Real-Time Water Quality Report

Waterford River at Kilbride
NL02ZM0009

Deployment Period
May 22, 2024, to July 17, 2024

Government of Newfoundland & Labrador
Department of Environment & Climate Change
Water Resources Management Division

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GENERAL

The Water Resources Management Division (WRMD), in partnership with Water Survey of Canada - Environment and Climate Change Canada (WSC-ECCC), maintain a real-time water quality and water quantity monitoring station on Waterford River at Kilbride.

The purpose of the real-time water quality station is to monitor, process and publish real-time water quality data.

This deployment report discusses water quality related events occurring at this station from the instrument deployment on May 22, 2024, until removal on July 17, 2024, 57 days later.

To ensure the success of the RTWQ program, it is crucial to stay acquainted with the latest advancements in water quality monitoring technology. In the station's history, the YSI 6600 and YSI EXO2 has been utilized for both short and long-term deployment. However, moving forward, it is important to trial new equipment and methods.

The InSitu Aqua TROLL 800 utilized in this deployment is an advanced multiparameter sonde equipped with seven customizable ports and non-vented pressure measurement. It combines EPA-approved water quality sensors with the convenience of smartphone mobility, allowing users to collect and analyze data using the VuSitu Mobile App on their mobile devices or the Win-Situ 5 software on a PC/laptop. Notable features include a user-friendly LCD status screen that provides visual indicators for overall readiness, battery life, internal log, and sensor status. It also includes integrated Bluetooth connectivity for wireless data access and an onboard micro SD card for data backup and download.

Figure 1: Aqua TROLL 800

With its low power consumption, the sonde offers a battery life of at least 6 months (with central wiper) and incorporates advanced antifouling measures to protect all sensors. The Aqua TROLL 800 includes self-compensating turbidity, optical RDO, and level sensors, and can easily integrate with the current telemetry system at Waterford River station to provide real-time feedback from remote water monitoring sites.

Figure 1: Waterford River at Kilbride Real-Time Water Quality and Quantity Station.

QUALITY ASSURANCE AND QUALITY CONTROL

As part of the Quality Assurance and Quality Control protocol (QA/QC), 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 (Table 1).

At deployment and removal, a QA/QC Sonde is temporarily deployed adjacent to the Field Sonde. Values for temperature, pH, conductivity, dissolved oxygen, and turbidity are compared between the two instruments**.** Based on the degree of difference between the parameters on the Field Sonde and QA/QC Sonde at deployment and at removal, a qualitative statement is made on the data quality (Table 2).

WRMD staff at the Department of Environment & Climate Change (ECC) are responsible for maintaining and calibrating the water quality instrument, as well as grooming, analyzing, and reporting on water quality data recorded at the station. WSC staff are responsible for the data logging/communication aspect of the network and maintenance of the water quantity monitoring equipment. WSC staff visit the site regularly to ensure the data logging and data transmitting equipment are working properly and are responsible for handling stage and streamflow data issues. The water quantity data is transmitted via satellite and published online with the water quality data on the WRMD website. Water quantity data has not been corrected or groomed when published online or used in the monthly reports for the stations. While WSC oversees the hydrometric component of these stations, due to differences in protocols, quality control for WSC hydrometric data occurs less frequently than for water quality data.

The hydrometric data presented in this report is provisional and has not undergone quality control checks. Accurate hydrometric data can be accessed at https://wateroffice.ec.gc.ca/ or by request to Water Survey Canada.

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Table 1: Instrument Performance 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

Table 2: Instrument performance rankings for Waterford River at Kilbride

Station	**Date**	**Action**	**Comparison Ranking**				
			Temperature	**pH**	**Conductivity**	**Dissolved Oxygen**	**Turbidity**
Waterford River @ Kilbride	**May 22, 2024**	**Deployment**	Good	Good	Fair	Excellent	Excellent
		Grab Sample # 2024-1704-00-SI-SP	N/A	Excellent	Fair	N/A	Excellent
	July 17, 2024	**Removal**	Excellent	Excellent	Excellent	Excellent	Poor

The performance rankings for the water quality instruments at the Waterford River at Kilbride station provide insights into the reliability and accuracy of the measurements taken during deployment and removal, as well as a comparison with grab samples.

On May 22, 2024, during the deployment of the instrument, the temperature and pH readings were ranked as "Good," indicating reliable measurements, though not perfect. Conductivity was rated "Fair," suggesting some level of concern regarding its accuracy or consistency. Both dissolved oxygen and turbidity were ranked "Excellent," indicating high reliability and confidence in the measurements for these parameters.

A grab sample taken on the same day (sample #2024-1704-00-SI-SP) showed an "Excellent" ranking for pH and turbidity, aligning well with the deployment ranking, thus validating these instrument readings. The conductivity was rated "Fair,", also aligning with the deployment ranking, indicating some discrepancies or issues the field sonde.

