Water Quality near Maxcys Mills, West Branch Sheepscot River, Windsor, Maine

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Remnant dam at Maxcys Mills

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Introduction

Despite the restoration efforts of numerous groups since the 1970s, the population size of Atlantic salmon (*Salmo salar*) in Maine has remained low (USASAC 2025). According to the 2018 recovery plan for Gulf of Maine Atlantic salmon, freshwater conservation is the second action listed to restore populations (USFWS and NMFS 2018). This includes maintaining and improving habitat complexity and optimal water quality. Midcoast Conservancy is leading a project to remove a remnant dam on the West Branch Sheepscot River at Maxcys Mills (also known as Sprouls Mill), where a dam was built in 1809 to run a sawmill and later a gristmill and shingle mill. The dam was blown out by storm flows some time after 1950 but the remaining rubble pile enhances a 2-mile low-gradient (0.1%) section of the river (Strouse 2013). Removal of small, surface-spill dams (or their remnants) typically results in increased resiliency to the effects of climate change, including improvements in water quality such as decreased temperatures and increased dissolved oxygen concentrations (Abbott et al. 2022; Paukert et al. 2021; Poff et al. 2002; Zaidel 2018; Zaidel et al. 2021). To characterize water quality conditions around the remnant dam, environmental monitoring was conducted by Midcoast Conservancy and the Maine Department of Environmental Protection (MDEP) during four summers from 2018-2025. This report summarizes existing water quality.

Methods

Study Location

West Branch Sheepscot River originates at the mouth of Branch Pond in Palermo and flows to the mainstem of the Sheepscot River in Whitefield, flowing through the homeland of the Nanrantsouak (Norridgewock) Tribe of Wabanaki (Native Land Digital, 2026). The river is assigned the Statutory Class of AA (the highest designation) under Maine's Water Classification Program (38 M.R.S.§§ 464). The 51-square-mile watershed is non-developed (91.8%), primarily consisting of forest (59.7%) and wetlands (17%), with some agricultural and residential use (Dewitz 2023). The

Sheepscot River watershed is home to the southernmost distinct genetic population of endangered Atlantic salmon, likely making it the most thermally tolerant population to warming waters as a result of climate change, however only 16 adults returned to the watershed in 2024, with two redds found in the West Branch (USASAC 2025). Data were collected within the impounded reach, immediately upstream of the remnant dam (SHP17-A and MM_US_18), and in riffles downstream to Maxcys Mill Rd, as well as at a site 7.5 km further downstream at Howe Rd. (Fig. 1; see Appendix I Table I-1 for site descriptions).

