Real-Time Water Quality Deployment Report

Paddy's Pond at Outlet

April 25, 2024, to June 3, 2024

Newfoundland Labrador

Government of Newfoundland & Labrador
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CONTENTS

General

The Department of Environment and Climate Change, Water Resources Management Division staff monitor water quality in real-time at Paddy's Pond at outlet to Three Arm Pond (47.488129N, 52.893809W).

Data compilation and analysis for this report includes the dates between April 25, 2024, to June 03, 2024.

Figure 1: Paddy's Pond at Outlet Real-Time Water Quality Station location.

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 QA/QC 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.

Table 1: Ranking classifications for deployment and removal

	Rank				
Parameter	**Excellent**	**Good**	**Fair**	**Marginal**	**Poor**
Temperature (°C)	<=+/-0.2	>+/-0.2 to 0.5	>+/-0.5 to 0.8	>+/-0.8 to 1	<+/-1
pH (unit)	<=+/-0.2	>+/-0.2 to 0.5	>+/-0.5 to 0.8	>+/-0.8 to 1	>+/-1
Sp. Conductance (µS/cm)	<=+/-3	>+/-3 to 10	>+/-10 to 15	>+/-15 to 20	>+/-20
Sp. Conductance > 35 µS/cm (%)	<=+/-3	>+/-3 to 10	>+/-10 to 15	>+/-15 to 20	>+/-20
Dissolved Oxygen (mg/L) (% Sat)	<=+/-0.3	>+/-0.3 to 0.5	>+/-0.5 to 0.8	>+/-0.8 to 1	>+/-1
Turbidity <40 NTU (NTU)	<=+/-2	>+/-2 to 5	>+/-5 to 8	>+/-8 to 10	>+/-10
Turbidity > 40 NTU (%)	<=+/-5	>+/-5 to 10	>+/-10 to 15	>+/-15 to 20	>+/-20

At the end of a deployment period, a freshly cleaned and calibrated QA/QC Sonde is placed *in situ*, adjacent to the Field Sonde. Deployment and removal comparison rankings for the station at Paddy's Pond deployed from April 25, 2024, to June 3, 2024, are summarized in Table 2.

Table 2: Qualitative QA/QC comparison rankings for Paddy's Pond at outlet station April 25, 2024, to June 3, 2024.

Station	Date	Action	Comparison Ranking				
			Temperature	**pH**	**Conductivity**	**Dissolved Oxygen**	**Turbidity**
Paddy's Pond at Outlet	2024-04-25	Deployment	Marginal	Excellent	Poor	Excellent	Excellent
	2024-04-25	Grab Sample #2024-1703-00-SI-SP	N/A	Excellent	Excellent	N/A	Excellent
	2024-06-03	Removal	Good	Poor	Poor	Excellent	Excellent

On April 25, 2024, a real-time water quality monitoring instrument was deployed at the station Paddy's Pond at Outlet. The instrument was deployed for a period of 40 days and was removed on June 3, 2024.

Comparison rankings between the Quality Assurance/Quality Control (QAQC) instrument and the field instrument at Paddy's Pond outlet on April 25, 2024, reveal alignment in some parameters but discrepancies in others. Both instruments agree on pH, dissolved oxygen and turbidity, ranking them as 'Excellent', indicating accurate and reliable measurements. However, there are disparities in temperature and conductivity rankings, with the field instrument showing a 'Marginal' ranking for temperature and a 'Poor' ranking for conductivity. Given the 'Excellent' comparison ranking for conductivity between grab sample (#2024-1703-00-SI-SP) and the field sonde, this indicates the likelihood of a calibration error or sensor issue with the QaQc sonde sensor. Grab sample comparison rankings were also provided for pH and turbidity as 'Excellent'.

Upon removing the instrument on June 3, 2024, the temperature ranking had slightly improved from 'Marginal' to 'Good'. The pH ranking of 'Poor' was likely influenced by sensor drift, while specific conductivity consistently ranked 'Poor' due to calibration issues, as noted earlier. Meanwhile, both dissolved oxygen and turbidity retained their rankings of 'Excellent'.

DATA INTERPRETATION

The following graphs and discussion illustrate water quality data obtained hourly from April 25, 2024, to June 3, 2024, at Paddy's Pond at outlet to Three Arm Pond, St. John's, NL.

