Real-Time Water Quality Deployment Report

Mobile Environmental Monitoring Platform (MEMP)

Seal Cove Brook at Butterpot Provincial Park
July 26, 2023 to November 28, 2023

Newfoundland Labrador

Government of Newfoundland & Labrador
Department of Environment and Conservation
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2023-07-25 to 2023-11-28

General

The Mobile Environmental Monitoring Platform (MEMP) was deployed by the Water Resources Management Division (WRMD) near the town of Holyrood, in Seal Cove Brook (47.392353N, 53.059348W) within Butter Pot Provincial Park for 127 days from July 26, 2023, to November 28, 2023. This site was selected in collaboration with Parks and Natural Areas, for the purpose of determining the functional capacity of the unit and its instrumentation and equipment. The park's security measures provided a safeguard against major theft and damages.

Please note, the MEMP was not equipped with stage and flow instrumentation for this deployment.

Within the 48.4 square kilometers watershed area, there exists a notable low developmental pressure, primarily attributed to the stringent management policies upheld by the Provincial Park. To ensure environmental integrity and sustainable growth, the park enforces a substantial one-kilometer referral buffer zone dedicated to the monitoring and regulation of any developmental activities.

Throughout the months spanning from May to October, the park serves as a hub for various recreational pursuits, including RV camping, tenting, boating, and fishing. These activities contribute to the vibrant seasonal tourism economy, fostering both enjoyment and appreciation of the natural environment. However, it's essential to note that the park undergoes closure from mid-October to mid-May, during which time roads remain unattended, unplowed, and unsalted, aligning with conservation principles and only used by the Avalon Nordic Ski Club during winter snowfall months.

While the park remains a refuge for nature/camping enthusiasts, the watershed extends beyond its borders and buffer zone, notably intersecting with the Town of Holyrood. There is limited development in this area, however, cottage construction, accompanied by linear infrastructure such as gravel and paved roads, a highway, and the prominent Labrador-Island transmission line exist.

Maintenance and Calibration of Instrument

As part of the Quality Assurance and Quality Control protocol (QAQC), an assessment of the reliability of data recorded by an instrument is made at the beginning and end of the deployment period. The procedure is based on the approach used by the United States Geological Survey.

- Upon deployment, a QA/QC Sonde is temporarily deployed *in situ*, adjacent to the Field Sonde. Depending on the degree of difference between each parameter from the Field and QAQC sondes a qualitative rank is assigned (See Table 1). The possible ranks, from most to least desirable, are: Excellent, Good, Fair, Marginal, and Poor. A grab sample is also taken for additional confirmation of conditions at deployment and to allow for future modelling studies.
- At the end of a deployment period, a freshly cleaned and calibrated QAQC Sonde is placed *in situ*, adjacent to the Field Sonde. Values are compared between all parameters and differences are ranked for placement in Table 1.

Table 1: Qualitative QAQC Ranking

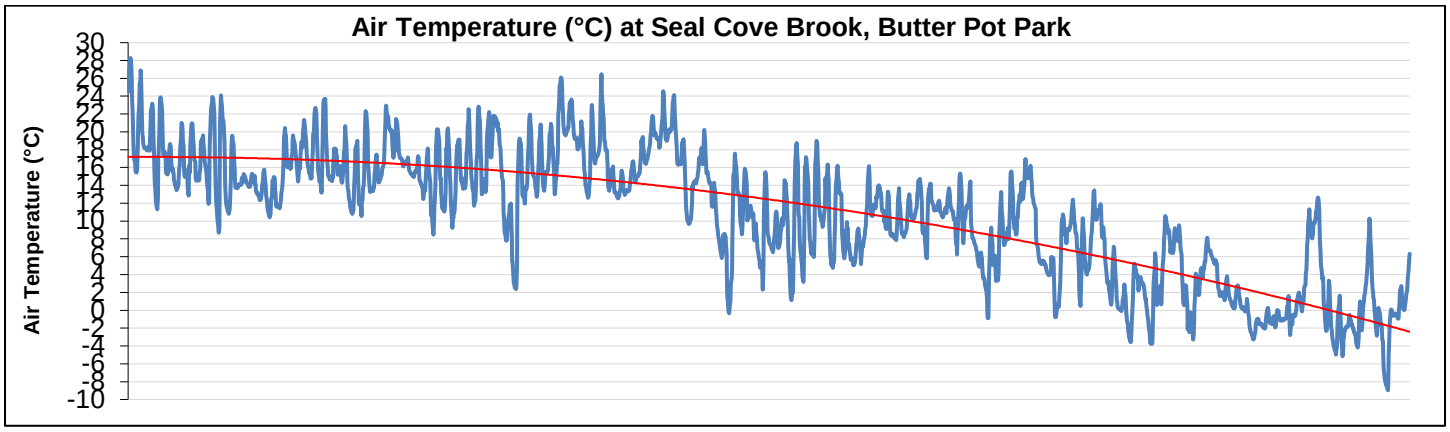
Station	Date	Action	Comparison Ranking				
			Temperature	pH	Conductivity	Dissolved Oxygen	Turbidity
Seal Cove Brook, Butter Pot Park	2023-07-26	Deployment	Marginal	Excellent	Good	Good	Excellent
	2023-1708-00-SI-SP	Grab Sample	--	Excellent	Good	--	Excellent
	2023-11-28	Removal	--	--	--	--	--

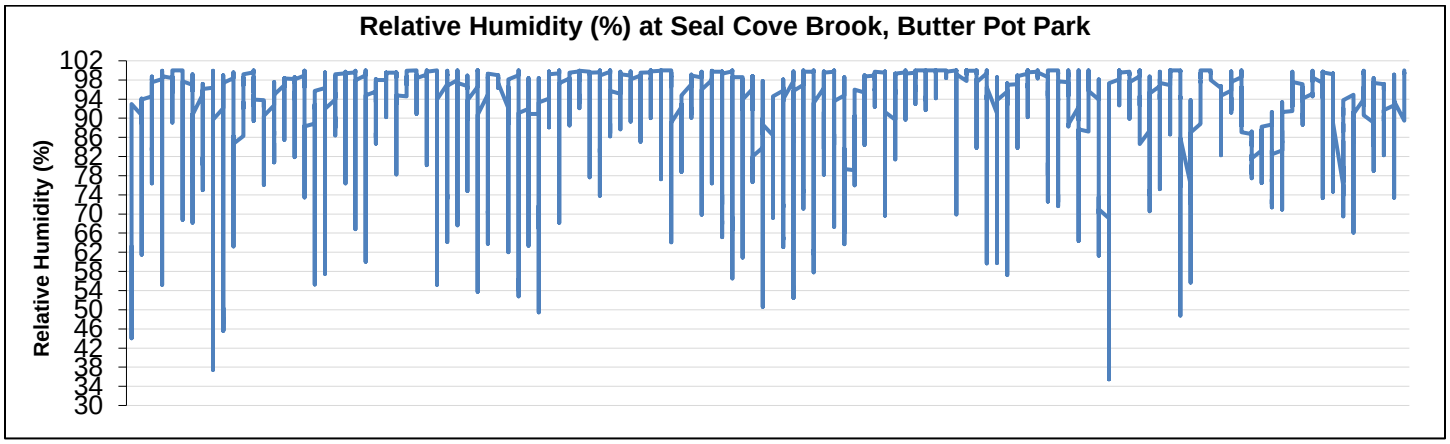
On July 26, 2023, during deployment, the field instrument demonstrated marginal performance in temperature measurements, while excelling in pH and turbidity assessments, and registering good results in conductivity and dissolved oxygen measurements. The grab sample taken at the start of deployment was found to be in close agreement with the deployed EXO2 giving good credibility to data.

