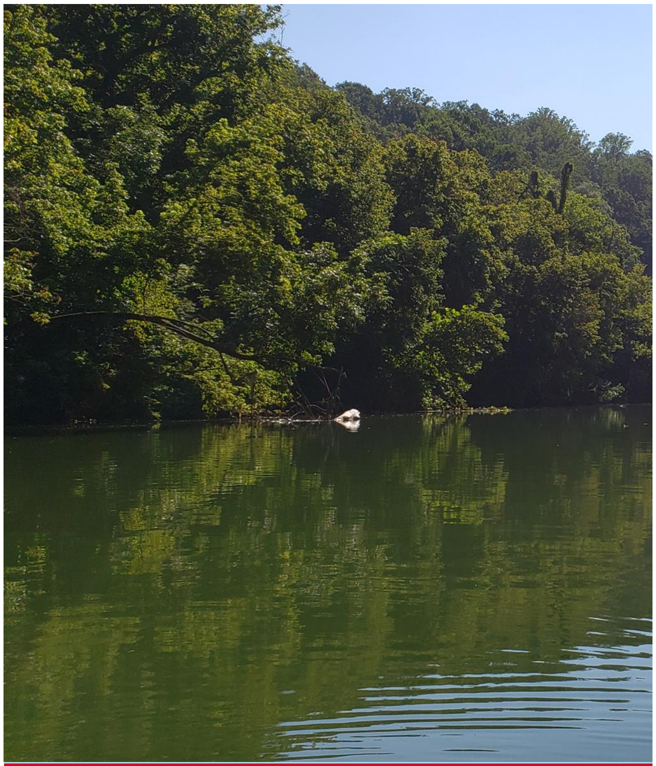

Water Quality Study Report

Niagara Hydroelectric Project
(FERC No. 2466)

December 6, 2021

Prepared by:

HDR

Prepared for:

Appalachian Power Company

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Acronyms and Abbreviations

°C	degrees Celsius
AEP	American Electric Power
Appalachian or Licensee	Appalachian Power Company
DO	dissolved oxygen
CFR	Code of Federal Regulations
cfs	cubic feet per second
CWA	Clean Water Act
FERC or Commission	Federal Energy Regulatory Commission
ft	feet/foot
mg/l	milligrams per liter
Hydrolab	Hach Hydrolab® MS5
ILP	Integrated Licensing Process
ISR	Initial Study Report
PAD	Pre-Application Document
PM&E	protection, mitigation, and enhancement
Project	Niagara Hydroelectric Project
RSP	Revised Study Plan
SPD	Study Plan Determination
TMDL	total maximum daily load
USGS	U.S. Geological Survey
VAC	Virginia Administrative Code
VDEQ	Virginia Department of Environmental Quality
μS/cm	microsiemens per centimeter

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1 Project Introduction and Background

Appalachian Power Company (Appalachian or Licensee), a unit of American Electric Power (AEP) is the Licensee, owner, and operator of the 2.4-megawatt run-of-river Niagara Hydroelectric Project (Project) (Project No. 2466), located on the Roanoke River (River Mile 355) in Roanoke County, Virginia.

The Project is currently licensed by the Federal Energy Regulatory Commission (FERC or Commission) under the authority granted to FERC by Congress through the Federal Power Act, 16 United States Code §791(a), et seq., to license and oversee the operation of non-federal hydroelectric projects on jurisdictional waters and/or federal land. The Project underwent relicensing in the early 1990s, and the current operating license for the Project expires on February 29, 2024. Accordingly, Appalachian is pursuing a subsequent license for the Project pursuant to the Commission's Integrated Licensing Process (ILP), as described at 18 Code of Federal Regulations (CFR) Part 5. In accordance with FERC's regulations at 18 CFR §16.9(b), the licensee must file its final application for a new license with FERC no later than February 28, 2022.

In accordance with 18 CFR §5.11 of the Commission's regulations, Appalachian developed a Revised Study Plan (RSP) for the Project that was filed with the Commission and made available to stakeholders on November 6, 2019. The Commission issued the Study Plan Determination (SPD) on December 6, 2019.

On July 27, 2020, Appalachian filed an updated ILP study schedule and a request for extension of time to file the Initial Study Report (ISR) to account for Project delays resulting from the COVID-19 pandemic. The request was approved by FERC on August 10, 2020, and the filing deadline for the ISR for the Project was extended from November 17, 2020 to January 11, 2021. Appalachian conducted a virtual ISR Meeting on January 21, 2021 and filed the ISR Meeting summary with the Commission on February 5, 2021. Stakeholders provided written comments in response to Appalachian's filing of the ISR meeting summary, which are addressed in this Updated Study Report (USR) along with study methods and results.

Appalachian has conducted studies in accordance with 18 CFR §5.15, as provided in the RSP and as subsequently modified by FERC. This USR describes the methods and results of the Water Quality Study conducted in support of preparing an application for new license for the Project.

2 Study Goals and Objectives

The goals and objectives of the Water Quality Study are to:

- Gather baseline water quality data sufficient to determine consistency of existing Project operations with applicable Virginia state water quality standards and designated uses (Virginia Administrative Code [VAC] Chapter 260).
- Provide data (temperature and dissolved oxygen [DO] concentration) to determine the presence and extent, if any, of temperature or DO stratification in the Niagara impoundment.

- Provide data to support a Virginia Water Protection Permit application (Clean Water Act [CWA] Section 401 Certification).
- Provide information to support evaluation of whether additional or modified protection, mitigation, and enhancement (PM&E) measures may be appropriate for the protection of water quality at the Project.

3 Study Area

The study area for the Water Quality Study includes the Roanoke River within and immediately upstream and downstream of the Niagara Project boundary as shown on Figure 3-1. Appalachian's consultant, HDR Engineering, Inc. (HDR) established eight water quality monitoring locations for approximately three months in 2020:

- One location in the free-flowing section of river upstream of the reservoir and confluence with Tinker Creek;
- One location in Tinker Creek;
- One location in the reservoir downstream of the confluence with Tinker Creek;
- Two locations in the forebay area (one near surface and the other near bottom);
- One location in the tailrace below the powerhouse; and
- Two locations in the bypass reach (upstream location and downstream location).

During the 2020 water quality monitoring period, flows in the bypass reach were higher than normal due to higher than normal Project inflows, damage to the sluice gate hoist operating system, and a powerhouse outage which began on September 8, 2020 and lasted through the end of the study period. While water quality data collected in the bypass reach met Virginia Class IV standards during the 2020 study period, it was recommended that two continuous temperature and DO sondes be re-installed in the bypass reach during the warmest portion of the year in 2021 (i.e., July through October) to record daily fluctuations in temperature and DO under a more typical bypass flow regime. In addition, water quality data (temperature, DO, pH, and specific conductivity) recorded at both the Thirteenth Street Bridge U.S. Geological Survey (USGS) gage (USGS 02055080) and USGS gage at Tinker Creek above Glade Creek (USGS 0205551614) are included in the 2021 water quality monitoring reporting. As a result, during 2021, water quality monitoring was conducted at four monitoring locations by HDR and also reported from the two USGS gages mentioned previously from July through October 2021:

- One location on the Roanoke River at the Thirteenth Street Bridge (USGS 02055080; continuous monitoring) (data collection by others);
- One location at Tinker Creek above Glade Creek (USGS 0205551614; continuous monitoring) (data collection by others);
- One location in the forebay area (i.e., discrete vertical profile data);
- One location in the tailrace below the powerhouse (continuous monitoring); and
- Two locations in the bypass reach: upstream location and downstream location (continuous monitoring).

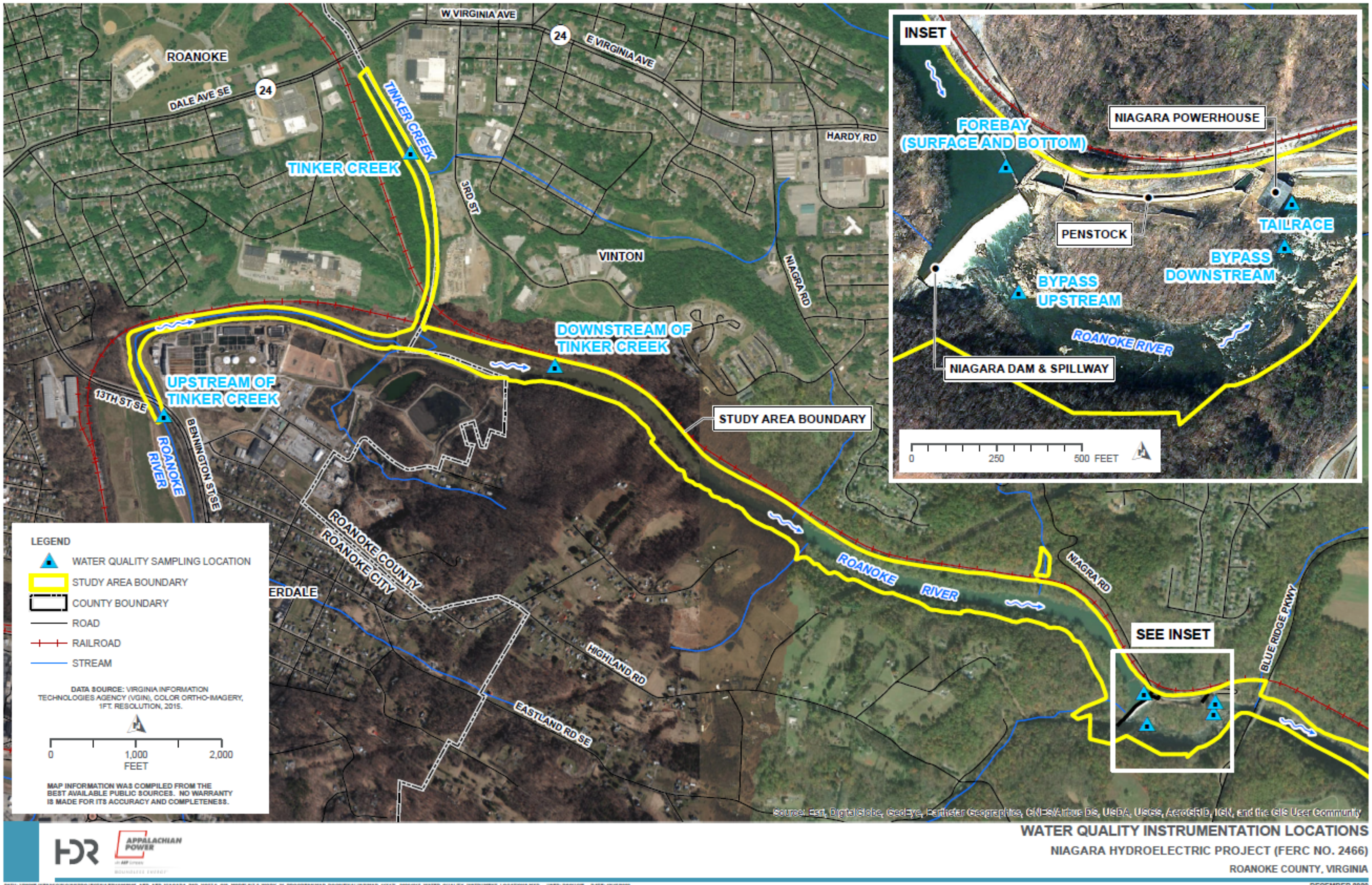

Figure 3-1. Water Quality Study Monitoring Locations

4 Background and Existing Information

Existing relevant and reasonably available information regarding water quality in the Project vicinity was presented in Section 5.3 of the Niagara Pre-Application Document (PAD) (Appalachian 2019). The PAD includes historical water quality data collected by the USGS and the Virginia Department of Environmental Quality (VDEQ) upstream and downstream of the study area. Temperature, DO, pH, and specific conductivity data indicate that inflows to and outflows from the Project meet numeric water quality standards (9VAC25-260-50) required to support designated uses identified at 9VAC25-260-10.

The VDEQ is responsible for carrying out the mandates of the State Water Control Law as well as meeting federal obligations under the CWA (VDEQ 2017a). Waters in the Roanoke River Basin are classified in 9VAC25-260-450. The Roanoke River is designated as Class IV (Mountainous Zone) waters. Tinker Creek is designated as Class VII (Swamp Waters). Numerical criteria for DO, pH, and water temperature for Class IV and VII waters are identified in 9VAC25-260-50 and are summarized in Table 4-1.

Table 4-1. Numeric Water Quality Criteria for Class IV and VII Waters

Parameter	Class IV Standard (Roanoke River)	Class VII (Tinker Creek)
Minimum Instantaneous DO* **	4.0 milligram per liter (mg/l)	*
Daily Average DO	5.0 mg/l	*
pH	6.0 – 9.0	3.7-8.0*
Maximum water temperature	31 degrees Celsius (ºC)	**

*This classification recognizes that the natural quality of these waters may fluctuate outside of the values for DO and pH set forth above as water quality criteria in Class I through VI waters. The natural quality of these waters is the water quality found or expected in the absence of human-induced pollution. Water quality standards will not be considered violated when conditions are determined by the VDEQ to be natural and not due to human-induced sources. The State Water Control Board may develop site specific criteria for Class VII waters that reflect the natural quality of the waterbody when the evidence is sufficient to demonstrate that the site-specific criteria rather than narrative criterion will fully protect aquatic life uses. Virginia Pollutant Discharge Elimination System limitations in Class VII waters shall not cause significant changes to the naturally occurring dissolved oxygen and pH fluctuations in these waters.
** Maximum temperature will be the same as that for Classes I through VI waters as appropriate.
Note: mg/l = milligrams per liter
***The water quality criteria in this section do not apply below the lowest flow averaged (arithmetic mean) over a period of seven consecutive days that can be statistically expected to occur once every 10 climatic years (a climatic year begins April 1 and ends March 31). Site-specific adjustments to these criteria are defined by 9VAC25-260-310 and 9VAC25-260-380 through 9VAC25-260-540.

Due to factors unrelated to Project operations, multiple reaches within the Project boundary were listed as impaired in the 2018 §305(b)/303(d) Water Quality Assessment Integrated Report, including fish consumption advisories (VDEQ 2019). However, the source of impairment is not associated with the Project and it is expected that continued operation of the Project will have no effect on whether these reaches continue to be listed as impaired. Potential sources for water quality impairment include discharges from an upstream wastewater treatment plant, municipal separate storm sewer systems, industrial point source discharge, landfills, municipal areas, individual private treatment systems, sanitary sewer outflows, and wildlife (VDEQ 2019).

Total maximum daily loads (TMDLs) for aquatic life (benthic) use, polychlorinated biphenyls, and bacteria have been developed for the Roanoke River (Berger 2006; Tetra Tech, Inc. 2009; GMU & Berger 2006).

According to the benthic TMDL prepared for the upper Roanoke River (Berger 2006), sediment has been identified as the most probable stressor impacting benthic macroinvertebrates in the biologically impaired segments of the Roanoke River. Excessive sediment loading can negatively impact benthic macroinvertebrates through siltation of habitat, water quality degradation (e.g., decreased light, temperature, and DO concentrations) due to excess sediment in the water column, and bringing invertebrates into contact with other pollutants that enter surface water via adhesion to sediment particles. Potential sources of sediment loading in the watershed include urban stormwater runoff, streambank erosion, and sediment loss from habitat degradation associated with urbanization.

In late July 2017, approximately 165 gallons of Termix 5301, a type of surfactant that is added to herbicide and pesticide products before application, was spilled into Tinker Creek in Cloverdale, Virginia, upstream of the Project. The resulting fish kill was estimated at tens of thousands of fish in Tinker Creek. The fish kill occurred outside of the Project boundary, and no effects have been identified in the mainstem of the Roanoke River (VDEQ 2017b).

5 Methodology

5.1 Data Collection

Continuous temperature and DO monitoring as well as discrete multiparameter water quality sampling were carried out at locations within the study area. Vertical profile data was also collected at the reservoir and forebay monitoring locations (Figure 3-1).