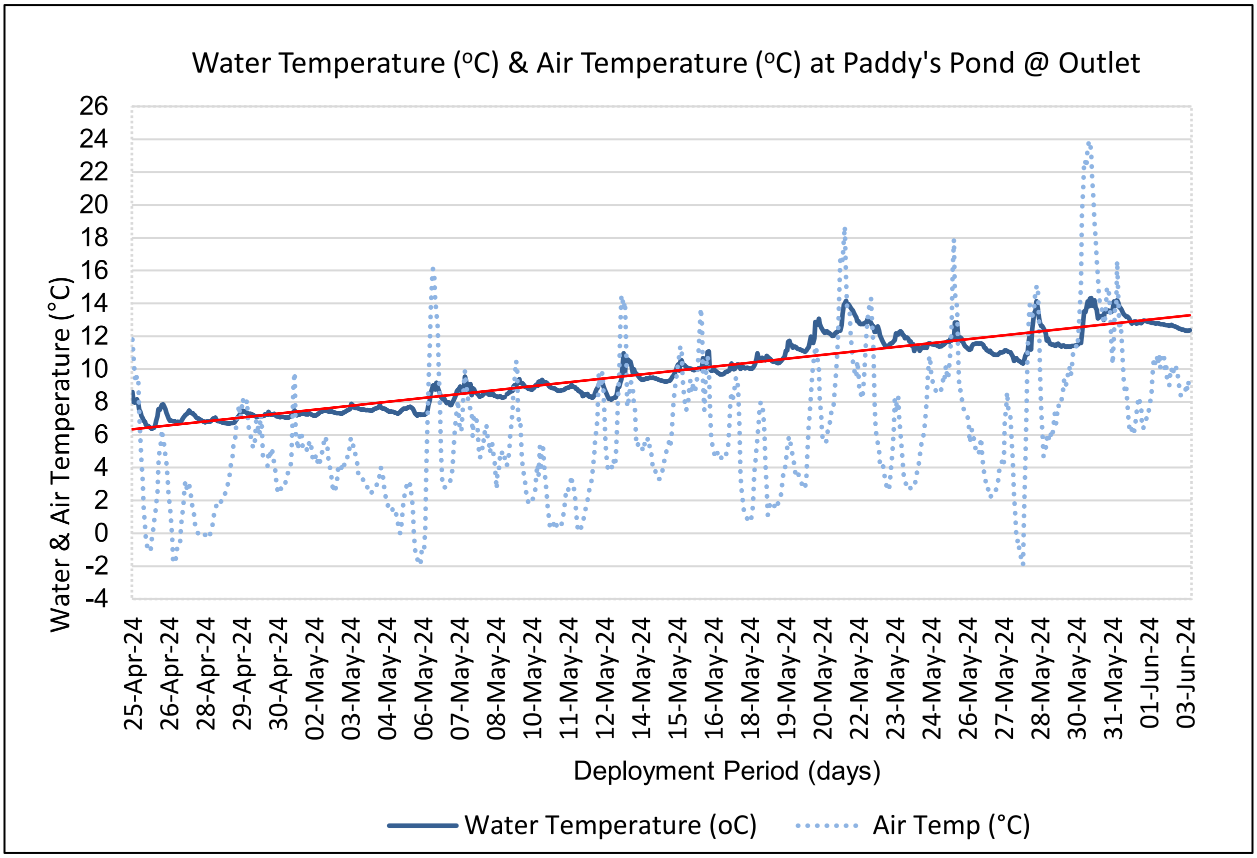
Stage is not monitored at this station to date and as such cannot be discussed with respect to other monitored water quality parameters. All data used in the preparation of the graphs and subsequent discussion adhere to this stringent QA/QC protocol.

Mean daily temperature and total precipitation data was obtained from the Department of Environment and Climate Change Canada (ECCC) historical weather data at https://climate.weather.gc.ca/historical_data/search_historic_data_e.html and can be found illustrated in Appendix A. Gaps in available daily data were removed for graphing purposes.

Water Temperature

Water Temperature is a major factor used to describe water quality. Temperature has major implications on both the ecology and chemistry of a water body, governing processes such as the metabolic rate of aquatic plants and animals and the degree of dissolved oxygen saturation.

It should be noted that the temperature sensor on any sonde is the most important. All other parameters can be broken down into three groups: temperature dependent, temperature compensated and temperature independent. As the temperature sensor is not isolated from the rest of the sonde, the entire sonde must be at the same temperature before the sensor will stabilize. The values may take some time to climb to the appropriate reading; if a reading is taken too soon it may not accurately portray the water body.



Water Temp	Mean	Median	Min	Max
Hourly	9.81	9.69	6.36	14.33

Figure 2: Water temperature (°C) values at Paddy's Pond at Outlet.

The daily temperature for Paddy's Pond at Outlet Station over a 40-day period are depicted in Figure 2, spanning from April 25, 2024 to June 3, 2024. Temperature fluctuations ranged from a minimum of 6.36°C to a maximum of 14.33°C, with a median of 9.69°C and a mean of 9.81°C. These variations likely reflect seasonal changes from spring to summer, as water temperature fluctuated naturally in correlation to air temperature.

The water temperature exhibited variability throughout the observed period, starting at 8.61°C on April 25, 2024. From late April to early May, temperatures generally decreased, reaching a low around 6.36°C on April 26, 2024. This period likely reflects lingering colder conditions from winter transitioning into spring.

From early May onwards, there was a noticeable upward trend in temperatures. By May 2, 2024, temperatures had risen to around 7.44°C and continued to increase steadily. A significant rise occurred around May 6, 2024, when temperatures spiked to 9.17°C, suggesting a possible warming trend.

Throughout May and into early June, temperatures fluctuated between approximately 7.16°C and 9.54°C, indicating some variability but generally maintaining above 7°C. These fluctuations are typical during seasonal transitions as water bodies respond to changing air temperature and increasing length of sun hours.

