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Project 1007
Six-Month Investigation
Progress Report

Minnesota Pollution Control Agency

October 13, 2020

Quality information

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Table of Contents

Figures

Tables

Appendices

Note to Reader

This report was drafted in August 2020 and includes PFAS data collected by AECOM since August 2019.

Since the date of issuance of the draft of this report, the Minnesota Pollution Control Agency has issued a new Site-Specific Water Quality Criterion (SSWQC) for Perfluorooctanesulfonic acid (PFOS) of 0.05 nanograms per liter (ng/L) or 0.00005 µg/L, applicable to the Project 1007 area.

1. Introduction and Background

AECOM has prepared this Progress Report for the Minnesota Pollution Control Agency (MPCA) to summarize the data collected in FY19 and FY20 along the Project 1007 Corridor (the Site) in Washington County, Minnesota (**Figure 1a**). Data were collected to assess the presence and extent of PFAS in various media, including surface water, sediment, foam, groundwater, and soils, at select locations throughout the Site (**Figure 1b**). Investigation activities were completed as part of the FY20 work order 3000025376 under task item #1 and FY20 work order 3000024460 under task item #1. **Table 1** summarizes the 2019-2020 Sampling Events that have been completed to-date. **Table 2** summarizes the surface sampling locations across the Project 1007 Corridor.

The Site includes a hydraulically diverse system of surface waters that includes intermittent and continuous flowing creeks, wetlands, ponds, lakes and rivers. These surface water bodies are part of an interconnected system of water conveyance and water storage features with unique hydrologic properties that affect how water is transported along the linear corridor that is Project 1007 and the way surface water infiltrates and interacts with shallow groundwater and numerous bedrock aquifers. This system is influenced by environmental conditions that include seasonal temperature and precipitation variability, heterogeneous near-surface geologic layers resulting in a high degree of surface water infiltration and surface water storage variability, and a series of constructed surface water elevation control structures. Ongoing PFAS surface water, sediment, and foam sampling events, along with knowledge of geologic features, known PFAS groundwater impacts, and PFAS data gaps within these bedrock aquifers has provided the basis for locating and installing additional bedrock aquifer wells. Due to the complexity of this hydrological system, investigation techniques, data collection locations, and the quantity of data collected from areas throughout the Site may vary while attempting to identify the role that Project 1007 plays in the fate and transport of PFAS along the approximately 14-mile Site corridor.

For presentation and organizational purposes, Project 1007 was geographically divided west to east into sampling areas and given unique sample identification prefixes:

- Raleigh Creek and Tri-Lakes Area (RC)
- Eagle Point Lake and Lake Elmo Area (EP)
- West Lakeland Storage Sites (WL)
- St. Croix River Area (SC)
- Valley Branch Creek and Afton Area (VB)

In addition to the above geographic areas and unique sample identification prefixes, there are a number of select surface water bodies that are outside of the current Project 1007 surface water flow path that may be contributing to, or hydrologically connected to the system through historic surface flow paths, flood control surface water pumping, or subsurface flow paths. Some of these water bodies include:

- Farney Creek (FC)
- Goose Lake (GL)
- Brown's Pond (BP)

In the event that additional surface water bodies are added to future sampling events, they will also be designated with unique identification prefixes.

As the Project 1007 investigation progresses, general project areas that are bounded by specific sample location identifiers will be grouped together based on geographical area, similar hydrologic/hydrogeologic features, or water body type. Although these locations do not represent individual investigation areas, they may have a similar distribution of PFAS concentrations or share an investigative focus that may be unique to a given general project area. When presenting the summary of investigation results, these areas may be referenced individually or grouped together based on the data being presented and the variability in PFAS concentrations within general project areas.

Below is a summary of general project areas:

- Project 1007 including the Tri-Lakes Area prior to the confluence with Raleigh Creek (RC1 and RC2 to RC14)
  - Project 1007 originates at the outlets of Lake Jane and Lake Olson (RC1 and RC2).
  - Water is piped from the Tri-Lakes Area to an outlet north of 34th St N.
  - A historical connection from the Washington County Landfill was made to the Project 1007 pipe before the outlet (RC16A).
  - Small wetlands are present in and along the channel after the pipe outlet (RC16A).
  - Surface water flow continues through Beutel's Pond which was historically present before construction of Project 1007 (RC15).
  - Project 1007 flows into Raleigh Creek at Tablyn Park (RC14).
- Raleigh Creek from the Oakdale Disposal Site (ODS) to Ideal Ave (RC3 to RC20)
  - Raleigh Creek exits ODS through a culvert under Hadley Ave (RC3).
  - A wetland system stretches from the ODS outlet to a culvert underneath Interstate-694 and then continues to a culvert underneath a set of railroad tracks (downstream of RC6).
  - The stream becomes more channelized as it flows through a residential area (RC7).
  - The stream continues through two small ponds (RC22 and RC23) before widening into a wetland (Ideal Avenue Wetland Complex between 31st Avenue N and Ideal Avenue N).
  - At Ideal Avenue is a culvert (RC20) that is set above the wetland elevation, effectively acting as a control structure and preventing downstream flow when water levels are below the invert elevation of the culvert. Limited observations made between August 2019 through July 2020 identified water flowing through the culvert underneath Ideal Avenue only after rain events.
  - The surface water to groundwater connection in this segment of Raleigh Creek is unknown.
- Ideal Avenue to Confluence with Project 1007 (RC20 to RC13)
  - Downstream of the culvert that conveys water underneath Ideal Avenue at RC20 to Tablyn Park at RC13, Raleigh Creek is periodically dry or contains no continuous flowing water. Approximately 150 feet farther downstream of RC13 is the confluence of Raleigh Creek with Project 1007 (Confluence). Water flow through this stretch of Raleigh Creek is influenced by the elevation of the culvert at Ideal Avenue, precipitation amount, and the suspected high rates of water infiltration due to the streambed composition. Flow is typically only observed following rain events and seasonally during late winter/spring snow melt. The environmental features that influence water flow between Ideal Avenue and Tablyn Park are what allow Raleigh Creek to connect to Project 1007 at Tablyn Park.
  - This segment appears to be highly affected by streambank erosion, with steep banks that are periodically undercut and a stream bed comprised of coarse-grained sand, gravel and a rocky channel bottom.
  - This segment is located primarily in forested low-density residential areas.
  - An additional tributary (RC8) flows into Raleigh Creek upstream of RC10 and has also only been observed with flow after a rain event.
- Raleigh Creek from the Confluence to the northern portion of Eagle Point Lake (RC21 to downstream of EP17)
  - This segment has sustained surface water flow during all observation events but the surface water to groundwater connection is unknown.
  - This segment flows primarily as a single channel through forested areas until shortly after entering the Lake Elmo Park Reserve where it widens into a wetland after the Red Trail (RC18 to EP1).
- Eagle Point Lake (EP1) to Lake Elmo (EP20)
  - Raleigh Creek flows into the northwest corner of Eagle Point Lake.
  - Other surface water inputs to Eagle Point Lake are Farney Creek (slightly south of Raleigh Creek) and Goose Lake when the Valley Branch Watershed District pumps the lake into Eagle Point Lake to control

flooding following high rain events. Goose Lake is periodically pumped into the southeastern end of Eagle Point Lake near EP18. Farney Creek connects with Eagle Point Lake after a constructed dam (FC2) at the northwestern end of the lake.

  - Eagle Point Lake is located completely within Lake Elmo Park Persevere, has a maximum depth of 6 feet, and is mostly surrounded by wetland vegetation.
  - Downstream of Eagle Point Lake is the approximate location of the regional groundwater divide (between EP4 and EP5).
  - The outlet of Eagle Point Lake, which is on the northeastern corner, passes through a series of channels and small ponds to the Eagle Point Lake Dam (EP19 to EP8).
  - Eagle Point Lake Dam (EP8) diverts water underneath Lake Elmo through a 22-inch diameter pipe to the outlet (EP10) where it mixes with the outlet of Lake Elmo (EP11). Both discharge pipes (EP10 and EP11) are located east of Lake Elmo Avenue.

- Lake Elmo (EP9, EP14, EP15, EP21, EP11)
  - Lake Elmo is surrounded by Lake Elmo Park Reserve and residential homes. The shoreline primarily consists of forest, beaches, and wetland vegetation.
  - The maximum depth of the lake is 137 feet.
  - According to geologic maps, the lake is underlain by a buried bedrock valley (MGS, 2016), potentially allowing for a significant hydraulic connection between surface water, groundwater, and bedrock aquifers.
  - Construction of the Project 1007 diversion pipe from Eagle Point Lake resulted in no direct surface water inlets to Lake Elmo.
  - The primary outlet is from a culvert that discharges into a channel (EP11) east of Lake Elmo Avenue and mixes with the discharge from the Eagle Point Lake diversion pipe (EP10).
- Mixing of outlets of Eagle Point Lake and Lake Elmo (EP12) to the inlet of North Pond (WL8)
  - A channel extends from the outlets of the discharge pipes from Eagle Point Lake and Lake Elmo to a culvert at the western edge of The Royal Club golf course (EP16).
  - A series of pipes and two ponds (EP13 and WL1) allow the water to flow through The Royal Club golf course to the inlet of Horseshoe Lake (WL2) on the northwestern lobe of the lake.
  - Horseshoe Lake is surrounded by the golf course, residential homes, and a forested area.
  - Horseshoe Lake has a maximum depth of 7 feet.
  - Project 1007 construction included the installation of a control structure that redirected flow from the eastern lobe (at the WL5 outlet) that is piped underneath Manning Avenue to a culvert (WL6) and into a channel that directs flow to the North Pond.
- North Pond (WL8) to St. Croix Discharge (downstream of WL20)
  - The West Lakeland Storage Ponds consist of three ponds (North, Middle, South) connected by constructed channels.
  - Per review of historic imagery, North Pond is situated in the approximate location of an old gravel pit that was present prior to the construction of Project 1007.
  - Per review of historic imagery, Middle and South Ponds periodically go dry during drought conditions.
  - Channels between the ponds have been reported to be losing to the groundwater due to high rates of infiltration (VBWD 2015).
  - Downstream of South Pond, water is exclusively piped to the outlet of the St. Croix River (downstream of WL20) except for the I-94 Rest Area Pond (WL18 and WL19).
- St. Croix River (SC1-4)
  - Project 1007 discharges upstream of the Interstate-94 (I-94) bridge

- Valley Branch Creek (North Branch) (VB1-3)
  - The pre-Project 1007 flow path involved a series of wetlands that were hydraulically connected to surface water features to the north of I-94 and ultimately discharged to Lake Edith and Valley Branch Creek.
  - Upgradient of Lake Edith is a small stream with intermittent flow (VB1).
  - Lake Edith has an approximate maximum depth of 38 feet and is surrounded by residential homes, forested areas, and wetland vegetation.
  - Valley Branch Creek downstream of Lake Edith has consistently sustained stream flow and passes through forested areas until the confluence with the south branch of Valley Branch Creek (downstream of VB3) which is a popular East Metro trout stream.
- Lakes in close proximity to the Project 1007 Corridor
  - Goose Lake (GL1)
    - Goose Lake is located south of Eagle Point Lake, largely surrounded by forested land and residential areas, and is bisected into Goose Lake North and Goose Lake South by 10th Ave N.
    - As a flood control measure, Goose Lake is pumped into Eagle Point Lake when lake levels overflow onto 10th Ave N.
  - Brown's Pond (BP1)
    - Brown's Pond is located in the Lake Elmo Park Reserve southeast of Beta Site 13 and is underlain by the inferred buried bedrock valley.
  - Sunfish Lake (EP24 and EP25)
    - Sunfish Lake is located northwest of Lake Elmo and southeast of the Washington County Landfill
    - Sunfish Lake has a maximum depth of 13 feet and is surrounded by Sunfish Lake Park, residential areas, and undeveloped forested land.

1.1 Geology

A series of geological maps and cross-sections produced by the Minnesota Geological Survey (MGS, 2016) indicate that the geology of the Twin Cities area consists of Precambrian basement rock situated below Cambrian and Ordovician stratigraphy that is subsequently overlain by unconsolidated Quaternary glacial sediments. The Minnesota Geological Survey identifies multiple geologic units that include, from youngest to oldest in ascending order:

- Quaternary sediment;
- Decorah Shale and Platteville and Glenwood Formations;
- St. Peter Sandstone – Tonti and Pig's Eye Members;
- Shakopee Formation;
- Oneota Formation;
- Jordan Sandstone;
- St. Lawrence Formation;
- Tunnel City Group - Mazomanie Formation (aquifer) and Lone Rock Formation;
- Wonewoc Sandstone;
- Eau Claire Formation; and
- Mt. Simon Sandstone.

