27.1	7.4	0.2	0.104	2.2	0.07	0.7	0.1
7/9/2020 5:11	7/9/2020 6:54	0.26	3264	0	3264	12.0	25.2	6.8	0.2	0.097	2.1	0.06	0.6	0.1
7/14/2020 7:14	7/14/2020 8:30	0.37	6016	0	6016	22.2	15.4	7.9	0.1	0.062	1.0	0.20	0.6	0.2
7/14/2020 14:00	7/14/2020 14:52	0.06	1104	0	1104	4.1	8.5	2.3	0.1	0.033	0.7	0.02	0.2	0.0
7/18/2020 2:56	7/18/2020 4:44	0.39	4933	0	4933	18.2	38.0	10.3	0.3	0.146	3.2	0.10	1.0	0.1
7/18/2020 20:24	7/18/2020 22:18	0.11	554	0	554	2.0	4.3	1.2	0.0	0.016	0.4	0.01	0.1	0.0
7/21/2020 7:41	7/21/2020 11:06	0.43	5955	0	5955	7.4	32.7	4.8	0.1	0.057	2.3	0.19	0.9	0.2
7/25/2020 18:35	7/25/2020 22:48	0.44	14446	0	14446	53.2	111.3	30.2	0.9	0.428	9.2	0.28	2.9	0.4
7/26/2020 4:11	7/26/2020 10:12	0.39	7166	0	7166	26.4	55.2	15.0	0.4	0.212	4.6	0.14	1.4	0.2
7/28/2020 2:33	7/28/2020 4:36	0.10	1532	0	1532	5.6	11.8	3.2	0.1	0.045	1.0	0.03	0.3	0.0
8/9/2020 13:00	8/9/2020 13:45	0.07	2229	0	2229	8.2	17.2	4.7	0.1	0.066	1.4	0.04	0.4	0.1
8/9/2020 21:15	8/10/2020 4:30	0.79	7075	0	7075	26.1	54.5	14.8	0.4	0.210	4.5	0.14	1.4	0.2
8/12/2020 11:00	8/12/2020 20:00	0.36	4872	0	4872	3.0	21.0	2.1	0.1	0.041	1.5	0.11	0.5	0.2
8/14/2020 20:21	8/14/2020 21:15	0.48	7575	0	7575	27.9	58.4	15.9	0.5	0.224	4.8	0.15	1.5	0.2
8/17/2020 1:21	8/17/2020 2:36	0.02	283	1	282	0.3	1.4	0.2	0.0	0.002	0.1	0.01	0.0	0.0
8/22/2020 0:21	8/22/2020 3:41	0.25	4373	0	4373	16.1	33.7	9.2	0.3	0.129	2.8	0.08	0.9	0.1
8/28/2020 5:21	8/28/2020 7:08	0.40	4900	0	4900	21.4	19.9	9.8	0.2	0.078	1.5	0.24	0.8	0.3
8/31/2020 2:36	8/31/2020 9:32	0.54	9368	0	9368	34.5	72.2	19.6	0.6	0.277	6.0	0.18	1.9	0.3
9/6/2020 4:08	9/6/2020 5:34	0.05	1201	0	1201	4.4	9.3	2.5	0.1	0.036	0.8	0.02	0.2	0.0
9/7/2020 15:24	9/7/2020 23:06	0.21	1776	0	1776	6.5	13.7	3.7	0.1	0.053	1.1	0.03	0.4	0.0
9/9/2020 14:00	9/9/2020 18:42	0.15	1312	0	1312	0.8	10.1	0.6	0.0	0.011	0.4	0.01	0.1	0.0
9/11/2020 23:00	9/12/2020 1:45	0.08	977	0	977	3.6	7.5	2.0	0.1	0.029	0.6	0.02	0.2	0.0
9/24/2020 7:00	9/24/2020 9:18	0.07	658	0	658	2.4	5.1	1.4	0.0	0.019	0.4	0.01	0.1	0.0
9/30/2020 18:21	9/30/2020 20:04	0.09	2032	0	2032	7.5	15.7	4.3	0.1	0.060	1.3	0.04	0.4	0.1
10/11/2020 23:56	10/12/2020 6:30	0.91	15534	0	15534	83.4	209.9	56.2	2.1	1.089	13.8	0.06	4.9	0.3
Sum		16.17	258,999	604	258,395	**952**	**1991**	**541**	**15.7**	**7.65**	**165.2**	**5.0**	**51.2**	**7.0**
Average		0.37	5,886	14	5,873	22	45	12	0.4	0.17	3.8	0.11	1.2	0.2
Weighted Ave														
STDEV														
Median														
Min														
Max														
Percent Capture					99.8%	**99.8%**	**99.8%**	**99.8%**	**99.8%**	**99.8%**	**99.8%**	**99.8%**	**99.8%**	**99.8%**

< Sample was not detected above the method detection limit (value reported)
GREY FONT Events with no sampling data (weighted average concentration used)
BOLD Sampling ev Sampled Event

City of Saint Paul
2020 Water Quality and Quantity Report
Table C.9
WSB Project Number: 015938

BATTLE CREEK WATER QUALITY SUMMARY

LAB ID	Date Composite Sampling Started	Date Composite Sampling Ended	TSS (mg/L)	TDS (mg/L)	VSS (mg/L)	TP (mg/L)	Ortho-P (mg/L)	Chloride (mg/L)	Ammonia as N (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Nitrate + Nitrite as N (mg/L)	Hardness as CaCO3 (mg/L)	Copper (mg/L)	Lead (mg/L)	Zinc (mg/L)	Total Organic Carbon (mg/L)	pH	COD (mg/L)	E. Coli (MPN/ 100 mL)
2843366	2/3/2020 13:05	2/3/2020 13:05	8.0	1007.0	4.0	0.07	0.006 J	521.5	0.30	0.75	0.327 <	254	0.0021	0.0007 J	0.01450	3.4000		33.0	
2850497	3/4/2020 11:05	3/4/2020 11:05	3.0	725.0	2.0 J	0.04 J	0.007 J	302.7	0.04 J	0.84	0.266 <	297	0.0010 J	0.0003 <	0.00350 J	3.9000		21.0	150
2878731	6/29/2020 10:11	6/29/2020 10:11																	3100
2879139	6/28/2020 19:52	6/29/2020 12:54	41.0	189.5	9.0 J	0.11	0.007 J	66.3	0.06 <	0.68	0.303 <	59	0.0024	0.0021	0.01430	8.6000		24.0	
2883112	7/14/2020 10:21	7/14/2020 10:21																	63
2885367	7/21/2020 3:52	7/21/2020 8:53	3.0	345.0	2.0 J	0.05	0.010 <	125.0	0.06 <	0.77	0.260 <	129	0.0006 J	0.0003 <	0.00270 J	7.5000		24.0	
2890619	8/9/2020 22:38	8/10/2020 9:53	9.0	463.5	5.0 J	0.06	0.010 <	179.0	0.06 <	1.14	0.260 <	174	0.0008 J	0.0004 J	0.00430 J	13.7000		56.0	
2891773	8/12/2020 13:08	8/12/2020 19:08	3.0 J	381.0	2.0 J	0.05 J	0.010	136.1	0.06	0.78	0.260 <	164	0.0020	0.0003	0.00210	9.0000 #		37.0 #	
2892783	8/14/2020 21:08	8/15/2020 3:24	4.5	380.0	3.0	0.02 J		150.0	0.06 <	0.86		162	0.0013	0.0004 J	0.00410 J	6.8000		20.0	
2896361	8/28/2020 6:23	8/28/2020 7:53	7.0	562.0	5.0	0.06	0.010 <	184.5	0.06 <	0.83	0.260 <	199	0.0007 J	0.0003 <	0.00270 J	23.4000		97.0	
2901190	9/12/2020 1:08	9/12/2020 15:53	5.0	505.0	3.0 J	0.05		218.4	0.06 <	0.89	0.260 <	202	1.0000 <	1.0000 <	5.00000 <			39.0	
2908784	10/12/2020 0:53	10/12/2020 11:38	18.0	354.0	8.0	0.12	0.010 <	137.7	0.06 <	0.82	0.260 <	183	2.0000	1.0000 <	7.60000	7.8000		35.0	
2908788	10/12/2020 11:45	10/12/2020 11:45															8.14		9600
2801324	9/2/2019 23:06	9/3/2019 5:56	13.0	358.0	5.0	0.09	0.005 <	135.9	0.02 <	0.78	0.260 <	117	0.0014	0.0007 J	0.00800	7.4000		70.0	
2809943	10/1/2019 9:47	10/1/2019 9:47																	2420 >
2809944	9/30/2019 17:17	10/1/2019 4:22	8.0	396.0	5.0	0.07	0.007 J	162.5	0.03 J	0.78	0.260 <	170	0.0012	0.0003 <	0.00470 J	9.6224		34.0	
MINIMUM			**3.0**	**189.5**	**2.0**	**0.0**	**0.0**	**66.3**	**0.0**	**0.7**	**0.3**	**59.4**	**0.0**	**0.0**	**0.0**	**3.4**	**8.1**	**20.0**	**62.6**
AVERAGE			**10.2**	**472.2**	**4.4**	**0.1**	**0.0**	**193.3**	**0.1**	**0.8**	**0.3**	**175.8**	**0.3**	**0.2**	**1.1**	**9.2**	**8.1**	**40.8**	**3066.5**
MEDIAN			**7.5**	**388.5**	**4.5**	**0.1**	**0.0**	**156.3**	**0.1**	**0.8**	**0.3**	**172.0**	**0.0**	**0.0**	**0.0**	**7.8**	**8.1**	**34.5**	**2420.0**
MAXIMUM			**41.0**	**1007.0**	**9.0**	**0.1**	**0.0**	**521.5**	**0.3**	**1.1**	**0.3**	**296.5**	**2.0**	**1.0**	**7.6**	**23.4**	**8.1**	**97.0**	**9600.0**

Laboratory analysis was completed by Metroplian Council Environmental Services

Grab Sample | Duplicate

< - Analyte not detected above the Method Detection Limit (MDL), MDL value reported

J - Result reported as estimated between the MDL and Reporting Limit (RL)

> - Analyte exceeded the maximum dection level (was not fully diluted prior to analysis)

City of Saint Paul
2020 Water Quality and Quantity Report
Table C.10
WSB Project No.: 015938

BATTLE CREEK VOLUME AND POLLUTANT SUMMARY

Sampling Data

Event Time Interval		TSS		TDS		VSS		TP		Ortho-P		Chloride		Ammonia as N		Total Kjeldahl Nitrogen		Nitrate + Nitrite as N	
Start	End	mg/L		mg/L		mg/L		mg/L		mg/L		mg/L		mg/L		mg/L		mg/L	
6/18/20 19:14	6/19/20 13:05	32		251		8		0.1		0.01		91		0.1		0.7		0.3	
6/21/20 17:35	6/22/20 18:25	32		251		8		0.1		0.01		91		0.1		0.7		0.3	
6/28/20 19:15	7/3/20 19:05	**41**		**190**		**9**	J	**0.11**		**0.007**	J	**66.3**		**0.06**	<	**0.68**		**0.30**	<
7/5/20 7:55	7/5/20 21:50	32		251		8		0.1		0.01		91		0.1		0.7		0.3	
7/9/20 5:25	7/9/20 21:45	32		251		8		0.1		0.01		91		0.1		0.7		0.3	
7/14/20 14:15	7/14/20 21:30	32		251		8		0.1		0.01		91		0.1		0.7		0.3	
7/18/20 3:00	7/18/20 15:25	32		251		8		0.1		0.01		91		0.1		0.7		0.3	
7/21/20 8:10	7/21/20 17:25	**3**		**345**		**2**	J	**0.05**		**0.010**	<	**125.0**		**0.06**	<	**0.77**		**0.26**	<
7/25/20 19:00	7/26/20 3:20	32		251		8		0.1		0.01		91		0.1		0.7		0.3	
7/26/20 6:40	7/26/20 13:35	32		251		8		0.1		0.01		91		0.1		0.7		0.3	
8/9/20 21:45	8/10/20 12:30	**9**		**464**		**5**	J	**0.06**		**0.010**	<	**179.0**		**0.06**	<	**1.14**		**0.26**	<
8/12/20 12:00	8/13/20 3:30	**3**	J	**381**		**2**	J	**0.05**	J	**0.010**	0	**136.1**		**0.06**	0	**0.78**		**0.26**	<
8/14/20 20:45	8/15/20 6:05	**5**		**380**		**3**		**0.02**	J	0.01		**150.0**		**0.06**	<	**0.86**		0.3	
8/21/20 23:45	8/22/20 13:00	32		251		8		0.1		0.01		91		0.1		0.7		0.3	
8/28/20 5:45	8/28/20 17:00	**7**		**562**		**5**		**0.06**		**0.010**	<	**184.5**		**0.06**	<	**0.83**		**0.26**	<
8/31/20 3:00	8/31/20 21:00	32		251		8		0.1		0.01		91		0.1		0.7		0.3	
9/12/20 0:15	9/13/20 1:45	**5**		**505**		**3**	J	**0.05**		0.01		**218.4**		**0.06**	<	**0.89**		**0.26**	<
9/24/20 7:05	9/24/20 19:45	32		251		8		0.1		0.01		91		0.1		0.7		0.3	
10/12/20 0:30	10/12/20 11:15	**18**		**354**		**8**		**0.12**		**0.010**	<	**137.7**		**0.06**	<	**0.82**		**0.26**	<
Sum																			
Average		11.3		397.5		4.6		0.07		0.010		149.62		0.05		0.85		0.27	
Weighted Avg		31.9		251.0		7.7		0.10		0.008		90.90		0.06		0.73		0.29	
STDEV		13.0		114.3		2.7		0.03		0.001		45.79		0.00		0.13		0.02	
Min		3.0		189.5		2.0		0.02		0.007		66.34		0.06		0.68		0.26	
Max		41.0		562.0		9.0		0.12		0.010		218.40		0.06		1.14		0.30	