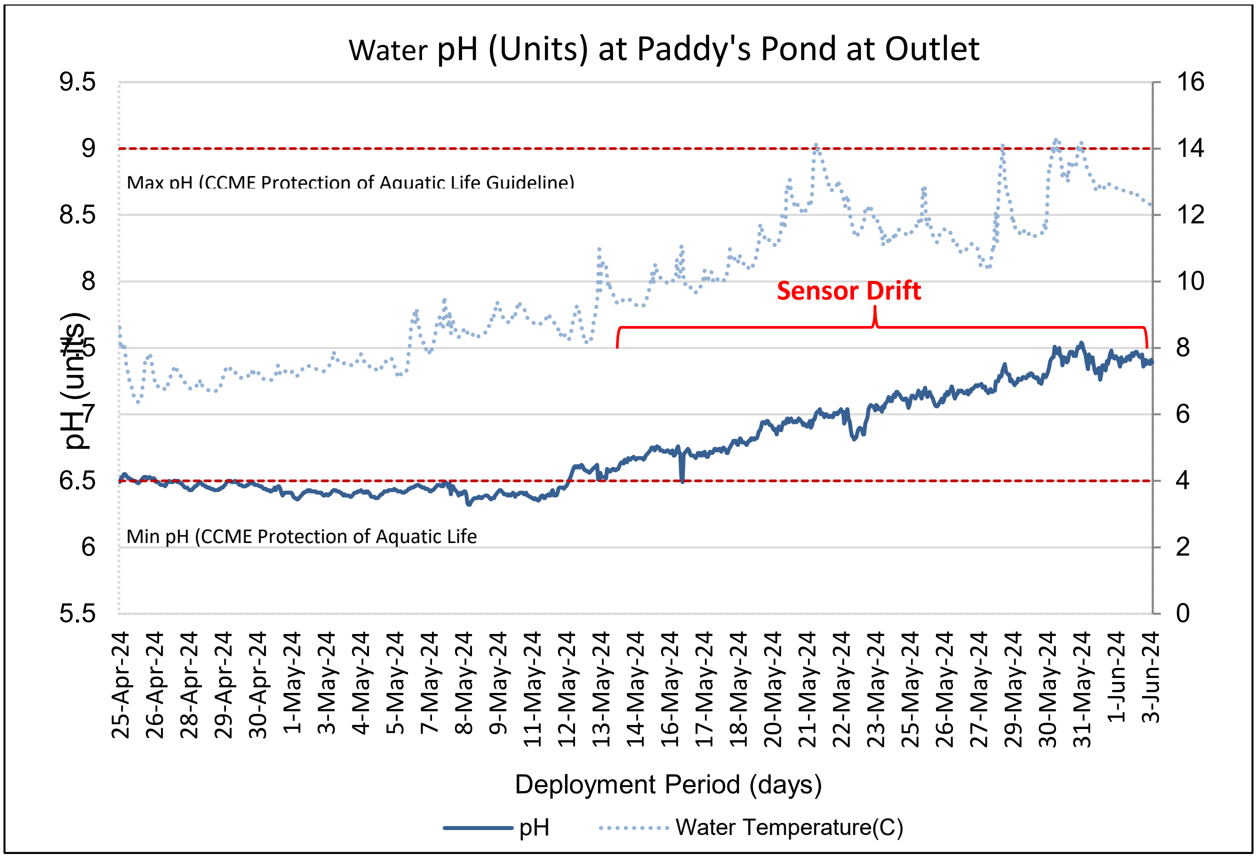
Overall, the dataset clearly illustrates the warming trend of the water temperatures at Paddy's Pond as spring progresses into summer. The consistent rise in both average and minimum temperatures suggests a warming environment, likely influenced by seasonal changes, while the fluctuations in maximum temperatures may indicate periodic weather variations or other local environmental factors impacting the pond.

A diurnal fluctuation pattern was characterized by significant fluctuations between daytime and nighttime temperatures, as expected during this time of the year. Daytime temperatures typically rise due to solar radiation and warm air temperatures, while nighttime temperatures tended to decrease as heat dissipated into the atmosphere. These diurnal variations reflect the dynamic interplay between solar heating, atmospheric conditions, and water body characteristics, contributing to the overall thermal dynamics of the aquatic environment.

pH

pH is used to give an indication of the acidity or basicity of a solution. A pH of seven (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.

pH values are temperature dependant as well as influenced by photosynthesis and respiration by aquatic organisms. The concentration of dissolved carbon dioxide in the water throughout the day, especially overnight when oxygen production is reduced relative to carbon dioxide levels. Carbon dioxide dissolved in water yields a slightly acidic solution.



pH	Mean	Median	Min	Max
Hourly	6.45	6.43	6.32	6.62

Figure 3: pH (pH units) at Paddy's Pond at outlet from April 25, 2024, 2024, through June 3, 2024.