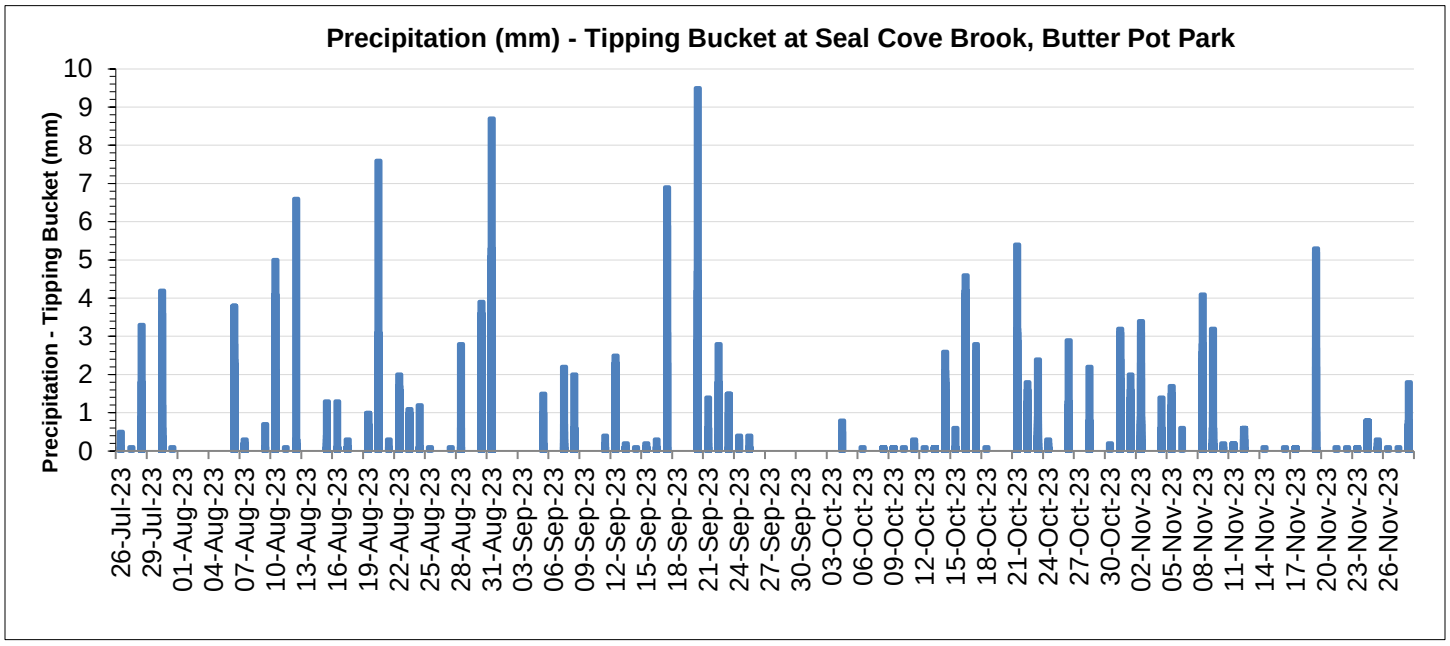
Due to adverse weather conditions and forecasted snowfall on November 28, 2023, the instrument was removed out of necessity and under significant time restraints. No QAQC instrument was deployed during removal which prevented end of deployment rankings.

