Investigation of Factors Contributing to Cyanobacteria Blooms in Rainbow Reservoir (Farmington River) Windsor, CT.

Farmington River Watershed Association

749 Hopmeadow Street

Simsbury, CT 06070

Sponsoring Agency:

Connecticut Department of Energy and Environmental Protection

January 2024

Contents

Tables

Figures

Introduction

Rainbow Reservoir, located in Windsor, CT, is a run of the river impoundment on the Farmington River (Figure 1). The dam is 8.33 miles upstream of the confluence with the Connecticut River and the reservoir receives water from a 609 square mile watershed that extends generally northwest from Rainbow Reservoir and crosses the Connecticut border with Massachusetts. There are 33 towns in the watershed (Table 1), 23 of which are in Connecticut. The watershed land use can be described as mixed, according to the National Land Cover Database 2011 (NLCD 2011), with approximately 58% forested, 8% wetland, 7% agricultural, 3% open water, and 24% developed. There are 9 wastewater treatment facilities that discharge upstream (Table A-28 to Table-A-36).

Rainbow Reservoir covers an area of 235 acres at full pool elevation according to a 1991 DEP compendium of data for Connecticut lakes, but the water level is controlled at the dam and can be appreciably lowered in anticipation of storms for flood control and protection of the hydropower apparatus. From the point where the channel widens markedly downstream of Rt 187 the area is about 225 acres (910,000 m^2) and is often the case with run-of-the-river impoundments, it is difficult to be certain where the river becomes the reservoir. The reservoir is generally linear with increasing depth from upstream to near the dam. The bathymetry at full pool elevation (Figures 2 and 3) indicates a volume of 2569 acre-feet or 112 million cubic feet or 3,170,000 cubic meters and a mean depth of 11.5 feet or 3.5 meters. The bathymetric map is not accurate near the dam, possibly due to access issues, but is the only source available. The distribution of depth vs area (Figure 4) indicates a fairly uniform loss of area with declining water level to a depth of 3 m, after which the decline is more rapid. The distribution of volume vs depth (Figure 5) similarly suggests roughly uniform loss of volume to about 3 m, after which more volume is lost per unit of declining water depth in an accelerating fashion.

Table 1. Watershed Towns in Connecticut and Massachusetts.

Watershed Towns, Connecticut		
Avon	Farmington	Simsbury
Barkhamsted	Granby	Suffield
Bloomfield	Hartland	Torrington
Bristol	Harwinton	Wolcott
Burlington	New Hartford	Winchester
Canton	Norfolk	Windsor
Colebrook	Plainville	Windsor Locks
East Granby	Plymouth	
Watershed Towns, Massachusetts		
Becket	New Marlborough	Tolland
Blandford	Otis	Tyringham
Granville	Sandisfield	
Monterey	Southwick	

Figure 1. Rainbow Reservoir

Figure 2. Rainbow Reservoir bathymetric map.

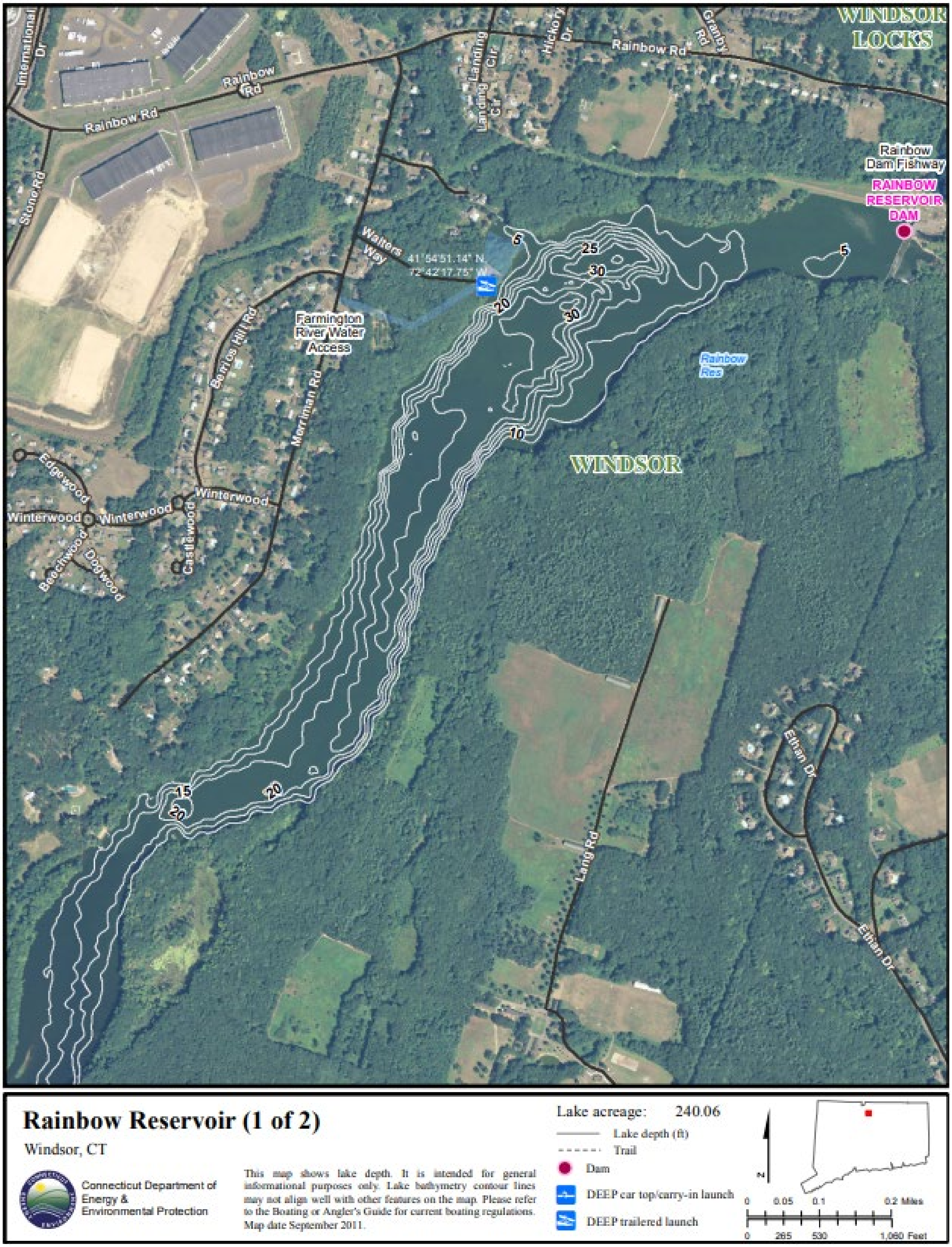


Figure 3. Rainbow Reservoir bathymetric map (continued).

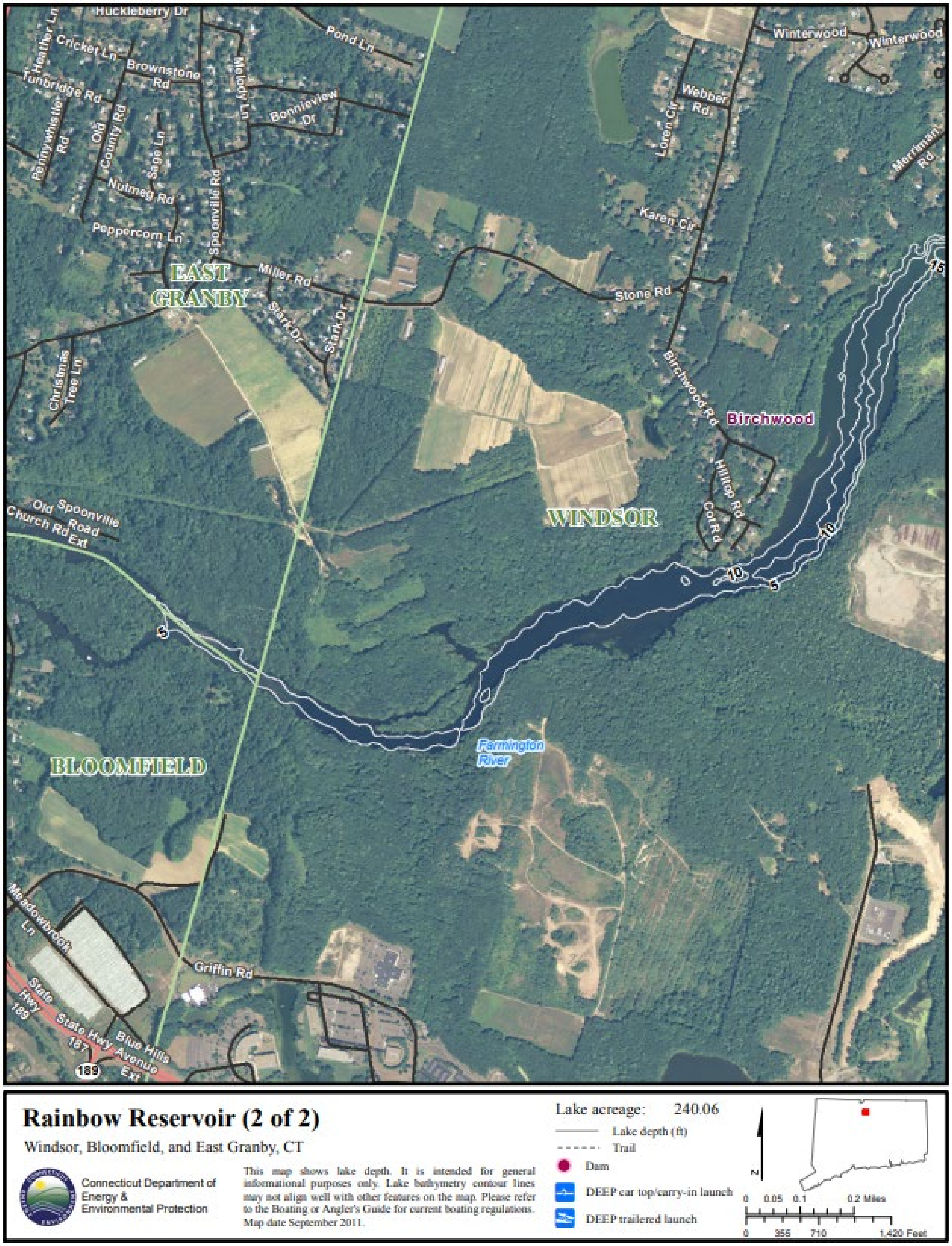


Figure 4. Rainbow Reservoir Depth vs Area.

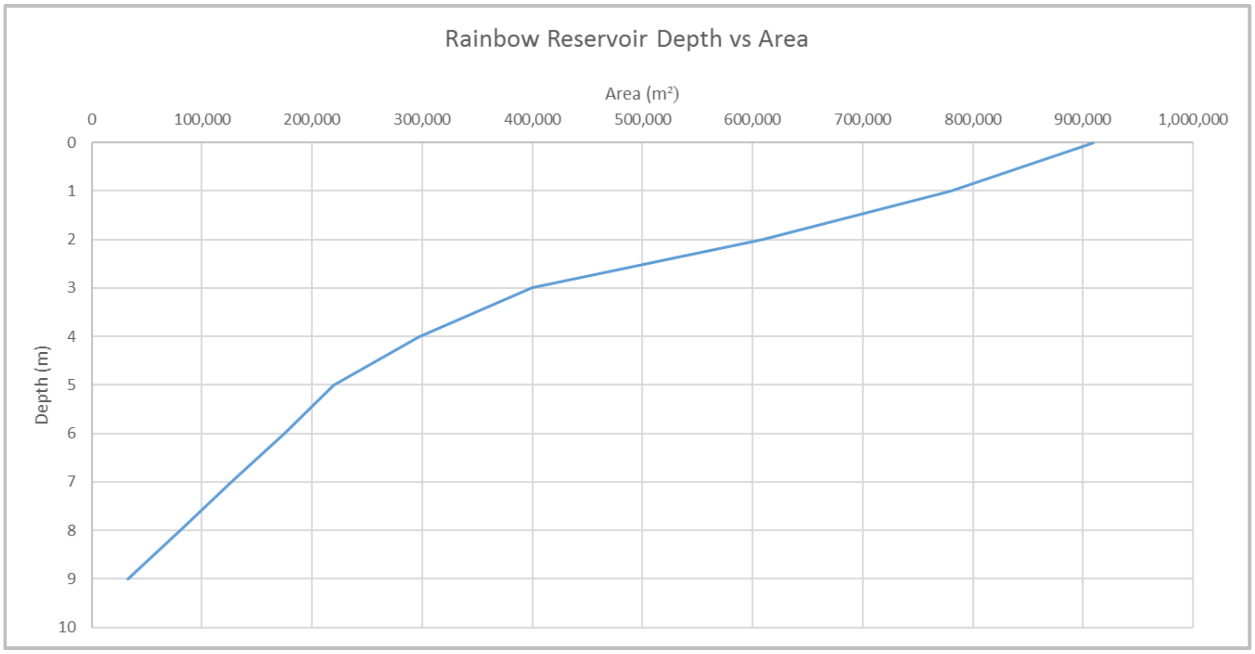
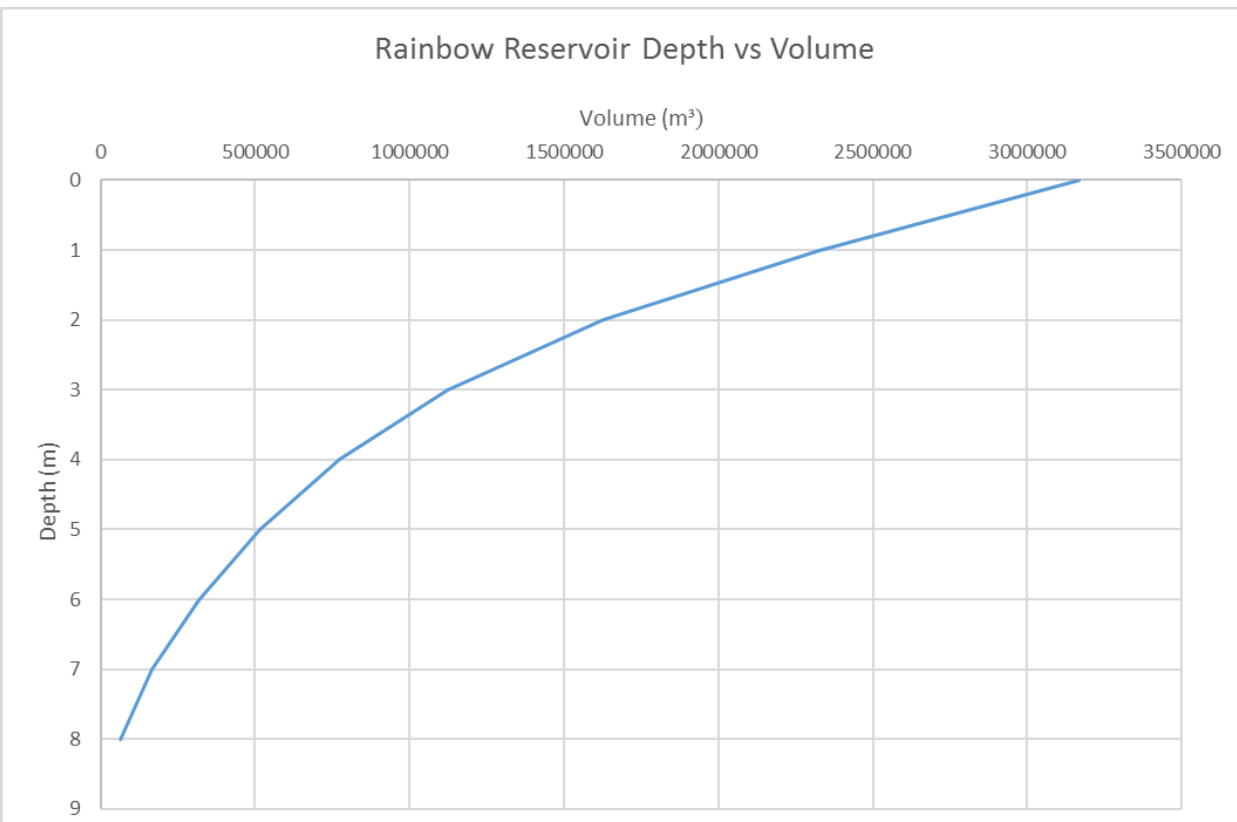


Figure 5. Rainbow Reservoir Depth vs Volume



Rainbow Reservoir is a multi-use waterbody with a hydropower facility at the dam, a large day camp on the north shore (Camp Shalom) and considerable open space in several parks and wildlands along the south shore. Swimming is popular at the day camp, from some parks, from boats, and from many private residences. Rainbow Reservoir has a public boat ramp and is also popular for fishing. CT DEEP owns a fishway at the dam, however the operation of the upstream fishway has been suspended per CT DEEP as of March 29th, 2023. This due a result of the fishway not providing safe, timely and effective upstream fish passage.

The Farmington River Watershed Association (FRWA) has been devoted to the protection and improvement of the Farmington River since 1953. The FRWA and has worked on issues that include water quality, water allocation, habitat restoration, recreation, open space, and wetland and floodplain protection. The FRWA works with federal, state, and local governments, business and industry, and with people in the watershed's 33 communities to protect the river and its surrounding landscape. With the help of members, supporters, and partners, the FRWA looks after the river that connects so many people, with a wide range of research, education, and advocacy programs.

Cyanobacteria have become an issue in recent years in Rainbow Reservoir throughout much of the summer and early autumn that seems to be increasing in frequency and duration. The blooms impair water quality in Rainbow Reservoir and ultimately spill downstream below Rainbow Dam throughout the Wild & Scenic Farmington River to the confluence at the Connecticut River. Rainbow Reservoir is used by boaters, anglers, swimmers, summer camp youth, park visitors, a rowing group, and a canine training search and rescue team. From 2019-2020 the CT DEEP call-in line for cyanobacteria blooms had approximately 500 notifications from the public. There are potential health risks for swimmers, boaters, dogs and wildlife encountering toxins that may be produced by the algae. Pets swimming in waters containing cyanobacteria toxins may become ill or die after drinking or licking themselves, and unfortunately, dog deaths can sometimes be the first warning that a toxic cyanobacterial bloom is occurring.

Toxins associated with cyanobacteria have been implicated as the cause of mass mortalities of fish and birds. Rainbow Reservoir is obviously suffering cyanobacteria blooms, but whether or not, or when, they are producing toxins is unknown, thus precautions must be taken to avoid contact with waters potentially affected when blooms are present. The cyanobacteria blooms have prevented Camp Shalom from allowing campers to use the waterfront as a recreational resource during parts of the past few summers. Concern by users and the FRWA resulted in application for a grant from CT DEEP to evaluate the factors leading to these blooms. The grant was received, and monitoring in 2021 was covered in a separate report. The grant was continued for 2023 after a hiatus in 2022, and this report covers the results of the 2023 investigation conducted by the FRWA with the assistance of Water Resource Services, Inc. of Wilbraham, Massachusetts. This report also includes data generated by the FRWA on its own during a cyanobacteria bloom in 2022.

Methods

Five stations in Rainbow Reservoir were sampled (Figure 6) on one date in 2022 in response to an algae bloom and on seven dates between May and September 2023 as part of this grant program. A boat and driver were provided by Camp Shalom. Analyses included multi-probe sensor monitoring for temperature, conductivity, dissolved oxygen, chloride and turbidity, using a Xylem YSI ProDSS sonde.

A Van Dorn bottle was used to collect samples, with a single sample at 1 meter at stations 1 and 2, composite samples of the top 3 meters at stations 3, 4, and 5, and samples just off the bottom at stations 4 and 5 on each of the seven dates. Water samples were tested at the UCONN Center of Environmental Science and Engineering (CESE) laboratory for forms of nitrogen and phosphorus. Phytoplankton samples were collected as whole water samples (part of the near surface water quality samples), preserved with glutaraldehyde and analyzed microscopically by WRS. Sediment samples were collected with an Ekman dredge at stations 4 and 5 on July 13th.

Flow data were obtained from USGS site 01189995, Farmington River in Tariffville, CT, 2.67 miles upstream of Rainbow Reservoir. Weather data were obtained from the Bradley Airport station. Additional data were obtained from CT DEEP and FRWA programs.

Figure 6. Rainbow Reservoir sampling stations for this investigation.

Results

Review of Data from Other Sources

Precipitation and Flow

The weather pattern over the period of study was rather unusual, indicative of the high variability induced by ongoing climate change. Precipitation in spring 2021 was near normal while summer 2021 precipitation was well above average (Table 2). Drier conditions prevailed from May through July 2022, with above average precipitation in August and September. In 2023 precipitation was close to average in May, well below average in June, and set a high record in July. Precipitation was slightly above average in August 2023 but was again very high in September. While the precipitation in any month is not expected to closely track the long-term average, the rainfall during summer 2023 was wildly variable and very wet overall, resulting in much higher flows in the Farmington River than normally encountered. This greatly increased flushing of Rainbow Reservoir and resulted in water level management by Farmington River Power Company, a subsidiary of Stanley Black & Decker, Inc., to limit damage to hydropower turbines.

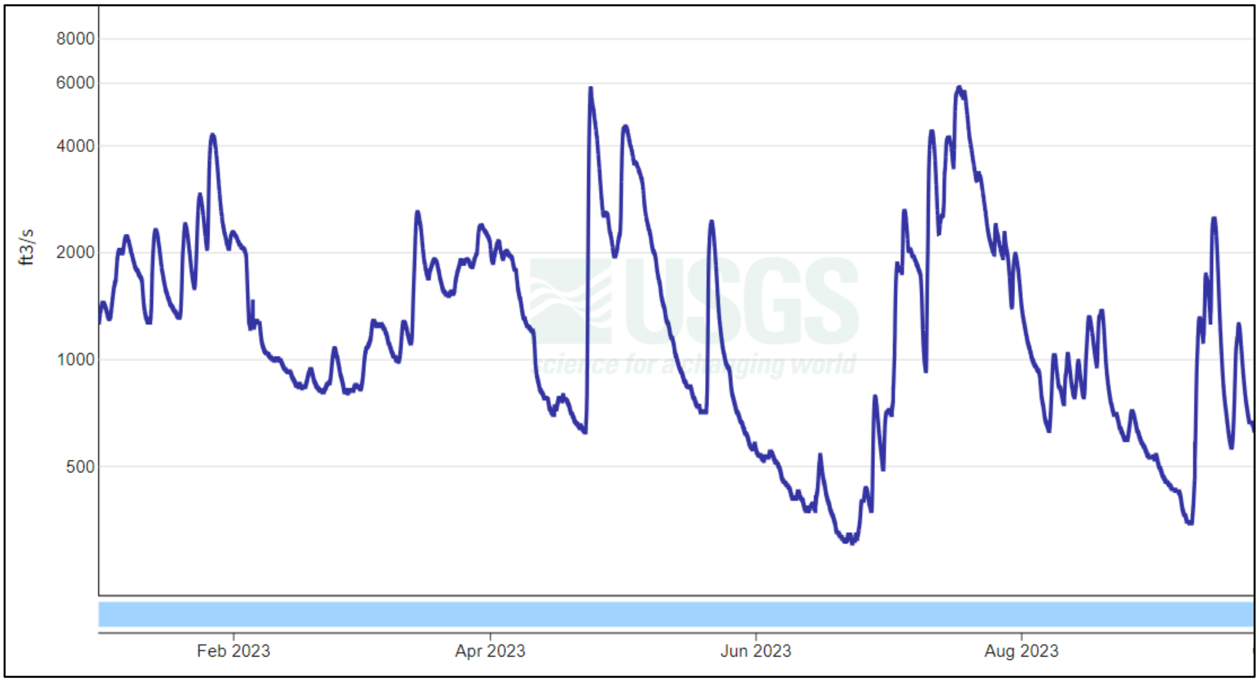
Table 2. Precipitation in the Rainbow Reservoir area (from Bradley Airport).

	Precipitation in Inches			
Month	Long-term Average	2021	2022	2023
May	3.3	4.9	2.9	3.0
June	3.9	2.6	2.6	1.3
July	3.2	10.1	2.7	13.9
August	3.2	7.0	5.1	3.9
September	3.6	7.5	6.1	12.2

The USGS 01189995 Farmington River at Tariffville site is 2.67 mi upstream from Station 1 on Rainbow Reservoir at latitude 41.908278, longitude -72.759361. While not all flow entering Rainbow Reservoir is captured at this site, it is a reasonable surrogate for flow into the reservoir. Flow at the dam is managed for hydropower and may not represent natural upstream flows.

The Farmington River at the USGS gauge in Tariffville, CT, typically has lower flows in the range of 150-400 cfs during the months of July to October. In 2023, flow was higher than usual, staying above 500 cfs, with the exception of early June, and with a maximum of 5810 cfs in July (Figure 7).

Figure 7. Daily Discharge at USGS gauge, Farmington River at Tariffville January 2023 - September 2023

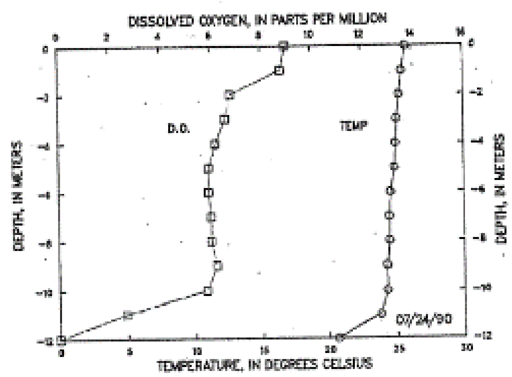


Water Quality

Available water quality data for the reservoir include measurements reported in Trophic Classification of 49 Lake, CT DEP 1991, where the trophic classification of Rainbow Reservoir is listed as eutrophic. Total phosphorus, organic nitrogen, NH_4, NO_X and total nitrogen were measured (Figure 8). CT DEEP sampled chemical properties in 2019 and 2020 (Tables A-12 to A-35). In general, phosphorus and nitrogen concentrations are high, alkalinity is moderate, and water clarity is low. Oxygen is low only occasionally near the bottom in the deepest part of the reservoir. While reports of cyanobacteria appear to be more recent, Rainbow Reservoir has suffered from excessive fertilization and related productivity for many years.

Figure 8. Trophic Classification of 49 Lake, DEP 1991, Rainbow Reservoir.

Date	Alkalinity/$CaCO_3$	Transparency	Sample Depth	pH	Chlorophyll-a	Total P	Organic N	NH_4 - N	$NO_2N + NO_3N$	Total N
	mg/l	m	m	units	ppb					
05/02/90	24	2.6	comp	7.4	-	65	470	131	579	1180
07/24/90	24	1.8	0.3	7.7	6.6	108	360	36	747	1143
			5.5	6.7	-	122	370	125	751	1246
			10.7	6.3	-	143	800	298	508	1606



Biological Data

CT DEEP fisheries data include electrofishing data from 1989, 1992, 1998, and 2014 (Tables A-5 to A-6) and numbers of anadromous fish passing through the Rainbow fishway from 1976-2021 (Table A-7). There are many species of fish in Rainbow Reservoir, and it hosts spawning areas for multiple anadromous species. The high fertility has generally been considered favorable for fish production, but with the advent of more frequent cyanobacteria blooms, this attitude may shift.

CT DEEP issued a warning in July 2019, based on data that included a sample at Camp Shalom beach with results of 59,389 total algal cells/mL, 56,862 of which were cyanobacteria (all *Microcystis* sp., a potentially toxic form). This sample result suggests moderate probability of adverse health effects according to the World Health Organization Recreational Guidance of 20,001-100,000 cells/mL, but no toxicity test results were available.

Available biological data generated by the FRWA include bacterial and macroinvertebrate assessments. FRWA site FR-EG1 is the closest site upstream Rainbow Reservoir, located 1.6 miles upstream from station 1. FR-EG1 is at the Farmington River in East Granby on Spoonville Rd at the Rt. 187 Bridge. This site has been monitored for *E.coli* and temperature from 2007 to 2023, excluding 2008-2010 and 2020. The Recreational Geometric Mean for designated swimming, nondesignated swimming, and all other contact recreational uses is less than 126/100 mL. FR-EG1 geometric means are typically above 126/100 mL although not by much, except for 2001 at 365/100 mL and 2018 at 293/100 mL. 2013, 2015, 2019, and 2023 offered lower values with ranges of 74-78/100 mL (Table A-9.)

Macroinvertebrate data from upstream tributaries covers Salmon Brook in East Granby, East Branch Salmon Brook and West Branch Salmon Brook in Granby, plus Hop Brook in Simsbury. All macroinvertebrate data were collected using the CT DEEP Riffle Bioassessment for Volunteers (RBV) protocol. The protocol aims to assess high-quality waters by monitoring with a target of four or more most sensitive species. Salmon Brook has been monitored with most collections containing 4 or more sensitive species, indicating high quality water. East Branch Salmon Brook was monitored with only two collections, containing less than four sensitive species. West Branch Salmon Brook has been monitored with six years having four or more sensitive species. Hop brook was monitored and both collections had less than four sensitive species (Table A-8). There is clearly a range of water quality in tributaries to the Farmington River.

Wastewater

The permitted wastewater discharges upstream of the reservoir are of concern in overall river water quality and possible impacts on the reservoir. The Farmington River receives over 35 million gallons per day of treated wastewater from 9 publicly owned sewage treatment plants, with MDC Windsor located downstream Rainbow Reservoir (Table 3). Nitrogen and phosphorus limits with sampling frequency (Tables A-36 to A-44) suggest high quantities of nutrients in most discharges. Phosphorus limits are <1 mg/L for the Plainville, Bristol and Plymouth facilities, but are in excess of 2 mg/L in the other facilities and some have no limit at all. While the removal of phosphorus from the three treatment facilities with relatively low phosphorus discharge concentration limits is in line with best practical technology, the concentrations are still too high to avoid productivity issues in slow moving water and dilution is an essential component of minimizing impacts.

Table 3. NPDES Permit designed flow rates and secondary treatments.

Permitee	Designed Flow Rate (Million Gallons per Day)	Secondary Treatment
MDC Windsor	5	Chlorine Disinfection
Farmington	5.65	Nitrification and chlorine disinfection
Plainville	3.8	Denitrification, UV disinfection, and seasonal phosphorous removal
Bristol	10.75	Denitrification, phosphorous removal and UV disinfection
Plymouth	1.75	Ammonia removal, denitrification and UV disinfection
Simsbury	3.8	Denitrification and UV disinfection
Canton	0.95	UV disinfection
New Hartford	0.4	Denitrification and UV disinfection
Winchester	3.5	Nitrification and chlorine disinfection (and dechlorination)

2022 Data

Field Data for Rainbow Reservoir on 8/10/22

While monitoring in 2022 was not covered by any CT DEEP grant, a cyanobacteria bloom occurred in August and the FRWA responded by repeating the monitoring protocols developed for the 2021 study funded by CT DEEP. There was a slight thermal gradient from top to bottom in the reservoir (Table 4), enough to prevent mixing without substantial wind and enough to allow oxygen depletion at the sediment-water interface. Oxygen was below saturation in deeper water but was not depleted at any of the 5 stations on the day of sampling. However, it is likely that oxygen was negligible at the sediment-water interface for some of the preceding weeks, allowing P release from sediment. Conductivity was somewhat elevated but not unusual for this waterbody. Turbidity was highly variable and highest in the upper waters of the most downstream stations, leading to declining and generally low water clarity in the downstream direction. The cyanobacteria bloom, comprised mostly of Microcystis but including some Aphanizomenon and Dolichospermum, was the cause of higher turbidity in surface waters and low water clarity.

Table 4: Data from field measurements in Rainbow Reservoir on 8/10/22

Station ID	R1			R2					R3			
Depth (m)	0	1	1.6	0	1	2	3	3.5	0	1	2	2.2
Temp (°C)	29.3	27.6	27.3	31.1	29	28.4	27.5	27.3	30.8	29.1	28.9	28.8
Cond (µS/cm)	307.6	292.2	296.7	340.3	304.1	301.3	297	299.7	326.6	310.6	307.3	306.9
Turbidity (FNU)	0.63	2.02	9.04	21.15	3.95	0.78	2.43	5.19	13.71	14.46	6.52	9.3
ODO (mg/L)	8.56	9.79	7.04	18.44	11.5	8.44	6.57	6.37	15.46	13.93	11.86	11.33
Secchi Depth	2.4			1.15					1.2			

Station ID	R4								R5										
Depth (m)	0	1	2	3	4	4.4	6	6.9	0	1	2	3	4	5	6	7	8	9	9.8
Temp (°C)	31.3	29.2	28.8	28.5	28.4	28.4	28.1	27.5	31.3	29.7	29	28.7	28.5	28.3	28	27.8	27.7	27.5	27.2
Cond (µS/cm)	369.1	337.4	317.4	308.3	306.8	305.8	306.6	304.1	366.9	348.4	320.6	309.7	307.7	308.5	309.1	308.8	307.6	308.4	310.3
Turbidity (FNU)	13.98	28.91	13.05	3.33	2.69	2.64	2.36	11.77	12.71	22.53	26.88	5.92	4.25	2.33	2.37	2.23	2.68	3.22	11.06
ODO (mg/L)	19.42	17.79	13.54	9.04	7.92	7.85	6.88	4.51	18.4	18.2	14.1	9.44	8.99	7.83	7.05	6.26	5.74	5.05	3.51
Secchi Depth	0.79								0.9										

Nutrient Data for Rainbow Reservoir on 8/10/22

Samples for nutrient chemistry (Table 5) suggest elevated concentrations for total N and total P. Ammonium nitrogen was not strongly elevated and nitrate nitrogen was not negligible, suggesting that strong anoxic conditions were not present at the time of sampling. Total dissolved nitrogen (TDN) was highest at the upstream station (St 1) and declined in the downstream direction and with increasing water depth. Total N and P did not change substantially in the downstream direction. N to P ratios (Table 6) were generally low to moderate, favoring cyanobacteria.

Table 5: Nutrient Data from Rainbow Reservoir on 8/10/22

	Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Station ID	**Date**	**NH3**	**NOX**	**TN**	**TDN**	**TP**	**TDP**
R1	8/10/22	0.025	0.536	0.805	1.021	0.072	0.062
R2	8/10/22	*0.006*	0.184	0.914	0.449	0.090	0.031
R3	8/10/22	*0.006*	0.111	0.819	0.351	0.073	0.013
R4T	8/10/22	*0.009*	*0.009*	0.947	0.294	0.096	0.013
R4B	8/10/22	0.011	0.245	0.751	0.475	0.057	0.021
R5T	8/10/22	*0.005*	0.011	0.896	0.275	0.088	0.016
R5B	8/10/22	0.122	0.430	0.790	0.729	0.053	0.027

Italicized are between the MDL and PQL and are to be used as a reference only

Table 6: N:P Ratios Rainbow Reservoir 8/10/22

	1	2	3	4T	4B	5T	5B
8/10/2022	11.2	10.2	11.2	9.9	10.2	13.2	14.9

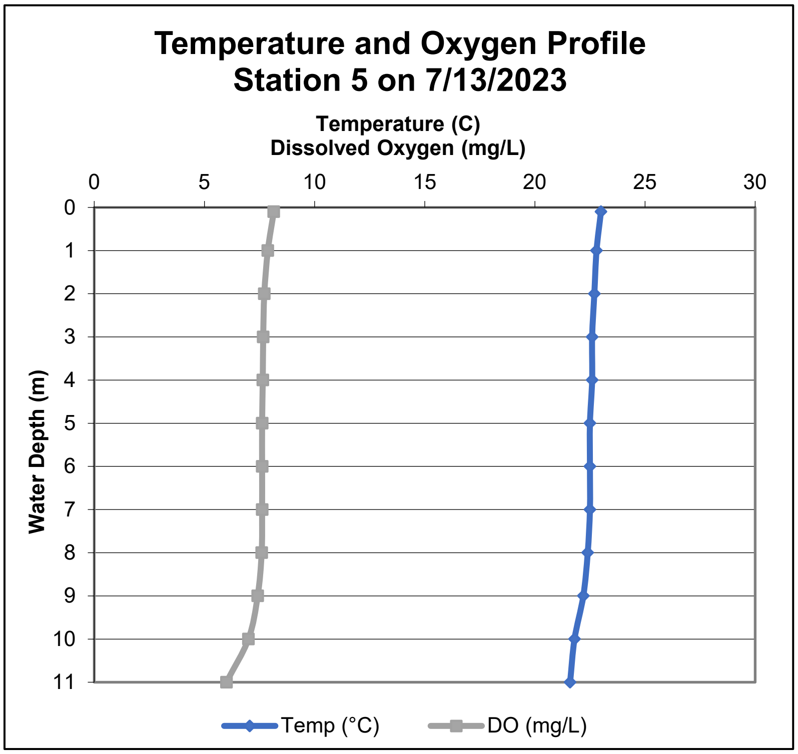
2023 Data

Thermal and Oxygen Regimes from 2023 Data

Rainbow Reservoir can stratify to some extent in a “dry” year but did not in 2023, owing to the high flows in the Farmington River. While there is a slight thermal gradient on some sampling dates (Figure 9, showing the greatest top to bottom differential observed, with other profiles in Figures A-1 through A-35), the reservoir was relatively well mixed throughout the sampling period and oxygen depletion was not observed near the bottom at any station. As P can be released from sediment exposed to low oxygen, the continued presence of oxygen is expected to have limited such release. The potential for such release would exist during periods of low oxygen (<2 mg/L in the overlying water) in low flow years but not in 2023. Actual release will depend on the severity and duration of low oxygen episodes and the amount of available P in the surficial sediments (see Sediment Features section).