PFAS impacts of municipal wells, residential wells, and surface water bodies have been observed throughout the Project 1007 Corridor. Aquifers spanning from shallow, Quaternary water table aquifers down to the St. Lawrence

Formation have known PFAS groundwater impacts, but the fate and transport of PFAS within these aquifers is poorly understood.

1.2 Report Purpose and Organization

The purpose of this Progress Report is to provide an update on data that has been collected between the completion of the August 2019 Baseline Sampling Event (Baseline Event) until the end of FY20 in June of 2020. Data in this Progress Report include sampling results from the Baseline Event, Beta Site bedrock well installation, and other data gap sampling events of surface water, sediment and suspected PFAS-containing foam. Based on the large number of data points collected, the timing and date of collection, and the extended laboratory analytical results turnaround time for PFAS samples, there are numerous samples that were collected during FY20 that may not be included in this Progress Report.

This Progress Reports includes a tabulated summary of all data that have been collected to-date along with project Site figures that identify sampling locations. This Progress Report is intended to provide a summary of PFAS data collected, a description of supporting non-PFAS analytical sampling data, and key observations during investigative activities. Detailed analysis of data findings, presentation of a robust conceptual site model (CSM) and recommendations for mitigative measures to address the wide-spread PFAS impacts are ongoing and will be presented in future reports.

The Progress Report is organized into the following sections:

Section 1- Provides a description of the Site, data types collected to-date, and report organization.

Section 2- Provides a summary of work completed to-date.

Section 3- Provides a description and summary of results of the Beta Site investigations between November 2019 to January 2020.

Section 4- Provides a description of Beta Site investigations between May 2020 and June 2020.

Section 5- Provides a description and summary of PFAS results of the winter 2020 seasonal surface water sampling event.

Section 6- Provides a description and summary of PFAS results of the April – May 2020 sediment sampling event.

In addition to the field data collected since 2019, several other bodies of work related to better understanding PFAS within and adjacent to the Project 1007 Corridor, such as a preliminary evaluation of other potential PFAS source areas (**Appendix A**), a detailed understanding of the subsurface geology using geophysical data (**Appendix B**), a preliminary corridor-wide assessment of PFAS in foam (**Appendix C**), and the development of a visual CSM that depicts potential subsurface migration pathways (**Appendix D**), are summarized and included as Appendices.

Appendices F-1 through **F-5** and **Appendix H** were included as a comprehensive working dataset of current and historical PFAS surface water data. **Appendix I** was included as a working dataset for other water quality parameters. **Appendices G-1** through **G-5** were included as a comprehensive working dataset of PFAS sediment data and **Appendices K** and **L** were included as working datasets for other sediment analytical parameters.

2. Summary of Work Completed

Two reports have been submitted by AECOM to the MPCA for Project 1007:

1. *Baseline Sampling Memo (AECOM 2019a)*

   The Baseline Sampling Memo summarized the data collected during the initial corridor-wide sampling event in August 2019 and was submitted to the MPCA on December 19, 2020. Sampling locations across the corridor were pre-determined and included the collection of surface water, sediment, and foam samples, when present, for PFAS and/or water quality analyses. The surface water and sediment samples were collected

during a single, short duration sampling event, under similar conditions, throughout the entire Project 1007 Corridor to begin establishing a robust PFAS dataset. A total of 102 samples were collected during the Baseline Sampling Event.

2. *Sampling and Analysis Plan Draft 1 (AECOM 2019b)*

The Sampling and Analysis Plan (SAP) provides detailed information for appropriately executing sampling events. The SAP is a working document and is updated as necessary when new sampling methods are utilized and when any new, specific types of sampling are completed.

Table 1 summarizes the 2019-2020 Sampling Events that have been completed. A summary of work completed from November 11, 2019 through May 15, 2020 that is included in this report is provided below:

BETA SITE INVESTIGATIONS – BEDROCK WELLS				
Drilling Investigation Date(s)	**Area(s) of Investigation**	**Beta Site Locations**	**Total Wells Installed**	**Media Sampled**
November 11, 2019 – January 16, 2020	Central (**Figures 3-1a** and **3-1b**)	3, 4, 5, 6	7	Groundwater, Soil, Surface Water, Sediment
May 26, 2020 – June 26, 2020*	Corridor-Wide (**Figure 2**)	2, 7, 9, 13	5	Groundwater, Soil

*data presented are preliminary and limited to well construction information and boring logs

FOLLOW-UP DATA GAP INVESTIGATIONS – SURFACE SAMPLING LOCATIONS				
Date(s)	**Sampling Event**	**Area(s) of Investigation**	**Total Samples Collected***	**Media Sampled**
February 24-26, 2020	Winter Seasonal Sampling Event	Corridor-Wide (**Figures 5-1a** through **5-1d**)	31	Surface Water, SML, Foam
April 22, 2020 – May 15, 2020	Sediment Sampling Event	Corridor-Wide (**Figures 6-1a** through **6-1e**)	61	Sediment, Surface Water, SML, Foam

SML – Surface Microlayer
*Sample count excludes equipment blanks

3. Beta Site Subsurface Investigation: November 11, 2019 – January 16, 2020

3.1. Background

The Beta Site Drilling Event is a corridor-wide, phased drilling investigation that involves the installation of monitoring wells (MW) in select areas referred to herein as “Beta Sites” along the Project 1007 Corridor (**Figure 2-2**). Beta Site locations have been identified by AECOM as areas where collection of detailed chemical, physical and geochemical data at key locations may contribute to significant advancement in understanding the role Project 1007 plays in PFAS migration in the East Metro. These key locations may include areas of known or inferred PFAS groundwater impacts, geologic units of suspected high infiltration rates, locations where PFAS retention may be occurring (secondary sources), or locations where PFAS and/or detailed geologic information is absent. In order to address geologic data gaps and to verify bedrock lithologic contacts identified during logging, geophysical data were collected at all Beta Sites wells. Geophysical logging services and geophysical data interpretations were provided by the MGS. Logging activities were conducted as needed between November 2019 and January 2020. A detailed summary of geophysical data collected between November 2019 and June 2020 is provided in **Appendix B**.

Four Beta Sites were chosen for the initial round of Beta Site drilling activities during the Drilling Event from November 11, 2019 until January 16, 2020. A total of seven monitoring wells were installed at four Beta Sites along the Project 1007 Corridor. Well pairs were installed at Beta Sites 3, 5, and 6, and one well was installed at Beta Site 4.

Beta Sites 3, 4, and 5 are located at the Lake Elmo Park Reserve at 1515 Keats Ave N, Lake Elmo, MN (**Figure 3-1a**). Beta Site 6 is located on The Royal Club golf course property located at 11455 20th St N, Lake Elmo, MN (**Figure 3-1b**).

3.2. Methods

3.2.1. Drilling

A state-approved subcontractor was retained by AECOM to complete all drilling activities to-date. A Rotosonic Drilling Rig was used to install all 4-inch diameter monitoring wells. All wells were constructed with steel casing to the targeted bedrock interval and were completed either as an open hole or with a stainless-steel screen. A summary of all Beta Site wells completed to-date is provided on **Table 3-1**.

A 6-inch diameter by 10-foot long core barrel was advanced into the subsurface and soil and bedrock samples were collected and placed into an acetate bag for soil logging. Soils and bedrock cores were collected on a continuous basis and logged by an AECOM field geologist during boring advancement. The following parameters were recorded during soil field screening: primary and secondary soil or bedrock classification, moisture content, trace constituents, evidence of oxidation, and Munsell soil color. Additionally, grain size and shape, grading, and plasticity were also recorded depending on the grain sizes observed (i.e., coarse or fine). Boring logs are provided in **Appendix E** and photos taken during the drilling event are provided in **Appendix Q**.

3.2.2. Wells Survey

All monitoring wells were surveyed by a licensed land surveyor from the Minnesota Department of Natural Resources on June 5, 2020. Well construction details and depth to water measurements that were collected on a quarterly basis (where applicable) are provided on **Tables 3-2** and **4-1**.

3.2.3. Analytical Sampling

At Beta Site locations where there were well pairs (Beta Sites 3, 5, 6) observations of soil cuttings and subsurface lithology from the first borehole were used to identify targeted intervals for soil and groundwater sampling in the second borehole. Soil samples from all wells were collected for PFAS analysis from unconsolidated Quaternary sediments of varying grain sizes and lithologic units, including confining units and high transmissivity units, to identify locations and depths of preferential PFAS adsorption. With the exception of BS4, groundwater samples were collected at all Beta Sites and co-located with soil samples from the same depth interval or adjacent to the groundwater depth interval. Groundwater samples were collected for PFAS analysis using Vertical Aquifer Profiling (VAP) to collect discrete sample depth intervals to assess conditions of vertical stratification in PFAS concentrations at each Beta Site location. A detailed discussion of the VAP Sampling Method is provided in the VAP SOP. The rationale that was used to select soil and/or groundwater depth intervals for sampling is provided in **Table 3-3**. The groundwater PFAS VAP analytical results are summarized in **Figures 3-2a** and **3-2b**. The soil PFAS analytical results are summarized in **Figures 3-3a** and **3-3b**. Laboratory reports of data submitted for analysis are provided in **Appendix R** though **Appendix V**.

Two equipment blanks were collected at each Beta Site during sample collection over the course of the November 2019 – January 2020 Drilling Event. A table of all PFAS analytical results collected as equipment blanks is provided on **Appendix M**.

All groundwater, soil and, surface water samples collected for PFAS analysis using Method MLA-110 were shipped to SGS AXYS Analytical Services ltd (AXYS) in Sidney, British Columbia.

3.3. Rationale For Investigation

The four Beta Sites that were selected for the November 2019 – January 2020 Drilling Event met the following criteria:

- Location within an existing, inferred PFAS plume,
- Proximity to a surface water body with known PFAS surface water and/or sediment impacts,
- Location is downgradient of a surface water body or impacted aquifer where vertical and horizontal PFAS migration and vertical distribution may be observed in a multi-aquifer well nest,
- Minimal existing PFAS data points within the area; and
- Approved and timely access agreements with property owners.

3.3.1. Beta Site 3

Beta Site 3 (BS3) is located on the southeastern corner of Eagle Point Lake. BS3 is an area of interest for evaluating the role that infiltration of PFAS-impacted surface water plays in contributing to groundwater plumes to the south of Eagle Point Lake. These higher rates of infiltration are supported by regional mapping of Quaternary deposits that indicate a greater distribution of coarse sediment near the southern end of Eagle Point Lake compared to the northern end of the lake. Surface water PFAS data for Eagle Point Lake from 2019-2020 include concentrations of PFOA (ranging from 0.0345 µg/L to 0.078 µg/L) and PFOS (ranging from 0.157 µg/L to 0.279 µg/L). These data indicate exceedances of the Minnesota Department of Health (MDH) Health-Based Values (HBVs) for drinking water for PFOA and PFOS.

3.3.2. Beta Site 4

According to geologic maps of the area, the BS4 surface location was mapped within the western fringe of the inferred buried bedrock valley (MGS, 2016). As a result, BS4 was placed within a small peninsula west of Lake Elmo to assess the presence of PFAS impacts within the western flange of the buried bedrock valley.

3.3.3. Beta Site 5

BS5 is located west of the Lake Elmo Park Reserve fishing pier. There are large data gaps west of Lake Elmo within the Lake Elmo Park Reserve. BS5 was intended to identify soil or groundwater impacts migrating west to east through Lake Elmo Park Reserve that may be contributing to PFAS compounds in Lake Elmo surface water and to identify the northern extent of the inferred PFAS plume in this area.

Surface water PFAS analytical results from Lake Elmo near BS4 and BS5 collected in August 2019 indicate exceedances of the MDH HBV for PFOA (ranging from 0.0642 µg/L to 0.075 µg/L) and PFOS (ranging from 0.0673 µg/L to 0.0884 µg/L). With the exception of locations along Raleigh Creek directly downgradient of the ODS, PFBA surface water detections from Lake Elmo ranging from 0.358 µg/L to 0.988 µg/L contain the highest concentrations observed in the Project 1007 Corridor.

3.3.4. Beta Site 6

BS6 was placed in an area downgradient of Lake Elmo and adjacent to the Project 1007 Corridor at the far eastern edge of The Royal Club golf course. The BS6 location was identified to address an absence of groundwater data between the southeast end of Lake Elmo and the eastern edge of Horseshoe Lake. This location will provide data to assess PFAS impacts in soils and groundwater relative to the location of the Project 1007 conveyance system east of Lake Elmo and to evaluate the effects of the shallow tributary of

the buried bedrock valley within the vicinity of BS6 that may behave as a high conductivity, preferential subsurface flow path that enables PFAS compounds to readily migrate away from Lake Elmo and east towards Horseshoe Lake.

