Real-Time Water Quality Report

Outer Cove Brook Network

Deployment Period
September 30, 2014 to November 3, 2014

Newfoundland Labrador

Government of Newfoundland & Labrador
Department of Environment and Conservation
Water Resources Management Division

Outer Cove Brook, Newfoundland and Labrador

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Outer Cove Brook, Newfoundland and Labrador

General

The Water Resources Management Division (WRMD), in partnership with the City of St. John's and Environment Canada, maintain two real-time water quality and water quantity monitoring stations along Outer Cove Brook.

This deployment report discusses water quality related events occurring at the stations: Outer Cove Brook below Airport and Outer Cove Brook at Clovelly Golf Course in St. John's.

WRMD staff monitors the real-time web pages regularly. The City of St. John's will be notified of any water quality issues that arise so mitigated measures can be taken.

The purpose of these real-time stations is to monitor, process and publish hydrometric (water quantity) and real-time water quality data at the real-time stations. Outer Cove Brook is in the vicinity of the Torbay Road North Commercial Development Area and the real-time stations allow for assessment and management of the water body.

This report covers the 34-day period from deployment on September 30, 2014 until removal on November 3, 2014.

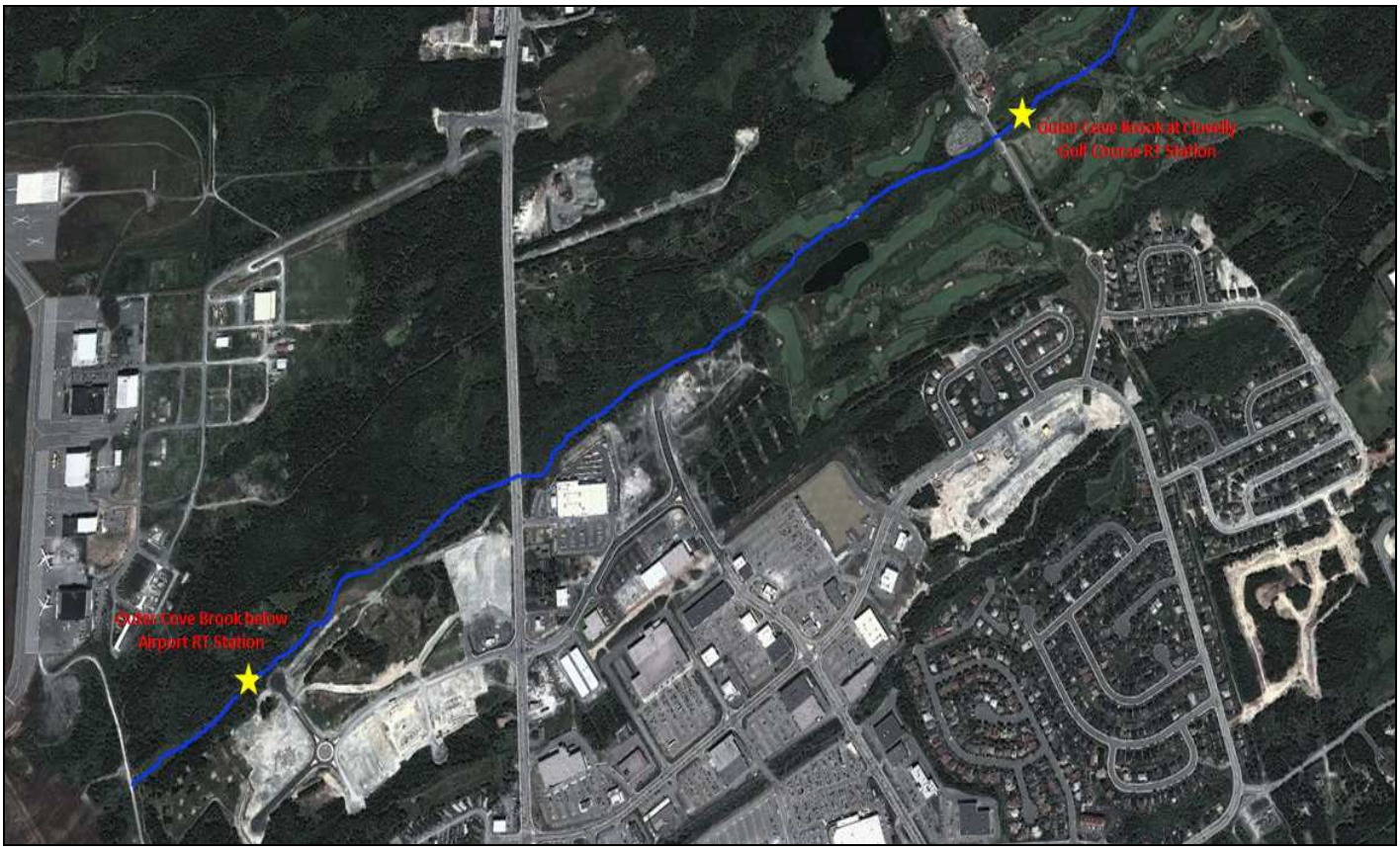

Figure 1: Outer Cove Brook Real-Time Water Quality and Quantity Stations.

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.

At deployment and removal, a QA/QC Sonde is temporarily deployed alongside 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 1).

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 dependant, 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 taken too soon it may not accurately portray the water body.

Deployment and removal instrument performance rankings for **Outer Cove Brook below Airport** for the period of September 30, 2014 to November 3, 2014 are summarized in Table 2.

Table 2: Instrument performance rankings for Outer Cove Brook below Airport

Station	**Date**	**Action**	**Comparison Ranking**				
			Temperature	**pH**	**Conductivity**	**Dissolved Oxygen**	**Turbidity**
Below Airport	**Sept 30 2014**	**Deployment**	Excellent	Good	Excellent	Excellent	Good
	Nov 3 2014	**Removal**	Good	Good	Good	Fair	Poor

- During the Outer Cove Brook below Airport station deployment, water temperature, conductivity and dissolved oxygen all ranked as 'excellent'. With pH and Turbidity ranking as 'good'.

- At removal, water temperature, pH and conductivity ranked as 'good'. Dissolved Oxygen ranked as 'fair', while turbidity ranked as 'poor'. The lower turbidity ranking was likely a result of the dirt and debris

