Real-Time Water Quality Report

Waterford River at Kilbride

Deployment Period
March 31, 2022 to May 16, 2022

Newfoundland Labrador

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

Waterford River at Kilbride, Newfoundland and Labrador

Prepared by:

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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 instrument deployment on March 31, 2022 until removal on May 16, 2022. It should be noted that sonde turbidity and dissolved oxygen sensor issues were observed from March 31, 2022 to April 1, 2022, but were corrected for the remainder of the deployment period.

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).

Waterford River at Kilbride, Newfoundland and Labrador

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. WSC is responsible for QA/QC of water quantity data. Corrected stage and streamflow data can be obtained upon request to WSC.

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

It should be noted that the temperature sensor on any sonde is the most important. All other parameters can be divided into subgroups of: temperature dependent, temperature compensated and temperature independent. Due to the temperature sensor's location on the sonde, the entire sonde must be at a constant temperature before the temperature sensor will stabilize. The values may take some time to climb to the appropriate reading; if a reading is recorded to early it may not accurately portray the water body.

Table 2: Instrument performance rankings for Waterford River at Kilbride

Station	**Date**	**Action**	**Comparison Ranking**				
			Temperature	**pH**	**Conductivity**	**Dissolved Oxygen**	**Turbidity**
Waterford River @ Kilbride	**March 31, 2022**	**Deployment**	Excellent	Good	Excellent	Excellent	Excellent
		Grab Sample # 1703	N/A	Fair	Excellent	N/A	Excellent
	May 16, 2022	**Removal**	Excellent	Excellent	Fair	Excellent	Excellent

Waterford River at Kilbride, Newfoundland and Labrador

Upon deployment, all sensors ranked ‘Excellent’ and ‘Good” against the QA/QC sonde.

All measured grab sample (#1703) parameters ranked ‘Excellent’ and ‘Fair’ in comparison to the field sonde. The “Fair” ranking associated with pH is most likely the result of insufficient time for the field sonde to acclimate to water conditions in addition to delayed laboratory analysis resulting in increased sample temperature.

At the removal of the instrument, after a 46-day deployment period, parameters ranked ‘Excellent’, and ‘Fair’ against the QA/QC sonde.

DATA INTERPRETATION

Water Temperature

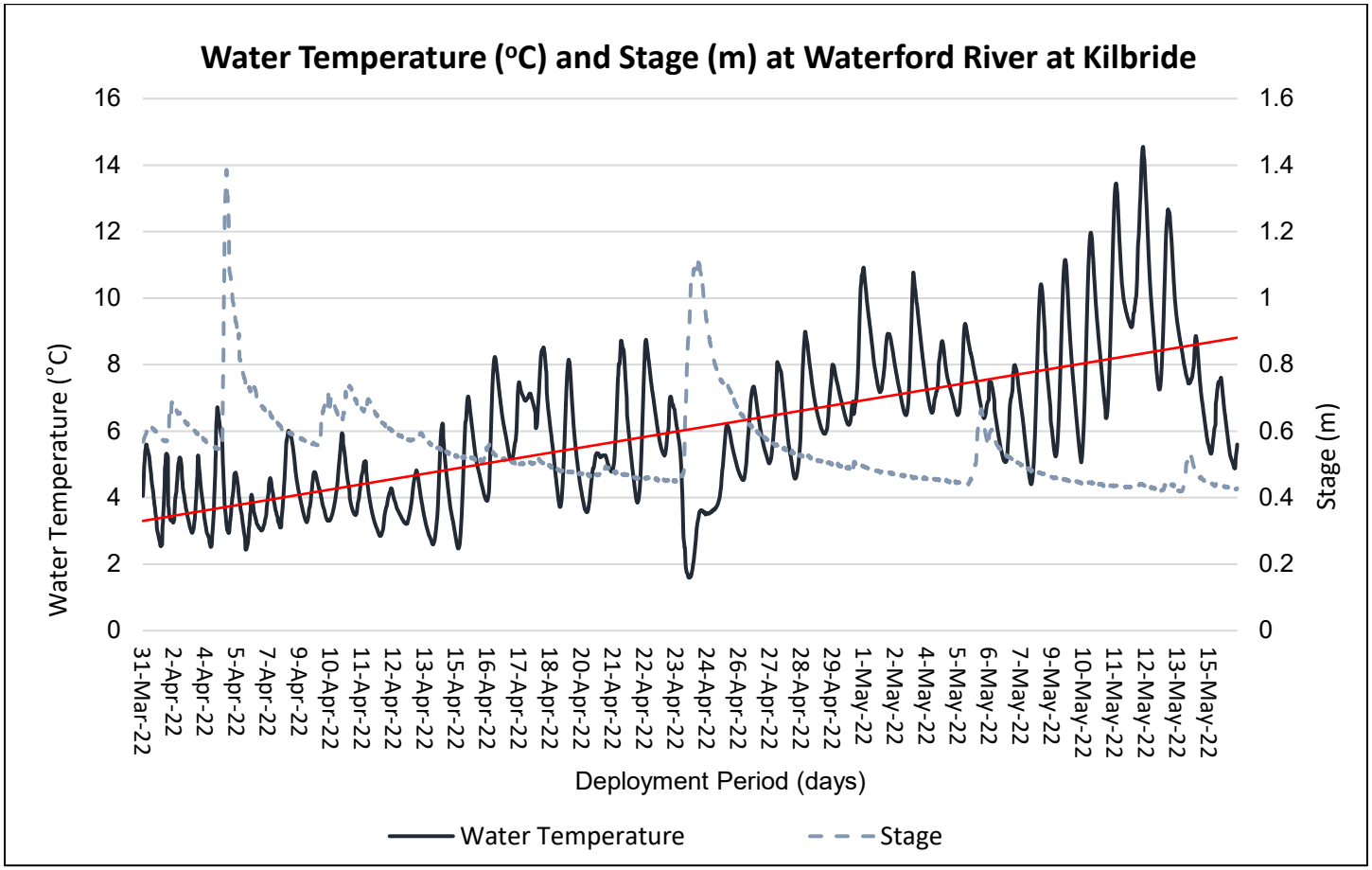
Water temperature ranged from 1.59 °C to 14.55 °C during this deployment period (Figure 2).