During the initial deployment and subsequent download events, discrete multi-parameter water quality measurements (i.e. spot measurements) of temperature, DO concentration, pH, and specific conductivity were collected at each monitoring location using a Hach Hydrolab® MS5 (Hydrolab). For riverine monitoring locations, Hydrolab water quality data was collected at one location within the water column at a depth similar to the sondes. Profile measurements were collected at 1.0-foot (ft) vertical intervals using the Hydrolab for the two reservoir monitoring locations to record temperature and DO values throughout the water column at the time of the data sonde downloads.

Calibrated Onset® HOBO U26 DO/Temperature Loggers (i.e. sondes) were deployed for continuous in situ measurements and were set to record water temperature and DO at 15-minute intervals. During the 2020 study period, continuous data was collected from July 29 through November 10 and the data sondes were downloaded five times (August 12 and 26, September 22-23, October 21, and November 9-10, 2020). At each of the eight continuous monitoring locations, two data sondes were deployed to provide redundancy. In the forebay, one sonde was deployed near the water surface and a second was deployed near the reservoir bottom to capture temperature and DO stratification. The download schedule was accelerated from monthly to bi-weekly when possible to reduce effects associated with biofouling, which was greater than anticipated at the time of the RSP development. During the 2021 study period, continuous data was collected from June 29 through October 27. At each of the three continuous monitoring locations installed by HDR (i.e., bypass reach upstream, bypass reach downstream, and tailrace), two data sondes were deployed to provide redundancy. The download schedule was roughly every two to three weeks, and the data sondes were downloaded seven times over the monitoring period.

5.2 Data Analysis and Processing

Upon completion of the field data collection effort, data was checked for errors and omissions. Data that more closely matched the discrete measurement readings made in the field during download events were preferentially reported and analyzed for each monitoring location. Note there are several data gaps that occurred during the field data collection period that were the result of biofouling, equipment malfunction, and/or equipment theft. These data gaps did not affect the overall summary results and conclusions of this study report.

Real-time flow data (15-minute) was obtained from the USGS Roanoke River at Niagara Gage (USGS 02056000), which is approximately 500 ft downstream of the Niagara powerhouse and includes the combined flows from the powerhouse and bypass reach. Flows have been recorded since October 1990 at the USGS Roanoke River at Niagara gage and corresponding stage from October 2007 to present.

5.3 Equipment Calibration and Quality Assurance

Prior to the first deployment, Onset HOBO® Model U26 DO/Temperature Loggers were initialized with a new DO sensor cap and calibrated. The Hydrolab multi-parameter water quality sonde was lab calibrated by the manufacturer. Prior to each instantaneous sample collection, the Hydrolab was checked against a suite of standards. A Hydrolab® Surveyor 4a (Surveyor) is the handheld display that connects to the Hydrolab sonde for attended monitoring applications. The Surveyor was sent to the manufacturer for calibration prior to the field deployment. The water quality sensor specifications as specified by the manufacturer are presented in Table 5-1.

Table 5-1. Water Quality Sensor Specifications

Water Quality Sensor Accuracy		
Sensor	Hydrolab® MS5[2]	Onset HOBO® Model U26[3]
Temperature	+/- 0.1°C	+/- 0.2°C
DO[1]	+/- 0.1 mg/l for 0 – 8 mg/l; +/- 0.2 mg/l for greater than 8 mg/l	+/- 0.2 mg/l for 0.0 – 8.0 mg/l; +/- 0.5 mg/l for greater than 8.0 mg/l
Specific conductivity	+/- 0.5 % of reading; +/- 0.001 millisiemens/centimeter	N/A
pH	+/- 0.2 units	N/A

Note:
[1] Hach LDO® - Luminescent Dissolved Oxygen sensor or Onset RDO ® - Rugged Dissolved Oxygen. Both use light to optically measure dissolved oxygen.
[2] Specifications for the Hydrolab® MS5: https://s.campbellsci.com/documents/ca/product-brochures/series_5_br.pdf
[3] Specifications for the Onset HOBO® Model U26: https://www.onsetcomp.com/products/data-loggers/u26-001/

6 Study Results

6.1 Water Temperature

Figure 1-1 and Figure 1-2 in Attachment 1 provide continuous and discrete water temperature data at all water quality locations for 2020 and 2021, respectively. At the time of initial data sonde deployment on July 29, 2020, water temperatures were in the 24 – 27ºC range at the Roanoke River monitoring locations and in the 20 – 25ºC range at the Tinker Creek monitoring location. Water temperatures recorded at the USGS 02055080 (Roanoke River at the Thirteenth Street Bridge in Roanoke) water quality monitoring station (immediately upstream of the reservoir) peaked at 28.7ºC on July 20, 2020; approximately one week prior to initial deployment of the data sondes. Water temperatures generally decreased during the 2020 study period and dropped to approximately 10ºC by early November 2020. Tinker Creek water temperatures were several degrees cooler and exhibited larger daily fluctuations compared to the Roanoke River monitoring locations. The Tinker Creek monitoring location is heavily canopied which may contribute to the cooler temperatures, and the drainage area is relatively small[1] which may contribute to the larger daily fluctuations.

Water temperature measurements during July and August 2021 were slightly higher than during 2020 at all monitoring locations with daily peaks in the 25 – 30ºC range. The diurnal variation in temperature fluctuation at the two bypass reach monitoring locations in 2021 was also greater than 2020. The higher water temperatures and greater diurnal variation in water temperatures were likely the result of lower Project inflows during 2021, particularly in the bypass reach. While 2021 water temperatures were generally higher than in 2020, water temperatures for both years were less than the state maximum water temperature limit of 31ºC.

All discrete temperature data for 2020 and 2021 are included in Tables 2-1 and 2-2 (Attachment 2). Water temperature vertical profile plots for the forebay are presented on Figure 3-1 and 3-2 (Attachment 3). Vertical profile temperature plots for the reservoir are shown on Figure 3-7 (Attachment 3) and vertical profile data are included in Tables 2-3 through 2-6 (Attachment 2). While water temperature varied seasonally, there was no thermal stratification at the reservoir monitoring location during 2020 and no to very weak (i.e., <1.0ºC) thermal stratification at the forebay monitoring location for most of 2020 and 2021. The one exception was during the September 15, 2021 download event where the difference between forebay surface and bottom temperatures was approximately 3.1ºC. This download event occurred during a powerhouse outage when flows in the forebay area were reduced, thus allowing the water column to thermally stratify.

6.2 Dissolved Oxygen

Figures 1-3 and 1-4 in Attachment 1 provide continuous and discrete DO concentration data at the upstream water quality monitoring locations (Thirteenth Street Bridge and Tinker Creek) during 2020 and 2021, respectively. All upstream measurements were greater than the 5.0 mg/l daily average DO state standards with daily fluctuations in the 2 – 5 mg/l range at both locations. The sharp

[1] The drainage area at the Tinker Creek monitoring location is approximately 78 square miles; 66 of which are classified as urban land use, as compared to the Roanoke River drainage area at the Thirteenth Street Bridge monitoring location which is approximately 390 square miles.

decline in Tinker Creek DO concentrations the first week of September 2020 was likely the result of a 3-inch rainfall runoff event that occurred at the beginning of that week (see Figure 4-1 of Attachment 4 for rainfall and streamflow data during the 2020 study period). All discrete DO data for 2020 and 2021 are included in Table 2-1 and Table 2-2 of Attachment 2.

Figure 1-5 (Attachment 1) provides continuous and discrete DO concentration data at the Project's forebay and tailrace monitoring locations in 2020. DO values exceeded the 4.0 mg/l instantaneous and 5.0 mg/l daily average standard (9 VAC 25-260-50) except in the Project's forebay on September 8 and 11, 2020. Instantaneous DO concentrations on these dates (recorded at the sonde near the reservoir bottom) were 3.3 mg/l and 3.4 mg/l, respectively. Each occurrence of instantaneous DO concentrations below 4.0 mg/l lasted less than 1.5 hours in duration. Also, both dates coincided with the start of a planned outage at the Niagara plant, which began on September 8, 2020 and continued throughout the end of the monitoring period. Because there was no flow through the powerhouse, instantaneous DO concentrations fluctuated (albeit very short-lived) between the forebay surface and bottom elevations. During these two events, DO concentrations near the surface remained above 5.0 mg/l and as a result, overall DO concentrations in the forebay met the state's DO criteria.[2] Daily fluctuations in DO concentrations were in the 1.0 – 2.0 mg/l range at the forebay and tailrace monitoring locations; slightly less than the daily fluctuations at the two upstream monitoring locations. Similar to water temperature profile trends, there was little (i.e., < 0.5 mg/l) difference in DO concentrations between the forebay surface and bottom sonde locations (with the exception of the two events noted above); indicating little to no stratification of DO concentrations throughout the forebay water column. DO concentrations in the tailrace were generally higher (by less than 0.5 mg/l) compared to the surface forebay monitoring location during both periods of generation and non-generation (see data pre- and post- powerhouse outage on September 8, 2020).

Figure 1-6 (Attachment 1) provides continuous and discrete DO measurements at the forebay and tailrace locations for 2021. DO concentrations exceeded the 4.0 mg/l instantaneous and 5.0 mg/l daily average standards throughout the 2021 monitoring period at these two monitoring locations.

Figure 1-7 (Attachment 1) provides continuous and discrete DO concentration data at the bypass reach upstream and downstream monitoring locations for the 2020 study period. Overall magnitude and trends in DO concentrations were very similar between the forebay, tailrace and bypass reach monitoring locations. All measurements were greater than the 5.0 mg/l daily average DO standard with daily fluctuations in the 1.5 – 2.5 mg/l range prior to the powerhouse outage that occurred on September 8, 2020; after which, daily fluctuations were less than 1 mg/l due to the large flow throughput in the bypass reach when generation flows ceased.

Figure 1-8 (Attachment 1) provides continuous and discrete DO concentration data at the bypass reach monitoring locations for 2021. During 2021, continuous and discrete DO concentration data indicated that all values exceeded the 4.0 mg/l instantaneous and 5.0 mg/l daily average standard with the exception of the upper bypass reach monitoring location during the hottest portion of the summer (July/August) when bypass flows were at the 8.0 cubic feet per second (cfs) minimum required release. The upper bypass reach data sonde is located in a slow moving/stagnant pool

[2] For a thermally stratified man-made lake or reservoir in Class III, IV, V or VI waters that are listed in 9VAC25-260-187, these dissolved oxygen and pH criteria apply only to the epilimnion of the waterbody. When these waters are not stratified, the dissolved oxygen and pH criteria apply throughout the water column.

which at times exhibited DO concentrations less than 4.0 mg/l during nighttime hours on several days in July and August. Hot, relatively dry weather conditions conducive to supersaturation due to photosynthesis during daylight hours and a DO sag during nighttime hours is assumed to be the principal cause; significant biofouling that occurred in these instruments under the lowest monitored flow likely contributed to low DO values. From August 11 – 13, 2021, the bypass flow was increased from 8.0 cfs to approximately 20 cfs due to an operational adjustment associated with the Obermeyer trash sluice gate (see Figure 4-2 in Attachment 4). During this 2-day period, DO concentrations at the upstream bypass reach monitoring location remained above the 4.0 mg/l instantaneous and 5.0 mg/l daily average standard and did not experience a nighttime DO sag. After August 13, 2021, the Obermeyer gate returned to its normal operating mode and DO concentrations in the bypass reach remained above the Virginia standard during the remainder of the 2021 monitoring period. A planned powerhouse maintenance outage occurred from September 7 – 30, 2021, during which time all Project inflow was routed through the bypass reach. This resulted in DO concentrations greater than 8.0 mg/l during the outage. As water temperatures continued to cool during October 2021, DO concentrations in the bypass reach remained high (i.e., > 8.0 mg/l).

DO vertical profile data for the forebay monitoring location are presented in Tables 2-3 and 2-5 (Attachment 2) and on Figures 3-1 and 3-2 (Attachment 3). Vertical profile data for the reservoir is presented in Table 2-4 (Attachment 2) and is shown on Figure 3-7 (Attachment 3). Similar to the water temperature profile data, during 2020 there was no stratification of DO concentrations at the reservoir monitoring location and no to very weak stratification at the forebay monitoring location. During 2021, vertical DO profile measurements during several download events in August and September indicated some degree of DO stratification at the forebay monitoring location; the strongest of which was measured on September 15, 2021 during the powerhouse outage described in Section 6.1. During this download event, DO concentrations ranged from 8.0 mg/l at the surface to 5.0 mg/l near the bottom of the forebay. All DO concentrations measured at the forebay monitoring location in 2021 were greater than 5.0 mg/l at all depths.

6.3 pH

Vertical profile data showing pH is provided in Tables 2-3, 2-4, and 2-6 and presented in Figures 3-3 and 3-4 (forebay location) and Figure 3-8 (reservoir location) of Attachment 3. The range in pH range at both locations during the 2020 and 2021 monitoring periods showed only minor variations (between 7.5 and 8.0) during each discrete sampling event, and there was little to no stratification between the reservoir surface and bottom measurements at both monitoring locations. All discrete pH data for 2020 and 2021 are included in Tables 2-1 and 2-2 (Attachment 2).

Figure 1-9 (Attachment 1) provides continuous pH measurements at the upstream USGS water quality monitoring locations for 2021. The pH at both locations ranged from 7.6 – 8.5, which was slightly higher than the discrete pH measurements at the forebay, tailrace, and bypass reach monitoring locations in 2021, but was within the Virginia standard for pH values.

6.4 Specific Conductivity

While Virginia does not have a state standard for specific conductivity, concentrations between 150-500 microsiemens per centimeter (µS/cm) are generally considered suitable for most fish species (USEPA 2012). Specific conductivity vertical profile data are provided in Attachments 2 and 3. Figure

3-5 and Figure 3-6 show the forebay monitoring location for 2020 and 2021, respectively. Figure 3-9 shows the reservoir monitoring location for 2020. For the 2020 sampling period, conductivity at the forebay monitoring location varied with each sampling event, but concentrations were typically the same from reservoir surface to bottom and ranged from 370 – 435 µS/cm over four sampling events during the study period. Specific conductivity at the reservoir monitoring location also varied with each sampling event and concentrations were typically the same from reservoir surface to bottom, but with a slightly higher (and narrower) range between 411 – 436 µS/cm) over the four sampling events. For 2021, specific conductivity at the forebay monitoring location was slightly higher than in 2020 ranging from 369 – 501 µS/cm over eight sampling events.

Discrete measurements of specific conductivity at the Tinker Creek monitoring location (2020 only) ranged from 461 – 494 µS/cm which is slightly higher than at the Thirteenth Street Bridge monitoring location, which ranged from 319 – 396 µS/cm (see Table 2-2 of Attachment 2 for discrete sampling results). As expected, specific conductivity concentrations at the monitoring locations downstream from these two sampling points fit within these two ranges, the result of blended inflow to the reservoir. All discrete specific conductivity data for 2020 and 2021 are included in Tables 2-1 and 2-2 (Attachment 2).

Figure 1-10 (Attachment 1) provides continuous specific conductivity for the upstream Thirteenth Street Bridge and Tinker Creek monitoring locations during the 2021 study period. Similar to the discrete monitoring results, specific conductivity in Tinker Creek is generally higher than at the Thirteenth Street Bridge monitoring location by approximately 100 µS/cm on average. Sharp declines in specific conductivity at both upstream locations correspond to higher flows during rainfall runoff events.

7 Summary and Discussion

7.1 Consistency with Applicable Virginia State Water Quality Standards

Continuous and discrete water quality data collected during the 2020 study period met Virginia Class IV (Roanoke River) and Class VII (Tinker Creek) water quality standards for temperature (<31 ºC), DO (>4.0 mg/l instantaneous minimum; >5.0 mg/l daily average), and pH (range 6.0 – 9.0 for Class IV and 3.7 – 8 for Class VII) at all monitoring locations during the study period. The continuous monitoring data captured two events when forebay bottom DO concentrations dropped to, or slightly below 4 mg/l for a short period (typically less than 1.5 hours in duration for each event), which was likely the result of a powerhouse outage. Even with these short-lived events, the Project met state water quality criteria throughout the 2020 study period.