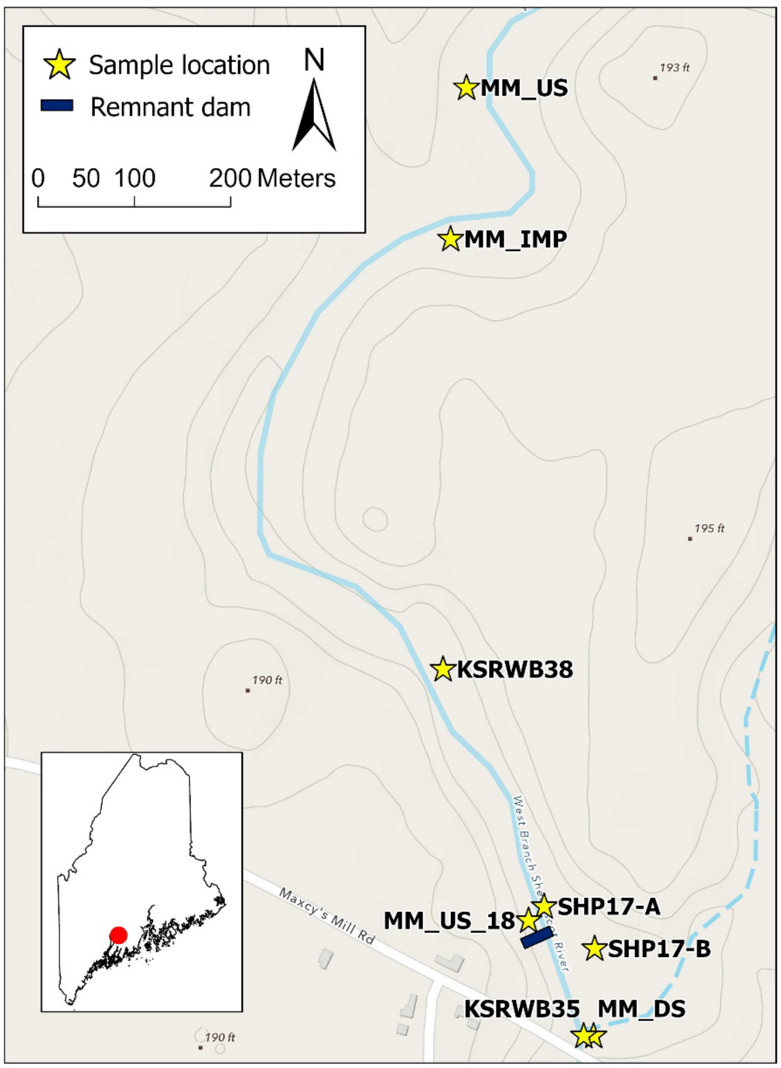

Figure 1. *Map of the sampling locations on the West Branch Sheepscot River near Maxcys Mills. The Howe Rd. sampling location is 7.5km further downstream.*

Water Quality

Continuous data loggers collected temperature and dissolved oxygen data every 10-30 minutes. Continuous data were corrected as needed based on quality control procedures as described in MDEP (2016) and using a sonde as a reference field meter (Eureka Manta2 Sub2 or YSI ProODO meter). Discrete measurements of pH and specific conductance were collected every three weeks in 2025. Surface grab samples for calcium, dissolved organic carbon, acid neutralization capacity and nutrients (nitrate + nitrite, total Kjeldahl nitrogen, and total phosphorus) were collected in 2025 following the methods in Zimmermann (2018), and compared to samples collected since 2000 throughout the watershed. In addition, a vertical profile of discrete measurements of dissolved oxygen, temperature, pH, and specific conductance was collected in August in a deep portion of the impounded section. Macroinvertebrates and algae were collected downstream of the remnant dam in 2025, following the MDEP Biological Monitoring Program's sampling methods, however results were not yet available for this report (MDEP 2014).

Data Visualization and Analysis

Water quality data were analyzed using the Water Resources Database (WRDB) 8.0.0.20 (Wilson Engineering 2025) and R 4.4.1 (R Core Team 2024). All figures were created in WRDB. All data are presented as mean ± standard deviation (SD) unless otherwise noted. Durations of stressful events, based on thresholds for the protection of salmon and other aquatic life, were calculated based on how many consecutive data points exceeded the water quality threshold before recovery.

Results and Discussion

Dissolved Oxygen

Dissolved oxygen (DO) periodically dropped below the healthy range for fish (>7 mg/L) and below the Maine Water Quality Standard minimum criterion at all sites near Maxcys Mills for an average of 16% of the summer period (June 15 – Sept. 15; Fig. 2; Appendix II Tables II-1 and II-3; 38 M.R.S. §§ 465.2.B; Stanley and Trial 1995). DO at Howe Brook Rd. never exceeded the stress threshold, possibly due to aeration of the