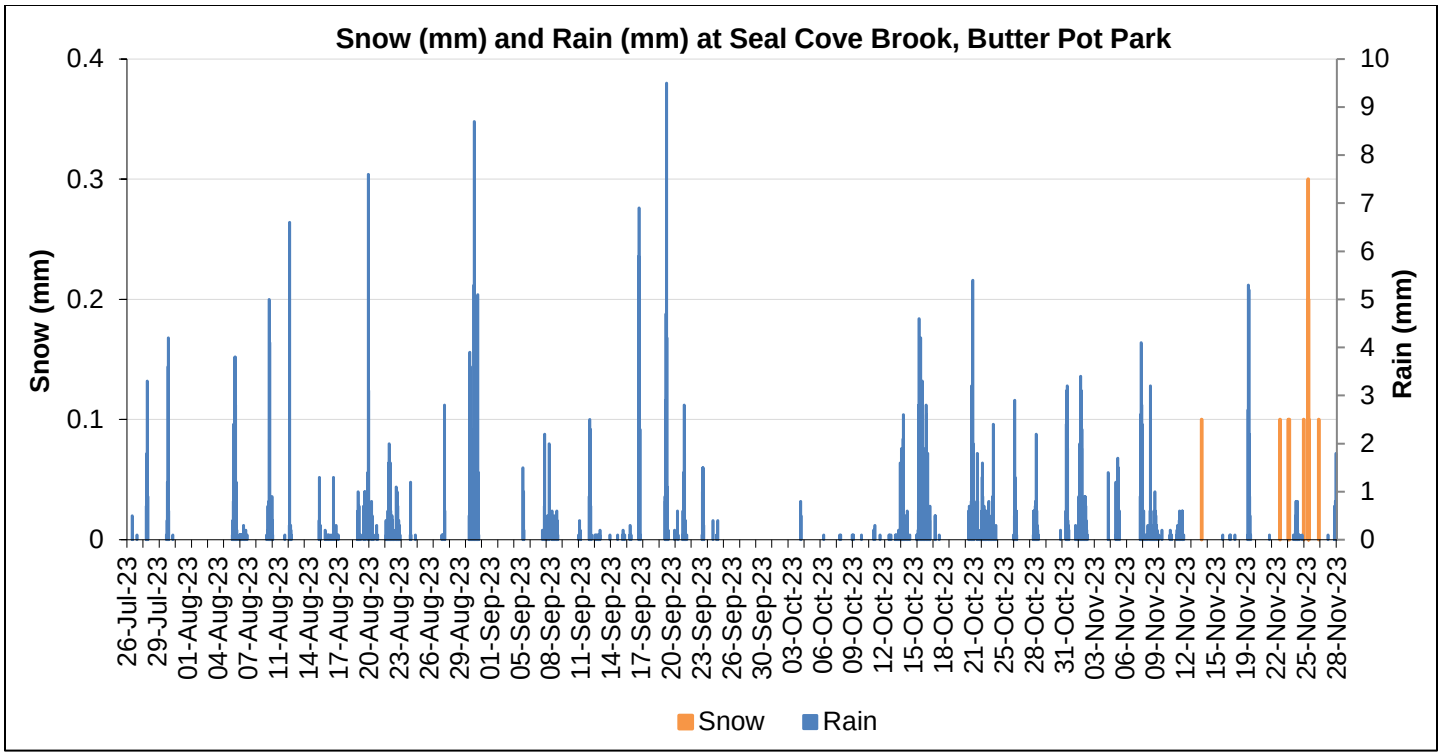
Data Interpretation

Weather









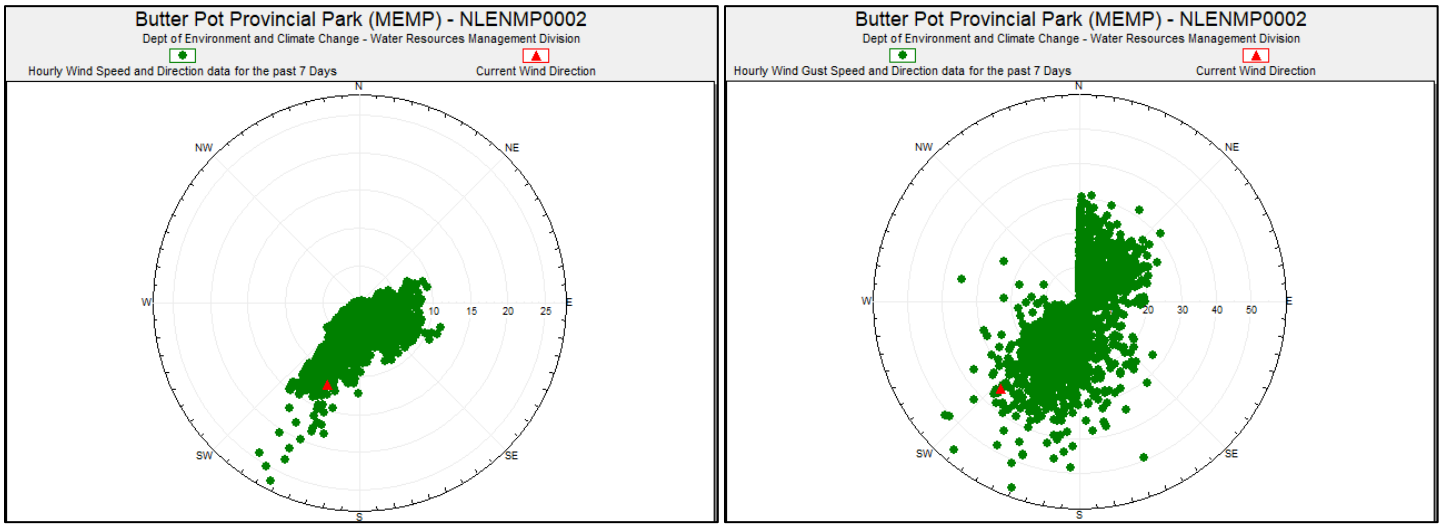
Variable	Mean	Median	Min	Max
Air Temperature (C)	10.75	11.79	-8.97	28.27
Relative Humidity (%-Sat)	90.2	94.9	35.46	100
Precipitation (mm - water equivalent)	0.1559	0	0	9.5
Rain (mm)	0.1726	0	0	9.5
Snow (mm)	0.0041	0	0	0.3

Figure 1: Meteorological variable trends and statistical analysis from July 26, 2023 to November 28, 2023 at Butter Pot Provincial Park.

Figure 1 and the associated data table presents various meteorological parameter trends, along with their mean, median, minimum, and maximum values, over the deployment period. Air temperature, measured in Celsius, shows a mean of 10.75°C and ranges from a minimum of -8.97°C to a maximum of 28.27°C. The decrease in air temperature from July to November can be attributed to primarily the transition from summer to fall and near winter in this region.

Relative humidity, expressed as a percentage of saturation, observed from July to November exhibits a mean of 90.2%, indicating a consistently high level of moisture in the air throughout this period. Relative humidity measures the amount of water vapor present in the air relative to the maximum amount it can hold at a given temperature. The range of relative humidity values from 35.46% (October 30, 2023) to 100% indicates significant variability in moisture levels during this timeframe. At the lower end of the range, relative humidity values around 35.46% suggest drier conditions. Relative humidity reaching 100% indicates saturated air, where the atmosphere cannot hold any more moisture, often leading to the formation of dew, fog, or precipitation.

Precipitation, measured in millimeters of water equivalent, has a mean of 0.1559 mm, and varies from 0 mm to 9.5 mm (September 20, 2023). Specifically, rain and snowfall are detailed, with rain having a mean of 0.1726 mm and snow having a mean of 0.0041 mm, both ranging from 0 mm to 9.5 mm and 0.3 mm, respectively. Despite multiple precipitation events, none are deemed significant. Over the course of 157 days, a total precipitation of 468.1 mm was recorded, with 467.1 mm attributed to rainfall and 1.2 mm to snowfall. Notably, all snowfall was confined to the month of November.



Variable	Mean	Median	Min	Max
Wind Speed (km/h)	4.51	3.97	0	26.34
Wind Direction (Deg)	182.82	198.95	51.26	333.8
Wind Gust Speed (km/h)	14.25	13.34	0	57.29
Wind Gust Direction (Deg)	143.98	194.9	0.048	297.9

Figure 2: Wind rose representing wind speed and direction and wind gust speed and direction from July 26, 2023 to November 28, 2023 at Butter Pot Provincial Park.

Mild to moderate, predominantly south to southwest winds from 0 to 26 km/h were observed, with strongest winds on November 19, 2023. As per Table 1 below and wind rose above, the monthly average wind speed was consistent throughout the deployment ranging from 4.2m/s to 4.67m/s. Wind speed may have been influenced by the geographical features of the area, as the MEMP was deployed within a valley area. Due to an error in filtering out impossibly high wind speed values at one of WRMDs other sites, the wind direction values at this site between 300° and 360° have been clamped to zero erroneously. This is why there are no values between 300° and 360° on the wind rose or in the database. This issue has since been resolved and are now correctly recorded. The average wind direction demonstrates a gradual shift throughout these months, starting from around 199 degrees in July and gradually decreasing to approximately 167 degrees by November. This shift suggests a change in prevailing wind patterns as the months progress.