It should be noted that for statistical analysis, pH data from May 14, 2024 to the end of the deployment period, June 3, 2024, was removed due to electrode sensor drift. This can be caused by a variety of factors, such as aging of the electrode, contamination of the electrode surface, or changes in the internal electrolyte solution. This assumption was verified by the "Poor" ranking comparison of the field sonde against the QaQc sonde upon removal.

The pH of Paddy's Pond in the specified period ranged from 6.32 to 6.62 pH units, with a median of 6.43 and mean of 6.45 pH units. From the end of April to the beginning of May, the average daily pH was relatively stable, fluctuating around 6.5. As mentioned above, erroneous data was removed beyond this date due to electrode sensor drift.

The freshwater pH shows a dynamic range of values, reflecting changing environmental conditions over the deployment period. Initially, on April 25, the pH was recorded at 6.55, indicating slightly acidic water. This trend of slight acidity continued, with the pH gradually decreasing to a low of 6.38 by May 11.

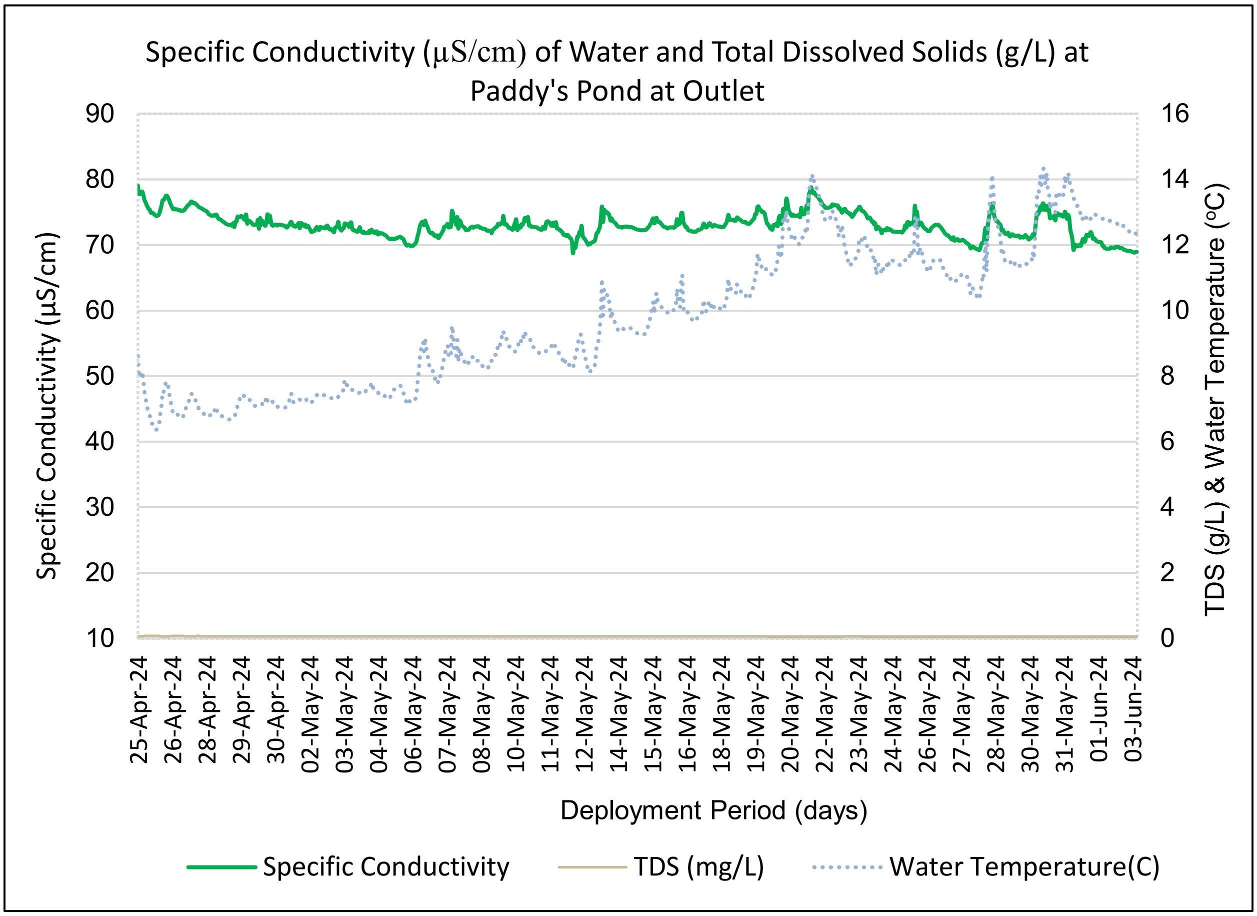
From May 12 onwards, there was a noticeable shift, with pH values starting to rise, reaching 6.68 by May 14. This upward trend suggests that the water was becoming less acidic, possibly due to reduced runoff, changes in temperature, or decreased organic decay.

Most pH values were below 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. This guideline provides a basis for the overall health of the waterbody. Paddy's Pond at Outlet pH values were slightly below the minimum guideline but historically typical for this waterbody. Other pH reducing influences include lower water temperatures and the addition of more acidic rainwater and/or snowmelt runoff during precipitation events. (See Figure 7 – Appendix A).