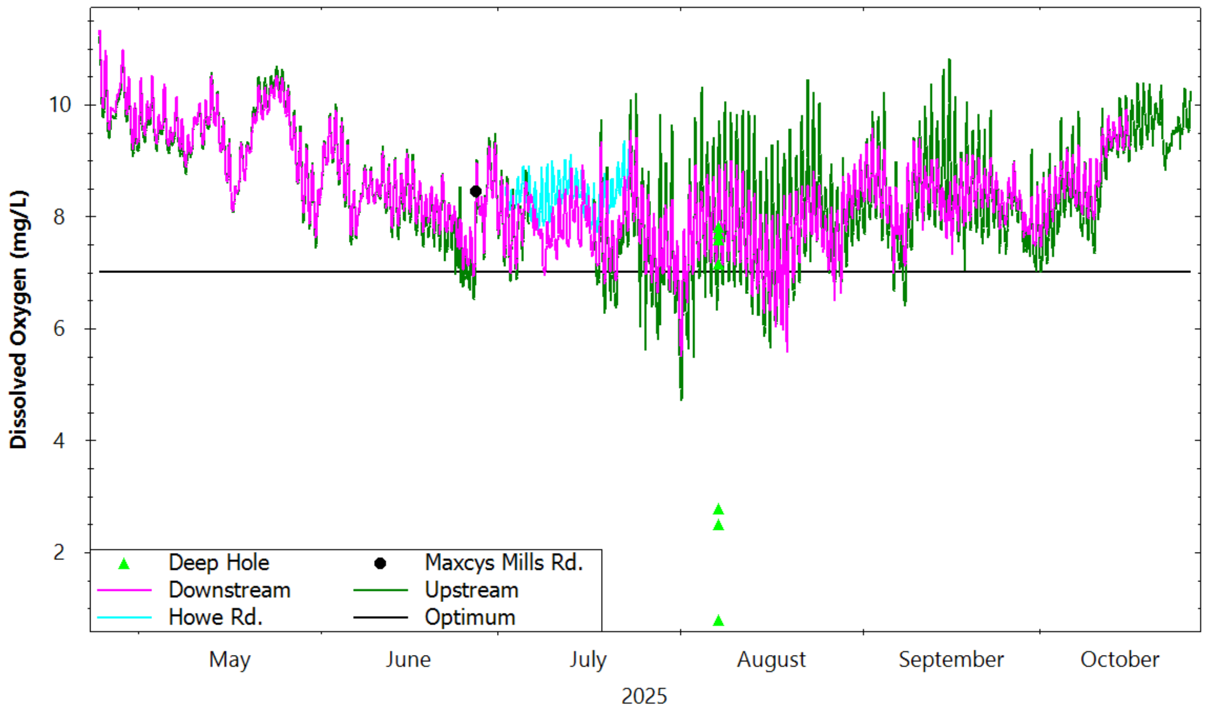

Figure 2. *Dissolved oxygen near Maxcys Mills and Howe Rd. on the West Branch Sheepscot River in 2025.*

stream water as it cascades over the bedrock ledges just upstream of the sampling site. Stressful DO conditions were most acute in 2018, with a maximum duration of 2.9 days, coinciding with the abnormally dry conditions (average flow 20 cfs; U.S. Drought Monitor, 2026). Flows were higher during the other study years (144 cfs on average), with stressful DO conditions lasting on average 6.6 hours, with a maximum duration of 21.5 hours in the impoundment in 2021, a year with moderate to severe drought (U.S. Drought Monitor, 2026).

All sites near Maxcys Mills had large diurnal ranges, with an average maximum of 3.6 mg/L. In contrast, the site at Howe Brook Rd. had much smaller diurnal swings, with a maximum of 1.1 mg/L. In general, diurnal range was greatest upstream of the remnant dam, possibly because of the slower flows and reduced shading from riparian vegetation due to the wide stream channel. The threshold of 5 mg/L, below which salmon experience acute physiological and behavioral stress, was only exceeded at three sites and not every year, for a total of <1% of the monitoring period (Appendix II

Table II-3; USEPA 1986). Average duration <5 mg/L was 1.6 hrs, with a maximum duration of 7 hrs upstream of Maxcys Mills. In the deepest section upstream of the remnant dam (3 m deep), DO was below the acute stress threshold in the bottom meter, coinciding with thermal stratification. DO conditions stressful for aquatic life occurred every year of the study and at all sites near Maxcys Mills. Near the confluence with the mainstem Sheepscot River, DO concentrations remained sufficient for aquatic life throughout the monitored summers.

Temperature

Temperatures near Maxcys Mills were similar across all years of the study and between all monitored sites, exceeding the stress threshold of 22°C for 53% of the summer period (June 15 – Sept. 15; Fig. 3; Appendix II Tables II-1 and II-3; Cunjak et al. 2005; Elliott and Elliott 2010; Lund et al. 2002). Stressful temperatures lasted on average 1.3 days, with a maximum duration of 24 days just above the remnant dam in 2018, an abnormally dry year (U.S. Drought Monitor, 2026). The survival threshold for salmon adults, 26-27°C, was exceeded at all sites, for a total of 4.3% of the summer