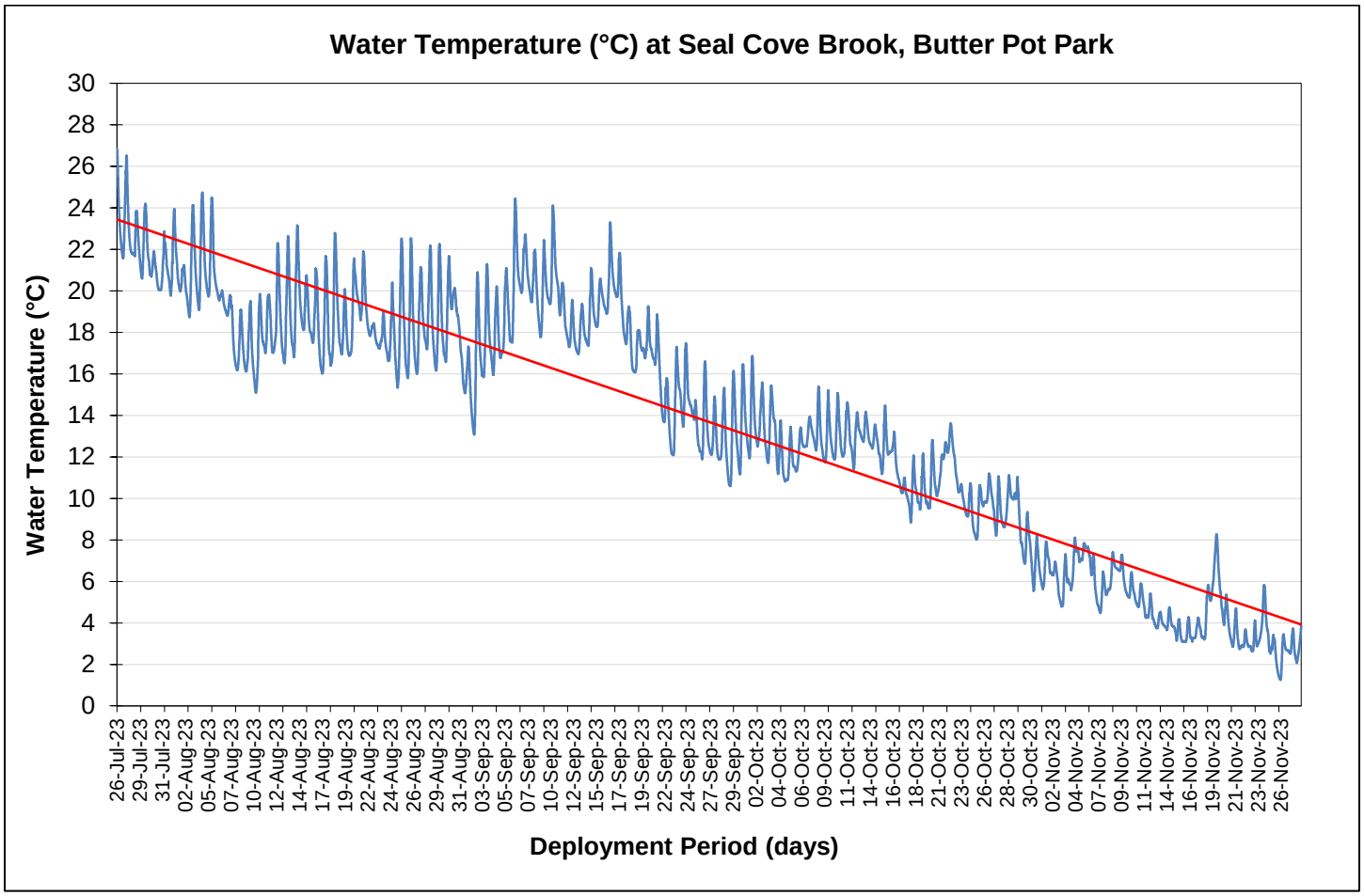
Table 2: Monthly average wind speed (m/s) and wind direction (degrees).

MONTH	Average WIND_SPEED	Average WIND_DIR
July	4.237558824	199.1264706
August	4.668920646	192.12125
September	4.338679167	183.6095278
October	4.536604839	183.9161962
November	4.538244681	166.8398936

Wind gust speed statistics reveal higher values, with a mean of 14.25 km/h and a median of 13.34 km/h, ranging from 0 km/h to 57.29 km/h. Wind gust direction also varies widely, from north, northeast, south and southwest, with a mean of 143.98 degrees and a median of 194.9 degrees, spanning from 0.048 degrees to 297.9 degrees.

Temperature

Water temperature is a crucial determinant of water quality due to its profound impact on biological activity, oxygen solubility, chemical reactions, stratification, habitat suitability, and pollution transport. It affects the metabolic rates of aquatic organisms, with warmer water generally increasing oxygen demand and decreasing dissolved oxygen levels. Cold water holds more dissolved oxygen, essential for supporting aquatic life. Temperature influences chemical reactions and nutrient cycling, while stratification can create hypoxic conditions in deeper layers of lakes and reservoirs. Additionally, temperature fluctuations can disrupt habitat suitability and stress sensitive species, ultimately affecting the ecological balance of aquatic ecosystems and the transport and behavior of pollutants. Thus, managing and monitoring water temperature is vital for maintaining healthy aquatic environments.