Event Loading and Volume Data

Event Time Interval		Interval Rain	Flow Volume	TSS	TDS	VSS	TP	Ortho-P	Chloride	Total Nitrogen	Captured Ammonia as N	Kjeldahl Nitrogen	Nitrate + Nitrite as N
Start	End	In.	cu-ft	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
6/18/20 19:14	6/19/20 13:05	0.16	998523.8	1985.4	15644.9	478.3	6.17	0.479	5666.06	63.64	3.74	45.42	18.22
6/21/20 17:35	6/22/20 18:25	0.31	955503.9	1899.9	14970.9	457.7	5.91	0.458	5421.95	60.90	3.58	43.46	17.44
6/28/20 19:15	7/3/20 19:05	4.27	10540415.1	26978.7	124694.0	5922.1	74.36	4.606	43652.79	645.51	39.48	446.13	199.38
7/5/20 7:55	7/5/20 21:50	1.99	1679351.9	3339.2	26312.1	804.4	10.38	0.805	9529.38	107.03	6.29	76.39	30.65
7/9/20 5:25	7/9/20 21:45	0.18	1214153.0	2414.2	19023.4	581.6	7.50	0.582	6889.64	77.38	4.55	55.23	22.16
7/14/20 14:15	7/14/20 21:30	0.22	102632.0	204.1	1608.0	49.2	0.63	0.049	582.38	6.54	0.38	4.67	1.87
7/18/20 3:00	7/18/20 15:25	0.59	752320.3	1495.9	11787.4	360.4	4.65	0.361	4269.00	47.95	2.82	34.22	13.73
7/21/20 8:10	7/21/20 17:25	0.46	667531.7	125.0	14377.0	83.3	2.17	0.417	5209.91	43.05	2.50	32.21	10.83
7/25/20 19:00	7/26/20 3:20	0.87	596594.0	1186.3	9347.5	285.8	3.69	0.286	3385.34	38.02	2.23	27.14	10.89
7/26/20 6:40	7/26/20 13:35	0.41	609872.0	1212.7	9555.5	292.1	3.77	0.292	3460.68	38.87	2.28	27.74	11.13
8/9/20 21:45	8/10/20 12:30	0.31	546690.6	307.2	15818.7	170.6	2.08	0.341	6109.05	47.78	2.05	38.91	8.87
8/12/20 12:00	8/13/20 3:30	0.45	634885.9	118.9	15100.8	79.3	1.78	0.396	5392.29	41.10	2.38	30.80	10.30
8/14/20 20:45	8/15/20 6:05	0.49	496409.6	139.5	11776.1	93.0	0.62	0.238	4649.71	35.83	1.86	26.78	9.06
8/21/20 23:45	8/22/20 13:00	0.35	505072.9	1004.3	7913.5	241.9	3.12	0.242	2866.01	32.19	1.89	22.97	9.22
8/28/20 5:45	8/28/20 17:00	0.35	449865.3	196.6	15783.3	140.4	1.80	0.281	5180.12	30.56	1.69	23.25	7.30
8/31/20 3:00	8/31/20 21:00	0.75	785606.1	1562.1	12308.9	376.3	4.86	0.377	4457.87	50.07	2.94	35.73	14.34
9/12/20 0:15	9/13/20 1:45	0.15	401313.8	125.3	12651.9	75.2	1.28	0.192	5471.61	28.71	1.50	22.20	6.51
9/24/20 7:05	9/24/20 19:45	0.11	239053.7	475.3	3745.5	114.5	1.48	0.115	1356.50	15.24	0.90	10.87	4.36
10/12/20 0:30	10/12/20 11:15	1.1	782343.3	879.1	17289.4	390.7	5.67	0.488	6724.30	52.84	2.93	40.15	12.70
Sum		13.52	22958139	45649.5	359708.7	10996.7	141.91	11.01	130274.6	1463.2	86.0	1044.3	419.0
Average			1208323										
Weighted Avg													
STDEV													
Min													
Max													

< Sample was not detected above the method detection limit (value reported)
GREY FONT Events with no sampling data (weighted average concentration used)
BOLD Sampling event

City of Saint Paul
2020 Water Quality and Quantity Report
Table C.11
WSB Project Number: 015938

SACKETT WATER QUALITY SUMMARY

LAB ID	Date Composite Sampling Started	Date Composite Sampling Ended	TSS (mg/L)	TDS (mg/L)	VSS (mg/L)	TP (mg/L)	Ortho-P (mg/L)	Chloride (mg/L)	Ammonia as N (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Nitrate + Nitrite as N (mg/L)	Hardness as CaCO3 (mg/L)	Copper (mg/L)	Lead (mg/L)	Zinc (mg/L)	Total Organic Carbon (mg/L)	pH	COD (mg/L)	E. Coli (MPN/ 100 mL)
2843368	2/3/2020 12:52	2/3/2020 12:52	1.0 J	1071.0	1.0 J	0.05 J	0.008 J	406.3	0.07	0.34	3.337 <	519	0.0013 J	0.0005 <	0.01450	1.8000		19.0	
2850499	3/4/2020 11:27	3/4/2020 11:27	2.0 J	719.0	1.0 J	0.05	0.011	231.9	0.02 J	0.49	3.567 <	262	0.0009 J	0.0003 <	0.00780	2.0000		11.0 J	3
2876244	6/18/2020 18:46	6/18/2020 19:52	175.0	85.0	50.0	0.59	0.066	13.7	0.06 <	2.92	0.531	64	0.0164	0.0187	0.08980	8.9000		121.0	
2877174	6/21/2020 16:41	6/21/2020 17:37	124.0	132.0	36.0	0.35	0.038	21.3	0.30	2.32	0.795 <	60	0.0127	0.0123	0.07440	10.0000		125.0	
2878730	6/29/2020 9:52	6/29/2020 9:52																	2420
2879135	6/28/2020 19:12	6/28/2020 20:09	319.0	140.0	91.0	1.03	0.052	25.0	0.06 <	3.30	0.501 <	83	0.0218	0.0285	0.11000	9.0000		158.0	
2881126	7/5/2020 14:12	7/5/2020 15:16	327.0	76.0	103.0	0.77	0.064	8.4	0.28	4.20	0.428	45 <	0.0313	0.0497	0.14100	8.7000		232.0	
2883109	7/14/2020 9:59	7/14/2020 9:59																	2420 >
2885357	7/21/2020 7:43	7/21/2020 9:34	29.0	195.0	12.0	0.19	0.083	38.9	0.16	1.05	1.106	112	0.0072	0.0044	0.02720	7.1000		43.0	
2886831	7/25/2020 18:43	7/25/2020 22:28	122.0	84.0	39.0	0.35	0.057	10.6	0.06 <	1.57	0.425	57	0.0129	0.0191	0.07940	7.0000		72.0	
2890625	8/9/2020 21:28	8/10/2020 4:30	202.0	321.0	71.0	0.85	0.017	68.4	0.06 <	3.47	1.534	197	0.0216	0.0208	0.11000	13.3000		149.0	
2891760	8/12/2020 11:58	8/12/2020 13:18	27.0	117.0	12.0	0.19	0.056	18.1	0.07	1.06	0.693	56	0.0087	0.0038	0.03620	9.5000		59.0	
2892785	8/14/2020 20:28	8/14/2020 21:31	323.0	85.0	96.0	0.73		13.4	0.06 <	3.45		45 <	0.0517	0.0497	0.19300	5.3000		142.0	
2901194	9/11/2020 23:13	9/12/2020 0:44	25.0	467.0	10.0	0.17	0.010 <	99.9	0.06 <	1.01	1.860 <	301	6.6000	3.3000	25.10000	11.0000		50.0	
2908789	10/12/2020 12:46	10/12/2020 12:46													19.10000		8.04		3100
MINIMUM			**1.0**	**76.0**	**1.0**	**0.0**	**0.0**	**8.4**	**0.0**	**0.3**	**0.4**	**45.0**	**0.0**	**0.0**	**0.0**	**1.8**	**8.0**	**11.0**	**3.1**
AVERAGE			**139.7**	**291.0**	**43.5**	**0.4**	**0.0**	**79.6**	**0.1**	**2.1**	**1.3**	**150.1**	**0.6**	**0.3**	**3.5**	**7.8**	**8.0**	**98.4**	**1985.7**
MEDIAN			**123.0**	**136.0**	**37.5**	**0.4**	**0.1**	**23.1**	**0.1**	**1.9**	**0.8**	**73.5**	**0.0**	**0.0**	**0.1**	**8.8**	**8.0**	**96.5**	**2419.8**
MAXIMUM			**327.0**	**1071.0**	**103.0**	**1.0**	**0.1**	**406.3**	**0.3**	**4.2**	**3.6**	**519.1**	**6.6**	**3.3**	**25.1**	**13.3**	**8.0**	**232.0**	**3100.0**

Laboratory analysis was completed by Metroplian Council Environmental Services

Grab Sample Duplicate

< - Analyte not detected above the Method Detection Limit (MDL), MDL value reported

J - Result reported as estimated between the MDL and Reporting Limit (RL)

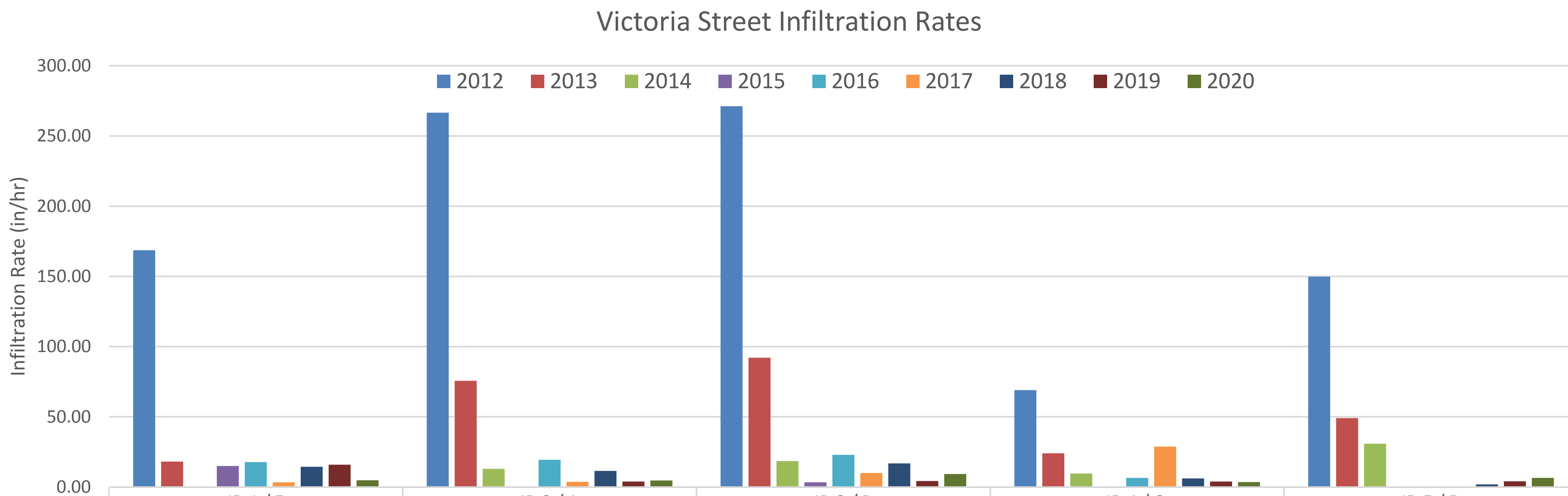
> - Analyte exceeded the maximum dection level (was not fully diluted prior to analysis)