Over the duration of the deployment period, the water temperature, in correlation with air temperatures, increased as seasonal temperatures continued to rise (see Appendix A).

During high stage events, the water temperature often decreased for a short period due to the addition of cooler precipitation.

Water temperature values display a natural diurnal pattern with temperatures increasing during the day and decreasing overnight. All brooks and ambient waterways have natural diurnal patterns. The range of the diurnal variation increased in May in correlation with higher daytime air temperatures and longer sunlight hours.

Please note the stage data is raw data. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request to WSC.



Mean	Median	Min	Max
6.06	5.83	1.59	14.55

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

pH

Throughout the deployment period, pH values were relatively stable, with a range between 6.28 pH units and 7.43 pH units, a mean of 6.97 and median of 7.06 pH units (Figure 3).

Upon deployment, the sonde appeared to require additional time to acclimate to water conditions.

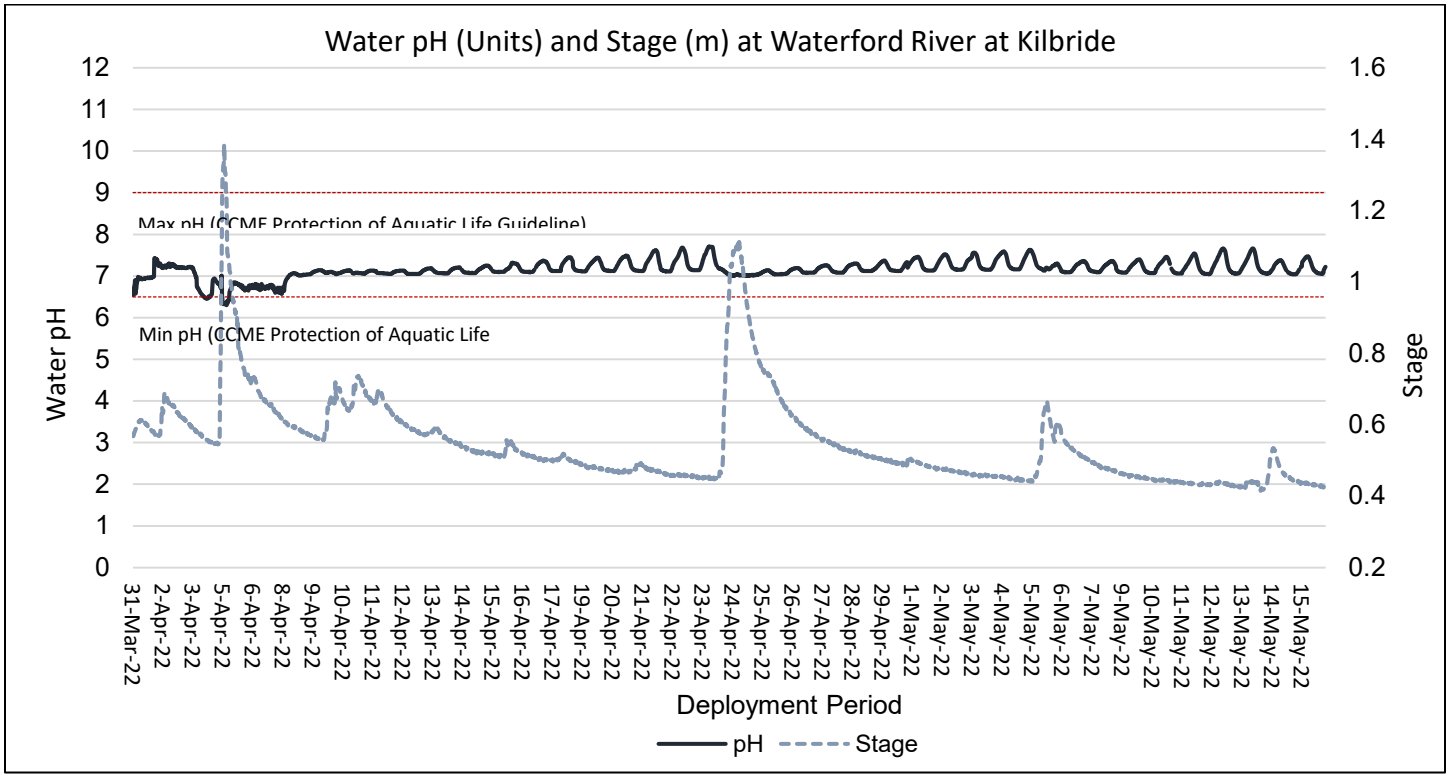
The CCME guideline for the protection of aquatic life states the requirement of a minimum pH value of 6.5 and maximum value of 9.0. The CCME guideline provides a basis by which to judge the overall health of the brook. Waterford River pH values remained within the guidelines for the majority of the deployment with exception to April 4th – 5th, 2022, when pH level decreased below the minimum guideline. This is likely due to the observed precipitation event at this time (See Figure #7).

During higher stage events, the pH values dip temporarily before returning to background levels.

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.

The diurnal variation pattern were variable throughout the deployment period. The magnitude of variation increased over time in correlation to the larger daily water temperature ranges and length of days as expected at this time of the year. Diurnal pH variation decreased temporarily during stage events as result of the addition of rainwater.

Please note the stage data is raw data. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request to WSC.