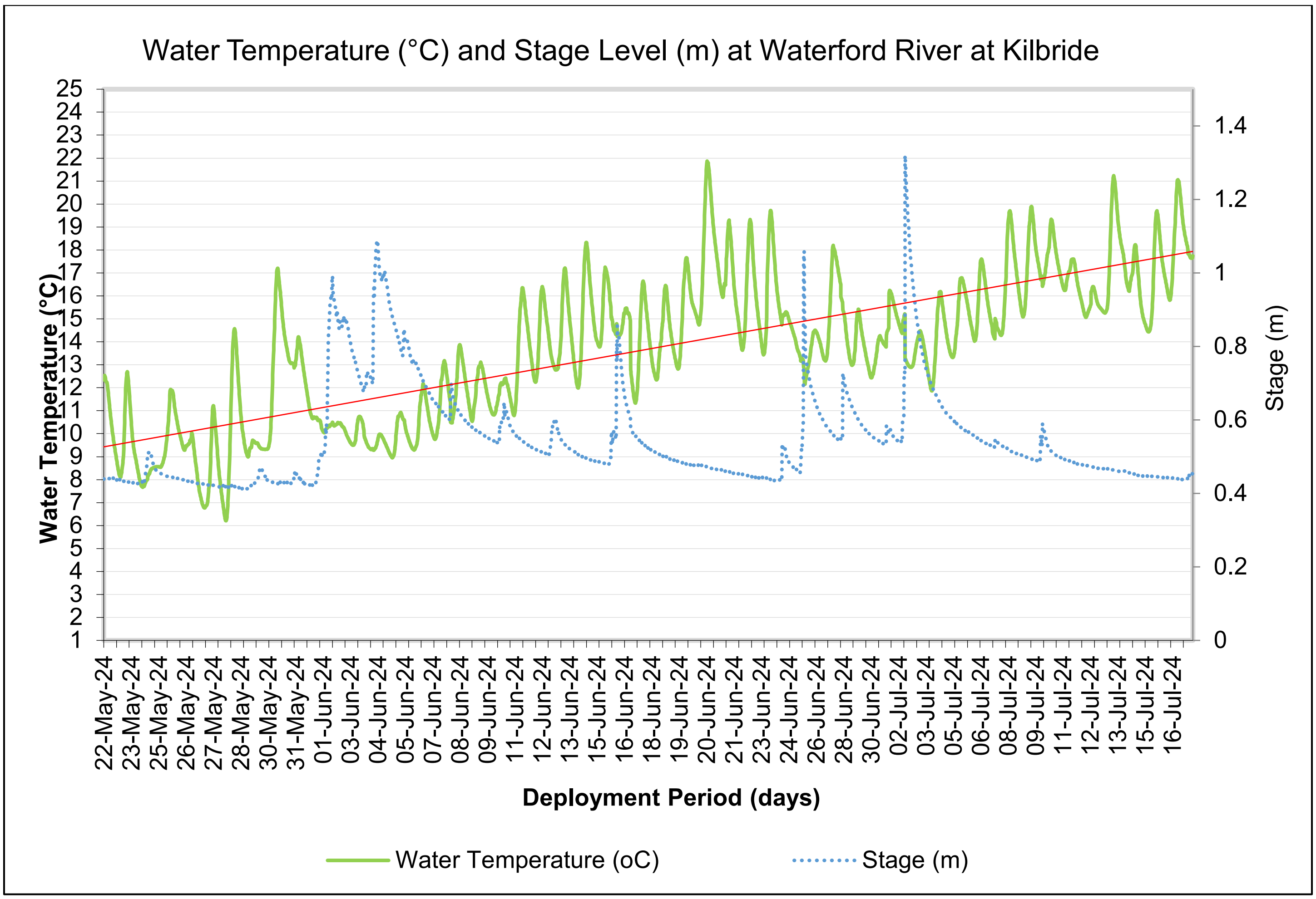
During the removal of the instruments on July 17, 2024, all parameters except turbidity were rated "Excellent," indicating very reliable measurements for temperature, pH, conductivity, and dissolved oxygen. However, turbidity received a "Poor" ranking as a result of the temporary lodging of sediment and organic matter within the sonde casing, thus, interference affecting the readings at that time.

DATA INTERPRETATION

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. Variations in water temperature can influence biological processes, aquatic habitats, and water chemistry, making it a crucial parameter to monitor in understanding ecosystem dynamics. Additionally, tracking temperature trends over time can provide valuable information for assessing the impacts of climate change, seasonal variations, and anthropogenic influences on aquatic ecosystems.

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.



Temperature (oC)	Mean	Median	Min	Max
Hourly	13.68	13.93	6.21	21.87

Figure 2: Water temperature (°C) and Stage (m) values at Waterford River at Kilbride

The water temperature data in Figure 2, provides valuable insights into the thermal characteristics of the aquatic environment under consideration. With a mean temperature of 13.68°C and a median of 13.93°C, the dataset indicates relatively consistent temperatures across the observations, suggesting stability in thermal conditions over the measured period. The minimum temperature recorded at 6.21° (May 28), represents cold conditions, possibly associated with freezing or near-freezing temperatures, and expected for this time of year. The maximum temperature of 21.87°C was reached on June 20th. This upward trend suggests a gradual warming of the river water, most likely influenced by seasonal changes, and due to an increase in sun hours from spring to summer.