Continuous and discrete water quality data collected during the 2021 study period also met Virginia Class IV (Roanoke River) water quality standards with the exception of the DO instantaneous standard (4.0 mg/l) at the upstream bypass reach monitoring location during the hottest portion of the summer (July/August) when bypass flows were at the 8.0 cfs minimum required release. Increasing the bypass reach flow to approximately 20 cfs for a 2-day period in mid-August 2021 reduced nighttime DO sags and resulted in DO concentrations above the Virginia standard. After the 2-day period, the Obermeyer trash sluice gate returned to normal operations and DO concentrations at the upstream monitoring location remained above the Virginia standard for the remainder of the 2021 study period.

7.2 Temperature and Dissolved Oxygen Stratification in the Niagara Impoundment

Continuous and discrete water quality data collected during the 2020 study period indicated little to no thermal or DO stratification at the reservoir and forebay monitoring locations. Water temperatures typically varied less than 1.0ºC from reservoir surface to bottom, and DO concentrations typically varied less than 1.0 mg/l from reservoir surface to bottom. Continuous water temperatures recorded at the USGS Thirteenth Street Bridge water quality monitoring station (immediately upstream of the reservoir) peaked at 28.7ºC on July 20, 2020; approximately one week prior to initial deployment of the data sondes. As a result, water temperatures recorded during this study are representative of both warmer summer months and cooler fall months.

Continuous and discrete water quality data collected during the 2021 study period indicated little to no thermal or DO stratification (forebay location) with the exception of periods of relatively low Project inflow and/or powerhouse outages when thermal and DO stratification in the forebay area was present. The maximum extent of stratification was observed during the September 15, 2021 download event which coincided with a Niagara plant outage (i.e., no powerhouse flows). During this download event, water temperatures ranged from 24.7ºC at the forebay surface to 21.6ºC near the bottom. DO concentrations ranged from 8.0 mg/l near the surface to 5.0 mg/l near the bottom. Even during periods of thermal and DO stratification, Virginia temperature and DO standards were met.

7.3 Need for Protection, Mitigation, and Enhancement Measures to Protect Water Quality

Water quality in the streams flowing into the Niagara reservoir, the reservoir itself (including the Project's forebay area), tailrace, and bypass reach is consistent with applicable Virginia state water quality standards for temperature, DO, and pH for Class IV (Roanoke River) and Class VII (Tinker Creek) surface waters. While there is no state standard for specific conductivity, concentrations were above 150 µS/cm and less than 550 µS/cm, which is generally considered to be suitable for most fish (USEPA 2012). Appalachian will continue to operate the Project in the existing run-of-river mode with minimum flow releases to the bypass reach over the new license term, for the protection of water quality and other resources. As a result, there is no need for additional PM&E measures to protect water quality at the Project.

7.4 Additional Future Water Quality Data Needs

Water quality data collected during 2020 (higher than normal Project inflows) and 2021 (normal Project inflows) met Virginia Class IV (Roanoke River) and Class VII (Tinker Creek) water quality standards with the exception of the DO 4.0 mg/l instantaneous standard at the upstream bypass reach monitoring location during the hottest portion of the 2021 summer (July/August) when bypass flows were at the 8.0 cfs minimum required release. Increasing the bypass reach flow to approximately 20 cfs reduced nighttime DO sags and resulted in DO concentrations above the Virginia standard. The Niagara forebay area experiences some thermal and DO stratification during periods of relatively low Project inflows and/or powerhouse outages, however, the temperature and DO regime throughout the water column met Virginia temperature and DO standards. Based on these data, Appalachian does not propose additional water quality monitoring at the Project during the new license term.

8 Variances from FERC-Approved Study Plan

Based on the results and findings from the 2020 water quality monitoring period, FERC approved a study modification requiring additional water quality data collection at Niagara in 2021. FERC required that Appalachian conduct continuous monitoring in the bypass reach (two locations) and tailrace (one location) in 2021, as well as the discrete collection of water quality data in the forebay (i.e., vertical profiles), tailrace, and bypass reach. In lieu of reinstalling continuously recording sondes in the upper end of the impoundment, Tinker Creek, and the Roanoke River upstream of the confluence with Tinker Creek, Appalachian proposed, and FERC agreed, to include 2021 water quality data (temperature, DO, pH, and specific conductivity) recorded at both the Thirteenth Street Bridge USGS gage (USGS 02055080) and USGS gage at Tinker Creek above Glade Creek (USGS 0205551614) in the USR. FERC also required that the 2021 water quality monitoring period extend from July through the end of October. The 2021 water quality study incorporated FERC's requirements from the May 10, 2021 determination for study modifications.

9 Germane Correspondence and Consultation

FERC issued a determination on requests for study modifications for the Niagara Project on May 10, 2021. Study modifications included continued collection of water quality parameters at select monitoring locations from July through October 2021. This additional data has been summarized in the USR and correspondence has been added to Attachment 2 (FERC Consultation) of the USR.

10 References

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Attachment 1

Attachment 1 – Continuous Temperature, Dissolved Oxygen, pH, and Specific Conductivity Plots

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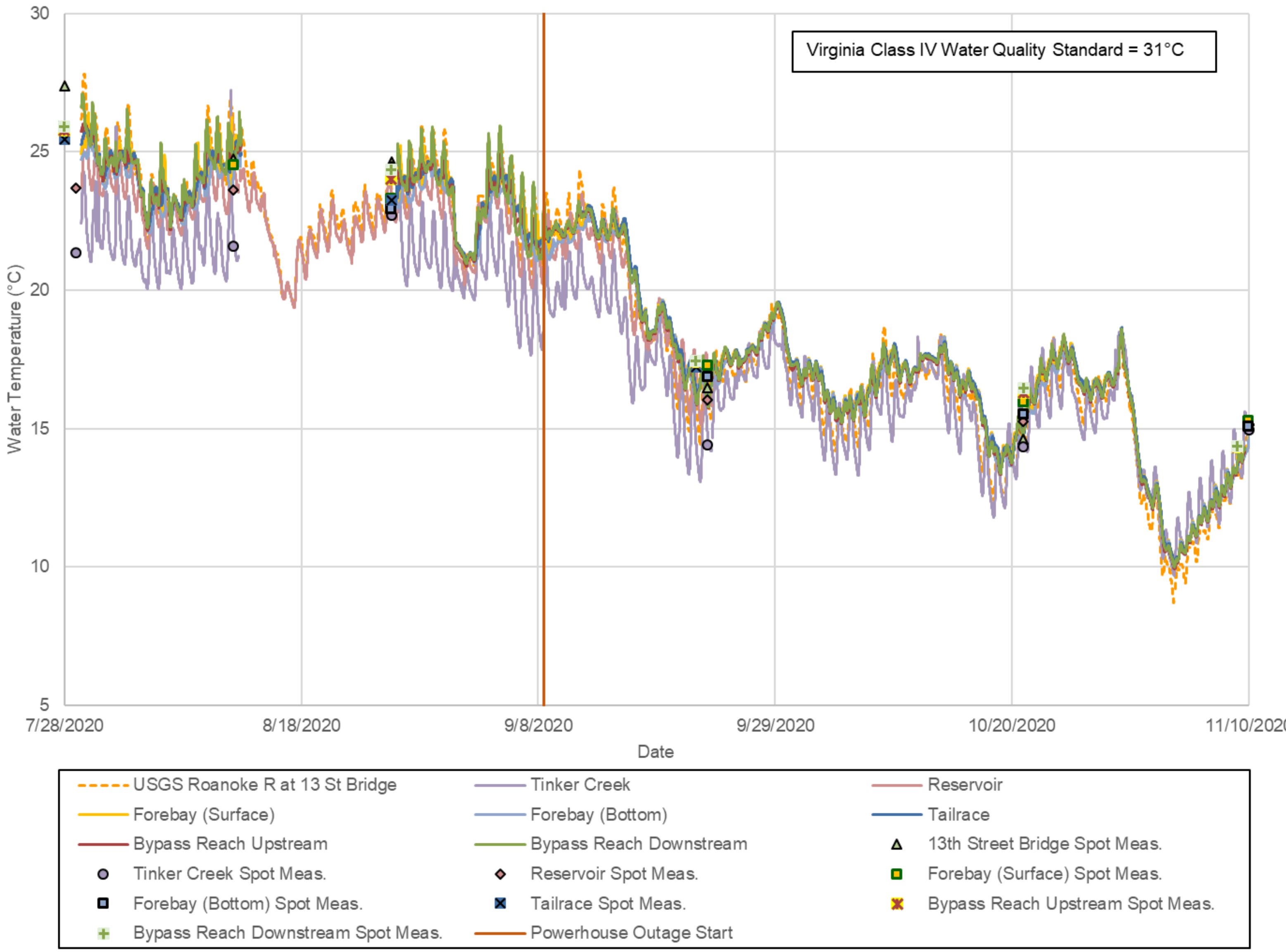

Figure 1-1. Continuous and Discrete Temperature Measurements at All Water Quality Monitoring Locations (2020)

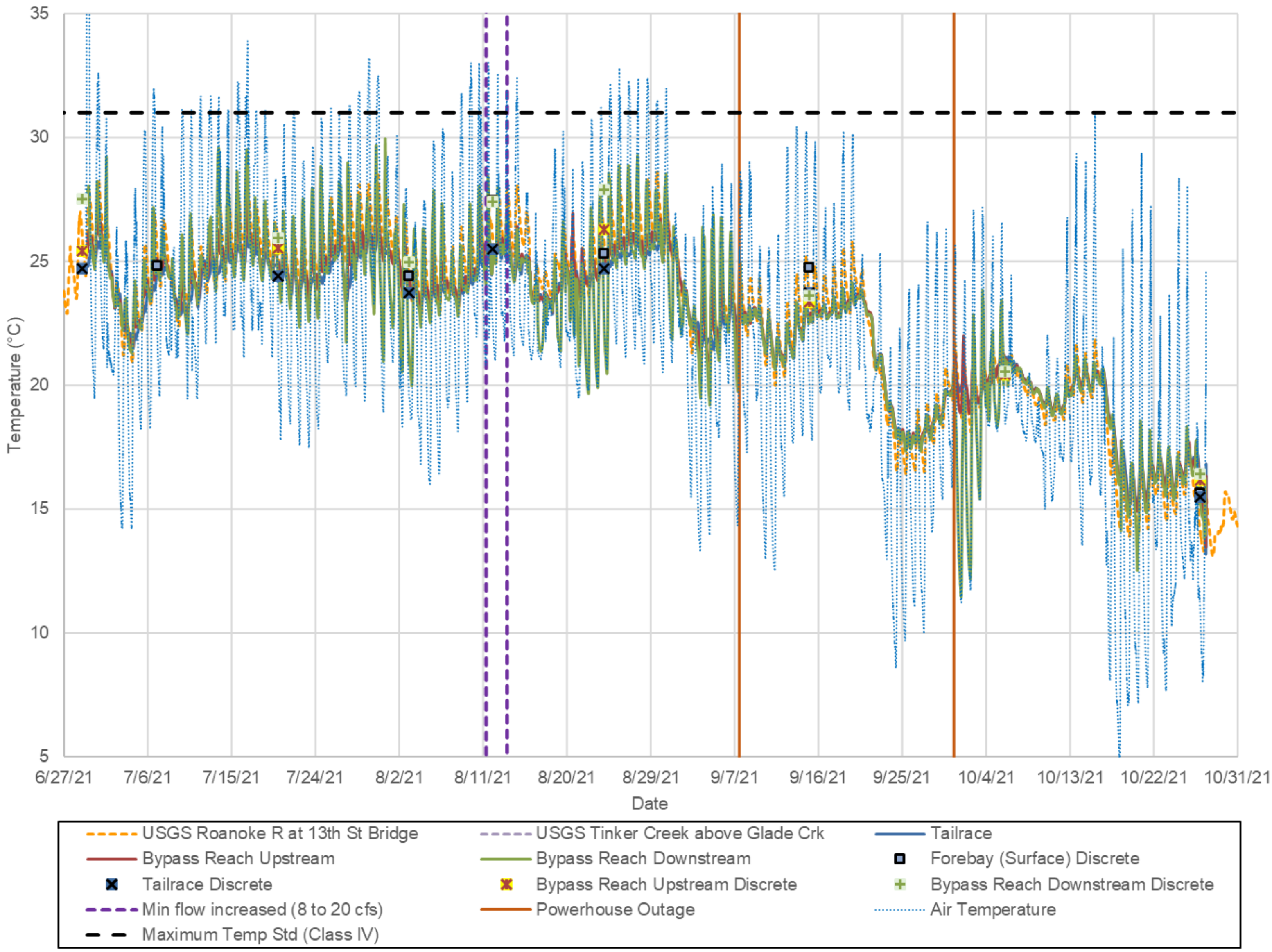

Figure 1-2. Continuous and Discrete Temperature Measurements at All Water Quality Monitoring Locations (2021)

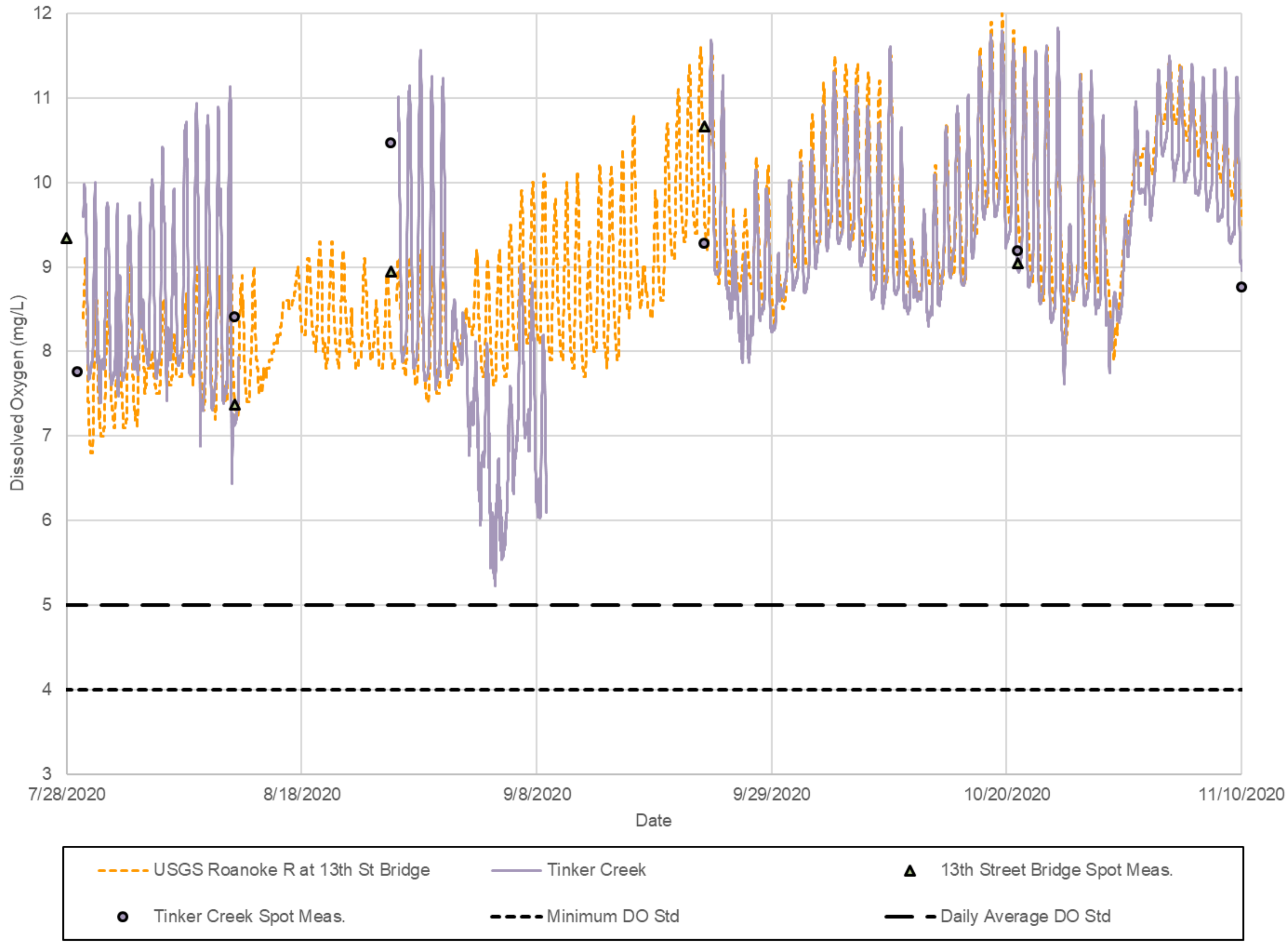

Figure 1-3. Continuous and Discrete Dissolved Oxygen Concentrations at the Upstream Water Quality Monitoring Locations (2020)