Variable	Mean	Median	Min	Max
Water Temperature (°C)	11.30186346	11.09	8.75	14.88

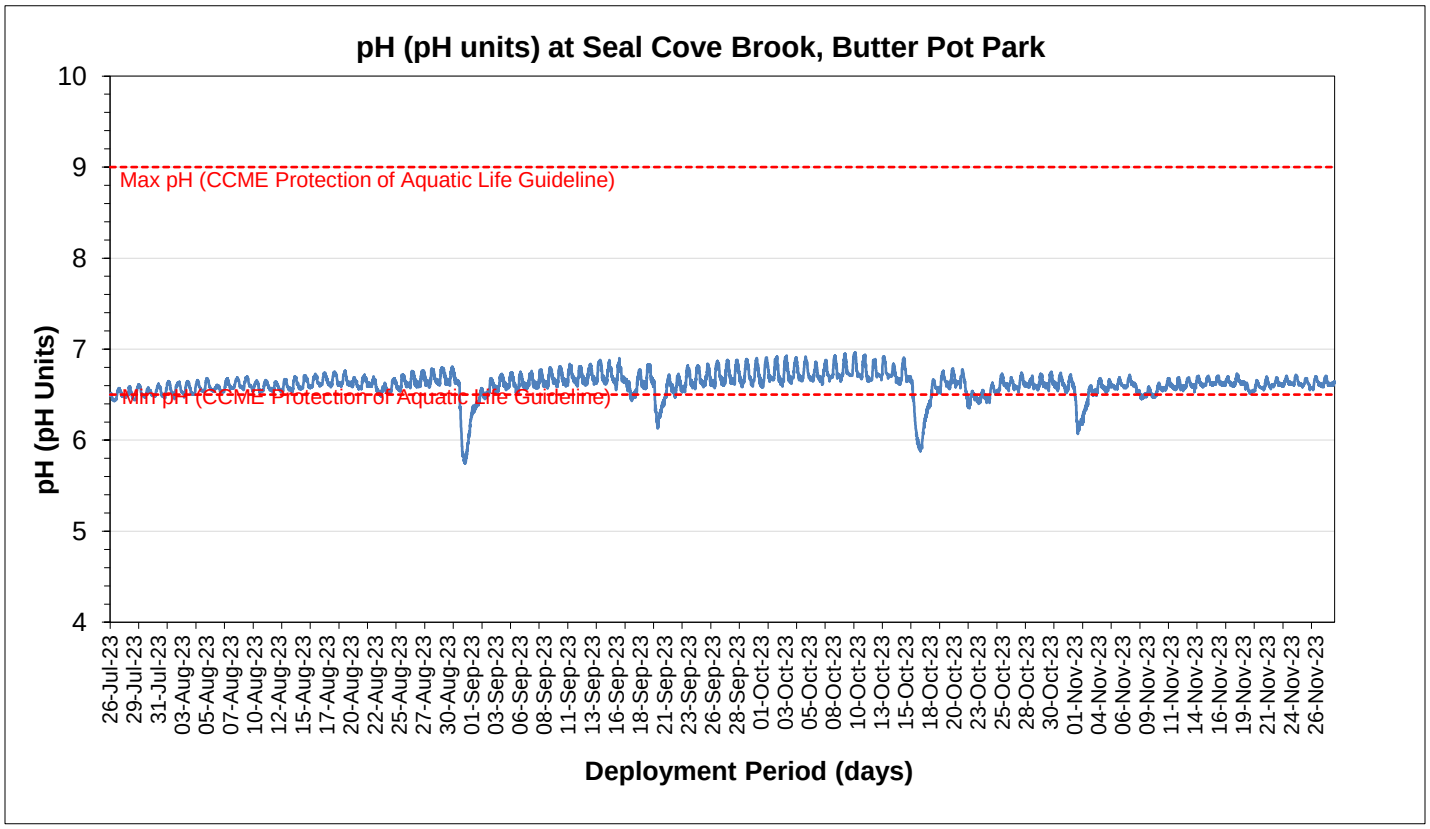
Figure 3: Water Temperature (°C) of Seal Cove Brook, from July 26, 2023 to November 28, 2023 at Butter Pot Provincial Park.

The decreasing trend in water temperature from July 26 to November 28, 2023 (Figure 3) reflects the natural transition from warmer to cooler seasons. Water temperatures tend to peak during the summer months, as more sunlight and higher air temperatures are received. As the year progresses into autumn

and eventually winter, air temperature and the amount of sunlight decreases, leading to a gradual cooling of water temperatures. Factors such as weather systems, wind patterns, and geographic location can also influence water temperature variations over time. This seasonal fluctuation in water temperature is natural and plays a significant role in shaping aquatic ecosystems and influencing the behavior of aquatic organisms.

pH

pH is used to give an indication of the acidity or basicity of a solution. A pH of 7 denotes a neutral solution while lower values are acidic and higher values are basic. Technically, the pH of a solution indicates the availability of protons to react with molecules dissolved in water. Such reactions can affect how molecules function chemically and metabolically.



Variable	Mean	Median	Min	Max
pH (Units)	6.62	6.62	5.74	6.96

Figure 4: Water pH (pH units) of Seal Cove Brook, from July 26, 2023 to November 28, 2023 at Butter Pot Provincial Park.

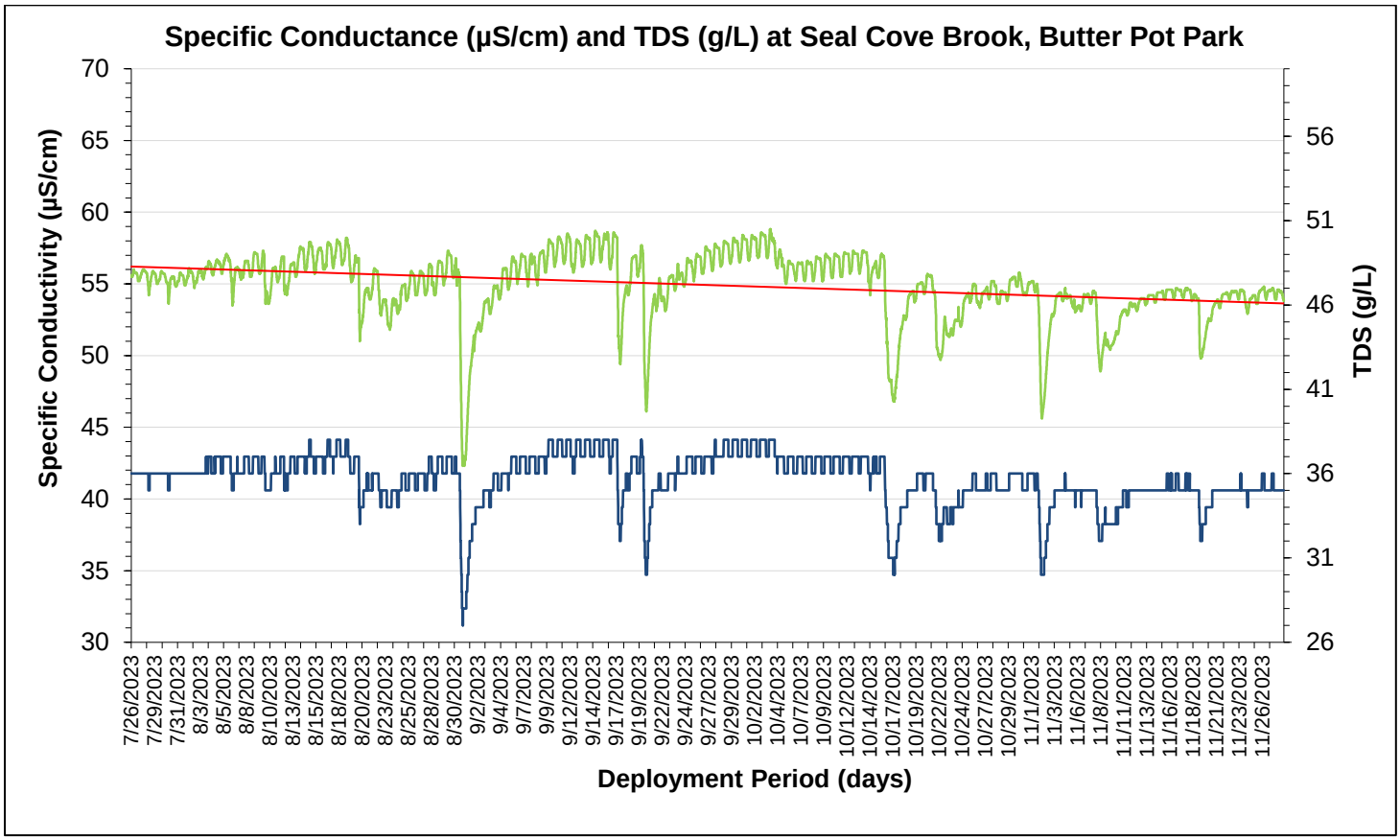
The statistical analysis of pH levels in the water body reveals a mean pH of 6.62, indicating slightly acidic conditions. Both the median and mean pH values align, suggesting consistency in acidity levels across the dataset. The recorded pH ranges from a minimum of 5.74 to a maximum of 6.96, indicating a moderate fluctuation within the acidity range.