The maintenance of mixed conditions and at least moderate oxygen levels during 2023 is one of the benefits of elevated flow. Internal loading of P (and N) will be minimized and any development of cyanobacteria at the sediment-water interface with synchronous rise to form blooms will be retarded. The general lack of a low flow period during the 2023 sampling program limits our ability to assess what might have happened in terms of thermal stratification, oxygen regime, and internal P loading. Similar conditions prevailed in 2021 and there were no cyanobacteria blooms in either year. Lower flows and less flushing in 2022 appear to have allowed a cyanobacteria bloom to form in August of that year.

Figure 9. Temperature and Oxygen Profile Example from Rainbow Reservoir on 7/13/23.



Nutrient Status

Nitrate Nitrogen

Nitrate nitrogen is the most available form of this essential plant and algae nutrient and is often exhausted in lakes during the summer. Nitrite nitrogen is measured as part of nitrate nitrogen in this testing program but is a very minor component of the total in oxic waters; the combined total is often referred to as NOx. Many cyanobacteria can utilize dissolved nitrogen gas and depend less on NOx, so the loss of NOx tends to favor cyanobacteria. NOx concentrations <0.3 mg/L are considered low while values >0.6 mg/L are considered high. Concentrations of NOx at the five stations within Rainbow Reservoir over the sampling period (Figure 10) were <0.3 mg/L on the two July sampling dates but were otherwise higher. Most values were below 0.6 mg/L but a few values early and late in the sampling program were between 0.6 and 0.75 mg/L. NOx was rarely low enough to favor cyanobacteria during the 2023 sampling program.

Ammonium Nitrogen

Ammonium nitrogen (NH_4) is another available form of nitrogen used by algae and higher plants but tends to be relatively low in oxic waters, the conversion to nitrite and nitrate being fairly rapid in the presence of oxygen and key bacteria. A portion of the ammonium nitrogen, depending on pH, dissolved solids, and temperature, will be ammonia (NH_3), which can be toxic. However, in oxic waters it is very rare to have ammonia at a high enough level (>0.02 mg/L) to cause any toxicity. NH_4 concentrations <0.3 mg/L are considered low while values >0.6 mg/L are considered high. Concentrations of ammonium nitrogen at the five stations within Rainbow Reservoir over the sampling period (Figure 11) were always <0.3 mg/L and usually <0.1 mg/L for 2023 samples.

Figure 10. NO_X over space and time in Rainbow Reservoir in 2023

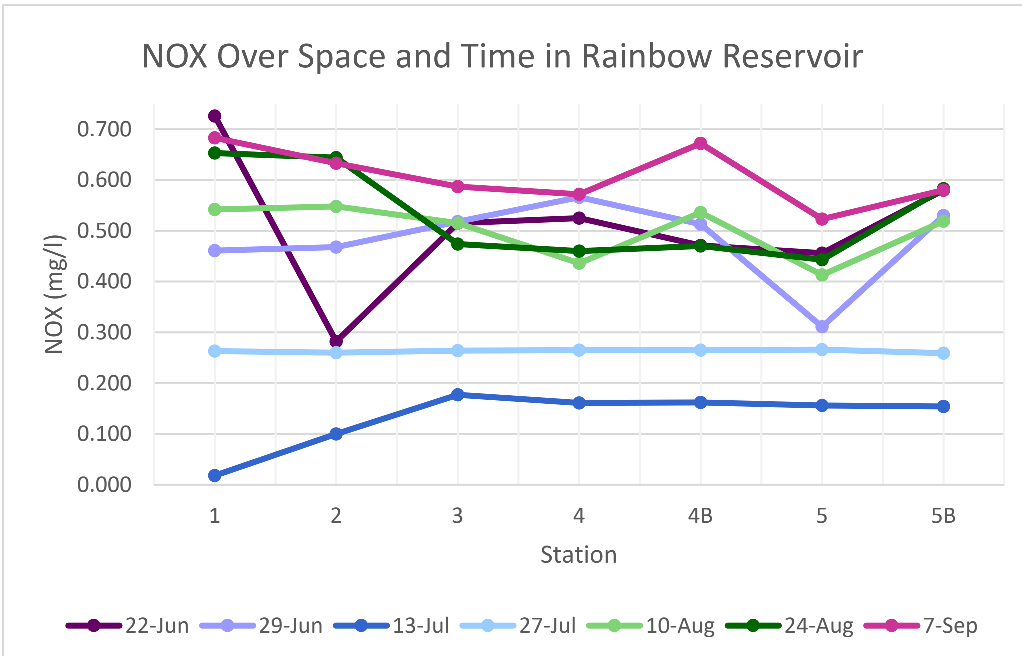
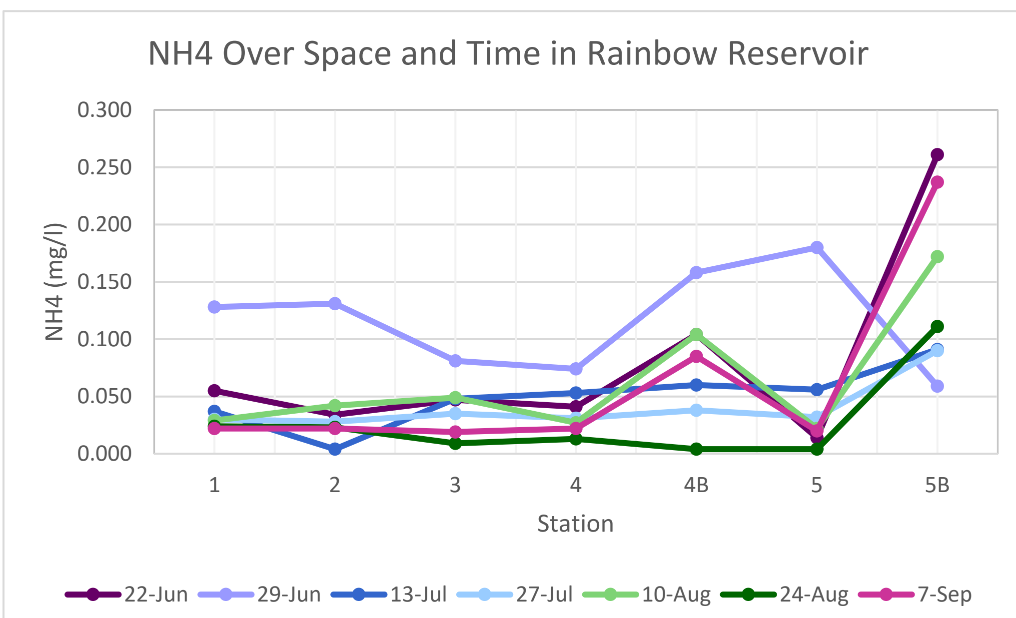


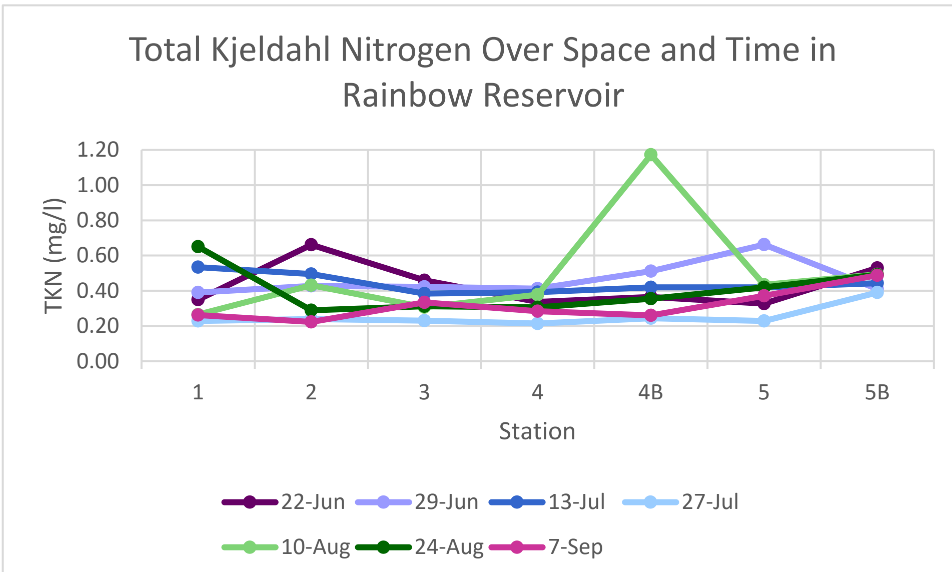
Figure 11. NH_4 over space and time in Rainbow Reservoir in 2023



Total Kjeldahl Nitrogen

TKN is a measure of organic nitrogen plus ammonium nitrogen. Adding NOx to TKN yields total nitrogen. The organic fraction (TKN minus NH_4-N) may reflect algal abundance, but other particles in the water column also contain organic nitrogen (e.g., leaf bits, zooplankton). By themselves, TKN values are hard to interpret, as the split between organic nitrogen and NH_4 is important, but values <0.5 mg/L are often considered low and values >0.8 mg/L are considered high. Concentrations of TKN at the five stations within Rainbow Reservoir over the 2023 sampling period (Figure 12) were >0.5 mg/L in only 5 of 35 samples and only 1 sample exceeded 7 mg/L.

Figure 12. Total Kjeldahl Nitrogen over space and time in Rainbow Reservoir



Total Nitrogen

Total nitrogen (TN) includes all measurable forms of nitrogen and is usually compared to total phosphorus to get an impression of which of these two key plant and algae nutrients is more limiting to productivity. TN values <0.6 mg/L are usually considered low and values >1 mg/L are often considered high. Much higher values are possible where wastewater or runoff from agricultural areas is substantial. Concentrations of TN at the five stations within Rainbow Reservoir over the 2023 sampling period (Figure 13) were mostly between 0.5 and 1.0 mg/L. Overall, nitrogen was not excessive in Rainbow Reservoir in 2021 but concentrations were mostly moderate and there was ample nitrate for non-cyanobacteria algae to flourish.

Based on the flows into Rainbow Reservoir on sampling dates in 2023 and the corresponding total nitrogen concentrations at station 1, the daily load to the reservoir ranged from 834 kg/day to 3363 kg/day (Figure 14). The daily load increased with the greater precipitation in July.

Figure 13. Total Nitrogen over space and time in Rainbow Reservoir in 2023

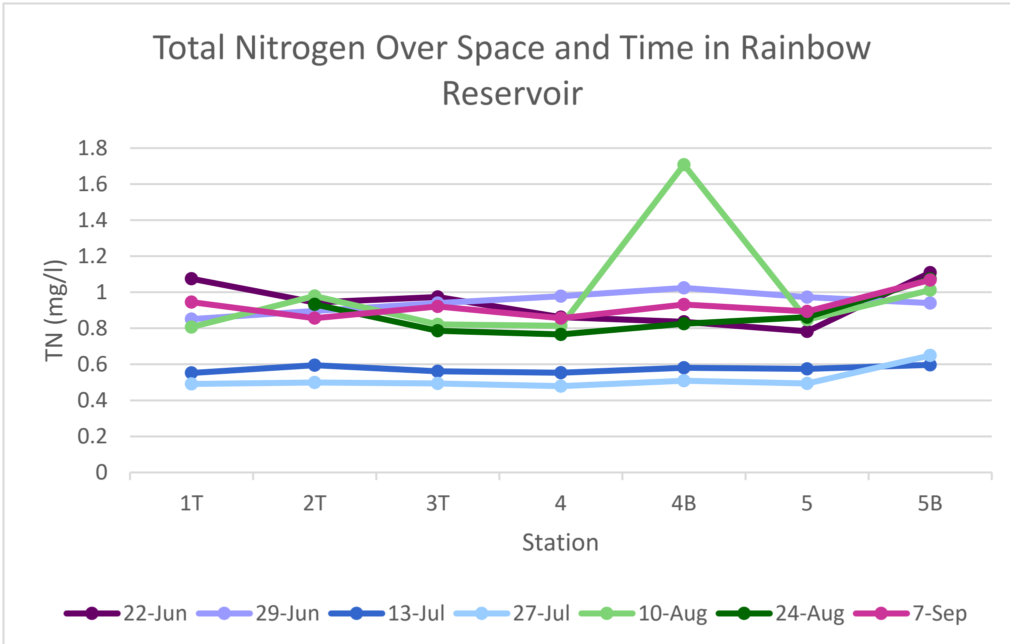
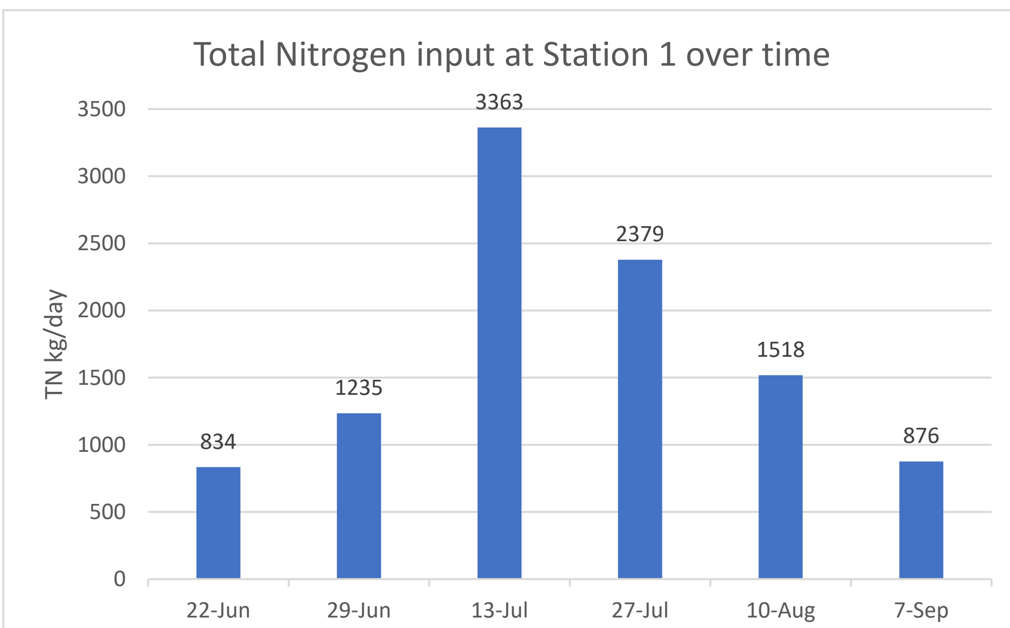


Figure 14. Total Nitrogen input at Station 1 over time in 2023

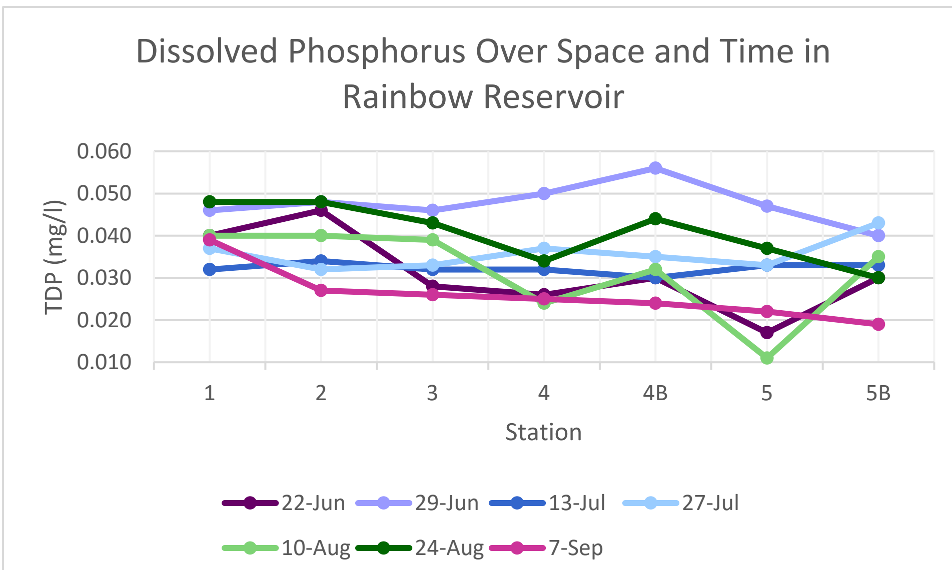


Total Dissolved Phosphorus

Total dissolved phosphorus (TDP) is the readily available form of phosphorus in the aquatic environment but is rarely abundant in natural waters. It is measured by the same method as total phosphorus (TP) after a filtration step to remove particulates. TDP is not the same as soluble reactive phosphorus or orthophosphorus, potentially including other dissolved phosphorus forms, but the values for those various dissolved fractions are usually similar.

Phosphorus is most often the limiting nutrient for growth of higher plants and algae in freshwater lakes and is rapidly taken up. TP may be much higher than DP and is usually a better indicator of overall fertility, as DP is often undetectable but is recycled rapidly in the water column. Concentrations of DP <10 ug/L are low while concentrations >20 ug/L are high, a fairly narrow range. Concentrations of DP at the five stations within Rainbow Reservoir over the sampling period (Figure 15) were routinely high, often very high, with most values exceeding 30 ug/L (0.03 mg/L). This suggests a large source of readily available P for algae growth.

Figure 15. Dissolved Phosphorus over space and time in Rainbow Reservoir in 2023

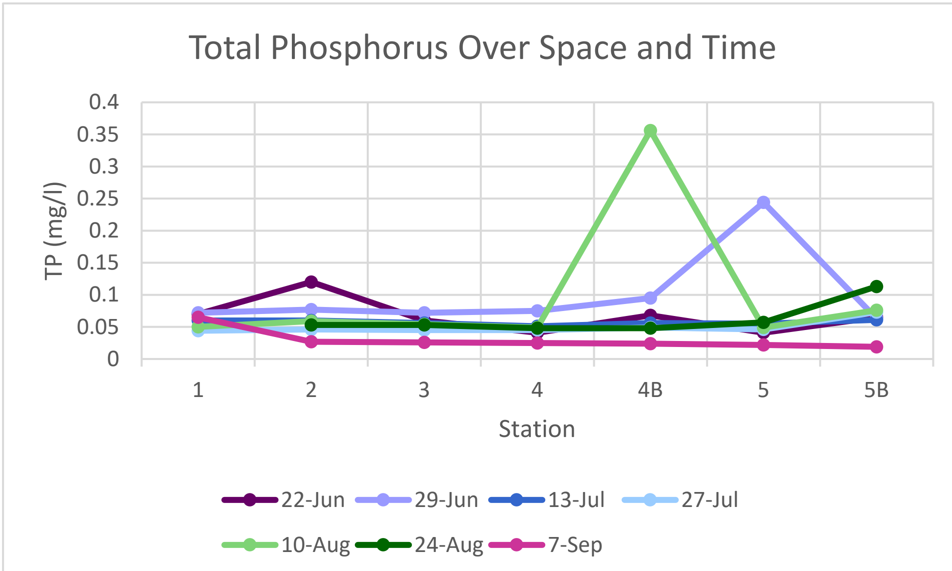


Total Phosphorus

TP is most often the nutrient that determines how much algae can be present. It may not always be the limiting factor, as light or flushing may control algal biomass, but TP tends to correlate best with overall algal biomass in most lakes whereas total nitrogen (TN) and its ratio to TP tends to determine which types of algae will be most abundant. TP <10 ug/L is considered low while values >25 ug/L are considered high, a fairly narrow range from minimal bloom probability to a high probability of algal blooms. Sometimes the TP is mostly refractory (unavailable organic) particles and TP will correlate less well with algal biomass, and sometimes other factors (like light or flushing) control algal biomass, but TP is considered a major predictive factor for algae blooms. Concentrations of TP at the five stations within Rainbow Reservoir over the sampling period (Figure 16) were >50 ug/L except in September 2023 and four values exceeded 100 ug/L. Once

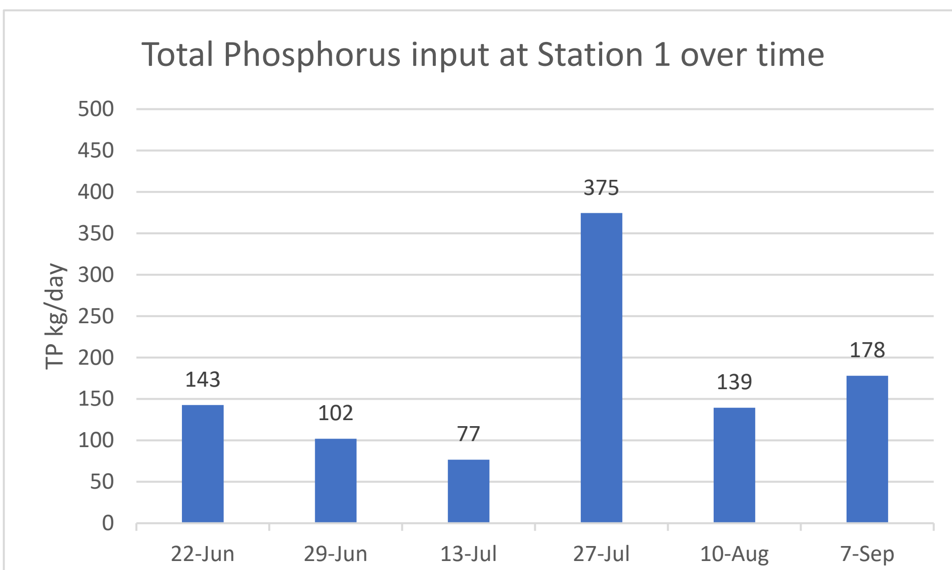
TP exceeds 100 ug/L phosphorus is often not limiting, so most of the TP values are in what could be considered a transition zone.

Figure 16. Total Phosphorus over space and time in Rainbow Reservoir in 2023



Based on the flows into Rainbow Reservoir on sampling dates in 2023 and the corresponding TP concentrations at station 1, the daily load to the reservoir ranged from 77 kg/day to 178 kg/day (Figure 17). Except for the high load on July 27th late in a very wet month, TP loading averaged around 100 kg/day.

Figure 17. Total Phosphorus input at Station 1 over time in 2023



TN:TP ratios for Rainbow Reservoir (Table 7) ranged from 4.0:1 to 40.6:1 and station averages ranged from 13.0:1 to 18.5:1, mostly considered moderate values. Ratios <10:1 tend to favor cyanobacteria while ratios >20:1 tend to favor other algae, especially green algae (Chlorophyta). There is no clear temporal pattern for the ratios, suggesting that the nature of inflows determine ratios in the reservoir. There is also no spatial pattern for the surface samples from the five reservoir stations; ratio values do not routinely increase or decrease as water passes through the reservoir in 2023. N to P ratios were lower for the one sampling date in 2022 when a cyanobacteria bloom was in progress. However, the values for the bottom stations within the reservoir (4B and 5B) are among the lowest observed and suggest that there may be some influence from P released from sediment at those deeper stations.

Table 7. Ratios of TN:TP in Rainbow Reservoir over time in 2023

	1	2	3	4T	4B	5T	5B
6/22/2023	15.4	7.9	16.2	21.0	12.3	19.1	17.1
6/29/2023	11.8	11.6	13.1	13.0	10.8	4.0	14.9
7/13/2023	9.2	9.9	10.0	10.8	10.4	10.5	9.8
7/27/2023	11.2	10.8	11.0	10.6	10.4	10.7	8.9
8/10/2023	16.1	16.6	15.2	16.6	4.8	17.3	13.3
8/24/2023	QNS*	17.6	14.8	16.0	17.2	15.1	9.5
9/7/2023	14.5	31.7	35.4	34.2	38.8	40.6	56.2
Average	13.0	15.2	16.5	17.5	15.0	16.8	18.5
Maximum	16.1	31.7	35.4	34.2	38.8	40.6	56.2
Minimum	9.2	7.9	10.0	10.6	4.8	4.0	8.9

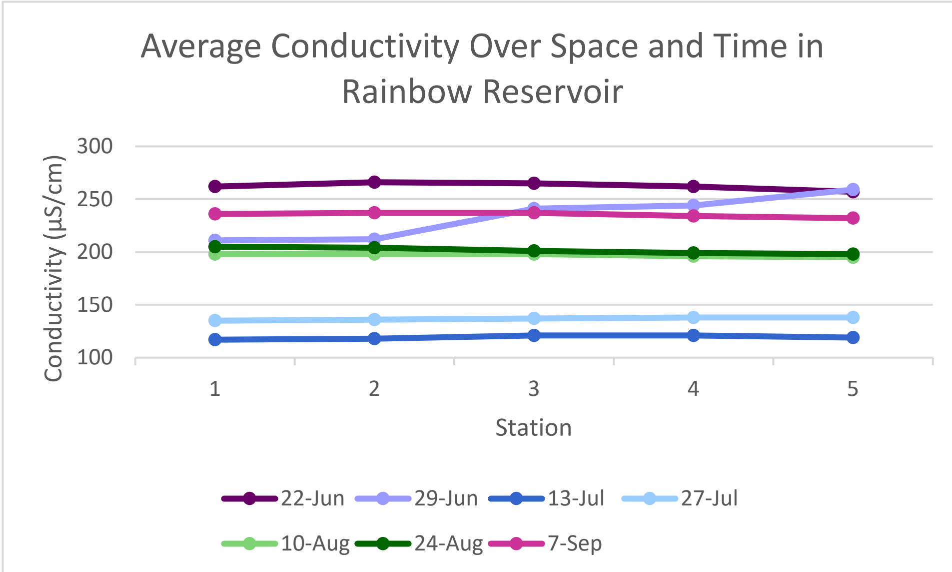
* Not enough liquid was saved to perform TN and TP on 8/24/2023

Conductivity/Total Dissolved Solids

Conductivity is the ability of water to conduct electricity, which is largely dependent on the quantity of charged solids dissolved in that water. While the relationship between conductivity and total dissolved solids (TDS) varies somewhat among water sources and with increasing concentration of TDS, in southern New England over the range of values typically found here, TDS in mg/L is about two thirds of conductivity as uS/cm. Conductivity values <100 uS/cm are considered low while values >500 uS/cm are considered high. Additions of agricultural or urban runoff and wastewater discharges raise conductivity. Salt used on roads also increases conductivity significantly and accumulation of previously applied salt in groundwater can raise conductivity for many years. While higher conductivity is generally undesirable for most uses, higher conductivity (or TDS) does not have strong meaning without some analysis of the solids causing elevated values.

Conductivity in Rainbow Reservoir (Figure 18) varied between 120 and 260 uS/cm in 2023, about a twofold range but all in the moderate range. There was very little variation over space on any date other than June 29, 2023, which exhibited a minor increase in the downstream direction. There is no temporal pattern to the data, suggesting that inflows to the reservoir are controlling conductivity levels.

Figure 18. Average Conductivity over space and time in Rainbow Reservoir in 2023



Turbidity/Secchi Transparency

Water clarity is a major feature of water with distinct implications for various uses. Clarity is a function of light penetration, which is reduced by higher concentrations of suspended particles, which can include algae or suspended non-living particles of organic or inorganic origin. Turbidity is a measure of light transmission through a sample and is related to particle concentration, although the relationship depends on the size distribution of particles. Smaller particles impart greater turbidity than the same mass of larger particles as a function of the probability of light hitting a particle and being scattered.

Turbidity (Figure 19), and Secchi transparency (Figure 20) in Rainbow Reservoir exhibited a substantial range, but generally suggest low to moderate clarity as a function of non-algal particles in the water column. Chlorophyll-a was not monitored in 2023, but in 2021 concentrations were not high enough to cause lower clarity readings, suggesting that suspended sediment, organic or inorganic, is more likely to have controlled clarity. Algae blooms in past summers produced higher chlorophyll-a values and were likely a stronger influence in water clarity, but the high flows and flushing of 2021 limited that effect.

Water clarity did change spatially over the five reservoir stations, but not to any extreme or with any consistent trend. Sometimes clarity increased, a phenomenon expected as particles settle out in the slower flowing reservoir water, but clarity also increased on several dates, suggesting either additional particulate inputs between the stations or high variability in Farmington River features, a strong possibility with the many rainstorms of summer 2023.

Figure 19. Average Turbidity over space and time in Rainbow Reservoir in 2023

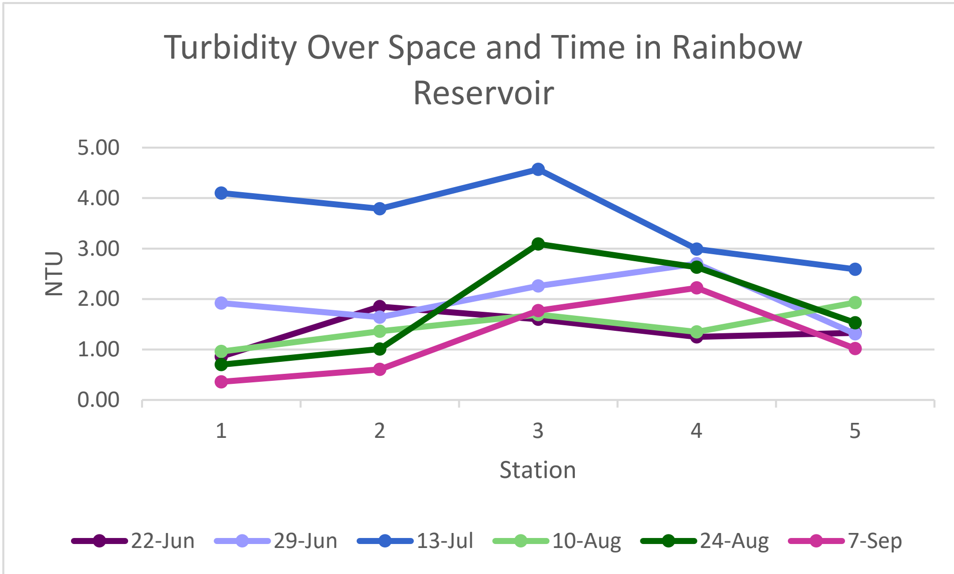
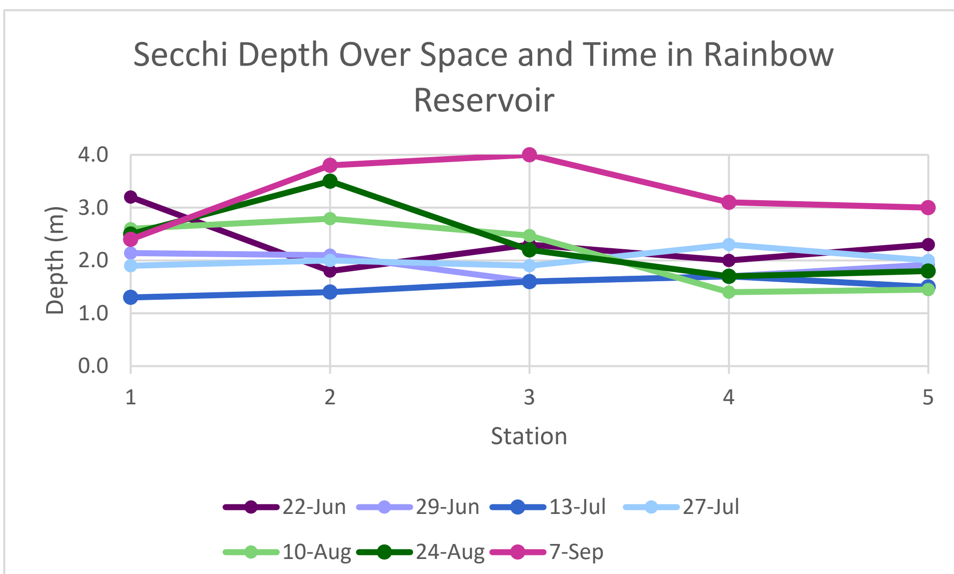


Figure 20. Secchi Depth over space and time in Rainbow Reservoir in 2023



Sediment Features

Soft sediment, or substrate that is more water than solids and can be penetrated easily with a rod or even the viewing camera on a cable, tends to be dominated by organic matter and often contains substantial amounts of P that can be released back into the overlying water. Coarser materials like sand and gravel almost always contain less P overall and certainly less available P. Examination of Rainbow Reservoir in 2021 revealed no soft sediment in the vicinity station 1. Sand and gravel graded into organic muck at around 2.5 m (8.3 ft) of water depth, although there was some variation and the range of water depths for the sand to muck "edge" was 1.6 to 3.8 m (5.3 to 12.5 ft). Given the bathymetry of Rainbow Reservoir, the approximate edge of the muck layer delineates an area of 105 acres (Figure 21). Based on a reservoir area of 225 acres, this represents 47% of the total reservoir area at full pool elevation and suggests a substantial area on which low oxygen could act to release P into the overlying waters.

Five sediment samples were collected at the monitoring stations (Figure 6) in 2021 and tested for solids content, specific gravity, and various phosphorus fractions, with results provided in the report for 2021 sampling. It was apparent that the sediment at stations 4 and 5 is most conducive to P release and samples from R4 and R5 were retested in 2023 (Table 8).

The testing included sequential extractions to quantify fractions of the phosphorus pool. The ammonium chloride (NH_4Cl) extract captures the loosely sorbed phosphorus, which is mostly dissolved P in the porewater of the sediment. This fraction tends to be a negligible component of sediment P (<20 mg/kg) and that was the case for all Rainbow Reservoir sediment samples. The Fe-bound P fraction is what is most readily released under anoxia and can be large. A portion of the organic fraction, often linked to Fe as well, can also be released, albeit more slowly than the pure Fe-P. Different labs analyzed the samples from 2021 and 2023, and the concentrations of Fe-P and biogenic P varied substantially among years and labs, but the sum of the concentrations for these two most available fractions were comparable.

For R4, the 2021 sediment P deemed "available" was 470 mg/kg while for R5 the 2021 that quantity was 535 mg/kg. For the 2023 samples, the corresponding values were 436 and 629 mg/kg (Fe-P + biogenic P from Table 8). While the concentrations in sediment offer insights, a conversion to actual P mass that can become available is needed to fully understand the potential for internal loading to support algae blooms. Using the solids content, specific gravity, and available sediment P, the mass of P in a 10 cm surficial sediment layer can be calculated (Table 9). For the 2021 samples, the values for R4 and R5 were 16.0 and 12.1 g P/m^2. For the 2023 samples, the corresponding values are 12.2 and 14.2 g P/m^2. All these values are large and considering the range of possible values, these are all fairly similar.

From the 2021 sediment data, it was concluded that the total amount of P that might be released in the area associated with R4 and R5 could not be higher than about 400 kg over the course of the summer. The same analysis with 2023 data suggests that about 350 kg of P might be released. Compared to the watershed input, which averaged 165 kg/day during the summers of 2021 and 2023, this is a minor part of the total P load to Rainbow Reservoir. Summer internal loading might

Figure 21. Portion of Rainbow Reservoir with organic substrate.