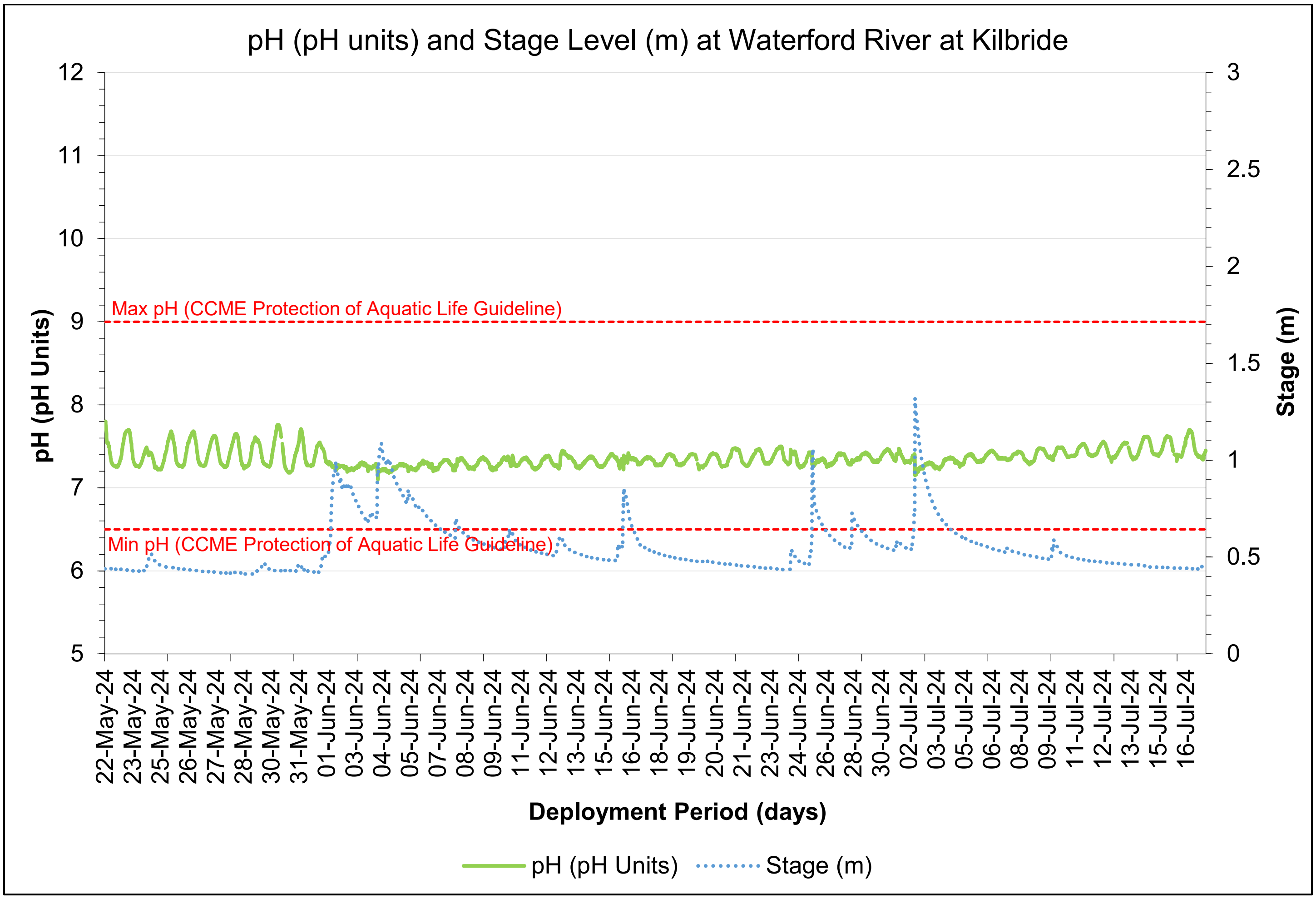
The water temperature dynamics observed reveal a diurnal pattern characterized by temperature increases during the day and decreases overnight. This pattern highlights the river's responsiveness to external influences, particularly daily air temperature fluctuations and precipitation events. Warmer air temperatures during the day contribute to elevated water temperatures, while cooler nighttime temperatures lead to declines. Precipitation events, such as rainfall, also play a significant role, introducing cooler water into the river and contributing to fluctuations in temperature. Additionally, the changing length of days, with increasing daylight hours as spring progresses, likely influences the river's thermal patterns, affecting the duration and intensity of temperature fluctuations.

The hydrometric data presented in this report is provisional and has not undergone quality control checks. Accurate hydrometric data can be accessed at https://wateroffice.ec.gc.ca/ or by request to Water Survey Canada.

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.



Temperature (oC)	Mean	Median	Min	Max
Hourly	7.36	7.34	7.10	7.80

Figure 3: pH (pH units) and stage level (m) values at Waterford River at Kilbride.

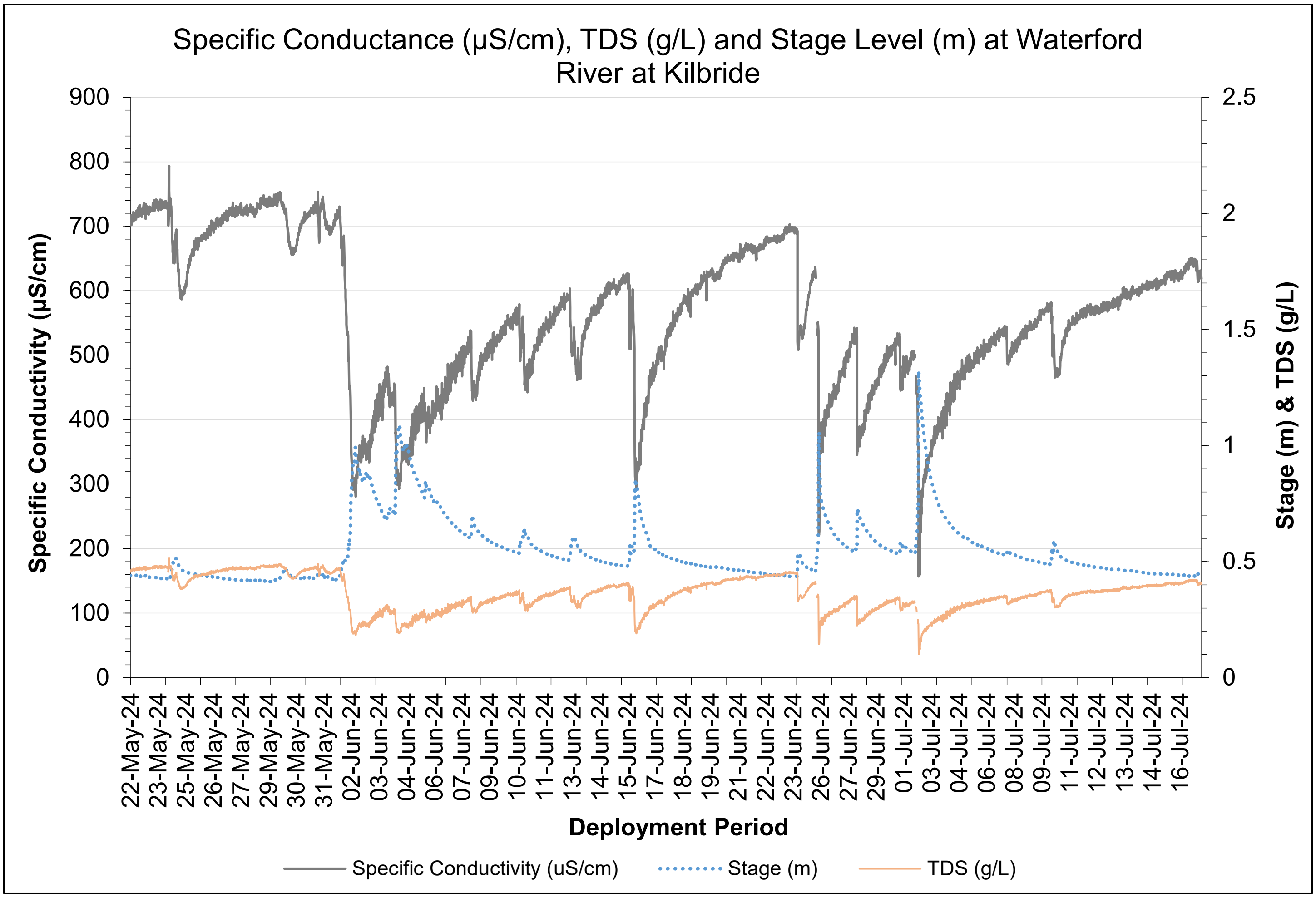
The water pH statistics for the Waterford River provide valuable insight into the acidity or alkalinity levels of the river water during the monitoring period. The mean pH of 7.36 indicates a neutral to slightly alkaline nature on average. Similarly, the median pH of 7.34 reinforces this trend, indicating that most pH measurements clustered around this value. The minimum pH recorded at 7.10 represents the lowest acidity level observed, suggesting occasional fluctuations towards neutrality. On the other hand, the maximum pH of 7.80 indicates the highest alkalinity level recorded (Figure 3).