Most pH values were at or near the CCME Protection of Aquatic Life minimum pH guideline of 6.5 units and below the maximum pH CCME Protection of Aquatic Life guideline (horizontal dashed lines). It must be noted that these are national guidelines and do not reflect the peculiarities of Newfoundland geology. The pH level at Seal Cove Brook tended towards slightly acidic conditions like most water bodies in this region of the province. pH was generally stable, aside from diurnal variations throughout the deployment period, with exception to sudden drops due to precipitation events like observed on August 31, September 20, October 16, November 2, 2023.

A precipitation event can affect the pH of a water body through multiple pathways. Firstly, the addition of slightly more acidic rain can directly lower pH upon contact with surface water. Additionally, runoff from precipitation can introduce acidic substances like decomposing organic matter and fertilizers, further reducing pH. Heavy precipitation can also dilute alkaline or acidic components already present in the water, potentially altering pH levels depending on the initial conditions. These changes in pH, influenced by factors such as the acidity of precipitation, surrounding environment, and water body's buffering capacity, have implications for aquatic ecosystems and water quality, highlighting the importance of monitoring and mitigating anthropogenic acidity or alkalinity sources.

Specific Conductivity

Conductivity relates to the ease of passing an electric charge – or resistance – through a solution. Conductivity is highly influenced by the concentration of dissolved ions in solution: distilled water has zero conductivity (infinite resistance) while salty solutions have high conductivity (low resistance). Specific Conductivity is corrected to 25°C to allow comparison across variable temperatures. Monitoring specific conductivity is crucial for assessing water quality, identifying potential sources of contamination, and ensuring the health of aquatic ecosystems. Deviations from expected conductivity levels may signal the need for further investigation and management actions to maintain water quality and ecosystem integrity.



Variable	Mean	Median	Min	Max
Conductivity (uS/cm)	54.9	55.2	42.3	58.8

Figure 5: Specific Conductivity (µS/cm) and Total Dissolved Solids (g/L) of Seal Cove Brook, from July 26, 2023 to November 28, 2023 at Butter Pot Provincial Park.

The analysis of water specific conductivity reveals a mean value of 54.9µS/cm, with a median of 55.2 µS/cm. This indicates relatively consistent conductivity levels across the dataset. The recorded specific conductivity ranges from a minimum of 42.3µS/cm to a maximum of 58.8µS/cm, suggesting a moderate

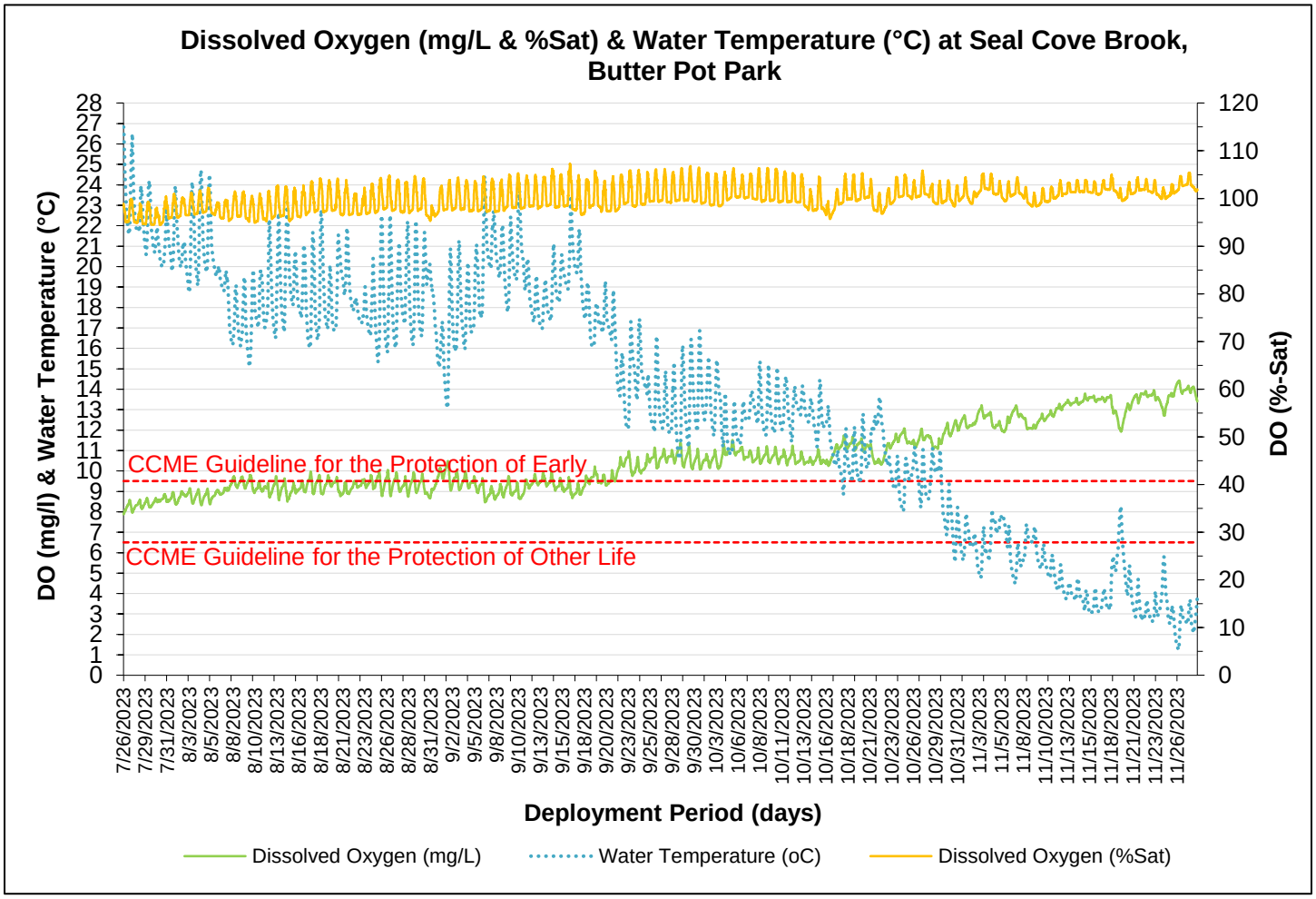
variability within the conductivity range. While the mean and median values are close, slight variations in conductivity levels within the dataset may be attributed to factors such as variations in dissolved ion concentrations, temperature fluctuations, and seasonal changes.