SACKETT PARK VOLUME AND POLLUTANT SUMMARY

Event Time Interval		Sampling Data									Event Loading and Volume Data										
		TSS	TDS	VSS	TP	Ortho-P	Chloride	Ammonia as N	Total Kjeldahl Nitrogen	Nitrate + Nitrite as N	Interval Rain	Flow Volume	TSS	TDS	VSS	TP	Ortho-P	Chloride	Captured Ammonia as N	Kjeldahl Nitrogen	Nitrate + Nitrite as N
Start	End	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	In.	cu-ft	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
5/9/20 18:45	5/9/20 21:00	244	130	73	0.7	0.06	22	0.1	2.9	0.6	0.16	186.8	2.9	1.5	0.8	0.01	0.001	0.26	0.00	0.03	0.01
5/14/20 0:55	5/14/20 4:53	244	130	73	0.7	0.06	22	0.1	2.9	0.6	0.08	623.6	9.5	5.1	2.8	0.03	0.002	0.87	0.00	0.11	0.02
5/16/20 20:42	5/18/20 0:14	244	130	73	0.7	0.06	22	0.1	2.9	0.6	2.51	281713.5	4299.4	2286.8	1279.2	13.11	0.970	393.68	1.79	51.30	10.39
5/23/20 5:59	5/23/20 9:02	244	130	73	0.7	0.06	22	0.1	2.9	0.6	0.12	11484.7	175.3	93.2	52.1	0.53	0.040	16.05	0.07	2.09	0.42
5/23/20 13:14	5/23/20 15:55	244	130	73	0.7	0.06	22	0.1	2.9	0.6	0.08	10953.0	167.2	88.9	49.7	0.51	0.038	15.31	0.07	1.99	0.40
5/26/20 19:44	5/27/20 5:30	244	130	73	0.7	0.06	22	0.1	2.9	0.6	0.79	169756.7	2590.7	1378.0	770.8	7.90	0.585	237.23	1.08	30.91	6.26
6/2/20 17:58	6/2/20 20:00	244	130	73	0.7	0.06	22	0.1	2.9	0.6	0.37	27431.9	419	223	125	1.28	0.094	38.33	0.17	5.00	1.01
6/5/20 1:00	6/5/20 3:30	244	130	73	0.7	0.06	22	0.1	2.9	0.6	0.24	9075.3	139	74	41	0.42	0.031	12.68	0.06	1.65	0.33
6/6/20 20:45	6/7/20 2:00	244	130	73	0.7	0.06	22	0.1	2.9	0.6	0.29	7328.1	112	59	33	0.34	0.025	10.24	0.05	1.33	0.27
6/9/20 16:30	6/10/20 4:45	244	130	73	0.7	0.06	22	0.1	2.9	0.6	0.17	31560.2	482	256	143	1.47	0.109	44.10	0.20	5.75	1.16
6/18/20 18:50	6/18/20 23:15	**175**	**85**	**50**	**0.59**	**0.066**	**13.7**	**0.06** <	**2.92**	**0.53**	0.7	36045.2	394	191	113	1.32	0.149	30.78	0.14	6.56	1.19
6/21/20 16:45	6/21/20 19:00	**124**	**132**	**36**	**0.35**	**0.038**	**21.3**	**0.30**	**2.32**	**0.80** <	0.32	12185.0	94	100	27	0.27	0.029	16.19	0.23	1.76	0.60
6/23/20 18:30	6/23/20 23:30	244	130	73	0.7	0.06	22	0.1	2.9	0.6	0.11	5155.8	79	42	23	0.24	0.018	7.21	0.03	0.94	0.19
6/28/20 19:04	6/29/20 13:32	**319**	**140**	**91**	**1.03**	**0.052**	**25.0**	**0.06** <	**3.30**	**0.50** <	4.5	247143.7	4922	2160	1404	15.89	0.802	385.25	0.93	50.91	7.73
6/30/20 1:06	6/30/20 2:12	244	130	73	0.7	0.06	22	0.1	2.9	0.6	0.03	8835.5	135	72	40	0.41	0.030	12.35	0.06	1.61	0.33
7/5/20 14:07	7/5/20 20:00	**327**	**76**	**103**	**0.77**	**0.064**	**8.4**	**0.28**	**4.20**	**0.43**	1.99	77492.7	1582	368	498	3.70	0.310	40.54	1.36	20.32	2.07
7/6/20 8:03	7/6/20 10:15	244	130	73	0.7	0.06	22	0.1	2.9	0.6	0.15	5523.8	84	45	25	0.26	0.019	7.72	0.04	1.01	0.20
7/7/20 9:42	7/7/20 12:31	244	130	73	0.7	0.06	22	0.1	2.9	0.6	0.07	15901.9	243	129	72	0.74	0.055	22.22	0.10	2.90	0.59
7/9/20 5:13	7/9/20 7:34	244	130	73	0.7	0.06	22	0.1	2.9	0.6	0.18	14430.7	220	117	66	0.67	0.050	20.17	0.09	2.63	0.53
7/14/20 2:19	7/14/20 16:56	244	130	73	0.7	0.06	22	0.1	2.9	0.6	0.22	16612.4	254	135	75	0.77	0.057	23.22	0.11	3.03	0.61
7/18/20 3:00	7/18/20 5:46	244	130	73	0.7	0.06	22	0.1	2.9	0.6	0.55	17379.3	265	141	79	0.81	0.060	24.29	0.11	3.16	0.64
7/18/20 20:42	7/18/20 23:30	244	130	73	0.7	0.06	22	0.1	2.9	0.6	0.08	11653.9	178	95	53	0.54	0.040	16.29	0.07	2.12	0.43
7/21/20 7:42	7/21/20 12:24	**29**	**195**	**12**	**0.19**	**0.083**	**38.9**	**0.16**	**1.05**	**1.11**	0.46	29743.2	54	362	22	0.35	0.154	72.17	0.30	1.95	2.05
7/25/20 18:44	7/26/20 11:30	**122**	**84**	**39**	**0.35**	**0.057**	**10.6**	**0.06** <	**1.57**	**0.42**	1.29	66660.8	508	350	162	1.47	0.237	44.11	0.25	6.52	1.77
8/9/20 21:15	8/10/20 9:00	**202**	**321**	**71**	**0.85**	**0.017**	**68.4**	**0.06** <	**3.47**	**1.53**	0.31	18348.3	231	368	81	0.98	0.019	78.30	0.07	3.98	1.76
8/12/20 11:15	8/12/20 20:50	**27**	**117**	**12**	**0.19**	**0.056**	**18.1**	**0.07**	**1.06**	**0.69**	0.45	28211.8	48	206	21	0.34	0.099	31.91	0.12	1.86	1.22
8/14/20 20:20	8/14/20 22:30	**323**	**85**	**96**	**0.73**	0.06	**13.4**	**0.06** <	**3.45**	0.6	0.49	30532.7	616	162	183	1.39	0.105	25.50	0.11	6.58	1.13
8/17/20 1:18	8/17/20 2:27	244	130	73	0.7	0.06	22	0.1	2.9	0.6	0.05	2967.7	45	24	13	0.14	0.010	4.15	0.02	0.54	0.11
8/21/20 22:45	8/22/20 5:25	244	130	73	0.7	0.06	22	0.1	2.9	0.6	0.35	22013.5	336	179	100	1.02	0.076	30.76	0.14	4.01	0.81
8/28/20 5:25	8/28/20 7:36	244	130	73	0.7	0.06	22	0.1	2.9	0.6	0.35	12008.9	183	97	55	0.56	0.041	16.78	0.08	2.19	0.44
8/31/20 2:30	8/31/20 11:30	244	130	73	0.7	0.06	22	0.1	2.9	0.6	0.75	52423.7	800	426	238	2.44	0.181	73.26	0.33	9.55	1.93
9/7/20 15:30	9/7/20 23:41	244	130	73	0.7	0.06	22	0.1	2.9	0.6	0.19	13284.7	203	108	60	0.62	0.046	18.56	0.08	2.42	0.49
9/9/20 13:01	9/9/20 18:58	244	130	73	0.7	0.06	22	0.1	2.9	0.6	0.17	12405.9	189	101	56	0.58	0.043	17.34	0.08	2.26	0.46
9/11/20 23:06	9/12/20 4:43	**25**	**467**	**10**	**0.17**	**0.010** <	**99.9**	**0.06** <	**1.01**	**1.86** <	0.12	8003.1	12	233	5	0.09	0.005	49.93	0.03	0.50	0.93
9/21/20 14:42	9/21/20 16:27	244	130	73	0.7	0.06	22	0.1	2.9	0.6	0.03	1989.4	30	16	9	0.09	0.007	2.78	0.01	0.36	0.07
9/24/20 6:00	9/24/20 8:09	244	130	73	0.7	0.06	22	0.1	2.9	0.6	0.1	2239.6	34	18	10	0.10	0.008	3.13	0.01	0.41	0.08
9/27/20 19:00	9/27/20 20:48	244	130	73	0.7	0.06	22	0.1	2.9	0.6	0.05	2308.5	35	19	10	0.11	0.008	3.23	0.01	0.42	0.09
9/30/20 17:09	9/30/20 22:42	244	130	73	0.7	0.06	22	0.1	2.9	0.6	0.07	10276.3	157	83	47	0.48	0.035	14.36	0.07	1.87	0.38
10/11/20 23:53	10/12/20 11:49	244	130	73	0.7	0.06	22	0.1	2.9	0.6	1.1	71393.7	1090	580	324	3.32	0.246	99.77	0.45	13.00	2.63
Sum											20.04	1403285	21416	11391	6372	65.3	4.83	1961.0	8.9	255.5	51.8
Average		167.3	170.2	52.0	0.52	0.049	31.8	0.12	2.43	0.87		35982	549	292	163	1.7	0.12	50.3	0.2	6.6	1.3
Weighted Avg		244.5	130.0	72.7	0.75	0.055	22.4	0.10	2.92	0.59											
STDEV		123.4	128.0	36.2	0.31	0.024	29.9	0.10	1.19	0.52											
Min		25.0	76.0	10.0	0.17	0.010	8.4	0.06	1.01	0.42											
Max		327.0	467.0	103.0	1.03	0.083	99.9	0.30	4.20	1.86											

< Sample was not detected above the method detection limit (value reported)
GREY FONT Events with no sampling data (weighted average concentration used)
BOLD Sampling event