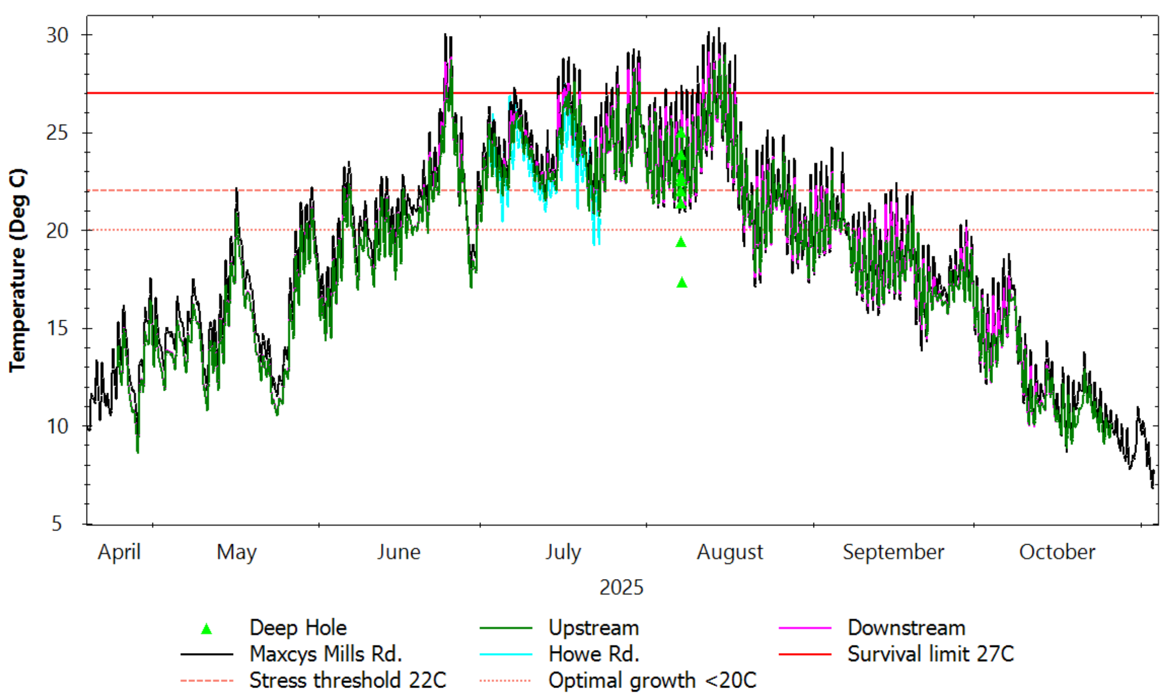

Figure 3. *Water temperature near Maxcys Mills and Howe Rd. on the West Branch Sheepscot River in 2025.*

period, lasting on average 7 hours (Appendix II Table II-3; Shepard 1995 as cited in Frechette et al. 2018). Maximum duration above the adult salmon survival threshold was 1.8 days just above the remnant dam in 2018. Temperature stratification occurred below 1m in the deep hole in the impoundment.

Maximum daily temperature range averaged 5.23°C. The largest observed daily range (7.07°C) occurred above the road bridge in 2025, however the logger was deployed near the edge of the stream and may have been more strongly influenced by air temperature due to the shallower water with slower flow as compared to the center of the channel. Although discharge and drought stage varied drastically between the study years (ranging from an average 20 cfs in abnormally dry 2018 to 196 cfs in 2023, a year with no drought), stream temperature did not vary significantly, indicating that other factors such as air temperature and solar gain may have a stronger influence on water temperature. Water temperatures are likely causing sublethal stress and reduced growth in salmon during the summers, however daily temperature fluctuations may provide nightly thermal refugia.

Other water quality parameters

At all sites, pH remained above 6.5, an optimal minimum pH for the protection of the most sensitive salmon life stages (alevins and smolts; Appendix II Table II-1; Kroglund and Staurnes 1999; Kroglund et al. 2008). At the Howe Rd. site, pH fell below the stress threshold in 10% of historic discrete samples (1999-2006), however continuous data collected in spring 2025 never exceeded the stress threshold, possibly indicating an improvement in the buffering capacity of the watershed with time. Historic data throughout the watershed provide further support of the high buffering capacity of the West Branch Sheepscot River, including relatively low organic content (DOC of 6.39 ± 2.56 mg/L), high calcium concentrations (9.1 ± 4.4 mg/L), and high acid neutralization capacity (511 ± 317 µEq/L; Appendix II Table II-2).

Specific conductance was similar between all sites (94 ± 36 µS/cm; Appendix II Table II-1). The sites around Maxcys Mills are upstream of a road and are therefore not expected to be significantly impacted by road salts. The relatively low specific conductance at the Howe Rd. site (114 ± 38 µS/cm) suggests that any potential impacts from road salts from road crossings downstream of Maxcys Mills are outweighed by dilution.