Slight diurnal variation pattern was visible as the magnitude of variation correlates to daily water temperature range, length of days and fluctuations in photosynthesis and respiration rates. Inconsistencies to the diurnal variation pattern, as seen on May 12-16, 2024, May 23, 2024, and June 1-3, 2024, is likely the result of an increase in precipitation events as seen in Appendix A - Figure 7. The addition of cool precipitation can decrease water temperature, lowering the concentration of dissolved ions and specific conductivity.

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.



Parameter	Mean	Median	Min	Max
Sp. Conductivity	73.0	72.9	68.7	79.0
TDS	0.0668	0.0700	0.0600	0.0800

Figure 4: Specific Conductivity (µS/cm) & TDS values at Paddy's Pond at Outlet.

Specific conductivity measurements recorded hourly from April 25 to June 3, 2024, indicated in Figure 4, indicate a minimum and maximum range of 68.7 to 79.0 µS/cm, a mean of 73.0 µS/cm and median of 72.9 µS/cm. These close mean and median values suggest a fairly symmetrical distribution of the data.

From April 25 through May 10, there is a general declining trend in specific conductivity, with values dropping from around 79.03 µS/cm to 69.9 µS/cm. This trend indicates a decrease in dissolved ion concentrations, which could be due to dilution from rainfall or other hydrological inputs, such as snowmelt. The lowest value during this period, 69.9 µS/cm, was recorded on May 5, after which there was a gradual increase, peaking at 73.69 µS/cm on May 6. Following this peak, the conductivity values stabilized around the low 70s.

From mid-May to early June, the dataset continues to show variability, with conductivity values generally fluctuating between 70 and 75 µS/cm. This period exhibits several peaks and troughs, suggesting dynamic changes in the water's ionic content. For instance, between May 10 and May 15, the values oscillate, reflecting possible intermittent inputs of dissolved substances or variable water mixing conditions.

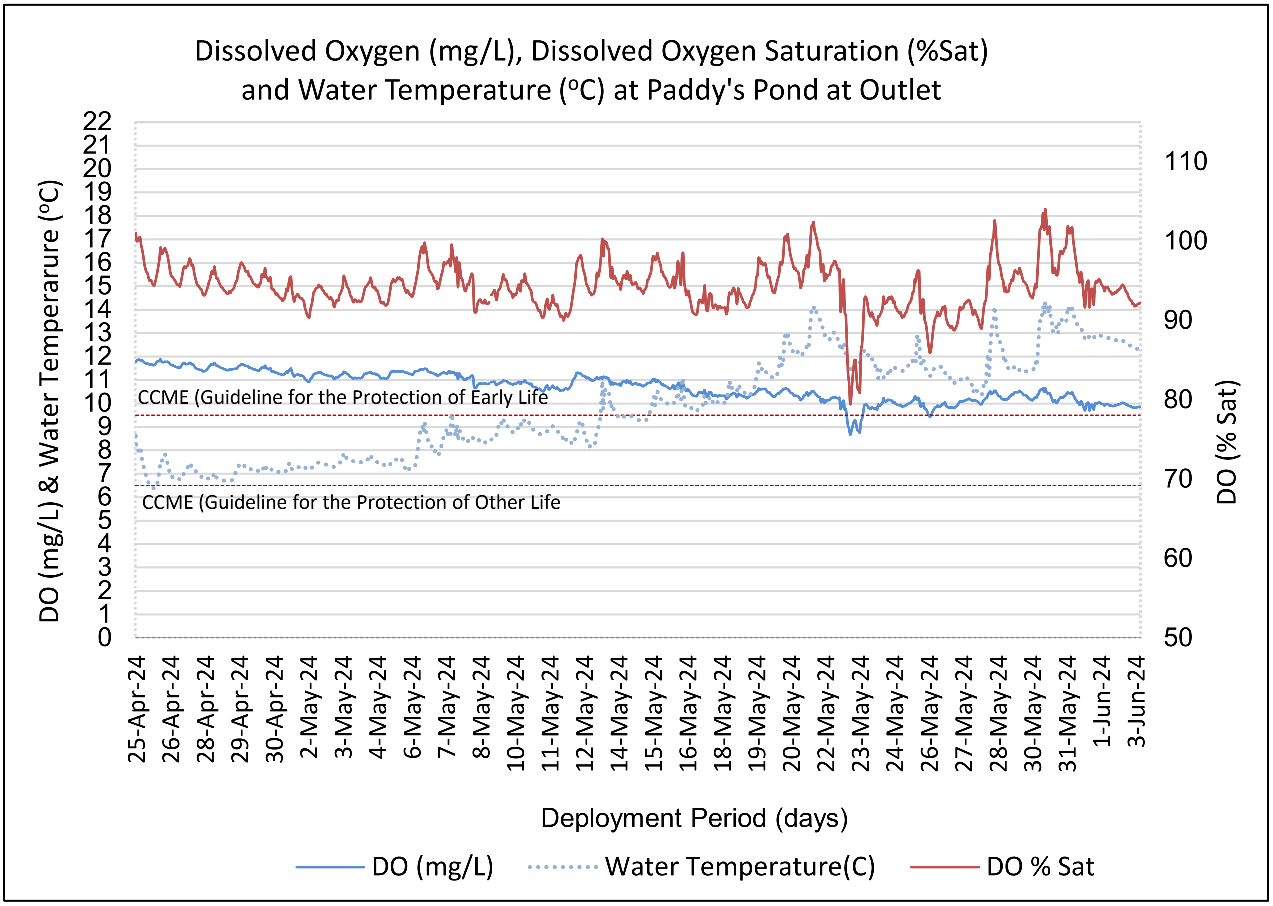
A closer look at the end of the dataset, from late May to June 3, reveals a more stabilized pattern, with conductivity values consistently ranging from 72 to 74 µS/cm. This stabilization could indicate a period of less hydrological disturbance, such as reduced rainfall or consistent water flow, leading to a steady state of dissolved ion concentrations.