Table 8. Sediment features at two sample stations in Rainbow Reservoir in 2023

SAMPLE ID	% SOLIDS	TOC (%)	TOTAL-P (mg/kg)	LOOSELY BOUND P (NH4CL) (mg/kg)	FE BOUND P (DITHIONATE) (mg/kg)	AL BOUND P (NAOH) (mg/kg)	CA BOUND P (HCL) (mg/kg)	BIOGENIC P (mg/kg)	ORGANIC P (mg/kg)	Aluminum (mg/kg)	Iron (mg/kg)	Calcium (mg/kg)
R4	22.7%	PENDING	1698	<2.00	382	958	208	53.5	149	13310	20370	3500
R5	20.1%	PENDING	2283	<2.00	606	1264	278	23.1	136	15400	27810	4240

Table 9. Available sediment phosphorus in Rainbow Reservoir in 2023

	2023	
Lake or Area	R4	R5
Mean Available Sediment P (mg/kg DW) (uses BD Fe-P + NaOH Fe-P)	436	629
Target Depth of Sediment to be Treated (cm)	10	10
Volume of Sediment to be Treated per m2 (m3)	0.100	0.100
Specific Gravity of Sediment	1.21	1.13
Percent Solids (as a fraction)	0.23	0.20
Mass of Sediment to be Treated (kg/m2)	27.9	22.6
Mass of P to be Treated (g/m2)	12.17	14.23
Target Area (ac)	55.0	14.0
Target Area (m2)	221774	56452
Total mass of available P in upper 10 cm in area (kg)	2700	803
Probable P release at 10% of available P in upper 10 cm (kg)	270	80

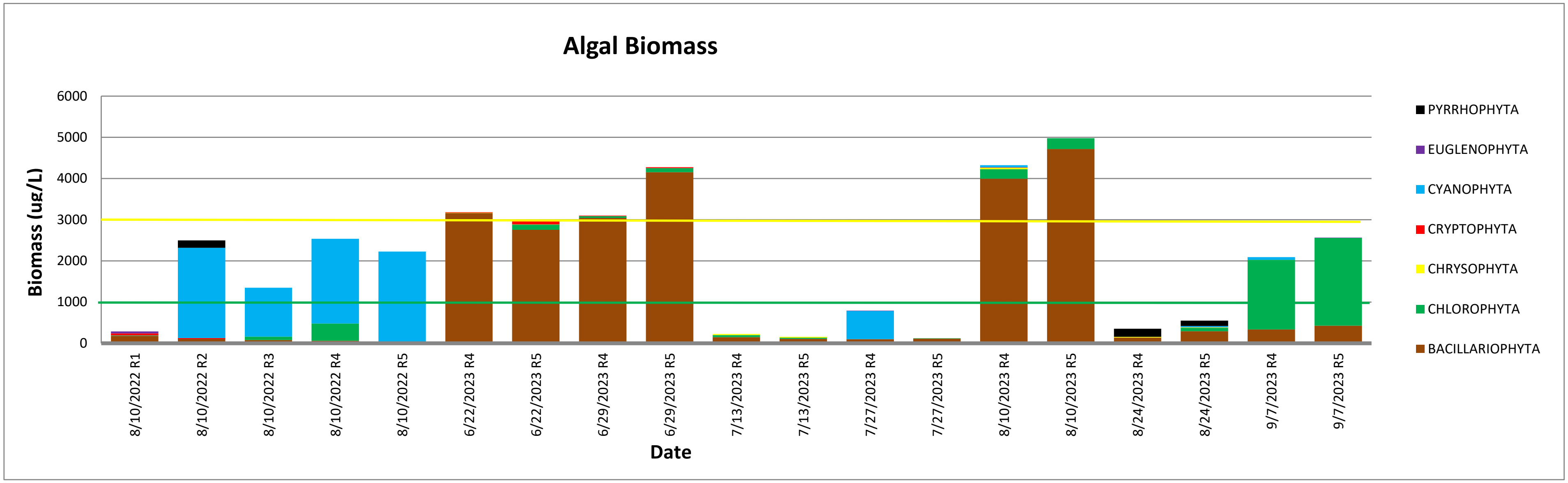
be significant under summer drought conditions with much lower watershed inputs, as occurred in 2022, but on a regular basis the load of P from the sediment to Rainbow Reservoir is a minor component of the total P load.

Phytoplankton

Phytoplankton samples were collected on each of the water quality sampling dates from all five stations in 2021, from all five stations during the cyanobacteria bloom of August 2022, and from stations R4 and R5 on all sampling dates in 2023. Samples were analyzed microscopically to quantify the types of algae present in the water column. The summary of phytoplankton composition and biomass for 2021 revealed generally low algal biomass and almost no cyanobacteria at any time. The bloom in 2022 (Figure 22) was dominated by Microcystis with several other potential toxin-producing cyanobacteria present, but the overall biomass in open water samples was not high. Windblown shoreline accumulations, not sampled but quite visible in August 2022, would have exhibited much higher biomass.

Phytoplankton in 2023 (Figure 22) included mainly diatoms, sometimes at high biomass, with peaks during June and August, the dry months that year. The influence of flow and detention time on phytoplankton composition and biomass is apparent. The only significant concentration of cyanobacteria was in July when N to P ratios were at their lowest (near 10:1), bu that concentration was not high. The algal community transitioned to dominance by green algae near the end of summer. Dominant taxa included the diatoms Aulacoseira and the flagellated green Eudorina. The cyanobacteria found in July included Dolichospermum and Aphanizomenon, bloom-forming species found in 2022, but not achieving bloom levels in 2023.

Figure 22. Phytoplankton biomass in Rainbow Reservoir in 2022 and 2023



Evaluation and Management Needs

Cyanobacteria Blooms

The primary concern that prompted this study and the one in 2021 is the occurrence of potentially toxic cyanobacteria blooms in Rainbow Reservoir, threatening use by the public and possibly ecological functions. Neither year was an ideal time for such a study, given higher than average flows and a lack of distinct cyanobacteria blooms, but data were collected in association with a bloom in summer 2022, and considerable data provides insights into how conditions in Rainbow Reservoir interact to foster cyanobacteria blooms.

Cyanobacteria blooms form by one of three main mechanisms:

1. Growth from some small seed population in the upper waters, requiring adequate P and light and a long enough detention time (two weeks or more) to allow bloom development by growth processes. Almost any cyanobacterium could form a bloom by this mechanism and the limiting factor in Rainbow Reservoir is likely to be the flushing rate, as average detention time is listed as only about 1 day by the CT DEEP. Nutrients are adequate to support blooms and the N to P ratio is low enough to favor cyanobacteria some of the time. Blooms would be most likely during droughts when detention time increases.
2. Growth near the thermocline, utilizing P released from sediment below but with enough light to allow development of an algal layer that can then be mixed or actively rise to the surface by forming gas bubbles within cells. *Planktothrix*, *Planktolyngbya*, and *Pseudanabaena* are examples of cyanobacteria that bloom by this mechanism. There does not appear to be a stable thermocline in Rainbow Reservoir from all available data, but it is possible that temporary stratification covering an area of up to 25 acres in the downstream end of the reservoir might support this growth mode in dry summers. Yet it seems unlikely that this growth mode could produce enough cyanobacteria to cause a widespread problem in Rainbow Reservoir and the species that commonly bloom by this mode are not common in this waterbody.
3. Growth at the sediment-water interface, utilizing P released from sediment before it gets into the water column, but with enough light to allow growth, with a synchronous rise of cell aggregates by formation of gas bubbles within cells to form surface blooms. The need for light will limit such growth to the portion of the reservoir with water depth of <3 times the average summer Secchi depth, or about 6 m for Rainbow Reservoir. The portion of the reservoir with a substantial P-rich, organic sediment base, is about 70 acres, but adequate light limits the likely supporting area to about 45 acres or 20% of the reservoir. *Microcystis*, *Dolichospermum* (formerly *Anabaena*), *Aphanizomenon*, and *Woronichinia* (formerly *Coelosphaerium*) are the most common cyanobacteria that bloom by this mechanism and the first three have been involved in recent blooms. This growth mode may be restricted to the downstream portion of the reservoir but could be a factor in observed blooms, especially with windblown accumulation along shorelines.

Some combination of mechanisms 1 and 3 are likely to produce observed blooms in Rainbow Reservoir, but in light of past and present hydrology, nutrient concentrations, and algae reports, it seems that bloom formation in Rainbow Reservoir may be most limited by flushing rate. The typical low flow range during summer is 150 to 400 cfs, suggesting a detention time of no more than 9 days. In 2021 and 2023 the median summer flow was close to 1000 cfs, yielding a detention time of 1.3 days, close to the long-term average listed by CT DEEP for the entire year. During drought conditions, as in 2022, detention time can increase to nearly two weeks, fostering bloom development from excessive concentrations of nutrients in the water column as a function of inputs from the Farmington River. Growth at the sediment-water interface and rise in the water column may accelerate bloom formation and would also be favored by lower flows associated with drought conditions. Drought conditions are not a regular occurrence in the Rainbow Reservoir watershed but are increasing in frequency with climate change and may be largely responsible for the increased frequency of cyanobacteria blooms in recent years.

In addition to the effect of climate change on drought (and flood) frequency, the accompanying increase in temperature also favors cyanobacteria. Algae have seasonal periodicity related to food storage products, with cyanobacteria metabolizing reserves best at higher temperatures (>25°C). Diatoms and golden algae prefer colder temperatures (<20°C), leading to dominance from late fall through early spring in most aquatic habitats. Green algae are intermediate, tending to follow the diatoms and goldens in the spring as the water warms and giving way to cyanobacteria later in summer when water temperature is maximum. In a system like the Farmington River, temperatures tend to be colder, and with short detention time in Rainbow Reservoir, temperatures often do not favor cyanobacteria. In 2021 the temperature throughout the water column exceeded 25°C only at the start of July after a relatively dry June. The temperature was well above 25°C during the August 2022 bloom, but only exceeded 25°C in late August and early September in 2023 and then just at the reservoir surface. Temperatures >25°C were also recorded in some recent lower flow years by CT DEEP, suggesting that during periods of lower flow the reservoir may heat up fairly quickly and become a more favorable habitat for cyanobacteria.

The contribution of P from sediment to the water column concentration appears inconsequential; the maximum conceivable summer load is no higher than the inputs from the Farmington River over several days. In a drier summer the relative contribution could be higher but is unlikely to ever exceed 10% of the total P load to the reservoir. However, there is potential for certain cyanobacteria to grow at the sediment-water interface from P available from the sediment then synchronously rise to form a bloom in surface waters. With the typical summer detention time of just a few days, such blooms would be very short-lived and unlikely to represent a major threat to human use of the reservoir. However, with drought conditions such a cyanobacteria bloom could linger and even intensify with the high availability of P in the water column.

The ratio of N to P is lowest near the bottom of the reservoir, favoring cyanobacteria developing at the sediment-water interface, although the deepest part of the reservoir may not supply adequate light. The moderate concentration of nitrate in the water column will not favor cyanobacteria but will not strongly favor other algae and if cyanobacteria rise from the sediment there could be ongoing growth with high available P in surface waters. Flushing remains the most likely overall control on bloom formation in Rainbow Reservoir, but with lower flows the potential for cyanobacteria bloom formation increases.

Possible Control Options

As discussed in the report of the 2021 study, direct control of cyanobacteria is possible with flushing or algaecides, removing the algae from the system. High flushing is the normal condition in Rainbow Reservoir, but when watershed flows decline to the point where detention is high enough that a bloom could exist in the reservoir, it is because there is not enough water entering the reservoir. Providing additional water will be very difficult. More water could be released from upstream waterbodies, but under the kind of drought conditions that could sufficiently limit flushing of Rainbow Reservoir it is unlikely that such releases would be acceptable to those managing those upstream waterbodies. The only practical alternative would be to discharge more water from Rainbow Reservoir. This is done in anticipation of flood events, was fairly common in 2021 and 2023, and could also be done when flushing is too low, albeit with a drop in water level that could restrict access and enjoyment of the reservoir. Such an approach would only work for a short time unless a very large drawdown is acceptable, and even then, the bloom might be sent downstream with possible impacts in other locations, so this approach is not ideal.

Control by algaecides is only likely to be needed sporadically, probably no more than once per year, and the low cost of algaecides may be attractive. Proper use requires tracking of the algae assemblage, however, best done on a weekly basis, necessitating some additional expense for monitoring. Ongoing vigilance and rapid response when a problem appears imminent is also needed.

Most algaecides are based on copper or peroxide as the active ingredient and treatment of waterbodies with most algaecides is restricted by permit to half the waterbody. Peroxides work well on most cyanobacteria and have fewer non-target impacts. Peroxides would be recommended for Rainbow Reservoir, given the many life forms in or downstream of the reservoir that could be affected by copper. It is possible to apply a pelletized peroxide formulation that would sink to the bottom and attack the cyanobacterial colonies growing at the sediment-water interface. It has not been determined that this is the primary mode of bloom formation in Rainbow Reservoir, but if that is the case such a treatment could be conducted over the roughly 45 acres of area that appear suitable for such cyanobacteria growth at a reasonable cost and could prevent surface blooms from forming.

Direct control is less desirable than prevention, whereby conditions are altered to minimize the probability of a bloom. Decreasing light penetration by the addition of dyes is one option, but with the short detention time in Rainbow Reservoir, even under extreme drought, the dye would travel downstream and may raise permitting issues as well as cost concerns for maintaining adequate dye concentrations. Lowering P concentrations is the logical target of preventive effort intended to minimize algae blooms in general and cyanobacteria blooms in particular.

In order to reduce P concentrations in Rainbow Reservoir it will be necessary to reduce the amount of P entering from the Farmington River. The concentration of TP in the incoming Farmington River water in 2021, 2022, and 2023 samples was mostly between 40 and 100 ug/L, enough to support algae blooms, although particulate P may settle out if the detention time is long enough. Yet the portion of TP that was readily available (dissolved P) was substantial, with concentrations mostly between 20 and 60 ug/L in samples from 2021-2023. While the ratio of N to P is not consistently low enough to suggest that cyanobacteria will be favored, there is enough available P to support algae blooms if other factors, mostly notably flushing rate and light, are not limiting.

The daily load from upstream flows and data for P at station 1 in 2021 and 2023 indicate P input ranging from 77 to 511 kg/day with an average of 165 kg/day. Lower values might be expected during drought conditions, although inputs from the wastewater treatment facilities upstream will keep the concentration from declining too much with less watershed runoff. In order to have an inflow TP concentration of <20 ug/L, a value that should minimize cyanobacteria abundance, the TP load from the watershed would need to be lowered to no more than 63.4 kg/day. From the average wet summer loading from 2021 and 2023 that would be more than a 60% decrease. For anticipated drier summer inputs of about 100 kg/day, that represents a 37% decrease. Decreases in non-point source watershed loading of more than about 20% are very difficult to accomplish and usually require multiple years to bring to fruition.

A decrease in P loading will require addressing both point sources and non-point sources in the Farmington River watershed. A detailed assessment of loading is beyond the scope of this assessment, but data for wastewater treatment facilities should be available and sampling of key tributaries is advised to assess whether there are “hotspots” of P input in the watershed that can be prioritized to establish a plan for P loading reductions. The primary sources are direct discharges from wastewater treatment facilities, many of which have high or no permit limits on the concentration of P discharged, agricultural lands which produce P-rich runoff and have been historically difficult to regulate, and urban land that contributes P-laden stormwater runoff.

It may be possible to select representative tributaries to sample based on land use in their drainage areas, then sample to determine if there are features of those drainage areas that make high P concentrations more or less likely. Stormwater drainage systems and best management practices are likely critical factors for non-point sources, while the level of treatment and size of discharge are the primary issues for point sources. At least some of the communities draining to the Farmington River are subject to Municipal Separate Storm Sewer System regulations, making towns responsible for input reductions, and such a study may help determine the most effective actions to take.

One option for at least interim control that could be effective is to treat the incoming Farmington River water. Addition of a P binder such as aluminum can inactivate much of the incoming P and make it unavailable to algae. Many aluminum compounds act as coagulants, enhancing the settling of particles as well as extracting bioavailable P from the water column. A dosing station would be needed, consisting of a storage tank for aluminum product (most likely polyaluminum chloride), a discharge header that injects the aluminum product, and a pump system to move the aluminum product from the tanks to the discharge point. A discharge location somewhere near Rt 187 would be advantageous, but anywhere in the upper portion of the reservoir could work. Several dosing systems operate in Massachusetts, and many have been in use in Florida for many years, but this would be a new approach in Connecticut.

The water in Rainbow Reservoir would be less fertile and much clearer with a P inactivation system in place. Given the rapid flushing rate and infrequent algae problems, the system would not have to run all the time. Rather, inactivation would occur just during low flow periods to minimize the probability of algae blooms. Such inactivation systems have been very effective at reducing cyanobacteria blooms, tending to shift the N to P ratio in a way that favors other algae even if P levels are still high enough to support elevated algae abundance. But in many cases algae problems can be eliminated. The settling of the aluminum to the bottom would also provide some inactivation of surficial sediment, limiting future recycling of P from those sediments.

Summary and Recommendations

Data collected from past studies have indicated elevated nutrient concentrations in Rainbow Reservoir, but the very short detention time has minimized algal blooms in general and cyanobacteria in particular. More recently there have been cyanobacteria blooms, but there is no clear indication of an increase in nutrient loading. Increased temperature, which favors cyanobacteria over other algae, and lowered inflows that increase detention time are likely factors in the increase in cyanobacteria and are logically related to climate change. Sampling in 2021, 2022, and 2023 revealed high concentrations of P and generally moderate but sometimes low ratios of N to P that favor cyanobacteria. However, 2021 and 2023 exhibited very wet summers and detention time was very short; algae concentrations were generally low and very few cyanobacteria were detected. Clarity was low to moderate but was mostly a function of non-algal particles suspended in the water column, a function of watershed runoff during an abnormally wet season. Drought conditions in summer 2022 raised water temperatures and increased detention time; there was a cyanobacteria bloom in August.

Low oxygen conditions that favor release of P from surficial sediments are not common in Rainbow Reservoir but are possible under low flows and increased detention time. The reservoir is not known to strongly stratify and was well mixed from top to bottom on all sampling dates in 2021 and 2023, with a slight gradient in August 2022. Testing of sediment in 2021 and 2023 revealed substantial amounts of available sediment P, but the maximum estimated release rate suggests a contribution of only a very small portion of the annual P load. Inputs of P from the Farmington River control P concentration in Rainbow Reservoir most of the time.

Despite the relatively small contribution of sediment P to the overall P load to Rainbow Reservoir, it is possible that cyanobacteria can grow at the sediment-water interface where oxygen is low but adequate light penetrates to the bottom to allow growth. Those bottom originating cyanobacteria can form gas pockets within cells and rise in the water column to form surface blooms. An area of about 45 acres of Rainbow Reservoir provides suitable conditions for such cyanobacteria growth, all in the lower portion of the reservoir, mostly between water depths of 10 and 20 feet. Low detention time will limit such blooms, but during drought conditions it is possible that cyanobacteria blooms could be initiated by this mechanism. The observed bloom forming cyanobacteria are all species known to initiate growth at the sediment-water interface. Once cyanobacteria rise in the water column, nutrients are more than sufficient to allow growth and wind is likely to cause excessive shoreline concentrations. However, detention time is too short to allow such bloom development except under prolonged dry conditions.

Direct control of cyanobacteria is routinely offered through rapid flushing in Rainbow Reservoir, but when such flushing is inadequate, the use of algaecides may be justified. Application of a pelletized peroxide formulation could kill any growing colonies of cyanobacteria at the sediment-water interface and prevent blooms. Knowing when to apply such an algaecide is difficult to state clearly, given a limited record of blooms, but detention time may allow blooms to develop by that mechanism when flows drop below about 200 cfs. It is possible that windblown cyanobacteria accumulations could present a hazard at somewhat higher flows, so a higher flow threshold might be considered. Application to water between 10 and 20 feet deep where organic sediment is dominant (45 acres in the lower part of the reservoir) would be recommended if this preventive approach is pursued.

Use of peroxide as an algaecide should present minimal threat to non-target organisms in Rainbow Reservoir as long as treatment does not occur during fish spawning, as the eggs may be susceptible. Blooms have been a summer phenomenon, however, a time at which fish spawning should be negligible in this system. If blooms are rare, this is a cost-effective approach, but does not attack the true cause of the problem. As an interim measure to minimize threats to human users and waterbody ecology, peroxide application may be useful and acceptable, but reduction in P concentration in Rainbow Reservoir is the preferred long-term approach to improving conditions in the reservoir.

All available data indicate that P concentration in Rainbow Reservoir is a function of incoming P concentrations in the Farmington River. P inactivation near Rt 187 could lower P in the incoming water sufficiently to minimize the potential for any algal blooms in the reservoir. Use of aluminum compounds has been effective in other systems and has minimized cyanobacteria in the receiving waterbodies. As flushing is normally adequate to prevent blooms, inactivation would only be necessary during times of low flow, so this could be a practical means to improve reservoir conditions. However, it would be preferable to manage P at or near the sources, providing benefits throughout the Farmington River system while limiting algal blooms in the reservoir. P sources in the watershed include point sources (9 wastewater treatment facilities, 8 of which are upstream Rainbow Reservoir) and non-point sources (mainly developed and agricultural land) and a multi-pronged approach will be needed over an extended period of time to reduce P loading.

The primary need at this stage is a more complete understanding of P loading throughout the watershed and comparison of drainage areas for features that lead to more or less P input. Data from the wastewater treatment facilities should be available to allow assessment of corresponding contributions. Data for various tributaries should be collected to facilitate an analysis of relative contributions from different sub-basins of the Farmington River system. The study should be designed to allow relative contributions from different drainage areas with known features to be quantified. Characteristics such as % urban (with sub-groups, possibly based on level of impervious surface) and % agricultural land (with sub-categories like row and cover crops, concentrated feeding areas, and pastureland) should be considered when choosing target tributaries and sampling points to provide maximum insight. Sampling should include pre-storm, early storm, and late storm assessment to facilitate evaluation of the role of diffuse runoff vs permitted discharges and aid consideration of options for P loading reduction (e.g., loading vs precipitation curves, needed detention capacity or other BMP needs).

Analysis of loading suggests that at least a 37% decrease in P loading is needed to minimize cyanobacteria bloom potential in Rainbow Reservoir, and a loading decrease closer to 60% may be needed. Further refinement of that estimate is needed based on more data for P loading from the watershed, but it may be infeasible to reduce P loading sufficiently to avoid the need for in-lake pre-emptive actions like algaecides or P inactivation.

APPENDIX

Table A- 1. Phytoplankton cell counts for Rainbow Reservoir in 2023.

* = potentially toxic ** = likely toxic # = taste and odor producer	PHYTOPLANKTON DENSITY (CELLS/ML)													
	Rainbow 4	Rainbow 5	Rainbow 4	Rainbow 5	Rainbow 4	Rainbow 5	Rainbow 4	Rainbow 5	Rainbow 4	Rainbow 5	Rainbow 4	Rainbow 5	Rainbow 4	Rainbow 5
TAXON	06/22/23	06/22/23	06/29/23	06/29/23	07/13/23	07/13/23	07/27/23	07/27/23	08/10/23	08/10/23	08/24/23	08/24/23	09/07/23	09/07/23
BACILLARIOPHYTA														
Centric Diatoms														
Acanthoceras	0	0	0	0	0	0	0	0	0	0	11	15	0	12
Aulacoseira #	3312	2755	3325	4960	0	41	0	0	8196	9525	114	330	851	1190
Melosira	20	19	0	0	17	0	18	21	74	51	68	0	0	0
Urosolenia	0	0	0	0	0	0	0	0	12	0	11	0	15	12
Araphid Pennate Diatoms														
Asterionella #	78	76	0	0	0	0	0	0	99	102	137	435	122	198
Colonial Fragilaria/related taxa #	137	238	171	198	0	0	0	0	0	0	0	135	0	0
Single Fragilaria/Synedra	10	0	0	0	0	0	26	0	99	51	23	30	15	0
Tabellaria #	0	0	0	0	0	0	35	0	0	0	0	0	30	0
Monoraphid Pennate Diatoms														
Achnanthidium/related taxa	0	0	0	0	34	81	0	0	0	0	0	0	0	0
Cocconeis	0	0	0	0	0	0	0	32	0	0	0	15	0	0
Biraphid Pennate Diatoms														
Cymbella/related taxa	0	0	0	0	17	8	0	32	0	0	0	0	0	0
Eunotia	0	0	0	0	0	0	9	11	0	0	0	0	0	0
Gomphonema/related taxa #	0	0	0	0	0	0	9	11	0	0	0	15	0	0
Navicula/related taxa	0	0	0	0	34	57	0	32	0	0	0	0	0	0
Nitzschia #	0	0	0	0	25	16	35	32	0	0	11	0	0	0
Pinnularia	0	0	0	0	8	0	0	0	0	0	0	0	0	0
CHLOROPHYTA														
Flagellated Chlorophytes														
Eudorina	0	304	0	0	0	0	0	0	0	0	0	0	3891	2976
Pandorina	0	76	152	446	0	0	0	0	0	0	0	120	0	397
Coccoid/Colonial Chlorophytes														
Actinastrum	0	0	0	0	0	0	0	0	99	0	0	0	0	99
Crucigenia	0	0	0	0	0	65	0	0	0	0	0	0	0	0
Desmodesmus #	0	0	0	0	34	0	0	0	0	0	0	0	0	0
Micractinium	0	0	0	0	0	0	0	0	0	0	0	0	0	298
Pediastrum #	0	0	0	0	0	0	0	0	0	203	0	0	0	0
Scenedesmus #	0	0	38	0	0	0	0	84	50	0	0	0	61	0
Schroederia/Ankyra	0	0	10	0	0	8	0	0	25	25	0	0	0	0
Sphaerocystis	0	0	0	298	0	0	0	0	0	0	0	360	638	0
Tetradesmus #	0	0	0	0	34	0	0	0	0	0	0	0	0	0
Filamentous Chlorophytes														
Desmids														
CHRYSOPHYTA														
Flagellated Classic Chrysophytes														
Dinobryon #	0	0	0	0	8	8	0	0	12	0	0	0	0	0
Mallomonas #	10	10	0	0	0	0	0	0	0	0	34	15	0	0
Non-Motile Classic Chrysophytes														
Haptophytes														
Tribophytes/Eustigmatophytes														
Raphidophytes														
CRYPTOPHYTA														
Cryptomonas #	10	10	10	12	0	0	0	0	50	0	0	30	0	0
CYANOPHYTA														
Unicellular and Colonial Forms														
Filamentous Nitrogen Fixers														
Aphanizomenon **#	0	0	0	0	0	0	0	0	0	0	0	0	152	0
Dolichospermum **#	0	0	0	0	0	0	3432	0	248	0	0	150	228	0
Filamentous Non-Nitrogen Fixers														
EUGLENOPHYTA														
Euglena	0	0	0	0	0	0	0	0	0	0	0	0	0	12
PYRRHOPHYTA														
Ceratium #	0	0	0	0	0	0	0	0	0	0	11	8	0	0

Table A- 2. Phytoplankton cell counts for Rainbow Reservoir in 2023 (continued).

DENSITY (CELLS/ML) SUMMARY														
BACILLARIOPHYTA	**3557.4**	**3087.5**	**3496**	**5158.4**	**134.4**	**202.5**	**132**	**168**	**8481.6**	**9728.2**	**376.2**	**975**	**1033.6**	**1413.6**
Centric Diatoms	3332	2774	3325	4960	16.8	40.5	17.6	21	8283.2	9575.8	205.2	345	866.4	1215.2
Araphid Pennate Diatoms	225.4	313.5	171	198.4	0	0	61.6	0	198.4	152.4	159.6	600	167.2	198.4
Monoraphid Pennate Diatoms	0	0	0	0	33.6	81	0	31.5	0	0	0	15	0	0
Biraphid Pennate Diatoms	0	0	0	0	84	81	52.8	115.5	0	0	11.4	15	0	0
CHLOROPHYTA	**0**	**380**	**199.5**	**744**	**67.2**	**72.9**	**0**	**84**	**173.6**	**228.6**	**0**	**480**	**4590.4**	**3769.6**
Flagellated Chlorophytes	0	380	152	446.4	0	0	0	0	0	0	0	120	3891.2	3372.8
Coccoid/Colonial Chlorophytes	0	0	47.5	297.6	67.2	72.9	0	84	173.6	228.6	0	360	699.2	396.8
Filamentous Chlorophytes	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Desmids	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CHRYSOPHYTA	**9.8**	**9.5**	**0**	**0**	**8.4**	**8.1**	**0**	**0**	**12.4**	**0**	**34.2**	**15**	**0**	**0**
Flagellated Classic Chrysophytes	9.8	9.5	0	0	8.4	8.1	0	0	12.4	0	34.2	15	0	0
Non-Motile Classic Chrysophytes	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Haptophytes	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tribophytes/Eustigmatophytes	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Raphidophytes	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CRYPTOPHYTA	**9.8**	**9.5**	**9.5**	**12.4**	**0**	**0**	**0**	**0**	**49.6**	**0**	**0**	**30**	**0**	**0**
CYANOPHYTA	**0**	**0**	**0**	**0**	**0**	**0**	**3432**	**0**	**248**	**0**	**0**	**150**	**380**	**0**
Unicellular and Colonial Forms	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Filamentous Nitrogen Fixers	0	0	0	0	0	0	3432	0	248	0	0	150	380	0
Filamentous Non-Nitrogen Fixers	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EUGLENOPHYTA	**0**	**0**	**0**	**0**	**0**	**0**	**8.8**	**0**	**0**	**0**	**0**	**0**	**0**	**12.4**
PYRRHOPHYTA	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**11.4**	**7.5**	**0**	**0**
TOTAL	**3577**	**3486.5**	**3705**	**5914.8**	**210**	**283.5**	**3572.8**	**252**	**8965.2**	**9956.8**	**421.8**	**1657.5**	**6004**	**5195.6**
CELL DIVERSITY	**0.16**	**0.35**	**0.19**	**0.27**	**0.91**	**0.77**	**0.10**	**0.82**	**0.20**	**0.10**	**0.77**	**0.85**	**0.52**	**0.55**
CELL EVENNESS	**0.18**	**0.39**	**0.25**	**0.39**	**0.95**	**0.85**	**0.11**	**0.90**	**0.19**	**0.13**	**0.80**	**0.76**	**0.52**	**0.57**
NUMBER OF TAXA														
BACILLARIOPHYTA	**5**	**4**	**2**	**2**	**6**	**5**	**6**	**7**	**5**	**4**	**7**	**7**	**5**	**4**
Centric Diatoms	2	2	1	1	1	1	1	1	3	2	4	2	2	3
Araphid Pennate Diatoms	3	2	1	1	0	0	2	0	2	2	2	3	3	1
Monoraphid Pennate Diatoms	0	0	0	0	1	1	0	1	0	0	0	1	0	0
Biraphid Pennate Diatoms	0	0	0	0	4	3	3	5	0	0	1	1	0	0
CHLOROPHYTA	**0**	**2**	**3**	**2**	**2**	**2**	**0**	**1**	**3**	**2**	**0**	**2**	**3**	**4**
Flagellated Chlorophytes	0	2	1	1	0	0	0	0	0	0	0	1	1	2
Coccoid/Colonial Chlorophytes	0	0	2	1	2	2	0	1	3	2	0	1	2	2
Filamentous Chlorophytes	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Desmids	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CHRYSOPHYTA	**1**	**1**	**0**	**0**	**1**	**1**	**0**	**0**	**1**	**0**	**1**	**1**	**0**	**0**
Flagellated Classic Chrysophytes	1	1	0	0	1	1	0	0	1	0	1	1	0	0
Non-Motile Classic Chrysophytes	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Haptophytes	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tribophytes/Eustigmatophytes	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Raphidophytes	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CRYPTOPHYTA	**1**	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**1**	**0**	**0**
CYANOPHYTA	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**1**	**0**	**0**	**1**	**2**	**0**
Unicellular and Colonial Forms	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Filamentous Nitrogen Fixers	0	0	0	0	0	0	1	0	1	0	0	1	2	0
Filamentous Non-Nitrogen Fixers	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EUGLENOPHYTA	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**1**
PYRRHOPHYTA	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**0**	**0**
TOTAL	**7**	**8**	**6**	**5**	**9**	**8**	**8**	**8**	**11**	**6**	**9**	**13**	**10**	**9**

Table A- 3. Phytoplankton biomass for Rainbow Reservoir in 2023.

	PHYTOPLANKTON BIOMASS (UG/L)													
	Rainbow	Rainbow	Rainbow	Rainbow	Rainbow	Rainbow	Rainbow	Rainbow	Rainbow	Rainbow	Rainbow	Rainbow	Rainbow	Rainbow
	4	5	4	5	4	5	4	5	4	5	4	5	4	5
TAXON	06/22/23	06/22/23	06/29/23	06/29/23	07/13/23	07/13/23	07/27/23	07/27/23	08/10/23	08/10/23	08/24/23	08/24/23	09/07/23	09/07/23
BACILLARIOPHYTA														
Centric Diatoms														
Acanthoceras	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.7	18.0	0.0	14.9
Aulacoseira #	3051.7	2622.0	2992.5	4092.0	0.0	12.2	0.0	0.0	3500.5	4457.7	34.2	99.0	255.4	357.1
Melosira	47.0	45.6	0.0	0.0	5.0	0.0	5.3	6.3	22.3	15.2	20.5	0.0	0.0	0.0
Urosolenia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.9	0.0	13.7	0.0	18.2	14.9
Araphid Pennate Diatoms														
Asterionella #	15.7	15.2	0.0	0.0	0.0	0.0	0.0	0.0	19.8	20.3	27.4	87.0	24.3	39.7
Colonial Fragilaria/related taxa #	41.2	71.3	51.3	59.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	40.5	0.0	0.0
Single Fragilaria/Synedra	7.8	0.0	0.0	0.0	0.0	0.0	21.1	0.0	436.5	223.5	18.2	24.0	12.2	0.0
Tabellaria #	0.0	0.0	0.0	0.0	0.0	0.0	28.2	0.0	0.0	0.0	0.0	0.0	24.3	0.0
Monoraphid Pennate Diatoms														
Achnanthidium/related taxa	0.0	0.0	0.0	0.0	3.4	8.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cocconeis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.6	0.0	0.0	0.0	6.0	0.0	0.0
Biraphid Pennate Diatoms														
Cymbella/related taxa	0.0	0.0	0.0	0.0	16.8	8.1	0.0	31.5	0.0	0.0	0.0	0.0	0.0	0.0
Eunotia	0.0	0.0	0.0	0.0	0.0	0.0	8.8	10.5	0.0	0.0	0.0	0.0	0.0	0.0
Gomphonema/related taxa #	0.0	0.0	0.0	0.0	0.0	0.0	8.8	10.5	0.0	0.0	0.0	15.0	0.0	0.0
Navicula/related taxa	0.0	0.0	0.0	0.0	16.8	64.8	0.0	15.8	0.0	0.0	0.0	0.0	0.0	0.0
Nitzschia #	0.0	0.0	0.0	0.0	20.2	13.0	28.2	25.2	0.0	0.0	9.1	0.0	0.0	0.0
Pinnularia	0.0	0.0	0.0	0.0	84.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CHLOROPHYTA														
Flagellated Chlorophytes														
Eudorina	0.0	121.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1556.5	1190.4
Pandorina	0.0	7.6	15.2	44.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.0	0.0	39.7
Coccoid/Colonial Chlorophytes														
Actinastrum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.9	0.0	0.0	0.0	0.0	9.9
Crucigenia	0.0	0.0	0.0	0.0	0.0	6.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Desmodesmus #	0.0	0.0	0.0	0.0	50.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Micractinium	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	892.8
Pediastrum #	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	40.6	0.0	0.0	0.0	0.0
Scenedesmus #	0.0	0.0	3.8	0.0	0.0	0.0	0.0	8.4	5.0	0.0	0.0	0.0	6.1	0.0
Schroederia/Ankyra	0.0	0.0	23.8	0.0	0.0	20.3	0.0	0.0	217.0	222.3	0.0	0.0	0.0	0.0
Sphaerocystis	0.0	0.0	0.0	59.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	72.0	127.7	0.0
Tetradesmus #	0.0	0.0	0.0	0.0	3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Filamentous Chlorophytes														
Desmids														
CHRYSOPHYTA														
Flagellated Classic Chrysophytes														
Dinobryon #	0.0	0.0	0.0	0.0	25.2	24.3	0.0	0.0	37.2	0.0	0.0	0.0	0.0	0.0
Mallomonas #	4.9	4.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.1	7.5	0.0	0.0
Non-Motile Classic Chrysophytes														
Haptophytes														
Tribophytes/Eustigmatophytes														
Raphidophytes														

Table A- 4. Phytoplankton biomass for Rainbow Reservoir in 2023 (continued).