Low water specific conductivity and Total Dissolved Solids (TDS), as observed in Seal Cove Brook, indicate a low concentration of dissolved solids, indicative of high water purity and minimal contamination. Such conditions are common in freshwater bodies like rivers, streams, and lakes, particularly those fed by rainfall or snowmelt. While low conductivity suggests good water quality and supports sensitive aquatic ecosystems, excessively low values may indicate a lack of essential minerals and nutrients, posing potential challenges for ecosystem health.

A slight decrease in specific conductivity of water from July to November, corresponds with increased frequency of precipitation. Increased precipitation and runoff may dilute the water body, lowering the concentration of dissolved ions and specific conductivity, as observed on August 31, September 20, October 16, November 2, 2023. Changes in biological activity, such as decreased photosynthesis and respiration rates in cooler temperatures, can also contribute to lower conductivity. Lastly, seasonal changes in water flow and mixing patterns may homogenize ion concentrations, further reducing specific conductivity.

Dissolved Oxygen

Dissolved oxygen is a metabolic requirement of aquatic plants and animals. The concentration of oxygen in water depends on many factors, principally temperature – the saturation of oxygen in water is inversely proportional to water temperature. Oxygen concentrations also tend to be higher in flowing water compared to still, lake environments. Low oxygen concentrations can give an indication of excessive decomposition of organic matter or the presence of oxidizing materials.



Variable	Mean	Median	Min	Max
DO (mg/l)	10.57	10.36	7.88	14.42
DO (%Sat)	100.1	99.9	94.4	107.3

Figure 6: Dissolved Oxygen (mg/l), Dissolved Oxygen (%Sat) and Water Temperature (°C) of Seal Cove Brook, from July 26, 2023 to November 28, 2023 at Butter Pot Provincial Park.

On average, the dissolved oxygen concentration was 10.57 mg/l, with a median of 10.36 mg/l, indicating a relatively stable distribution around the mean. The minimum dissolved oxygen concentration recorded was 7.88 mg/l, while the maximum was 14.42 mg/l, reflecting variability in

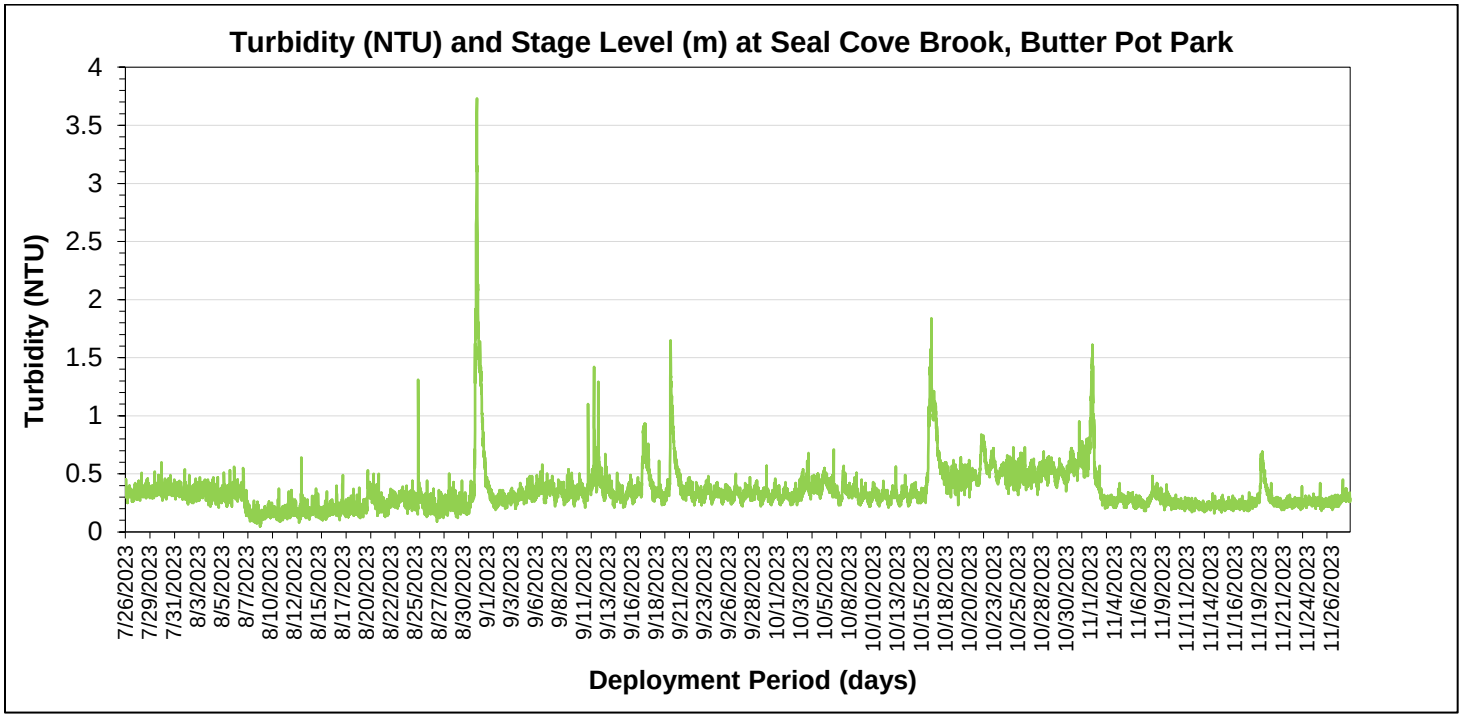
oxygen levels during the deployment period. The percent saturation of dissolved oxygen averaged 100.1%, with a median of 99.9%. The minimum percent saturation observed was 94.4%, while the maximum was 107.3%, suggesting occasional supersaturation.

The observed increase in dissolved oxygen (DO) levels from July to November corresponds to decreasing water temperatures throughout deployment. From the data, water temperature likely peaked in July when the instrument was deployed. As temperatures dropped due to the natural transition from summer to fall, the solubility of oxygen in water increased due to the colder water's ability to hold more dissolved gases. Dissolved oxygen level remained consistently above the Canadian Council of Ministers of the Environment (CCME) Guideline for the Protection of the Other Life (6.5 mg/L), and at or above the CCME guideline of 9.5 mg/l for the protection of early life stage cold water biota for most of the deployment period.

A diurnal variation pattern was evident. The extent of this variation is linked to the daily range of water temperature, duration of daylight, and fluctuations in rates of photosynthesis and respiration. Consequently, the observed attenuation of the diurnal pattern is expected, given the decrease in aquatic biotic activity, and narrowing daily temperature ranges during the summer-fall season.