present on the field sensor. As debris covers the sensor window it can impede on the accuracy of the turbidity reading. The 'fair' ranking for dissolved oxygen was also likely a result of fouling on the sensor (Pictures taken Appendix I).

- Deployment and removal instrument performance rankings for **Outer Cove Brook at Clovelly Golf Course** for the period of September 30, 2014 to November 3, 2014 are summarized in Table 3.

Table 3: Instrument performance rankings for Outer Cove Brook at Clovelly Golf Course

Station	Date	Action	Comparison Ranking				
			Temperature	pH	Conductivity	Dissolved Oxygen	Turbidity
Clovelly Golf Course	Sept 30 2014	Deployment	Excellent	Excellent	Excellent	Fair	Excellent
	Nov 3 2014	Removal	Excellent	Poor	Good	Excellent	Poor

- Comparison of the field sonde and QAQC data during the deployment at Outer Cove Brook Clovelly Golf Course indicated the following: water temperature, pH, conductivity and turbidity comparison data all ranked as 'excellent'. Dissolved Oxygen data ranked as 'Fair' during initial deployment. It may be assumed that during deployment there was some interference from air bubbles or placement of the sonde while the values were being recorded, that caused a difference of 0.8 mg/L between the field sonde and the QAQC sonde.

- At removal the comparison between the field sonde and QAQC sonde indicated that, water temperature, and dissolved oxygen ranked as 'excellent'. Specific Conductivity ranked as 'Good'. pH and Turbidity ranked as 'Poor' at the end of the deployment period. During removal there was evidence of fouling on the sensors. The fouling can interfere with the accuracy of the data (Appendix I pictures of fouling on sensors).

Outer Cove Brook below Airport

Water Temperature

Water temperature ranged from 8.10°C to 14°C during this deployment period (Figure 2).

There are noticeable increases and decreases in the water temperature during the deployment period. This is consistent with ambient air temperatures over this time period, generally increasing during daylight hours and cooling overnight.

The higher water temperatures indicated on the graph also correspond with higher averaged daily air temperatures. As displayed on October 7th-6th, October 9th, October 18th to the 20th, and October 30th on Figure 2 below.

Dips in water temperatures can indicate rainfall events; rainfall can lower the water temperature slightly over a short period of time. This is displayed on October 12th the slight dip in water temperature corresponds with a rainfall event on the same day of almost 30 mm.

The water temperatures at this station display diurnal variations. Shallow streams and ponds are highly influenced by natural diurnal variations in the surrounding air temperatures.