CRYPTOPHYTA														
Cryptomonas #	15.7	100.7	15.2	19.8	0.0	0.0	0.0	0.0	9.9	0.0	0.0	6.0	0.0	0.0
CYANOPHYTA														
Unicellular and Colonial Forms														
Filamentous Nitrogen Fixers														
*Aphanizomenon **#*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.8	0.0
*Dolichospermum **#*	0.0	0.0	0.0	0.0	0.0	0.0	686.4	0.0	49.6	0.0	0.0	30.0	45.6	0.0
Filamentous Non-Nitrogen Fixers														
EUGLENOPHYTA														
Euglena	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.2
PYRRHOPHYTA														
Ceratium #	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	198.4	130.5	0.0	0.0
DENSITY (UG/L) SUMMARY														
BACILLARIOPHYTA	**3163.4**	**2754.1**	**3043.8**	**4151.5**	**146.2**	**106.1**	**100.3**	**112.4**	**3994.0**	**4716.8**	**136.8**	**289.5**	**334.4**	**426.6**
Centric Diatoms	3098.8	2667.6	2992.5	4092.0	5.0	12.2	5.3	6.3	3537.7	4472.9	82.1	117.0	273.6	386.9
Araphid Pennate Diatoms	64.7	86.5	51.3	59.5	0.0	0.0	49.3	0.0	456.3	243.8	45.6	151.5	60.8	39.7
Monoraphid Pennate Diatoms	0.0	0.0	0.0	0.0	3.4	8.1	0.0	12.6	0.0	0.0	0.0	6.0	0.0	0.0
Biraphid Pennate Diatoms	0.0	0.0	0.0	0.0	137.8	85.9	45.8	93.5	0.0	0.0	9.1	15.0	0.0	0.0
CHLOROPHYTA	**0.0**	**129.2**	**42.8**	**104.2**	**53.8**	**26.7**	**0.0**	**8.4**	**231.9**	**262.9**	**0.0**	**84.0**	**1690.2**	**2132.8**
Flagellated Chlorophytes	0.0	129.2	15.2	44.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.0	1556.5	1230.1
Coccoid/Colonial Chlorophytes	0.0	0.0	27.6	59.5	53.8	26.7	0.0	8.4	231.9	262.9	0.0	72.0	133.8	902.7
Filamentous Chlorophytes	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Desmids	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CHRYSOPHYTA	**4.9**	**4.8**	**0.0**	**0.0**	**25.2**	**24.3**	**0.0**	**0.0**	**37.2**	**0.0**	**17.1**	**7.5**	**0.0**	**0.0**
Flagellated Classic Chrysophytes	4.9	4.8	0.0	0.0	25.2	24.3	0.0	0.0	37.2	0.0	17.1	7.5	0.0	0.0
Non-Motile Classic Chrysophytes	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Haptophytes	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tribophytes/Eustigmatophytes	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Raphidophytes	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CRYPTOPHYTA	**15.7**	**100.7**	**15.2**	**19.8**	**0.0**	**0.0**	**0.0**	**0.0**	**9.9**	**0.0**	**0.0**	**6.0**	**0.0**	**0.0**
CYANOPHYTA	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**686.4**	**0.0**	**49.6**	**0.0**	**0.0**	**30.0**	**65.4**	**0.0**
Unicellular and Colonial Forms	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Filamentous Nitrogen Fixers	0.0	0.0	0.0	0.0	0.0	0.0	686.4	0.0	49.6	0.0	0.0	30.0	65.4	0.0
Filamentous Non-Nitrogen Fixers	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
EUGLENOPHYTA	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**8.8**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**6.2**
PYRRHOPHYTA	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**198.4**	**130.5**	**0.0**	**0.0**
TOTAL	**3184.0**	**2988.7**	**3101.8**	**4275.5**	**225.1**	**157.1**	**795.5**	**120.8**	**4322.6**	**4979.7**	**352.3**	**547.5**	**2090.0**	**2565.6**
BIOMASS DIVERSITY	**0.10**	**0.25**	**0.09**	**0.10**	**0.77**	**0.76**	**0.28**	**0.84**	**0.33**	**0.20**	**0.68**	**0.93**	**0.42**	**0.53**
BIOMASS EVENNESS	**0.12**	**0.27**	**0.11**	**0.15**	**0.80**	**0.85**	**0.31**	**0.93**	**0.31**	**0.25**	**0.71**	**0.84**	**0.42**	**0.56**

	6/22/23	6/22/23	6/29/23	6/29/23	7/13/23	7/13/23	7/27/23	7/27/23	8/10/23	8/10/23	8/24/23	8/24/23	9/7/23	9/7/23
DENSITY (UG/L) SUMMARY														
BACILLARIOPHYTA	3163	2754	3044	4152	146	106	100	112	3994	4717	137	290	334	427
CHLOROPHYTA	0	129	43	104	54	27	0	8	232	263	0	84	1690	2133
CHRYSOPHYTA	5	5	0	0	25	24	0	0	37	0	17	8	0	0
CRYPTOPHYTA	16	101	15	20	0	0	0	0	10	0	0	6	0	0
CYANOPHYTA	0	0	0	0	0	0	686	0	50	0	0	30	65	0
EUGLENOPHYTA	0	0	0	0	0	0	9	0	0	0	0	0	0	6
PYRRHOPHYTA	0	0	0	0	0	0	0	0	0	0	198	131	0	0

Table. A- 5 CT DEEP Electrofishing Data.

Station ID	RAINBOW RESERVOIR (id:19357)			
OBJECTID	4227	4228	4229	4230
Sample Year	1989	1992	1998	2014
Sample ID	193571989	193571992	193571998	193572014
American Eel	12	11	9	0
Alewife	0	0	0	0
American Shad	0	0	2	0
Brown Bullhead	0	0	1	1
Black Crappie	3	7	52	15
Bridled Shiner	0	0	0	0
Bluegill Sunfish	13	56	56	73
Blueback Herring	0	0	0	0
Brook Trout - Stocked	0	0	0	0
Blacknose Dace	0	0	0	0
Bluntnose Minnow	0	0	0	0
Brown Trout - Stocked	2	2	0	0
Bluegill x Pumpkinseed Hybrid	0	0	0	0
Banded Sunfish	0	0	0	0
Common Carp	7	2	4	4
Channel Catfish	0	0	0	0
Creek Chubsucker	0	0	0	0
Cutlips Minnow	0	0	0	0
Chain Pickerel	0	0	0	0
Creek Chub	0	0	0	0
Common Shiner	0	0	0	0
Fallfish	1	5	0	0
Fathead Minnow	0	0	0	0
Fourspine Stickleback	0	0	0	0
Goldfish	0	0	0	0
Green Sunfish	0	0	0	0
Golden Shiner	9	17	3	2
Hogchoker	0	0	0	0
Banded Killifish	0	0	0	0
Brook Lamprey	0	0	0	0
Longnose Dace	0	0	0	0
Burbot	0	0	0	0
Largemouth Bass	11	16	7	14
Central Mudminnow	0	0	0	0
Mummichog	0	0	0	0
Northern Pike	0	0	0	0
Ninespine Stickleback	0	0	0	0
Pumpkinseed x Redbreast Hybrid	0	0	0	0
Pumpkinseed	30	4	56	33
Rock Bass	6	34	10	18
Redfin Pickerel	0	0	0	0
Redbreast Sunfish	8	3	5	7

Table A- 6. CT DEEP Electrofishing Data (continued).

Station ID	RAINBOW RESERVOIR (id:19357)			
OBJECTID	4227	4228	4229	4230
Sample Year	1989	1992	1998	2014
Sample ID	193571989	193571992	193571998	193572014
Rainbow Trout - Stocked	0	0	0	0
Atlantic Salmon - Stocked	3	2	0	0
Slimy Sculpin	0	0	0	0
Swamp Darter	0	0	0	0
Striped Killifish	0	0	0	0
Sea Lamprey	0	0	0	0
Smallmouth Bass	11	35	92	57
Spottail Shiner	124	115	109	257
Tessellated Darter	0	0	0	30
Tidewater Silverside	0	0	0	0
Tomcod	0	0	0	0
Three Spine Stickleback	0	0	0	0
Tiger Trout - Stocked	0	0	0	0
Walleye	0	0	0	0
Brook Trout - Wild	0	0	0	0
Brown Trout - Wild	0	0	0	1
White Catfish	0	0	0	0
White Perch	196	58	35	12
Rainbow Trout - Wild	0	0	0	0
White Sucker	108	71	347	281
Yellow Bullhead	0	0	0	0
Yellow Perch	95	259	157	483
No fish in sample	0	0	0	0
Bowfin	0	0	0	0
Brook Silverside	0	0	0	0
Black Bullhead	0	0	0	0
Grass Carp	0	0	0	0
Gizzard Shad	0	0	0	0
Hickory Shad	0	0	0	0
Inland Silverside	0	0	0	0
Koi	0	0	0	0
Kokanee Salmon	0	0	0	0
Menhaden	0	0	0	0
Striped Mullet	0	0	0	0
Mimic Shiner	0	0	0	0
Rainbow Smelt	0	0	0	0
Fat Sleeper Goby	0	0	0	0
Tench	0	0	0	0
White Crappie	0	0	0	0
Striped Bass	0	0	0	0
Mosquito Fish	0	0	0	0
Tiger Musky	0	0	0	0
Warmouth	0	0	0	0

Table A- 7. Numbers of anadromous fish passed, Rainbow fishway, 1976-2021.

Numbers of anadromous fish passed, Rainbow fishway, 1976-2021.

Year	American shad	Atlantic salmon	Alewife	Blueback herring	Sea lamprey	Lamprey[1] juveniles	Striped bass	Sea-run[2] trout	Gizzard shad
1976	1,189	0	0	5	n.a.	n.a.	0	n.a.	0
1977	804	0	0	5	n.a.	n.a.	0	n.a.	0
1978	1,053	(56)	1	11	129	n.a.	0	1	0
1979	514	(32)	3	5	249	n.a.	0	1	0
1980	480	(26)	3	15	280	n.a.	1	0	0
1981	167	(62)	0	6	27	n.a.	0	0	0
1982	729	(41)	6	13	371	n.a.	1	4	0
1983	1,570	(14)	3	57	3,700	n.a.	1	4	0
1984	2,289	(6)	1	37	3,426	n.a.	0	13	0
1985	1,042	(7)	0	19	393	n.a.	0	7	0
1986	1,205	(39)	14	56	1,405	n.a.	0	2	(1)
1987	792	(126)	3	34	2,985	n.a.	2	6	(2)
1988	387	(14)	0	16	883	n.a.	2	3	0
1989	215	(24)	0	52	2,747	n.a.	5	34	(1)
1990	432	(37)	0	49	2,125	n.a.	3	20	(2)
1991	591	(33)	0	55	1,448	n.a.	3	18	1/(9)
1992	793	(97)	0	25	622	7	6	20	(5)
1993	460	1/(13)	4	14	1,708	7	0	5	1/(9)
1994	250	(42)	2	102	1,200	11	0[3]	10	(20)
1995	246	(22)	3	503	376	0	1	15	(123)
1996	668	(29)	5	1,254	2,722	0	7	9	(8)
1997	421	1/(60)	3	672	3,140	1	4	9	(22)
1998	262	(50)	2	498	2,681	0	6	12	(6)
1999	70	(36)	25	35	414	0	1	5	6/(78)
2000	283	(6)	5	1	1,037	0	1	3	16/(35)
2001[5]	151	(6)	52	52	8,082	18	2	5	(26)
2002	110	(4)	71	37	1,660	72	0	13	1/(5)
2003	76	(2)	54	63	2,770	678	0	4	(1)
2004	123	(13)	19	38	3,404	0[4]	0	4	(5)
2005	8	(15)	1	4	2,354	0[4]	1	3	1
2006	73	(43)	0	0	984	0[4]	1	2	0
2007	156	(7)	0	7	8,007	0[4]	0	7	0
2008	92	(24)	6	4	8,302	0[4]	0	4	0
2009	35	(12)	0	0	1,856	0[4]	1	5	0
2010	548	(4)	0	25	3,090	0[4]	0	5	0
2011	267	(15)	0	0	6,509	0[4]	1	5	0
2012	172	(5)	0	0	712	0[4]	2	10	0
2013	84	(6)	0	17	1,999	0[4]	1	4	0
2014	531	3	0	26	4,276	0[4]	0	0	0
2015	316	5	0	18	1,567	0[4]	0	2	0
2016	141	0	0	0	449	0[4]	0	2	0
2017[6]	613	3	0	15	2,187	0[4]	0	0	0
2018	342	0	3	3	896	0[4]	0	0	1
2019	276	0	1	0	950	0	0	0	0
2020	510	0	0	0	3,628	0	0	0	0
2021	47	3	0	0	470	0	0	0	0
Total	21,583	16/(1,028)	290	3,850	98,220	794	53	276	26/(359)
Mean	469	(24)	6	84	2,232	26	1	6	1/(8)

[1]sea lamprey transformants emigrating down to the ocean.

[2]sea-run brown trout (Salmo trutta) only, except for one sam-brown (Atlantic salmon x brown trout hybrid passed in 1979 and two in 1982.

[3]observed in window but not passed.

[4]does not include night-time video counts of lamprey juveniles observed in the window during the fall.

[5]counts from 2001 onward include night-time video counts.

[6]Starting in 2017 the fishway was operated without sorting gates and all fish passage was documented on video.

Note: *Numbers in parenthese indicate fish entered the trap but were retained and not passed.*

Table A- 8. Macroinvertebrate data from upstream tributaries.

Station ID	Waterbody	Location	Town	Basin ID	Watershed	Lat	Long	Year	Most Sensitive
14435	Salmon Brook	adjacent to Granbrook Park	East Granby	4320	Farmington	41.9366	-72.7749	2016	5
14435	Salmon Brook	adjacent to Granbrook Park	East Granby	4320	Farmington	41.9366	-72.7749	2009	7
14435	Salmon Brook	adjacent to Granbrook Park	East Granby	4320	Farmington	41.9366	-72.7749	2002	5
15171	EB Salmon Brook	downstream Rt 20	Granby	4320	Farmington	41.955	-72.7794	2007	5
15171	EB Salmon Brook	downstream Rt 20	Granby	4320	Farmington	41.955	-72.7794	2006	3
15171	EB Salmon Brook	downstream Rt 20	Granby	4320	Farmington	41.955	-72.7794	2005	4
15171	EB Salmon Brook	downstream Rt 20	Granby	4320	Farmington	41.955	-72.7794	2004	5
15171	EB Salmon Brook	downstream Rt 20	Granby	4320	Farmington	41.955	-72.7794	2003	3
15171	EB Salmon Brook	downstream Rt 20	Granby	4320	Farmington	41.955	-72.7794	2002	5
15171	EB Salmon Brook	downstream Rt 20	Granby	4320	Farmington	41.955	-72.7794	2001	6
15170	WB Salmon Brook	adjacent Salmon Brook Park	Granby	4319	Farmington	41.9438	-72.7957	2019	12
15170	WB Salmon Brook	adjacent Salmon Brook Park	Granby	4319	Farmington	41.9438	-72.7957	2016	1
15170	WB Salmon Brook	adjacent Salmon Brook Park	Granby	4319	Farmington	41.9438	-72.7957	2011	2
15170	WB Salmon Brook	adjacent Salmon Brook Park	Granby	4319	Farmington	41.9438	-72.7957	2007	1
15170	WB Salmon Brook	adjacent Salmon Brook Park	Granby	4319	Farmington	41.9438	-72.7957	2006	3
15170	WB Salmon Brook	adjacent Salmon Brook Park	Granby	4319	Farmington	41.9438	-72.7957	2005	2
15170	WB Salmon Brook	adjacent Salmon Brook Park	Granby	4319	Farmington	41.9438	-72.7957	2004	4
15170	WB Salmon Brook	adjacent Salmon Brook Park	Granby	4319	Farmington	41.9438	-72.7957	2003	4
15170	WB Salmon Brook	adjacent Salmon Brook Park	Granby	4319	Farmington	41.9438	-72.7957	2002	4
15170	WB Salmon Brook	adjacent Salmon Brook Park	Granby	4319	Farmington	41.9438	-72.7957	2001	4
15105	Hop Brook	below old mill pond adj. Waterfall Way	Simsbury	4318	Farmington	41.8701	-72.8106	2009	1
15105	Hop Brook	below old mill pond adj. Waterfall Way	Simsbury	4318	Farmington	41.8701	-72.8106	2008	2

Table A- 9. Site FR-EG1 *E.coli* Geometric mean MPN/100mL 2007-2023.

Geometric Mean (MPN/100mL)												
2023	2022	2021	2019	2018	2017	2016	2015	2014	2013	2013	2011	2007
96	70	130	74	293	219	181	74	135	78	169	365	158

Table A- 10. Site FR-EG1 Temperature Averages 2007-2023.

FR-EG1 Temperature Average per year (°C)													
	2023	2022	2021	2019	2018	2017	2016	2015	2014	2013	2012	2011	2007
	16.5	20.3	21.1	16.0	21.0	14.0	18.0	17.0	19.0	18.0	20.0	17.0	20.0
	21.2	23.9	22.3	17.0	19.0	20.0	21.0	17.5	19.5	20.0	20.0	17.5	22.0
	21.4	25.5	19.3	23.0	22.0	20.0	22.0	21.0	22.5	23.0	24.0	21.0	18.0
	22.7	22.0	21.9	25.0	22.0	22.0	26.0	22.0	20.0	21.0	22.0	23.0	17.0
	21.3	25.2	22.4	23.0	21.0	19.0	22.0	21.0	23.0	20.0	25.5	20.0	21.0
		20.4	22.5	25.0	20.0	22.0	24.0	24.0	20.5	21.0	23.0		
Average	20.6	22.9	21.6	21.5	20.8	19.5	22.2	20.4	20.8	20.5	22.4	19.7	19.6

Table A- 11. Rainbow Reservoir Temperature Average per Sampling Day and Overall, in 2023.

Rainbow Reservoir Temperature Average per Sampling Day (°C)							
6/22/2023	6/29/2023	7/13/2023	7/27/2023	8/10/2023	8/24/2023	9/7/2023	Average
21.5	23.3	22.4	21.2	22.0	21.4	23.7	22.2

Table A- 12. Rainbow Reservoir chemical data from CT DEEP 7/9/19-7/10/19.

Sample Name	I_SW1	I_01	I_02	I_03	I_04	I_SW2	I_05	J_SW1	J_01	J_02	J_SW2	J_03	J_04	J_05
Date	7/9/2019	7/9/2019	7/9/2019	7/9/2019	7/9/2019	7/9/2019	7/9/2019	7/10/2019	7/10/2019	7/10/2019	7/10/2019	7/10/2019	7/10/2019	7/10/2019
Notes_1	spoonville	spoonville	spoonville	spoonville	spoonville	spoonville	spoonville	spoonville	spoonville	spoonville	spoonville	spoonville	spoonville	spoonville
lat_garmin	0	0	41.89265	41.91081	0	0	0	0	0	0	0	41.89511	41.89263	41.90413
lon_garmin	0	0	-72.74342	-72.70385	0	0	0	0	0	0	0	-72.74195	-72.74367	-72.71418
Cl (mg/L)	37.27639	57.104498	59.352469	47.049468	14.815864	40.501772	1.7218152	40.068604	18.451829	48.3922968	39.918699	30.320664	22.884875	49.132943
NO3_N (mg/L)	0.554985	0.5854612	1.3208236	4.3674942	1.4816801	0.4893042		0.58701563	0.1602182	4.47797499	0.1846698	2.6186338	0.2792282	2.9505062
PO4 (mg/L)	0.2437135	0.2437135	0.2437135	0.2437135	0.2437135	0.2437135	0.2437135	0.24371351	0.2437135	0.24371351	0.2437135	0.5055844	0.2437135	0.2437135
SO4_S (mg/L)	2.437601	6.3192544	6.2883854	5.1673028	2.7725378	2.5490322	2.6702236	2.52200911	8.7082032	5.32092542	2.9095729	15.478139	2.270239	4.920663
NH3 (mg/L)	0.0532958	0.0532958	0.249	0.0532958	0.0532958	0.0532958	0.0532958	0.05329581	0.0532958	0.05329581	0.0532958	0.0532958	0.0532958	0.0532958
NPOC (mg/L)	3.157	1.301	1.081	1.086	1.19	2.98	0.6464	2.647	1.335	1.083	2.962	1.005	0.8633	0.5628
TN (mg/L)	0.7721	0.6361	1.399	4.421	1.574	0.7359	0.1088	0.7331	0.2753	4.461	0.4136	2.5	0.1255	2.853
air_temp				35										
air_pressure				29.89										
seep_surf_temp			15.66	14.57										
seep_subsurface_temp			14.32	12.71										
seep_cond			267	61										
seep_DO			4.71	8.81										
seep_sample_name			Farm_27_R	Farm_27_R										
seep_gas_ID			0, 19	27,22										

Table A- 13. Rainbow Reservoir chemical data from CT DEEP 8/15/19.

Sample Name	AM_01	AM_02	AM_SW1	AM_04	AM_05	AM_06	AM_07	AM_08	AM_09	AM_10
Date	8/15/2019	8/15/2019	8/15/2019	8/15/2019	8/15/2019	8/15/2019	8/15/2019	8/15/2019	8/15/2019	8/15/2019
Notes_1	spoonville 1	spoonville 1	spoonville 1	spoonville 1	spoonville 1	spoonville 1	spoonville 1	spoonville 1	spoonville 1	spoonville 1
lat_garmin	41.89645	41.8963	41.89647	41.89573	41.89575	41.89516	41.89515	41.8951	41.895	41.89462
lon_garmin	-72.74532	-72.74532	-72.74531	-72.74313	-72.74315	-72.74213	-72.74212	-72.74203	-72.74196	-72.74133
Cl (mg/L)	55.55922008	28.98085956	48.2861917	102.614392	160.9734647	66.53013591	49.0741867	29.31228354	29.60333734	29.4018007
NO3_N (mg/L)	2.615351535	0.494599259	0.78774624	3.86639555	3.39250592	3.90856553	5.01166508	3.446525812	4.441175326	4.438874443
PO4 (mg/L)	0.243713507	0.243713507	0.24371351	0.24371351	0.243713507	0.243713507	0.24371351	0.243713507	0.243713507	0.243713507
SO4_S (mg/L)	5.054356479	4.747420379	3.41970763	5.46791501	6.93825935	5.819489616	5.6268742	4.589420493	3.899463609	9.532490758
NH3 (mg/L)	0.053295805	0.108999997	0.132	0.186	0.136000007	0.053295805	0.05329581	0.112999998	0.053295805	0.053295805
NPOC (mg/L)	1.553	1.33	2.627	1.491	1.412	1.964	0.8808	1.218	1.157	0.8347
TN (mg/L)	2.544	0.5782	0.926	3.618	2.488	3.662	4.579	3.191	4.109	4.117
CH4 (ppm)	0.47070825	0.47070825	8.47486499	0.47070825	0.47070825	0.47070825	0.47070825	1.003848872	0.47070825	0.47070825
CO2 (ppm)	17942.20037	2801.859919	525.457886	4473.83531	7447.232339	5440.538513	3472.87465	5968.425449	6312.430537	3414.123307
N20 (ppm)	5.901439646	0.390560188	0.39056019	9.92808074	8.063980422	7.716308639	6.63549312	4.967809136	4.098922235	4.031998463
N2 (ppm)	18.51519745	16.15657662		16.8715772	17.41067713	19.60923385	19.2941534	20.02327152	18.03121284	18.58582095
O2 (ppm)	8.13752076	8.193395316		8.04859527	8.135789386	7.846615988	7.91538245	7.692770859	7.726051372	7.861059189
Ar (ppm)	0.666612317	0.609742504		0.5920979	0.604156623	0.69602637	0.67700875	0.702976145	0.660107841	0.629468858
N2:Ar	27.77506054	26.49737639		28.4945737	28.81815158	28.17311915	28.4991196	28.48357183	27.31555622	29.52619612
Wet Weight (g)	318.76	378.61		410.98	269.05		454.84	301.69	372.36	333.05
WW Gravel	44.66	66.1		162.85	107.76		204.54	155.79	181.38	255.35
WW Sub (g)	229.61	267.51		178.84	122.82		208.09	104.62	164.81	57.78
WW Soil	213.38	254.99		164.84	115.9		203.77	102.47	156.9	56.88
Dry Weight	164.77	205.83		132.24	90.35		161.35	78.6		45.62
SWC (%)	29.50172968	23.88378759		24.6521476	28.27891533		26.2906725	30.36895674		24.68215695
V of Core (cm3)	181.5787	181.5787		181.5787	181.5787		181.5787	181.5787	181.5787	181.5787

Table A- 14. Rainbow Reservoir chemical data from CT DEEP 8/15/19 (continued).

Sample Name	AM_11	AL_SW1	AL_01	AL_02	AL_03	AL_04	AL_05	AL_06	AL_07	AL_08	AL_09	AL_10
Date	8/15/2019	8/15/2019	8/15/2019	8/15/2019	8/15/2019	8/15/2019	8/15/2019	8/15/2019	8/15/2019	8/15/2019	8/15/2019	8/15/2019
Notes_1	spoonville 1	spoonville 1	spoonville 1	spoonville 1	spoonville 1	spoonville 1	spoonville 1	spoonville 1	spoonville 1	spoonville 1	spoonville 1	spoonville 1
lat_garmin	41.89299	0	41.89283	41.89399	41.89299	41.89271	41.89257	41.89281	41.89256	41.89292	41.89263	41.89298
lon_garmin	-72.74218	0	-72.74429	-72.74584	-72.74449	-72.74386	-72.74362	-72.74429	-72.74315	-72.74451	-72.74367	-72.74454
Cl (mg/L)	60.1256581	47.3209809	59.47500239	160.86135	44.0476221	42.0391299	30.20486957	60.02928902	79.7560273	45.3883191	27.9704157	42.976103
NO3_N (mg/L)	1.02280992	0.76792651	1.238971727	3.12890227	1.65722944	1.45724888	0.02705025	1.346852948	0.77752768	1.26749729	0.02705025	2.28061401
PO4 (mg/L)	0.24371351	0.24371351	0.243713507	0.24371351	2.43221548	0.24371351	0.243713507	0.243713507	0.24371351	0.68529632	0.24371351	0.66533534
SO4_S (mg/L)	5.18466861	3.27448078	12.08212006	6.70865047	22.6661155	3.96387744	1.652698063	12.28247944	8.19725634	26.164787	2.30987464	26.2397641
NH3 (mg/L)	0.11	0.114	0.053295805	0.108	0.21600001	0.119	0.053295805	0.162	0.05329581	0.116	0.123	0.05329581
NPOC (mg/L)	1.57	2.501	0.9584	0.9951	1.215	0.9771	0.9208	0.9858	0.8014	0.9959	0.8555	0.9714
TN (mg/L)	0.9767	0.8873	1.132	2.953	1.526	1.326	0.1143	1.313	0.7739	1.248	0.155	1.979
CH4 (ppm)			0.998444578	0.47070825	1.18832942	0.47070825	0.47070825	0.47070825	0.47070825	1.05639644	0.47070825	0.47070825
CO2 (ppm)			11912.00694	7125.97648	11237.5854	10138.1672	8859.544001	11242.87191	396.478715	10731.1973	9522.55321	8418.49085
N20 (ppm)			5.869990269	7.48368718	7.51237528	6.04215764	0.390560188	6.058601036	2.92035609	5.98075909	0.99922422	5.54578996
N2 (ppm)			18.97966577	17.7743396	19.6709797	19.8100445	19.01251375	18.93540892	18.7045261	19.8225613	19.7941322	18.1289677
O2 (ppm)			8.182271984	8.240508	8.19709394	8.17179572	8.282066638	8.208506709	8.29481823	8.35753501	8.32334189	8.60158104
Ar (ppm)			0.69114241	0.66731327	0.71129529	0.7267911	0.697320546	0.705625202	0.67987501	0.70137216	0.72227308	0.69461826
N2:Ar			27.46129525	26.6356754	27.6551523	27.2568615	27.26509903	26.83493854	27.5117128	28.2625434	27.4053301	26.0991809
Wet Weight (g)			300.8	271.2	323.61	308.34	388.98	297.27				258.31
WW Gravel (g)			41.54	0	65.49	69.43	240.26	148.19				159.43
WW Sub (g)			231.09	271.2	210.98	215.52	112.37	121.95				74.91
WW Soil			214.23	245.4	185.56	205.79	94.21	112.11				64.86
Dry Weight			173.53	187.19	139.45	171.87	73.8	87.19				48.24
SWC (%)			23.45415778	31.0967466	33.0656149	19.7358469	27.65582656	28.58125932				34.4527363
V of Core (cm3)			181.5787	181.5787	181.5787	181.5787	181.5787	181.5787				181.5787

Table A- 15. Rainbow Reservoir chemical data from CT DEEP 8/15/19 (continued).

Sample Name	AM_01	AM_02	AM_SW1	AM_04	AM_05	AM_06	AM_07	AM_08	AM_09	AM_10	AM_11	AL_01	AL_02	AL_03	AL_04	AL_05	AL_06	AL_10
Date	8/15/2019	8/15/2019	8/15/2019	8/15/2019	8/15/2019	8/15/2019	8/15/2019	8/15/2019	8/15/2019	8/15/2019	8/15/2019	8/15/2019	8/15/2019	8/15/2019	8/15/2019	8/15/2019	8/15/2019	8/15/2019
Notes_1	spoonville 1	spoonville 1	spoonville	spoonville 1	spoonville 1	spoonville	spoonville	spoonville 1	spoonville	spoonville 1	spoonville	spoonville 1	spoonville	spoonville	spoonville 1	spoonville	spoonville	spoonville 1
lat_garmin	41.89645	41.8963	41.89647	41.89573	41.89575	41.89516	41.89515	41.8951	41.895	41.89462	41.89299	41.89283	41.89399	41.89299	41.89271	41.89257	41.89281	41.89298
lon_garmin	-72.74532	-72.74532	-72.74531	-72.74313	-72.74315	-72.74213	-72.74212	-72.74203	-72.74196	-72.74133	-72.74218	-72.74429	-72.74584	-72.74449	-72.74386	-72.74362	-72.74429	-72.74454
Bulk Density	1.15338418	1.49758755		1.62513555	1.09104207		2.0150491	1.29084524		1.6575182		1.18444509	1.0309029	1.1286566	1.32890036	1.7296082	1.2962974	1.1436914
Bulk Density Gravel	0.245953958	0.36402948		0.89685629	0.59346168		1.1264537	0.85797508	0.9989057	1.40627728		0.22877133	0	0.3606701	0.38236864	1.3231728	0.81612	0.8780215
Bulk Density Gravel Free	0.907430222	1.13355807		0.72827925	0.49758039		0.8885954	0.43287016		0.25124092		0.95567377	1.0309029	0.7679866	0.94653172	0.4064353	0.4801775	0.2656699
Sand %	95.44820052	98.5424865		96.5970962	93.3591588		97.830803	98.7277354		95.6159579		99.4237308	97.596025	96.055934	98.8363298	95.257453	93.691937	90.671642
Clay %	1.213813194	0.24291891		0	1.66021029		1.2395414	1.27226463		1.09601052		0.57626923	0	0	1.16367022	0	3.4407616	2.0729685
Silt %	3.337986284	1.21459457		3.40290381	4.98063088		0.929656	0		3.28803157		0	2.4039746	3.944066	0	4.7425474	2.8673013	7.2553897
K (Thermal Conductivity)	1.6873	1.9232		1.2091	1.786		1.7994	1.8665	2.1845	1.382		1.8777	1.606	1.5714	1.7989	1.3312	1.6888	0.9424
(volumetric specific heat capacity)	2.968	2.6053		2.1373	3.0193		2.8119	3.2194	3.0152	2.8517		2.772	2.8801	3.0605	2.1144	3.0493	2.0431	2.615
D (thermal diffusivity)	0.568	0.738		0.566	0.592		0.64	0.58	0.724	0.485		0.677	0.558	0.513	0.851	0.437	0.555	0.36
Organic Matter %	0.968188105	0.84151473			0.83449235		0.8391608	1.12201964	0.1402525	1.3986014		0.69348128	2.1067416	0.7002801	0.41608877	1.1034483	1.10957	1.1157601

Table A- 16. Rainbow Reservoir chemical data from CT DEEP 8/15/19 (continued).

Sample Name	AM_01	AM_02	AM_SW1	AM_04	AM_05	AM_06	AM_07	AM_08	AM_09	AM_10
Date	8/15/2019	8/15/2019	8/15/2019	8/15/2019	8/15/2019	8/15/2019	8/15/2019	8/15/2019	8/15/2019	8/15/2019
Notes_1	spoonville 1	spoonville 1	spoonville 1	spoonville 1	spoonville 1	spoonville 1	spoonville 1	spoonville 1	spoonville 1	spoonville 1
lat_garmin	41.89645	41.8963	41.89647	41.89573	41.89575	41.89516	41.89515	41.8951	41.895	41.89462
lon_garmin	-72.74532	-72.74532	-72.74531	-72.74313	-72.74315	-72.74213	-72.74212	-72.74203	-72.74196	-72.74133
air_temp	22.8	22.7	22.7	25.7	22.8	24.1		24.4	24.6	26.2
air_pressure	29.93	29.93	29.93	29.93	29.93	29.91		29.91	29.91	29.88
surface_cond			261							
surface_temp			21.99							
surface_DO			8.59							
surface_sample_name			AM03							
surface_gasID			222, 212							
seep_surf_temp	14.7	19		17.6	16.2	13.3		12.4	14.2	19.7
seep_subsurface_temp	14.1	18		15.8	15.2	12.7		11.9	12.8	15.6
seep_cond	365	217		323	603	500		287	258	315
seep_DO	5.17	6.94		2.78	3.79	4.14		10.74	13.87	7.34
seep_sample_name	AM01	AM02		AM04	AM05	AM06		AM08	AM09	AM10
seep_gas_ID	253, 247	221, 51		220, 227	217, 202	229, 231		215, 240	200, 204	213, 203
seep_MIMS_	AM01, AM02	AM03, AM04		AM05, AM06	AM07, AM08	AM09, AM10		AM13, AM14	AM15, AM16	AM17, AM18
sed_sample	AM01	AM02		AM04	AM05	N/A		AM08	AM09	AM10

Table A- 17. Rainbow Reservoir chemical data from CT DEEP 8/15/19 (continued).

Sample Name	AM_11	AL_01	AL_02	AL_03	AL_04	AL_05	AL_06	AL_07	AL_08	AL_09	AL_10
Date	8/15/2019	8/15/2019	8/15/2019	8/15/2019	8/15/2019	8/15/2019	8/15/2019	8/15/2019	8/15/2019	8/15/2019	8/15/2019
Notes_1	spoonville 1	spoonville 1	spoonville 1	spoonville 1	spoonville 1	spoonville 1	spoonville 1	spoonville 1	spoonville 1	spoonville 1	spoonville 1
lat_garmin	41.89299	41.89283	41.89399	41.89299	41.89271	41.89257	41.89281	41.89256	41.89292	41.89263	41.89298
lon_garmin	-72.74218	-72.74429	-72.74584	-72.74449	-72.74386	-72.74362	-72.74429	-72.74315	-72.74451	-72.74367	-72.74454
air_temp	27										
air_pressure	29.86										
surface_cond											
surface_temp											
surface_DO											
surface_sample_name											
surface_gasID											
seep_surf_temp		14.5	16.71	11.6	13.6	12.1	13.1	22.9	12.5	13.9	15.1
seep_subsurface_temp		13.4	14.73	10.1	11.9	11	11.4		11.2	12.5	13.6
seep_cond		203	353	197	120	71	205	251	220	75	213
seep_DO		7.3	7.7	8.2	7.9						
seep_sample_name		AL01	AL02	AL03	AL04	AL05	AL06	AL07	AL08	AL09	AL10
seep_gas_ID		209, 233	6, 230	208, 239	219, 22	245, 206	234, 216	254, 36	235, 56	252, 218	232, 242
seep_MIMS_			5.1, 5.2	6.1, 6.2	7.1, 7.2	9.1, 9.2	10.1, 10.2	12.1, 12.2	15.1, 15.2	19.1, 19.2	20.1, 20.2
sed_sample		IB01	IB05	IB06	IB07	IB09	IB10	IB12	IB15	IB19	IB20

Table A- 18. Rainbow Reservoir chemical data from CT DEEP 9/21/19.

Sample Name	BE01	BE02_SW1	BE03	BE04	BE05	BE06	BE07	BE08	BE09	BE10	BE11_SW2
Date	9/21/2019	9/21/2019	9/21/2019	9/21/2019	9/21/2019	9/21/2019	9/21/2019	9/21/2019	9/21/2019	9/21/2019	9/21/2019
Notes_1	spoonville 2	spoonville 2	spoonville 2	spoonville 2	spoonville 2	spoonville 2	spoonville 2	spoonville 2	spoonville 2	spoonville 2	spoonville 2
lat_garmin	41.896363	41.896464	41.89636	41.895712	41.895775	41.895097	41.895149	41.895032	41.895017	41.894592	41.894523
lon_garmin	-72.745264	-72.74529	-72.745323	-72.743102	-72.743109	-72.742277	-72.742032	-72.74194	-72.741963	-72.74134	-72.74141
Cl (mg/L)	84.5709353	46.827605	36.122411	90.296925	89.029728	74.31828	58.572521	34.885122	26.296709	28.532984	47.902343
NO3_N (mg/L)	6.1553009	0.770725	0.1154071	3.6912571	2.9537151	4.39873805	5.3179889	3.9673845	5.3841378	4.2077535	0.9029184
PO4 (mg/L)	0.56589497	0.490345	0.6476912	0.5784824	0.5879221	0.61938297	0.6036535	0.5942149	0.5879221	0.7451502	0.5753356
SO4_S (mg/L)	8.37187049	3.5387801	7.2786638	5.3121132	6.009333	5.90006631	5.7906129	4.7862779	4.1341225	9.7727853	3.9497305
NH3 (mg/L)	0.05329581	0.0532958	0.0532958	0.0532958	0.0532958	0.05329581	0.0532958	0.0532958	0.0532958	0.253	0.0532958
NPOC (mg/L)	1.192	2.356	1.556	1.4	1.42	1.97	1.268	1.435	1.115	0.7421	2.571
TN (mg/L)	6.47	0.9844	0.2792	3.825	3.07	4.45	5.265	3.9	5.461	4.15	1.052
CH4 (ppm)	0.47070829	7.3705966	4.44955	0.4707083		0.47070829	0.4707083	0.9758967	0.4707083	0.4707083	6.8944738
CO2 (ppm)	25215.2714	988.20763	12005.966	5025.4717		6625.47306	3935.4154	6388.8396	7391.8207	2313.5472	167.63573
N20 (ppm)	19.4306179	0.3905602	0.3905602	10.845402		8.94667203	8.26955	4.5343555	4.1149825	3.6052124	0.3905602
N2 (ppm)	18.9144196		18.421463	16.794051	17.729534	19.1812934	18.94808	19.150394	17.450114	18.092957	
O2 (ppm)	8.34640693		8.3172236	8.4813035	8.4070683	8.34210547	8.4527408	8.3931956	8.5003948	8.5345532	
Ar (ppm)	0.65476842		0.6963342	0.5992533	0.6236426	0.69264685	0.6767392	0.683149	0.6483125	0.6302731	
N2:Ar	28.8871896		26.454915	28.024962	28.428998	27.6927462	27.999088	28.032529	26.916208	28.706535	

Table A- 19. Rainbow Reservoir chemical data from CT DEEP 9/21/19 (continued).