Overall, the data from April 25 to June 3 shows periods of both decline and stabilization in specific conductivity. These trends are likely influenced by environmental factors such as rainfall, runoff, and water mixing.

Total dissolved solids (TDS), which measure the combined content of all inorganic and organic substances dissolved in the water, have a mean value of 0.0668 g/L and a median of 0.0700 g/L over the deployment period. The close values of the mean and median values suggest a relatively balanced distribution. The minimum TDS recorded is 0.0600 g/L, while the maximum is 0.0800 g/L. This range of TDS values indicates fluctuations in the concentration of dissolved substances, likely correlating with changes in 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, especially 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.



Parameter	Mean	Median	Min	Max
DO (mg/L)	10.71	10.71	8.67	11.88
DO (% Sat)	94.3	94.2	79.5	104.0

Figure 5: Dissolved Oxygen (mg/L & Percent (%) Saturation) values at Paddy's Pond at Outlet.

Statistical analysis of dissolved oxygen (DO) levels in a Paddy's Pond, detailing both concentrations measured in (mg/L) and percent saturation (% Sat) were calculated and mean and median values for DO concentration were determined to be around 10.71 mg/L, showcasing stability within this range. However, fluctuations are evident, with instances of lower concentrations (minimum value of 8.97 mg/L) and higher concentrations (maximum value of

11.88 mg/L) observed across sampling period. Similarly, the mean and median values for DO saturation percentage indicate a generally high level of oxygen saturation at around 94.3%.

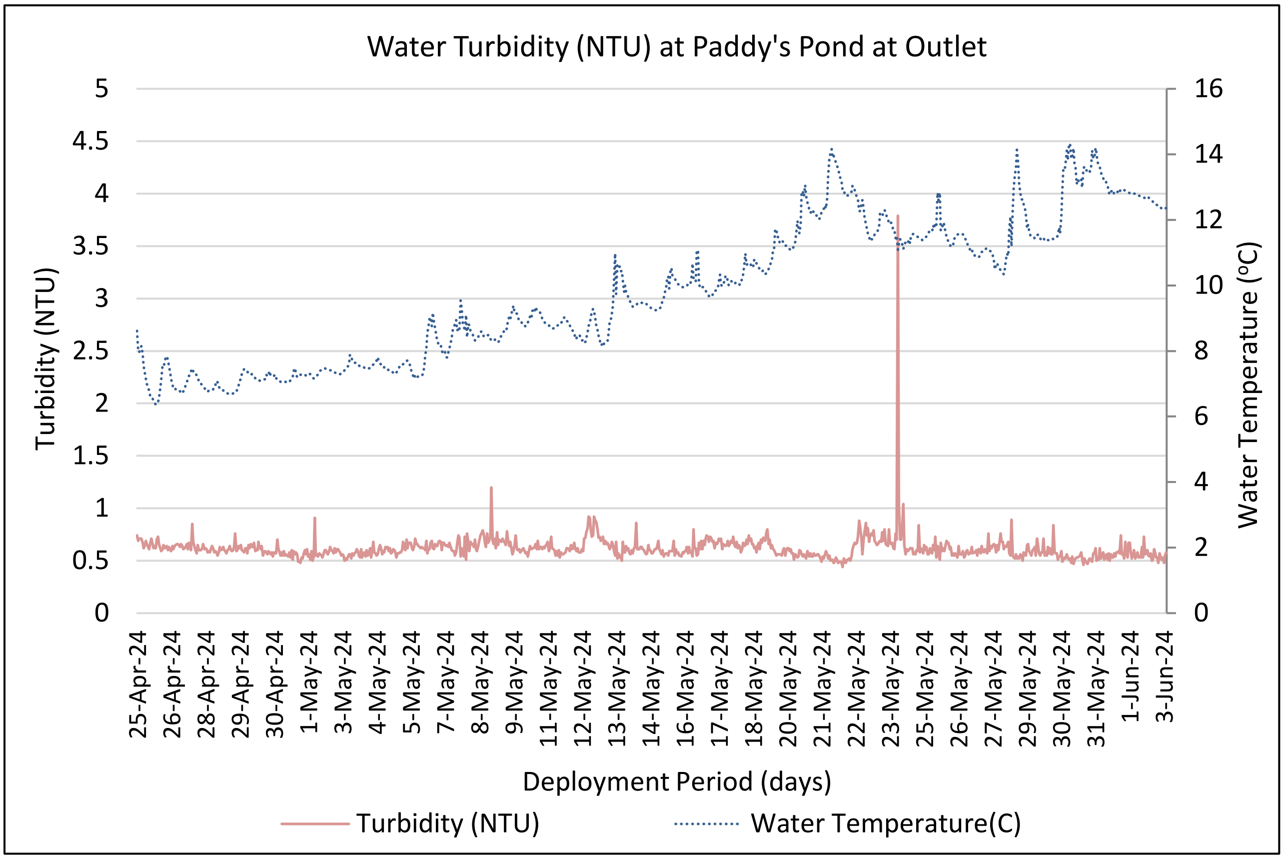
The range between the minimum (79.5%) and maximum (104.0%) values indicates notable variability, potentially reflecting environmental dynamics or measurement anomalies. Low DO concentrations indicate possible instances where the water may be relatively undersaturated with oxygen. This could potentially be a cause for concern as it indicates a lower-than-ideal oxygen level for aquatic organisms. The maximum value of 104.0% is somewhat high and could indicate either an error in measurement or some exceptional environmental conditions, such as super-saturation due to rapid aeration or photosynthesis. Dissolved oxygen (% Saturation) readings of greater than 100% air saturation can occur in ambient water because of the production of pure oxygen by photosynthetically-active organisms and/or because of non-ideal equilibration of dissolved oxygen between the water and the air above it.