The data shows relatively stable pH levels throughout, with minor fluctuations within a narrow range. These variations may be influenced by factors such as natural fluctuations in water chemistry, input from surrounding environments, and changes in weather conditions. Despite these minor fluctuations, the average pH values suggest that the Waterford River maintains a relatively stable neutral to slightly alkaline environment throughout the monitoring period.

The diurnal fluctuation in water pH is temperature dependent and rises during the day followed by nighttime decreases. This pattern emphasizes the river's sensitivity to external factors, especially daily shifts in air temperature and more acidic precipitation, resulting in a temporary increase in stage and decrease in fluctuation range, as seen dramatically in early June.

Specific Conductivity & Total Dissolved Solids

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.



Parameter		Mean	Median	Min	Max
Specific Conductivity (µS/cm)	Hourly	559.3	561.3	156.8	793.5
TDS (mg/L)	Hourly	0.3636	0.3649	0.1019	0.5157

Figure 4: Specific conductivity (µS/cm), and TDS (g/mL) values at Waterford River at Kilbride.

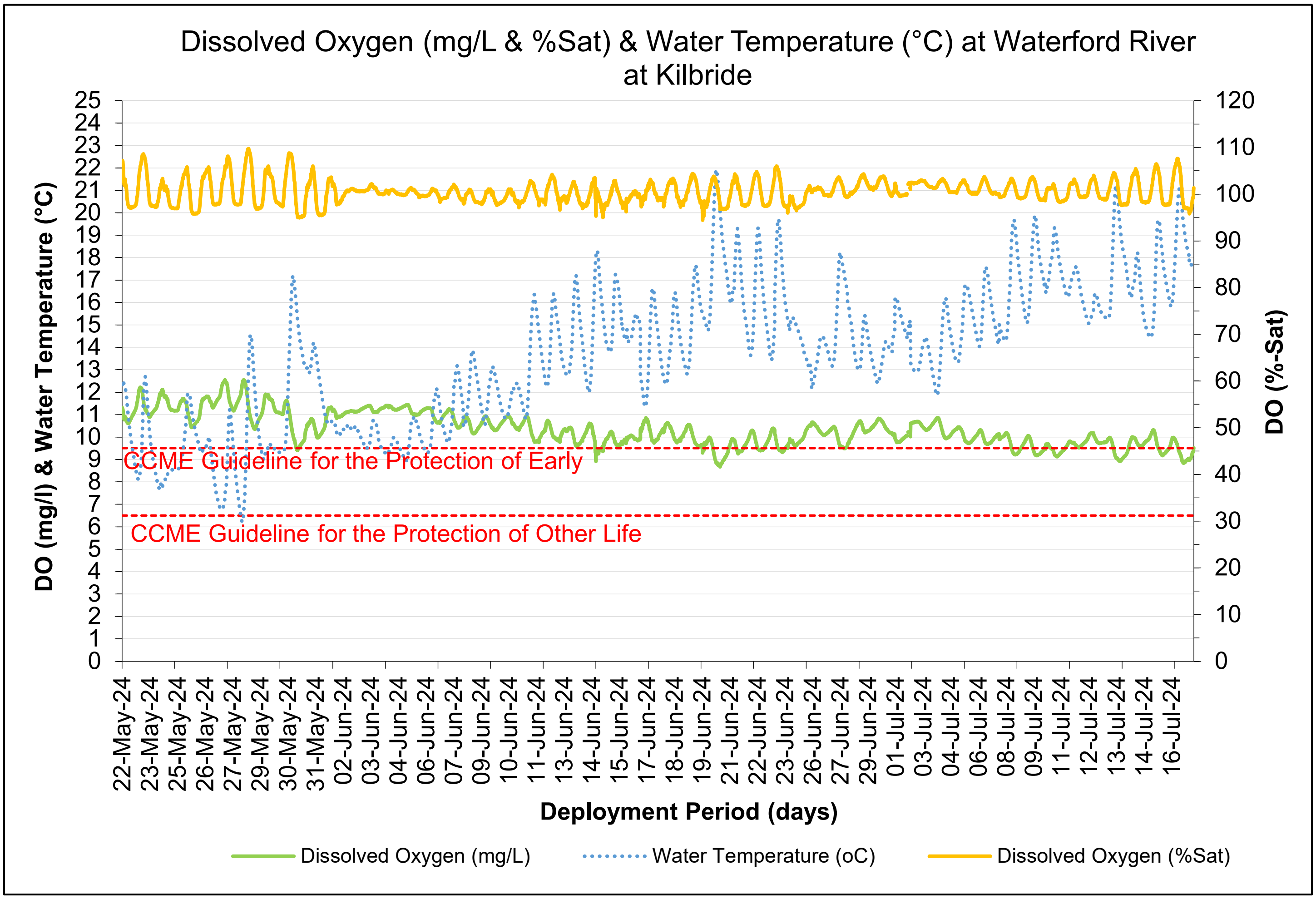
The specific conductivity and total dissolved solids (TDS) data (Figure 4) for the Waterford River provide essential insights into its chemical composition and overall water quality. The data shows a varied pattern over the observed period, starting at 704.37 µS/cm on May 22, 2024, and remaining relatively stable until reaching its peak at 793.45 µS/cm on May 24. Notable fluctuations are observed throughout, with occasional spikes and dips in conductivity levels. For instance, a significant decrease in conductivity observed on June 1, 2024, as a result of a precipitation event that saw 22.8 mm of rain. Multiple drops in conductivity, depicted above, are a result of additional rain events observed until June 16, 2024. As the volume of rainfall was less that seen on June 1 to June 5, conductivity began to increase slowly for the remainder of the deployment period.