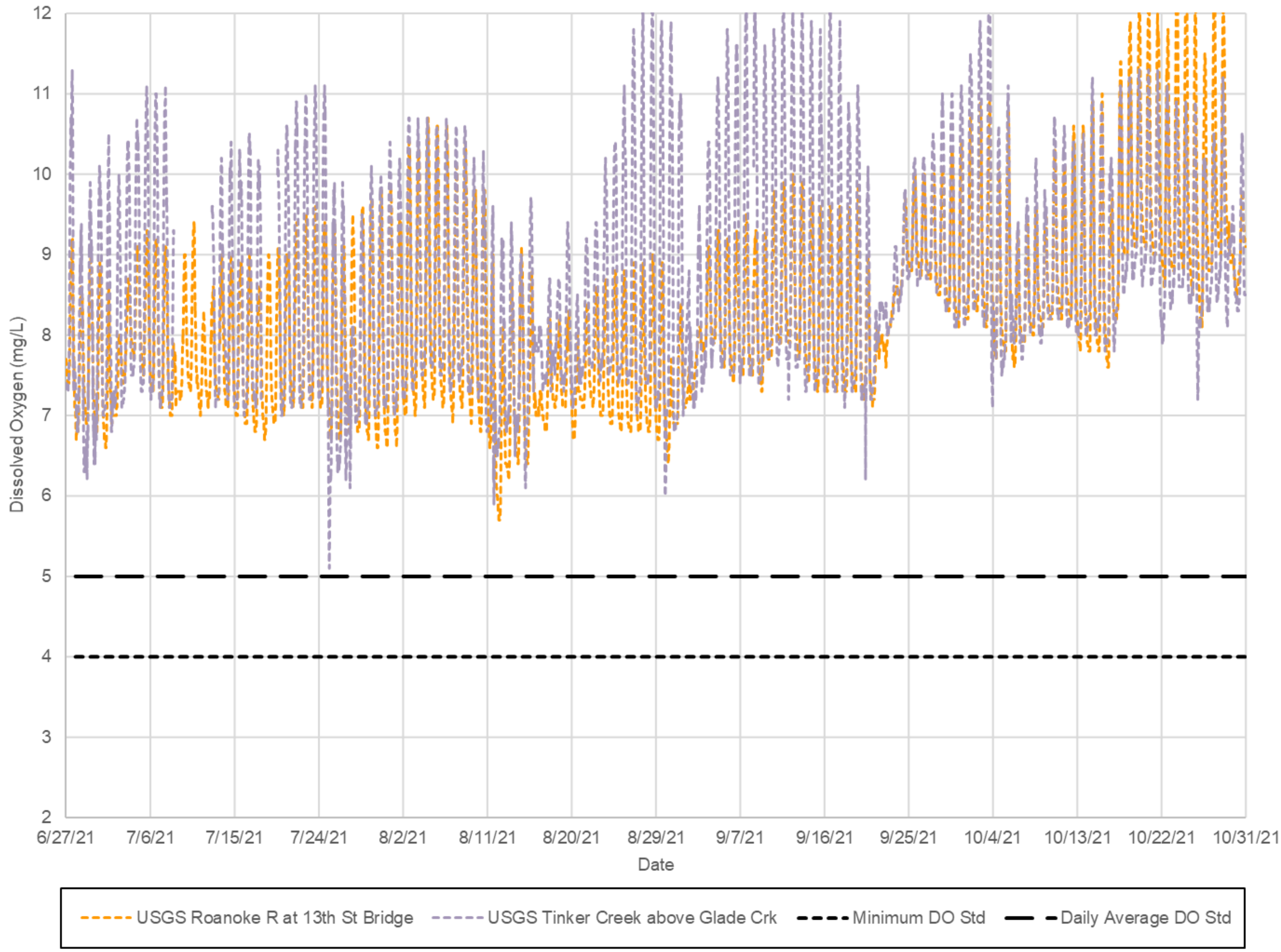

Figure 1-4. Continuous and Discrete Dissolved Oxygen Concentrations at the Upstream USGS Water Quality Monitoring Locations (2021)

Figure 1-5. Continuous and Discrete Dissolved Oxygen Concentrations at the Forebay and Tailrace Water Quality Monitoring Locations (2020)

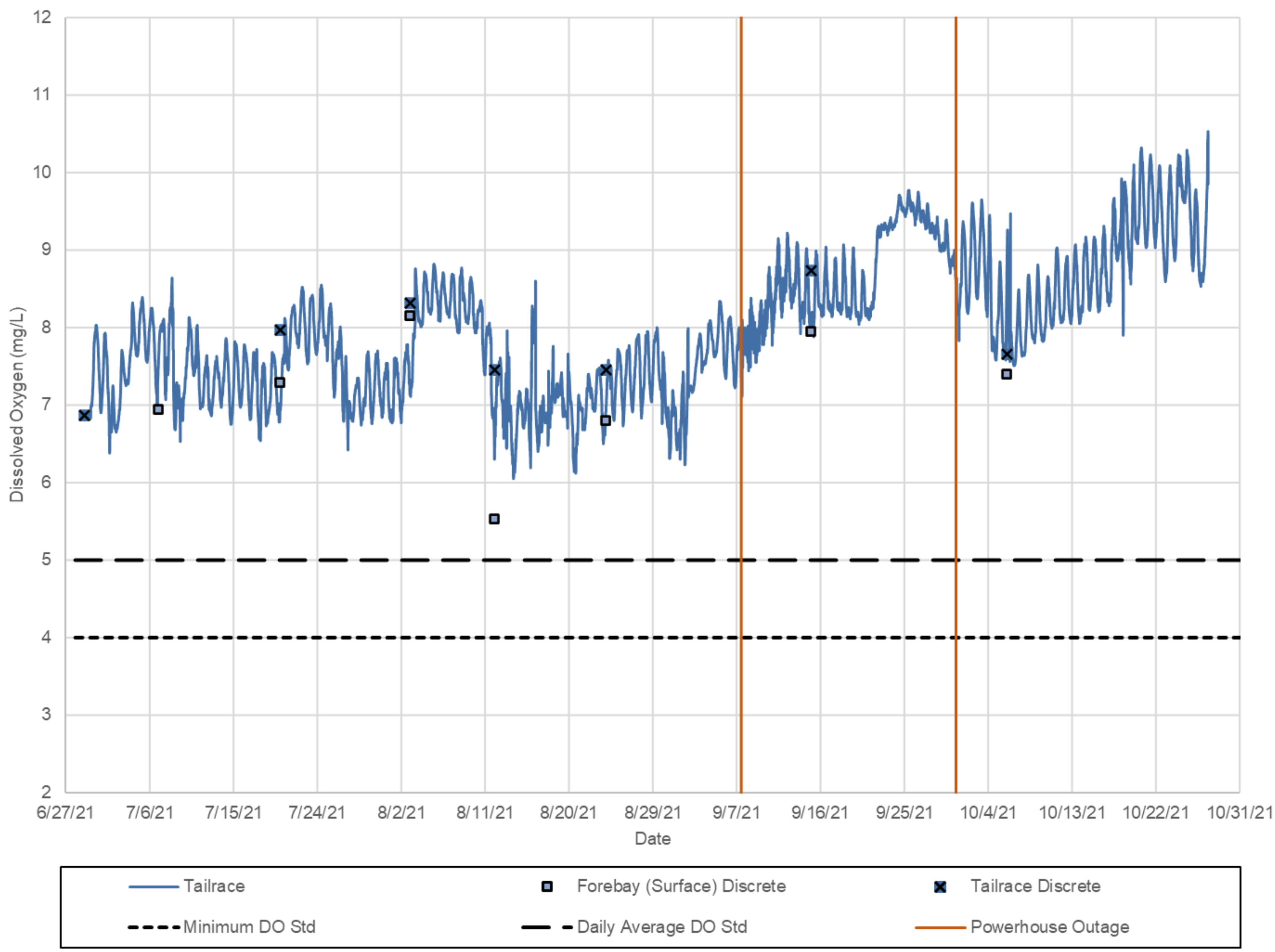

Figure 1-6. Continuous and Discrete Dissolved Oxygen Concentrations at the Forebay and Tailrace Water Quality Monitoring Locations (2021)

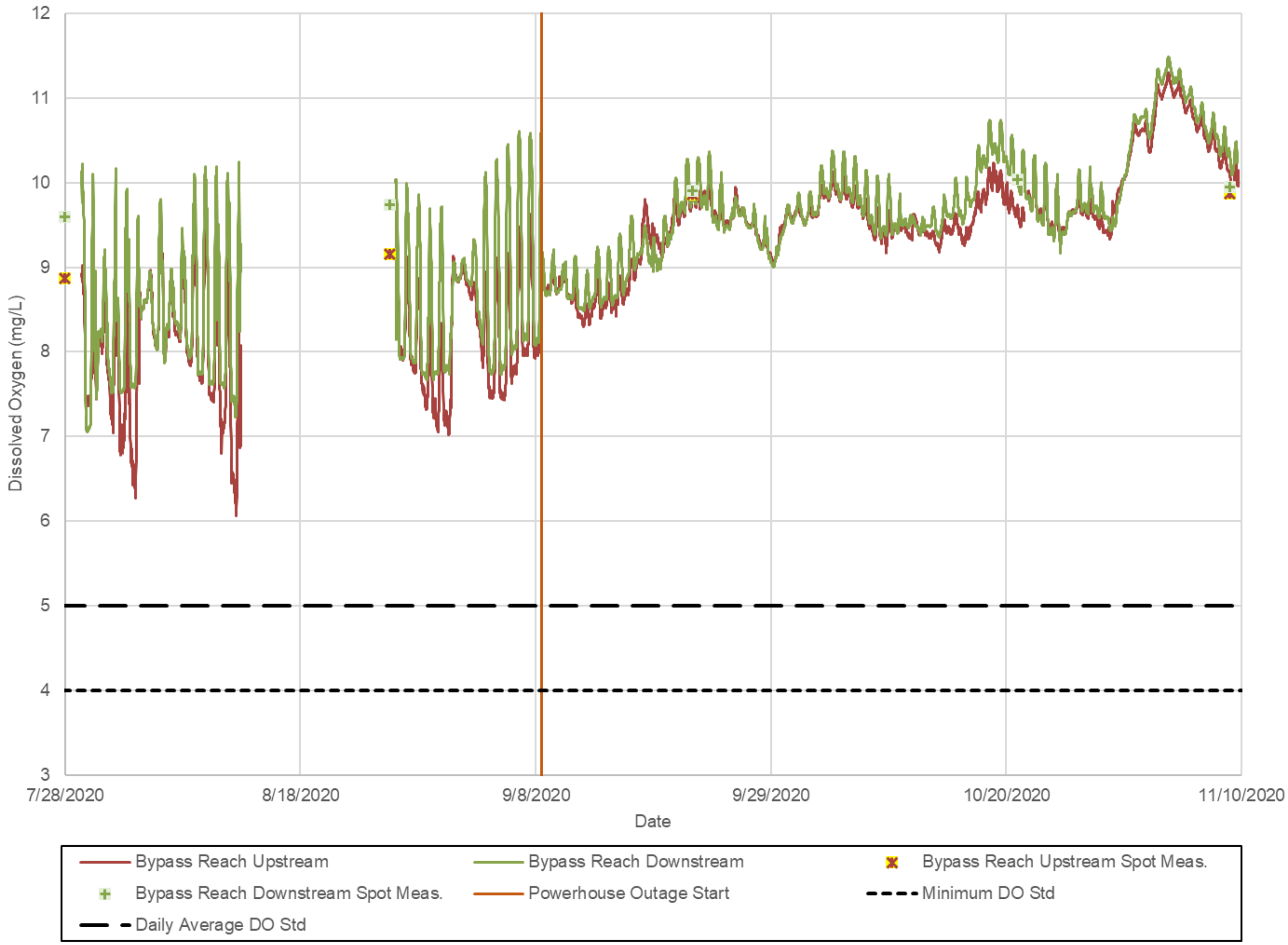

Figure 1-7. Continuous and Discrete Dissolved Oxygen Concentrations at the Bypass Reach Water Quality Monitoring Locations (2020)

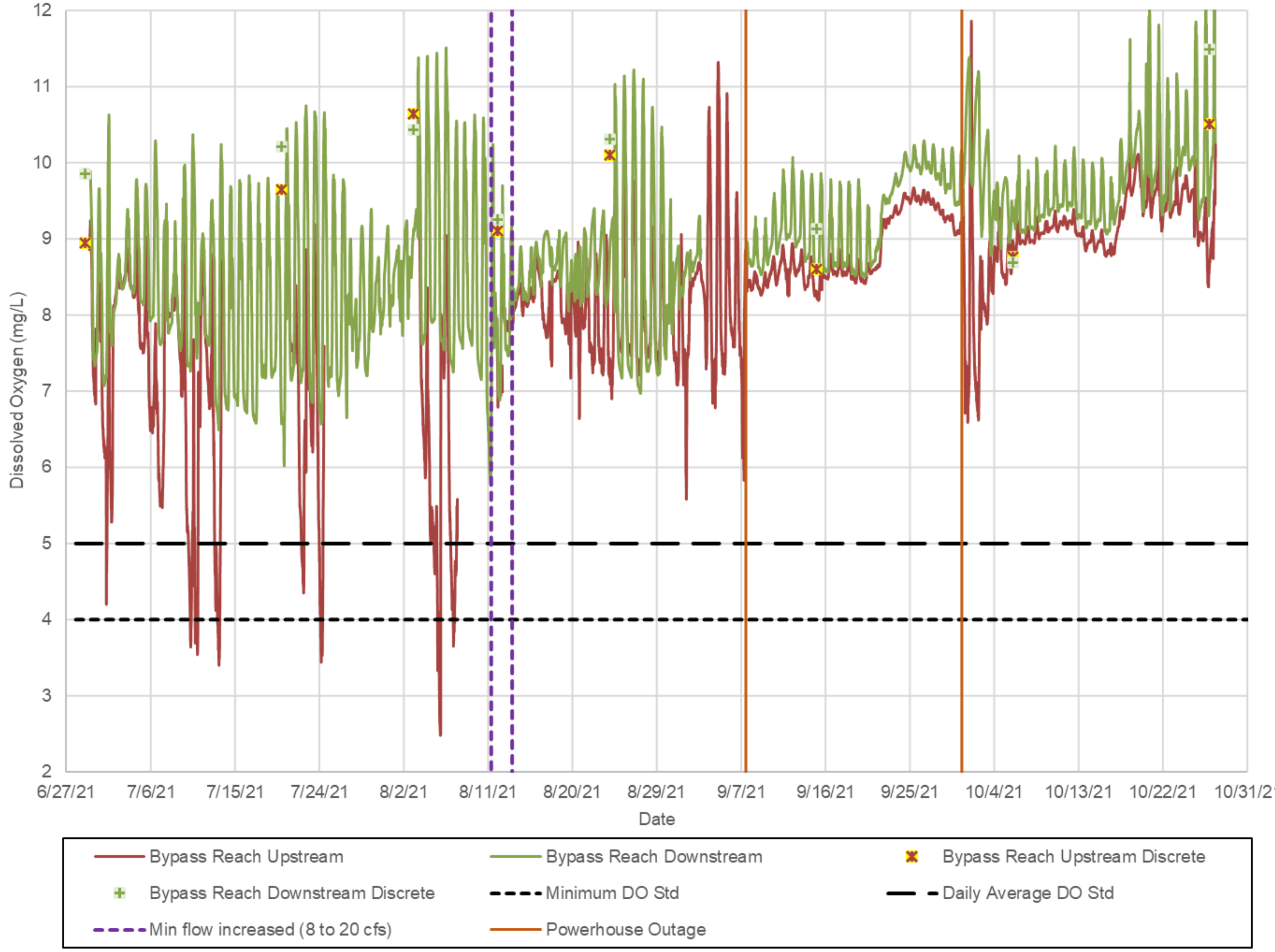

Figure 1-8. Continuous and Discrete Dissolved Oxygen Concentrations at the Bypass Reach Water Quality Monitoring Locations (2021)