3.3.4.1. Additional Surface Water Sampling

Two surface water and sediment samples were collected from EP-12 and EP-16 on November 21, 2019 from a Project 1007 waterway inside The Royal Club golf course, near BS6, to compare PFAS compounds detected in surface water and sediment with PFAS in soil and groundwater in the BS6 boreholes. The PFAS analytical results from EP-12 were also compared to results from the same location during the August 2019 Baseline Sampling Event. Sample location EP-16 was a new, previously unsampled location approximately 700 feet downgradient of EP-12 and represents the closest location of Project 1007 surface water to BS6. Both locations consist of a mixture of surface water and sediment discharged from Eagle Point Lake through the Project 1007 diversion pipe and surface water and sediment discharged directly from Lake Elmo.

3.4. Investigation-Derived Waste

Winter conditions prompted the need for special arrangements in the storage and handling of Investigation-Derived Waste (IDW) during the November 2019 – January 2020 Drilling Event. Solid media such as soil cuttings and bedrock cores were placed inside steel drums and stored in a secured portable pod unit until transported to the Clean Harbors Deer Trail Landfill. Aqueous IDW such as drilling mud and purge water from monitoring wells were pumped and transported off-site daily by Clean Harbors, Inc. (Clean Harbors) and stored inside a frac tank at a secured facility in Afton, MN. Compound detections in IDW soils were limited to arsenic (1.1 to 1.8 milligrams per kilogram (mg/kg)), barium (13.2 to 16.6 mg/kg), chromium (10.9 to 13.7 mg/kg), and lead (1.7 to 2.8 mg/kg). Soil characterization IDW analytical results are provided in **Appendix N**. Compound detections in IDW water were limited to diesel-range organics (DRO) (130 µg/L) and toluene (6.4 µg/L). Wastewater characterization IDW analytical results are provided in **Appendix O**. On July 27, 2020, the remaining contents of the frac tanks were emptied and transported to the Spruce Ridge Landfill by Clean Harbors.

3.5. Preliminary Beta Site Findings

The installation of bedrock wells in impacted aquifers, the detailed lithologic descriptions of soil cuttings, and the PFAS groundwater VAP and targeted interval soil sampling that accompanies the drilling of boreholes are all critical components in identifying the magnitude and extent of PFAS compounds in various areas across the Project 1007 Corridor. PFAS VAP sampling will help identify the surface and subsurface conditions that create hydrologic and hydrogeologic preferential flow paths for PFAS compounds and will aid in understanding the fate and transport of PFAS in soils and groundwater. Glacial unconsolidated sediments are present in all monitoring well locations but vary in dominant soil types and porosity at each location.

Well construction details, GPS coordinates, and general borehole stratigraphy for each Beta Site monitoring well are provided on **Table 3-1**. Screened or open hole intervals, targeted aquifers, and quarterly gauging measurements are provided on **Table 3-2**. Boring logs are provided in **Appendix E**.

In the absence of a site-specific groundwater screening criteria, PFAS concentrations in groundwater are compared to the MDH HBVs for drinking water when available. HBVs have been established for PFOA (0.035 micrograms per liter (µg/L)), PFOS (0.015 µg/L)[1], PFBA (7.0 µg/L), PFHxS (0.047 µg/L), and PFBS (2.0 µg/L).

[1] Since the date of issuance of the draft of this report, the MPCA has issued a new Site-Specific Water Quality Criteria (SSWQC) for PFOS of 0.05 nanograms per liter (ng/L) or $5x10^{-5}$ µg/L, applicable to the Project 1007 area.

Soil PFAS results were compared to state-wide soil screening criteria for MPCA Residential/Recreational and Commercial/Industrial Soil Reference Values (SRVs) in micrograms per kilogram (µg/kg). Residential/Recreational SRVs have been established for PFOA (240 µg/kg), PFOS (41 µg/kg), PFBA (38,000 µg/kg), PFHxS (130 µg/kg), and PFBS (5,700 µg/kg). Commercial/Industrial SRVs have been established for PFOA (3,200 µg/kg), PFOS (560 µg/kg), PFBA (520,000 µg/kg), PFHxS (1,700 µg/kg), and PFBS (77,000 µg/kg). Although soil PFAS values were compared with Residential/Recreational and Commercial/Industrial SRVs, the sampled soil intervals were generally deeper than the maximum soil screening depth established for the SRVs that protect human exposure through ingestion, inhalation, and dermal contact.

3.5.1. Beta Site 3

Two bedrock monitoring wells, MW3A and MW3B, were installed at BS3. Static groundwater was measured at 17.85 ft bgs and regional bedrock aquifer groundwater flow is inferred to the southwest towards the Mississippi River.

The unconsolidated sediment in MW3A is approximately 74 feet thick and consists primarily of poorly graded, medium to coarse, and sub-angular to well-rounded sand with interbedded fine to coarse gravel. Few intervals of silt with sand or gravel and silt with clay are also present from 10.5 ft bgs to 32 ft bgs. Observations from MW3B closely match conditions observed in the adjacent well (3A) with unconsolidated sediment approximately 79 feet thick and intervals of silty sand and sandy silty clay near the top of the borehole from the surface to 19 ft bgs.

Five VAP groundwater and 10 targeted interval soil samples were collected from MW3B (**Tables 3-4** and **3-7**). The sampling rationale for the PFAS samples collected from MW3B is provided in **Table 3-3**. A summary of PFAS detections in groundwater and soils is provided below:

PFOA – Groundwater

- The lowest concentration was at the 16.5 ft bgs to 19 ft bgs interval at the water table.
- Samples from 31 ft bgs to 79 ft bgs ranged from 0.136 µg/L to 0.368 µg/L, exceeding the MDH HBV of 0.035 µg/L.
- From 31 ft bgs to 55 ft bgs, the concentrations decreased with increasing depth; however, the highest detection was at the 75 ft bgs to 79 ft bgs interval.

PFOS - Groundwater

- The concentration at the 16.5 ft bgs to 19 ft bgs interval at the water table was below the detection limit.
- Samples from 31 ft bgs to 79 ft bgs ranged from 0.279 µg/L to 0.589 µg/L, exceeding the MDH HBV of 0.015 µg/L.
- Concentrations increased with increasing depth, with the highest detection at the 75 ft bgs to 79 ft bgs interval.

PFHxS - Groundwater

- Concentrations ranged from 0.0138 µg/L to 0.0392 µg/L, below the MDH HBV of 0.047 µg/L.
- The concentration at the 16.5 ft bgs to 19 ft bgs interval at the water table was below the detection limit.
- From 31 ft bgs to 55 ft bgs, concentrations decreased with increasing depth; however, the highest detection was at the 75 ft bgs to 79 ft bgs interval.

PFBA - Groundwater

- Concentrations ranged from 0.0138 µg/L to 0.0392 µg/L, below the MDH HBV of 7.0 µg/L.
- The lowest detection was at the 16.5 ft bgs to 19 ft bgs interval at the water table.
- From 31 ft bgs to 55 ft bgs, concentrations generally decreased with increasing depth; however, the highest detection was at the 75 ft bgs to 79 ft bgs interval.

PFBS - Groundwater

- Concentrations ranged from 0.00248 µg/L to 0.0239 µg/L, below the MDH HBV of 2.0 µg/L.
- The lowest detection was at the 16.5 ft bgs to 19 ft bgs interval at the water table.
- From 31 ft bgs to 55 ft bgs, concentrations decreased with increasing depth; however, the highest detection was at the 75 ft bgs to 79 ft bgs interval.

PFOA - Soil

- The only detection in soil was an estimated concentration of 0.114 µg/kg from the 74 ft bgs to 75 ft bgs interval.

PFOS - Soil

- PFOS was detected in soil samples collected from 41-42 ft bgs down to 74-75 ft bgs, with the highest detection (0.184 µg/kg) in the 74 ft bgs to 75 ft bgs interval.
- PFOS was not detected in soils sampled from 75 ft bgs to 79 ft bgs.

Summary

Notable patterns were observed in the soil and groundwater PFAS samples, primarily in the 74 ft bgs to 79 ft bgs interval where PFAS compounds were consistently found at the highest concentrations, directly above the first encountered bedrock unit (Shakopee Formation). In addition, the lowest observed PFAS concentrations were at the first encountered water table depth interval of 16.5 ft bgs to 19 ft bgs.

3.5.2. Beta Site 4

One bedrock monitoring well, MW4A, was installed at BS4. Static groundwater was measured at 3.72 ft bgs and regional groundwater flow is inferred to the east towards Lake Elmo.

The unconsolidated sediment in MW4A is approximately 90 feet thick and consists primarily of well graded, fine to coarse, and sub-angular to well-rounded sand with interbedded clayey sand and silty sand. A layer of coarse gravel to cobble-sized sediment is present from 78 ft bgs to 85 ft bgs. The first encountered bedrock unit in MW4A is the Shakopee Formation. The depth to bedrock in this area indicates that the buried bedrock valley may be narrower and located farther to the east of MW4A than originally mapped.

A total of 13 soil PFAS samples were collected from MW4A (**Table 3-8**). The sampling rationale for the PFAS sampling at BS4 is provided in **Table 3-3**. Due to project constraints, no groundwater VAP samples were collected.

With the exception of an estimated concentration of 1.1 µg/kg of 6:2 FTS, which has no established standard, at 80 ft bgs to 81 ft bgs, PFOS was the only compound detected in soil samples analyzed from MW4A. Detections of PFOS ranged from 0.076 µg/kg to 0.201 µg/kg, with the highest PFOS detection in soil of 0.201 mg/kg observed at 37 ft bgs to 38 ft bgs. This sampled interval consisted of well graded, fine- to coarse-grained sand with trace gravel and sits beneath a one-foot thick interval of a stiff, medium-plasticity clay.

3.5.3. Beta Site 5

Two bedrock monitoring wells, MW5A and MW5B, were installed at BS5. Static groundwater was measured at 21.53 ft bgs in MW5A and 21.23 ft bgs in MW5B. Regional groundwater flow is inferred to the east towards Lake Elmo.

The unconsolidated sediment in MW5A is approximately 60 feet thick and consists primarily of poorly graded, fine to coarse, and sub-angular to well-rounded sand. An interval of low plasticity silt with trace clay is

present from 8 ft bgs to 11 ft bgs, and a relatively thick interval of stiff, low plasticity clay with trace medium- to coarse-grained gravel is present from 13 ft bgs to 30 ft bgs. The unconsolidated sediment in MW5B is approximately 58 feet thick and consists of silty, fine to coarse-grained sand with trace gravel near the surface; an interval of stiff, low plasticity clay with trace gravel and cobbles; and fine- to coarse-grained sand with gravel interbedded with sandy silt, low plasticity clay, and fine to medium gravel. The first encountered bedrock unit in both MW5A and MW5B is the Shakopee Formation.

Three groundwater and seven soil samples were collected from MW5B (**Tables 3-5** and **3-9**). The sampling rationale for the PFAS sampling at BS5 is provided in **Table 3-3**. A summary of PFAS detections in groundwater and soils is provided below:

PFOA- Groundwater

- Concentrations ranged from 0.00375 µg/L to 0.00618 µg/L, below the MDH HBV of 0.035 µg/L.

PFOS - Groundwater

- Concentrations ranged from 0.00359 µg/L to 0.00501 µg/L, below the MDH HBV of 0.015 µg/L.

PFHxS - Groundwater

- Concentrations ranged from 0.00400 µg/L to 0.00437 µg/L, below the MDH HBV of 0.047 µg/L.

PFBA - Groundwater

- Concentrations ranged from 0.0165 µg/L to 0.258 µg/L, below the MDH HBV of 7.0 µg/L.

PFBS - Groundwater

- Concentrations ranged from 0.00262 µg/L to 0.00307 µg/L, below the MDH HBV of 2.0 µg/L.

PFAS Compounds - Soil

- No PFAS compounds were detected in any soil samples analyzed.

Summary

All PFAS detections in groundwater samples were minimal and below the MDH HBV. No PFAS compounds were detected in the soil samples submitted for analysis.

3.5.4. Beta Site 6

Two bedrock monitoring wells, MW6A and MW6B, were installed at BS6. Static groundwater is measured at 10.03 ft bgs in MW6A and 10.55 ft bgs in MW6B. Groundwater flow is inferred to the east-southeast towards the St. Croix River.