Diurnal variation pattern was visible throughout the deployment period due longer sun hours and the correlation between water temperature and air temperature. Variations can be influenced by water depth during deployment as shallow water temperatures will change more rapidly, especially in a lake environment such as Paddy's Pond. As well as linked to the daily range of water temperature, duration of daylight, precipitation (as seen on May 23, 2024) and fluctuations in rates of photosynthesis and respiration.

The dissolved oxygen values were above the CCME Guideline for the Protection of Early Life Stages (9.5 mg/L) and remained above the CCME Guideline for the Protection of Other Life Stages (6.5mg/L) for the entire deployment period.

Turbidity

Turbidity is typically caused by fine suspended solids such as silt, clay, or organic material. Consistently high levels of turbidity tend to block sunlight penetration into a waterbody, discouraging plant growth. High turbidity can also damage the delicate respiratory organs of aquatic animals and cover spawning areas.



Turbidity	Mean	Median	Min	Max
Hourly	0.6	0.6	0.4	3.8

Figure 6: Water turbidity (NTU) values at Paddy's Pond at Outlet

The turbidity data collected from April 25 to June 3, 2024, reveals a consistent pattern. With a mean turbidity of 0.6 NTU, the average clarity suggests generally clear water conditions with minimal suspended particles or sediment. The median turbidity of 0.6 NTU aligns with the mean, indicating relatively consistent clarity across the dataset, albeit with some variability. The minimum turbidity value of 0.4 NTU represents exceptionally clear water, highlighting periods of excellent visibility within the pond. However, the maximum turbidity of 3.8 NTU signifies instances of slightly elevated cloudiness, likely attributed to environmental factors such as sediment runoff or wave action.