The mean specific conductivity of 559.3 µS/cm indicates a moderately high level of ion concentration, reflecting the presence of dissolved salts, minerals, and other conductive substances. The median conductivity (561.3 µS/cm) closely aligns with the mean, indicating consistent conductivity levels across the dataset. The minimum conductivity value of 156.8 µS/cm (July 3) suggests times with lower ion concentration, while the maximum conductivity of 793.45 µS/cm (May 24) signifies elevated ion levels, likely influenced by various anthropogenic and natural factors such as variations in precipitation, runoff from surrounding areas, and changes in water flow.

In terms of the calculated TDS, the mean value of 0.3636 mg/L indicates a low concentration of dissolved solids, which is generally favorable for freshwater ecosystems. The median TDS of 0.0.3649 mg/L suggests consistent dissolved solids levels throughout the dataset. Instances of exceptionally low TDS content, represented by the minimum value of 0.1019 mg/L, may occur in areas with minimal anthropogenic influence or pristine environmental conditions. Conversely, the maximum TDS of 0.5157 mg/L indicates higher concentrations of dissolved solids, potentially influenced by agricultural runoff, urban pollution, or natural geological processes.

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.



Dissolved Oxygen		Mean	Median	Min	Max
DO (%Sat)	Hourly	100.5	100.3	94.4	109.7
DO (mg/L)	Hourly	10.34	10.26	8.67	12.55

Figure 5: Dissolved Oxygen (mg/L & Percent Saturation) values at Waterford River at Kilbride.

The statistical data for dissolved oxygen (DO) concentrations (mg/L) and percent saturation (% Sat) offers valuable insights into the water quality dynamics of each freshwater river within the monitoring period (Figure 5). The mean DO saturation percentage of 100.5% suggests that, on average, the water is fully saturated with oxygen, which is optimal for aquatic organisms' respiration and survival. This high mean value indicates that the river generally maintains healthy oxygen levels throughout the recorded period. The median DO saturation percentage (100.3%) is consistent with the mean, further confirming the overall stability of oxygen saturation levels.

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Examining the minimum and maximum DO saturation percentages provides additional insights into the range of oxygen levels experienced in the river. The minimum value of 94.4% indicates a slight decrease in oxygen saturation, likely influenced by factors such as temperature fluctuations, organic matter decomposition, or reduced water flow. Conversely, the maximum value of 109.7% suggests instances of oxygen supersaturation, which could be caused by factors like increased photosynthetic activity, enhanced aeration, or lower water temperatures.

Considering dissolved oxygen concentrations in milligrams per liter (mg/L), the mean DO concentration of 10.34 mg/L aligns well with the saturation percentage data, indicating adequate oxygen levels to support aquatic life. The median DO concentration (10.26 mg/L) is also consistent with the mean, reflecting the stability of dissolved oxygen levels throughout the dataset. The minimum DO concentration of 8.67 mg/L represents a temporary decrease in oxygen levels, likely influenced by environmental factors impacting oxygen solubility or biological oxygen demand. The maximum DO concentration of 12.55 mg/L indicates periods of elevated oxygen levels, which can be beneficial for supporting sensitive aquatic species and promoting overall ecosystem resilience.

Notably, there's a decrease in DO (mg/L) values from June 5 to the end of the deployment period. This decline could be attributed to various factors, including increased water temperature, and/or reduced flow rates.

Overall, 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 but significantly altered by rain events throughout the deployment period, as seen from June 1 to June 5, 2024. 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.

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. Furthermore, it highlights the significance of monitoring and managing turbidity levels to uphold the health and functionality of aquatic ecosystems.