Nutrients near Maxcys Mills were typical of minimally disturbed streams in Maine (Appendix II Table II-2). Biologically available nitrogen (nitrate + nitrite) was quite low in 2025 (0.002 mg/L upstream and 0.004 mg/L downstream), as compared to historic samples (0.049 ± 0.042). Total Kjeldahl nitrogen (0.3 mg/L) and total phosphorus (10 µg/L) were comparable to historic samples in the watershed. Nutrients were typical of minimally disturbed streams in Maine.

Conclusions

Water quality near Maxcys Mills is less than optimal for salmon and other aquatic life due to high summer temperatures and periodically low dissolved oxygen. Conditions were most stressful for aquatic life in the low-gradient impounded section above the remnant dam at Maxcys Mills, and especially in the deep hole, where thermal stratification contributed to hypoxia in the bottom waters. The ledge falls near the confluence with the main stem Sheepscot River may help reduce negative impacts from low dissolved oxygen through aeration of the water.

Works Cited

Abbott, K.A., Zaidel, P.A., Roy, A.H., Houle, K.M., and Nislow, K.H. 2022. Investigating impacts of small dams and dam removal on dissolved oxygen in streams. PLoS One. 17(11). 23 p.

Cunjak, R.A., Roussel, J.-M., Gray, M.A., Dietrich, J.P., Cartwright, D.F., Munkittrick, K.R., and Jardine, T.D. 2005. Using stable isotope analysis with telemetry or mark-recapture data to identify fish movement and foraging. Oecologia. 144: 1-11.

Dewitz, J. 2023. National Land Cover Database (NLCD) 2021 Products: U.S. Geological Survey data release. URL: https://doi.org/10.5066/P9JZ7AO3. Using: ArcGIS Pro Version 3.5.5. Redlands, CA: Environmental Systems Research Institute, Inc., 2010. Date accessed 2/13/2026.

Elliott, J.M., and Elliott, J.A. 2010. Temperature requirements of Atlantic salmon Salmo salar, brown trout Salmo trutta and Arctic charr Salvelinus alpinus: predicting the effects of climate change. Journal of Fish Biology. 77: 1793-1817.

Frechette, D.M., Dugdale, S.J., Dodson, J.J., and Bergeron, N.E. 2018. Understanding summertime thermal refuge use by adult Atlantic salmon using remote sensing, river temperature monitoring, and acoustic telemetry. Canadian Journal of Fisheries and Aquatic Sciences. 75: 1999-2010.

Lund, S.G., Caissie, D., Cunjak, R.A., Vijayan, M.M., and Tufts, B.L. 2002. The effects of environmental heat stress on heat-shock mRNA and protein expression in Miramichi Atlantic salmon (Salmo salar) parr. Canadian Journal of Fisheries and Aquatic Sciences. 59: 1553-1562.

Kroglund, F., and Staurnes, M. 1999. Water quality requirements of smolting Atlantic salmon (Salmo salar) in limed acid rivers. Canadian Journal of Fisheries and Aquatic Sciences. 56: 2078-2086.

Kroglund, F., Rosseland, B.O., Teien, H.-C., Salbu, B., Kristensen, T., and Finstad, B. 2008. Water quality limits for Atlantic salmon (Salmo salar) exposed to short term reductions in pH and increased aluminum simulating episodes. Hydrology and Earth Systems Sciences. 12: 491-507.

Maine Department of Environmental Protection. 2014. QAPP for Biological Monitoring of Maine's Rivers, Streams, and Freshwater Wetlands. Appendix Di: Methods for Biological Sampling and Analysis of Maine's Rivers and Streams. DEP-LW-0387-C2014, revised date 4/1/2014. URL https://www.maine.gov/dep/water/ monitoring/biomonitoring/materials/qapp2019.pdf.

Maine Department of Environmental Protection. 2016. Continuous Monitoring of Water Quality SOP, revision No. 1, effective date 6/7/2016. URL: https://www.maine.gov/dep/water/monitoring/ Continuous%20Monitoring%20SOP%202023.pdf.