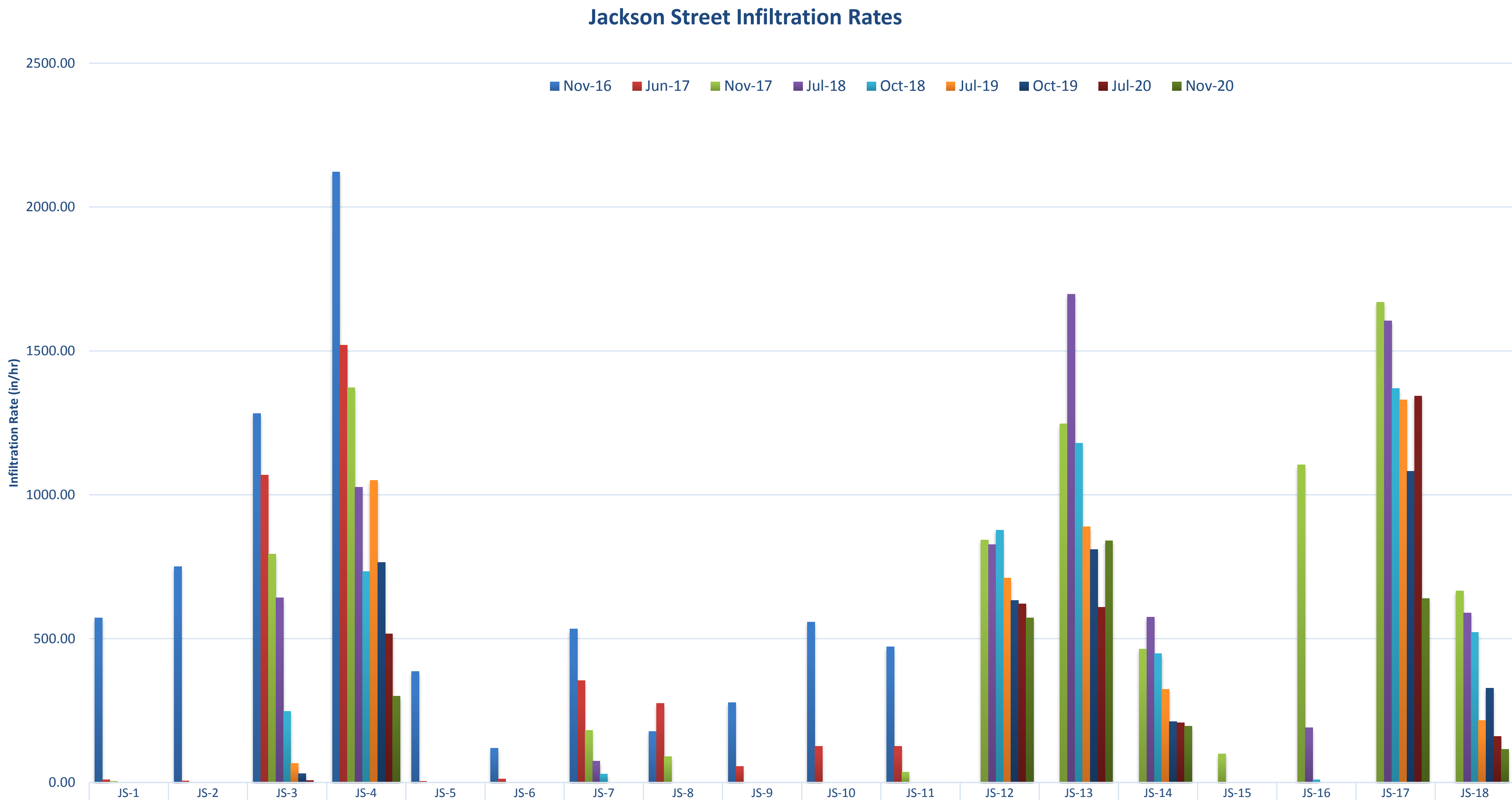
City of Saint Paul
2020 Water Quality and Quantity Report
Chart D.1
WSB Project No.: 015938-000



	IR-1 / E	IR-2 / A	IR-3 / B	IR-4 / C	IR-5 / D
2012	168.60	266.60	271.10	69.10	149.80
2013	18.10	75.70	92.20	24.00	49.20
2014	0.00	12.93	18.56	9.72	30.81
2015	15.11	0.00	3.44	0.00	0.00
2016	17.77	19.38	22.97	6.55	0.00
2017	3.41	3.78	10.05	28.91	0.00
2018	14.51	11.47	16.92	6.25	1.92
2019	15.89	4.06	4.35	4.03	4.21
2020	4.94	4.68	9.39	3.65	6.56

Monitoring Location

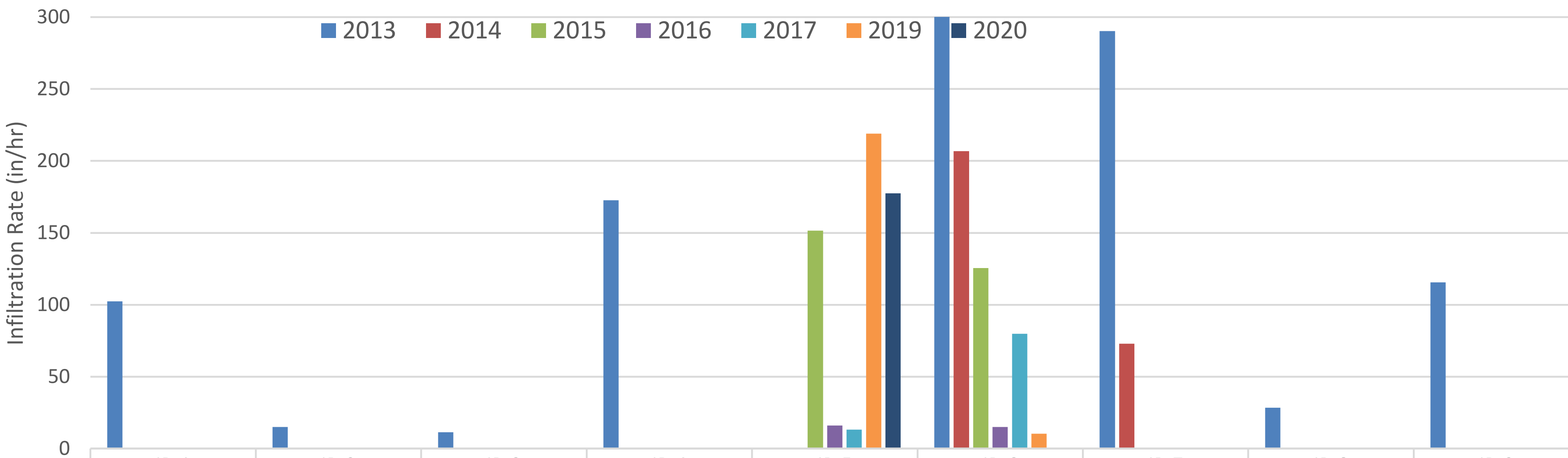
City of Saint Paul
2020 Water Quality and Quantity Report
Chart D.2
WSB Project No.: 015938-000



	JS-1	JS-2	JS-3	JS-4	JS-5	JS-6	JS-7	JS-8	JS-9	JS-10	JS-11	JS-12	JS-13	JS-14	JS-15	JS-16	JS-17	JS-18
Nov-16	572.60	750.40	1282.07	2122.21	385.88	118.70	533.72	177.47	277.93	557.90	471.54							
Jun-17	9.29	6.30	1069.04	1520.13	4.49	12.12	353.94	275.34	56.12	125.46	125.40							
Nov-17	3.86	0.00	793.76	1371.96	0.00	0.00	181.73	90.77	2.38	2.07	35.49	843.29	1246.74	464.43	99.97	1104.44	1669.95	665.40
Jul-18	0.00	0.00	642.24	1026.71	0.00	0.00	73.71	0.00	0.00	0.00	0.00	827.22	1696.93	575.13	0.00	190.07	1604.98	589.63
Oct-18	0.00	0.00	247.09	733.69	0.00	0.00	29.44	0.00	0.00	0.00	0.00	877.09	1179.25	447.48	0.00	9.02	1369.65	521.52
Jul-19	0.00	0.00	67.07	1050.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	710.52	889.49	323.26	0.00	0.00	1329.45	215.70
Oct-19	0.00	0.00	30.35	764.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	633.28	809.62	211.40	0.00	0.00	1082.13	327.70
Jul-20	0.00	0.00	7.05	516.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	620.41	608.65	207.81	0.00	0.00	1343.21	160.40
Nov-20	0.00	0.00	0.00	299.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	572.01	839.81	195.40	0.00	0.00	640.06	115.47

City of Saint Paul
2020 Water Quality and Quantity Report
Chart D.3
WSB Project No.: 015938-000

Hamline Midway Library Infiltration Rates



	IR-1	IR-2	IR-3	IR-4	IR-5	IR-6	IR-7	IR-8	IR-9
2013	102.4	14.9	11.4	172.7	0	1125.3	290.2	28.4	115.6
2014	0	0	0	0	0	206.7	73	0	0
2015	0	0	0	0	151.5	125.6	0	0	0
2016	0	0	0	0	16	15	0	0	0
2017	0	0	0	0	13.11	79.89	0	0	0
2019	0.00	0.00	0.00	0.00	218.96	10.30	0.00	0.00	0.00
2020	0.00	0.00	0.00	0.00	177.48	0.00	0.00	0.00	0.00