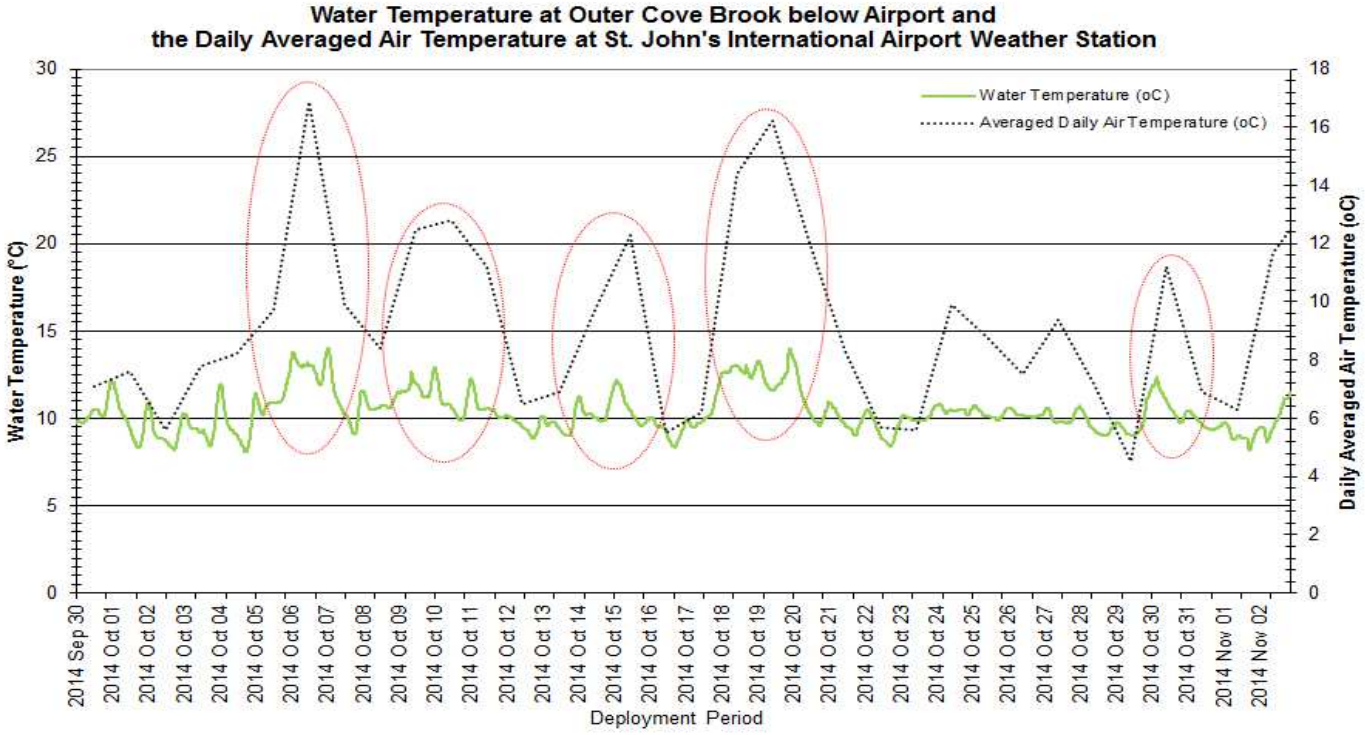

Figure 2: Water temperature (°C) values at Outer Cove Brook below Airport and daily Air Temperature at St. John 's International Airport

pH

Throughout this deployment period pH values ranged between 6.01 pH units and 6.73 pH units (Figure 3).

During this deployment, the pH values at this station were along the minimum CCME Guideline for the Protection of Aquatic Life (between 6.5 and 9 pH units). There were pH values below the CCME Guideline for the Protection of Aquatic Life during the deployment period as well.

The pH dipped below the CCME guideline on a number of occasions. All dips in pH noted corresponded with increases in stage level during the same time frames. Rainfall will cause a drop in pH value for a short period of time.

The CCME guideline provides a basis by which to judge the overall health of the brook. Naturally, all streams and brooks are different. During this deployment period the median pH level was 6.53 pH units, which was slightly lower than last month.