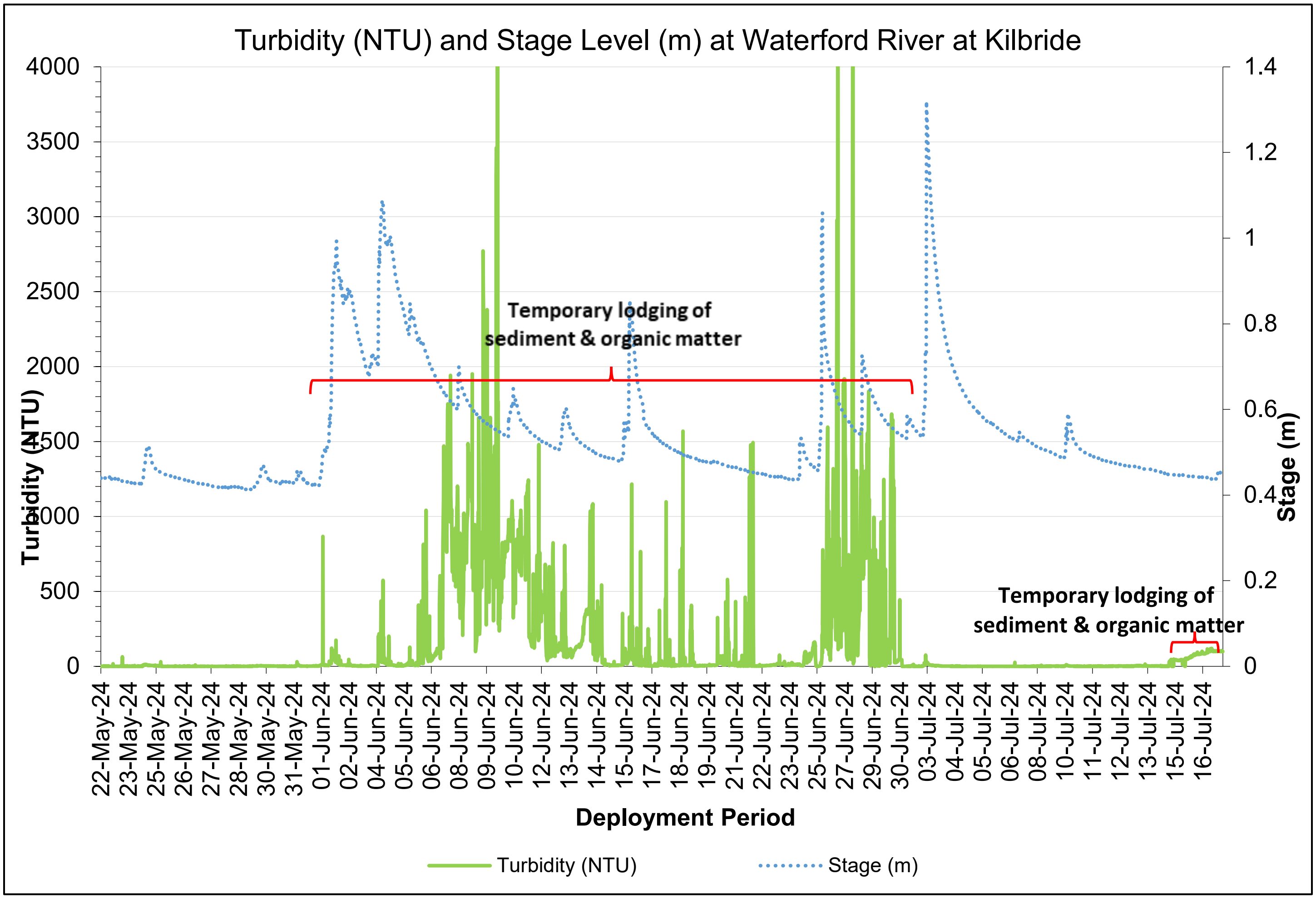
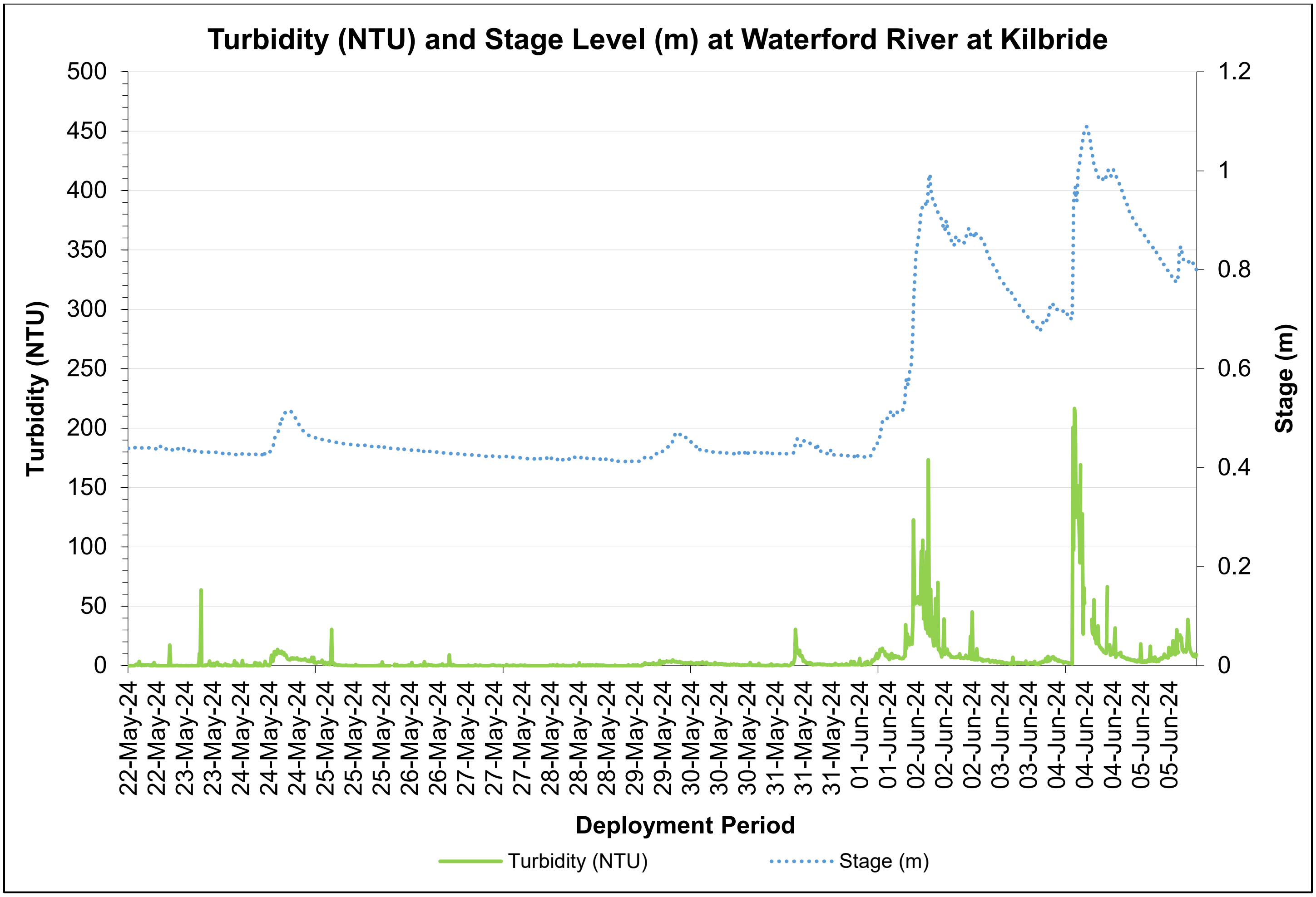


Figure 6: Turbidity (NTU) and stage (m) values at Waterford River at Kilbride.