Mean	Median	Min	Max
6.97	7.06	6.28	7.43

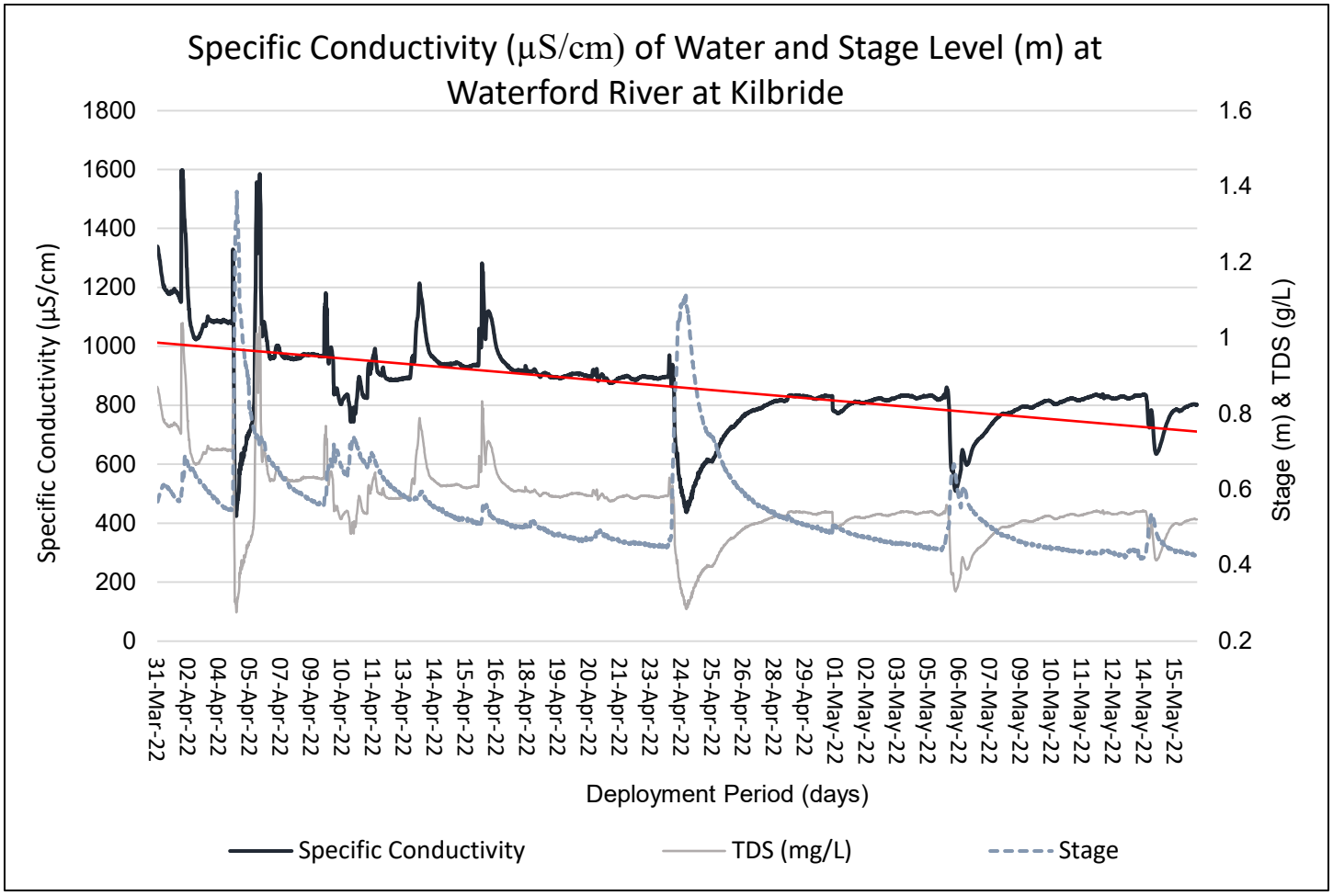
Figure 3: pH (pH units) and stage level (m) values at Waterford River at Kilbride.

Specific Conductivity & Total Dissolved Solids

The conductivity concentration levels were within 424 µS/cm and 1598 µS/cm during this deployment period. TDS (a calculated value) ranged from 0.2760 g/L to 1.0420 g/L (Figure 4).

Throughout the deployment period, conductivity levels at Waterford River decreased during high stage events before rebounding. This is likely a result of the minerals and dissolved material present in the brook being diluted and flushed for a short period of time before returning to background levels. Spikes above background levels in conductivity were observed throughout the beginning of the deployment period. These may be a result of road salts being washed into the brook during precipitation events (See Figure 7). Given the location, the river is highly influenced by urban roads, residential housing and pedestrian traffic.

Please note the stage data is raw. It is not corrected for backwater effect. WSC is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request to WSC.



	Mean	Median	Min	Max
Specific Conductivity (µS/cm)	863.3	832.0	424.0	1598.0
TDS (mg/L)	0.5636	0.5410	0.2760	1.0420

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

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.