Monitoring Location

Battle Creek Logger - 6/12/2020

Battle Creek Ponding – 6/29/20

Battle Creek 8/10/2020

Battle Creek – 10/12/2020

Damage to rain garden overflow at Beacon Bluff – 6/12/20

Beacon Bluff BMP – 10/5/2020

Saint Albans BMP – 10/5/2020

Victoria BMP – 6/12/2020

Sackett Park Ponding – 6/29/2020

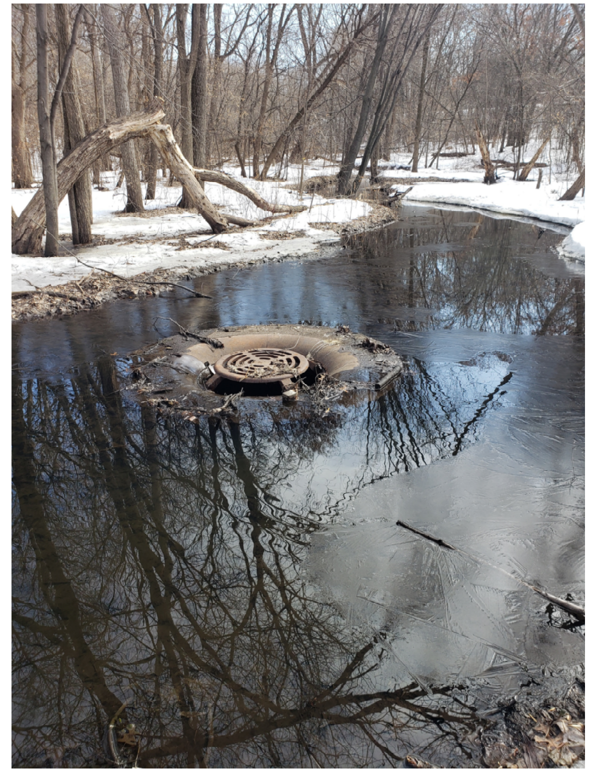
Barge Channel Road Pond – 7/20/2020

Hampden Park Pre-treatment – 10/5/2020

Hampden Park Pre-treatment – 10/5/2020

Victoria BMP 10/5/2020

Sackett OCS and Park 3/16/2020



Sackett Park OCS – 6/12/2020

Sackett OCS - 8/18/2020

Sackett Park OCS – 9/23/2020

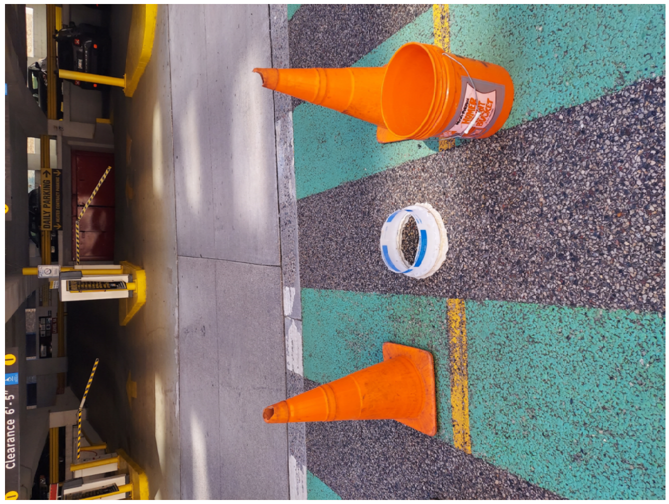
Sackett OCS – 10/12/2020

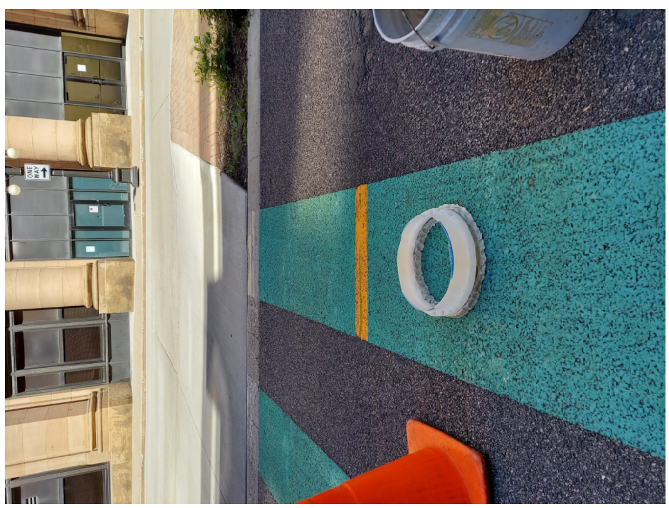
Jackson Street Bike Trail – 7/23/20

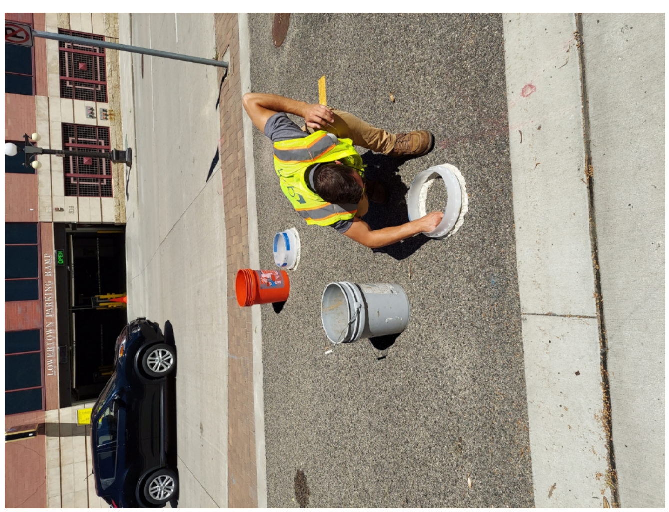


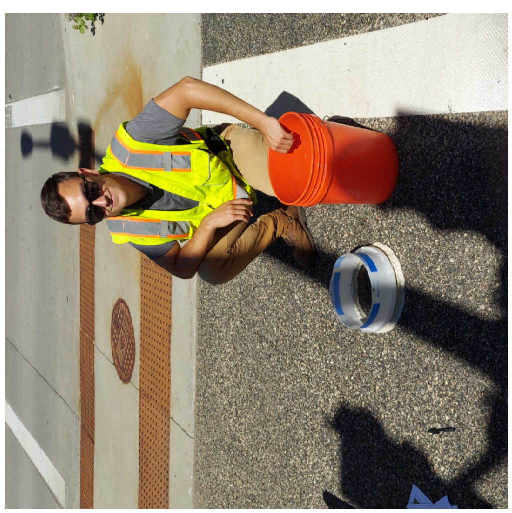





Clearance 6'5"
DAILY PARKING







Victoria Permeable Pavers – 7/23/2020

STORMWATER MONITORING PROTOCOL

2020 Stormwater Monitoring Program
Field Standard Operating Procedures

FOR THE CITY OF
ST. PAUL, MINNESOTA

SAINT PAUL
The Most Livable City in America

wsb

TITLE PAGE

TABLE OF CONTENTS

I. Contents

Attachments:

WSB Confined Space Entry Permit

Metropolitan Council Environmental Services Laboratory Chain-of-Custody (BMP Infiltration Sites)

I. Objectives

This section provides a summary of objectives for this monitoring effort. These objectives are presented in question form anticipating that the answers will be obtained through analysis of the data collected as part of this monitoring program.

a) How do team members maintain a safe work environment?

b) How much stormwater runoff volume reduction is achieved by each BMP on an event and annual basis?

c) What is the average measured infiltration rate of each BMP?

d) How often does each BMP require maintenance?

e) How many volume reduction credits are available at each BMP? Do they perform in accordance with or exceed watershed district rules?

f) What is the cost per cubic-foot of volume reduction actually being achieved by each BMP?

g) What is the mass of pollutants (TP, TSS, chlorides, etc.) removed from the stormwater system by each BMP on an average annual basis?

II. Safety Overview

The following safety guidelines have been developed to ensure that all WSB team members are providing and maintaining a safe work environment. Proper planning and situational awareness can help team members identify and eliminate potentially dangerous situations. Every team member has stop work authority if they feel endangered by unsafe working conditions. All team members are encouraged to report unsafe acts or unsafe working conditions to their supervisor as soon as possible. The following sections describe potentially hazardous working conditions and hazard mitigation procedures.

II.1 Adverse Weather Conditions:

Field team members will likely encounter a wide range of weather conditions during field duties. Field staff should be aware of the weather conditions and take proper measures to protect themselves from the elements.

- During excessive heat and sun conditions, field staff should stay hydrated, don skin protective clothing, and apply sunscreen .During excessive cold conditions, field staff should dress in layers and avoid perspiration
- During lightning producing conditions, field staff must seek shelter in a work vehicle or other safe location if a lightning strike or thunder is observed. The field staff should wait at least 30 minutes from the last lightning strike before resuming outdoor activities. <u>Lightning safety is especially important due to the likelihood of thunderstorms during stormwater sampling events</u>
- Field staff should be aware of the signs of heat exhaustion, heat stroke, hypothermia, and frostbite, and have an understanding of basic first aid procedures

II.2 Working in the street:

At times, it will be necessary for team members to access manholes in roadways.

- While working in roadways, field staff should be visible to traffic, don reflective vests and hardhats, and utilize vehicle hazard lights
- Field staff should park close to the manhole and encompass work area with safety cones
- Field staff should be aware of any unauthorized entry into the work area by untrained personnel or the public

II.3 Confined Space Entry[1]

Only staff with OSHA Confined Space Entry training can complete a confined space entry. When entry to confined spaces is required for monitoring activities, the following checklist must be reviewed and adhered to:

<u>Permits/Notifications:</u>

- Execute a confined space entry permit form and follow appropriate protocols (**Confined Space Entry Permit Attached**). See WSB's safety office, Trent Noeker, for a copy of the form
- Obtain a no fee lane use right-of-way permit if work is to be done in the street:
    - St. Paul ROW: 651-266-6151

[1] Review <u>Entering and Working in Confined Spaces</u>, Confined Space Entry Program for WSB & Associates, Inc. for WSB's confined space entry protocols prior to entering a confined space.

- ☐ Notify City staff
    - St. Paul Sewer Maintenance: 651-266-9836
- ☐ Notify local fire department of planned confined space entry

Required Safety Gear:

- ☐ Hard hat
- ☐ Sturdy boots
- ☐ Reflective safety vest
- ☐ 4-Gas Monitor
- ☐ Tripod
- ☐ 3-way lifeline winch
- ☐ Body harness
- ☐ Air ventilation blower and generator
- ☐ 28" reflective traffic cones and vehicle hazard lighting

Gear Maintenance:

- ☐ **Calibrate 4-gas monitor every 180 days:** The 4-gas monitor will indicate when calibration is needed. Viking Safety Products will calibrate the device free of charge. Call Viking for more information: 651-646-6374.
- ☐ **Inspect the tripod for wear and damage annually:** Viking Safety Products will inspect the equipment and provide a formal certificate of inspection. Call Viking for more information: 651-646-6374

General Confined Space Entry Procedures:

- ☐ Never complete a confined space entry during a rain event. Check the weather forecast and ensure clear conditions for the duration of the entry.
- ☐ Prior to leaving the office, confirm all equipment is functioning and that monitoring equipment is in compliance with the calibration schedule.
- ☐ Secure the area from untrained personnel and pedestrians.
- ☐ Ensure team members are knowledgeable of the roles and responsibilities of the confined space entrant, attendant, and supervisor.
- ☐ Complete air monitoring prior to, and for the duration of the confined space entry. Ensure team members are knowledgeable of the 4-gas monitor alarms and unsafe gas levels that prompt an evacuation of the confined space.
- ☐ Utilize a rope and bucket to deliver equipment to the entrant.
- ☐ Ensure there is a reliable method of communication between all team members completing the confined space entry.

III. Monitoring Sites

Below is a summary of sites which are included in this monitoring effort. Equipment and methods used and monitoring parameters analyzed for each site are provided for quick reference. (See Figures for site locations and monitoring configuration.)

III.1 Beacon Bluff:

This site consists of an infiltration basin situated over the top of an underground infiltration pipe gallery system. Stormwater flows into the infiltration basin from three storm sewer outfalls and into the underground chambers from a single storm sewer pipe. An outlet pipe connected directly to the underground chambers conveys overflow back to the storm sewer when the system reaches capacity.

<u>Equipment:</u>

3 – ISCO 2150 Area velocity sensors (Upstream, Downstream, WPO)
5 – System Level Loggers
- BMP Pipe
- OCS
- BaroTroll (atmospheric logger)

2 – Rugged Troll 100
- GW-50
- GW-53

1 – ISCO 6712 Portable Water Quality Sampler

<u>Monitoring Parameters:</u>

- Rainfall
- Flow Rate/Volume
- Water Level/Infiltration rate
- Water Quality **(NPDES Permit Required Parameters)**

III.2 Battle Creek:

Battle Creek flow from Battle Lake, passing through residental areas of Maplewood and St. Paul before it empties into Pigs Eye Lake. Water flows into a 72” arch pipe and daylights on the west side of McKinght Road. The sensor is located on the east side of McKight Road near the inlet into the storm sewer system.

<u>Equipment:</u>

1 – ISCO 2150 Area Velocity Sensors (72” Arch Pipe)
1 – Level Troll 500
- Battle Creek

1 – ISCO 712 Portable Water Quality Sampler

<u>Monitoring Parameters:</u>

- Rainfall
- Flow Rate/Volume

- Water Level
- Water Quality **(NPDES Permit Required Parameters)**

III.3 St. Albans:

The St. Albans Street infiltration system was constructed in 2010 to provide volume reduction along the Central Corridor. The system was constructed in an offline configuration. When the system reaches its storage capacity, water stops flowing into the system and continues through the storm sewer. The system includes a pretreatment structure which consists of box culvert sections and baffled weirs to provide skimming and settling of runoff prior to entering the infiltration chamber.

<u>Equipment:</u>

3 – ISCO 2150 Area Velocity Sensors (Upstream, Downstream)
1 – ISCO 6712 Portable Water Quality Sampler
1 - Level Troll 500
BMP Pipe

<u>Monitoring Parameters:</u>

- Rainfall
- Flow Rate/Volume
- Water Level/Infiltration Rate
- Water Quality **(NPDES Permit Required Parameters)**

III.4 Sackett Playground:

Sackett Playground consists of ball fields and a roughly 6 acre wooded area containing a flood plain that takes stormwater from Flandrau and Case Street. Water not infiltrated in the flood plain is conveyed from an outlet structure underneath a ball field through a 42" round pipe towards Ames Avenue.

<u>Equipment:</u>

1 - Level Troll 500
OCS Structure in floodplain
1 – ISCO 2150 Area Velocity Sensor (48" pipe)
1 – ISCO 6712 Portable Water Quality Sampler

<u>Monitoring Parameters:</u>

- Rainfall
- Water Level/Infiltration Rate
- Flow Rate/Volume
- Water Quality **(NPDES Permit Required Parameters)**

III.5 Hampden Park

The Hampden Park infiltration gallery was constructed in 2014. The system consists of eight parallel perforated pipes that are five feet in diameter and range in length from 40 to 100 feet. Runoff is routed to the pretreatment system via a 24" RCP from main storm sewer near Hampden and Raymond Avenues. From that location, stormwater enters a pretreatment structure which consists of a box culvert section and baffled weir to provide skimming and settling of runoff prior to entering the infiltration chamber. The infiltration gallery receives flow from a second inlet location along Raymond Avenue, farther to the north. When the system reaches full capacity, stormwater is routed back to the storm sewer via a 24" pipe from the southeast side of the system.

Equipment:

1 – ISCO 2150 Area Velocity Sensor (Upstream)
1 – ISCO 6712 Portable Water Quality Sampler
1 – Rugged Troll 100
BMP

Monitoring Parameters:

- Rainfall
- Water level/Infiltration rate
- Flow Rate
- Water Quality **(NPDES Permit Required Parameters)**

III.6 Victoria Street

This site was constructed in an offline configuration. Flow is diverted from the main storm sewer to the system. When the system has reached its storage capacity, water stops flowing into the system and continues through the storm sewer. The system includes a pretreatment structure which consists of a box culvert section and a baffled weir to provide skimming and settling of runoff prior to entering the infiltration chamber. A permeable paver parking area is located above this system and discharges filter stormwater into it via an 8-inch drain tile.