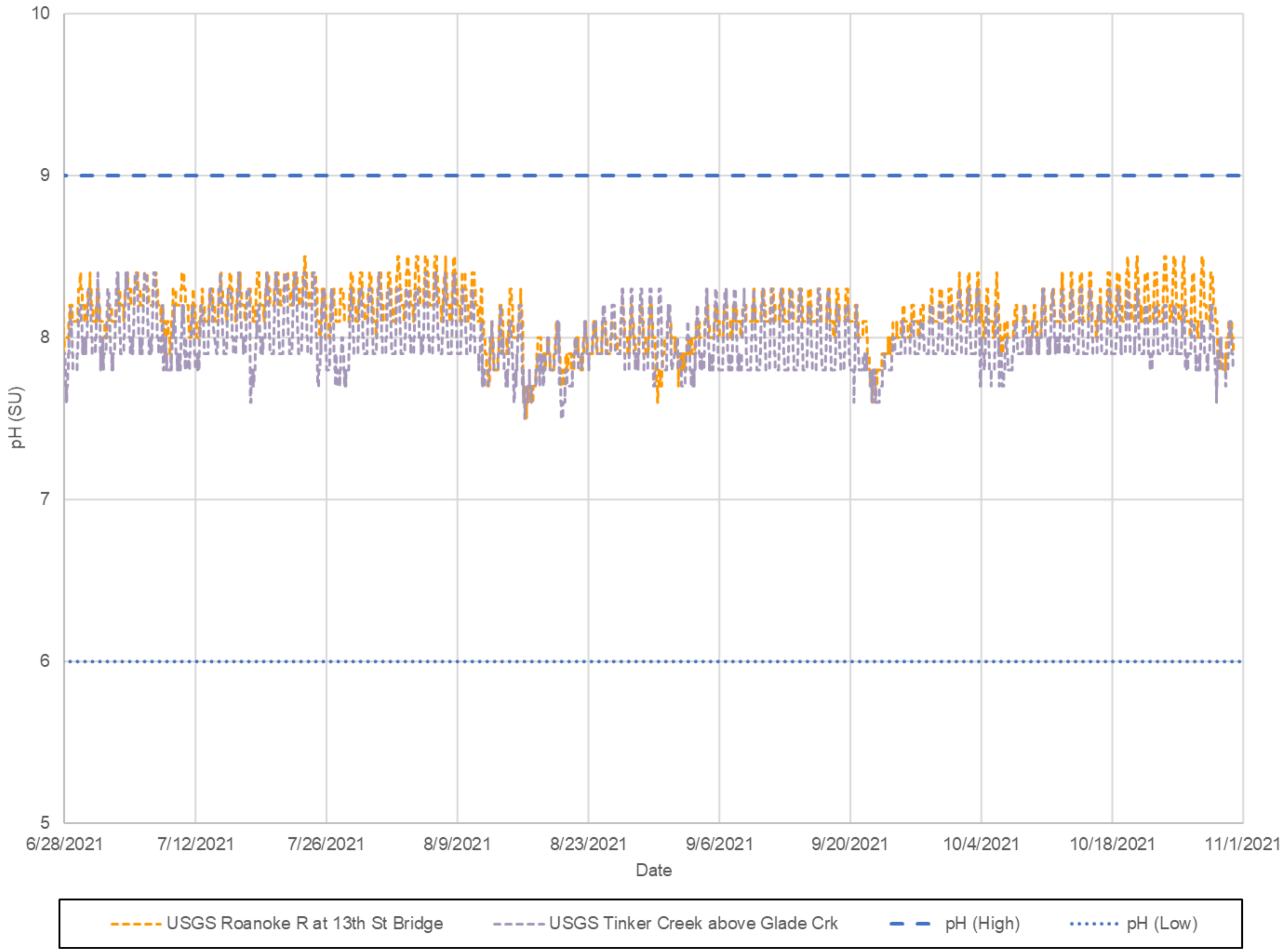

Figure 1-9. Continuous pH Measurements at the Upstream USGS Water Quality Monitoring Locations (2021)

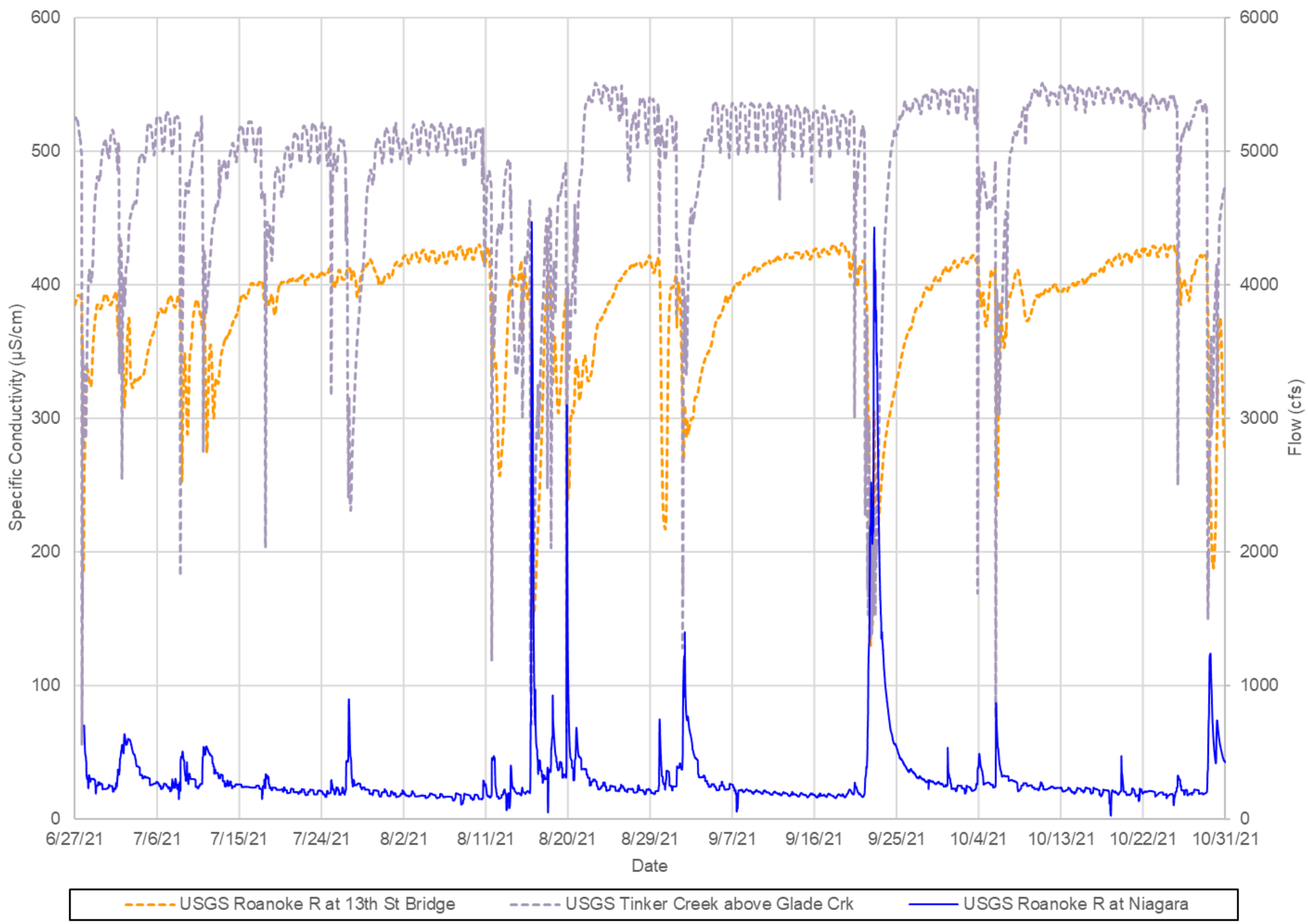

Figure 1-10. Continuous Specific Conductivity Concentrations at the Upstream USGS Water Quality Monitoring Locations (2021)

Attachment 2

Attachment 2 – Discrete Measurement Tables

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Table 2-1. Discrete Measurements at each Water Quality Monitoring Location (2020)

Location	Date	Temperature (°C)	Dissolved Oxygen (mg/L)	pH (SU)	Specific Conductivity (µS/cm)
13th Street Bridge	7/28/2020	27.4	9.3	8.2	396
	8/12/2020	24.7	7.4	8.0	389
	8/26/2020	24.6	9.0	8.3	319
	9/23/2020	16.5	10.7	8.3	NA
	10/21/2020	14.6	9.0	8.0	365
	11/10/2020	15.1	9.5	8.1	339
Tinker Creek	7/29/2020	21.4	7.8	7.8	461
	8/12/2020	21.6	8.4	7.9	479
	8/26/2020	22.7	10.5	8.2	482
	9/23/2020	14.4	9.3	7.9	489
	10/21/2020	14.3	9.2	7.9	497
	11/10/2020	15.0	8.8	7.9	494
Reservoir	7/29/2020	23.7	6.4	7.8	457
	8/12/2020	23.6	6.7	7.7	450
	8/26/2020	24.5	8.1	7.9	392
	9/23/2020	16.1	8.5	7.7	436
	10/21/2020	15.3	NA	7.8	432
	11/10/2020	15.1	8.5	7.8	423
	11/10/2020	15.2	8.7	7.8	411
Forebay	7/28/2020	25.9	6.1	7.6	470
	8/12/2020	24.5	6.7	7.7	439
	8/26/2020	23.3	7.3	7.8	369
	9/23/2020	17.8	9.2	7.9	433
	10/21/2020	16.2	8.9	7.9	435
	11/10/2020	15.3	8.5	7.8	405
Tailrace	7/28/2020	25.5	7.3	7.7	467
	8/12/2020	NA	NA	NA	NA
	8/26/2020	23.2	7.4	7.8	373
	9/22/2020	17.2	9.8	7.8	423
	10/21/2020	NA	NA	NA	NA
	11/9/2020	14.4	9.9	7.9	397
Bypass Reach Upstream	7/28/2020	25.8	8.9	8.1	460
	8/12/2020	NA	NA	NA	NA
	8/26/2020	24.0	9.2	8.2	371
	9/22/2020	17.4	9.9	8.1	427
	10/21/2020	16.3	NA	8.1	432
	11/9/2020	14.3	9.9	8.0	394

Location	Date	Temperature (°C)	Dissolved Oxygen (mg/L)	pH (SU)	Specific Conductivity (µS/cm)
Bypass Reach Downstream	7/28/2020	25.9	9.6	8.2	456
	8/12/2020	NA	NA	NA	NA
	8/26/2020	24.4	9.7	8.3	367
	9/22/2020	17.5	9.9	8.2	425
	10/21/2020	16.5	10.0	8.3	434
	11/9/2020	14.4	10.0	8.0	395

Note:

NA = not available. Instrument was not functioning correctly and/or conditions did not provide a valid reading

Table 2-2. Discrete Measurements at each Water Quality Monitoring Location (2021)

Location	Date	Temperature (°C)	Dissolved Oxygen (mg/L)	pH (SU)	Specific Conductance (µS/cm)
Forebay	6/29/2021	24.6	6.8	7.7	456
	7/20/2021	24.83	7.1	7.7	470
	8/3/2021	24.16	8.1	8.0	491
	8/12/2021	25.7	5.7	7.6	425
	8/24/2021	25.1	6.7	7.7	474
	9/15/2021	23.6	7.8	7.8	501
	10/6/2021	20.4	7.4	7.8	369
	10/27/2021	15.7	8.9	7.9	457
Tailrace	6/29/2021	24.7	6.9	7.6	399
	7/20/2021	24.4	8.0	7.8	464
	8/3/2021	23.75	8.3	7.9	491
	8/12/2021	25.5	7.5	7.6	424
	8/24/2021	24.7	7.5	7.7	470
	9/15/2021	23.7	8.7	8.0	495
	10/6/2021	20.4	7.7	7.8	362
	10/27/2021	15.5	9.6	7.9	457
Bypass Reach Upstream	6/29/2021	25.4	8.9	8.0	390
	7/20/2021	25.5	9.7	8.3	454
	8/3/2021	25.0	10.6	8.3	477
	8/12/2021	27.4	9.1	8.1	415
	8/24/2021	26.3	10.1	8.3	459
	9/15/2021	23.4	8.6	8.1	497
	10/6/2021	20.4	8.8	8.0	368
	10/27/2021	16.2	10.5	8.2	453
Bypass Reach Downstream	6/29/2021	27.5	9.9	8.3	383
	7/20/2021	25.94	10.2	8.4	446
	8/3/2021	25.0	10.4	8.3	475
	8/12/2021	27.4	9.3	8.2	414
	8/24/2021	27.9	10.3	8.5	449
	9/15/2021	23.6	9.1	8.2	496
	10/6/2021	20.5	8.7	8.0	361
	10/27/2021	16.4	11.5	8.3	444

Table 2-3. Forebay Vertical Profile Data (2020)

	Temperature (°C)				Dissolved Oxygen (mg/L)				pH (SU)				Specific Conductivity (µS/cm)			
Depth (ft)	8/26/2020	9/23/2020	10/21/2020	11/10/2020	8/26/2020	9/23/2020	10/21/2020	11/10/2020	8/26/2020	9/23/2020	10/21/2020	11/10/2020	8/26/2020	9/23/2020	10/21/2020	11/10/2020
1	23.3	17.8	16.2	15.3	7.3	9.2	8.9	8.5	7.8	7.9	7.9	7.8	369	433	435	405
2	23.3	17.3	16.0	15.3	7.3	9.2	8.9	8.5	7.8	7.9	7.9	7.7	370	433	435	405
3	23.2	17.1	15.8	15.2	7.3	9.3	8.9	8.5	7.8	7.9	7.9	7.7	374	431	433	406
4	23.0	17.1	15.7	15.1	7.2	9.4	8.9	8.5	7.8	7.9	7.9	7.7	373	430	433	406
5	22.9	17.0	15.7	15.1	7.2	9.4	9.0	8.5	7.8	7.9	7.9	7.7	373	429	432	407
6	22.9	17.0	15.7	15.1	7.1	9.4	9.0	8.4	7.8	7.9	7.9	7.7	374	429	431	407
7	22.9	17.0	15.6	15.1	7.1	9.5	8.9	8.5	7.8	7.9	7.9	7.7	374	428	431	407
8	22.9	16.9	15.5	15.1	7.1	9.5	8.9	8.4	7.8	7.9	7.9	7.7	374	427	431	407
9	--	16.9	15.5	15.1	--	9.5	8.7	8.5	--	7.9	7.8	7.7	--	426	430	407
10	--	16.8	--	15.1	--	9.5	--	8.4	--	7.9	--	7.7	--	426	--	407
11	--	16.8	--	15.1	--	9.5	--	8.4	--	7.9	--	7.7	--	425	--	407

Table 2-4. Reservoir Vertical Profile Data (2020)