Sample Name	BE01	BE02_SW1	BE03	BE04	BE05	BE06	BE07	BE08	BE09	BE10	BE11_SW2
Date	9/21/2019	9/21/2019	9/21/2019	9/21/2019	9/21/2019	9/21/2019	9/21/2019	9/21/2019	9/21/2019	9/21/2019	9/21/2019
Notes_1	spoonville 2	spoonville 2	spoonville 2	spoonville 2	spoonville 2	spoonville 2	spoonville 2	spoonville 2	spoonville 2	spoonville 2	spoonville 2
lat_garmin	41.896363	41.896464	41.89636	41.895712	41.895775	41.895097	41.895149	41.895032	41.895017	41.894592	41.894523
lon_garmin	-72.745264	-72.745286	-72.745323	-72.743102	-72.743109	-72.742277	-72.742032	-72.74194	-72.741963	-72.741339	-72.741407
air_temp											28.1
air_pressure											30.03
surface_cond		268									260.2
surface_temp		17.04									
surface_DO		10.18									
surface_sample_name		BE_Stream1									BE11 (BE_stream2)
surface_gasID		253, 08									40, 17
seep_surf_temp	14.04		15.375		16.129	14.52	13.101	13.484	15.336	17.259	
seep_subsurface_temp	14.32		15.005		15.677	13.529	12.764	13.002	13.46	14.939	
seep_cond	530		311	604	575	501.4	442.4	289.9	251.1	304.9	
seep_DO	1.92		3.62	2.08	2.09						
seep_sample_name	BE01		BE03	BE04	BE05	BE06	BE07	BE08	BE09	BE10	
seep_gas_ID	4, 230		20, 99	21, 50		205, 24	74, 215	63, 60	86, 66	212, 273	
seep_MIMS_	BE01_1, BE01_2		BE03_3, BE03_4	BE04_5, BE04_6	BE05_7, BE05_8	BE06_9, BE06_10	BE07_11, BE07_12	BE08_13, BE08_14	BE09_15, BE0916	BE10_17, BE10_18	
sed_sample	BE01		BE03	BE04	BE05	BE06	BE07	BE08	BE09	BE10	

Table A- 20. Rainbow Reservoir chemical data from CT DEEP 9/24/19.

Sample Name	BHSW1	BH01	BH02	BH03	BH04	BH05	BH06	BH07	BH08	BH09	BH10	BHSW2
Date	9/24/2019	9/24/2019	9/24/2019	9/24/2019	9/24/2019	9/24/2019	9/24/2019	9/24/2019	9/24/2019	9/24/2019	9/24/2019	9/24/2019
Notes_1	spoonville 2	spoonville 2	spoonville 2	spoonville 2	spoonville 2	spoonville 2	spoonville 2	spoonville 2	spoonville 2	spoonville 2	spoonville 2	spoonville 2
lat_garmin	0	41.89401	41.89293	41.89295	41.89285	41.89283	41.89281	41.89265	41.8926	41.89265	41.89257	41.89288
lon_garmin	0	-72.7458	-72.74451	-72.74447	-72.74437	-72.74429	-72.74422	-72.74381	-72.74368	-72.7435	-72.74307	-72.74215
Cl (mg/L)	46.25856377	158.3833946	50.3638847	55.3525662	39.213836	63.7777356	54.862417	75.1885909	28.889255	35.499548	79.978995	46.569423
NO3_N (mg/L)	0.815928587	2.83220781	2.52639904	1.92070026	1.724334	1.05624298	1.1084904	1.93360493	0.1661015	0.0270502	0.7632396	0.8061774
PO4 (mg/L)	0.55960081	0.243713507			0.776573	0.60679954	0.6162372	0.24371351	0.5218295	0.4934937	0.6571259	0.5596008
SO4_S (mg/L)	3.412341658	6.168397415	20.2793829	19.4657565	16.615884	9.42872844	10.23997	4.70979492	2.1183267	1.4894334	7.7239013	3.3926504
NH3 (mg/L)	0.053295805	0.053295805	0.05329581	0.05329581	0.0532958	0.05329581	0.0532958	0.05329581	0.145	0.0532958	0.0532958	0.0532958
NPOC (mg/L)	2.591	0.7607	0.743	1.005	0.9242	0.7456	0.856	0.4926	0.461	0.4911	0.2612	2.521
TN (mg/L)	0.9865	2.738	2.428	1.902	1.601	1.112	1.128	1.812	0.267	0.1377	0.7905	0.9264
CH4 (ppm)	5.832659316	0.47070829	0.47070829	0.47070829	0.4707083	0.47070829	0.4707083	0.47070829	0.4707083	0.4707083	0.4707083	5.7367866
CO2 (ppm)	961.9721831	6757.038665	9177.26856	11703.9397	10846.672	12192.1925	10167.663	17069.8886	10995.088	11307.077	167.63573	533.69803
N20 (ppm)	0.390560188	6.327792293	4.85584175	5.8097727	6.1857436	4.18193406	2.8634618	5.6349851	1.1107452	0.3905602	2.7064984	0.3905602
N2 (ppm)		18.07623214	17.9696379	18.2076541	19.288887	17.0815149	16.793864	18.7052708	19.291774	19.297435	19.208589	
O2 (ppm)		8.566960869	8.42074093	8.47359811	8.3796564	8.34487351	8.3574183	8.27538436	8.1146329	8.265076	8.2845109	
Ar (ppm)		0.686408898	0.68822553	0.63283446	0.7229047	0.65380329	0.6344893	0.69003747	0.7262453	0.7265116	0.7103875	
N2:Ar		26.33449564	26.1101006	28.7715907	26.682476	26.1263826	26.468315	27.1076162	26.563715	26.561772	27.039594	

Table A- 21. Rainbow Reservoir chemical data from CT DEEP 9/24/19 (continued).

Sample Name	BHSW1	BH01	BH02	BH03	BH04	BH05	BH06	BH07	BH08	BH09	BH10	BHSW2
Date	9/24/2019	9/24/2019	9/24/2019	9/24/2019	9/24/2019	9/24/2019	9/24/2019	9/24/2019	9/24/2019	9/24/2019	9/24/2019	9/24/2019
Notes_1	spoonville 2	spoonville 2	spoonville 2	spoonville 2	spoonville 2	spoonville 2	spoonville 2	spoonville 2	spoonville 2	spoonville 2	spoonville 2	spoonville 2
lat_garmin	0	41.89401	41.89293	41.89295	41.89285	41.89283	41.89281	41.89265	41.8926	41.89265	41.89257	41.89288
lon_garmin	0	-72.7458	-72.74451	-72.74447	-72.74437	-72.74429	-72.74422	-72.74381	-72.74368	-72.7435	-72.74307	-72.74215
air_temp	19.8											23.1
air_pressure	29.67											29.63
surface_cond	251.5											250.2
surface_temp	19.99											21.09
surface_DO												
surface_sample_name	BH_Stream1											BH_Stream2
surface_gasID	90, 275											260, 235
seep_surf_temp			13.3	12.4	12.7	14	13	12.4	12.5	11.8	14.2	
seep_subsurface_temp		12.3	12.4	11	10.9	13.8	11.8	11.4	11.5	11.1	13.1	
seep_cond		696.7	398.6	404.3	346.6	317.3	301.1	334.5	142.2	155.8	455	
seep_DO		0	0	0	0	0	0	0	0	0	0	
seep_sample_name		BH01	BH02	BH03	BH04	BH05	BH06	BH07	BH08	BH09	BH10	
seep_gas_ID		208, 277	222, 51	240, 39	244, 239	202, 35	92, 207	261, 214	200, 102	249, 14	89, 41	
seep_MIMS_		BH01, BH02	BH03, BH04	BH05, BH06	BH07, BH08	BH09, BH10	BH11, BH12	BH13, BH14	BH15, BH16	BH17, BH18	BH19, BH20	
sed_sample		BH01	BH02	BH03	BH04	BH05	BH06	BH07	BH08	BH09	BH10	

Table A- 22. Rainbow Reservoir chemical data from CT DEEP 11/16/19-11/17/19.

Sample Name	BQSW1	BQ02	BQ03	BQ04	BQ05	BQ06	BQ07	BQ08	BQ09_SW2	BRSW1	BR01	BR02	BR03	BR04
Date	11/16/2019	11/16/2019	11/16/2019	11/16/2019	11/16/2019	11/16/2019	11/16/2019	11/16/2019	#########	11/17/2019	11/17/2019	11/17/2019	11/17/2019	11/17/2019
Notes_1	spoonville 3	spoonville 3	spoonville 3	spoonville 3	spoonville 3	spoonville 3	spoonville 3	spoonville 3	spoonville 3	spoonville 3	spoonville 3	spoonville 3	spoonville 3	spoonville 3
lat_garmin	0	41.89582	41.89516	41.8952	41.89514	41.89257	41.89263	41.89271	0	0	41.89399	41.89298	41.89292	41.89293
lon_garmin	0	-72.74323	-72.74217	-72.74224	-72.74197	-72.74362	-72.74367	-72.74386	0	0	-72.74584	-72.74454	-72.74451	-72.74451
Cl (mg/L)	43.3983342	95.055448	102.89191	74.9180165	59.709587	39.347659	44.89886	49.061059	42.643005	42.635542	159.24073	95.500424	46.356147	103.064752
NO3_N (mg/L)	0.73914532	1.8128684	6.3842261	5.46437549	4.8042396	0.0270502	0.2431622	1.529076	0.689602	0.6951465	3.016291	3.38968283	1.6983632	3.55040977
PO4 (mg/L)	0.91474286	0.9241582	0.9743616	1.01827373	1.0025925	0.795423	0.7577202	0.8236929	0.9084656	0.8990491	0.7011455	0.81741123	1.2000369	0.7640048
SO4_S (mg/L)	3.12542408	6.2524137	7.1134607	7.06184115	6.2918426	1.5908855	2.2448716	4.8247903	3.0911941	2.7680673	6.8691608	9.17591344	17.000862	6.99039131
NH3 (mg/L)	0.05329581	0.0532958	0.0532958	0.05329581	0.0532958	0.0532958	0.0532958	0.0532958	0.0532958	0.0532958	0.0532958	0.05329581	0.0532958	0.05329581
NPOC (mg/L)	3.306	1.767	1.518	1.062	1.208	0.6205	0.9985	0.8702	3.123	3.23	0.8889	0.8181	0.8937	0.7641
TN (mg/L)	0.9302	1.678	5.927	4.995	4.529	0.1185	0.3521	1.461	0.8343	0.8292	2.845	3.215	1.566	3.23
CH4 (ppm)	5.90933195	34.73044	0.4707083	0.47070829	0.4707083	0.4707083	1.9979158	0.4707083	6.2086197	8.4599653	1.2652915		4.5669363	0.47070829
CO2 (ppm)	677.349089	6057.8377	3795.3282	5139.17656	6651.8525	11410.627	12926.059	13079.149	1035.9557	1011.2118	8580.3444		11620.729	14695.9592
N20 (ppm)	0.39056019	2.8009493	8.2632414	11.0688716	8.774157	0.3905602	0.7693724	4.1906958	0.3905602	0.3905602	5.8014558		5.3207086	5.71123969

Table A- 23. Rainbow Reservoir chemical data from CT DEEP 11/16/19-11/17/19 (continued).

Sample Name	BQSW1	BQ02	BQ03	BQ04	BQ05	BQ06	BQ07	BQ08	BQ09_SW2	BRSW1	BR01	BR02	BR03	BR04
Date	11/16/2019	11/16/2019	11/16/2019	11/16/2019	11/16/2019	11/16/2019	11/16/2019	11/16/2019	11/16/2019	11/17/2019	11/17/2019	11/17/2019	11/17/2019	11/17/2019
Notes_1	spoonville 3	spoonville 3	spoonville 3	spoonville 3	spoonville 3	spoonville 3	spoonville 3	spoonville 3	spoonville 3	spoonville 3	spoonville 3	spoonville 3	spoonville 3	spoonville 3
lat_garmin	0	41.89582	41.89516	41.8952	41.89514	41.89257	41.89263	41.89271	0	0	41.89399	41.89298	41.89292	41.89293
lon_garmin	0	-72.74323	-72.74217	-72.74224	-72.74197	-72.74362	-72.74367	-72.74386	0	0	-72.74584	-72.74454	-72.74451	-72.74451
air_temp	4								1.3					
air_pressure	30.42								30.36					
surface_cond	106.9								216.2	216.2				
surface_temp	3.6								3.6					
surface_DO	12.35								0	12.3				
surface_sample_name														
surface_gasID	296, 293								295, 308?	309, 302				
seep_surf_temp		11	10.4	9.6	10.4	6.5	5.4	5.2						
seep_subsurface_temp		11.6	10.8	9.9	10.8	7.8	5	7.3						
seep_cond		535	657	529	438.2	186.5	203	269.1			615		438.9	510
seep_DO		2.16	2.2	3.13	2.09	2.96	4.39				2.63		3.51	4.24
seep_sample_name		BQ02	BQ03	BQ04	BQ05	BQ06	BQ07				BR01		BR03	BR04
seep_gas_ID		310, 284	218, 13	272, 294	280, 300	56, 282	225, 340				219, 666		288, 267	292, 216
seep_MIMS_		-	-	-	-	-	-				BR01_1, BR01_2		BR03	BR
sed_sample														

Table A- 24. Rainbow Reservoir chemical data from CT DEEP 6/26/20.

Sample_name	CM01_SW	CM02	CM03	CM04	CM05	CM06	CM07	CM08	CM09	CM10
Date	6/26/2020	6/26/2020	6/26/2020	6/26/2020	6/26/2020	6/26/2020	6/26/2020	6/26/2020	6/26/2020	6/26/2020
Month	June	June	June	June	June	June	June	June	June	June
Lat		41.895126	41.895155	41.895155	41.895144	41.895151	41.89507	41.895151	41.895094	41.89513
Long		-72.74236	-72.74219	-72.74208	-72.74201	-72.74198	-72.74204	-72.742	-72.74191	-72.74191
Sample Category	SW	GW	GW	GW	GW	GW	GW	GW	GW	GW
Sample Type	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal
Locations	Rainbow_A	Rainbow_A	Rainbow_A	Rainbow_A	Rainbow_A	Rainbow_A	Rainbow_A	Rainbow_A	Rainbow_A	Rainbow_A
GC Sample ID	CM01_77	CM02_61	CM03_231	CM04_305	CM05_05	CM06_100	CM07_280	CM08_276	CM09_258	CM10_87
CH4_ppb	4.812759	0.3853073	0.3631538	0.3452895	0.3813703	0.3238646	0.3994752	0.3699992	0.3717167	0.38556
CO2_ppb	2673.2455	22713.722	9671.0779	11581.604	16476.254	15713.405	18729.263	18762.033	18307.337	21553.05
N20_ppb	0.5502216	26.664279	41.341499	40.411779	30.403762	28.695428	20.424904	21.951395	21.02324	17.97911
Notes		IB21	IB22	IB23	IB24	IB26, mixed	IB25	IB27	IB28	IB29
FLIR_img		1070-1072	1073-1074	1075-1076	1077-1078	1079-1082	1083-1084;	1086		1088-1090
extent										
air_temp	20.8									
air_pressure	29.86									
surface_cond	218									
surface_temp	23.01									
surface_DO	7.3									
surface_sampleID	CM01									
surface_gas_ID	CM01_270; CM01_77									
seep_surf_temp		12.96	12.31	10.32	10.25	13.2	12.2	10.33	15.82	12.77
seep_subsurf_temp		12	10.816	9.96	10.19	10.74	11.63	9.7	11.68	10.303
seep_cond		532	628	564	454	435	363	361	293	250
seep_DO		2.97	2.03	2.84	2.56	2.69	2.6	3.37	3.51	3.17
seep_sampleID		CM02	CM03	CM04	CM05	CM06	CM07	CM08	CM09	CM10
seep_gas_ID		CM02_53; CM02_61	CM03_27; CM03_231	CM04_81; CM04_305	CM05_05; CM05_224	CM06_100; CM06_268	CM07_303; CM07_280	CM08_276; CM08_297	CM09_258; CM09_232	CM10_93; CM10_87
seep_MIMS_ID		CM02_A; CM02_B	CM03_A; CM03_B	CM04_A; CM04_B	CM05_A; CM05_B	CM06_A; CM06_B	CM07_A; CM07_B	CM08_A; CM08_B	CM09_A; CM09_B	CM10_A; CM10_B

Table A- 25. Rainbow Reservoir chemical data from CT DEEP 6/26/20 (continued).

Sample_name	CM11	CM12	CM13	CM14	CM15	CM16	CM17	CM18	CM19	CM20	CM21	CM22
Date	6/26/2020	6/26/2020	6/26/2020	6/26/2020	6/26/2020	6/26/2020	6/26/2020	6/26/2020	6/26/2020	6/26/2020	########	########
Month	June	June	June	June	June	June	June	June	June	June	June	June
Lat	41.895089	41.892994	41.893042	41.892924	41.892918	41.892898	41.892946	41.892875	41.892826	41.892847	41.89297	
Long	-72.741834	-72.74452	-72.74438	-72.744438	-72.74448	-72.74442	-72.74443	-72.7444	-72.74436	-72.74442	-72.7443	
Sample Category	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW	SW
Sample Type	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal
Locations	Rainbow_A	Rainbow_B	Rainbow_B	Rainbow_B	Rainbow_B	Rainbow_B	Rainbow_B	Rainbow_B	Rainbow_B	Rainbow_B	Rainbow_	Rainbow_B
GC Sample ID	CM11_267	CM12_234		CM14_275	CM15_201	CM16_209	CM17_301	CM18_304	CM19_256	CM20_307	CM21_298	CM22_210
CH4_ppb	0.4157876	0.4126877		0.4045958	0.382734	0.3499529	0.3717591	0.4303395	0.4259776	0.3527008	0.36326	7.785429
CO2_ppb	26384.928	45035.441		45601.514	44083.782	41518.161	44050.423	52565.452	51517.684	52327.353	33262.2	2404.188
N20_ppb	18.118701	33.809187		38.739708	41.038406	41.045244	42.301346	54.336326	42.685852	41.747477	24.97787	1.095096
Notes	IB30	IB31	IB32	IB33	IB34	IB35	IB36	IB37	IB38	IB39	IB40	
FLIR_img	1091-1092	1093	1094	1095	1096	1098	1099	1100	1101	1102	1104	
extent												
air_temp												
air_pressure												
surface_cond												219
surface_temp												23.7
surface_DO												7.77
surface_sampleID												CM22
surface_gas_ID												CM22_210; CM22_265
seep_surf_temp	16.8	13.19	16.55	14.31	15.66	12.363	11.407	13.201	13.059	11.687	17.24	
seep_subsurf_temp	12.03	11.998	13.31	11.795	11.757	10.499	9.86	10.207	11.588	10.697	12.09	
seep_cond	233	467	491	464	463	458	458	372	360	366	253	
seep_DO	3.27	4.26	3.38	2.66	1.91	3.43	1.96	2.14	2.92	2.08	4.76	
seep_sampleID	CM11	CM12	CM13	CM14	CM15	CM16	CM17	CM17	CM19	CM20	CM21	
seep_gas_ID	CM11_52; CM11_267	CM12_234; CM12_48	CM13_49; CM13_242	CM14_275; CM14_336	CM15_17; CM15_201	CM16_25; CM15_209	CM17_301; CM17_220	CM18_257; CM18_304	CM19_239; CM19_256	CM20_270; CM20_307	CM21_79; CM21_298	
seep_MIMS_ID	CM11_A; CM11_B	CM12_A; CM12_B	CM13_A; CM13_B	CM14_A; CM14_B	CM15_A; CM15_B	CM16_A; CM16_B	CM17_A; CM17_B	CM18_A; CM18_B	CM19_A; CM19_B	CM20_A; CM20_B	CM21_A; CM21_B	

Table A- 26. Rainbow Reservoir chemical data from CT DEEP 6/26/20 (continued).

Sample_name	CM01_SW	CM02	CM03	CM04	CM05	CM06	CM07	CM08	CM09	CM10
Date	6/26/2020	6/26/2020	6/26/2020	6/26/2020	6/26/2020	6/26/2020	6/26/2020	6/26/2020	6/26/2020	6/26/2020
Month	June	June	June	June	June	June	June	June	June	June
Lat		41.895126	41.895155	41.895155	41.895144	41.895151	41.89507	41.895151	41.895094	41.895126
Long		-72.74236	-72.74219	-72.74208	-72.74201	-72.74198	-72.74204	-72.742	-72.74191	-72.74191
Sample Category	SW	GW	GW	GW	GW	GW	GW	GW	GW	GW
Sample Type	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal
Locations	Rainbow_A	Rainbow_A	Rainbow_A	Rainbow_A	Rainbow_A	Rainbow_A	Rainbow_A	Rainbow_A	Rainbow_A	Rainbow_A
NO3 (mg N / L)	0.602243	4.0256364	5.5806159	5.3576038	4.4504666	4.4513217	4.4208029	4.3281288	4.4669922	4.9564448
Cl (mg / L)	40.412332	73.13933	85.868492	73.029093	55.9339	53.388694	41.136164	40.488539	28.621491	22.776869
SO4 (mg SO4 / L)	9.4364461	20.887	20.925946	20.345833	18.171206	17.573344	16.054294	16.274287	14.217883	12.873452
PO4 (mg PO4 / L)	0.4414055	0.1606371	0.1606371	0.1606371	0.1606371	0.1606371	0.3388912	0.3606557	0.393788	0.3679681
NPOC_ppm	3.154	2.043	1.298	1.317	1.159	1.059	1.276	1.261	1.233	1.114
TDN_ppm	0.6551	3.937	5.565	5.308	4.377	4.346	4.32	4.19	4.376	4.465
N2 conc		737.23009	721.71096	708.50654	726.02707	742.41067	736.63599	750.79875	713.13705	705.10737
O2 conc		259.39574	260.93033	255.76096	250.31002	247.12698	242.72751	241.31595	238.07575	235.27471
Ar conc		18.30388	17.915713	17.520722	17.866366	18.141942	18.125919	18.241461	17.669036	17.928217
N2:Ar		40.277257	40.283686	40.438204	40.636528	40.922337	40.639925	41.158916	40.360836	39.329476
N2_ppm		20.642442	20.207907	19.838183	20.328758	20.787499	20.625808	21.022365	19.967838	19.743006
Ar_ppm		0.7321552	0.7166285	0.7008289	0.7146546	0.7256777	0.7250368	0.7296584	0.7067614	0.7171287
N2_um		737.23009	721.71096	708.50654	726.02707	742.41067	736.63599	750.79875	713.13705	705.10737
Ar_um		18.30388	17.915713	17.520722	17.866366	18.141942	18.125919	18.241461	17.669036	17.928217
N2_excess		1.1846156	1.187523	1.2573957	1.3470779	1.4763209	1.3486142	1.5833017	1.2224098	0.7560292

Table A- 27. Rainbow Reservoir chemical data from CT DEEP 6/26/20 (continued).

Sample_name	CM11	CM12	CM13	CM14	CM15	CM16	CM17	CM18	CM19	CM20	CM21	CM22
Date	6/26/2020	6/26/2020	6/26/2020	6/26/2020	6/26/2020	6/26/2020	6/26/2020	6/26/2020	6/26/2020	6/26/2020	6/26/2020	6/26/2020
Month	June	June	June	June	June	June	June	June	June	June	June	June
Lat	41.895089	41.892994	41.893042	41.892924	41.892918	41.892898	41.892946	41.892875	41.892826	41.892847	41.892967	
Long	-72.74183	-72.74452	-72.74438	-72.74444	-72.74448	-72.74442	-72.74443	-72.7444	-72.744362	-72.74442	-72.74428	
Sample Category	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW	SW
Sample Type	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal
Locations	Rainbow_A	Rainbow_B	Rainbow_B	Rainbow_B	Rainbow_B	Rainbow_B	Rainbow_B	Rainbow_B	Rainbow_B	Rainbow_B	Rainbow_B	Rainbow_B
NO3 (mg N / L)	4.5059771	2.9015365	2.3166787	1.941125	2.0532416	2.1502565	2.0122179	2.1796589	2.7005677	2.6381261	2.3421007	0.4627508
Cl (mg / L)	20.589845	74.650944	57.135987	53.834965	56.505526	54.856307	54.734632	60.603318	57.523433	58.015476	40.339045	40.322202
SO4 (mg SO4 / L)	12.548236	43.417401	91.78865	86.570469	78.746901	78.393294	77.678076	25.732208	19.704641	19.671803	11.381571	8.5581053
PO4 (mg PO4 / L)	0.3826791	0.3950263	0.5308189	0.4979832	0.544093	0.542762	0.5215745	0.4049615	0.3716351	0.3643083	0.3716351	0.4174525
NPOC_ppm	1.091	1.027	0.6853	1.015	0.7461	0.9417	1.092	0.9542	1.074	1.028	0.7954	2.612
TDN_ppm	4.428	2.808	2.275	1.869	1.945	2.013	1.912	2.047	2.566	2.498	2.14	0.5967
N2 conc	716.58308	726.09573	701.7259	774.59702	745.78572	759.35871	759.83028	752.81815	745.52546	758.68623	681.71025	
O2 conc	229.9894	222.96417	258.48194	257.60304	260.29729	256.54154	253.85824	255.8051	252.02664	250.76549	259.04231	
Ar conc	18.11199	18.940917	18.449384	19.690355	18.892409	19.062991	19.12194	18.394838	17.999005	18.186101	17.739182	
N2:Ar	39.564016	38.334772	38.035194	39.338906	39.475416	39.834184	39.736045	40.925512	41.42037	41.717917	38.429634	
N2_ppm	20.064326	20.330681	19.648325	21.688716	20.882	21.262044	21.275248	21.078908	20.874713	21.243214	19.087887	
Ar_ppm	0.7244796	0.7576367	0.7379754	0.7876142	0.7556964	0.7625196	0.7648776	0.7357935	0.7199602	0.727444	0.7095673	
N2_um	716.58308	726.09573	701.7259	774.59702	745.78572	759.35871	759.83028	752.81815	745.52546	758.68623	681.71025	
Ar_um	18.11199	18.940917	18.449384	19.690355	18.892409	19.062991	19.12194	18.394838	17.999005	18.186101	17.739182	
N2_excess	0.8620882	0.3062237	0.1707548	0.7602934	0.8220229	0.9842582	0.9398794	1.4777564	1.7015313	1.836082	0.3491203	

Table A- 28. Rainbow Reservoir chemical data from CT DEEP 7/21/20.

Sample_name	CZ03	CZ04	CZ05	CZ06	CZ07	CZ08	CZ09	CZ10
Date	7/21/2020	7/21/2020	7/21/2020	7/21/2020	7/21/2020	7/21/2020	7/21/2020	7/21/2020
Month	July	July	July	July	July	July	July	July
Lat	41.895155	41.895155	41.895144	41.895151	41.89507	41.895151	41.895094	41.895126
Long	-72.742185	-72.74208	-72.74201	-72.74198	-72.74204	-72.742	-72.74191	-72.74191
Sample Category	GW	GW	GW	GW	GW	GW	GW	GW
Sample Type	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal
Locations	Rainbow_A	Rainbow_A	Rainbow_A	Rainbow_A	Rainbow_A	Rainbow_A	Rainbow_A	Rainbow_A
NO3 (mg N / L)	5.7775135	5.1148693	4.8671521	4.7707508	4.2336188	4.4507516	5.1004896	5.21361
Cl (mg / L)	87.292738	68.559585	56.765444	52.180121	37.826727	37.130516	24.225033	21.401136
SO4 (mg SO4 / L)	21.114435	19.033224	18.015355	17.147868	15.872677	15.986308	13.68956	12.251653
PO4 (mg PO4 / L)	0.1606371	0.1606371	0.3293012	0.3425006	0.3753092	0.4212153	0.3863749	0.4124465
NPOC_ppm	1.165	1.345	1.318	0.8347	1.227	1.145	1.063	1.331
TDN_ppm	5.714	4.952	5.01	4.557	4.078	4.256	4.941	5.122
N2 conc	729.66097	742.41145	753.5998	751.72477	781.4939	755.18392	748.18284	722.91226
O2 conc	268.53448	244.4182	240.10682	238.28365	213.41554	273.28149	269.4246	272.38975
Ar conc	18.146588	18.324597	18.568907	18.612664	19.009628	18.862934	18.796205	18.591294
N2:Ar	40.209266	40.514475	40.583961	40.387811	41.110427	40.035336	39.804995	38.884451
N2_ppm	20.430507	20.78752	21.100794	21.048294	21.881829	21.14515	20.949119	20.241543
Ar_ppm	0.7258635	0.7329839	0.7427563	0.7445066	0.7603851	0.7545174	0.7518482	0.7436518
N2_um	729.66097	742.41145	753.5998	751.72477	781.4939	755.18392	748.18284	722.91226
Ar_um	18.146588	18.324597	18.568907	18.612664	19.009628	18.862934	18.796205	18.591294
N2_excess	1.1538701	1.2918857	1.3233074	1.2346082	1.561375	1.0752192	0.9710587	0.5547886
Notes	IB22	IB23	IB24	IB25	IB26	IB27	IB28	IB29
FLIR_img	829	830	831	832	834	835	836	838
seep_surf_temp	13.23	11.98	11.555	14.654	11.316	11.199	11.877	12.528
seep_subsurf_temp	12.15	11.4	11.452	13.092	10.958	10.826	12.47	11.556
seep_cond	631	556	461	439	351	349	278	246
seep_DO	1.94	2.33	2.99	4.52	2.36	2.72	3.23	3.44
seep_MIMS_ID	CZ02_A; CZ02_B	CZ03_A; CZ03_B	CZ04_A; CZ04_B	CZ05_A; CZ05_B	CZ06_A; CZ06_B	CZ07_A; CZ07_B	CZ08_A; CZ08_B	CZ09_A; CZ09_B

Table A- 29. Rainbow Reservoir chemical data from CT DEEP 7/21/20 (continued).

Sample_name	CZ11	CZ12	CZ13	CZ14	CZ15	CZ16	CZ17	CZ18	CZ19	CZ20	CZ21	CZ22_SW
Date	7/21/2020	7/21/2020	7/21/2020	7/21/2020	7/21/2020	7/21/2020	7/21/2020	7/21/2020	7/21/2020	7/21/2020	7/21/2020	7/21/2020
Month	July	July	July	July	July	July	July	July	July	July	July	July
Lat	41.895089	41.892994	41.893042	41.892924	41.892918	41.892898	41.892946	41.892875	41.892826	41.892847	41.892967	
Long	-72.741834	-72.74452	-72.74438	-72.74444	-72.74448	-72.74442	-72.74443	-72.7444	-72.74436	-72.74442	-72.74428	
Sample Category	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW	SW
Sample Type	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal
Locations	Rainbow_A	Rainbow_B	Rainbow_B	Rainbow_B	Rainbow_B	Rainbow_B	Rainbow_B	Rainbow_B	Rainbow_B	Rainbow_B	Rainbow_B	Rainbow_B
NO3 (mg N / L)	5.2009478	2.4887334	2.1960823	1.9838713	1.8342263	2.3173068	1.9430408	2.2566188	2.5873019	2.6520515	2.1970294	0.4583251
Cl (mg / L)	22.069423	136.87474	62.645833	62.972212	59.481604	53.743768	53.730155	58.86776	54.077569	56.542922	56.03087	39.049966
SO4 (mg SO4 / L)	12.284115	35.998922	117.26114	86.059696	85.561616	70.096638	78.863159	24.015961	19.744575	19.484496	18.462284	7.7518576
PO4 (mg PO4 / L)	0.4161998	0.1606371	0.5123694	0.549425	0.564154	0.5032033	0.5520958	0.4037168	0.3863749	0.372859	0.393788	0.4249854
NPOC_ppm	1.182	1.144	1.05	0.9961	1.113	0.92	0.9761	0.9143	1.275	1.074	1.1	2.931
TDN_ppm	5.06	2.329	2.037	1.678	1.734	2.145	1.808	2.125	2.41	2.462	2.019	0.6018
N2 conc	737.131	714.5003	579.70111	815.35957	598.29842	770.16567	812.24613	815.54092	779.92208	779.27133	761.16984	
O2 conc	272.20295	270.53347	290.39629	262.21377	280.30713	262.56169	262.54391	249.59065	255.62565	255.13454	254.55058	
Ar conc	18.79832	19.245528	15.900931	20.456788	15.852228	19.547207	20.559765	19.810574	19.254199	19.25581	18.953672	
N2:Ar	39.212599	37.125524	36.457054	39.857653	37.74223	39.400291	39.506586	41.16695	40.506597	40.469414	40.159492	
N2_ppm	20.639668	20.006008	16.231631	22.830068	16.752356	21.564639	22.742892	22.835146	21.837818	21.819597	21.312755	
Ar_ppm	0.7519328	0.7698211	0.6360373	0.8182715	0.6340891	0.7818883	0.8223906	0.792423	0.770168	0.7702324	0.7581469	
N2_um	737.131	714.5003	579.70111	815.35957	598.29842	770.16567	812.24613	815.54092	779.92208	779.27133	761.16984	
Ar_um	18.79832	19.245528	15.900931	20.456788	15.852228	19.547207	20.559765	19.810574	19.254199	19.25581	18.953672	
N2_excess	0.7031774	-0.240598	-0.54288	0.9948707	0.0382763	0.7880518	0.8361184	1.586935	1.2883233	1.271509	1.1313625	
Notes	IB30	IB31	IB32	IB33	IB34	IB35	IB36	IB37	IB38	IB39	IB40	
FLIR_img	839	841	842	843	845	846	847	848	849	850	852	
seep_surf_temp	12.416	16.92	16.62	15.59	13.39	12.65	12.33	15.77	16.75	14.48	15.24	
seep_subsurf_temp	11.544	13.68	14.08	13.43	13.46	10.92	10.42	11.64	12.36	12.86	13.09	
seep_cond	241	612	562	473	490	446	456	366	350	357	353	
seep_DO	3.1	3.75	3.15	2.14	1.66	3.5	3.77	2.75	2.83	2.69	2.84	
seep_MIMS_ID	CZ10_A; CZ10_B	CZ11_A; CZ11_B	CZ12_A; CZ12_B	CZ13_A; CZ13_B	CZ14_A; CZ14_B	CZ15_A; CZ15_B	CZ16_A; CZ16_B	CZ17_A; CZ17_B	CZ18_A; CZ18_B	CZ19_A; CZ19_B	CZ20_A; CZ20_B	

Table A- 30. Rainbow Reservoir chemical data from CT DEEP 8/26/20.