Maine Revised Statutes (M.R.S.). Title 38: Waters and navigation. Chapter 3: Protection and improvement of waters. Article 4-A: Water Classification Program. Sections 464 and 465. URL https://www.mainelegislature.org/legis/statutes/38/ title38sec464.html.

Native Land Digital. 2022. URL native-land.ca

Paukert, C., Olden, J.D., Lynch, A.J., Breshears, D.D., Chambers, R.C., Chu, C., Daly, M., Dibble, K.L., Falke, J., Issak, D., Jacobson, P., Jensen, O.P., and Munroe, D. 2021. Climate change effects on North American fish and fisheries to inform adaptation strategies. Fisheries. 46(9): 449-464.

Poff, N.L., Brinson, M.M., and Day, J.W. 2002. Potential impacts on inland freshwater and coastal wetland ecosystems in the United States. Aquatic Ecosystems & Global Climate Change. 1-44.

R Core Team. 2024. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL http://www.R-project.org/.

Stanley, J.G., and Trial, J.G. 1995. Habitat suitability index models: nonmigratory freshwater life stages of Atlantic salmon. U.S. Department of the Interior. Biological Science Report 3.

Strouse, S.R. 2013. The effect of millponds on sedimentation in a post-glacial mid-coast Maine river valley. Master's thesis, Boston College.

United States Atlantic Salmon Assessment Committee (USASAC). 2025. Annual Report, no. 37 – 2024 activities.

United States Drought Monitor. 2026. National Drought Mitigation Center, Lincoln, NE. URL https://droughtmonitor.unl.edu/Maps/MapArchive.aspx

United States Environmental Protection Agency (USEPA). 1986. Quality Criteria for Water. EPA 440/5-86-001. URL https://www.epa.gov/sites/default/files/2018-10/documents/quality-criteria-water-1986.pdf.

U.S. Fish and Wildlife Service (USFWS) and NMFS. 2018. Recovery plan for the Gulf of Maine Distinct Population Segment of Atlantic salmon (Salmo salar). 74 pp. URL https://media.fisheries.noaa.gov/dam-migration/final_recovery_plan2.pdf.

Wilson Engineering, LLC. 2025. Water Resources Database (WRDB). St. Louis, Missouri. URL wrdb.com.

Zaidel, P.A. 2018. Impacts of small, surface-release dams on stream temperature and dissolved oxygen in Massachusetts. University of Massachusetts Amherst. Masters Theses. 680. 283 pp.

Zaidel, P.A., Roy, A.H., Houle, K.M., Lambert, B., Letcher, B.H., Nislow, K.H., and Smith, C. 2021. Impacts of small dams on stream temperature. Ecological Indicators. 120: 1-13.

Zimmermann, E. 2018. Reducing acidification in endangered Atlantic salmon habitat: baseline data. Maine Department of Environmental Protection: Augusta, ME. URL https://www.maine.gov/dep/water/monitoring/rivers_and_streams/salmon/2017-downeast-baseline-report.pdf.

Appendix I – Stream Characteristics

Table I-1. Study site locations and watershed characteristics. Multiparameter data type includes temperature, specific conductance, pH and dissolved oxygen. Mean wetted stream width and depth were measured every three weeks while sondes were deployed (n ~ 19).

Site Description	Site Code	Monitoring organization	Data Type	Latitude	Longitude	Wetted stream width (m)	Bankfull width (m)	Mean stream depth (cm)
Upstream end of impounded reach	MM_US	MC	Continuous	44.29913889	-69.56641667	-	-	-
Mid-impounded reach	MM_IMP	MC	Continuous	44.29772222	-69.56661111	-	-	-
Deep hole	KSRWB38*	DEP	Discrete profile	44.29369800	-69.56667000	22	-	301
Immediately upstream of remnant dam, river left 0.5m from bottom	SHP17-A	DEP	Continuous and grabs	44.29148650	-69.56533210	20.3	26	88
Immediately upstream of remnant dam, river right	MM_US_18	MC	Continuous	44.291354	-69.565534	-	-	-
Downstream riffle	SHP17-B	DEP	Continuous and grabs	44.29109536	-69.56467007	8.9	15.1	39
Downstream, near Maxcys Mill Rd.	KSRWB35	DEP	Continuous	44.29027871	-69.56467675	14.7	19.1	48
Downstream, near Maxcys Mill Rd.	MM_DS	MC	Continuous	44.29027778	-69.56480556	-	-	-
Howe Rd.	SHP6/S-550	DEP	Continuous and grabs	44.24398032	-69.57587928	17.2	29	39