Turbidity

Water turbidity is characterized by the cloudiness or haziness caused by suspended particles and can significantly impact water quality. High turbidity reduces light penetration, hindering photosynthesis and affecting aquatic vegetation growth and habitat suitability. It can lead to temperature fluctuations, oxygen depletion from microbial decomposition of organic matter, and sedimentation, smothering benthic habitats and compromising biodiversity. Turbidity can also transport nutrients and pollutants, contributing to eutrophication, algal blooms, and contamination of drinking water sources. Additionally, it diminishes aesthetic appeal and recreational value, highlighting the importance of monitoring and managing turbidity levels for maintaining the health and usability of aquatic ecosystems.



Variable	Mean	Median	Min	Max
Turbidity (NTU)	0.3	0.3	0.1	3.7

Figure 7: Water Turbidity (NTU) of Seal Cove Brook, from July 26, 2023 to November 28, 2023 at Butter Pot Provincial Park.

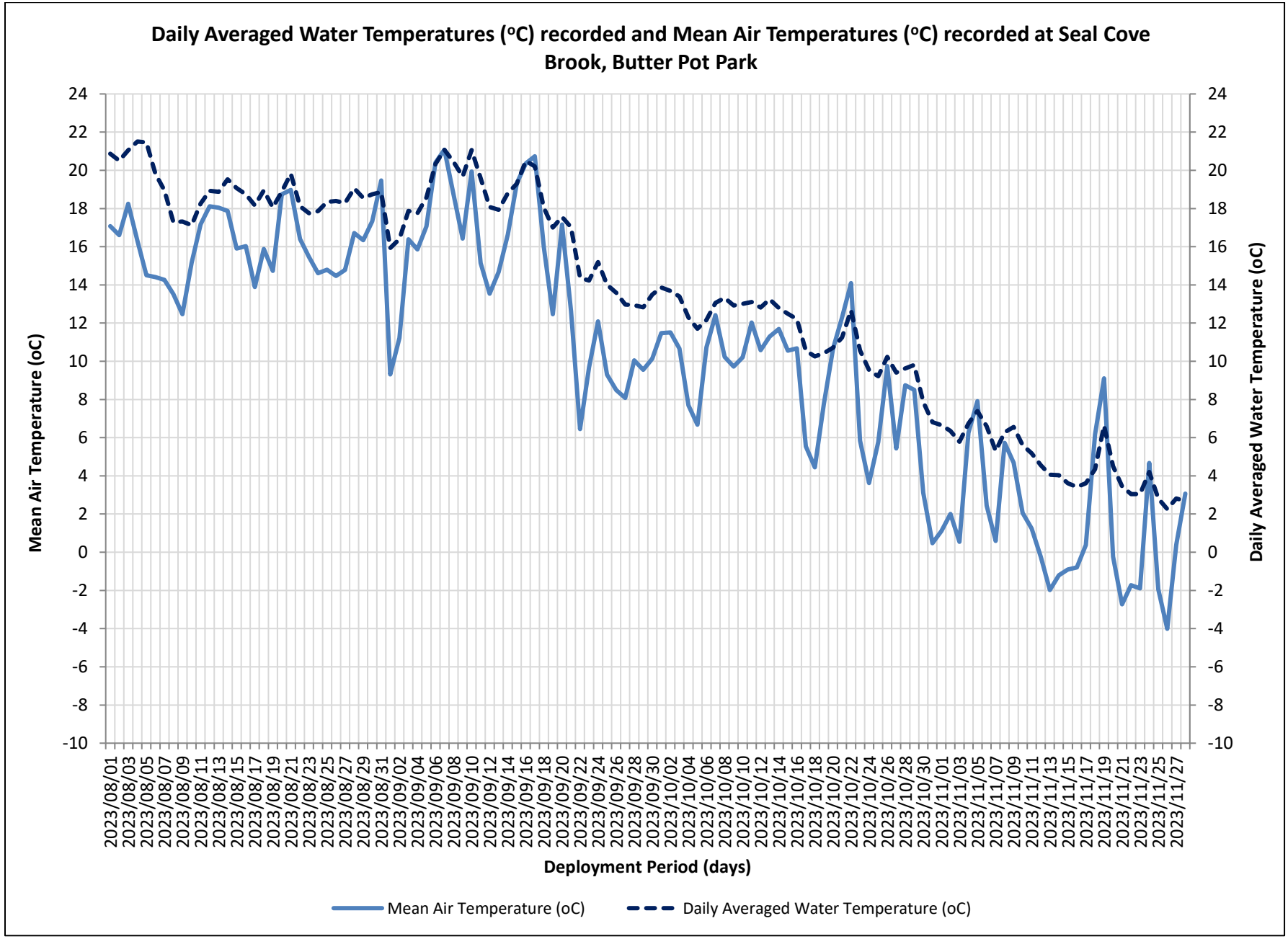
During the deployment period from July 25 to November 28, 2023, at Seal Cove Brook, the water turbidity remained consistently low, with an average turbidity of 0.3 NTU (Nephelometric Turbidity Units) and a median value also of 0.3 NTU. This indicates that most of the turbidity measurements fell close to the average value, reflecting stable and clear water conditions. The minimum turbidity recorded during this period was 0.1 NTU, suggesting occasional periods of exceptionally clear water, while the maximum turbidity observed was 3.7 NTU, indicating a slight increase in turbidity during precipitation events, as seen for example on August 31, September 20, October 16, November 2, 2023. Overall, these statistics suggest that Seal Cove Brook experienced consistently low levels of turbidity throughout the deployment period, which is indicative of good water clarity and potentially favorable environmental conditions for aquatic life.

Conclusions and Path Forward

The deployment of the MEMP in Butter Pot Provincial Park offered valuable insights into its functionality and the environmental conditions within the park's boundaries. Despite the lack of hydrometric instrumentation, the MEMP provided essential water quality and weather data for assessing the park's environmental integrity and monitoring the impacts of recreational activities. The collaboration between the Water Resources Management Division and Parks and Natural Areas highlights the importance of interdisciplinary efforts in environmental monitoring and management.

Moving forward, it is necessary to expand monitoring efforts by enhancing instrumentation capabilities to measure stage and flow in water bodies, facilitating a more comprehensive understanding of hydrological dynamics. Additionally, it would be advantageous for future MEMP deployments to increase the frequency of site visits aimed at collecting grab samples and ensuring quality assurance.

APPENDIX A: MEAN DAILY AIR TEMPERATURE AND AVERAGE WATER TEMPERATURE


Daily Averaged Water Temperatures (°C) recorded and Mean Air Temperatures (°C) recorded at Seal Cove Brook, Butter Pot Park
Mean Air Temperature (oC)
Daily Averaged Water Temperature (oC)
Deployment Period (days)
Mean Air Temperature (oC)
Daily Averaged Water Temperature (oC)

APPENDIX B: QA/QC GRAB SAMPLE FIELD RESULTS