Due to the collection of erroneous turbidity data, statistical analysis could not be completed for the entire deployment period. The instrument sensor was likely influenced by the temporary lodging and dislodging of sediments and organic matter within the sonde casing after June 6, 2024.



Turbidity (NTU)	Mean	Median	Min	Max
Hourly	5.9	1.0	0.0	216.5

Figure 7: Post June 5, 2024 turbidity (NTU) and stage (m) values at Waterford River at Kilbride.

Prior to June 6, 2024, the turbidity levels in the Waterford River at Kilbride showed fluctuations over the observed period. With an average turbidity of 5.9 NTU, the water was moderately clear, containing some suspended particles or sediment. The median turbidity value of 1.0 NTU indicates variability within the dataset. A minimum turbidity of 0.0 NTU represents periods of very clear water with good visibility. However, the maximum turbidity recorded at 216.5 NTU indicates significantly elevated cloudiness, likely due to sediment runoff, rainfall events, or other environmental disturbances. The average monthly turbidity from January 2020 to December 2023 for the Waterford River is approximately 124 NTU, suggesting that the maximum turbidity of 216.5 NTU (June 4) observed during this period could also be due to temporary sediment lodging or biofouling of the sensor. The image below illustrates the condition of the sonde at the end of the deployment period.

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Figure 8: July 17, 2024 – Instrument and casing after a 57-day deployment period in Waterford River.

Notably, significant spikes in turbidity, above the average monthly, were observed on June 2 and June 4, indicating a sudden decrease in water clarity, most likely due to high stage/precipitation events. Subsequently, turbidity levels gradually decrease but remain relatively elevated compared to the earlier part of the observed period.

Stage and Precipitation

Stage values are determined by a vertical reference and serves as an approximation of the water level at the monitoring station. In addition, stage plays a vital role in understanding various environmental parameters like specific conductivity, dissolved oxygen (DO), and turbidity. It typically rises in response to rainfall events, reflecting the influx of water into the river system. However, during snowfall, the increase in stage may not be as pronounced due to factors such as snow accumulation, which takes time to melt and contribute significantly to the water level. By tracking stage variations, we gain valuable insights into the impact of precipitation on river dynamics, helping us assess water quantity, quality, and potential environmental implications.

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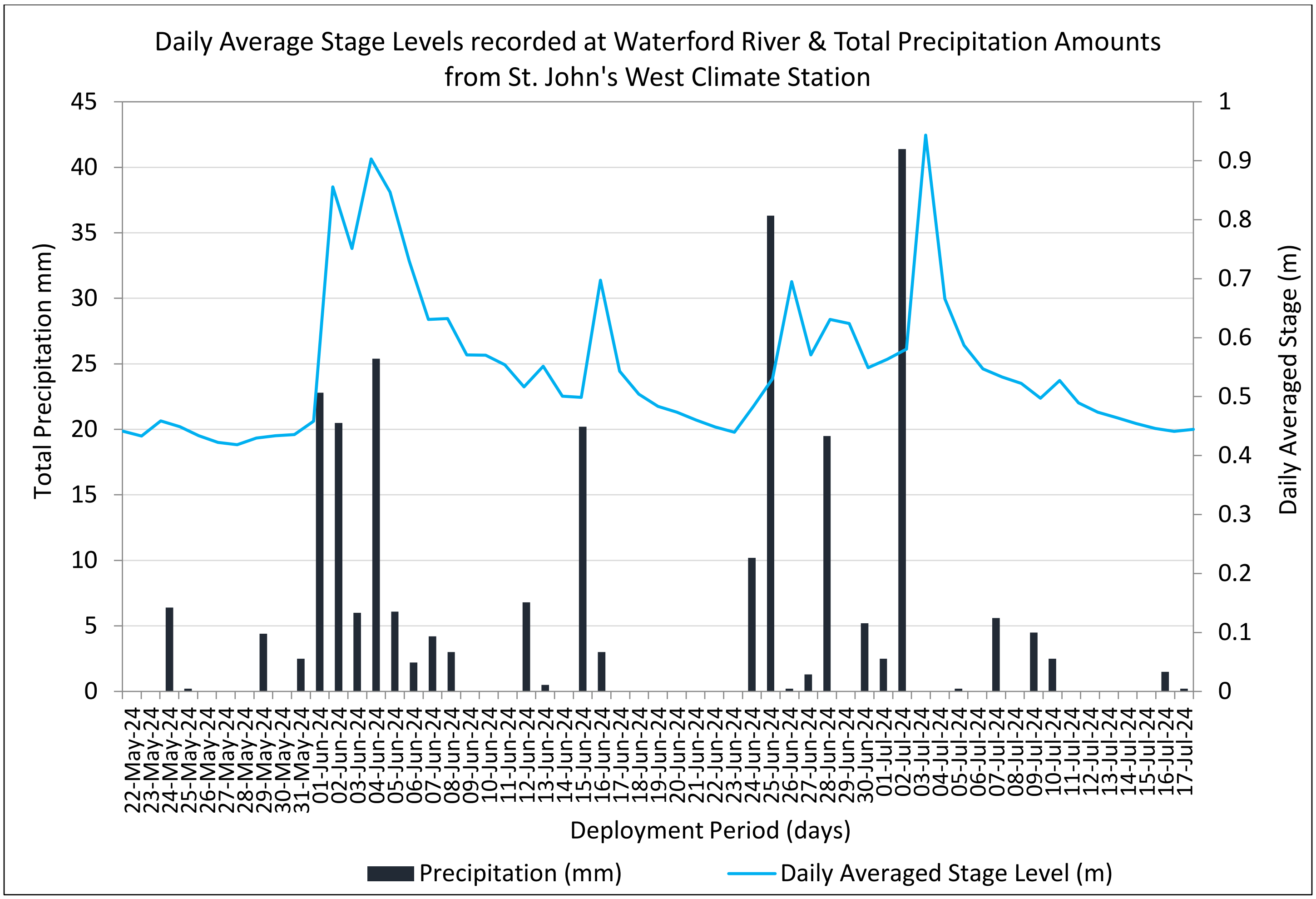


Stage (m)	Mean	Median	Min	Max
Daily Average	0.55	0.51	0.41	1.32

Figure 9: Daily average stage (m) values recorded at Waterford River at Kilbride and daily total precipitation (mm) from St. John's West Climate Station.