Depth (ft)	Temperature (°C)				Dissolved Oxygen (mg/L)				pH (SU)				Specific Conductivity (µS/cm)			
	9/23/2020	10/21/2020	11/10/2020	11/10/2020	9/23/2020	10/21/2020	11/10/2020	11/10/2020	9/23/2020	10/21/2020	11/10/2020	11/10/2020	9/23/2020	10/21/2020	11/10/2020	11/10/2020
1	16.1	15.3	15.1	15.2	8.5	NA	8.5	8.7	7.7	7.8	7.8	7.8	436	432	423	411
2	15.9	15.2	15.1	15.2	8.6	NA	8.6	8.6	7.7	7.8	7.8	7.8	436	432	423	412
3	15.9	15.2	15.1	15.2	8.7	NA	8.6	8.7	7.6	7.8	7.8	7.8	436	432	423	413
4	15.9	15.2	15.1	15.2	8.7	NA	8.6	8.6	7.6	7.8	7.8	7.8	435	432	424	413
5	15.9	15.2	15.1	15.2	8.7	NA	8.5	8.6	7.6	7.8	7.8	7.8	435	432	424	413
6	15.9	15.2	15.1	15.2	8.7	NA	8.5	8.6	7.6	7.5	7.8	7.8	435	432	424	413
6.5	--	--	15.1	--	--	--	8.5	--	--	--	7.8	--	--	--	424	--
7	15.9	15.3	--	15.2	8.8	8.8	--	8.6	7.6	7.7	--	7.8	435	430	--	414
7.5	--	--	--	15.1	--	--	--	8.5	--	--	--	7.8	--	--	--	NA

Table 2-5. Forebay Vertical Profile Data – Temperature and Dissolved Oxygen (2021)

	Temperature (°C)								Dissolved Oxygen (mg/L)							
Depth (ft)	7/7/2021	7/20/2021	8/3/2021	8/12/2021	8/24/2021	9/15/2021	10/6/2021	10/27/2021	7/7/2021	7/20/2021	8/3/2021	8/12/2021	8/24/2021	9/15/2021	10/6/2021	10/27/2021
1	24.8	25.5	24.4	27.4	25.3	24.7	--	15.9	6.9	7.3	8.2	5.5	6.8	8.0	--	9.0
1.5	--	--	--	--	--	--	20.4	--	--	--	--	--	--	--	7.4	--
2	24.6	24.8	24.2	25.7	25.1	23.6	--	15.7	6.8	7.1	8.1	5.7	6.7	7.8	--	8.9
3	24.5	24.6	24.0	25.4	24.9	23.3	20.3	15.6	6.8	7.1	8.0	5.6	6.6	7.5	7.4	8.9
4	24.3	24.5	23.9	25.3	24.7	22.8	20.3	15.5	6.8	7.2	7.9	5.5	6.6	6.9	7.3	8.8
5	24.1	24.4	23.7	25.1	24.4	22.3	20.3	15.5	6.7	7.2	7.5	5.3	6.5	6.6	7.3	8.8
6	24.0	24.3	23.4	25.0	24.1	21.8	20.3	15.5	6.6	7.0	6.9	5.1	5.8	5.5	7.2	8.8
7	23.8	24.3	23.4	24.9	24.0	21.7	20.3	15.4	6.4	7.1	6.6	5.0	5.5	5.4	7.2	8.8
8	23.7	24.3	23.4	24.8	24.0	21.7	20.3	15.4	6.3	7.0	6.6	5.0	5.4	5.3	7.2	8.8
9	23.7	24.3	23.3	--	--	21.6	--	15.4	6.3	7.0	6.6	--	--	5.0	--	8.8
10	23.7	--	--	--	--	--	--	--	6.3	--	--	--	--	--	--	--
10.5	23.7	--	--	--	--	--	--	--	6.2	--	--	--	--	--	--	--

Table 2-6. Forebay Vertical Profile Data – pH and Specific Conductivity (2021)

	pH (SU)								Specific Conductivity (µS/cm)							
Depth (ft)	7/7/2021	7/20/2021	8/3/2021	8/12/2021	8/24/2021	9/15/2021	10/6/2021	10/27/2021	7/7/2021	7/20/2021	8/3/2021	8/12/2021	8/24/2021	9/15/2021	10/6/2021	10/27/2021
1	7.7	7.8	8.0	7.7	7.7	7.8	--	7.9	456	470	490	428	474	500	--	458
1.5	--	--	--	--	--	--	7.8	--	--	--	--	--	--	--	369	--
2	7.7	7.7	8.0	7.6	7.7	7.8	--	7.9	456	470	491	425	474	501	--	457
3	7.7	7.7	8.0	7.6	7.7	7.8	7.7	7.9	455	469	491	423	473	498	369	458
4	7.7	7.7	7.9	7.7	7.7	7.8	7.7	7.9	452	467	491	424	471	497	369	458
5	7.6	7.7	7.9	7.6	7.7	7.8	7.7	7.9	450	465	490	425	468	499	369	458
6	7.6	7.7	7.8	7.6	7.6	7.7	7.7	7.9	449	463	488	431	465	498	369	458
7	7.6	7.7	7.8	7.6	7.6	7.7	7.7	7.9	448	463	486	436	464	498	369	458
8	7.6	7.7	7.8	7.6	7.6	7.7	7.7	7.9	448	462	486	439	464	498	370	458
9	7.6	7.7	7.8	--	--	7.7	--	7.9	448	462	486	--	--	498	--	458
10	7.6	--	--	--	--	--	--	--	448	--	--	--	--	--	--	--
10.5	7.6	--	--	--	--	--	--	--	447	--	--	--	--	--	--	--

Attachment 3

Attachment 3 – Water Quality Vertical Profile Figures

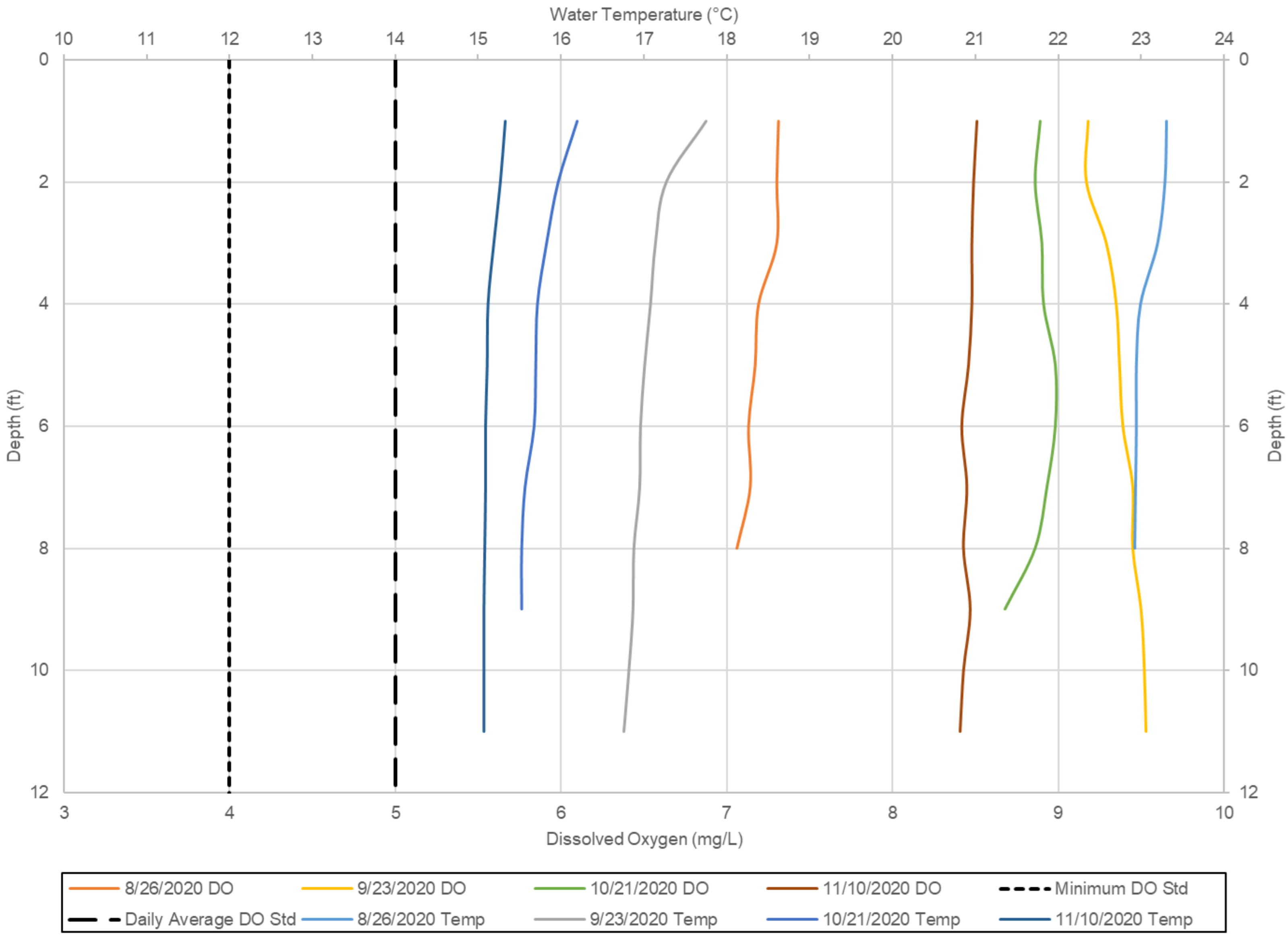

Figure 3-1. Forebay Vertical Profile—Temperature and Dissolved Oxygen Concentration (2020)

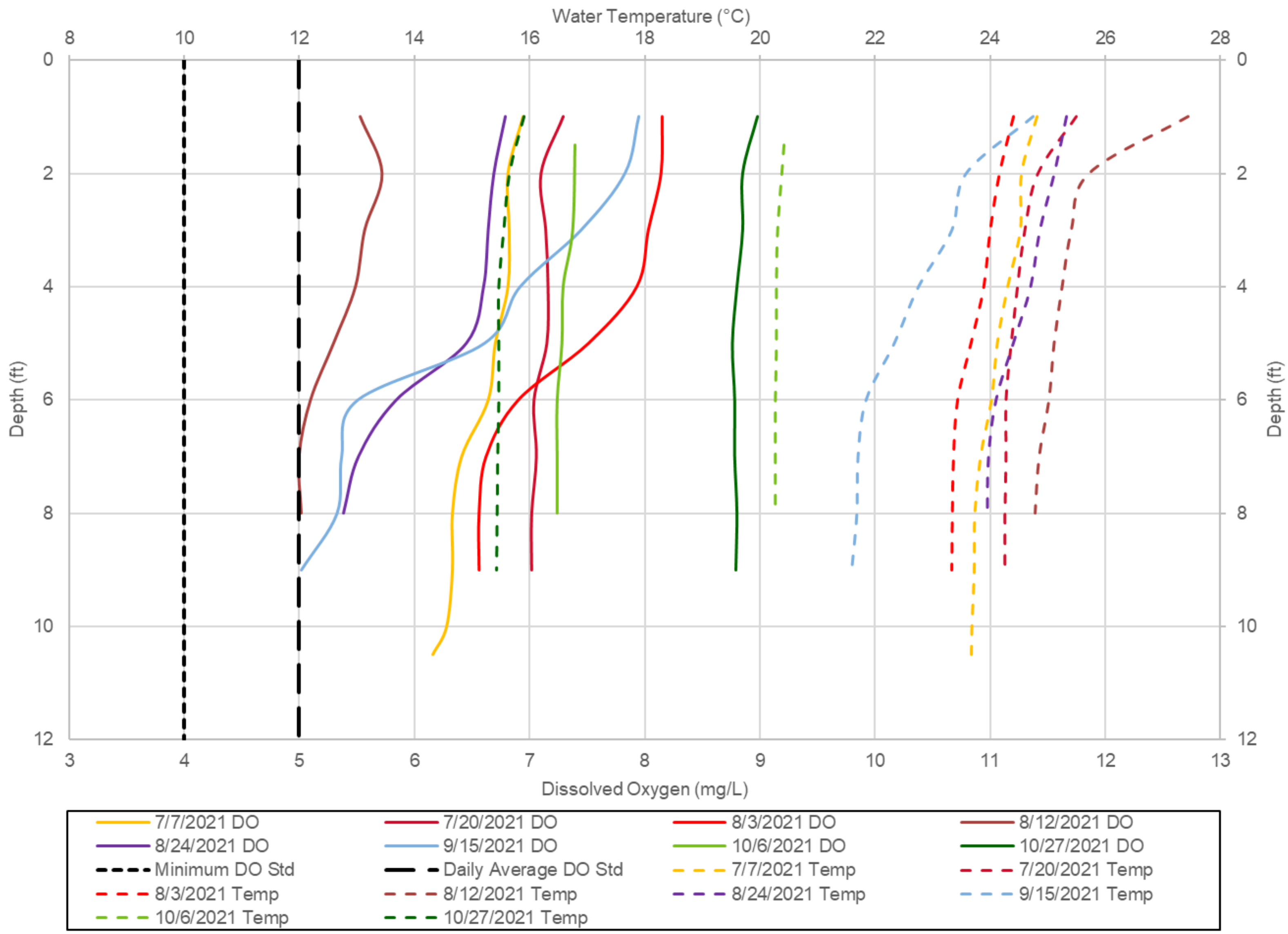

Figure 3-2. Forebay Vertical Profile—Temperature and Dissolved Oxygen Concentration (2021)

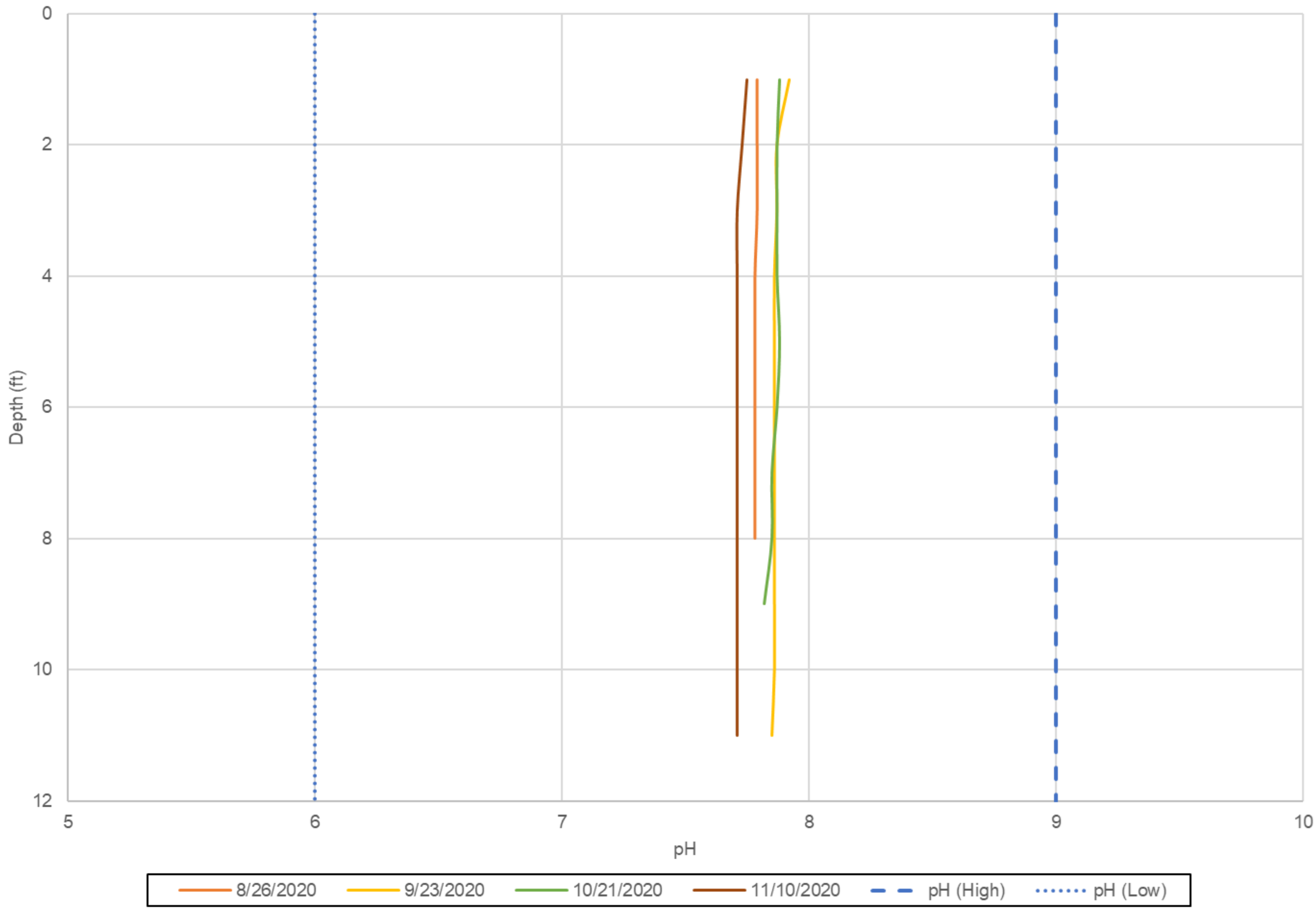

Figure 3-3. Forebay Vertical Profile—pH (2020)