Equipment (Complete set at each of the three ponds) :

2 – ISCO 2150 Area velocity sensors (Upstream and Downstream)
1 – ISCO 6712 Portable Water Quality Sampler
1 – Rugged Troll 100
BMP

Monitoring Parameters:

- Rainfall
- Water Level
- Flow Rate
- Water Quality **(NPDES Permit Required Parameters)**

IV. Preparation and Logistics

Preparedness is crucial to successful implementation of this monitoring program. Anticipation of target storm events, readiness with field equipment, and understanding of confined space entry procedures play a role in this process. This section provides essential information related to these items.

IV.1 Storm Selection Criteria for Water Quality Sampling

The activities below should be completed at least weekly to determine the potential need to prepare sampling equipment and mobilize crews to undertake water quality samplings:

- ☐ Track storms using local ALERT systems and by accessing National Weather Service forecasts: www.nws.noaa.gov
- ☐ Determine Quantity of Precipitation Forecast (QPF) for an impending storm
- ☐ If QPF is greater than 0.1-inches initiate sample collection preparation procedures (see **Section VI**)

IV.2 Portable Sampler (ISCO 6712) Preparation

This is to be done after all sampling events and or when receive a low battery alarm.

- ☐ Change out samples bottles in automated sampler with clean bottles
- ☐ Reset automated sampler for a new event. Update the sample flow volume interval if more or less samples need to be collected based on lab requirements, storm event size, or modification to protocols
- ☐ Ensure that batteries are adequately charged and positioned
- ☐ Make sure clean grab sample bottles are on hand

V. Visual Inspection and Manual Data Collection

Routine BMP inspections conducted on a visual basis will provide information related to specific maintenance needs and provide information that may be pertinent to any anomalies in the water quality sampling results. Additionally, the pervious pavement infiltration studies will consist of manual data collection in accordance with ASTM method C1701. The following section provides field guidance for those tasks.

Infiltration SystemsFrequency:

- Once per month

Visual Inspection:

- Identify significant obstructions present in the source pipes
- Indicate whether there is standing water in the infiltration system
- Indicate whether there is evidence of illicit discharges
- Identify any structural issues in the system
- Describe other observations
- Sketch inspection observations as appropriate

Manual Data Collection:

- Take digital photos of all visual inspection parameters
- Quantify the amount of sediment present in the system's:
  - Sump manhole
  - Pretreatment device
  - Stormwater storage area
- Quantify the amount of floatables present in the system's:
  - Sump manhole
  - Pretreatment device
  - Stormwater storage area

Required Equipment:

- Measuring rod
- Digital camera

Required Forms:

- Infiltration BMP Inspection and Maintenance Form

V.1 Pervious Pavement Infiltration Tests

Frequency:

- Once per year

Visual Inspection:

- Identify number and location of missing pavers (if present)
- Identify significant cracking, chips, or other damage
- Identify location and approximate depth of deflection

Manual Data Collection:

- ☐ Take digital photos of all visual inspection parameters
- ☐ Record depth of aggregate at six (6) locations (if pavers)
- ☐ Measure infiltration rate in six (6) locations
    - o Follow the modified ASTM method C1701
    - o Locations should be marked by a drill hole or a nail so that the same locations can be tested each time
    - o 3 locations should be within 1 foot of the concrete strip separating the permeable surface from the roadway

Equipment:

- ☐ Infiltration measurement apparatus
- ☐ Water tank and feeder hose
- ☐ Digital camera
- ☐ Scale
- ☐ 12” PVC Pipe
- ☐ Plumbers putty

Required Forms:

- ☐ Permeable paver inspection form

Monitoring Parameters:

- ☐ Infiltration rate
- ☐ BMP visual inspection

VI. Sample Collection, Preservation, and Laboratory Analysis

The following procedures must be followed to maintain a consistent approach for obtaining composite water quality samples and to reduce the risk of cross contamination when retrieving and transporting samples to the laboratories:

VI.1 Composite Sampling Using Automated Sampler:

Estimating pollutant loads as part of this monitoring program will include determination of the event mean concentration (EMC) for the target storm events using composite samples. To obtain composite samples that are representative of the storm events analyzed, the following minimum number of aliquots and percent capture values should be met:

Total Event Precipitation (in.)	Minimum Acceptable Number of Aliquots	Percent Capture Requirement[2]
0 – 0.25	6	85
0.25 – 0.50	8	80
0.50 – 1.0	10	80
> 1.0	12	75

To meet these requirements the automatic samplers should be programmed to collect samples at flow-paced intervals. Determination of the flow volume between sampling events should be based on the following information:

Total Event Precipitation (in.)	Robie Street Outfall	Beacon Bluff
	Runoff Volume (cu-ft)	Runoff Volume (cu-ft)
0.10-0.15"	30,840	4,500
0.25"	51,400	20,986
0.5"	102,800	63,000
1.0"	205,600	156,756
2.0"	411,200	373,550
3.0"	616,800	657,879

Program Automated Sampling Parameters:

Based on the information above and other considerations, the following provides the parameters that should be used for programming the automated samplers:

- **Start Time:** Begin sampling at specific water level depths
    - Hampden Park: 0.75-inches
    - Beacon Bluff: 1.25-inches
    - Saint Albans: 1.1-inches

[2] $Percent\ storm\ capture = \frac{flow\ volume\ that\ passed\ during\ sample\ collection}{total\ flow\ that\ passed\ during\ the\ entire\ monitoring\ event}$

- Victoria: 1.15-inches
- Sackett: 3.5-inches
- Battle Creek: 4-inches

- **Pacing:** Set sampler to collect samples at constant flow volume intervals
  - Beacon Bluff: minimum 1,500 cu-ft
  - Saint Albans: 200 cu-ft
  - Victoria: 175 cu-ft
  - Hampden Park: 300 cu-ft
  - Sackett: 250 cu-ft
  - Battle Creek: 1,500 cu-ft
- **Distribution:** Multiple samples per bottle - sample aliquot volume should be no less than 200 mL

Multiple bottles will be collected for each event. The testing laboratory should be directed to develop a composite sample with the collection of bottles by either batch mixing or by combining equal fractions of each bottle into a single bottle or container.

VI.2 Grab Sample Collection

Grab samples will be collected for E coli analysis at all monitoring locations Samples will be collected from the influent stormwater stream prior to entering the systems. The purpose of E. coli analysis is to ensure that human effluent is not contaminating the water. The following provides the process for obtaining the grab samples:

<u>Sampling Locations:</u>

- Man holes up stream of the automatic samplers

<u>Procedures:</u>

- Collect 3 samples (one every 10 minutes for composite testing) while it is raining.
- Use sterile sample bottles with an unbroken seal when testing for e-coli
- Place sample bottle directly below or in outfall water stream to collect the sample

<u>Required Equipment:</u>

- Personal rain gear
- Powder-free nitrile gloves
- 1-Liter plastic sample bottles and lids
- Sterile bacteria sample bottles and lids from laboratory
- Bottle labels and water proof pen
- Chain of custody forms for laboratory
- Manhole pick
- Cooler with ice
- Grab sample collection rod

VI.3 Analytical Parameters:

The following table provides a list of parameters and the sampling frequency as established by Permit No. MN0061263. Samples collected from the automated samplers will be analyzed for the water quality parameters in Table 1 of the City of St. Paul's MS4 permit (when volumes allow).

Monitoring Parameters		
Parameters	**Sample Type**	**Frequency**
BOD, Carbonaceous 5-Day (20 Deg C)	Composite or Grab	Quarterly
Chloride, Total	Composite or Grab	As noted for loading calculations (Par V.C7.f)
Copper, Total (asCu)	Composite or Grab	Monthly
E. coli	Grab	Quarterly
Flow	Measurement	
Hardness, Carbonate (as CaCo3)	Composite or Grab	Monthly
Lead, Total (as Pb)	Composite or Grab	Monthly
Nitrite Plus Nitrate, Total (asN)	Composite	As noted for loading calculations (Par V.C7.f)
Nitrogen, Ammonia, Un-ionized (as N)	Composite	Quarterly
Nitrogen, Kjeldahl, Total	Composite	As noted for loading calculations (Par V.C7.f)
pH	Composite or Grab	Quarterly
Phosphorus, total Dissolved or Ortho	Composite	Quarterly
Phosphorus, Total as P	Composite	As noted for loading calculations (Par V.C7.f)
Precipitation	Measurement	1 x Day
Solids, Total Dissolved (TDS)	Composite	Quarterly
Solids, Total Suspended (TSS)	Composite	As noted for loading calculations (Par V.C7.f)
Sulfate	Composite or Grab	2 x Year
Volatile Suspended Solids (VSS)	Composite	As noted for loading calculations (Par V.C7.f)
Zinc, Total (as Zn)	Composite or Grab	Monthly

VI.4 Sample Preservation

- Collect samples from automated sampler within 24 hours
- Composite individual sample containers from the autosampler into one, clean, 4-liter jug, provided by MCES Lab
  - If the storm event produced volume in exceess of 4 liters, the sample volume shall be composited in the churn sampler splitter.
  - Fill the churn will all samples collected from the event. One staff shall provide constant mixing using the paddle, while the other staff shall open the spickot, gradually filling the lab container with the mixed sample
  - The churn sampler splitter shall be cleaned between uses
- The sample containers shall be labeled with the relevant Site and sample information which shall include:

- Site Name [**See attached Chain of Custody (CoC)** examples for Site IDs].
- The composite start and end time, as indicated on the autosampler
- Name of staff collecting the sample

- The sampler shall complete a CoC form to submit with the sampler or communicate sample information to the Project Manager to complete the form electronically, and submit to the lab
- Place all samples to be analyzed in a cooler with ice
  - Target holding temperature for samples is 4˚C
- Deliver samples to lab

VI.5 Cleaning of Sample Equipment and Bottles

- **Clean sample bottles and churn splitter after every use:** wash them with a brush and soapy water or use a dishwasher
- **Clean the suction line, strainer, and pump tubes twice per year:** Place the end of the suction line in a cleaning solution and pump it through the system. Rinse with clean water

VI.6 Quality Assurance/Quality Control:

- Before samples are collected, make sure that all sampling equipment and bottles are cleaned using the appropriate cleaning procedures
- Wear powder-free nitrile gloves when handling bottles, lids, tubing, or strainers.
- Never touch the inside surface or exposed end of a sample bottle or lid, even with a gloved hand
- Never let any material other than sample water touch the inside surface or exposed end of sample bottle
- Avoid allowing rain water to drip from rain gear or other surfaces into sample bottles

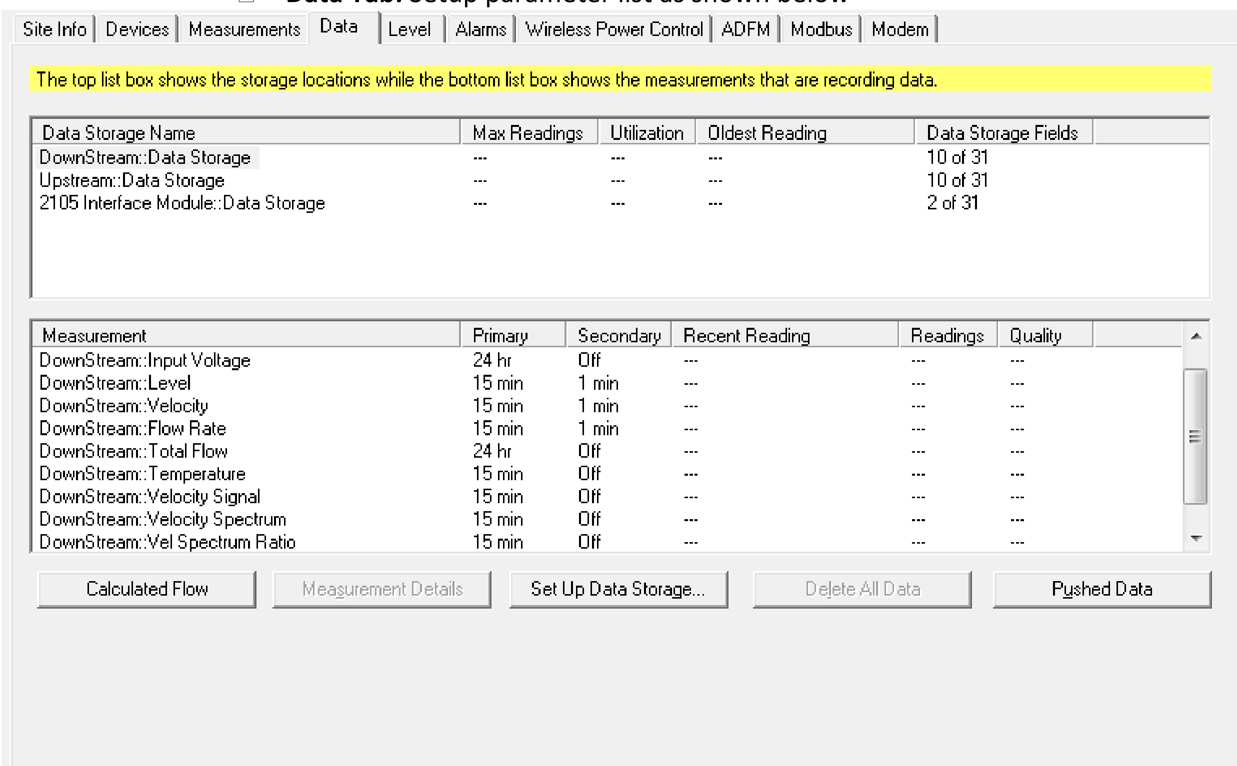
VII. Operation and Maintenance of Monitoring Equipment

The following provides a summary of procedures to follow for operating and maintaining monitoring equipment for collection of flow, rainfall, water level, and sampling data. These procedures should be followed when the devices are initially setup and during routine data dumps and maintenance activities.