APPENDIX A: MEAN DAILY TEMPERATURE AND TOTAL PRECIPITATION

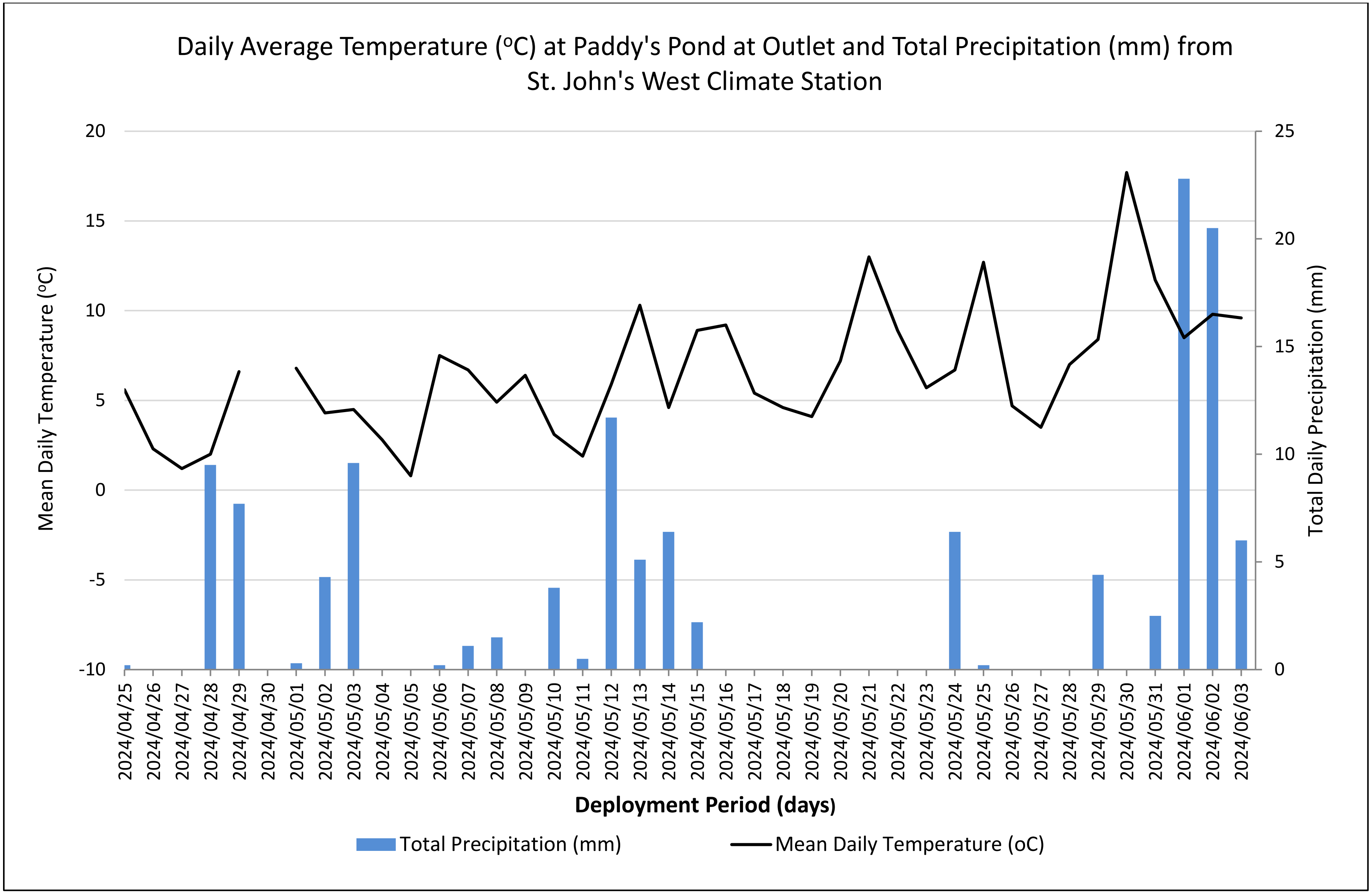


Figure 7: Mean daily air temperature and total precipitation at St. John's West near Paddy's Pond April 25, 2024, to June 3, 2024.

APPENDIX B: Water Parameter Description

Dissolved Oxygen - The amount of Dissolved Oxygen (DO) (mg/l) in the water is vital to aquatic organisms for their survival. The concentration of DO is affected by such things as water temperature, water depth and flow (e.g., aeration by rapids, riffles etc.), consumption by aerobic organisms, consumption by inorganic chemical reactions, consumption by plants during darkness, and production by plants during the daylight (Allan 2010).

pH - pH is the measure of hydrogen ion activity and affects: (i) the availability of nutrients to aquatic life; (ii) the concentration of biochemical substances dissolved in water; (iii) the efficiency of hemoglobin in the blood of vertebrates; and (iv) the toxicity of pollutants. Changes in pH can be attributed to industrial effluence, saline inflows or aquatic organisms involved in the photosynthetic cycling of CO_2 (Allan 2010).

Specific conductivity - Specific conductivity (µS/cm) is a measure of water's ability to conduct electricity, with values normalized to a water temperature of 25ºC. Specific conductance indicates the concentration of dissolved solids (such as salts) in the water, which can affect the growth and reproduction of aquatic life. Specific conductivity is affected by rainfall events, the composition of inflowing tributaries and their associated geology, saline inflow (e.g., road salt), agricultural run-off and industrial inputs (Allan 2010; Swanson and Baldwin 1965).

Stage – Stage (m) is the elevation of the water surface and is often used as a surrogate for the more difficult to measure flow.

Temperature - Essential to the measurement of most water quality parameters, temperature (°C) controls most processes and dynamics of limnology. Water temperature is influenced by such things as ambient air temperature, solar radiation, meteorological events, industrial effluence, wastewater, inflowing tributaries, as well as water body size and depth (Allan 2010; Hach 2006).

Total Dissolved Solids - Total Dissolved Solids (TDS) (g/l) is a measure of alkaline salts dissolved in water or in fine suspension and can affect the growth and reproduction of aquatic life. It is affected by rainfall events, the composition of inflowing tributaries and their associated geology, saline inflow (e.g., road salt), agricultural run-off and industrial inputs (Allan 2010; Swanson and Baldwin 1965).

Turbidity - Turbidity (NTU) is a measure of the translucence of water and indicates the amount of suspended material in the water. Turbidity is caused by any substance that makes water cloudy (e.g., soil erosion, micro-organisms, vegetation, chemicals, etc.) and can correspond to precipitation events, high stage, and floating debris near the sensor (Allan 2010; Hach 2006; Swanson and Baldwin 1965.

APPENDIX C: QA/QC GRAB SAMPLE FIELD RESULTS