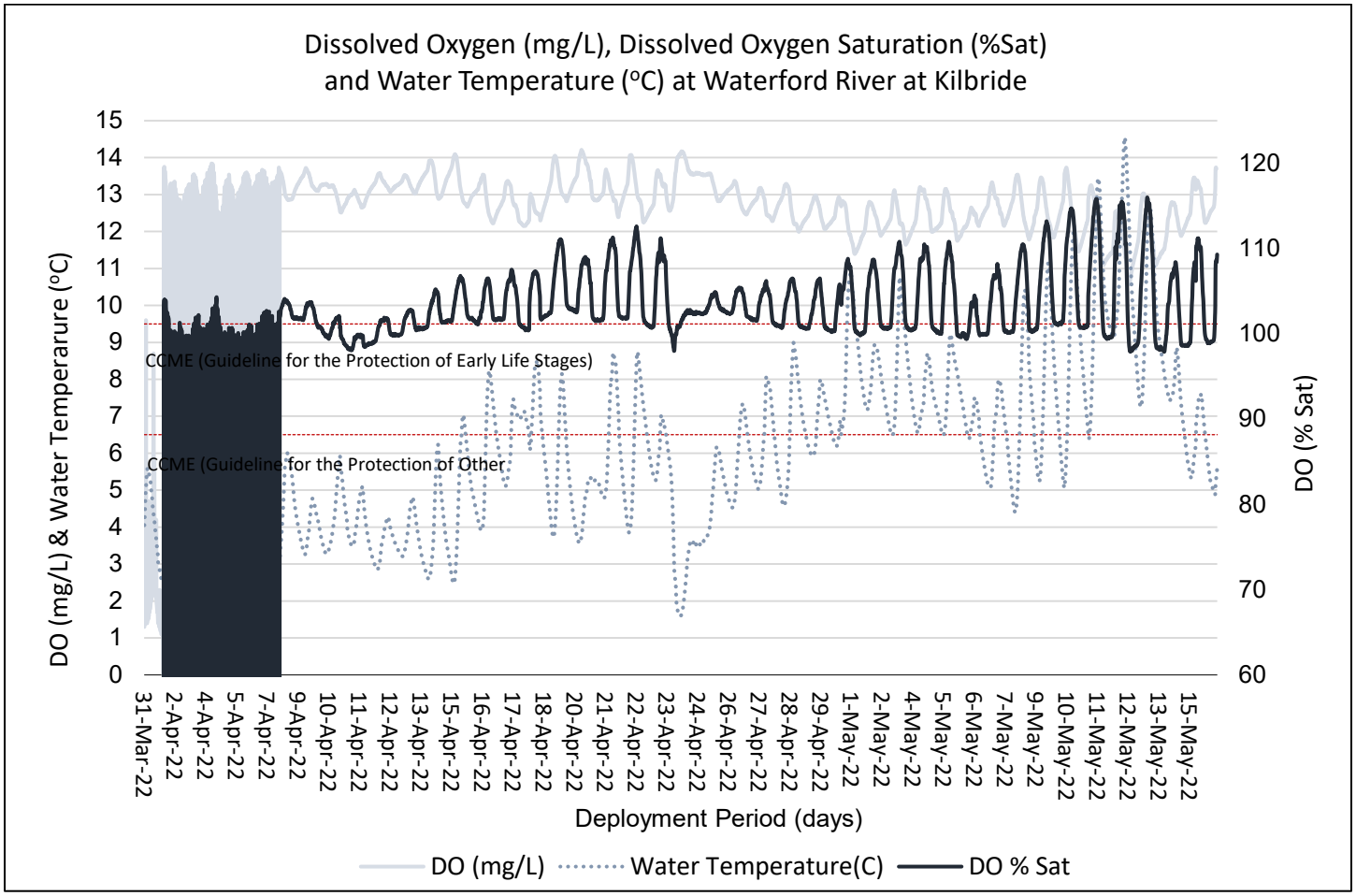
The water quality instrument measures dissolved oxygen (mg/L) with the dissolved oxygen probe. The instrument then calculates percent saturation (% Sat) taking into account the water temperature.

From March 31, 2022 to April 7, 2022, connectivity issues were observed as depicted in Figure 5 below. During the deployment, the dissolved oxygen concentration levels ranged within a minimum of 10.57 mg/L to a maximum of 14.21 mg/L. The percent saturation levels for dissolved oxygen ranged within 97.8 % Saturation to 105.2 % Saturation (Figure 5).

The dissolved oxygen values remained above the CCME Guideline for the Protection of Early life stages (9.5mg/L) and other life stages (6.5 mg/L).

A gradual decrease in dissolved oxygen concentration was observed in correlation with natural warming water temperatures. Sudden dips in dissolved oxygen are in relation to peaks in water temperature.

Diurnal variation was most visible from early March through the end of March. The magnitude of variation iincreased in correlation to the increasing daily water/air temperature range and the length of days.



	Mean	Median	Min	Max
DO (%Sat)	99.8	100.6	97.8	105.2
DO (mg/L)	13.18	13.21	10.57	14.21

Figure 5: Dissolved Oxygen (mg/L & Percent Saturation) values at Waterford River at Kilbride. *Erroneous data due to sensor issues was removed for the purpose of statistical analysis.