Sample_name	DTSW1	DT01	DT02	DT03	DT04	DT05	DT06	DT07	DT08	DT09
Date	8/26/2020	8/26/2020	8/26/2020	8/26/2020	8/26/2020	8/26/2020	8/26/2020	8/26/2020	8/26/2020	8/26/2020
Month	August	August	August	August	August	August	August	August	August	August
Lat		41.89513	41.89516	41.89516	41.89514	41.895151	41.89507	41.89515	41.89509	41.89513
Long		-72.74236	-72.74219	-72.74208	-72.74201	-72.74198	-72.74204	-72.742	-72.74191	-72.74191
Sample Category	SW	GW	GW	GW	GW	GW	GW	GW	GW	GW
Sample Type	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal
Locations	Rainbow_A	Rainbow_A	Rainbow_A	Rainbow_A	Rainbow_A	Rainbow_A	Rainbow_A	Rainbow_A	Rainbow_A	Rainbow_A
NO3 (mg N / L)	0.427229	4.612909	5.646667	5.116607	4.668012	4.7230647	4.205246	4.423186	4.719153	5.511181
Cl (mg / L)	42.55791	83.41385	91.41737	76.47785	58.2808	58.671713	37.72882	39.29231	23.95083	124.1491
SO4 (mg SO4 / L)	9.215863	20.38533	20.40412	20.00676	18.0856	17.432501	15.03385	15.51081	13.27323	11.81116
PO4 (mg PO4 / L)	0.160637	0.160637	0.160637	0.160637	0.160637	0.1606371	0.160637	0.160637	0.160637	0.160637
NPOC_ppm	2.902	1.875	0.9924	1.08	0.9311	0.8948	1.135	0.8959	1.027	1.208
TDN_ppm	0.6207	4.88	6.007	5.536	4.944	4.912	4.454	4.756	5.01	5.762
N2 conc		774.4789	751.2904	752.0422	750.8798	771.19736	789.733	793.6173	763.8309	724.1162
O2 conc		279.4742	283.7958	284.5171	276.9765	277.65116	281.5877	278.8558	278.4316	278.2577
Ar conc		19.33629	18.80829	18.61149	18.71202	19.122155	19.41497	19.47239	18.98492	18.45743
N2:Ar		40.05313	39.94464	40.40742	40.1282	40.330044	40.67649	40.75604	40.23355	39.2317
N2_ppm		21.68541	21.03613	21.05718	21.02463	21.593526	22.11252	22.22128	21.38727	20.27525
Ar_ppm		0.773452	0.752332	0.744459	0.748481	0.7648862	0.776599	0.778895	0.759397	0.738297
N2_um		774.4789	751.2904	752.0422	750.8798	771.19736	789.733	793.6173	763.8309	724.1162
Ar_um		19.33629	18.80829	18.61149	18.71202	19.122155	19.41497	19.47239	18.98492	18.45743
N2_excess		1.083265	1.034208	1.243476	1.117213	1.208486	1.36515	1.40112	1.164851	0.711814
GC Sample ID	DT_SW01_2	DT01_25	DT02_61	DT03_272	DT04_225	DT05_221	DT06_305	DT07_207	DT08_245	DT09_313
CH4_ppb	3.261173	0.351488	0.342935	0.34464	0.324542	0.3363376	0.357952	0.337723	0.341961	0.337057
CO2_ppb	2795.473	24900.22	10851.57	11503.27	16783.42	16527.932	16408.23	13187.65	17337.56	23217.31
N20_ppb	0.581454	29.55036	39.15145	40.03351	34.45368	31.640538	19.38844	21.23751	18.51754	14.61673
FLIR_img		1281	1282	1283	1284	1286	1285	1287	1288	1289
surface_cond	234									
surface_temp	24.35									
surface_DO	7.58									
seep_surf_temp		13.34	13.637	13.225	12.78	13.271	12.84	12.668	13.351	13.31
seep_subsurf_temp		13.138	13.232	12.65	12.681	13.003	12.231	11.963	12.786	12.737
seep_cond		581	667	590	483	464	359	376	289	263
seep_DO		2.32	2.37	2.84	4.81	3.9	2.72	3.68	3.92	3.99
seep_gas_ID		DT01_79;	DT02_305;	DT03_325;	DT04_225;	DT05_221;	DT06_305;	DT07_242;	DT08_51;	DT09_348;

Table A- 31. Rainbow Reservoir chemical data from CT DEEP 8/26/20 (continued).

Sample_name	DT10	DT11	DT12	DT13	DT14	DT15	DT16	DT17	DT18	DT18	DT20	DTSW2
Date	8/26/2020	8/26/2020	8/26/2020	8/26/2020	8/26/2020	8/26/2020	8/26/2020	8/26/2020	8/26/2020	8/26/2020	8/26/2020	8/26/2020
Month	August	August	August	August	August	August	August	August	August	August	August	August
Lat	41.895089	41.89299	41.89304	41.89292	41.89292	41.8929	41.89295	41.89288	41.89283	41.89285	41.892967	
Long	-72.74183	-72.74452	-72.74438	-72.74444	-72.74448	-72.74442	-72.74443	-72.7444	-72.74436	-72.74442	-72.74428	
Sample Category	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW	SW
Sample Type	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal
Locations	Rainbow_A	Rainbow_B	Rainbow_B	Rainbow_B	Rainbow_B	Rainbow_B	Rainbow_B	Rainbow_B	Rainbow_B	Rainbow_B	Rainbow_B	Rainbow_B
NO3 (mg N / L)	5.3681648	2.56468	2.306758	1.964776	1.757995	2.342044	1.874055	2.094064	2.089977	2.140366	2.2673767	0.480979
Cl (mg / L)	27.761971	188.7484	66.70135	60.47791	57.39956	53.60431	53.24755	60.06874	62.87022	64.19249	66.105178	41.87858
SO4 (mg SO4 / L)	11.105089	50.5973	103.1219	99.87987	61.88477	52.27795	58.37599	29.11359	19.68606	18.93159	20.499815	9.308561
PO4 (mg PO4 / L)	0.1606371	0.160637	0.427964	0.464496	0.160637	0.160637	0.160637	0.160637	0.160637	0.160637	0.1606371	0.160637
NPOC_ppm	1.027	1.104	1.304	1.214	1.022	0.9964	1.005	1.003	1.037	0.974	0.9352	2.789
TDN_ppm	5.792	2.588	2.207	1.876	1.843	2.394	1.948	2.125	2.196	2.261	2.333	0.5657
N2 conc	702.36551	689.4097	630.1168	736.0773	751.5221	755.0705	782.8801	789.7422	731.1621	775.612	724.41552	
O2 conc	284.39158	284.1451	280.0293	282.046	276.5044	277.6874	279.53	276.6294	281.6162	337.0252	333.59431	
Ar conc	18.108265	18.52881	17.01204	18.4791	18.91033	19.16689	19.65309	19.55157	18.4864	19.03491	18.263782	
N2:Ar	38.787014	37.20745	37.03947	39.83296	39.74136	39.39452	39.83497	40.39278	39.55134	40.74682	39.664048	
N2_ppm	19.666234	19.30347	17.64327	20.61017	21.04262	21.14197	21.92064	22.11278	20.47254	21.71714	20.283635	
Ar_ppm	0.7243306	0.741152	0.680481	0.739164	0.756413	0.766676	0.786123	0.782063	0.739456	0.761396	0.7305513	
N2_um	702.36551	689.4097	630.1168	736.0773	751.5221	755.0705	782.8801	789.7422	731.1621	775.612	724.41552	
Ar_um	18.108265	18.52881	17.01204	18.4791	18.91033	19.16689	19.65309	19.55157	18.4864	19.03491	18.263782	
N2_excess	0.5107276	-0.203552	-0.279513	0.983706	0.942284	0.785442	0.984614	1.236853	0.856357	1.39695	0.9073225	
GC Sample ID	DT10_232	DT11_33	DT12_222	DT13_666	DT14_258	DT15_230	DT16_8	DT17_217	DT18_266	DT19_70	DT20_228	DTSW02_2
CH4_ppb	0.3214287	0.31958	0.365644	0.337108	0.404324	0.344745	0.36403	0.372137	0.384815	0.361989	0.3529029	7.74651
CO2_ppb	23589.45	47247.75	42860.47	47007.98	47418.63	41083.58	46192.64	48576.76	52172.56	54645.59	47952.547	1186.966
N20_ppb	13.448781	34.85498	33.57711	37.54827	44.20429	50.56866	54.09163	46.14434	25.64355	30.8383	21.660752	0.58956
FLIR_img	1290	1291	1292	1293	1294	1295	1296	1297	1298	1299	1300	
surface_cond												
surface_temp												
surface_DO												
seep_surf_temp	13.159	15.795	16.188	14.375	12.609	12.582	12.692	12.935	14.317	13.153	15.126	
seep_subsurf_temp	12.738	13.755	14.346	12.919	11.677	11.189	11.404	11.314	12.518	12.674	12.936	
seep_cond	267	741	557	519	446	409	422	381	390	383	395	
seep_DO	3.87	4.07	4.4	3.21	2.45	4.08	2.36	3.25	3.36	2.98	5.04	
seep_gas_ID	DT10_53;	DT11_201;	DT12_292;	DT13_666;	DT14_258;	DT15_308;	DT16_08;	DT17_212;	DT18_266;	DT19_296;	DT20_288;	

Table A- 32. Rainbow Reservoir chemical data from CT DEEP 9/23/20.

Sample_name	EFSW1	EF01	EF02	EF03	EF04	EF05	EF06	EF07	EF08	EF09	EF10
Date	9/23/2020	9/23/2020	9/23/2020	9/23/2020	9/23/2020	9/23/2020	9/23/2020	9/23/2020	9/23/2020	9/23/2020	9/23/2020
Month	September	September	September	September	September	September	September	September	September	September	September
Lat		41.89513	41.89516	41.89516	41.89514	41.89515	41.89507	41.89515	41.895094	41.89513	41.89509
Long		-72.74236	-72.74219	-72.74208	-72.74201	-72.74198	-72.74204	-72.742	-72.74191	-72.74191	-72.74183
Sample Category	SW	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW
Sample Type	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal
Locations	Rainbow_A	Rainbow_A	Rainbow_A	Rainbow_A	Rainbow_A	Rainbow_A	Rainbow_A	Rainbow_A	Rainbow_A	Rainbow_A	Rainbow_A
NO3 (mg N / L)	0.835321	5.313186	5.222478	5.507578	5.000425	4.661747	5.016777	4.839525	4.7168054	5.497024	5.577034
Cl (mg / L)	53.72158	93.67959	89.44603	88.20574	66.71463	61.08319	54.69873	49.40929	35.977972	27.02142	29.40247
SO4 (mg SO4 / L)	14.07361	19.64393	19.83749	22.4735	19.09768	18.0829	17.20433	16.04509	14.075426	12.809	11.72514
PO4 (mg PO4 / L)	0.160637	0.160637	0.160637	0.160637	0.160637	0.160637	0.160637	0.160637	0.1606371	0.160637	0.160637
NPOC_ppm	2.35	1.156	1.084	0.9601	0.7586	0.9709	0.7614	0.9196	0.6897	1.056	1.137
TDN_ppm	0.9208	5.834	5.699	4.939	5.36	5.131	5.077	5.372	5.052	5.689	6.109
N2 conc		742.1698	745.7746	759.2595	764.3169	771.0674	766.4774	768.3016	767.85532	731.2694	699.8107
02 conc		302.0828	301.4516	303.3642	301.5855	302.9662	301.7877	301.5466	303.09893	299.772	295.9597
Ar conc		18.77377	18.81981	18.91021	19.07951	19.2303	19.13728	19.14939	19.206568	18.73552	18.06983
N2:Ar		39.53226	39.62711	40.15077	40.05956	40.09648	40.05152	40.12147	39.978789	39.03118	38.72813
N2_ppm		20.78075	20.88169	21.25927	21.40087	21.58989	21.46137	21.51244	21.499949	20.47554	19.5947
Ar_ppm		0.750951	0.752792	0.756408	0.76318	0.769212	0.765491	0.765976	0.7682627	0.749421	0.722793
N2_um		742.1698	745.7746	759.2595	764.3169	771.0674	766.4774	768.3016	767.85532	731.2694	699.8107
Ar_um		18.77377	18.81981	18.91021	19.07951	19.2303	19.13728	19.14939	19.206568	18.73552	18.06983
N2_excess		0.84773	0.890621	1.127418	1.086175	1.102869	1.082539	1.114167	1.0496484	0.621141	0.484102
GC Sample ID	EFSW_360	EF01_251	EF02_283	EF03_231	EF04_60	EF05_215	EF06_225	EF07_299	EF08_333	EF09_48	EF10_270
CH4_ppb	3.724658	0.347811	0.347754	0.330126	0.35933	0.336454	0.343388	0.343752	0.3413738	0.347762	0.347818
CO2_ppb	1736.753	18459.34	11041.52	11585.21	14824.15	18929.8	15627.67	13490.92	19806.543	24375.99	25729.41
N20_ppb	0.638521	36.33259	37.58231	44.75749	39.41651	38.95225	30.03177	26.18317	21.037883	16.95752	16.37077
FLIR_img		968	970, 971	972	973-975	976	977	978-979	980	981	982
surface_cond	314										
surface_temp	14.64										
surface_DO	9.96										
surface_gas_ID	EFSW_360 ; EFSW_312										
seep_surf_temp		13.52	13.04	13.1	13.02	12.89	13.01	12.78	13.28	13.44	13.6
seep_subsurf_temp		13.4	13.03	12.95	12.86	12.73	12.66	12.39	12.96	12.79	13.195
seep_cond		676	669	623	523	481	440	423	333	275	277
seep_DO		3.82	3.08	3.1	3.15	2.56	2.6	2.63	2.51	2.92	3
seep_gas_ID		EF01_74; EF01_251	EF02_254; EF02_283	EF03_231; EF03_322	EF04_301; EF04_60	EF05_278; EF05_215	EF06_225; EF06_81	EF07_239; EF07_299	EF08_280; EF08_333	EF09_48; EF09_284	EF10_13; EF10_270
seep_MIMS_ID		EF01_A; EF01_B	EF02_A; EF02_B	EF03_A; EF03_B	EF04_A; EF04_B	EF05_A; EF05_B	EF06_A; EF06_B	EF07_A; EF07_B	EF08_A; EF08_B	EF09_A; EF09_B	EF10_A; EF10_B

Table A- 33. Rainbow Reservoir chemical data from CT DEEP 9/23/20 (continued).

Sample_name	EF11	EF12	EF13	EF14	EF15	EF16	EF17	EF18	EF19	EF20
Date	9/23/2020	9/23/2020	9/23/2020	9/23/2020	9/23/2020	9/23/2020	9/23/2020	9/23/2020	9/23/2020	9/23/2020
Month	September	September	September	September	September	September	September	September	September	September
Lat	41.89299	41.89304	41.89292	41.89292	41.8929	41.89295	41.89288	41.89283	41.89285	41.89297
Long	-72.74452	-72.74438	-72.74444	-72.74448	-72.74442	-72.74443	-72.7444	-72.74436	-72.74442	-72.74428
Sample Category	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW
Sample Type	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal
Locations	Rainbow_B	Rainbow_B	Rainbow_B	Rainbow_B	Rainbow_B	Rainbow_B	Rainbow_B	Rainbow_B	Rainbow_B	Rainbow_B
NO3 (mg N / L)	0.251651	1.4104	1.931454	2.450215	1.984979	1.577715	2.63412	2.529796	2.138732	1.994531
Cl (mg / L)	187.8015	107.0874	128.9057	87.54426	62.21197	57.36011	62.8059	60.83262	61.53905	59.04363
SO4 (mg SO4 / L)	67.24942	72.2907	38.43827	36.53764	68.09496	66.12578	20.12046	24.66392	21.09669	20.92434
PO4 (mg PO4 / L)	0.160637	0.160637	0.160637	0.160637	0.160637	0.160637	0.160637	0.160637	0.160637	0.160637
NPOC_ppm	1.192	1.129	0.7444	0.8278	0.859	0.9266	0.9793	1.026	0.9946	1.017
TDN_ppm	0.2888	1.435	1.654	2.53	1.988	1.749	2.822	2.575	2.304	2.216
N2 conc	724.9411	708.5953	735.5735	715.0691	772.1466	795.4656	714.9367	695.5556	727.0455	689.1141
O2 conc	298.2286	296.0479	300.9845	297.738	299.5653	297.6959	298.6481	298.0409	299.733	298.8664
Ar conc	19.3743	18.66441	18.55937	18.65413	19.78352	20.12025	18.64142	18.36187	18.87414	18.23478
N2:Ar	37.41768	37.96505	39.63354	38.33301	39.02978	39.53557	38.35205	37.88043	38.52073	37.79118
N2_ppm	20.29835	19.84067	20.59606	20.02193	21.6201	22.27304	20.01823	19.47556	20.35727	19.29519
Ar_ppm	0.774972	0.746576	0.742375	0.746165	0.791341	0.80481	0.745657	0.734475	0.754965	0.729391
N2_um	724.9411	708.5953	735.5735	715.0691	772.1466	795.4656	714.9367	695.5556	727.0455	689.1141
Ar_um	19.3743	18.66441	18.55937	18.65413	19.78352	20.12025	18.64142	18.36187	18.87414	18.23478
N2_excess	-0.108487	0.139034	0.893525	0.305425	0.620507	0.849226	0.314036	0.10077	0.390315	0.060414
GC Sample ID	EF11_256	EF12_341	EF13_350	EF14_666	EF15_242	EF16_93	EF17_292	EF18_351	EF19_217	EF20_100
CH4_ppb	0.351649	0.346683	0.391532	0.326194	0.323148	0.352218	0.365748	0.31999	0.332239	0.405892
CO2_ppb	33184.23	29105.67	59772.01	51396.71	47842.15	49744.97	52106.83	51095.27	53542.14	47296.08
N20_ppb	3.059601	5.823913	65.79882	40.30449	61.1877	64.05967	30.32131	23.5739	27.48677	21.96438
FLIR_img	983	984	985	986	988	989	990	991-992	993-994	995-1000
surface_cond										
surface_temp										
surface_DO										
surface_gas_ID										
seep_surf_temp	14.55	13.41	13.03	12.46	11.95	11.82	13.23	13.88	12.22	13.15
seep_subsurf_temp	12.45	11.94	11.64	11.52	11.24	10.92	11.41	11.95	11.51	12.6
seep_cond	677	596	540	502	476	442	388	377	386	362
seep_DO	4.15	4.98	2.43	3.15	2.35	2.1	3.59	3.52	3.21	3.71
seep_gas_ID	EF11_256; EF11_249	EF12_210; EF12_341	EF13_253; EF13_350	EF14_32; EF14_666	EF15_201; EF15_242	EF16_92; EF16_93	EF17_292; EF17_245	EF18_351; EF18_40	EF19_208; EF19_217	EF20_100; EF20_244
seep_MIMS_ID	EF11_A; EF11_B	EF12_A; EF12_B	EF13_A; EF13_B	EF14_A; EF14_B	EF15_A; EF15_B	EF16_A; EF16_B	EF17_A; EF17_B	EF18_A; EF18_B	EF19_A; EF19_B	EF20_A; EF20_B

Table A- 34. Rainbow Reservoir chemical data from CT DEEP 10/15/20.

Sample_name	EP01	EP02	EP03	EP04	EP05	EP06	EP07	EP08	EP09	EP10
Date	10/15/2020	10/15/2020	10/15/2020	10/15/2020	10/15/2020	10/15/2020	10/15/2020	10/15/2020	10/15/2020	10/15/2020
Month	October	October	October	October	October	October	October	October	October	October
Lat	41.895126	41.895155	41.895155	41.895144	41.895151	41.89507	41.895151	41.895094	41.895126	41.895089
Long	-72.74236	-72.74219	-72.742077	-72.742007	-72.74198	-72.742038	-72.742	-72.741908	-72.74191	-72.741834
Sample Category	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW
Sample Type	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal
Locations	Rainbow_A	Rainbow_A	Rainbow_A	Rainbow_A	Rainbow_A	Rainbow_A	Rainbow_A	Rainbow_A	Rainbow_A	Rainbow_A
NO3 (mg N / L)	5.6553845	6.2017657	5.57151041	5.4883808	5.2432062	5.2836572	5.1803264	4.9927513	4.9030831	5.02328448
Cl (mg / L)	92.72589	97.712243	90.5848893	78.277936	77.19144	72.7843	70.352669	50.581959	38.12268	35.089744
SO4 (mg SO4 / L)	17.887579	19.589843	21.0445328	20.50228	20.862917	19.776961	17.99131	15.639559	14.035414	12.7901063
PO4 (mg PO4 / L)	0.1606371	0.1606371	0.16063713	0.1606371	0.1606371	0.1606371	0.1606371	0.1606371	0.1606371	0.16063713
NPOC_ppm	1.172	0.7681	0.7506	0.6073	0.735	0.8081	0.9578	0.7326	1.018	1.04
TDN_ppm	6.237	6.551	5.871	5.488	5.519	5.295	5.502	5.154	5.118	5.352
N2 conc	715.18706	709.98641	718.442623	728.61654	725.22027	739.5098	742.06986	736.56849	714.43855	713.621836
O2 conc	125.57696	123.76657	112.359932	102.58052	150.97126	111.35808	111.21607	136.97496	177.9883	164.821623
Ar conc	17.758158	17.609592	17.7024729	17.780924	17.693466	18.074766	18.145957	18.133387	17.845027	17.7584695
N2:Ar	40.273719	40.318162	40.5843087	40.977428	40.988028	40.913935	40.894501	40.619466	40.035723	40.1848727
N2_ppm	20.025238	19.879619	20.1163934	20.401263	20.306168	20.706274	20.777956	20.623918	20.004279	19.9814114
Ar_ppm	0.7103263	0.7043837	0.70809891	0.711237	0.7077386	0.7229906	0.7258383	0.7253355	0.7138011	0.71033878
N2_um	715.18706	709.98641	718.442623	728.61654	725.22027	739.5098	742.06986	736.56849	714.43855	713.621836
Ar_um	17.758158	17.609592	17.7024729	17.780924	17.693466	18.074766	18.145957	18.133387	17.845027	17.7584695
N2_excess	1.1830157	1.2031131	1.32346438	1.501233	1.5060264	1.4725215	1.4637333	1.3393627	1.0753939	1.14283943
GC Sample ID	EP01_51	EP02_308	EP03_268	EP04_222	EP05_263	EP06_297	EP07_42	EP08_94	EP09_321	EP10_72
CH4_ppb	0.3399794	0.3278042	0.34669455	0.3611637	0.356175	0.3562303	0.3463903	0.3388472	0.3460597	0.34337077
CO2_ppb	20812.849	11830.884	12533.2244	15825.501	20509.79	18456.991	15542.406	23538.633	35486.817	30669.8412
N20_ppb	35.596966	41.02096	53.3948589	48.337876	49.5416	47.595018	47.647889	27.628934	25.576558	22.2251917

Table A- 35. Rainbow Reservoir chemical data from CT DEEP 10/15/20 (continued).

Sample_name	EP11	EP12	EP13	EP14	EP15	EP16	EP17	EP18	EP19	EP20
Date	10/15/2020	10/15/2020	10/15/2020	10/15/2020	10/15/2020	10/15/2020	10/15/2020	10/15/2020	10/15/2020	10/15/2020
Month	October	October	October	October	October	October	October	October	October	October
Lat	41.892994	41.893042	41.892924	41.892918	41.892898	41.892946	41.892875	41.892826	41.892847	41.892967
Long	-72.744517	-72.744376	-72.744438	-72.744477	-72.744415	-72.744429	-72.744404	-72.744362	-72.74442	-72.744282
Sample Category	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW
Sample Type	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal	Temporal
Locations	Rainbow_B	Rainbow_B	Rainbow_B	Rainbow_B	Rainbow_B	Rainbow_B	Rainbow_B	Rainbow_B	Rainbow_B	Rainbow_B
NO3 (mg N / L)	2.4833132	2.19268038	2.4291191	2.2551695	2.14306942	2.4557724	2.5243046	2.6313048	2.2164209	1.8621738
Cl (mg / L)	104.94399	100.884918	163.56949	137.64797	70.058407	47.376356	53.585017	56.933432	53.956049	58.165455
SO4 (mg SO4 / L)	24.058069	56.2728979	18.106638	14.449868	55.2957936	32.143189	23.087441	20.913856	16.741557	13.123469
PO4 (mg PO4 / L)	0.1606371	0.16063713	0.1606371	0.1606371	0.16063713	0.1606371	0.1606371	0.1606371	0.1606371	0.1606371
NPOC_ppm	0.7984	0.8849	0.942	0.7938	0.7782	0.9264	0.9204	0.8984	0.9337	0.7752
TDN_ppm	2.555	2.232	2.413	2.37	2.288	2.609	2.711	2.853	2.722	2.018
N2 conc	680.90577	715.091411	659.73176	644.72892	738.99759	764.10192	746.34437	641.54892	704.80961	733.48413
O2 conc	165.00372	179.546873	235.48114	207.56113	123.753452	137.26971	150.32312	212.08692	132.50721	138.31782
Ar conc	17.669696	18.0030185	16.657878	17.003741	18.7732339	19.065773	18.661452	16.834816	18.052154	19.099999
N2:Ar	38.535227	39.7206398	39.60479	37.916888	39.3644268	40.077155	39.993906	38.10846	39.042964	38.402313
N2_ppm	19.065362	20.0225595	18.472489	18.05241	20.6919325	21.394854	20.897642	17.96337	19.734669	20.537556
Ar_ppm	0.7067879	0.72012074	0.6663151	0.6801496	0.75092935	0.7626309	0.7464581	0.6733927	0.7220862	0.7639999
N2_um	680.90577	715.091411	659.73176	644.72892	738.99759	764.10192	746.34437	641.54892	704.80961	733.48413
Ar_um	17.669696	18.0030185	16.657878	17.003741	18.7732339	19.065773	18.661452	16.834816	18.052154	19.099999
N2_excess	0.3968698	0.93291331	0.8805259	0.1172566	0.77183381	1.0941294	1.0564843	0.2038855	0.6264685	0.3367659
GC Sample ID	EP11_286	EP12_266	EP13_245	EP14_310	EP15_666	EP16_360	EP17_282	EP18_283	EP19_352	EP20_244
CH4_ppb	0.3295312	0.34995933	0.3425819	0.3481853	0.35634087	0.3661509	0.3505926	0.3652481	0.3617593	0.325393
CO2_ppb	57187.202	57820.8304	65949.711	55294.9	50697.0346	49655.38	49574.512	44134.881	58227.822	56220.549
N20_ppb	41.672823	48.5106881	36.993452	14.227481	57.2771056	54.491493	46.123831	24.968162	30.271298	33.614738

Table A- 36. CT DEEP Municipal NPDES Permit for MDC, Windsor. Nitrogen and Phosphorus Limits

Location: Windsor			Receiving Stream: Farmington River			
Flow/Time Based monitoring						
Parameter	Units	Month	Avg monthly limit	Max daily limit	Sample Freq.	Sample Type
Nitrogen, Ammonia (total as N)	mg/l	-	NA	-	Monthly	Daily composite
Nitrogen, Nitrate (total as N)	mg/l	-	NA	-	Monthly	Daily composite
Nitrogen, Nitrite (total as N)	mg/l	-	NA	-	Monthly	Daily composite
Nitrogen, Total Kjeldahl	mg/l	-	NA	-	Monthly	Daily composite
Nitrogen, Total	mg/l	-	NA	-	Monthly	Daily composite
Nitrogen, Total	lbs/day	-	NA	-	Monthly	Daily composite
Phosphorus, Total	mg/l	-	NA	-	Monthly	Daily composite

Table A- 37. CT DEEP NPDES Permit Farmington WPCA. Nitrogen and Phosphorus Limits

Location: Farmington			Receiving Stream: Farmington River			
Flow/Time Based monitoring						
Parameter	Units	Month	Avg monthly limit	Max daily limit	Sample Freq.	Sample Type
Nitrogen, Ammonia (total as N)	mg/l	June	15	-	3/week	Daily composite
Nitrogen, Ammonia (total as N)	mg/l	July-Sept	7	-	3/week	
Nitrogen, Ammonia (total as N)	mg/l	October	11.6	-	3/week	
Nitrogen, Ammonia (total as N)	mg/l	Nov-May	NA	-	3/week	
Nitrogen, Nitrate (total as N)	mg/l	-	NA	-	Monthly	ily composite
Nitrogen, Nitrite (total as N)	mg/l	-	NA	-	Monthly	Daily composite
Nitrogen, Total Kjeldahl	mg/l	-	NA	-	Monthly	Daily composite
Nitrogen, Total	mg/l	-	NA	-	Monthly	Daily composite
Nitrogen, Total	lbs/day	-	NA	-	Monthly	Daily composite
Phosphorus, Total	mg/l	Apr 1st -Oct 31st	3.11	6.22	Weekly	Daily composite
Phosphorus, Total	mg/l	Nov 1st - Mar31st	-	-	Monthly	Daily composite
Phosphorus, Total after upgrade	lbs/day	Apr 1st -Oct 31st	2.79	5.58	Weekly	Daily composite
Phosphorus, Total (Average Seasonal Load Cap)	lbs/day	Apr 1st -Oct 31st	70.11	NA	Weekly	Calculated

Table A- 38. CT DEEP NPDES Permit for Plainville. Nitrogen and Phosphorus Limits

Location: Plainville			Receiving Stream: Pequabuck River			
Flow/Time Based monitoring						
Parameter	Units	Month	Avg monthly limit	Max daily limit	Sample Freq.	Sample Type
Nitrogen, Ammonia (total as N)	mg/l	Jan-Mar	17.0	49.0	3/week	Daily composite
Nitrogen, Ammonia (total as N)	mg/l	April	15.0	45.0	3/week	Daily composite
Nitrogen, Ammonia (total as N)	mg/l	May	8.0	24.0	3/week	Daily composite
Nitrogen, Ammonia (total as N)	mg/l	Jun-Oct	2.0	6.0	3/week	Daily composite
Nitrogen, Ammonia (total as N)	mg/l	Nov 1st - Mar31st	8.0	23.0	3/week	Daily composite
Nitrogen, Ammonia (total as N)	mg/l	December	16.0	46.0	3/week	Daily composite
Nitrogen, Nitrate (total as N)	mg/l	-	NA	-	Monthly	Daily composite
Nitrogen, Nitrite (total as N)	mg/l	-	NA	-	Monthly	Daily composite
Nitrogen, Total Kjeldahl	mg/l	-	NA	-	Monthly	Daily composite
Nitrogen, Total	mg/l	-	NA	-	Monthly	Daily composite
Nitrogen, Total	lbs/day	-	NA	-	Monthly	Daily composite
Phosphorus, Total	mg/l	-	NA	NA	Weekly	Daily composite

Table A- 39. CT DEEP NPDES Permit for Bristol. Nitrogen and Phosphorus Limits

Location: Bristol			Receiving Stream: Pequabuck River			
Flow/Time Based monitoring						
Parameter	Units	Month	Avg monthly limit	Max daily limit	Sample Freq.	Sample Type
Nitrogen, Ammonia (total as N)	mg/l	Jan	17	-	3/week	Daily composite
	mg/l	Feb	14	-	3/week	Daily composite
	mg/l	Mar	-	-	3/week	Daily composite
	mg/l	Apr	5.5	-	3/week	Daily composite
	mg/l	May	4.5	-	3/week	Daily composite
	mg/l	June	3.4	-	3/week	Daily composite
	mg/l	July	2	-	3/week	Daily composite
	mg/l	Aug	2	-	3/week	Daily composite
	mg/l	Sept	2	-	3/week	Daily composite
	mg/l	Oct	2.7	-	3/week	Daily composite
	mg/l	Nov	15	-	3/week	Daily composite
	mg/l	Dec	16	-	3/week	Daily composite
Nitrogen, Nitrate (total as N)	mg/l	-	NA	-	Monthly	Daily composite
Nitrogen, Nitrite (total as N)	mg/l	-	NA	-	Monthly	Daily composite
Nitrogen, Total Kjeldahl	mg/l	-	NA	-	Monthly	Daily composite
Nitrogen, Total	mg/l	-	NA	-	Monthly	Daily composite
Nitrogen, Total	lbs/day	-	NA	-	Monthly	Daily composite
Phosphorus, Total	mg/l	Apr 1st -Oct 31st	0.14	0.31	2/week	Daily composite
Phosphorus, Total	mg/l	Nov 1st - Mar31st	NA	-	Monthly	Daily composite
Phosphorus, Total	lbs/day	Apr 1st -Oct 31st	-	-	2/week	Daily composite
Phosphorus, Total (Average Seasonal Load Cap)	lbs/day	Oct	7.48	-	2/week	Calculated

Table A- 40. CT DEEP Municipal NPDES Draft Permit for Plymouth. Nitrogen and Phosphorus Limits

Location: Plymouth			Receiving Stream: Pequabuck River			
Flow/Time Based monitoring						
Parameter	Units	Month	Avg monthly limit	Max daily limit	Sample Freq.	Sample Type
Nitrogen, Ammonia (total as N)	mg/l	Jan-Feb	6	-	3/week	Daily composite
	mg/l	Mar-Apr	9	-	3/week	Daily composite
	mg/l	May	8	-	3/week	Daily composite
	mg/l	June	4	-	3/week	Daily composite
	mg/l	July-Sept	2.5	-	3/week	Daily composite
	mg/l	Oct	4	-	3/week	Daily composite
	mg/l	Nov-Dec	5	-	3/week	Daily composite
Nitrogen, Nitrate (total as N)	mg/l	-	NA	-	Monthly	Daily composite
Nitrogen, Nitrite (total as N)	mg/l	-	NA	-	Monthly	Daily composite
Nitrogen, Total Kjeldahl	mg/l	-	NA	-	Monthly	Daily composite
Nitrogen, Total	mg/l	-	NA	-	Monthly	Daily composite
Nitrogen, Total	lbs/day	-	NA	-	Monthly	Daily composite
Phosphorus, Total	mg/l	Apr 1st -Oct 31st	0.78	1.56	2/week	Daily composite
Phosphorus, Total	mg/l	Nov 1st - Mar31st	NA	-	Monthly	Daily composite
Phosphorus, Total	lbs/day	Apr 1st -Oct 31st	-	-	Weekly	Daily composite
Phosphorus, Total (Average Seasonal Load Cap)	lbs/day	Oct	-	NA	Weekly	Calculated

Table A- 41. CT DEEP NPDES Permit for Simsbury. Nitrogen and Phosphorus Limits

Location: Simsbury			Receiving Stream: Farmington River			
Flow/Time Based monitoring						
Parameter	Units	Month	Avg monthly limit	Max daily limit	Sample Freq.	Sample Type
Nitrogen, Ammonia (total as N)	mg/l	-	NA	-	Monthly	Daily composite
Nitrogen, Nitrate (total as N)	mg/l	-	NA	-	Monthly	Daily composite
Nitrogen, Nitrite (total as N)	mg/l	-	NA	-	Monthly	Daily composite
Nitrogen, Total Kjeldahl	mg/l	-	NA	-	Monthly	Daily composite
Nitrogen, Total	mg/l	-	NA	-	Monthly	Daily composite
Nitrogen, Total	lbs/day	-	NA	-	Monthly	Daily composite
Phosphorus, Total	mg/l	May-Sept	NA	-	Monthly	Daily composite

Table A- 42. CT DEEP Municipal NPDES Permit for Canton. Nitrogen and Phosphorus Limits

Location: Canton			Receiving Stream: Farmington River			
Flow/Time Based monitoring						
Parameter	Units	Month	Avg monthly limit	Max daily limit	Sample Freq.	Sample Type
Nitrogen, Ammonia (total as N)	mg/l	-	NA	-	Monthly	Daily composite
Nitrogen, Nitrate (total as N)	mg/l	-	NA	-	Monthly	Daily composite
Nitrogen, Nitrite (total as N)	mg/l	-	NA	-	Monthly	Daily composite
Nitrogen, Total Kjeldahl	mg/l	-	NA	-	Monthly	Daily composite
Nitrogen, Total	mg/l	-	NA	-	Monthly	Daily composite
Nitrogen, Total	lbs/day	-	NA	-	Monthly	Daily composite
Phosphorus, Total	mg/l	Apr 1st -Oct 31st	NA	-	Weekly	Daily composite
Phosphorus, Total	mg/l	Nov 1st - Mar31st	NA	-	Monthly	Daily composite
Phosphorus, Total (Average Seasonal Load Cap)	lbs/day	October	24.8	NA	Monthly	Daily composite

Table A- 43. CT DEEP NPDES Permit for New Hartford. Nitrogen and Phosphorus Limits

Location: New Hartford			Receiving Stream: Farmington River			
Flow/Time Based monitoring						
Parameter	Units	Month	Avg monthly limit	Max daily limit	Sample Freq.	Sample Type
Nitrogen, Ammonia (total as N)	mg/l	-	NA	-	Monthly	Daily composite
Nitrogen, Nitrate (total as N)	mg/l	-	NA	-	Monthly	Daily composite
Nitrogen, Nitrite (total as N)	mg/l	-	NA	-	Monthly	Daily composite
Nitrogen, Total Kjeldahl	mg/l	-	NA	-	Monthly	Daily composite
Nitrogen, Total	mg/l	-	NA	-	Monthly	Daily composite
Nitrogen, Total	lbs/day	-	NA	-	Monthly	Daily composite
Nitrogen, Total	lbs/day	12 mo rolling avg	13.3	-	Monthly	Daily composite
Phosphorus, Total	lbs/day	Apr 1st -Oct 31st	-	NA	Monthly	Daily composite
Phosphorus, Total (Average Seasonal Load Cap)	lbs/day	Oct	10.92	NA	Monthly	Calculated

Table A- 44. CT DEEP Municipal NPDES Permit for Winchester. Nitrogen and Phosphorus Limits

Location: Winchester			Receiving Stream: Still River			
Flow/Time Based monitoring						
Parameter	Units	Month	Avg monthly limit	Max daily limit	Sample Freq.	Sample Type
Nitrogen, Ammonia (total as N)	mg/l	Jan	7.2	18	3/week	Daily composite
	mg/l	Feb	9	23	3/week	Daily composite
	mg/l	Mar	11.7	29	3/week	Daily composite
	mg/l	Apr	17.2	43	3/week	Daily composite
	mg/l	May	7.7	21	3/week	Daily composite
	mg/l	June	3.2	9	3/week	Daily composite
	mg/l	July	1.3	3.5	3/week	Daily composite
	mg/l	Aug	1.3	3.5	3/week	Daily composite
	mg/l	Sept	1.3	3.5	3/week	Daily composite
	mg/l	Oct	3.8	10	3/week	Daily composite
	mg/l	Nov	5.1	13	3/week	Daily composite
	mg/l	Dec	7.2	18	3/week	Daily composite
Nitrogen, Nitrate (total as N)	mg/l	-	NA	-	Monthly	Daily composite
Nitrogen, Nitrite (total as N)	mg/l	-	NA	-	Monthly	Daily composite
Nitrogen, Total Kjeldahl	mg/l	-	NA	-	Monthly	Daily composite
Nitrogen, Total	mg/l	-	NA	-	Monthly	Daily composite
Nitrogen, Total	lbs/day	-	NA	-	Monthly	Daily composite
Phosphorus, Total	mg/l	Apr 1st -Oct 31st	2.31	4.63	Weekly	Daily composite
Phosphorus, Total	mg/l	Nov 1st - Mar31st	-	-	Monthly	Daily composite
Phosphorus, Total	lbs/day	Apr 1st -Oct 31st	-	-	Weekly	Daily composite
Phosphorus, Total (Average Seasonal Load Cap)	lbs/day	October	-	-	Weekly	Calculated

Figure A- 1. Temperature and Oxygen profile at Station 1 on 6/22/23.