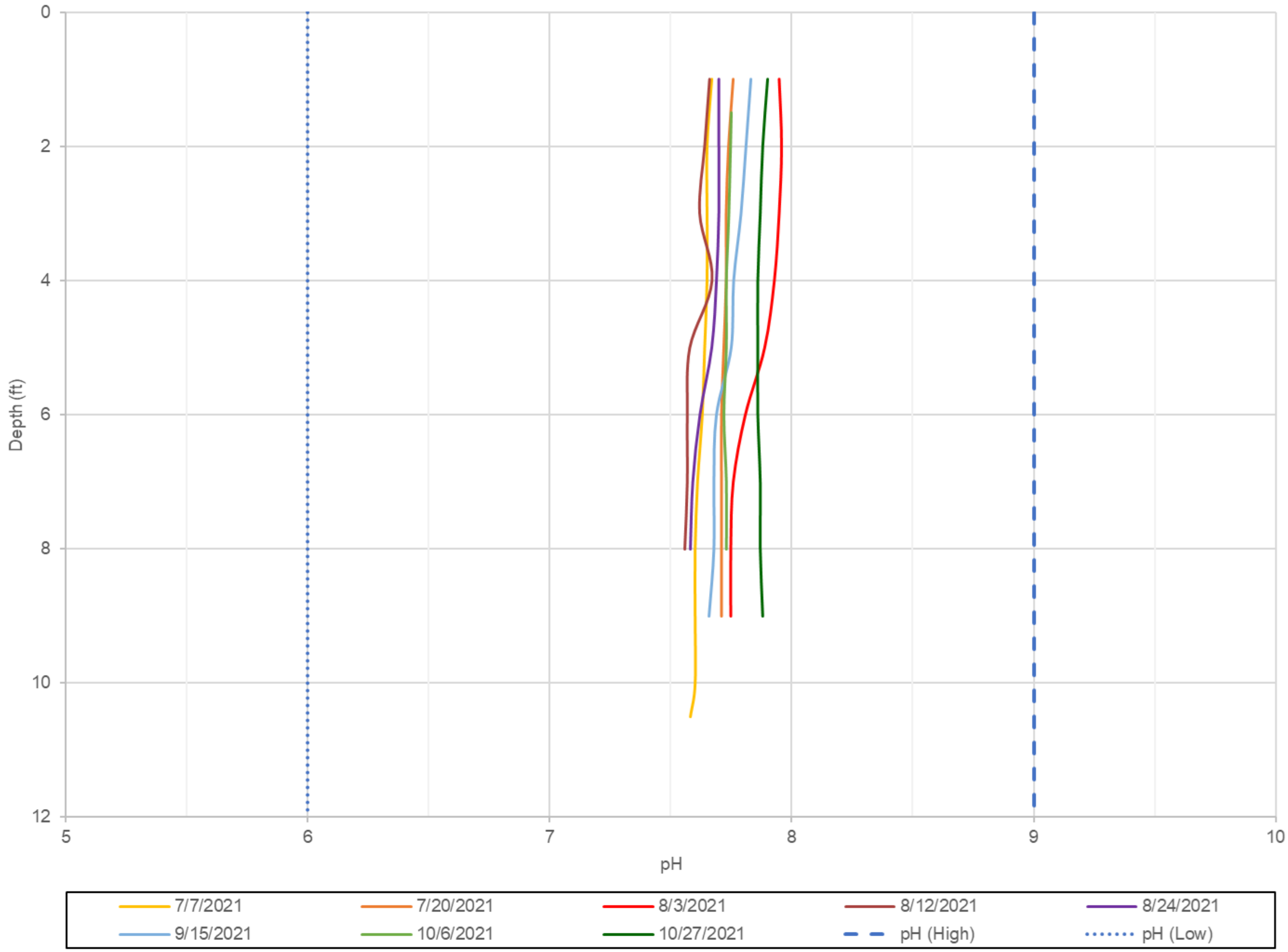

Figure 3-4. Forebay Vertical Profile—pH (2021)

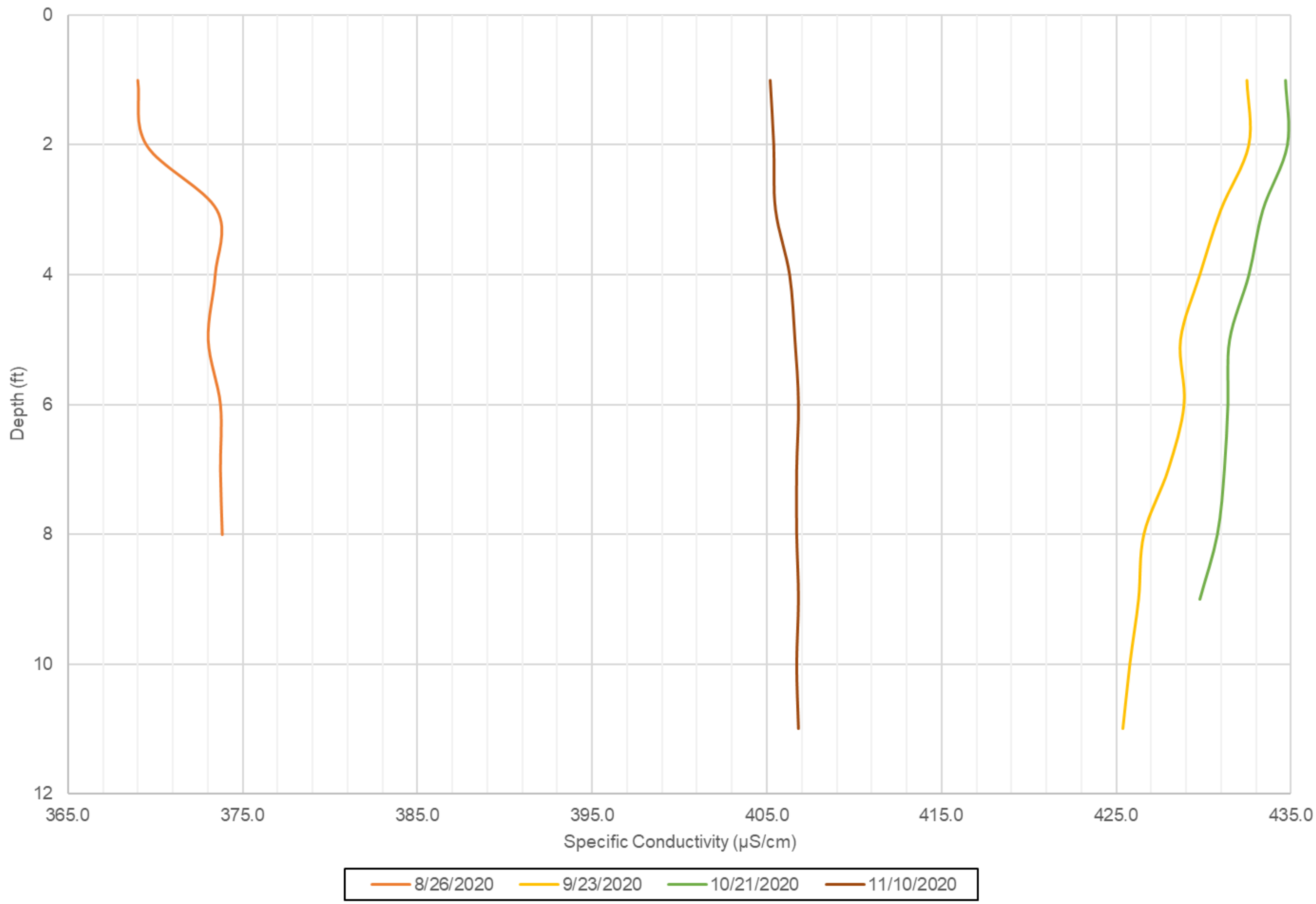

Figure 3-5. Forebay Vertical Profile—Specific Conductivity (2020)

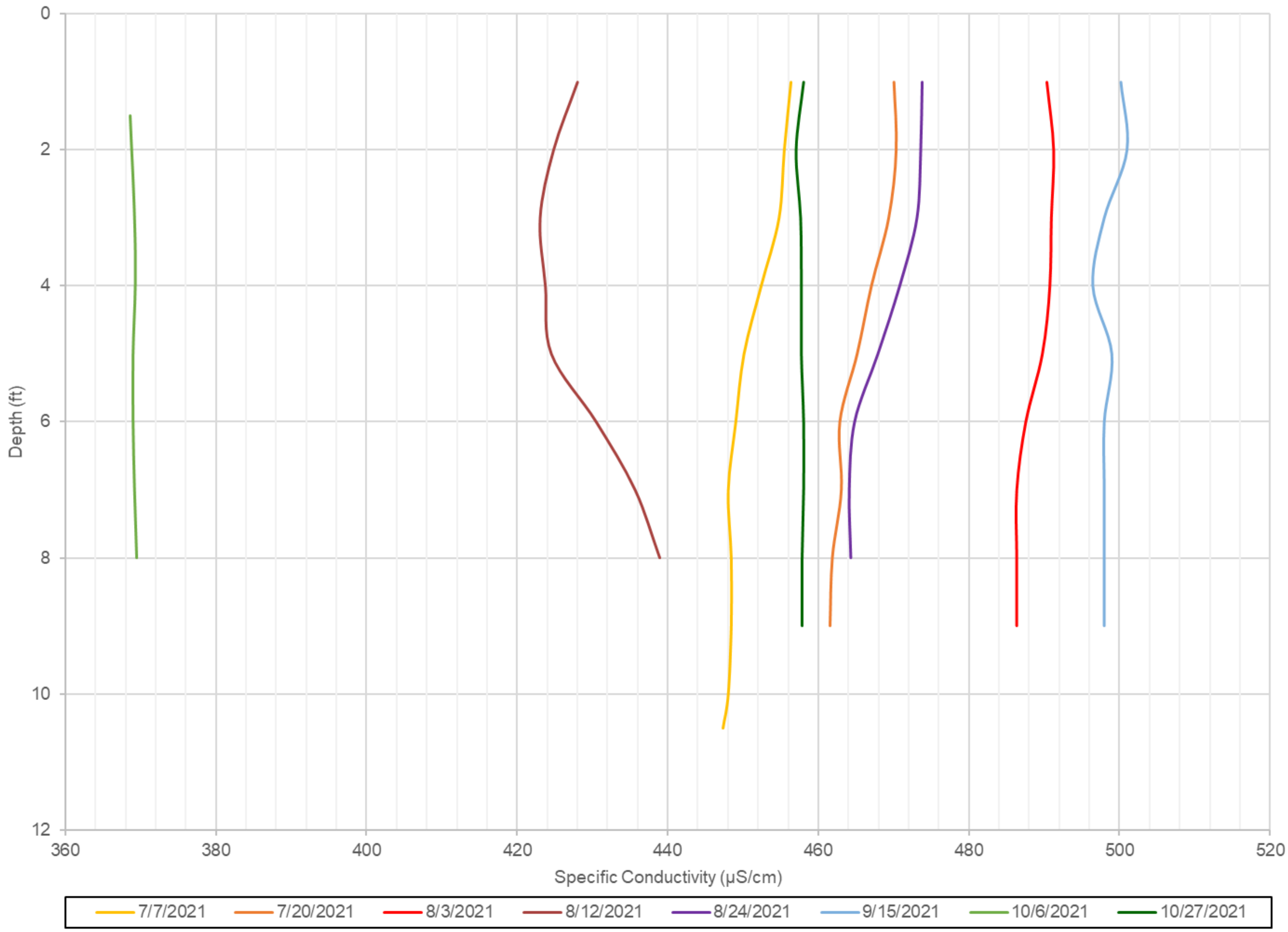

Figure 3-6. Forebay Vertical Profile—Specific Conductivity (2021)

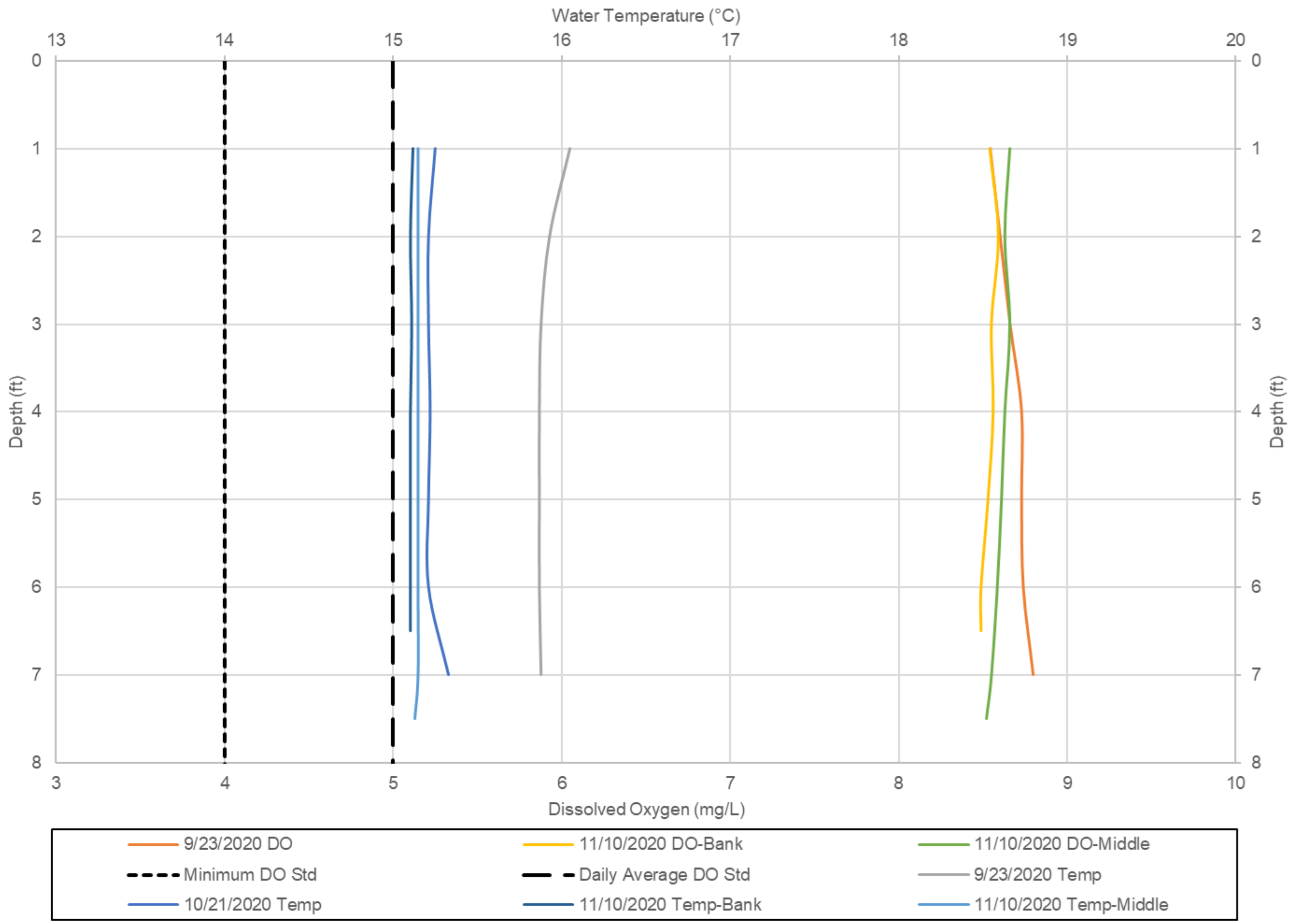

Figure 3-7. Reservoir Vertical Profile—Temperature and Dissolved Oxygen Concentration (2020)