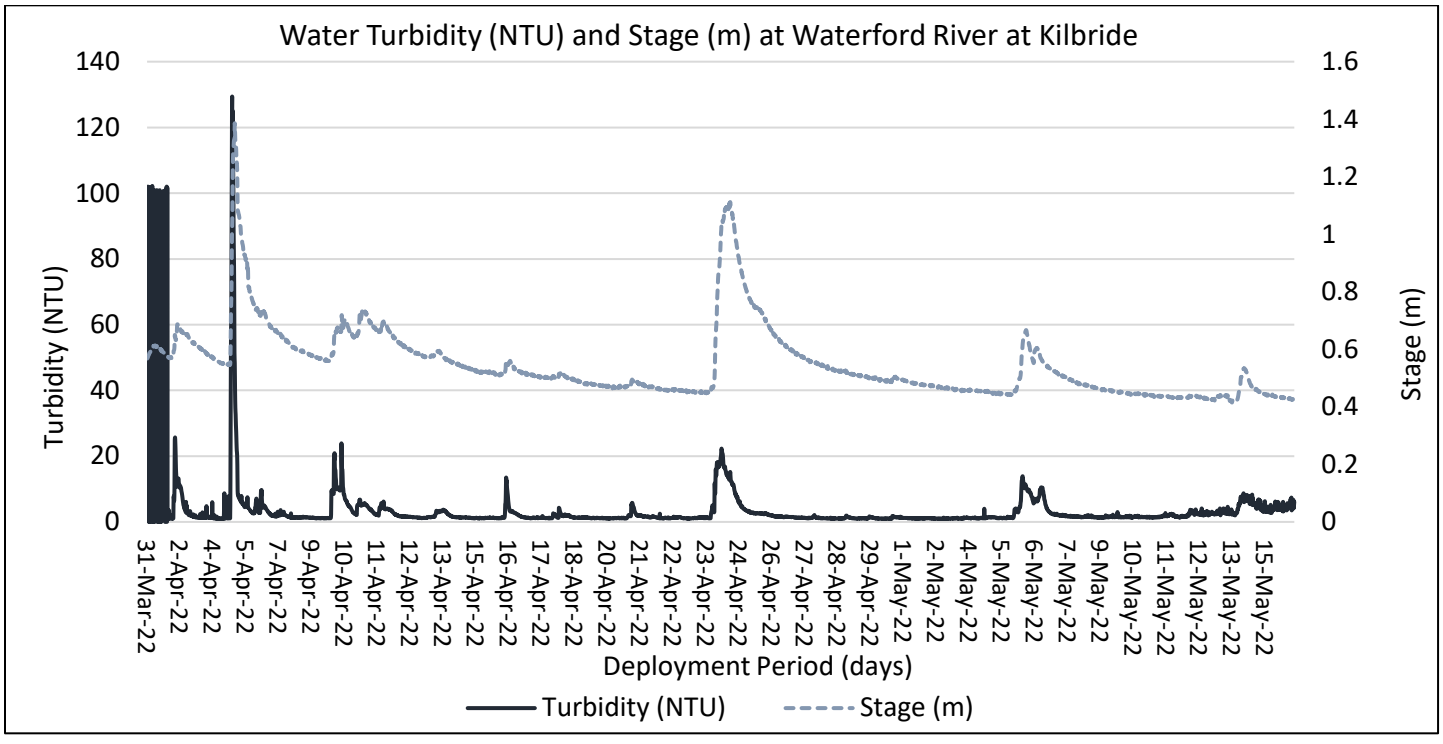
Turbidity

Turbidity levels during the deployment ranged from 0 NTU and 129.4 NTU, with a mean of 9.8 NTU and median of 2.0 NTU (Figure 6).

Turbidity measurements from March 31, 2022 through April 1, 2022 were erroneous due to a sensor issues. Turbidity throughout the deployment period is considered low with increases above baseline values as seen on April 4, 2022 due to higher stage events.

The higher turbidity events observed in Figure 6 correlate with increases in stage. Rainfall was recorded during all of the high stage events. Precipitation can increase the presence of suspended material in water through the movement of soil and sediment from nearby urban areas. Sediments and debris can temporarily become lodged within the sonde casing during precipitation events and cause spikes in turbidity values.

Please note the stage data is raw. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request to WSC.



Mean	Median	Min	Max
9.8	2.0	0.0	129.4

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

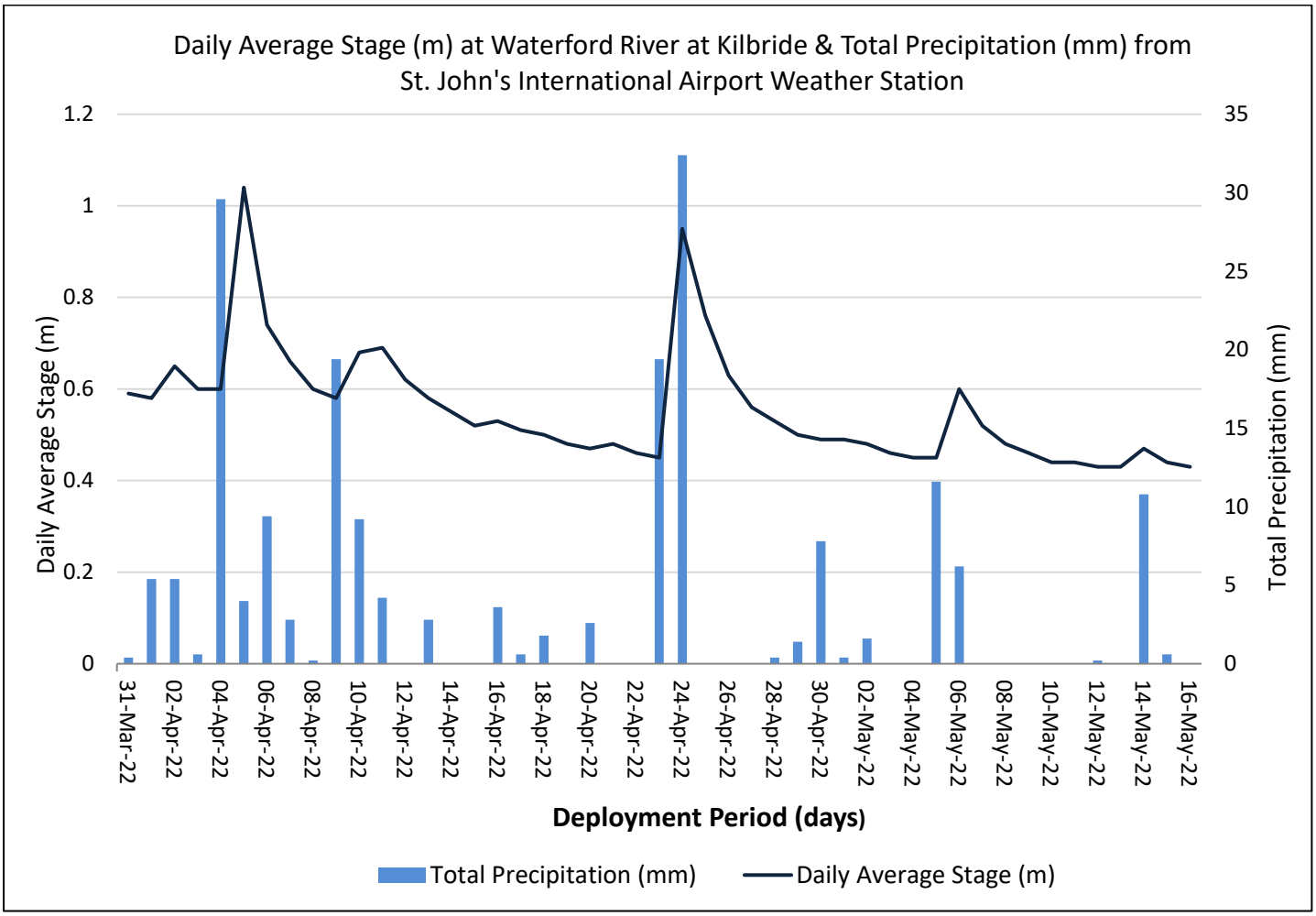
Stage and Precipitation

Please note the stage data graphed below is raw data. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data. Corrected data is available upon request to WSC.