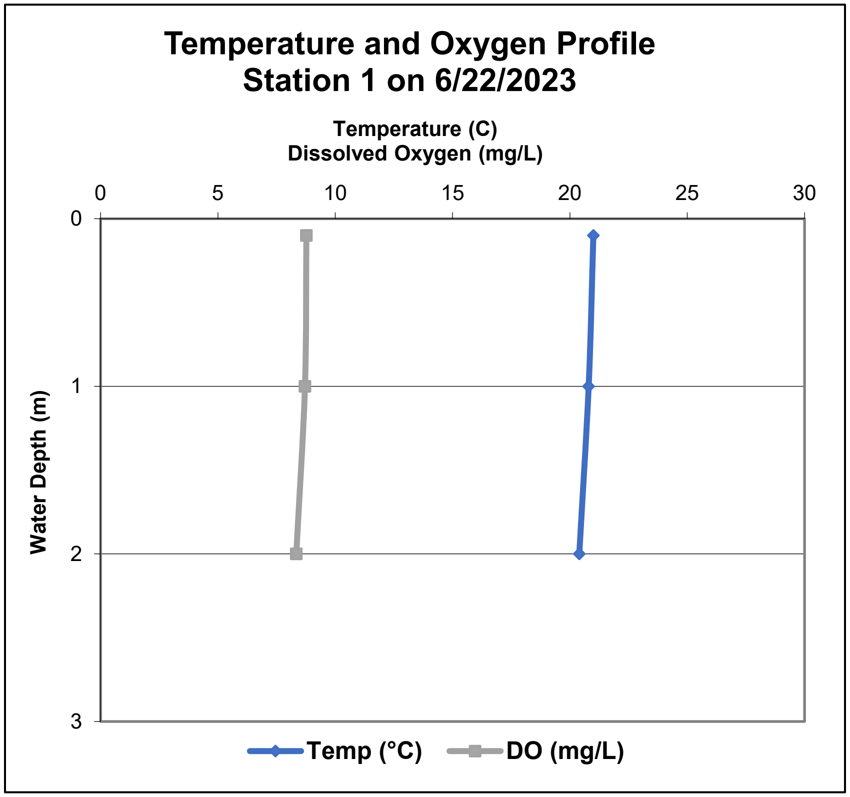


Figure A- 2. Temperature and Oxygen profile at Station 1 on 6/29/23.

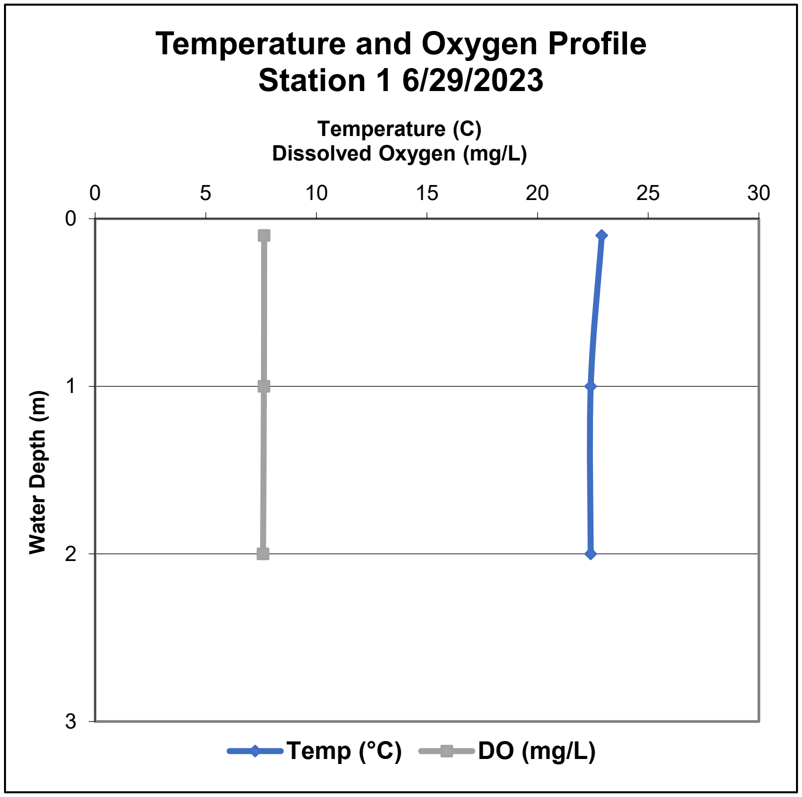


Figure A- 3. Temperature and Oxygen profile at Station 1 on 7/13/23.

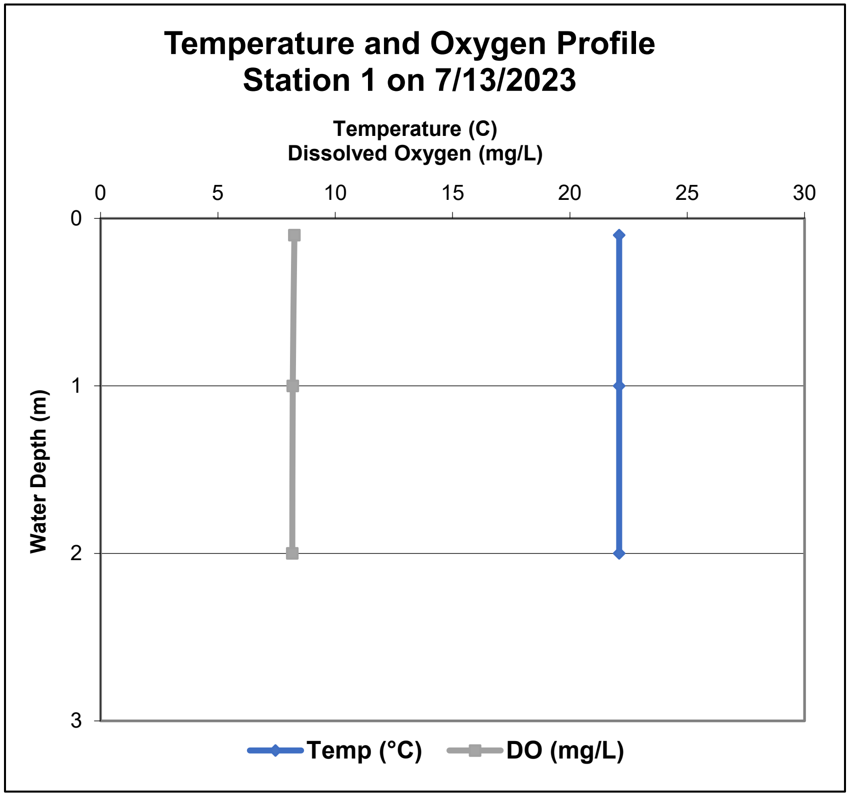


Figure A- 4. Temperature and Oxygen profile at Station 1 on 7/27/23.

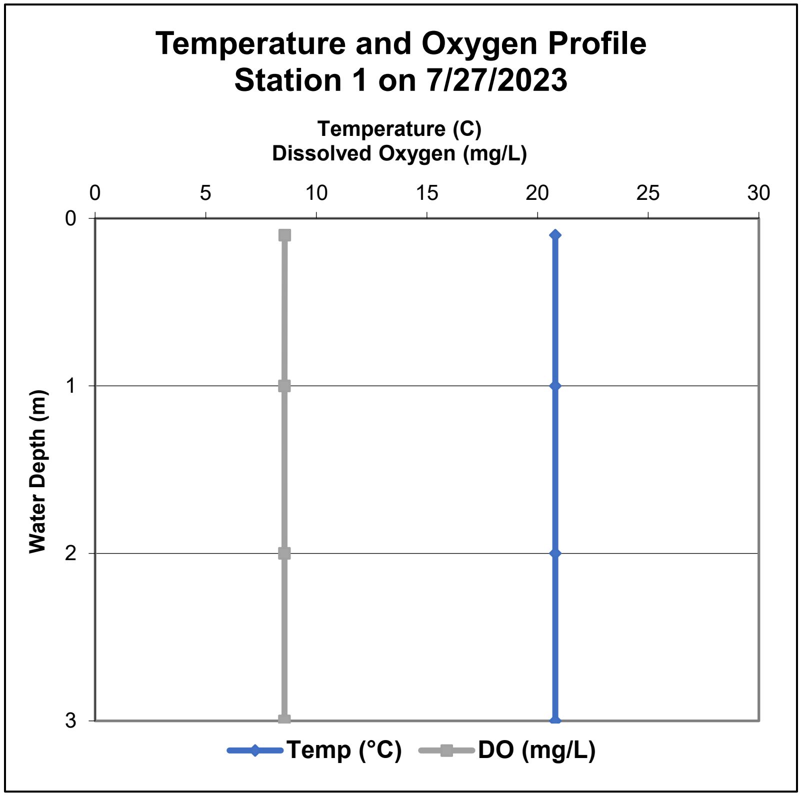


Figure A- 5. Temperature and Oxygen profile at Station 1 on 8/10/23.

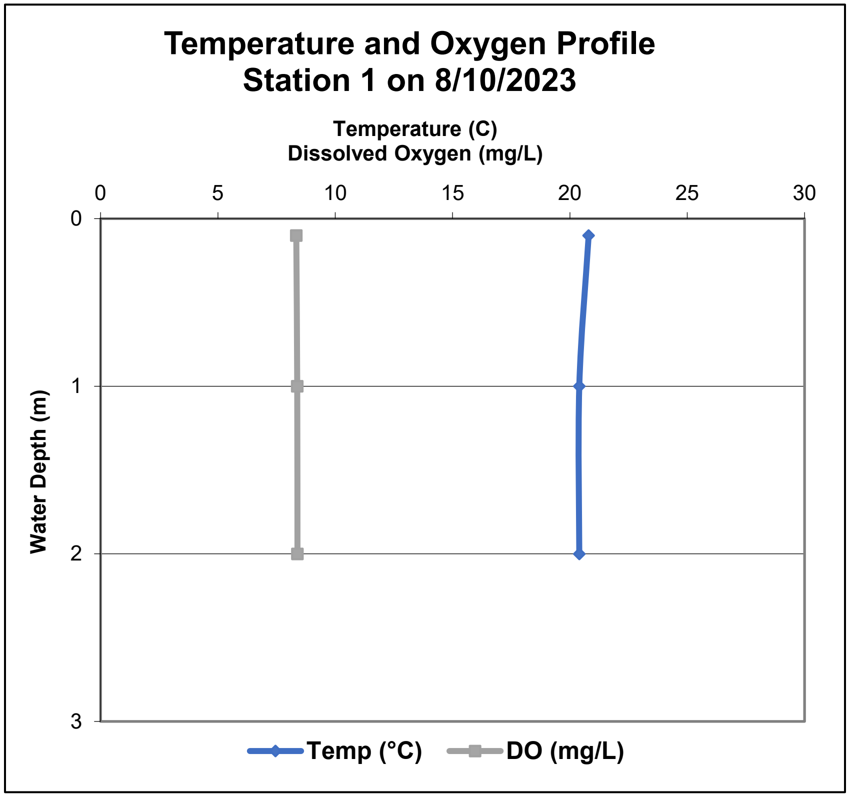


Figure A- 6. Temperature and Oxygen profile at Station 1 on 8/24/23.

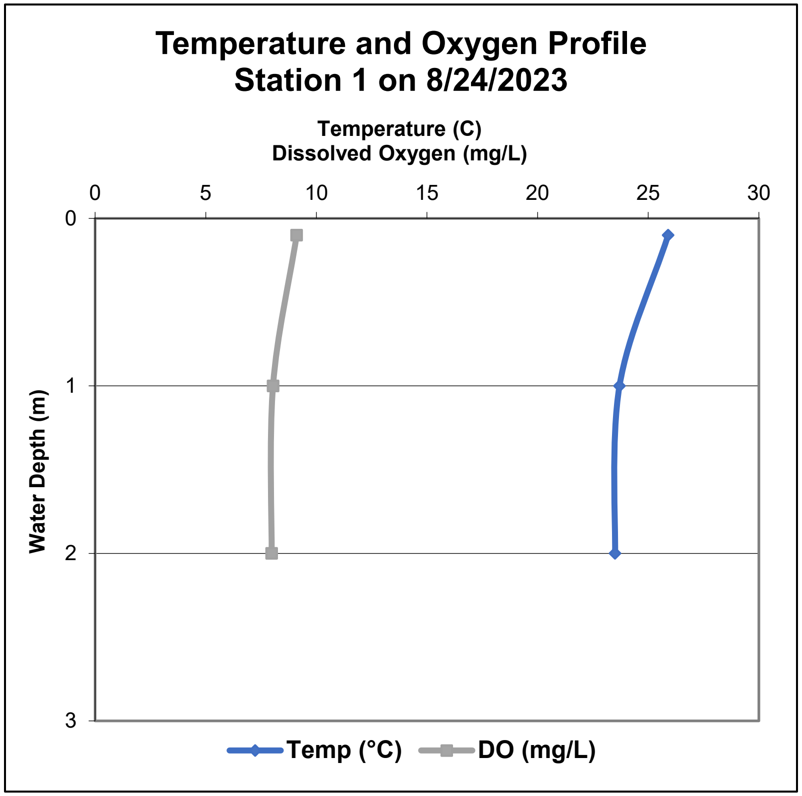


Figure A- 7. Temperature and Oxygen profile at Station 1 on 9/7/23.

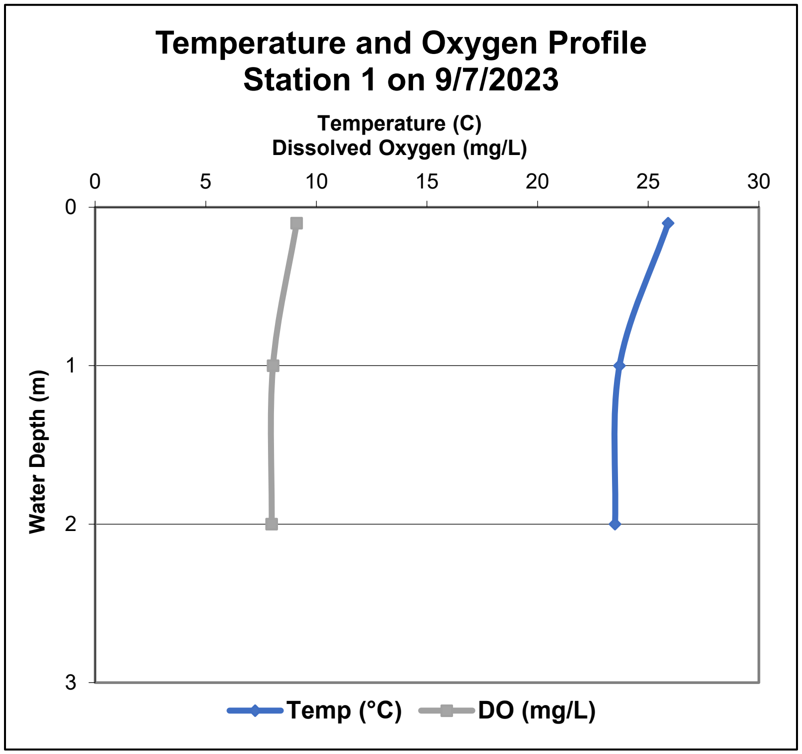


Figure A- 8. Temperature and Oxygen profile at Station 2 on 6/22/23.

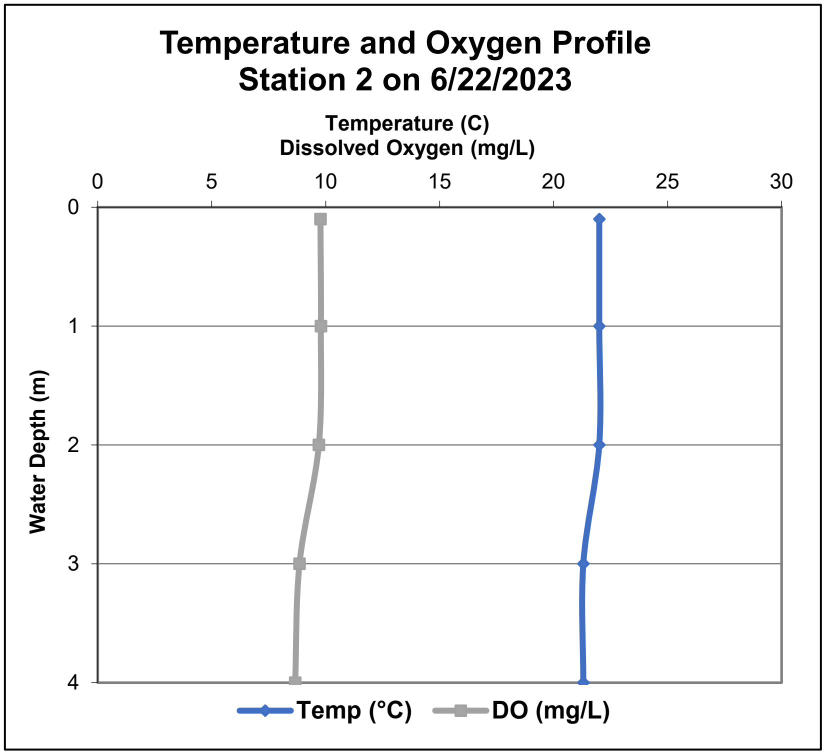


Figure A- 9. Temperature and Oxygen profile at Station 2 on 6/29/23.

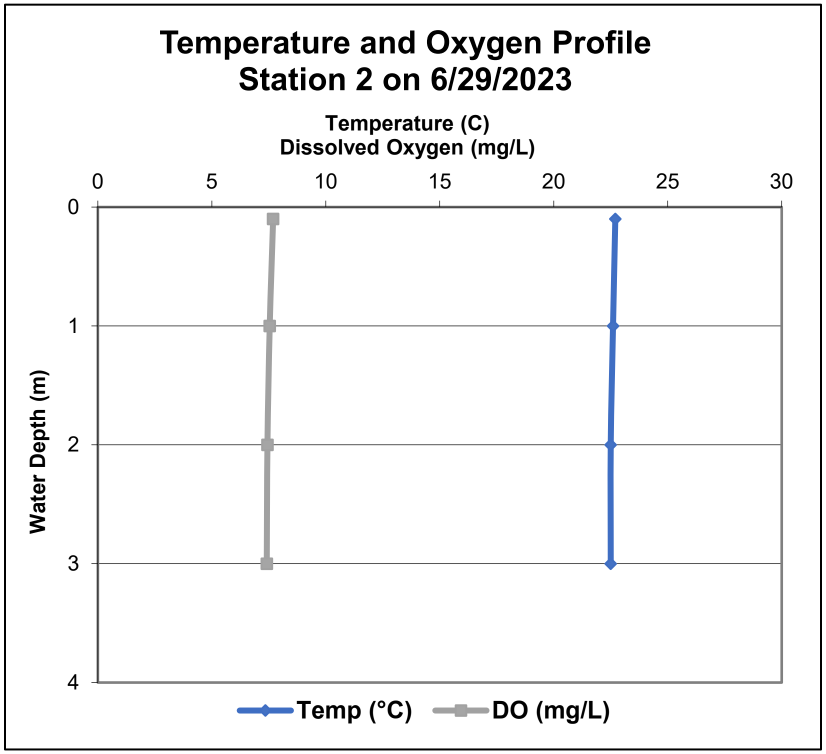


Figure A- 10. Temperature and Oxygen profile at Station 2 on 7/13/23.

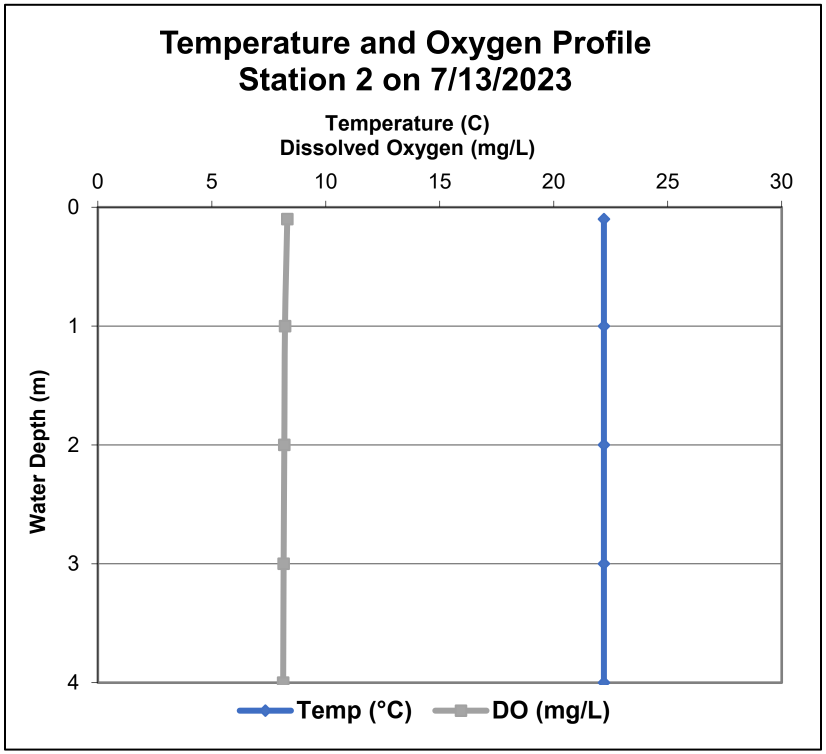


Figure A- 11. Temperature and Oxygen profile at Station 2 on 7/27/23.

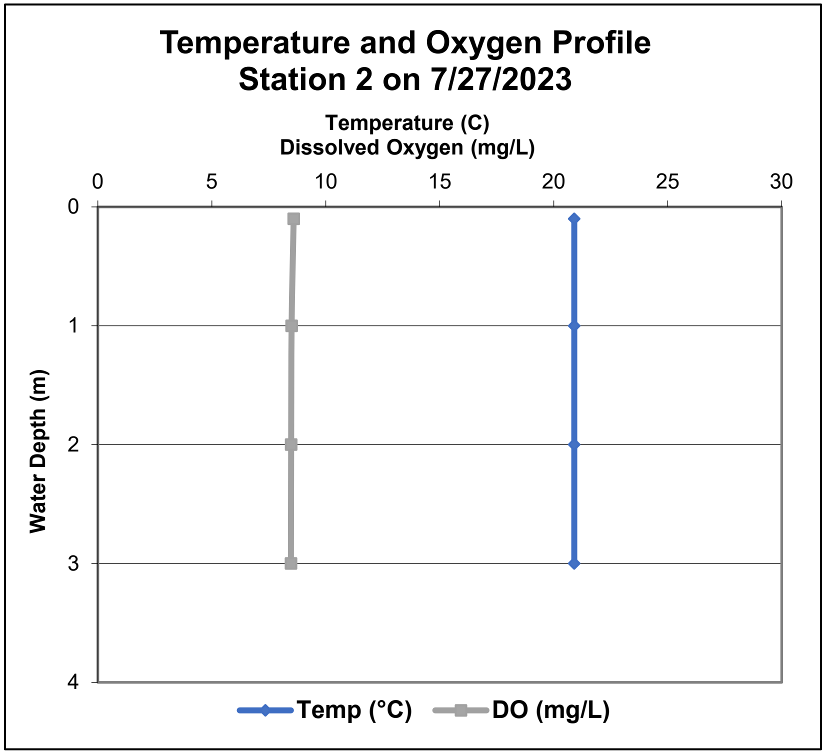


Figure A- 12. Temperature and Oxygen profile at Station 2 on 8/10/23.

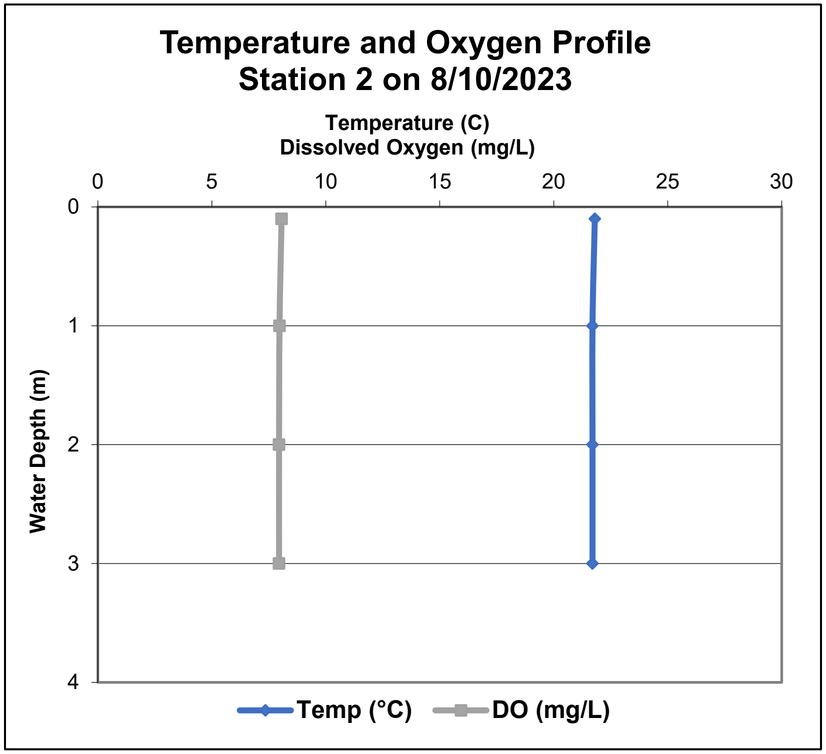


Figure A- 13. Temperature and Oxygen profile at Station 2 on 8/24/23.

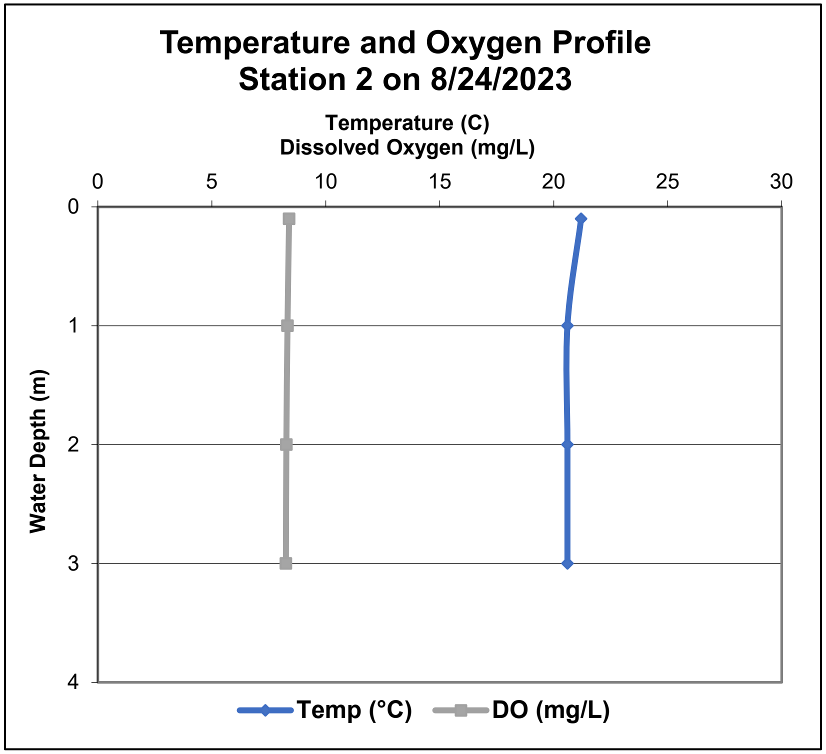


Figure A- 14. Temperature and Oxygen profile at Station 2 on 9/7/23.

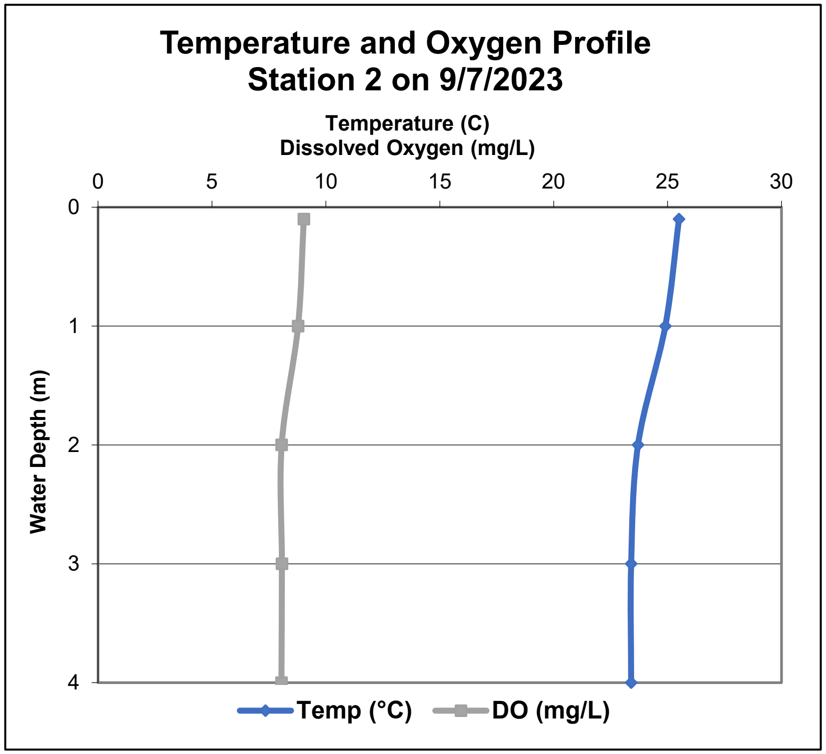


Figure A- 15. Temperature and Oxygen profile at Station 3 on 6/22/23.

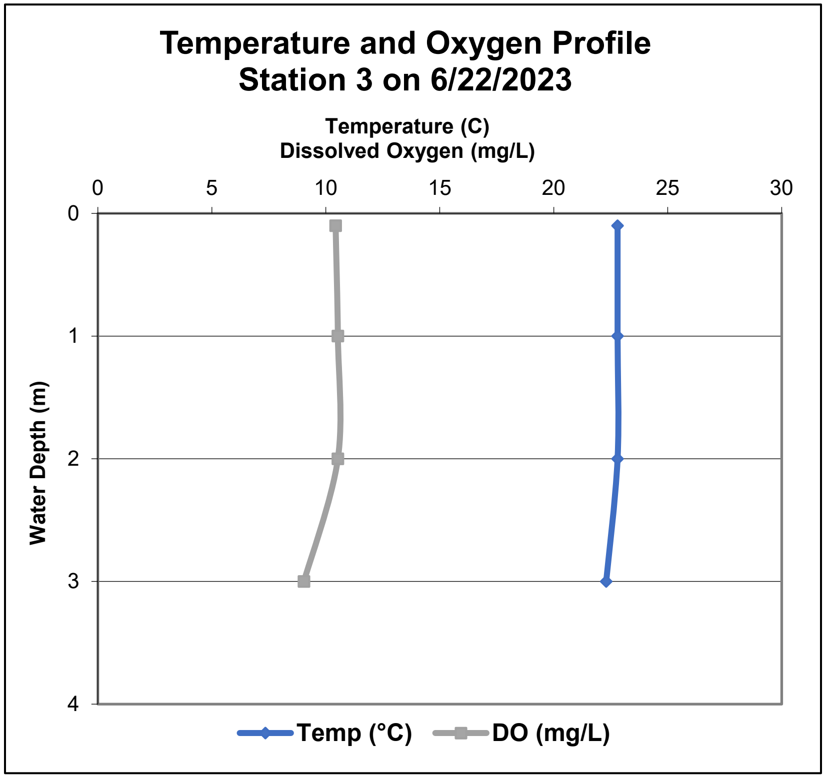


Figure A- 16. Temperature and Oxygen profile at Station 3 on 6/29/23.

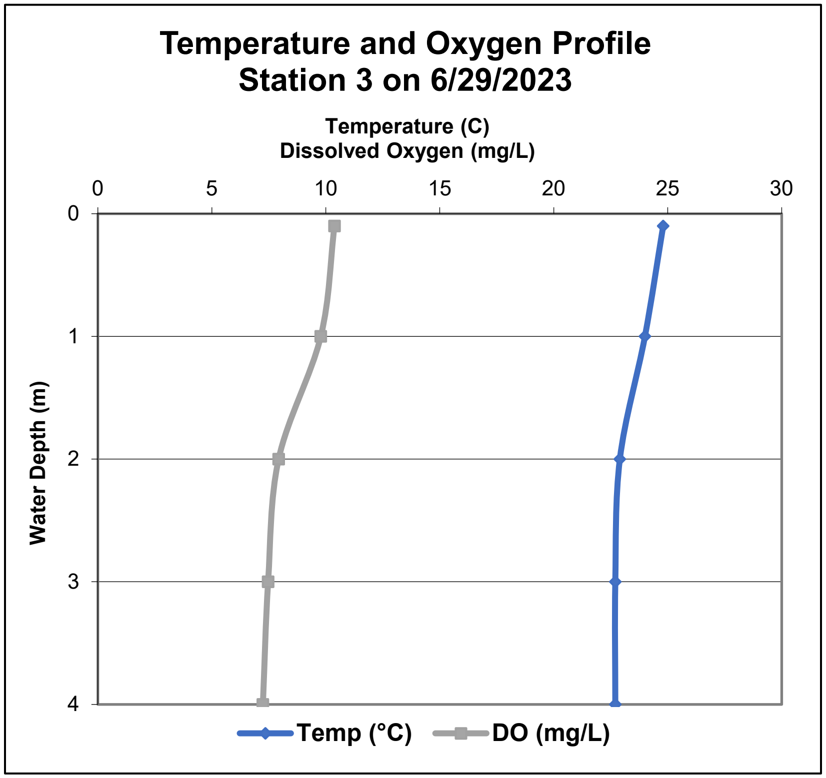


Figure A- 17. Temperature and Oxygen profile at Station 3 on 7/13/23.

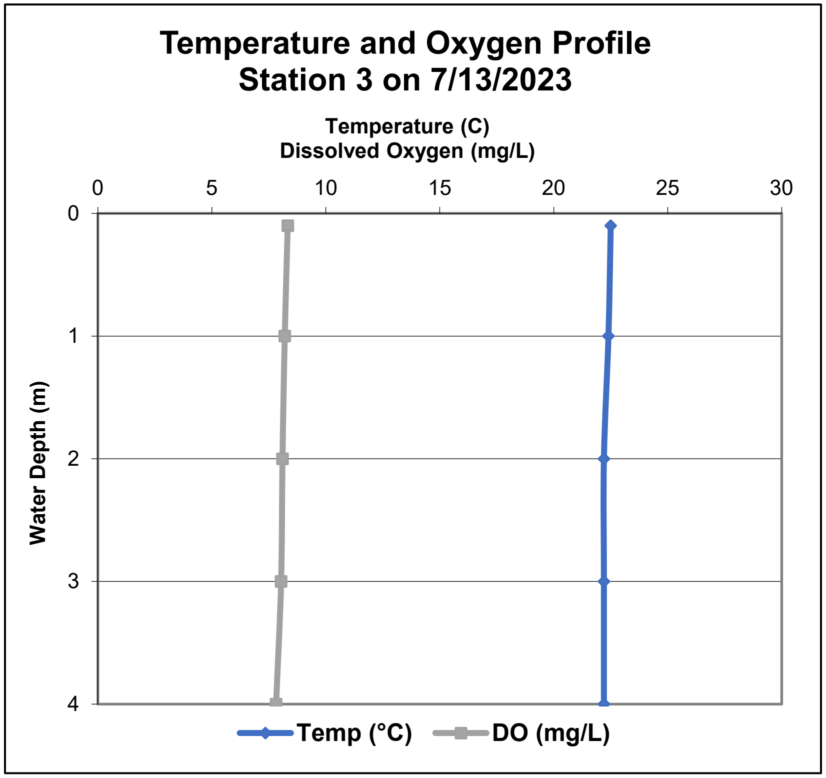


Figure A- 18. Temperature and Oxygen profile at Station 3 on 7/27/23.