VII.1 Flow Meters (ISCO 2150)[3] and Interface Modules (ISCO 2105/2103)[4]:

Setup/Initialization:

- **Software Required:** Flowlink
- **Quick Connect:** Connect the device to a laptop using the communication cable. Start Flowlink and select Quick Connect Icon in the tool bar. Use “Direct” Type Connection and check “Create New Site” for new instillation. Click on the large *2100 Instruments* button to connect
- **Site Info Tab:** Add applicable information and “Synchronize Site’s Time to Computer’s”
- **Devices Tab:** Change Module Names for Area Velocity Meters to reflect location
- **Data Tab:** Setup parameter list as shown below



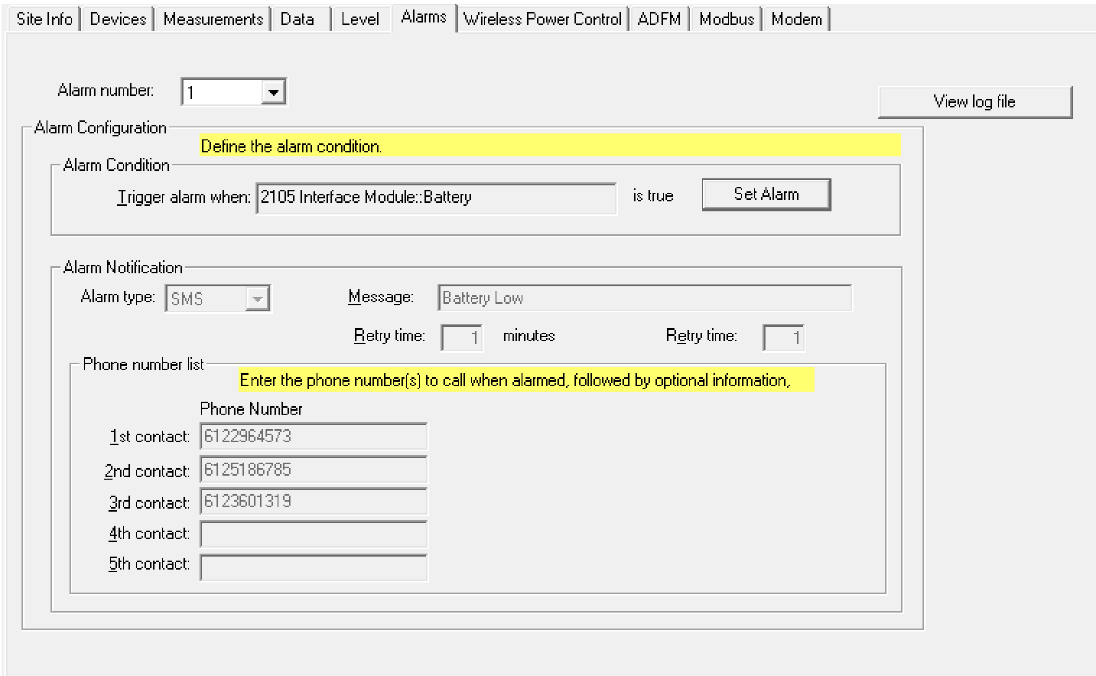
- **Measurement Details:** Set units for all measurements (in, cfs, or cf)
  - **Level:** If flow is present, measure the water depth from the water surface to the channel bottom. Enter the value on the *Level*

[3] See 2150 Area Velocity Flow Module and Sensor – Installation and Operation Guide, Teledyne ISCO, Rev. March 9, 2011.

[4] See 2105 Interface Module – Installation and Operation Guide, Teledyne ISCO, Rev. July 8, 2010.

measurement tab in FLowlink. If no flow is present, enter a value of zero. (Level measurements may drift over time, so it is important to do this routinely.)

  - **Velocity Measure Tab:**
    - **No Velocity Data:** Uncheck the *"Set flow rate to zero if no velocity data"* checkbox on the *Velocity* measurement tab in Flowlink. Data can be post processed to remove low level velocity noise
    - **Synchronize Velocity Measurements:** Check the Prevent *interference box* on the *Velocity* measurement tab in Flowlink to prevent velocity signal interference at sites with multiple modules
  - **Flow Rate Tab:** Input pipe shape and diameter.
- **Data Storage Rates:** Click on *Set Up Data Storage…* button on a measurement tab in Flowlink to set storage rate.
  - Level, Velocity, Flow Rate, Total flow,: Primary = *15 min*, Secondary = *1 min* (Flow Depth > 1in)
  - Temperature, Velocity Signal, Velocity Spectrum, Velocity Spectrum Ratio: Primary = 15 min
  - Input Voltage, Wireless Signal: Primary = *24 hours*
    Note: In "Condition Builder" set Hysteresis to 0.5" and Duration to 5 min for all Sampler Level Triggers.
- **Pushed Data Capability:** Click the Pushed Data button to set up a schedule for the data to be pushed
  - **Set IP address:** 207.173.231.99, Port 1700
  - Use Primary Data Transmission interval of *4 hours*
- **Alarms Tab:**
  - **Alarm Condition:** Define alarm condition using Equation Builder
    - Low Battery: When Modem Input voltage drops below 10V



- ☐ **Sampler Interface:**
  - o **Set Up Data Storage:** Select "Enable Logging"
  - o **Sampler enable:** Enable on Trigger - using equation builder to specify level threshold to enable sampler

    Note: In "Condition Builder" set Hysteresis to 0.5" and Duration to 5 min for all Sampler Level Triggers
  - o **Sampler Pacing:** input desired flow pulsing interval in cubic feet

<u>Routine Data Retrieval and Re-initialization:</u>

- ☐ **Frequency:** Once per month
- ☐ **Quick Connect:** Connect the device to a laptop using the communication cable Start Flowlink and click on the large *2100 Instruments* button to connect
- ☐ Download data and transfer to WSB server folder K:\01610-100\WR\Flow Data
- ☐ Set water level to zero. (Make sure to annotate date and time of level reset)

<u>Routine Maintenance:</u>

The following maintenance activities must be completed routinely and during every field visit:

- ☐ **Check desiccant cartridges:** When entire length of the cartridge turns pink or green, the desiccant needs to be replaced
- ☐ **Check battery voltage:** Replace both batteries when voltage is below 10
- ☐ **Check hydrophobic filter:** Rinse and dry if the filter is plugged
- ☐ **Check connector O-rings:** Replace or lubricate as needed
- ☐ **Check flow sensor:** Remove debris and clean sensor as needed
- ☐ **Check sensor cable for damage:** Replace if needed. Loose cable should be fastened to the structure

VII.2 Portable Sampler (ISCO 6712)[5]:

Setup/Initialization:

- **Software Required:** Flowlink
- **Measure length of suction hose:** Length will be a required input during Program setup. Cut hose to whole ft. Increments if required. Hose should generally slope downward toward the sampling probe
- **Use Standard Program:** Follow Steps in Table 4-2 of the operation guide for flow pacing. Make the corresponding deviations listed below. Standard Programing Flow Charts can also be found in Appendix A in the operation guide (Figures A-2 & A-3)
    - (3)Set appropriate Site Description (i.e. Robie Street, Beacon Bluff)
    - (8) Select 1 pulse between sample events
    - (9) Samples/Bottle
    - (11) 5 Samples/Bottle (200 mL each)
    - (12) No Delay to Start
- **Automatically index to next bottle when sampler is enabled:** This will allow each storm event to be composited separately, but may decrease the overall available sampling volume during multiple events
    - From home screen, enter 6712.9 and hit enter
    - Enter Code: 1199 and hit enter (Sampler should report Code Accepted)
- **Calibration:** The Sampler delivers accurate sample volumes without calibration. If you find that sample volumes vary significantly from the programmed values, first check the suction line for proper installation. Be sure it slopes continuously downhill to the liquid source and drains completely after each sampling cycle. Refer to Section 4.12 of the operation guide for additional calibration notes
    - Note: If sampler does not disable when the program is set to run, check all cable connections and then make sure the 2105 is configured correctly. If the water level is below the trigger threshold, the 2105 should be indicating that the Sampler is disabled. If the sampler is still not disabling, the cable or the sampler may be malfunctioning. The cable can be diagnosed by removing the sampler cable and using a paper clip to short pins “B” and “F” on the back of the sampler control head

Routine Data Retrieval and Re-initialization:

- **Frequency:** Once per month
- **Interrupt Program:** Press the Stop button once to pause the program. Scroll down to “VIEW DATA” and check for errors with sampling. See page 4-19 in the operators guide for more information. When complete, select “RESUME PROGRAM”

Routine Maintenance:

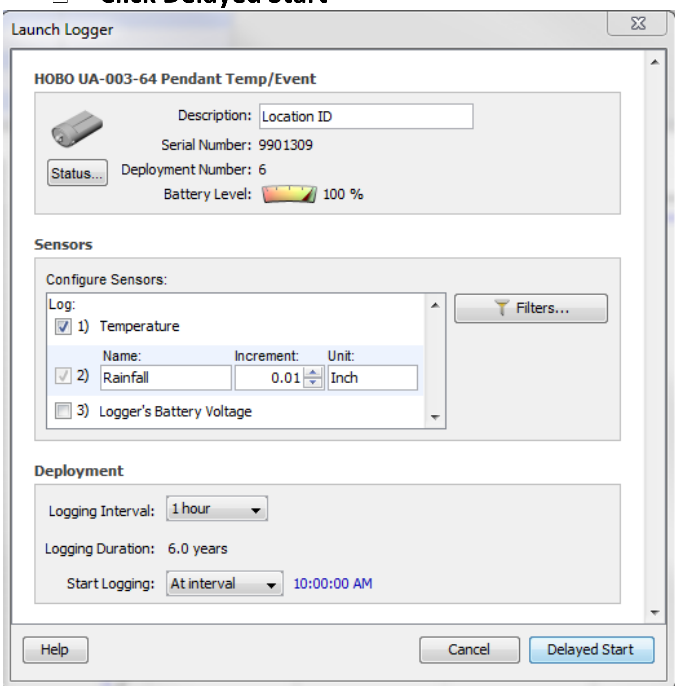
[5] See 6712 Portable Samplers – Installation and Operation Guide, Teledyne ISCO, Rev. April 11, 2011.