Stage is an estimation of water level at the station and can explain some of the events that are occurring with other parameters (i.e. Specific Conductivity, DO, turbidity). Stage will increase during rainfall events (Figure 7) and during any surrounding snow or ice melt, as runoff will collect in the brooks. However, direct snowfall will not cause stage to rise significantly.

During the deployment period, the stage values ranged from 0.43 m to 1.04 m. The larger peaks in stage correspond with substantial rainfall events as noted on Figure 7. Precipitation data was collected by Environment Canada's St. John's International Airport weather station. Daily Total Precipitation ranges for the deployment period were a minimum of 0.0 mm and a maximum of 32.4 mm on April 24, 2022.

A slight decrease in the daily average stage trend was observed late in the deployment period as a result of less precipitation events near the end of the deployment period.

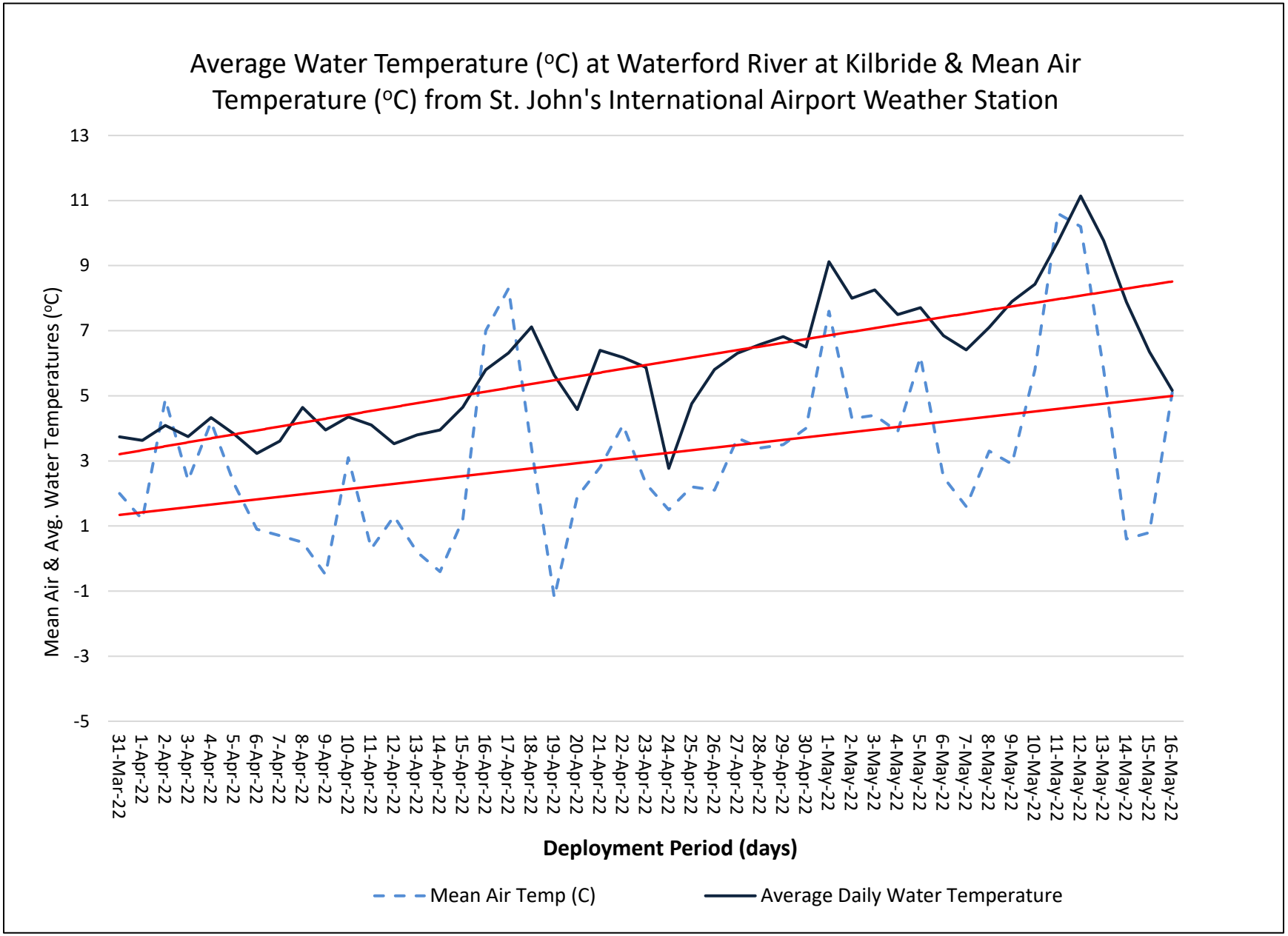


Mean	Median	Min	Max
0.55	0.52	0.43	1.04

Figure 7: Stage (m) values recorded at Waterford River at Kilbride and daily total precipitation (mm) from St. John's Airport Weather Station.