The unconsolidated sediment in MW6A is approximately 109.5 feet thick and consists almost exclusively of well graded, fine- to coarse-grained sand with trace gravel. A five-foot thick interval of fine to medium, angular to subangular gravel with trace cobbles is present at 104.5 ft bgs, which sits directly above the first encountered bedrock unit (the Shakopee Formation). The unconsolidated sediment in MW6B is approximately 132.6 feet thick and consists primarily of poorly graded, fine to medium sand with trace gravel and fine to coarse gravel with sand. The bottom-most sediment units consist of fine to coarse, angular to sub-rounded gravel with silt, which sits directly above the first encountered bedrock unit (the Oneota Formation). The approximate 23-foot difference in thickness of the unconsolidated sediment in MW6A and MW6B suggests that MW6B is positioned on the edge of the secondary, shallower buried bedrock valley extending off of the main north-south buried bedrock valley.

Six groundwater and ten soil samples were collected from MW6B (**Tables 3-6** and **3-10**). The sampling rationale for the PFAS sampling of BS6 is provided in **Table 3-3**. A summary of PFAS detections in groundwater and soils is provided below:

PFOA- Groundwater

- The concentration at the 11 ft bgs to 13 ft bgs interval at the water table was below the detection limit.
- Samples from 36 ft bgs to 85 ft bgs ranged from 0.065 µg/L to 0.0727 µg/L, exceeding the MDH HBV of 0.035 µg/L.
- Samples from 106 ft bgs to 140 ft bgs ranged from 0.00683 µg/L to 0.0233 µg/L, below the MDH HBV.
- From 36 ft bgs to 140 ft bgs, concentrations decreased with increasing depth with the highest concentration at the 36 ft bgs to 40 ft bgs interval.

PFOS - Groundwater

- The concentration at the 11 ft bgs to 13 ft bgs interval at the water table was below the detection limit.
- Samples from 36 ft bgs to 110 ft bgs ranged from 0.0358 µg/L to 0.146 µg/L, exceeding the MDH HBV of 0.015 µg/L.
- From 36 ft bgs to 140 ft bgs, concentrations decreased with increasing depth with the highest concentration at the 36 ft bgs to 40 ft bgs interval.

PFHxS - Groundwater

- The concentration at the 11 ft bgs to 13 ft bgs interval at the water table was below the detection limit.
- Concentrations ranged from below detection limit to 0.00931 µg/L, below the MDH HBV of 0.047 µg/L.
- From 36 ft bgs to 140 ft bgs, concentrations generally decreased with increasing depth with the highest concentration at the 36 ft bgs to 40 ft bgs interval.

PFBA - Groundwater

- Concentrations ranged from 0.0411 µg/L to 0.672 µg/L, below the MDH HBV of 7.0 µg/L.
- From 36 ft bgs to 140 ft bgs, concentrations decreased with increasing depth with the highest concentration at the 36 ft bgs to 40 ft bgs interval and the lowest concentration at the 136 ft bgs to 140 ft bgs interval.

PFBS - Groundwater

- Concentrations ranged from below detection limits to 0.0059 µg/L, below the MDH HBV of 2.0 µg/L.

PFOA - Soil

- The only detection in soil was an estimated concentration of 0.132 µg/kg from the 6 ft bgs to 7 ft bgs interval above the water table.

PFOS - Soil

- The only detection in soil was an estimated concentration of 0.079 µg/kg from the 37 ft bgs to 38 ft bgs interval.

Other PFAS Compounds - Soil

- No other compounds with established SRV standards were detected in any soil samples.

Summary

The highest concentrations of PFOA, PFOS, PFHxS, and PFBA in groundwater were observed at the 36 ft bgs to 40 ft bgs interval. PFOA in groundwater from the 36 ft bgs to 85 ft bgs interval exceeded the MDH HBV of 0.035 µg/L while PFOS in groundwater samples from 36 ft bgs to 110 ft bgs exceeded the MDH HBV of 0.015 µg/L. PFAS detections in soils were minimal and limited to PFOA (from the 6 ft bgs to 7 ft bgs interval) and PFOS (from the 37 ft bgs to 38 ft bgs interval).

3.5.4.1 Additional Surface Water Sampling Results

On November 21, 2019, two surface water and sediment samples were collected from EP12 and EP16 from the Project 1007 waterway, near BS6, to compare PFAS compounds detected in surface water and sediment with PFAS in soil and groundwater in the BS6 boreholes. Surface water PFAS results from EP12 indicate exceedances of PFOA and PFOS

MDH HBVs, which is consistent with and on the same order of magnitude as the August 2019 results from the same location.

All PFAS detections in surface water samples collected from EP12 and EP16 in November 2019 were comparable to and on the same order of magnitude (**Figure 3-4**) as PFAS concentrations detected in EP12 in August 2019. A comparison of PFAS concentrations in sediment between the two locations, however, indicate notable differences particularly for PFBA, PFOA, and PFOS concentrations when comparing the two locations (**Figure 3-5**). The only PFAS compound detected in EP12 sediment is PFOS, with a maximum concentration of 0.797 µg/kg in August 2019. PFAS detections in EP16 sediment include PFBA (0.785 µg/kg), PFOA (0.486 µg/kg), and PFOS (7.37 µg/kg). PFOS in EP16 sediment is an order of magnitude greater than PFOS in EP12 sediment.

This surface water and sediment sampling data will be used during future CSM development and are included in **Appendix F-2** and **G-2**, respectively.

4. Beta Site Subsurface Investigation: May 26, 2020 – June 26, 2020 - Preliminary Data

Four Beta Site locations were selected for drilling between May 26, 2020 and June 26, 2020. Five monitoring wells were installed at locations across the Project 1007 Corridor (**Figures 4-1a** through **4-1d**). Boring logs are provided in **Appendix E**. Sampling results and other details of this drilling event will be included in subsequent reports.

4.1. Background

Four Beta Sites along the Project 1007 Corridor were chosen for the second round of Beta Site drilling activities (May-June 2020 Drilling Event).

Five monitoring wells were installed at four Beta Sites along the Project 1007 Corridor during the second round of the Drilling Event from May 26, 2020 until June 26, 2020. A well pair was installed at Beta Site 13 and one well was installed at each location in Beta Sites 2, 7, and 9. Geophysical data were collected at Beta Sites to verify bedrock lithologic contacts identified during logging. All geophysical logging services and geophysical data interpretations were provided by the MGS. Logging activities were conducted as needed between May and June 2020. A detailed summary of geophysical data collected in May and June 2020 will be provided in future deliverables.

BS2 is located at Tablyn Park at Stillwater Boulevard N and Inwood Avenue N in Lake Elmo, MN. BS7 is located immediately southeast of Horseshoe Lake at Manning Trail N and Manning Avenue N in Lake Elmo, MN. BS9 is located immediately west of the Rentz Cemetery on Neal Avenue N in West Lakeland Township, MN. BS13, which includes two wells, is located within the Lake Elmo Park Reserve at 1515 Keats Ave N, Lake Elmo, MN (**Figures 4-1a** through **4-1d**).

Preliminary data collected from the May – June 2020 Drilling event that are presented in this progress report is limited to well construction information and boring logs**.** Additional data including PFAS analytical results and geophysical logging results will be included in future deliverables.

4.2. Methods

4.2.1. Drilling

Drilling methods used during the second round of drilling activities, and the wells survey, are discussed in Sections 3.2.1 and 3.2.3, respectively.

A summary of the four Beta Site wells completed and well construction details are provided on **Table 4-1**. Boring logs are provided in **Appendix E** and photos taken during the drilling event are provided in **Appendix Q**.

4.2.2. Analytical Sampling

At each Beta Site, groundwater sampling intervals were collected at the water table, at the bottom of the unconsolidated Quaternary sediments, and, where applicable, within bedrock aquifer units above the bedrock unit targeted for well placement. In addition, groundwater samples were collected periodically between the water table and the bottom of the unconsolidated Quaternary sediments to assess the vertical distribution of PFAS above the first encountered bedrock unit. At BS13, where a well pair was installed, observations of soil cuttings and subsurface lithology from the first borehole were used to identify targeted intervals for soil and groundwater sampling in the second borehole. At Beta Site locations 2, 7, and 9, groundwater sampling intervals were determined during borehole advancement following geologic interpretation of soil and bedrock cores.

Groundwater samples were collected using the VAP method and analyzed for PFAS, TOC, various anions and cations, and a suite of water quality parameters including turbidity, alkalinity, total suspended solids (TSS), total dissolved solids (TDS), and pH. At select intervals, groundwater samples were also collected for Total Oxidizable Precursors Assay (TOPA) analysis. Finally, the first groundwater sample at each Beta Site was collected and analyzed for three isotope analyses: enriched tritium, deuterium and oxygen-18, and strontium-87. At depth intervals where the source of groundwater was thought to differ within the same monitoring well (i.e., below a competent confining layer), a second set of isotope analyses was submitted for that groundwater interval. The same suite of analysis was also collected from the closest upgradient surface water body on the same day as the Beta Site monitoring well in order to interpret the results.

Soil samples were also collected directly from the acetate bags for analysis of PFAS, cation exchange capacity (CEC), and TOC. Sample intervals selected for analysis included above and at the water table, and at all intervals coincident with groundwater sample depths. The sample collected at the water table was also analyzed for various anions, and select intervals were collected for TOPA analysis. Evaluations of the isotope results and the TOPA analysis will be used to assess the extent of the surface water to groundwater connection and PFAS fate and transport within the system and will be presented in future deliverables. The rationale used to select the groundwater and soil sampling intervals and analysis is provided in **Table 4-2**. Laboratory reports of data submitted for analysis are provided in **Appendix R** though **Appendix V**.

Four equipment blanks were collected over the course of the May–June 2020 Drilling Event. A table of all PFAS analytical results collected as equipment blanks is provided in **Appendix M**.

Groundwater and soil samples collected for PFAS and TOPA analysis were shipped to AXYS in Sidney, British Columbia. Groundwater and surface water samples collected for isotope analysis were shipped to Isotope Tracer Technologies, Inc. in Waterloo, Ontario, Canada. Soil samples collected for CEC were delivered to Minnesota Valley Testing Laboratories, Inc (MVTL) in New Ulm, Minnesota. Groundwater and soil samples collected for all other parameters were delivered to Pace Analytical (Pace) in St. Louis Park, Minnesota.

4.3. Rationale For Investigation

The four Beta Sites that were selected for the May-June 2020 Drilling Event met the following criteria:

- Location within an existing, inferred PFAS plume,
- Proximity to a prominent surface water body with known PFAS surface water and/or sediment impacts,
- Location is downgradient of a surface water body or impacted aquifer where vertical and horizontal PFAS migration and vertical distribution may be observed in a multi-aquifer well nest,
- Minimal existing data points within the area; and

- Approved access agreements (or verbal permission) with property owners.

4.3.1. Beta Site 2

BS2 is located at Tablyn Park adjacent to Raleigh Creek near the Confluence at Stillwater Boulevard N in Lake Elmo, MN (**Figure 4-1a**). BS2 was placed to assess the area near the downstream, suspected losing stream segment of Raleigh Creek and to further asses the vertical and lateral extent of the PFAS contamination plume. Additionally, there are large groundwater data gaps from the Quaternary and shallow bedrock aquifer units (i.e., St. Peter Sandstone and Prairie du Chien Dolostone) due to high method detection limits from PFAS testing conducted primarily in 2006; furthermore, no groundwater analytical data is available from the Jordan aquifer in this area.

Surface water PFAS analytical results in Raleigh Creek near BS2 from the Baseline Event indicate exceedances of the MDH HBV for PFOA (ranging from 0.103 µg/L to 0.276 µg/L) and PFOS (ranging from 0.964 µg/L to 1.78 µg/L).

Four groundwater VAP samples from the unconsolidated Quaternary units and three groundwater samples from shallow bedrock aquifers were collected during boring advancement. Additionally, four soil samples, and two corresponding surface water samples were collected from the Project 1007 waterway prior to the Confluence (RC14) and after the Confluence (RC21) and analyzed for isotope analyses (i.e., enriched tritium, deuterium and oxygen-18, and strontium-87). The groundwater and soil sampling rationale for BS2 is provided in **Table 4-2**.

4.3.2. Beta Site 7

BS7 is located immediately southeast of Horseshoe Lake at Manning Trail N and Manning Avenue N in Lake Elmo, MN (**Figure 4-1b**). BS7 was placed downgradient of Horseshoe Lake and upgradient of PFAS-impacted bedrock wells in order to assess the role Horseshoe Lake plays in possible storage and transport of PFAS. In addition, geologic maps of the area show the presence of a shallow branch of the primary buried bedrock valley extending from the southeast corner of Lake Elmo towards and underlying Horseshoe Lake in the vicinity of BS7, indicating a potential eastward preferential groundwater flow path for PFAS contamination. For location reference, the beginning of this shallow branch is located near BS6 (MW6A and MW6B). In addition, past erosional processes are understood to have followed the formation of the buried bedrock valley, which resulted in highly fractured bedrock along the edges of the buried valley that compromise the effectiveness of vertical aquitards.