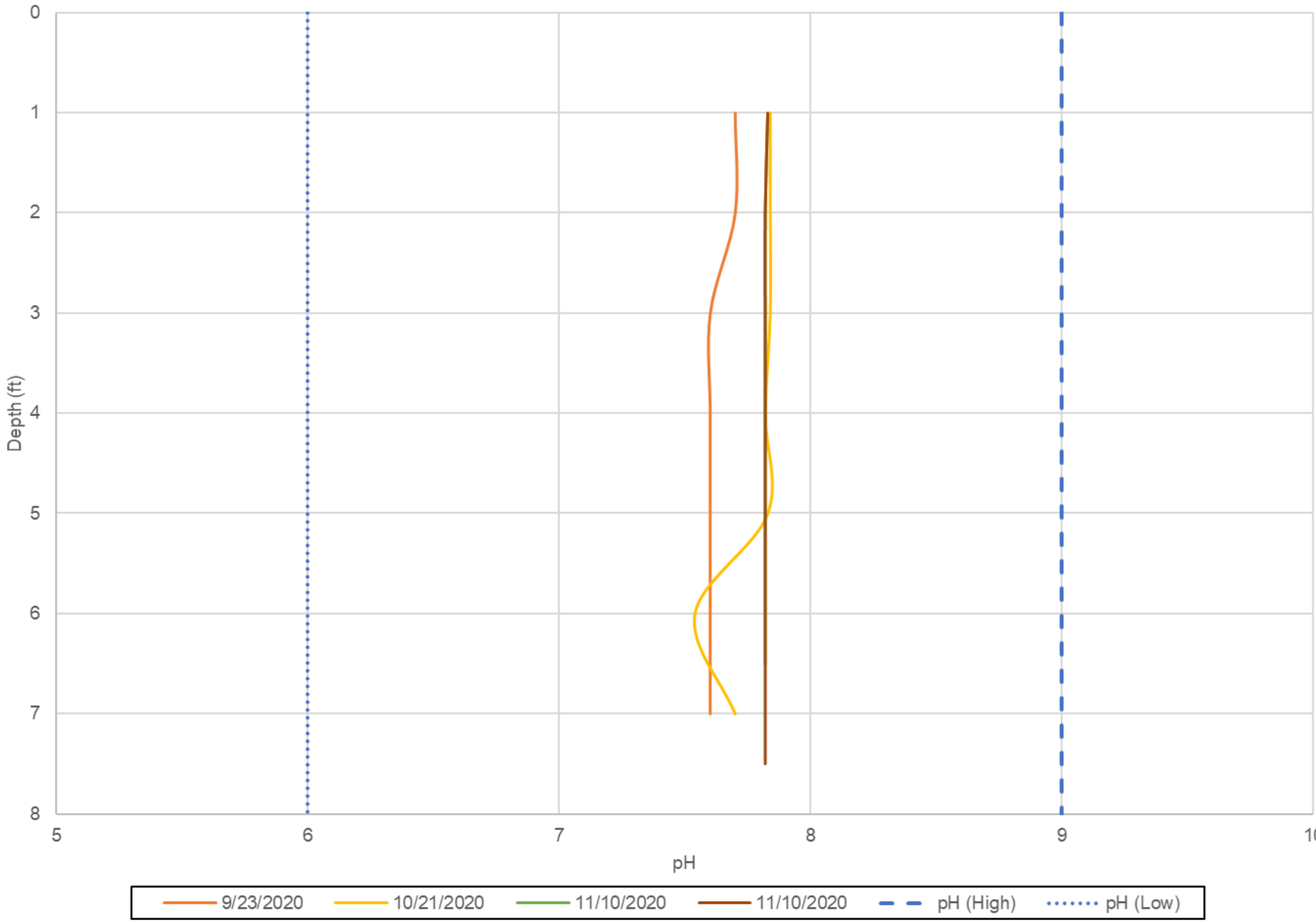

Figure 3-8. Reservoir Vertical Profile—pH (2020)

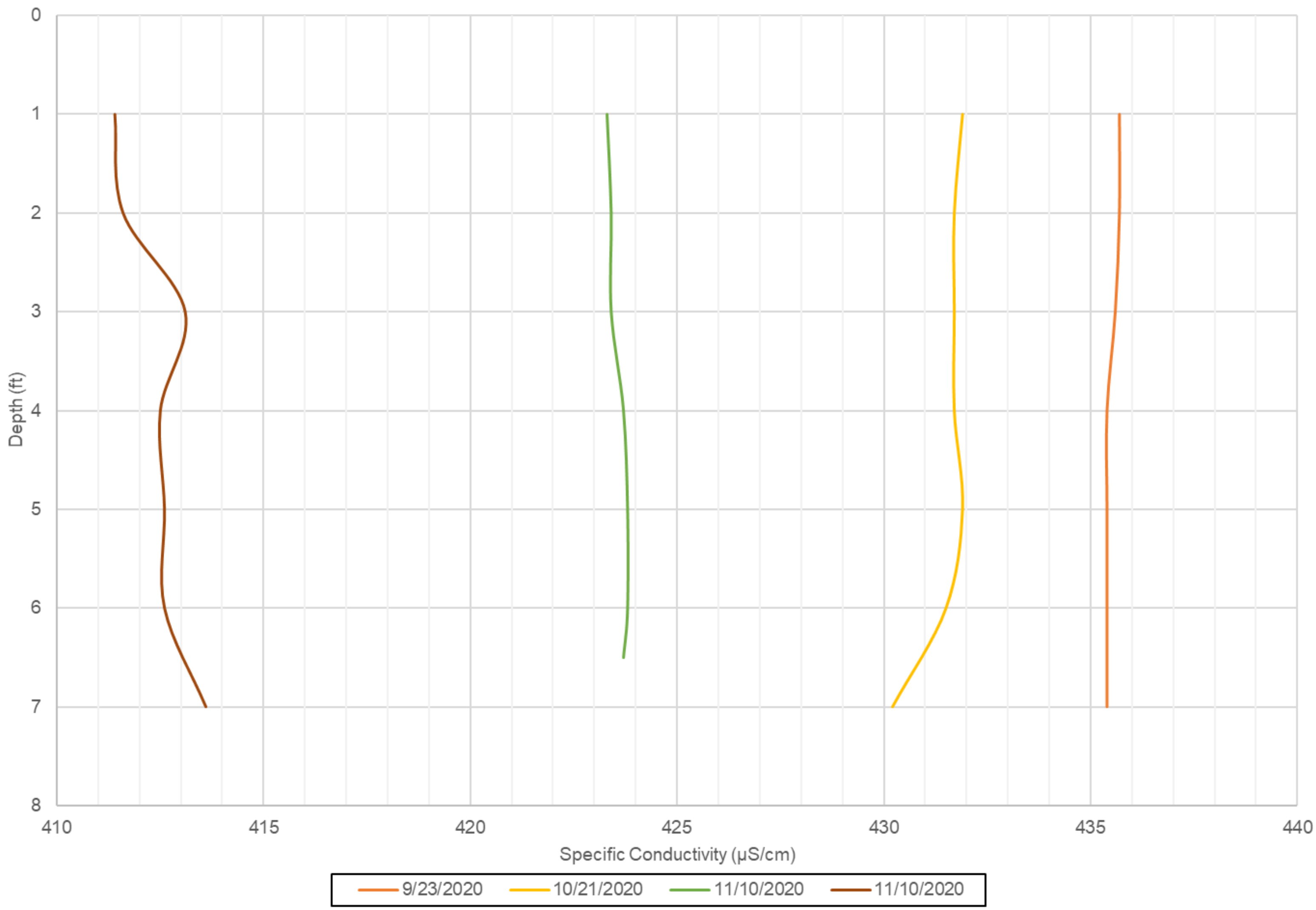

Figure 3-9. Reservoir Vertical Profile—Specific Conductivity (2020)

Attachment 4

Attachment 4 – Estimated Flow and Precipitation Comparison

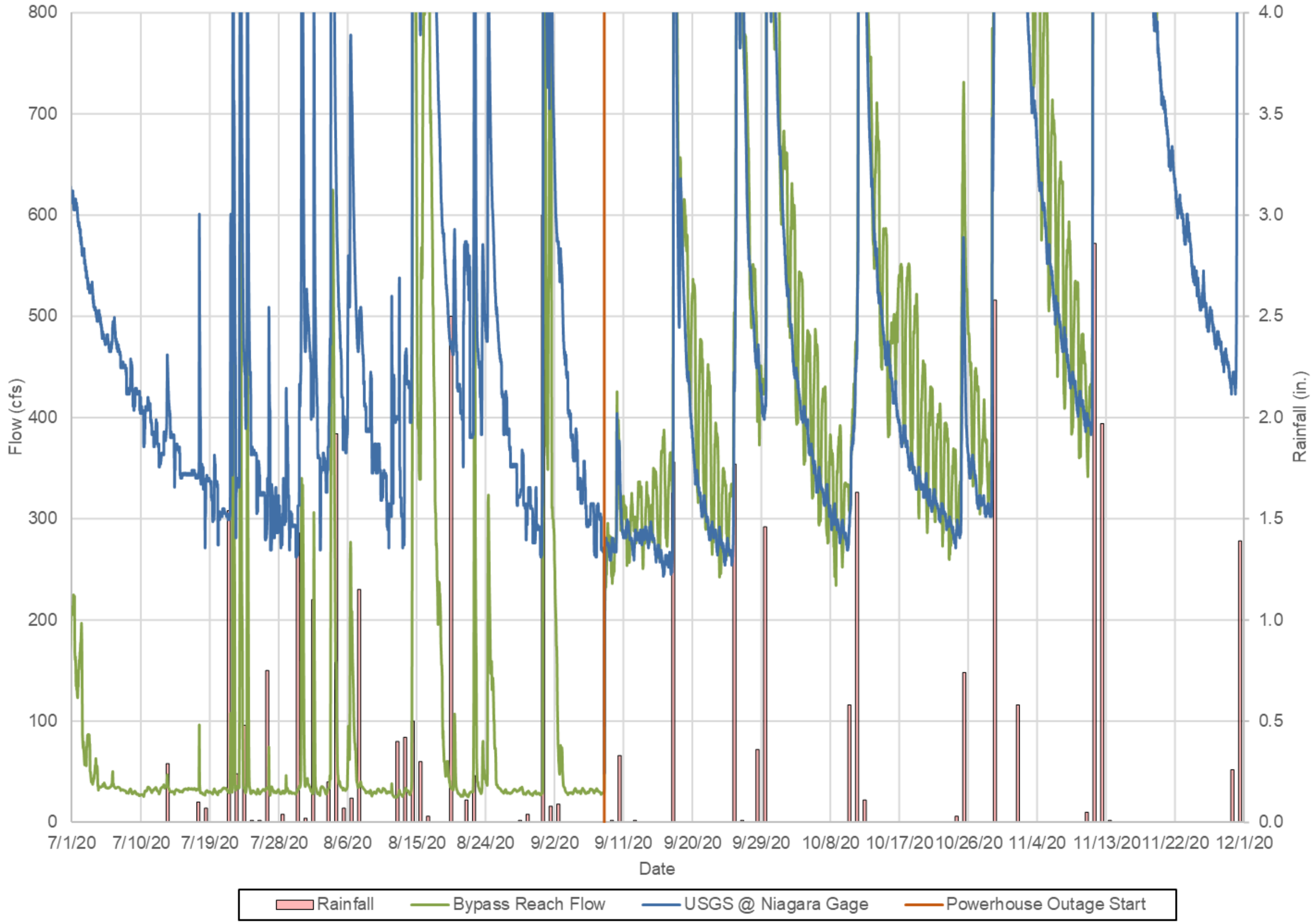

Figure 4-1. Bypass Reach Estimated Flow, Downstream Roanoke River Flow, and Rainfall Comparison (2020)

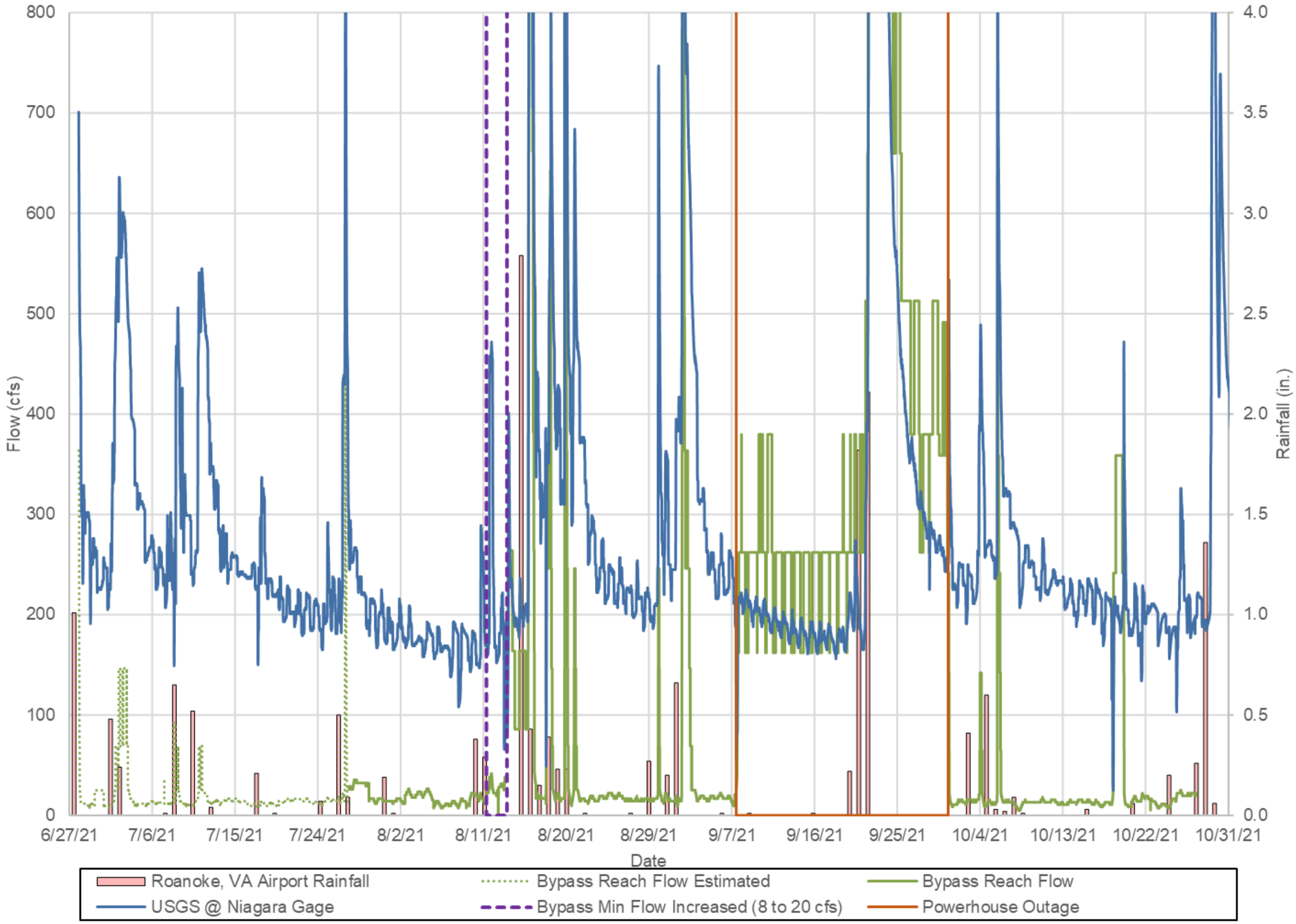

Figure 4-2. Bypass Reach Estimated Flow, Downstream Roanoke River Flow, and Rainfall Comparison (2021)