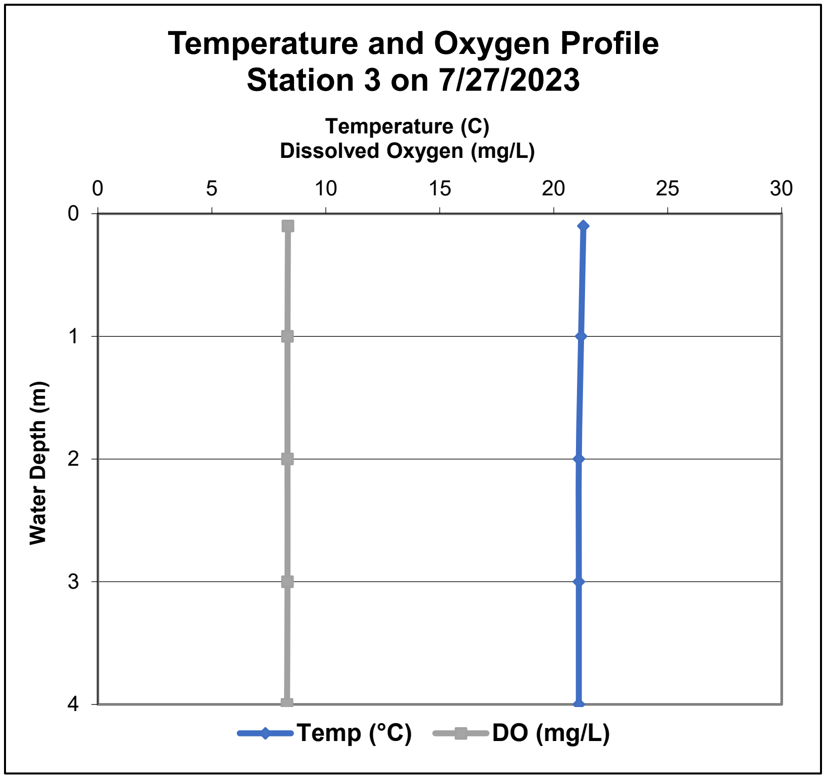


Figure A- 19. Temperature and Oxygen profile at Station 3 on 8/10/23.

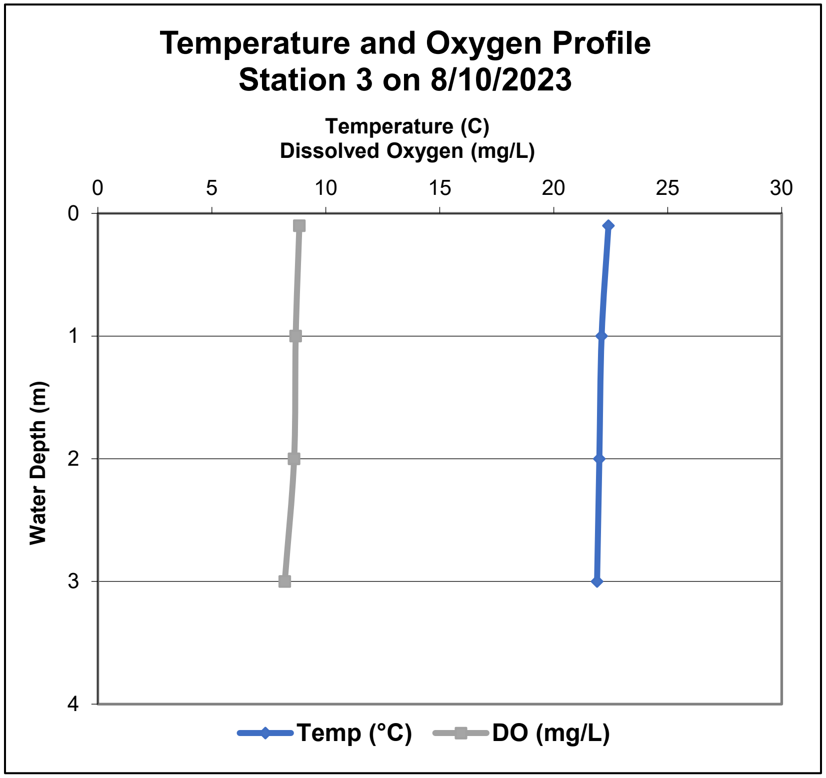


Figure A- 20. Temperature and Oxygen profile at Station 3 on 8/24/23.

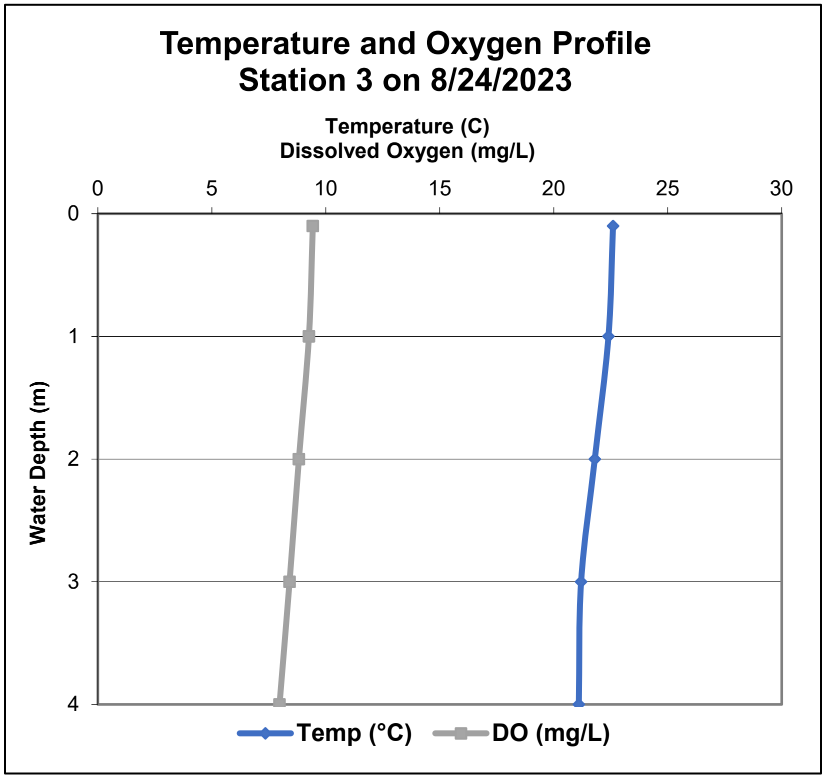


Figure A- 21. Temperature and Oxygen profile at Station 3 on 9/7/23.

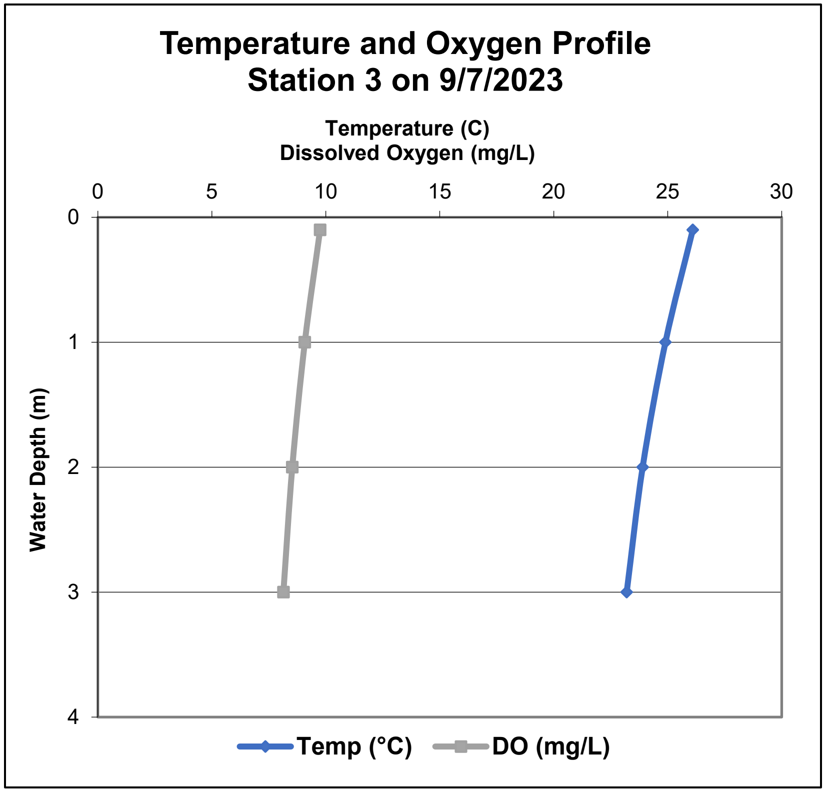


Figure A- 22. Temperature and Oxygen profile at Station 4 on 6/22/23.

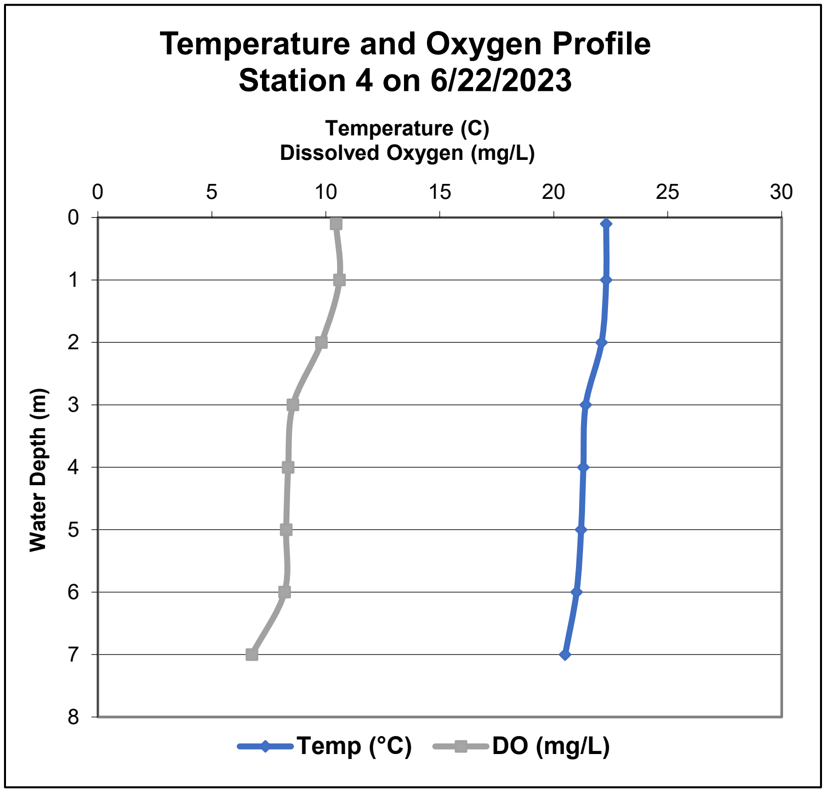


Figure A- 23. Temperature and Oxygen profile at Station 4 on 6/29/23.

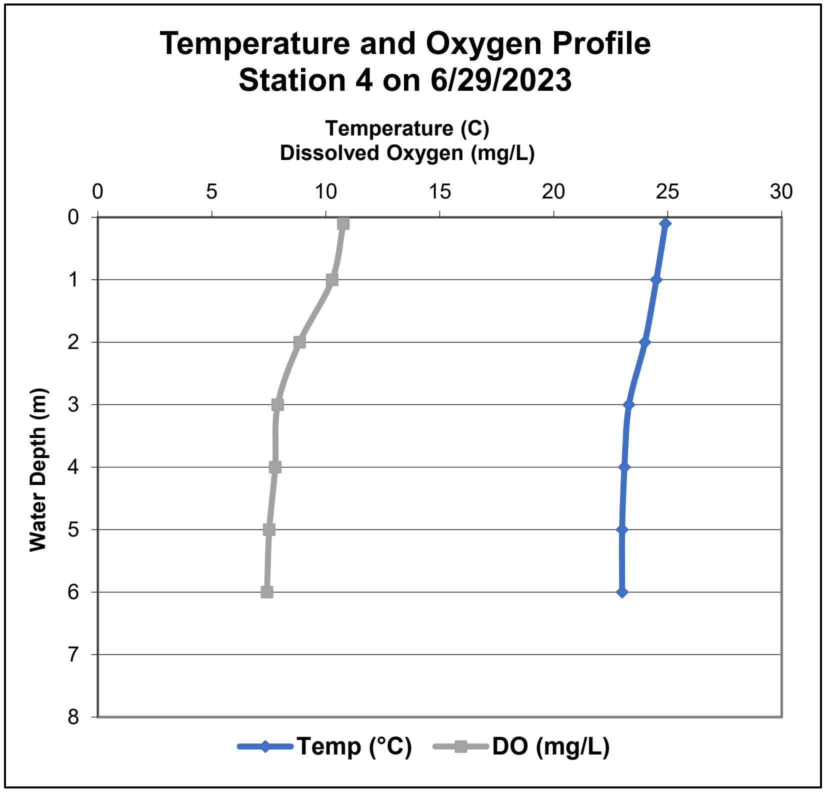


Figure A- 24. Temperature and Oxygen profile at Station 4 on 7/13/23.

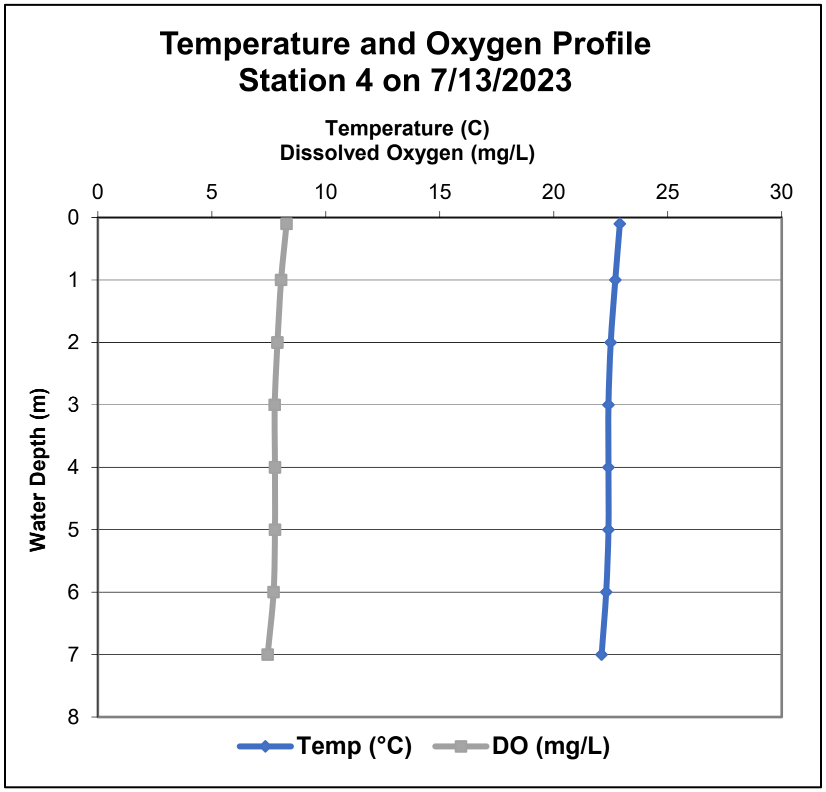


Figure A- 25. Temperature and Oxygen profile at Station 4 on 7/27/23.

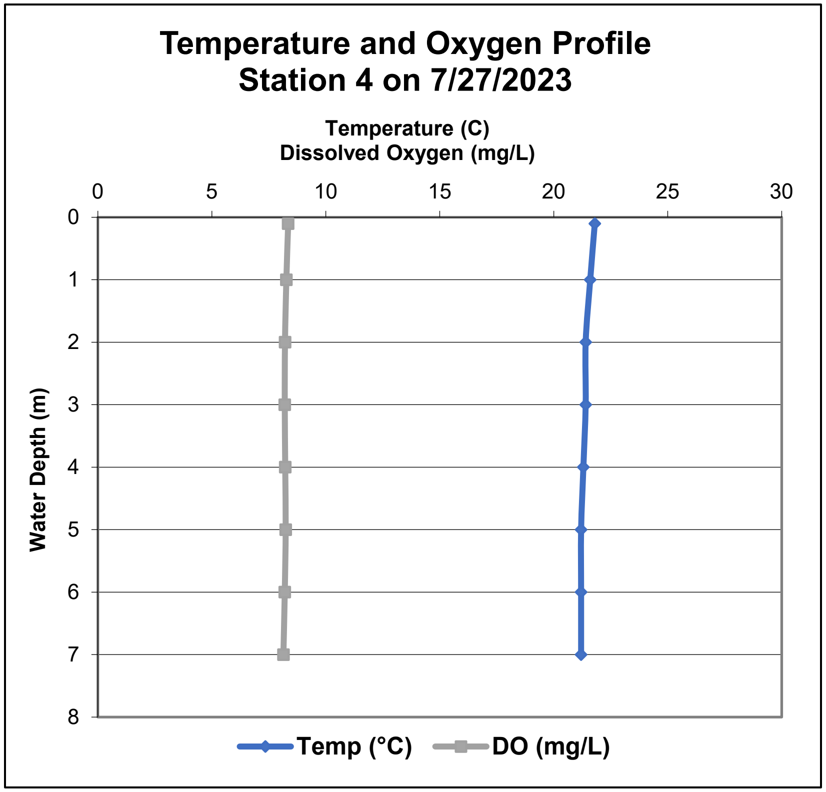


Figure A- 26. Temperature and Oxygen profile at Station 4 on 8/10/23.

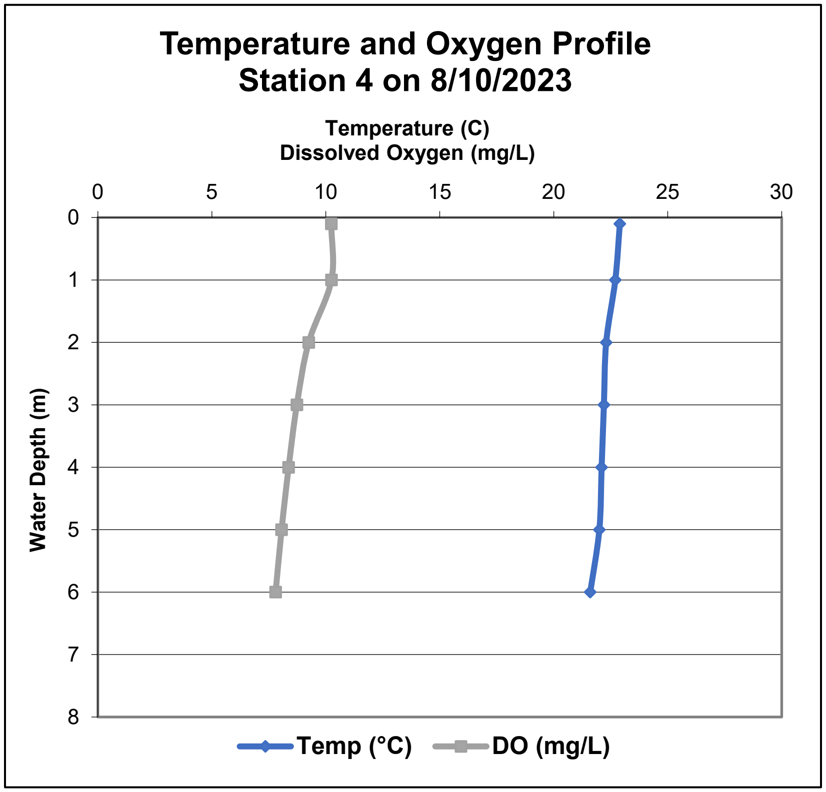


Figure A- 27. Temperature and Oxygen profile at Station 4 on 8/24/23.

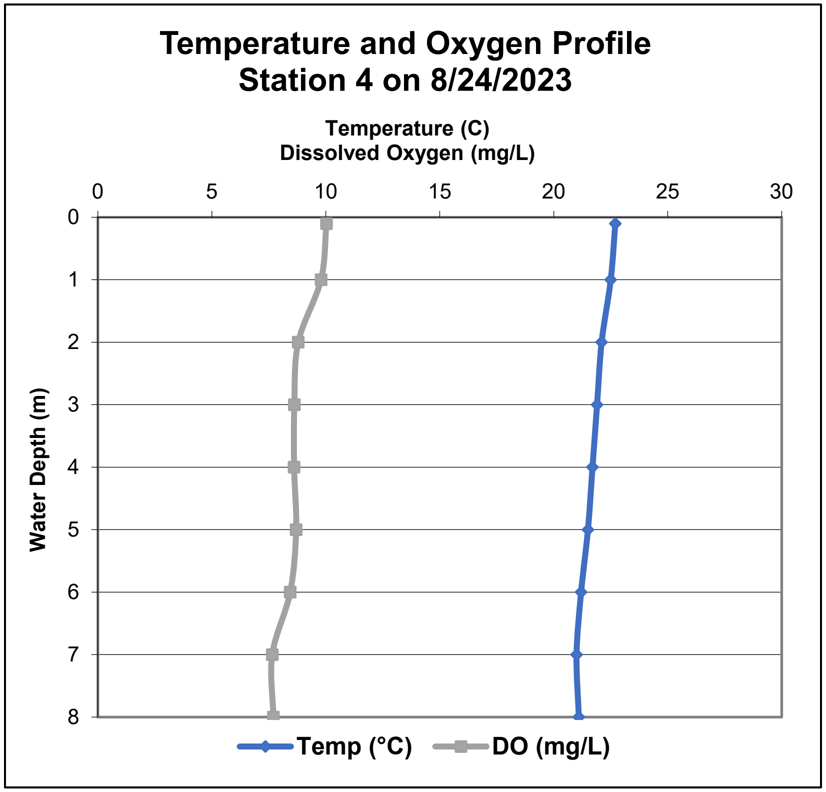


Figure A- 28. Temperature and Oxygen profile at Station 4 on 9/7/23.

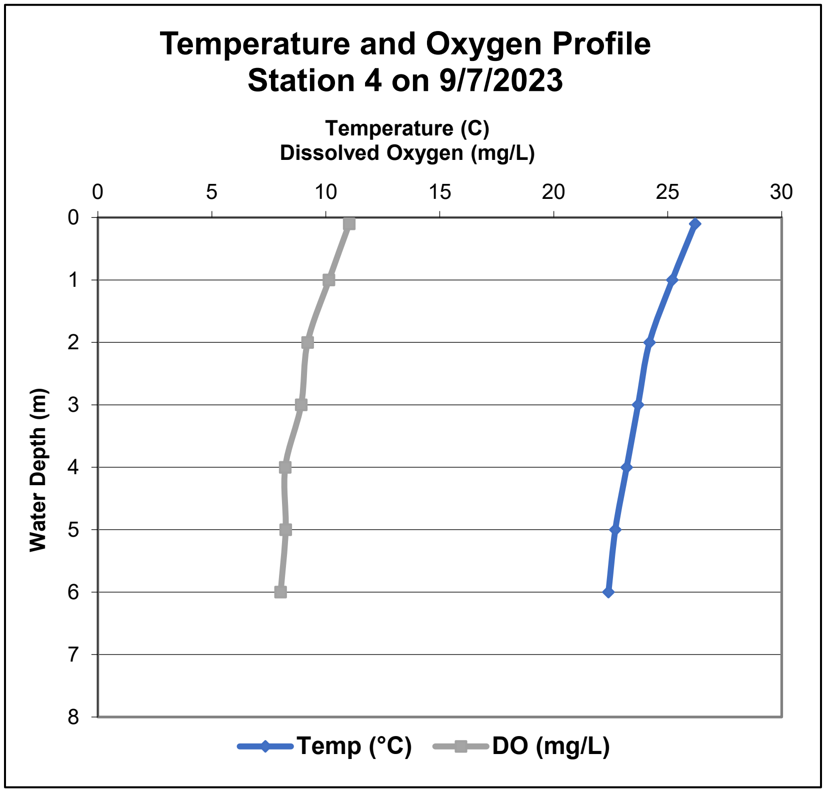


Figure A- 29. Temperature and Oxygen profile at Station 5 on 6/22/23.

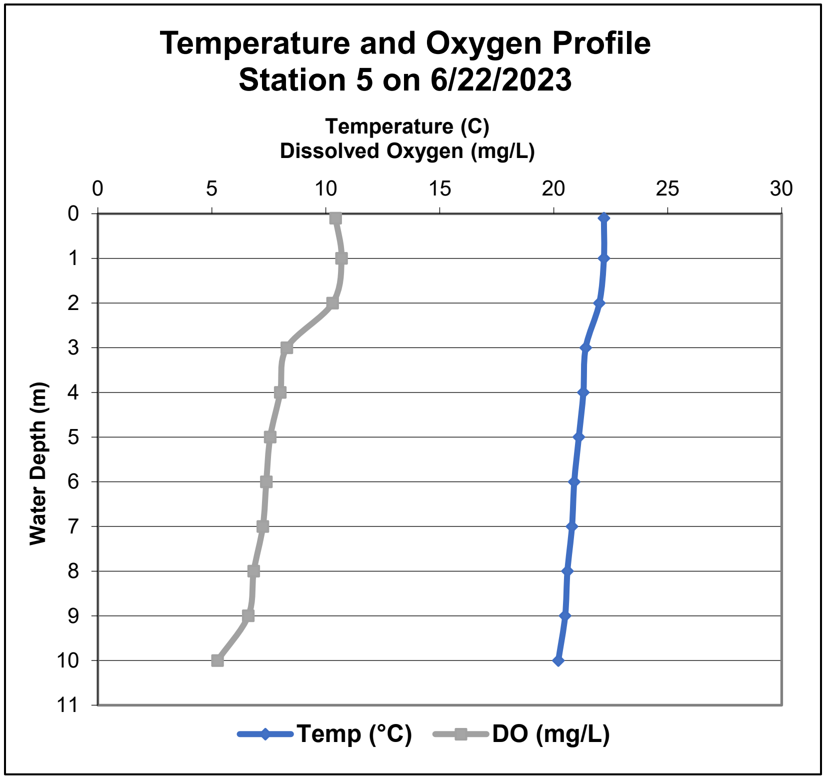


Figure A- 30. Temperature and Oxygen profile at Station 5 on 6/29/23.

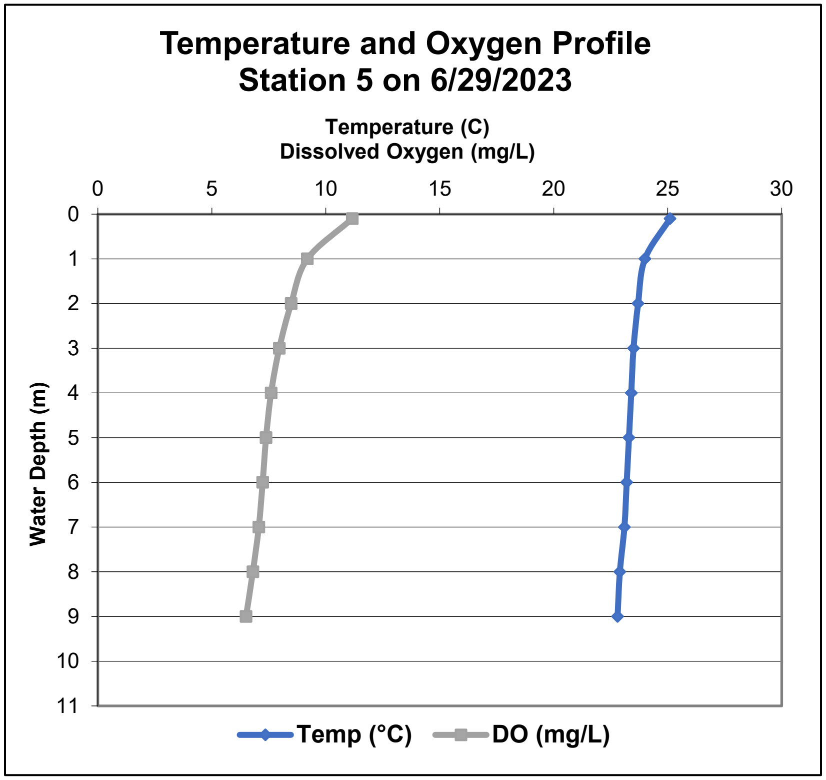


Figure A- 31. Temperature and Oxygen profile at Station 5 on 7/13/23.

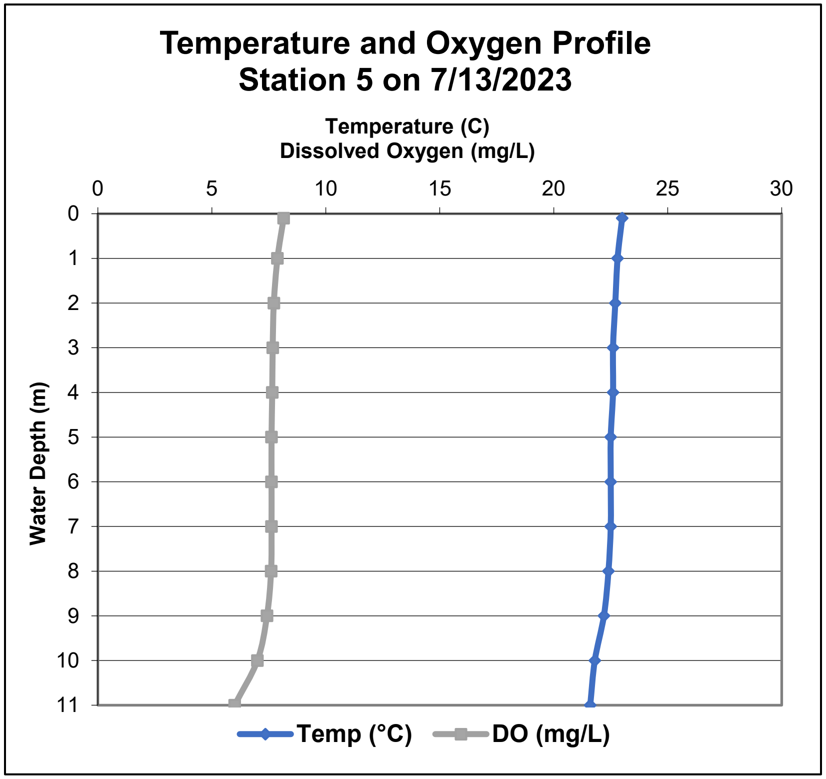


Figure A- 32. Temperature and Oxygen profile at Station 5 on 7/27/23.

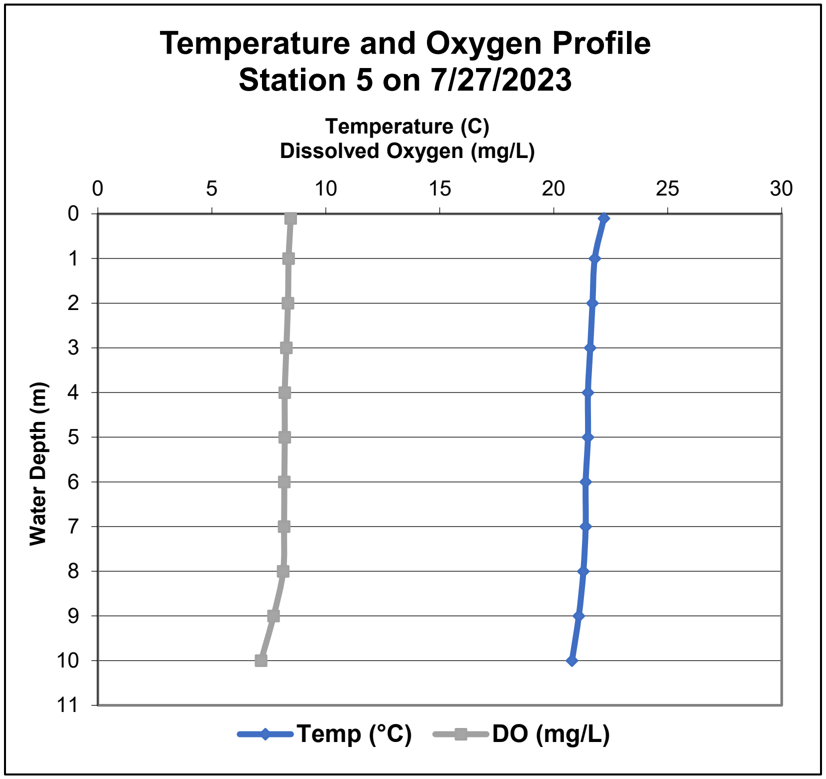


Figure A- 33. Temperature and Oxygen profile at Station 5 on 8/10/23.

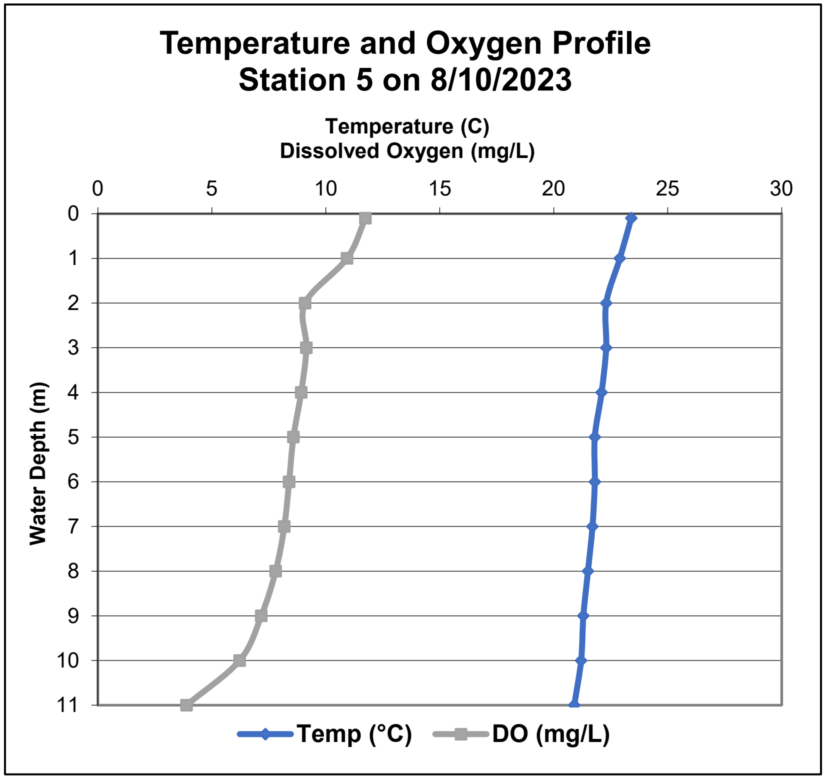


Figure A- 34. Temperature and Oxygen profile at Station 5 on 8/24/23.

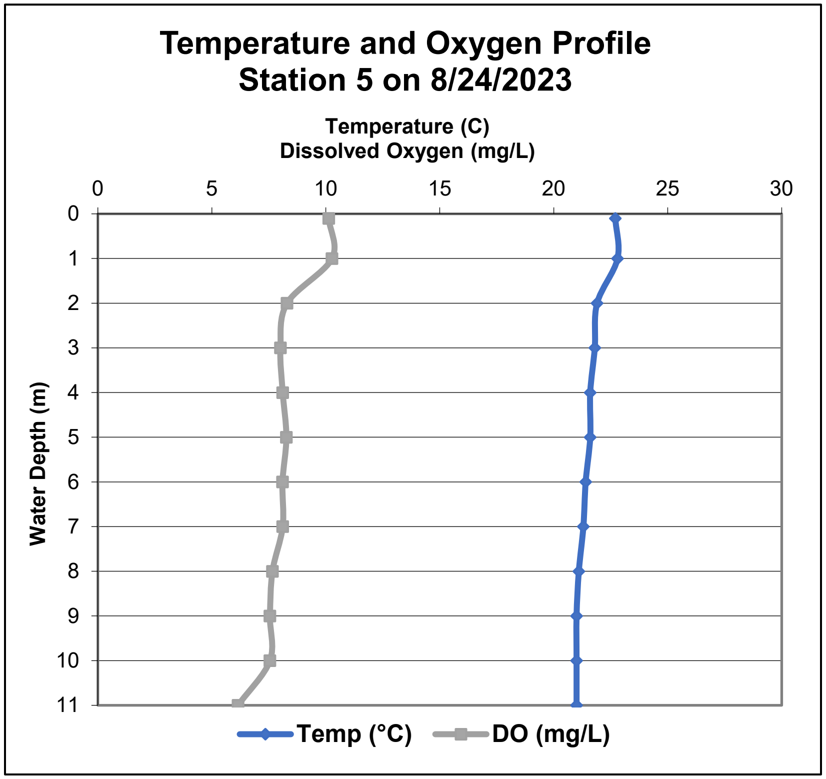


Figure A- 35. Temperature and Oxygen profile at Station 5 on 9/7/23.