Surface water PFAS analytical results from Horseshoe Lake and the downgradient Project 1007 waterway from the Baseline Event indicate exceedances of the MDH HBV for PFOA (ranging from 0.0565 µg/L to 0.0586 µg/L) and PFOS (ranging from 0.146 µg/L to 0.167 µg/L).

Four groundwater VAP samples from the unconsolidated Quaternary units and two groundwater samples from shallow bedrock aquifers were collected during boring advancement. Additionally, four soil samples, and one corresponding surface water sample was collected from Horseshoe Lake (WL5) and analyzed for isotope analyses. The groundwater and soil sampling rationale for BS7 is provided in **Table 4-2**.

4.3.3. Beta Site 9

BS9 is located immediately west of the Rentz Cemetery on Neal Avenue N in West Lakeland Township, MN (**Figure 4-1c**). BS7 was placed downgradient of Middle Pond and upgradient of PFAS-impacted bedrock wells to assess the pond and the associated channels connecting the storage ponds as a possible secondary source of PFAS contamination via groundwater infiltration. Groundwater analytical data show an increase in PFAS contamination east of the North, Middle, and South Ponds, particularly in the Jordan Sandstone

aquifer. VAP sampling within the shallow unconsolidated Quaternary units for both PFAS and isotope analysis in conjunction with surface water sampling for isotope analysis was conducted to identify and define, if present, this possible preferential flow path from the surface water system into groundwater.

Surface water PFAS analytical results from Middle Pond and the associated channels from the Baseline Event indicate exceedances of the MDH HBV for PFOA (ranging from 0.0565 µg/L to 0.0699 µg/L) and PFOS (ranging from 0.159 µg/L to 0.185 µg/L).

Three groundwater VAP samples from the unconsolidated Quaternary units and four soil samples were collected during boring advancement. One corresponding surface water sample was collected from the channel flowing into Middle Pond (WL11) and submitted for isotope analyses. The groundwater and soil sampling rationale for BS9 is provided in **Table 4-2**.

4.3.4. Beta Site 13

BS13, which includes two wells, is located within the Lake Elmo Park Reserve at 1515 Keats Ave N, Lake Elmo, MN (**Figure 4-1d**). AECOM retained the MGS to complete passive seismic surveys in Lake Elmo Park Reserve to better constrain the inferred location of the buried bedrock valley and better position the proposed BS13 location in the deepest portion of the buried valley. Following the collection of additional passive seismic data collected in this area, BS13 was placed within the suspected deepest portion of the bedrock valley south of Lake Elmo.

By targeting the area with the greatest depths to bedrock, BS13 was placed in the center of the bedrock valley where high conductivity, preferential flow paths are suspected to exist both southward along the valley and downward through the valley. The additional thickness of the unconsolidated units also allowed for the unique opportunity to set wells in much deeper bedrock aquifer units, specifically the bottom of the Jordan Sandstone and the Tunnel City Sandstone units. By setting monitoring wells in the lower Jordan Sandstone and the Tunnel City Sandstone, analytical and hydrologic data can be collected to assess PFAS impacts at depths and locations where there are very few existing monitoring points.

Surface water PFAS analytical results from Lake Elmo from the Baseline Event indicate exceedances of the MDH HBV for PFOA (ranging from 0.0545 µg/L to 0.0717 µg/L) and PFOS (ranging from 0.0673 µg/L to 0.276 µg/L).

Six groundwater VAP samples from the unconsolidated Quaternary units in the second hole (MW13B) and one groundwater VAP sample from the consolidated bedrock valley bottom in the first hole (MW13A) were collected during boring advancement. Nine soil samples were collected from the second hole (MW13B), and one corresponding surface water sample was collected from Brown's Pond (BP1) and submitted for isotope analyses. The groundwater and soil sampling rationale for BS13 is provided in **Table 4-2**.

4.4. Investigation-Derived Waste

As discussed in Section 3.4, aqueous IDW such as drilling mud and purge water from monitoring wells were pumped and transported off-site by Clean Harbors and stored inside a frac tank at a secured facility in Afton, MN. Solid media such as soil cuttings and bedrock cores were placed inside steel drums and stored in a secured portable pod unit until transported to the Clean Harbors Deer Trail Landfill.

5. Winter Seasonal Surface Water Sampling Event

Efforts to fill seasonal PFAS surface water data gaps warranted a Winter Seasonal Surface Water Sampling Event (Winter Sampling Event), which took place on February 24 through February 26, 2020. Several locations previously sampled during the Baseline Event were also selected for seasonal sampling. Additionally, new sampling locations

along the Project 1007 Corridor were identified and included in the Winter Sampling Event. A summary of sampling locations, sample IDs, sample type, and analyses is provided in **Table 5-1.** Detailed observations of sampling locations are provided on field sampling forms in **Appendix P**. Photos taken during the Winter Sampling Event are provided in **Appendix Q**.

A sampling method used to collect a thin micron-scale layer called the surface microlayer (SML) from a PFAS-impacted surface water body was also tested during this sampling event.

All surface water, SML, and foam samples were collected for MLA-110 PFAS analysis of 33 compounds and were analyzed by AXYS in Sidney, British Columbia. Samples collected were analyzed for water quality parameters including total dissolved solids (TDS), chloride, and total organic carbon (TOC) by Pace in St. Louis Park, Minnesota.

5.1. Site Conditions

Along most areas of the Project 1007 Corridor, there was continuous snow and/or ice cover and vegetation was either absent or dormant. In most cases, surface water bodies along the corridor were more accessible in the winter than in the summer due to the decrease in biological activity and extensive vegetation cover that may have prohibited safe land access to a sampling location during warmer months. Photographs taken during site reconnaissance and field sampling in February 2020 are provided in **Appendix Q**.

According to the National Weather Service (NWS) Twin Cities climate station, the average monthly temperature was 21.1 °F and a total of 7.5 inches of snow and a total of 0.58 inches of rain was recorded in February 2020 (https://www.weather.gov/media/mpx/Climate/MSP/feb2020.pdf).

5.1.1. Stream/Creek Channels

Variable conditions were present along the length of Raleigh Creek from Hadley Ave N until the Confluence at Tablyn Park. The upstream stretch of Raleigh Creek from RC3 to the culvert underneath the railroad (downstream of RC6) where extensive wetlands are present sustained low to no-flow conditions with ample ice and snow cover in the main channel. No flow was observed in the upstream segment between RC5 and the culvert underneath the railroad, downstream of RC6, during the early winter. In the downstream stretch, between Ideal Ave N and Tablyn Park (RC20 to RC13), flow was only observed following snow melt and rain events, and no flow was observed during the Winter Sampling Event.

In the waterways downgradient of the Tri-Lakes Area, between the Confluence and the inlet of Eagle Point Lake (downstream of RC18) where sustained surface water flow is observed year-round, Raleigh Creek was flowing and the banks of the channel contained thin overhanging ice shelves.

In the channels and creeks in the central portions of the Site between Eagle Point Lake and the West Lakeland storage ponds (i.e., between EP19 and WL8), observable flow was low to moderate.

Contrary to the creek channels in the central and western portions of the Site (upstream of Eagle Point Lake), ice cover, when present, in the eastern portion of the Site near the West Lakeland Storage Sites was thinner and less extensive.

When foam was observed, it was typically an orange-brown color, in stark contrast with the bright white color of the surrounding snow, and often appeared as thin, deflated windrows. In some cases, the foam appeared frozen or partially frozen, and in other cases the foam accumulated on top of a sheet of ice. Similar to the Baseline Event, foam was primarily observed in Raleigh Creek; however, unique to the Winter Sampling Event, foam was observed downgradient of Horseshoe Lake at WL6. A full discussion of foam types and occurrences across the Project 1007 Corridor is provided in **Appendix C**.

5.1.2. Wetlands

All observed wetland vegetation across the corridor was either absent or dormant, but the detritus remained in-situ. The lateral extent of the submerged portions of the wetlands was greatly reduced, with water primarily flowing in the center of the main channels. Within the main channels, snow-draped patches and thin discontinuous sheets of ice

were occasionally observed covering the channel during the Winter Sampling Event. Flow in wetlands beyond the main channel was only observed in the wetland system around Raleigh Creek from the Red Trail in the Lake Elmo Park Reserve until the main body of Eagle Point Lake (RC18 to EP17).

5.1.3. Lakes and Ponds

The lakes and ponds across the corridor appeared to be at least partially frozen, and most areas on the surface were covered by snow. In general, unfrozen portions of lakes and ponds were observed in areas of flow into or out of the water bodies (i.e., the inlet into Tartan Pond at EP13, the inlet into the eastern golf course pond at WL1, the inlet into Horseshoe Lake at WL2, and at the inlet and outlet to the Northern Pond at WL8/WL9). Minimal flow was observed at these locations. Flow was also observed in the discharge pipe from Eagle Point Lake (EP10) that that runs along the bottom of Lake Elmo and from the discharge pipe from the Lake Elmo elevation control structure that discharges water from Lake Elmo (EP11). Both discharge water into the Project 1007 waterway just east of Lake Elmo Avenue.

5.2. Sampling Rationale

Factors that were taken into consideration when determining the sampling locations included site access, extent of winter conditions such as the presence of ice or snow cover, variations in the PFAS concentrations observed during the Baseline Event, and an even geographical distribution of samples spread across the Project 1007 Corridor. Where appropriate, new sampling locations were added to the Baseline Event for the Winter Sampling Event and future seasonal sampling in an attempt to better characterize the seasonal changes in PFAS concentrations across the Site. Many of the samples added to the winter and subsequent sampling events were to evaluate the effect wetlands have on PFAS concentrations. All sampling locations, both from the Baseline Event and new locations, were determined to be well-distributed and representative of certain water body types and areas throughout the Project 1007 Corridor where samples could be collected long-term. Foam accumulating in sufficient quantities was collected and submitted for analysis in most sampling locations where it was observed to evaluate the potential presence of seasonal variability in PFAS foam concentrations.

PFAS compounds are surface active compounds that tend to dwell at the air-water interface. As a result, SML sampling was used to identify PFAS compounds that may preferentially concentrate in greater amounts within this approximately 50 micrometers (µm)-thin layer. SML samples were primarily collected during this sampling event to assess collection methods and equipment discussed in peer-reviewed literature (Battelle 2018) as well as the feasibility of sampling during seasonally cold temperatures. The two locations selected for SML sampling were RC17A and WL9. These locations were identified during winter site reconnaissance as: 1) areas in different portions of the Project 1007 Corridor with known PFAS impacts; and 2) channel locations that were shallow enough for safe access that would contain sufficient water to implement the SML method.

Chloride, total dissolved solids (TDS), and total organic carbon (TOC) were also sampled at each location to better characterize PFAS distribution in the system. These compounds will be included in future sampling and data analysis in subsequent seasonal and rain sampling events to develop a comprehensive CSM of the Site. These future analyses and data evaluation will also be used to assess the extent of the surface water to groundwater connection and PFAS fate and transport within the system and will be presented in future deliverables. A summary of sample identification, sample type and sample analyses is included in **Table 5-1**.

PFAS concentrations in surface water were also compared to ecological screening values. A complete presentation of this data is included in the *Screening Level Ecological Risk Assessment and Baseline Ecological Risk Assessment Work Plan* (AECOM 2020a). A comparison of maximum surface water PFAS concentrations to surface water ecological screening values is presented in **Table 6-8**.

5.3. Summary of Media Sampled

Targeted media for the Winter Sampling Event included surface water, SML samples, and foam (when observed in sufficient quantities to collect). If frozen conditions during field sampling prohibited the safe collection of a sample, an

alternative location was determined. All surface water samples collected were liquid and unfrozen. No ice samples or sediment samples were collected during this sampling event.

A total of 31 samples including surface water, SML, and foam samples were collected from 19 discrete locations and submitted for PFAS and/or water quality analyses (**Figure 5-1a** through **5-1d**). Additionally, six quality control and duplicate samples were collected and submitted for PFAS analysis. A summary of analytical results for winter surface water and SML PFAS compounds is provided in **Table 5-2**, winter foam PFAS compounds in **Table 5-3**, and winter surface water quality parameters in **Table 5-4**. PFAS analytical data tables are also summarized on **Figures 5-2a** through **5-2d** for surface water and **Figure 5-3** for foam.