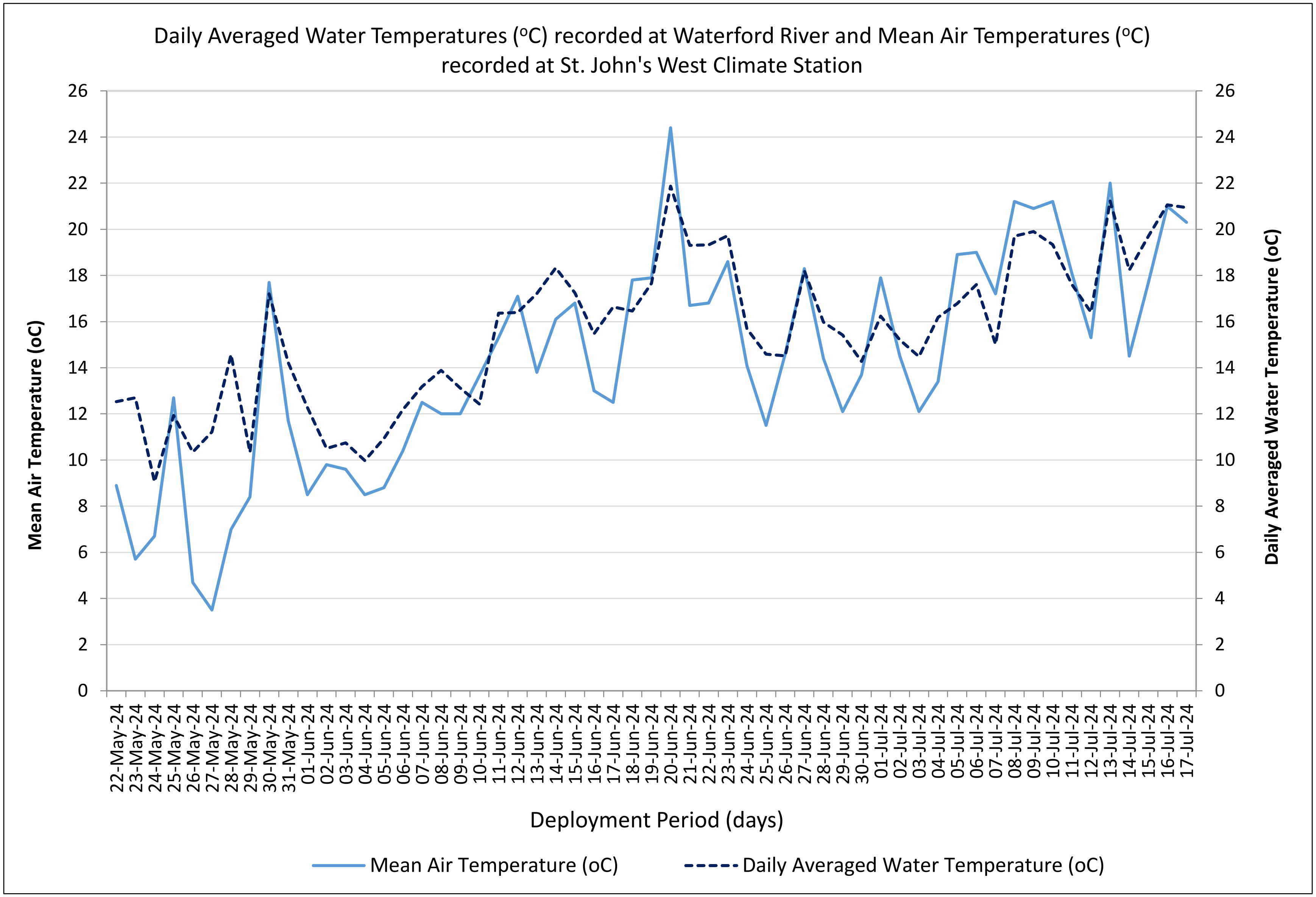
Comparing total precipitation against average daily stage provides insight into the relationship between rainfall and water levels in the Waterford River at Kilbride from May 22 to July 17, 2024. With a mean stage of 0.55 m, the average level of the river during this time frame, serves as a central reference point for observation of change. The median stage of 0.51 m, closely aligned with the mean, suggests a relatively symmetrical distribution. However, the range from the minimum stage of 0.41 units to the maximum stage of 1.32 units signifies variability in river levels (Figure 7).

On days with precipitation, there tends to be an observable increase in average daily stage, indicating a direct response of the river to rainfall events. For example, on June 1 to June 8, there was a total precipitation of 90.2 mm, corresponding to an increase in average daily stage from 0.45 to 0.90 m. Similarly, on June 25, with a substantial precipitation of 36.3 mm, there's a noticeable spike in stage, reaching 0.53 m, and on July 2, with 41.4 mm of rainfall received, a subsequent increase in stage on July 3 to a maximum of 1.32 m was observed.

However, there are instances where rainfall does not directly lead to increased water levels. For example, on May 29, despite a precipitation event of 4.4 mm, there's a slight increase in average daily stage and flow, but it's relatively minor compared to days with higher precipitation levels. Additionally, there are days with zero precipitation where stage and flow remain relatively stable or even decrease slightly.

These discrepancies highlight the complex interactions between precipitation and stage. Factors such as current soil moisture levels, land use, and basin characteristics can influence how much precipitation infiltrates the soil, runs off into the river, or evaporates.

APPENDIX A: MEAN DAILY AIR TEMPERATURE AND AVERAGE WATER TEMPERATURE



Daily Averaged Water Temperatures (oC) recorded at Waterford River and Mean Air Temperatures (oC) recorded at St. John's West Climate Station
Mean Air Temperature (oC)
Daily Averaged Water Temperature (oC)
Deployment Period (days)
22-May-24
17-Jul-24
Mean Air Temperature (oC)
Daily Averaged Water Temperature (oC)

APPENDIX B: QA/QC GRAB SAMPLE FIELD RESULTS