Appendix II – Summary Data Tables

Table II-1. Continuous and Discrete Data Summary. Summary statistics (mean, standard deviation (SD), minimum and maximum) of measurements from Onset Hobo U26 dissolved oxygen (DO) loggers, a pendant temperature logger (KSWR35), and Solinst Eureka Manta+ 20 multiparameter sondes. All specific conductance and pH data (except at Howe Rd.) and all data at KSRWB38 are discrete. Data range 2018-2025, June 15 – Sept. 15 for DO and temperature, and all months for specific conductance and pH. n ~ 9000 except at KSRWB35 n ~ 4,000; Howe Rd. DO n ~ 2,000 except temperature n ~ 14,000; MM_DS n ~ 15,000; KSRWB38 n ~ 7; specific conductance and pH at SHP17-A and SHP17-B n ~ 20.

Site Code	Year(s) sampled	Dissolved Oxygen (DO; mg/L)	DO Min	DO Max	Temperature (Temp; °C)	Temp Min	Temp Max	Specific Conductance (SPC; µS/cm)	SPC Min	SPC Max	pH	pH Min	pH Max
MM_US	2021 2023	8.0 ± 0.8	2.8	10.8	21.5 ± 2.4	15.0	30.2	-	-	-	-	-	-
MM_IMP	2021 2023	7.9 ± 0.8	5.2	10.4	21.5 ± 2.4	15.0	30.2	-	-	-	-	-	-
KSRWB38	2025	5.2 ± 3.0	0.8	7.8	21.3 ± 2.2	17.3	23.9	205 ± 22	192	250	7.18 ± 0.25	6.86	7.43
SHP17-A	2025	7.9 ± 0.9	4.7	10.8	22.3 ± 2.6	16.1	28.9	161 ± 45	80	214	7.38 ± 0.18	7.03	7.68
MM_US_18	2018	7.3 ± 1.2	4.2	10.9	21.4 ± 2.7	11.8	29.5	-	-	-	-	-	-
SHP17-B	2023	7.9 ± 0.6	5.5	9.6	22.5 ± 2.7	16.0	29.1	168 ± 56	80	264	7.42 ± 0.22	7.01	7.64
KSRWB35	2025	8.45*	-	-	23.0 ± 2.9	15.6	30.4	72 ± 36	43	101	7.00 ± 0.12	6.69	7.45
MM_DS	2018 2021 2023	7.6 ± 0.9	4.7	12.1	22.1 ± 2.6	15.0	30.1	-	-	-	-	-	-
Howe Rd.	2015 thru 2025	8.4 ± 0.3	7.7	9.8	23.9 ± 2.2	18.8	30.5	114 ± 45	45	203	7.02 ± 0.13	6.70	8.43

Table II-2. Discrete Data Summary. Summary statistics (mean, SD, minimum and maximum) from grab samples collected 1999-2025, n = 1.

Site Code	Sample size (n)	Calcium (mg/L)	Dissolved Organic Carbon (mg/L)	Nitrate + Nitrite as Nitrogen[1] (N+N; mg/L)	Total Kjeldahl Nitrogen[1] (TKN; mg/L)	Total Phosphorus[1] (µg/L)	ANC (µEq/L)
SHP17-A	1	22.8	3.7	0.002	0.29	10	1163
SHP17-B	1	22.4	3.7	0.004	0.27	9	1161
Howe Rd.	~ 20	10.7 ± 4.8	6.5 ± 2.7	0.05 ± 0.03	0.39 ± 0.10	17 ± 4	569 ± 308

Table II-3. Percent exceedances of temperature and dissolved oxygen thresholds.

Site Code	Temperature > 22 °C	Temperature > 27 °C	DO < 7 mg/L	DO < 5 mg/L
MM_US	38.8	1.6	7.9	0.1
MM_IMP	39.5	1.6	12.8	0
KSRWB38	57.1	0	42.8	42.9
SHP17-A	56.2	3.0	17.7	0.4
MM_US_18	54.2	7.4	41.1	1.4
SHP17-B	57.5	4.8	8.1	0
KSRWB35	63.2	8.4	0	0
MM_DS	40.7	2.8	26.3	0.3
Howe Rd.	76.5	2.0	0	0