5.4. Analytical Results

In the absence of site-specific surface water or foam screening criteria, PFAS concentrations in surface water and foam are compared to the MDH HBVs for drinking water when available. HBVs have been established for PFOA (0.035 µg/L), PFOS (0.015 µg/L)[1], PFBA (7.0 µg/L), PFHxS (0.047 µg/L), and PFBS (2.0 µg/L). Future surface water results will be compared to site-specific surface water criteria that are currently under development by the MPCA. Although the evaluation of PFAS compounds that do not have established HBVs and other analyzed non-PFAS water quality parameters are equally important in understanding surface water and groundwater interaction, fate and transport of PFAS and the building of a robust CSM, the analytical results presented below summarize only PFAS with established HBVs. Data presentation and data interpretation of all detected PFAS compounds will be provided in greater detail in future deliverables. Laboratory reports of data submitted for analysis are provided in **Appendix R** though **Appendix V**.

The winter seasonal surface water analytical results are presented below geographically west to east by general project areas as described in Section 1.

5.4.1. Raleigh Creek from ODS to Ideal Avenue

Sampled locations from this area of the Project 1007 Corridor included from west to east: RC3, RC5, and RC7A. At the time of the Winter Sampling Event, Raleigh Creek was dry or frozen downstream of RC7A. Sampling at RC5 and RC7A included a co-located foam sample; results summary included below in Section 5.4.7.

PFOA – Surface Water

- PFOA detections ranged from 0.880 µg/L to 1.680 µg/L, exceeding the MDH HBV.
- Concentrations were highest closest to the ODS (RC3) and decreased with greater distance, with the lowest detection at RC7A.
- These locations had the highest concentrations of PFOA in the Project 1007 Corridor during the Winter Sampling Event.

PFOS – Surface Water

- PFOS detections ranged from 1.37 µg/L to 2.94 µg/L, exceeding the MDH HBV.
- Concentrations were highest closest to the ODS (RC3) and decreased with greater distance, with the lowest detection at RC7A.
- These locations had the highest concentrations of PFOS in the Project 1007 Corridor during the Winter Sampling Event.

PFBA – Surface Water

- PFBA detections ranged from 0.659 µg/L to 0.904 µg/L, below the MDH HBV.
- Concentrations were highest closest to the ODS (RC3) and decreased with greater distance, with the lowest detection at RC7A.

- These three sample locations had the highest concentrations of PFBA in the Project 1007 Corridor. Similar concentrations of PFBA were identified at the two locations downstream of the Lake Elmo discharge to Project 1007 (EP11 and EP16).

PFHxS – Surface Water

- PFHxS detections ranged from 0.0845 µg/L to 0.171 µg/L, exceeding the MDH HBV.
- Concentrations were highest closest to the ODS (RC3) and decreased with greater distance, with the lowest detection at RC7A.
- These locations had the highest concentrations of PFHxS in the Project 1007 Corridor during the Winter Sampling Event.

PFBS – Surface Water

- PFBS detections ranged from 0.0329 µg/L to 0.0614 µg/L, below the MDH HBV.
- These locations had the highest concentrations of PFBS in the Project 1007 Corridor during the Winter Sampling Event.

Summary

All locations had concentrations with exceedances of the MDH HBVs for drinking water for PFOA, PFOS, and PFHxS. With the exception of PFPES, concentrations were highest closest to the ODS at RC3 and decreased with greater distance downstream. Across the Project 1007 Corridor, these three locations had the highest concentrations of every PFAS compound, with the exception of EP11 (outlet from Lake Elmo to Project 1007 waterway), which had the second highest concentration of PFBA in the Project 1007 Corridor during the Winter Sampling Event.

5.4.2. Project 1007 Conveyance: Tri-Lakes to Confluence with Raleigh Creek to Eagle Point Lake

Sampled locations from this area of the Project 1007 Corridor included (from north to south): RC14 (prior to the Confluence), RC21, RC17A, and RC18. At the time of the Winter Sampling Event, there was no flow observed at the Confluence at Tablyn Park. Sampling at RC21 included a co-located foam sample; results summary included below in Section 5.4.7.

PFOA – Surface Water

- PFOA detections ranged from 0.00732 µg/L to 0.00771 µg/L, below the MDH HBV.
- These locations had the lowest concentrations of PFOA in the Project 1007 Corridor during the Winter Sampling Event.

PFOS – Surface Water

- PFOS detections ranged from 0.00191 µg/L to 0.00244 µg/L, below the MDH HBV.
- These locations had the lowest concentrations of PFOA in the Project 1007 Corridor during the Winter Sampling Event.

PFBA – Surface Water

- PFBA detections ranged from 0.0867 µg/L to 0.0890 µg/L, below the MDH HBV.
- These locations had the lowest concentrations of PFBA in the Project 1007 Corridor during the Winter Sampling Event.

PFHxS – Surface Water

- PFHxS detections ranged from 0.00306 µg/L to 0.00329 µg/L, below the MDH HBV.
- These locations had the lowest concentrations of PFHxS in the Project 1007 Corridor during the Winter Sampling Event.

PFBS – Surface Water

- PFBS detections ranged from 0.00252 µg/L to 0.00267 µg/L, below the MDH HBV.

- With the exception of VB2 in Valley Branch Creek, which had a concentration of 0.00249 µg/L, these locations had the lowest concentrations of PFBS in the Project 1007 Corridor during the Winter Sampling Event.

Summary

All PFAS compounds with established standards were not detected above their respective MDH HBVs for drinking water and were the lowest in the Project Corridor, with the exception of concentrations at VB2 which were also among the lowest of any PFAS detections.

5.4.3. Eagle Point Lake and Lake Elmo

Sampled locations from this area of the Project 1007 Corridor included from west to east: EP19 (outlet at Eagle Point Lake), EP8 (sample from manhole at discharge pipe from Eagle Point Lake), EP20 (Lake Elmo, post-dam location), EP11 (Lake Elmo discharge pipe), and EP16 (channel downstream of mixing of Eagle Point Lake and Lake Elmo outlets). At the time of the Winter Sampling Event, Eagle Point Lake and Lake Elmo were largely frozen.

PFOA – Surface Water

- PFOA detections ranged from 0.0380 µg/L to 0.0651 µg/L, exceeding the MDH HBV.
- The lowest detection was observed at EP19. The highest detection was observed at EP11.

PFOS – Surface Water

- PFOS detections ranged from 0.0552 µg/L to 0.208 µg/L, exceeding the MDH HBV.
- The lowest detection was observed at EP11. The highest detection was observed at EP20.

PFBA – Surface Water

- PFBA detections ranged from 0.114 µg/L to 0.813 µg/L, below the MDH HBV.
- PFBA concentrations at EP11 were present at the same order of magnitude as samples collected immediately downstream of ODS.

PFHxS – Surface Water

- PFHxS detections ranged from 0.00617 µg/L to 0.0911 µg/L, below the MDH HBV.

PFBS – Surface Water

- PFBS detections ranged from 0.0334 µg/L to 0.0449 µg/L, below the MDH HBV.

Summary

All locations had concentrations with exceedances of the MDH HBVs for drinking water for PFOA and PFOS. The highest and lowest concentrations were not consistent among these locations. PFBA concentrations at EP11 were present at the same order of magnitude as at locations immediately downstream of ODS.

5.4.4. West Lakeland Area

Sampled locations from this area of the Project 1007 Corridor included from northwest to southeast: WL6, WL7, WL9, WL12, WL15, and WL18. At the time of the Winter Sampling Event, the North, Middle, and South Ponds were partially frozen with observable flow at the inlets, outlets, and in the channels between the ponds. Sampling at WL6 included a co-located foam sample; results summary included below in Section 5.4.7.

PFOA – Surface Water

- PFOA detections ranged from 0.0513 µg/L to 0.0559 µg/L, exceeding the MDH HBV.
- The lowest detection was at WL6, and the highest detection was at WL18. However, the concentrations did not generally increase from upstream to downstream.

PFOS – Surface Water

- PFOS detections ranged from 0.0761 µg/L to 0.110 µg/L, exceeding the MDH HBV.
- The lowest detection was observed at WL12. The highest detection was observed at WL18.

PFBA – Surface Water

- PFBA detections ranged from 0.422 µg/L to 0.463 µg/L, below the MDH HBV.

PFHxS – Surface Water

- PFHxS detections ranged from 0.0077 µg/L to 0.00884 µg/L, below the MDH HBV.

PFBS – Surface Water

- PFBS detections ranged from 0.00370 µg/L to 0.00402 µg/L, below the MDH HBV.

Summary

All locations had concentrations with exceedances of the MDH HBVs for drinking water for PFOA and PFOS. The highest and lowest concentrations were not consistent among these locations.

5.4.5. Valley Branch Creek

Only one location in Valley Branch Creek was sampled during the Winter Sampling Event (VB2). At the time of sampling, Valley Branch Creek was snow covered with no visible flow until downstream of Lake Edith. Shallow but fast-moving water was observed at the sampled location immediately downstream of the Lake Edith outlet.

PFOA, PFOS, PFBA, PFHxS, PFBS – Surface Water

- All PFAS compounds with established standards were detected below their respective MDH HBVs for drinking water and were among the lowest in the Project Corridor.
- VB2 had the lowest concentration of any PFAS detections in the Project Corridor.
- Concentrations of PFOA, PFOS, and PFHxS were lower only at the sampled locations from the Confluence until Eagle Point Lake (RC14 through RC18).

Summary

The concentrations of PFBS and PFHxA were the lowest at VB2 compared to other sampled locations along the Project 1007 Corridor. The concentration of all other PFAS compounds were among the lowest at VB2, higher only than those from the Confluence until Eagle Point Lake (RC14 through RC18).

5.4.6. Surface Micro-Layer (SML) Analytical Summary

Two locations (RC17A and WL9) were selected for the collection of SML samples. In addition, a replicate pair of SML samples were collected at WL9 to assess the reproducibility of the sample collection method while simultaneously collecting samples by two sampling teams in cross-gradient locations.

Both RC17A and WL9 represent stream segments with flowing water; PFAS concentrations in the SML sample were detected at the same order of magnitude as the bulk surface water sample collected from each of the two locations. The replicate pair of SML samples collected from WL9 resulted in data from the primary sample containing consistently higher concentrations than the sample identified as the duplicate sample (although at the same order of magnitude). Analytical results from SML samples are included with other winter seasonal surface water samples in **Table 5-2**.

Based on the results of this preliminary SML sampling event, environmental conditions leading to mixing of the surface microlayer with the bulk water column, such as stream flow velocity, wind speed, sampling techniques and sample team disturbances, may have contributed to the similarity in results between bulk surface water samples and SML samples. Although the glass plate method used during the Winter Sampling Event successfully captured PFAS detections, modifications to the sampling technique or modifications to conditions when and where SML samples are collected may be necessary to effectively sample PFAS compounds present near the air-water interface.

5.4.7. Foam Analytical Results

During the Winter Sampling Event, foam was collected at two locations from Raleigh Creek between ODS and Ideal Avenue (RC5 and RC7A), one location downstream of the Confluence (RC21), and one location along the Project 1007 Corridor downstream of Horseshoe Lake (WL6). At the time of sampling, Raleigh Creek was not connected at the Confluence and was dry or frozen between RC7A and RC13.

PFOA – Foam

- PFOA detections ranged from 1.24 µg/L to 6.79 µg/L, exceeding the MDH HBV.
- The lowest detection was observed at RC5. The highest detection was observed at RC21.

PFOS – Foam

- PFOS detections ranged from 30.7 µg/L to 1,630 µg/L, exceeding the MDH HBV.
- The lowest detection was observed at RC5. The highest detection was observed at WL6.
- These detections are the highest in the Project Corridor across all forms of sampled media.

PFBA – Foam

- PFBA detections ranged from 0.103 µg/L to 0.51 µg/L, below the MDH HBV.
- The lowest detection was observed at RC21. The highest detection was observed at RC5.
- PFBA was below detection limits at RC7A and WL6. However, both samples were lab diluted, so the detection limits were elevated at 3.18 µg/L and 3.17 µg/L, respectively.

PFHxS – Foam

- PFHxS detections ranged from 0.0752 µg/L to 1.13 µg/L, exceeding the MDH HBV.
- The lowest detection was observed at RC5. The highest detection was observed at RC21.
- PFHxS was below detection limits at RC7A and WL6. However, both samples were lab diluted, so the detection limits were elevated at 0.796 µg/L and 0.792 µg/L, respectively.

PFBS – Foam

- PFBS detections ranged from 0.00471 µg/L to 0.0205 µg/L, below the MDH HBV.
- The lowest detection was observed at RC21. The highest detection was observed at RC5.
- PFBS was below detection limits at RC7A and WL6. However, both samples were lab diluted, so the detection limits were elevated at 0.796 µg/L and 0.792 µg/L, respectively.