APPENDIX A : MEAN DAILY AIR TEMPERATURE AND AVERAGE WATER TEMPERATURE

Waterford River at Kilbride, Newfoundland and Labrador



APPENDIX B : QA/QC GRAB SAMPLE FIELD RESULTS

Your P.O. #: 220028978-5
Site Location: WATERFORD RIVER @ KILBRIDE
Your C.O.C. #: N/A, 2022-1703-00-SI-SP

Attention: Janice McCarthy

NL Department of Environment, Climate Change and Municipalities
Water Resources
PO Box 8700
St. John's, NL
CANADA A1B 4J6

Report Date: 2022/04/12
Report #: R7083273
Version: 2 - Final

CERTIFICATE OF ANALYSIS

BUREAU VERITAS JOB #: C290222
Received: 2022/04/04, 09:15

Sample Matrix: Water
Samples Received: 1

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Alkalinity	1	N/A	2022/04/08	ATL SOP 00142	SM 23 2320 B
Anions (1)	1	N/A	2022/04/11	CAM SOP-00435	SM 23 4110 B m
Colour	1	N/A	2022/04/08	ATL SOP 00020	SM 23 2120C m
Organic carbon - Diss (DOC) (2)	1	N/A	2022/04/08	ATL SOP 00203	SM 23 5310B m
Conductance - water	1	N/A	2022/04/08	ATL SOP 00004	SM 23 2510B m
Fluoride	1	N/A	2022/04/08	ATL SOP 00043	SM 23 4500-F- C m
Hardness (calculated as CaCO3)	1	N/A	2022/04/08	ATL SOP 00048	Auto Calc
Mercury - Total (CVAA,LL)	1	2022/04/07	2022/04/08	ATL SOP 00026	EPA 245.1 R3 m
Metals Water Total MS	1	2022/04/07	2022/04/07	ATL SOP 00058	EPA 6020B R2 m
Nitrogen Ammonia - water	1	N/A	2022/04/07	ATL SOP 00015	EPA 350.1 R2 m
Nitrogen - Nitrate + Nitrite	1	N/A	2022/04/08	ATL SOP 00016	USGS I-2547-11m
Nitrogen - Nitrite	1	N/A	2022/04/07	ATL SOP 00017	SM 23 4500-NO2- B m
Nitrogen - Nitrate (as N)	1	N/A	2022/04/08	ATL SOP 00018	ASTM D3867-16
pH (3)	1	N/A	2022/04/08	ATL SOP 00003	SM 23 4500-H+ B m
Calculated TDS (DW Pkg)	1	N/A	2022/04/08	N/A	Auto Calc
Total Kjeldahl Nitrogen in Water (1)	1	2022/04/11	2022/04/11	CAM SOP-00938	OMOE E3516 m
Organic carbon - Total (TOC) (2)	1	N/A	2022/04/08	ATL SOP 00203	SM 23 5310B m
Total Phosphorus (Colourimetric) (1)	1	2022/04/11	2022/04/12	CAM SOP-00407	SM 23 4500 P B H m
Total Suspended Solids	1	2022/04/06	2022/04/11	ATL SOP 00007	SM 23 2540D m
Turbidity	1	N/A	2022/04/08	ATL SOP 00011	EPA 180.1 R2 m

Reference Method suffix “m” indicates test methods incorporate validated modifications from specific reference methods to improve performance.

(1) This test was performed by Bureau Veritas Mississauga, 6740 Campobello Rd , Mississauga, ON, L5N 2L8
(2) TOC / DOC present in the sample should be considered as non-purgeable TOC / DOC.
(3) The APHA Standard Method require pH to be analyzed within 15 minutes of sampling and therefore field analysis is required for compliance. All Laboratory pH analyses in this report are reported past the APHA Standard Method holding time.

Your P.O. #: 220028978-5
Site Location: WATERFORD RIVER @ KILBRIDE
Your C.O.C. #: N/A, 2022-1703-00-SI-SP

Attention: Janice McCarthy

NL Department of Environment, Climate Change and Municipalities
Water Resources
PO Box 8700
St. John's, NL
CANADA A1B 4J6

Report Date: 2022/04/12
Report #: R7083273
Version: 2 - Final

CERTIFICATE OF ANALYSIS

BUREAU VERITAS JOB #: C290222
Received: 2022/04/04, 09:15

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Maryann Comeau, Customer Experience Supervisor/PM
Email: Maryann.COMEAU@bureauveritas.com
Phone# (902)420-0203 Ext:298
==========
Bureau Veritas has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per ISO/IEC 17025, signing the reports.
For Service Group specific validation please refer to the Validation Signature Page.

Bureau Veritas Job #: C290222
Report Date: 2022/04/12

NL Department of Environment, Climate Change and Municipalities
Site Location: WATERFORD RIVER @ KILBRIDE
Your P.O. #: 220028978-5
Sampler Initials: LB