- ☐ **Check the pump tube for wear:** Replace if necessary
- ☐ **Check the pump tubing housing:** Clean if necessary
- ☐ **Check the suction line:** Change if necessary
- ☐ **Check the humidity indicator:** Desiccant should be replaced when all indicator areas turn light pink or white
- ☐ **Check the controller's internal battery status:** Replace the battery every five years
- ☐ **Check the keypad label:** If it has bubbles under it, the air inside the controller has expanded, and pressure can be released by unscrewing the flow meter cable or connector cap on the back of the controller

VII.3 Data Logging Rain Gauge:

Setup/Initialization:

- **Software Required:** Onset HOBOware.
- **Connect Rain Gauge:** Open HOBOware and select Launch Device.
- **Configure Sensors:**
  - Log 1) Temperature
  - Log 2) Rainfall
    - Name: Rainfall
    - Increment: 0 .01
    - Unit: Inch
- **Deployment**
  - Logging Interval: 1 hour
  - Start Logging: At Interval
- **Click Delayed Start**



Routine Data Retrieval and Re-initialization:

- **Frequency:** Once per month
- **Connect to device using HOBOware:**
- Download data using readout device and transfer to WSB server folder K:\01610-100\WR\Exported Data. (Do not stop logging before reading out the logger until the end of the season)

Routine Maintenance:

- **Check the filter screen, funnel, and tipping mechanism for debris** (dirt, bugs, bird droppings, etc.): Clean with mild soap and water
- **Check the needle bearings and apply light oil annually**

VII.4 Water Level Logger (Level Troll 500)[6]:

Setup/Initialization:

- **Software Required:** Win-Situ 5
- **Piezometer Specifications:** 3" PVC Pipe should be used as a Piezometer for underground stormwater structures. Drill ½" holes on four sides of the pipe so that there are approximately 20 holes per foot of length in the pipe. Holes do not need to be drilled above top of BMP structure. Wrap section expected to be submerged in highly permeable geotextile fabric, and secure with zip ties. Secure the pipe to the floor, the manhole, and the overhead casting wall
- Hang the Logger from the eye bolt installed inside of PVC pipe piezometer. This will allow a more accurate set up of the reference elevation
- **Stabilization Time:** Allow the Level TROLL to stabilize to the water conditions for *about an hour* before logging data. A generous stabilization time is always desirable, especially in long-term deployments. Even though the cable is shielded, temperature stabilization, stretching, and unkinking can cause apparent changes in the probe reading. If you expect to monitor water levels to the accuracy of the probe, it's worth allowing the extra time for the probe to stabilize to its environment
- **Connection:** With the Troll Com plugged into a USB port, launch Win-Situ Software
- **Win-Situ Launches:** the screen shows the "My Data Tab".
    - On first connection, be sure to select the correct COM port for a USB connection
    - Then connect to the device
- When Connected, the focus shifts to the Home tab. Readings are shown in "meter" view. Values in gray are not being updated in real time
- **Set up a site**: Click the Site Button, select the Default Site or Click the New button to set up a custom site. The site name can have up to 32 characters. Location coordinates are optional
- **Set up a data log:** follow the steps in the logging setup wizard.
    - **Log Name:** Site_2017
    - **Log Parameters:** Pressure (PSI), Temperature (F), Elevation (ft.)
    - **Choose Logging Method:** Long-Term Monitoring – Event
    - **Choose Event Parameter:**
        - Check event parameter every 1 min
        - Log all parameters when the event is greater than 0.25 ft. above BMP invert, or normal water level elevation (sites with standing water in the BMP should utilize a threshold that will prevent the "event" setting from being continuously triggered)
        - Default record data every 60 measurements
    - **Schedule Start time:** on Next Hour
    - **Output:** Depth (BMP Sites) Depth to water (Groundwater Sites)

[6] See Level TROLL – Operator's Manual, In-Situ Inc., March 2010.

        - Be sure to note the casting invert reference elevation used, and the calculated elevation of the bottom of the sensor probe in the Notes option in the Site Data Folder for future reference
    - **Specific Gravity Value**: Custom 0.999
- **Finished Programing:** Disconnect the Troll Com and reattach the desiccant

Routine Data Retrieval and Re-initialization:

- **Frequency:** Once per month
- **Connect to device using Win-Situ 5:**
- Download data and transfer to WSB server folder K:\01610-100\WR\Exported Data. (Do not stop logging until the end of the season)
- Re-reference water level elevation
    - Select "Sensor Tab" then click on calibrate sensor.
    - **Adjust Level Reference:** input the New Reference if required

Routine Maintenance:

- **Check desiccant cartridge:** When entire length of the cartridge changes color, the desiccant needs to be replaced
- **Check minimum cable bend radius:** Half the cable diameter = Approx. 0.54".
- **Check the holes in the nose cone:** If they are plugged, swish the Level TROLL in a bucket of water, rinse under a tap, or soak in a mild acidic solution such as vinegar overnight
    - DON'T dig or scrape in the pressure sensor openings!
    - DON'T touch the pressure sensor diaphragm when the nose cone is removed!
- **Check twist-lock connectors**: Keep pins on all connectors free of dirt and moisture
- **Field Recalibration:** Sensor should be factory recalibrated every 12-18 months. The following procedure may be used, **with caution,** to "zero" the offset of a vented pressure sensor to correct for electronic drift. The drifted offset is visible when the sensor is in air and reading other than zero. It is recommended you **do not** zero the offset if it is outside the specified accuracy of your pressure sensor (30 PSI Sensor: ±0.03 PSI). If the reading in air deviates from zero by more than this amount, you may want to consider a factory recalibration

Attachments

WSB Confined Space Entry Permit

Metropolitan Council Environmental Services Laboratory Chain-of-Custody (BMP Infiltration Sites)

Metropolitan Council Environmental Services Laboratory Chain-of-Custody (TBNS Infiltration Sites)

Designation: C1701/C1701M – 09

Standard Test Method for Infiltration Rate of In Place Pervious Concrete[1]

This standard is issued under the fixed designation C1701/C1701M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers the determination of the field water infiltration rate of in place pervious concrete.

1.2 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.4 The text of this standard references notes that provide explanatory material. These notes shall not be considered as requirements of the standard.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C125 Terminology Relating to Concrete and Concrete Aggregates

C920 Specification for Elastomeric Joint Sealants

2.2 *Other Standards*

Federal Specification A-A-3110 (TT-P-1536A) Plumbing Fixture Setting Compound[3]

3. Terminology

3.1 *Definitions:*

3.1.1 The terms used in this test method are defined in Terminology C125.

4. Summary of Test Method

4.1 An infiltration ring is temporarily sealed to the surface of a pervious pavement. After prewetting the test location, a given mass of water is introduced into the ring and the time for the water to infiltrate the pavement is recorded. The infiltration rate is calculated in accordance with 9.1.

5. Significance and Use

5.1 Tests performed at the same location across a span of years may be used to detect a reduction of infiltration rate of the pervious concrete, thereby identifying the need for remediation.

5.2 The infiltration rate obtained by this method is valid only for the localized area of the pavement where the test is conducted. To determine the infiltration rate of the entire pervious pavement multiple locations must be tested and the results averaged.

5.3 The field infiltration rate is typically established by the design engineer of record and is a function of the design precipitation event.

5.4 This test method does not measure the influence on in-place infiltration rate due to sealing of voids near the bottom of the pervious concrete slab. Visual inspection of concrete cores is the best approach for determining sealing of voids near the bottom of the pervious concrete slab.

6. Apparatus

6.1 *Infiltration Ring*—A cylindrical ring, open at both ends (See Fig. 1). The ring shall be watertight, sufficiently rigid to retain its form when filled with water, and shall have a diameter of 300 ± 10 mm [12.0 ± 0.5 in.] with a minimum height of 50 mm [2.0 in.]. The bottom edge of the ring shall be even. The inner surface of the ring shall be marked or scored with two lines at a distance of 10 and 15 mm [0.40 and 0.60 in.] from the bottom of the ring. Measure and record the inner diameter of the ring to the nearest 1 mm [0.05 in.].

NOTE 1—Ring materials that have been found to be suitable include steel, aluminum, rigid plastic, and PVC.

6.2 *Balance*—A balance or scale accurate to 10 g [0.02 lb].

6.3 *Container*—A cylindrical container typically made of plastic having a volume of at least 20 L [5 gal], and from which water may be easily poured at a controlled rate into the infiltration ring.

6.4 *Stop Watch*—Accurate to 0.1 s.

6.5 *Plumbers Putty (Non-Hardening)*—Meeting Specification C920 or Federal Specification A-A-3110.

6.6 *Water*—Potable water.

[1] This test method is under the jurisdiction of ASTM Committee C09 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C09.49 on Pervious Concrete.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] http://www.everyspec.com

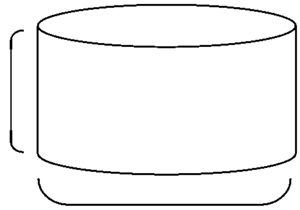

FIG. 1 Dimensions of Infiltration Ring

7. Test Locations

7.1 Perform tests at multiple locations at a site as requested by the purchaser of testing services. Unless otherwise specified, use the following to determine the number of tests to perform:

7.1.1 Three test locations for areas up to 2,500 m^2 [25,000 ft^2].

7.1.2 Add one test location for each additional 1,000 m^2 [10,000 ft^2] or fraction thereof.

7.2 Provide at least 1 m [3 ft] clear distance between test locations, unless at least 24 h have elapsed between tests.

7.3 Do not test if there is standing water on top of the pervious concrete. Do not test within 24 h of the last precipitation.

8. Procedure

8.1 *Infiltration Ring Installation*—Clean the pavement surface by only brooming off trash, debris, and other non-seated material. Apply plumbers putty around the bottom edge of the ring and place the ring onto the pervious concrete surface being tested. Press the putty into the surface and around the bottom edge of the ring to create a watertight seal. Place additional putty as needed

NOTE 2—In a hot environment where the surface temperature is over 38 °C [100 °F] plumbers putty may not adhere to the concrete surface easily. Therefore it is advisable to perform this test during cooler temperature.

8.2 *Prewetting*—Pour water into the ring at a rate sufficient to maintain a head between the two marked lines. Use a total of 3.60 ± 0.05 kg [8.0 ± 0.1 lb] of water. Begin timing as soon as the water impacts the pervious concrete surface. Stop timing when free water is no longer present on the pervious surface. Record the amount of elapsed time to the nearest 0.1 s.

8.3 *Test*—The test shall be started within 2 min after the completion of the prewetting. If the elapsed time in the prewetting stage is less than 30 s, then use a total of 18.00 ± 0.05 kg [40.00 ± 0.1 lb] of water. If the elapsed time in the prewetting stage is greater than or equal to 30 s, then use a total of 3.60 ± 0.05 kg [8.0 ± 0.1 lb] of water. Record the weight of water to the nearest 10 g [0.02 lb] (M). Pour the water into the ring at a rate sufficient to maintain a head between the two marked lines and until the measured amount of water has been used. Begin timing as soon as the water impacts the pervious concrete surface. Stop timing when free water is no longer present on the pervious surface. Record the testing duration (t) to the nearest 0.1 s.

NOTE 3—If a sloped pavement is being measured, maintain head between the two marked lines at the lowest point of the slope.

8.4 If a test is repeated at the same location, the repeat test does not require pre-wetting if conducted within 5 min after completion of the first test. If more than one test is conducted at a location on a given day, the infiltration rate at that location on that day shall be calculated as the average of the two tests. Do not repeat this test more than twice at the same location on a given day.

9. Calculation

9.1 Calculate the infiltration rate (*I*) using consistent units as follows:

$$I = \frac{KM}{(D^2 * t)}$$

where:

I = Infiltration rate, mm/h [in./h],
M = Mass of infiltrated water, kg [lb],
D = Inside diameter of infiltration ring, mm [in.],
t = time required for measured amount of water to infiltrate the concrete, s, and
K = 4 583 666 000 in SI units or 126 870 in [inch-pound] units.

NOTE 4—The factor *K* has units of $(mm^3 s)/(kgh)$ [$(in.^3 s)/(lbh)$] and is needed to convert the recorded data (*W*, *D*, and *t*) to the infiltration rate *I* in mm/h [in./h].

10. Report

10.1 Report the following information:

10.1.1 Identification number,

10.1.2 Location,

10.1.3 Date of test,

10.1.4 Age and thickness of concrete (label Unknown if not known),

10.1.5 Time elapsed during prewetting, s,

10.1.6 Amount of rain during last event, if known, mm [in.],

10.1.7 Weight of infiltrated water, kg [lb],

10.1.8 Inside diameter of infiltration ring, mm [in.],

10.1.9 Time elapsed during infiltration test, s,

10.1.10 Infiltration rate, mm/h [in./h], and

10.1.11 Number of tests performed at each location, if applicable.

11. Precision and Bias

11.1 Repeatability testing was performed by a single laboratory by making 2 replicate measurements at three locations on a newly placed pervious concrete pavement. The replicate measurements were repeated daily from day 1 to day 10. The single-operator coefficient of variation of the infiltration rate at one test location was found to be 4.7 %.

11.2 The multi-operator variability data has not been developed. The reproducibility of this test method is being determined and will be available on or before October 1, 2014.

11.3 This test method has no bias because the infiltration rate of in-place pervious concrete is defined only in terms of this test method.

12. Keywords

12.1 concrete; infiltration; pervious; water