Summary

Detections of PFOA, PFOS, and PFHxS in foam samples exceeded their respective MDH HBV for drinking water. The majority of foam samples were collected along Raleigh Creek. There were no observations of foam in the eastern portion of the Project 1007 Corridor, downgradient of Lake Elmo, prior to observations and sampling at WL6 in February 2020.

Only one Winter Sampling Event foam sample location, RC7A (which is slightly upstream of RC7), has data that can be compared for seasonal variability with other foam samples. During Baseline Event sampling, foam was observed and collected from RC7 prior to a high rain event and immediately following the high rain event; August 12, 2019 and August 14, 2019, respectively. The first foam sample was from a small accumulation that appeared deflated and was not a regenerating foam mass. The second foam sample was a much larger foam accumulation that appeared to be regenerating in the faster, post-rain event stream flow. Foam PFOA and PFOS detections at RC7A in February 2020 (5.21 µg/L and 531 µg/L, respectively) were greater than the results from the first sample collected on August 12, 2019 at RC7 (0.658 µg/L and 40.09 µg/L, respectively). However, foam PFOA and PFOS detections (175 µg/L and 13,800 µg/L) from the second, presumably fresher foam sample collected on August 14, 2019 at RC7 were greater than the sample collected during the Winter Sampling Event and represent the highest PFOS foam concentrations observed across the Site.

Additional discussion regarding the presence and distribution of PFAS-containing foam throughout the Project 1007 Corridor are included in **Appendix C**.

5.5. Winter Analytical Results Summary

The seasonal changes to PFAS concentrations in surface water and foam and the influences that changing flow conditions have on the presence of PFAS within Project 1007 is poorly understood. Although some seasonal variability has been seen in historical surface water samples (prior to 2019) collected along the Project 1007 Corridor, these historical samples were typically collected during warmer seasons. As a result, the seasonal variability of PFAS during winter conditions has not been well documented.

Similar to Baseline Event surface water results, exceedances of MDH HBV's for drinking water for PFOA (0.035 µg/L) and PFOS (0.015 µg/L)[1] during the Winter Sampling Event were consistently observed throughout the corridor.

As expected in select sample locations within close proximity to source areas, concentrations of PFOA and PFOS are typically observed to decrease one to two orders of magnitude from the upstream reaches of Raleigh Creek (RC3, RC5, and RC7A) when compared to locations farther downstream of source areas such as at the Project 1007 outlet at Eagle Point Lake (Eagle Point Lake Dam). In addition, observations from this limited seasonal data set identified decreasing concentration gradients between ODS and the Eagle Point Lake Dam during both warm season and cold season sampling. Downstream of Lake Elmo, these observations of decreasing PFAS concentrations (primarily PFOA, PFHxS and PFOS) with increasing distances from the source areas are no longer evident in either warm season or cold season sampling; PFAS concentrations stay relatively consistent within the same order of magnitude from the Lake Elmo outlet to the I-94 Rest Area Pond.

Notable observations from the Winter Sampling Event in areas downstream of Lake Elmo indicate relatively consistent concentrations of PFAS compounds during warm season and cold season sampling; however, PFOS was observed to decrease an order of magnitude in six of eight Winter Sampling Event locations when compared to samples collected during the Baseline Event from the same location. PFBA concentrations were also generally dissimilar to other PFAS concentrations throughout the Project 1007 Corridor. With the exception of sampling locations immediately downgradient of ODS, the highest concentration of PFBA in cold season sampling occurred at the outlet of Lake Elmo (EP11) and within Lake Elmo (EP15) during warm season sampling. This generally supports observations of higher relative contributions from short chain compounds to total PFAS mass at distances farther from source areas; however, Lake Elmo is the only location where PFBA concentrations change by an order of magnitude between adjacent surface water bodies.

One PFAS sample was collected from south of I-94 during the Winter Sampling Event at the outlet of Lake Edith into the north branch of Valley Branch Creek (VB2). Although there were no Baseline Event surface water samples collected from this location to provide a seasonal comparison, PFAS concentrations were generally an order of magnitude lower at VB2 than at locations within the current Project 1007 Corridor and no PFAS detections were present at concentrations above MDH HBVs.

In addition to PFAS sampling, the Winter Sampling Event included chloride, total dissolved solids (TDS) and total organic carbon analyses. Results from this water quality sampling will be used to develop the CSM and will be discussed in greater detail in future deliverables. Winter season water quality sample results are presented in **Table 5-4**.

6. April – May 2020 Sediment Sampling Event

Sediment sampling was completed during the Baseline Event and during eight days between April 23, 2020 and May 14, 2020 (April-May Event). The Baseline Event sediment sampling targeted shallow sediment in the 0-6-inch depth range from both streams/creeks and lakes/ponds. Sediment laboratory analytical data collected during the Baseline Event included only PFAS analysis to gain an understanding of the geographical distribution of PFAS throughout the Project 1007 Corridor. The April-May 2020 sediment sampling event included additional locations and analytical parameters to fill gaps in coverage along the Project 1007 Corridor, increased quantities of near-surface depth interval

sampling (0-6 inches down to depths of 42 inches) and expanded the sample coverage in low-flow, depositional environments such as wetlands and wide, channelized portions of the corridor. A summary of sample IDs, sample locations and sample analyses is provided in **Table 6-1.**

6.1. Site Conditions

Sediment sampling occurred over an eight-day sampling period between April 23, 2020 and May 14, 2020. Site and water flow conditions during the sediment sampling event remained consistent with no increases in stream flow conditions or significant precipitation events throughout the Project 1007 Corridor during sampling. Raleigh Creek was not flowing between Ideal Avenue and the Confluence at Tablyn Park, and as a result there was no active surface water connection between Raleigh Creek and Project 1007 during this sediment sampling event.

Early to mid-spring conditions resulted in the sediment sampling event occurring during the early stages of spring leaf out; little vegetative growth was present along stream banks or within ponds and lakes where sediment samples were collected. Detailed observations of sampling locations are provided on field sampling forms in **Appendix P**. Photographs taken during site reconnaissance and field sampling in April - May 2020 are provided in **Appendix Q**.

6.2. Sediment Sampling Rationale

Sediment sampling and investigation activities are ongoing to assess the distribution of PFAS-containing sediments in Raleigh Creek and throughout the Project 1007 Corridor. There are many factors influencing the distribution and accumulation of PFAS in Project 1007 sediments including surface water flow conditions, distance from primary source areas, hydrogeologic properties/infiltration conditions, and the physical and geochemical properties of the sediment. The extent to which PFAS adsorbs to sediments and the locations where PFAS accumulation occurs in sediments plays a role in the fate and transport of PFAS in surface water and groundwater, and also influences human health exposure to accessible sediments, ecological exposure through direct contact, incidental ingestion, and food web bioaccumulation throughout the Project 1007 Corridor.

The April-May 2020 sample locations were intended to fill geographical data gaps identified from the Baseline Event sampling, and were expanded to preferentially target low-flow depositional areas such as wetlands, small ponds, areas of dense aquatic vegetation, and areas of constricted or reduced flow where PFAS accumulation may be prevalent. This sampling rationale was also designed to target conditions where aquatic and semi-aquatic receptors may be present to better evaluate the potential for ecological risks associated with exposure to PFAS in sediment. PFAS sediment data from the Baseline Event and the April-May 2020 sampling event were used to develop the *Screening Level Ecological Risk Assessment* (AECOM, 2020a) that will guide further investigation and data collection during completion of the Baseline Ecological Risk Assessment.

Sediment sample laboratory analytical parameters were expanded during the April-May 2020 sediment sampling event to include physical and geochemical properties of sediments. The combination of the physiochemical properties of the PFAS compounds detected and the physical and geochemical properties of the sediment will be used to assess locations and conditions by which PFAS sorption is likely to occur and to better understand retention properties in Project 1007 Corridor sediments. Analytical methods are included in **Table 6-1**.

6.3. Summary of Media Sampled

Targeted media for the April-May 2020 Sediment Sampling Event included substrates from representative portions of the Project 1007 Corridor, including:

- **Channel Bottom/Channel Banks -** Sediment sampling during Baseline Event sampling focused primarily on 0-6-inch sampling from the center of the stream channel. April-May 2020 sampling was expanded to include additional depth profiling, depositional locations within the channel along point bars,

channel composites (left bank, right bank, channel bottom), and locations that may have been coincident with the presence of foam.

- **Wetlands -** Wetland sediment sampling included locations throughout Raleigh Creek and Project 1007 that are frequently or continually inundated with water. Wetland sediment samples included surface and depth profile sampling (0-6 inches up to 42 inches), wetland edges (saturated soils, typically no flow), and sediments from channelized areas of wetlands where water typically flows during low or baseflow conditions. All surface wetland samples (collected from the top 6 inches) were paired with a corresponding depth interval sample collected from an interval below the observed high-organic content top layer. The depth interval range of these co-located wetland samples extended to depths of 42 inches.
- **Ponds and Lakes -** Pond and Lake samples were collected from either surface sediments and/or depths up to 12 inches from Farney Creek Pond, Eagle Point Lake, Sunfish Lake, Goose Lake, Brown's Pond, and the North and South ponds of the Ideal Avenue Wetland Complex (located between 31st Avenue N and Ideal Avenue N). Samples were also collected from beach sediments adjacent to a residence located at the northern end of Lake Elmo and beach sediments coincident with the presence of foam adjacent to the Lake Elmo boat launch (EP21B) and canoe launch (EP21A) in Lake Elmo Park Reserve.

A total of 51 sediment samples were collected from 24 discrete locations and submitted for PFAS and/or physical and geochemical analyses (**Figures 6-1a** through **6-1e**). Additionally, five quality control and duplicate samples were collected and submitted for PFAS analysis. Sample numbers by analytical type include:

- PFAS- 51
- TOP Assay- 2
- TOC- 51
- Anions- 15
- Cations + CEC- 51
- Grain Size- 3

Laboratory reports of data submitted for analysis are provided in **Appendix R** though **Appendix V**. In addition to laboratory analytical parameters, visual observations of depositional environments and ecological habitats were collected and are documented on field sampling forms attached as **Appendix P**.

Analytical results are provided for sediment PFAS compounds (**Table 6-4**), Anion and TOC (**Table 6-5a**), Cation and CEC (**Table 6-5b**) and Grain Size Analysis (**Table 6-5c**). PFAS and water quality parameters collected at select co-located sediment/surface water locations (EP21B, EP18, GL1, RC22, RC23) are included in **Tables 6-2** and **6-6**. PFAS sediment analytical data are also summarized on **Figures 6-2a** through **6-2e,** surface water and SML sample results for locations that were co-located with sediment samples are presented on **Figures 6-3a** and **6-3b**. During the sediment sampling, co-located foam was also present at RC21, EP21A, and EP21B and was collected and submitted for analysis. The foam PFAS analytical data are summarized in **Table 6-3** and shown in **Figure 6-4**. The presence and distribution of PFAS-containing foam sampled throughout the Project 1007 Corridor is discussed in **Appendix C**.

Although additional non-PFAS analytical sampling has been performed and is presented in the above-listed tables, data presentation and analysis as it relates to surface water and groundwater interaction and PFAS fate and transport will be presented in future deliverables.

6.4. Sediment Analytical Results Summary

The presence of PFAS in shallow corridor sediments (0-6-inch samples collected during Baseline Event) provided a starting point for understanding PFAS concentrations and distribution along both Raleigh Creek and Project 1007. The April-May 2020 sediment sampling filled geographical data gaps and provided data that represented variability in flow conditions and depositional areas where stream/creek surface water flow may be dispersed across multiple channels. Site-specific sediment cleanup values (SDCV) for both 5-days/week and 2-days/week exposure scenarios were developed by MPCA for PFBA (87,000 µg/kg and 310,000 µg/kg, respectively), PFOA (540 µg/kg and 1,900 µg/kg,

respectively), PFBS (13,000 µg/kg and 46,000 µg/kg, respectively), PFHxS (290 µg/kg and 1,000 µg/kg, respectively), and PFOS (93 µg/kg and 330 µg/kg, respectively). The SDCVs are based on sediment contact to a depth of 5.5 feet (wading) to 6.5 feet (wading and swimming). All sediment samples collected during the Baseline Event and the April-May 2020 sediment sampling events were from depths of less than 6.5 feet below the water surface. Because of the limited temporal variability in sediment samples, the discussion of sediment results has been expanded to include both Baseline Event and April-May 2020 sediment data.

The sediment analytical results summary is presented below geographically from west to east by general project areas as described in Section 1.

6.4.1 Raleigh Creek from ODS to Ideal Avenue

This stretch of Raleigh Creek is dominated by low-flow depositional areas. Multiple depth profiles in low-flow depositional areas were collected to examine the relationship between PFAS concentrations and high organic matter and to identify areas of vertical PFAS stratification. Sampling locations from this area of the Project 1007 Corridor included (from west to east): RC3, RC3A, RC5, RC6, RC22, and RC23.