Sample Details/Parameters	A	Result	RDL	UNITS	Extracted	Analyzed	By	Batch
SHD894 WATERFORD RIVER AT KILBRIDE								
Sampling Date 2022/03/31 12:00								
Matrix W								
Sample # 2022-1703-00-SI-SP								
Registration # WS-S-0000								
RESULTS OF ANALYSES OF WATER								
Calculated Parameters								
Hardness (CaCO3)	-	69	1.0	mg/L	N/A	2022/04/08		7924342
Nitrate (N)	-	0.77	0.050	mg/L	N/A	2022/04/08		7924345
Total dissolved solids (calc., EC)	-	720	1.0	mg/L	N/A	2022/04/08		7925217
Inorganics								
Conductivity	-	1300	1.0	uS/cm	N/A	2022/04/08	SHW	7929247
Chloride (Cl-)	-	400(1)	5.0	mg/L	N/A	2022/04/11	LKH	7931402
Bromide (Br-)	-	ND	1.0	mg/L	N/A	2022/04/11	LKH	7931402
Sulphate (SO4)	-	22	1.0	mg/L	N/A	2022/04/11	LKH	7931402
Total Alkalinity (Total as CaCO3)	-	11	2.0	mg/L	N/A	2022/04/08	SHW	7929249
Colour	-	9.5	5.0	TCU	N/A	2022/04/08	MCN	7926982
Dissolved Fluoride (F-)	-	ND	0.10	mg/L	N/A	2022/04/08	SHW	7929250
Total Kjeldahl Nitrogen (TKN)	-	ND	0.10	mg/L	2022/04/11	2022/04/11	MJ1	7933260
Nitrate + Nitrite (N)	-	0.77	0.050	mg/L	N/A	2022/04/08	MCN	7926985
Nitrite (N)	-	ND	0.010	mg/L	N/A	2022/04/07	MCN	7926988
Nitrogen (Ammonia Nitrogen)	-	ND	0.050	mg/L	N/A	2022/04/07	MCN	7926742
Dissolved Organic Carbon (C)	-	2.2	0.50	mg/L	N/A	2022/04/08	NGI	7929275
Total Organic Carbon (C)	-	2.4	0.50	mg/L	N/A	2022/04/08	NGI	7929242
pH	-	7.10		pH	N/A	2022/04/08	SHW	7929248
Total Phosphorus	-	0.016	0.004	mg/L	2022/04/11	2022/04/12	SSV	7932918
Total Suspended Solids	-	1.2	1.0	mg/L	2022/04/06	2022/04/11	MKX	7925186
Turbidity	-	1.2	0.10	NTU	N/A	2022/04/08	SHW	7929418
MERCURY BY COLD VAPOUR AA (WATER)								
Metals								
Total Mercury (Hg)	-	ND	0.000013	mg/L	2022/04/07	2022/04/08	FJO	7926721
ELEMENTS BY ICP/MS (WATER)								
Metals								
Total Aluminum (Al)	-	0.072	0.0050	mg/L	2022/04/07	2022/04/07	BAN	7926741
Total Antimony (Sb)	-	ND	0.0010	mg/L	2022/04/07	2022/04/07	BAN	7926741
Total Arsenic (As)	-	ND	0.0010	mg/L	2022/04/07	2022/04/07	BAN	7926741
Total Barium (Ba)	-	0.038	0.0010	mg/L	2022/04/07	2022/04/07	BAN	7926741
Total Boron (B)	-	ND	0.050	mg/L	2022/04/07	2022/04/07	BAN	7926741
Total Cadmium (Cd)	-	0.000061	0.000010	mg/L	2022/04/07	2022/04/07	BAN	7926741
Total Calcium (Ca)	-	23	0.10	mg/L	2022/04/07	2022/04/07	BAN	7926741
Total Chromium (Cr)	-	ND	0.0010	mg/L	2022/04/07	2022/04/07	BAN	7926741
Total Copper (Cu)	-	0.0016	0.00050	mg/L	2022/04/07	2022/04/07	BAN	7926741
Total Iron (Fe)	-	0.14	0.050	mg/L	2022/04/07	2022/04/07	BAN	7926741
Total Lead (Pb)	-	ND	0.00050	mg/L	2022/04/07	2022/04/07	BAN	7926741

(1) ANIONS-L: Due to high concentrations of the target analytes, sample required dilution. Detection limits were adjusted accordingly.

Bureau Veritas 200 Bluewater Rd, Suite 105, Bedford, Nova Scotia Canada B4B 1G9 Tel: 902-420-0203 Toll-free: 800-565-7227 Fax: 902-420-8612 www.bvlabs.com

Bureau Veritas Job #: C290222
Report Date: 2022/04/12

NL Department of Environment, Climate Change and Municipalities
Site Location: WATERFORD RIVER @ KILBRIDE
Your P.O. #: 220028978-5
Sampler Initials: LB

Sample Details/Parameters	A	Result	RDL	UNITS	Extracted	Analyzed	By	Batch
SHD894 WATERFORD RIVER AT KILBRIDE								
Sampling Date 2022/03/31 12:00								
Matrix W								
Sample # 2022-1703-00-SI-SP								
Registration # WS-S-0000								
ELEMENTS BY ICP/MS (WATER)								
Metals								
Total Magnesium (Mg)	-	3.0	0.10	mg/L	2022/04/07	2022/04/07	BAN	7926741
Total Manganese (Mn)	-	0.16	0.0020	mg/L	2022/04/07	2022/04/07	BAN	7926741
Total Nickel (Ni)	-	ND	0.0020	mg/L	2022/04/07	2022/04/07	BAN	7926741
Total Phosphorus (P)	-	ND	0.10	mg/L	2022/04/07	2022/04/07	BAN	7926741
Total Potassium (K)	-	3.3	0.10	mg/L	2022/04/07	2022/04/07	BAN	7926741
Total Selenium (Se)	-	ND	0.00050	mg/L	2022/04/07	2022/04/07	BAN	7926741
Total Sodium (Na)	-	230	0.10	mg/L	2022/04/07	2022/04/07	BAN	7926741
Total Strontium (Sr)	-	0.082	0.0020	mg/L	2022/04/07	2022/04/07	BAN	7926741
Total Uranium (U)	-	ND	0.00010	mg/L	2022/04/07	2022/04/07	BAN	7926741
Total Zinc (Zn)	-	0.018	0.0050	mg/L	2022/04/07	2022/04/07	BAN	7926741

Bureau Veritas 200 Bluewater Rd, Suite 105, Bedford, Nova Scotia Canada B4B 1G9 Tel: 902-420-0203 Toll-free: 800-565-7227 Fax: 902-420-8612 www.bvlabs.com

NL Department of Environment, Climate Change and Municipalities
Site Location: WATERFORD RIVER @ KILBRIDE
Your P.O. #: 220028978-5
Sampler Initials: LB

GENERAL COMMENTS

Each temperature is the average of up to three cooler temperatures taken at receipt

Package 1	7.4°C

RESULTS OF ANALYSES OF WATER

Anions: ANIONS-L: Due to colour interferences, sample required dilution. Detection limits were adjusted accordingly.

Results relate only to the items tested.

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Bureau Veritas Job #: C290222
Report Date: 2022/04/12

NL Department of Environment, Climate Change and Municipalities
Site Location: WATERFORD RIVER @ KILBRIDE
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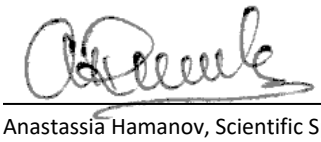
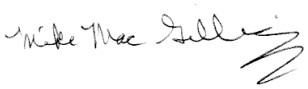
VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by:



Anastassia Hamanov, Scientific Specialist



Mike MacGillivray, Scientific Specialist (Inorganics)

Bureau Veritas has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per ISO/IEC 17025, signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

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