PFOS – Sediment

- Multiple samples exceeded the MPCA SDCV-5 days/week concentration of 93 µg/kg. All were collected from 0-6” in wetland or low-flow depositional locations (RC3, RC3A, RC5, RC6, RC22, RC23) except for RC23 where both the 0-6” and the 6-12” interval exceeded the SDCV.
- Main channel concentrations ranged from 5.89 µg/kg at RC3 to 179 µg/kg at RC3A.
- The samples collected from areas with greater wetland biomass generally had higher concentrations compared to similar depths in channelized portions of Raleigh Creek. At RC5, the main channel concentration was 27.5 µg/kg while the 3-12” interval of the wetland sample was 159 µg/kg. The 12-18” sampled interval from the wetland decreased to 19.8 µg/kg.
- In the Ideal Avenue Wetland Complex ponds, a decrease in concentration was observed with depth in the upgradient pond (RC22) from 129 µg/kg (0-6”) to 81.4 µg/kg (6-12”) but an increase in concentration was observed in the downstream pond (RC23) from 124 µg/kg (0-6”) to 185 µg/kg (6-12”).

There were seven (7) PFOS exceedances of the 5-day SDCV value in sediment samples collected from Raleigh Creek. Wetland sediment containing higher organic matter, especially the top layers that are predominantly comprised of biomass and higher TOC content, tend to have the highest concentrations of PFAS. Generally, PFAS concentrations decrease with depth and are greater in sediments collected within a wetland body compared to the channelized portion of the wetland.

6.4.2 Tri-Lakes Area to the Confluence with Raleigh Creek

The majority of this stretch is piped from Lake Jane and Lake Olson in the Tri-Lakes Area with the outlet just north of 34th St N. South of 34th St N is a small wetland area with sediment high in biomass. A wetland depth profile was completed, with a sample taken from a biomass-rich layer from 0-6” and a sample from 6-12” beneath the biomass-rich layer, to determine if sediments in this wetland area may contain PFAS. Downgradient samples were collected from the center of the channel, the outlet of Beutel’s Pond, and just upgradient of the Confluence with Raleigh Creek. Sampled locations from this area of the Project 1007 Corridor included (from north to south): RC1, RC2, RC16A, RC16, RC15, and RC14.

No PFAS SDCV exceedances were observed in sediment samples collected in the Tri-Lakes Area to the Confluence with Raleigh Creek. Overall, the Tri-Lakes Area and the channels and pipes south of the Tri-Lakes Area and north of the Confluence generally have lower or non-detectable PFAS concentrations compared to the remainder of the Project 1007 Corridor.

6.4.3 Raleigh Creek from Ideal Avenue to Confluence with Project 1007

This segment of Raleigh Creek is often dry or contains no continuous flowing water. Raleigh Creek is channelized with mostly erosional banks with intermittent sand and gravel depositional areas. There are no wetlands or ponds between

Ideal Avenue N and the Confluence. Sampled locations from this area of the Project 1007 Corridor included (from west to east): RC9, RC10, RC11, RC12, and RC13.

Sediment PFAS detections in this stretch of Raleigh Creek remained consistent across different segments of the channel with little flow rate variability and no instances of PFAS SDCV exceedances.

6.4.4 Raleigh Creek from Confluence to Eagle Point Lake

Raleigh Creek flow is channelized in this stretch until it reaches the Red Trail in Lake Elmo Park Reserve, between RC18 and EP17, where surface water flow becomes dispersed into a wetland area before flowing into Eagle Point Lake. One west bank sample and one east bank sample was collected at RC17 at two depths where foam accumulation has been observed. Sample location EP17 is unique in that it represents the end of the channelized stretch of Raleigh Creek and the beginning of a wetland area. As a result, the sample identifier for EP17 contained one sample from a channel segment (EP17-SED-0-6-01-042520) and two samples from wetland sediments at two different depths (EP17-SED-WET-0-6-01-042520 and EP17-SED-WET-6-12-01-042520). Sampled locations from this area of the Project 1007 Corridor included (from north to south): RC17, RC18, and EP17.

Similar to upstream stretches with minimal flow rate variation and no wetland features, PFAS sediment concentrations showed limited variability between RC21 and RC18. Although there were no instances of PFAS SDCV exceedances, the transition from channelized flow to dispersed wetland flow at EP17 resulted in order of magnitude increases of PFOA (ranged from non-detect (RC17) to 2.66 µg/kg (EP17)., PFHxS (ranged from 0.086 µg/kg (RC18) to 0.609 µg/kg (EP17)), and PFOS (ranged from 1.29 µg/kg (RC17) to 73.1 µg/kg (EP17)).

6.4.5 Eagle Point Lake to outlet of Eagle Point Lake Dam

Samples were collected from eight locations in the Eagle Point Lake area: lake inlet (EP1), southwestern lobe of the lake (EP2), southernmost end of the lake near BS3 (EP18), lake outlet (EP3), wetlands at the outlet of Eagle Point Lake (EP19), and EP4, EP5, and EP7 located between the lake outlet at EP3 and the Eagle Point Lake Dam (dam) at EP8.

No PFAS SDCV exceedances were observed in sediment samples collected from Eagle Point Lake to the outlet of Eagle Point Lake Dam. Samples from the outlet of Eagle Point Lake (EP3) and the southernmost point (EP18) had the highest PFAS concentrations of any Eagle Point Lake sediment. Concentrations of PFOS in the wetland sediments just upstream of the outlet from Eagle Point Lake and at the far southern end of Eagle Point Lake are similar at 90.7 µg/kg and 91.2 µg/kg, respectively.

6.4.6 Lake Elmo

Lake Elmo is primarily fed from groundwater and due to the size and depth of the lake, only a limited number of shallow sediment samples were collected to assess PFAS sediment conditions across the lake. Three samples (EP9, EP14, and EP15) were collected from the main body of the lake and one sample was collected near the downstream side of the dam into Lake Elmo at the approximate location of the historical pre-Project 1007 outlet into Lake Elmo (EP20). EP20 was sampled at four depth intervals 0-6”, 6-12”, 24-30” and 36-42”. All sediment samples collected from Lake Elmo were from depths of less than 6.5 feet below the water surface.

Beach sediment samples were collected from three locations where recreational use is likely during warmer seasons: at the canoe launch within Lake Elmo Park Reserve (EP21A), at the boat launch in Lake Elmo Park Reserve (EP21B) and from a private residence on the north end of Lake Elmo (EP23). Foam was observed during the sediment sampling event at the canoe and boat launches. All beach sediment samples were collected from depths of less than 6-inches below the water surface.

No PFAS SDCV exceedances were observed in sediment samples collected from Lake Elmo. Lake sediment collected from the northern part of Lake Elmo had a higher relative percentage of PFBA detections and a lower relative percentage of PFOS detections compared with locations upstream of Lake Elmo, which is consistent with the general distribution of PFAS concentrations in Lake Elmo surface water.

6.4.7 Outlets of Eagle Point Lake Dam and Lake Elmo to inlet of North Pond

The outlets of both the Eagle Point Lake Dam and Lake Elmo are piped to a channel east of Lake Elmo Ave N where discharged waters mix before flowing east. Sediment samples were collected downstream of this mixing point and before this channel ends at a culvert that discharges to Tartan Pond (EP16). Samples were also collected at Tartan Pond in the golf course (EP13), Horseshoe Lake at the inlet (WL2), the southwest lobe of Horseshoe Lake (WL3), and at the current outlet of Horseshoe Lake (WL5). After the Horseshoe Lake outlet, water flows east along open Project 1007 waterways until it reaches the inlet of North Pond in West Lakeland.

No PFAS SDCV exceedances were observed in sediment samples collected from the outlets of Eagle Point Lake Dam and Lake Elmo to the inlet of North Pond. Similar to other Project 1007 areas, the presence of higher relative PFAS concentrations in sediments compared to nearby samples were associated with locations that had lower flow conditions (Tartan Pond) or constrictions to flow as a result of culverts (EP16).

6.4.8 North Pond to St. Croix River discharge

The Horseshoe Lake outlet connects to a channel that flows into North Pond and continues south via channel flow into Middle Pond and South Pond in West Lakeland. From the channel downstream of South Pond, the water is conveyed through storm sewers to the I-94 Rest Area Pond followed by storm sewer conveyance from the I-94 Rest Area Pond to the St. Croix River. Sampled locations from this area of the Project Corridor included: WL6, WL7, WL9, WL10, WL11, WL12, WL13, WL14, WL15, and WL17.

No PFAS SDCV exceedances were observed in sediment samples collected from the North Pond to the St. Croix River discharge pipe. Concentrations of PFAS in sediments in the West Lakeland Area had relatively little variability. However, due to access limitations, no samples have yet been collected from sediments within the North, Middle, or South Ponds.

6.4.9 Other water bodies in close proximity to the Project 1007 Corridor

Other lakes and streams that are adjacent to the Project 1007 Corridor and may have groundwater connections and/or historic surface water connections were also sampled for sediment.

No PFAS SDCV exceedances were observed in sediment samples collected in these adjacent water bodies. Of note, Sunfish Lake (EP24) had a detection of 3.61 µg/kg. With the exception of EP15 (northern end of Lake Elmo), this is the highest concentration of PFBA measured in sediments from the project area.

6.5 Sediment Analytical Data Summary Discussion

PFAS generally decreased farther from ODS with the highest concentrations occurring in Raleigh Creek from ODS to Ideal Avenue. Sediment samples collected from low-flow or dispersed flow areas typical of wetland conditions that are present from Hadley Avenue to Ideal Avenue had exceedances of the MPCA SDCV-5 days/week standard (RC3, RC3A, RC5, RC6, RC22, and RC23). Eagle Point Lake was an exception to this decreasing PFAS sediment concentration distribution pattern, which occurs farther from the source area. Following a general decrease in sediment concentrations downstream of the Confluence with Project 1007, there was an order of magnitude increase in sediment concentrations in areas of Eagle Point Lake for both PFOA and PFOS (EP3 and EP18). These increased concentrations did not result in additional SDCV exceedances in Eagle Point Lake or in sediment sample locations downstream of Eagle Point Lake.

Upgradient of the Confluence with Raleigh Creek, PFAS concentrations in sediment from the Tri-Lakes Area and Project 1007 were either below detection limits or lower compared to sediment collected from Raleigh Creek both upgradient and downgradient of the Confluence.

Sediment data collected to-date is being used to build an understanding of the depositional conditions and locations where PFAS may be accumulating and forming secondary PFAS source areas, and to better understand how PFAS-containing sediments may contribute to human health and ecological exposure. Continued sediment and surface water collection and analysis of results collected will be used to develop a comprehensive sediment CSM to aid in the understanding of how the presence of PFAS contributes to:

- PFAS fate and transport and surface water/groundwater interaction
- human health exposure
- ecological receptor exposure

The discussion included in this Progress Report is an initial summary of the data collected to-date. Based on the sediment results gathered, additional areas may be sampled to better define the magnitude and extent of PFAS in sediments throughout the Site. As discussed in Section 6.3, additional non-PFAS analytical sampling has been performed and is presented in **Tables 6-5a** through **6-5c** and **Table 6-6**. Data analysis and presentation as it relates to PFAS-impacted sediments and the relationship between surface water and groundwater interaction and PFAS fate and transport will be presented in future deliverables.

PFAS concentrations in sediment were also compared to ecological screening values. A complete presentation of this data is included in the *Screening Level Ecological Risk Assessment and Baseline Ecological Risk Assessment Work Plan* (AECOM, 2020a). A comparison of maximum sediment PFAS concentrations to ecological screening values is also presented in **Tables 6-7a** through **6-7e** and **Table 6-8**.

7. References

AECOM 2019a. August 2019 Baseline Sampling Memo.

AECOM 2019b. Sampling and Analysis Plan.

AECOM 2020a. Screening Level Ecological Risk Assessment and Baseline Ecological Risk Assessment Work Plan.

Battelle 2018. *Current State of the Science for Quantitative Methods to Collect Surface Microlayer Samples Formed on the Water Surfaces of Water Bodies*. WA 2-24 Engineering Technical Support Center Technical Directive 2-11. May 25, 2018

Minnesota Geological Survey, 2016. Geologic Atlas of Washington County, Minnesota. County Atlas Series. Atlas C-30, Part A. University of Minnesota and Minnesota Geological Survey. 2016.

Valley Branch Watershed District (VBWD), 2015. 2015 – 2025 Valley Branch Watershed District Watershed Management Plan. September 2015.