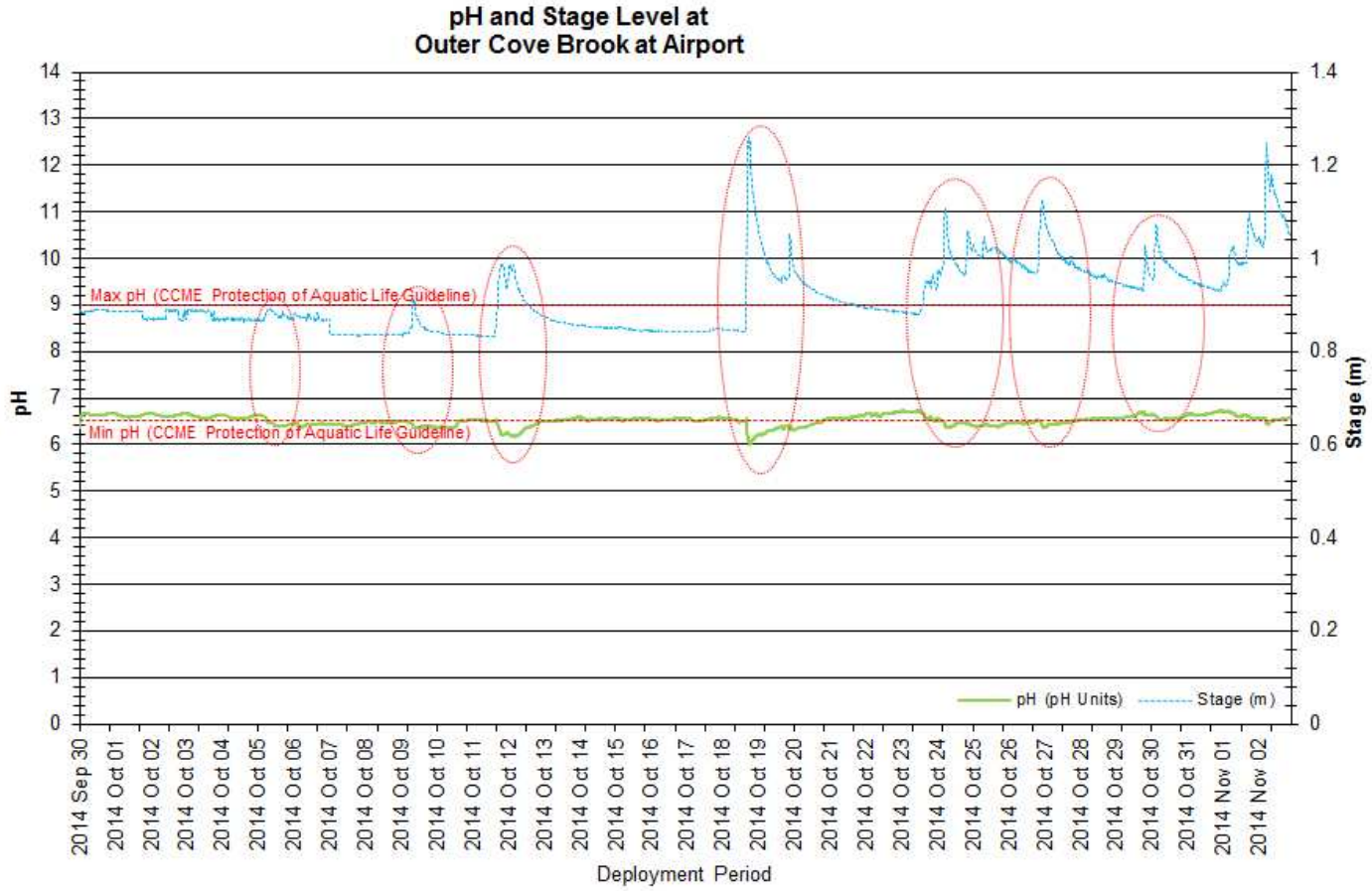

Figure 3: pH (pH units) and stage level (m) values at Outer Cove Brook below Airport

Specific Conductivity & TDS

The conductivity levels were within 64.9 µS/cm and 604 µS/cm during this deployment period. TDS ranged from 0.0416 g/L to 0.3860 g/L.

When stage levels rise, the specific conductance levels drop in response as the increased amount of water in the river system dilutes the solids that are present. This is displayed by majority of the conductivity dips on Figure 4.

On October 1st and 5th, there are several peaks in conductivity with no large event in stage to explain the movement in the levels of conductivity. There is a small turbidity event on October 5th that may explain the conductivity spike but nothing can be determined for the higher conductivity values on October 1st.

Total Dissolved Solids (TDS), is a parameter that the instrument calculates by an algothrim that utilizes the data from specific conductivity and water temperature to produce a TDS value. TDS generally always mirrors specific conductivity.

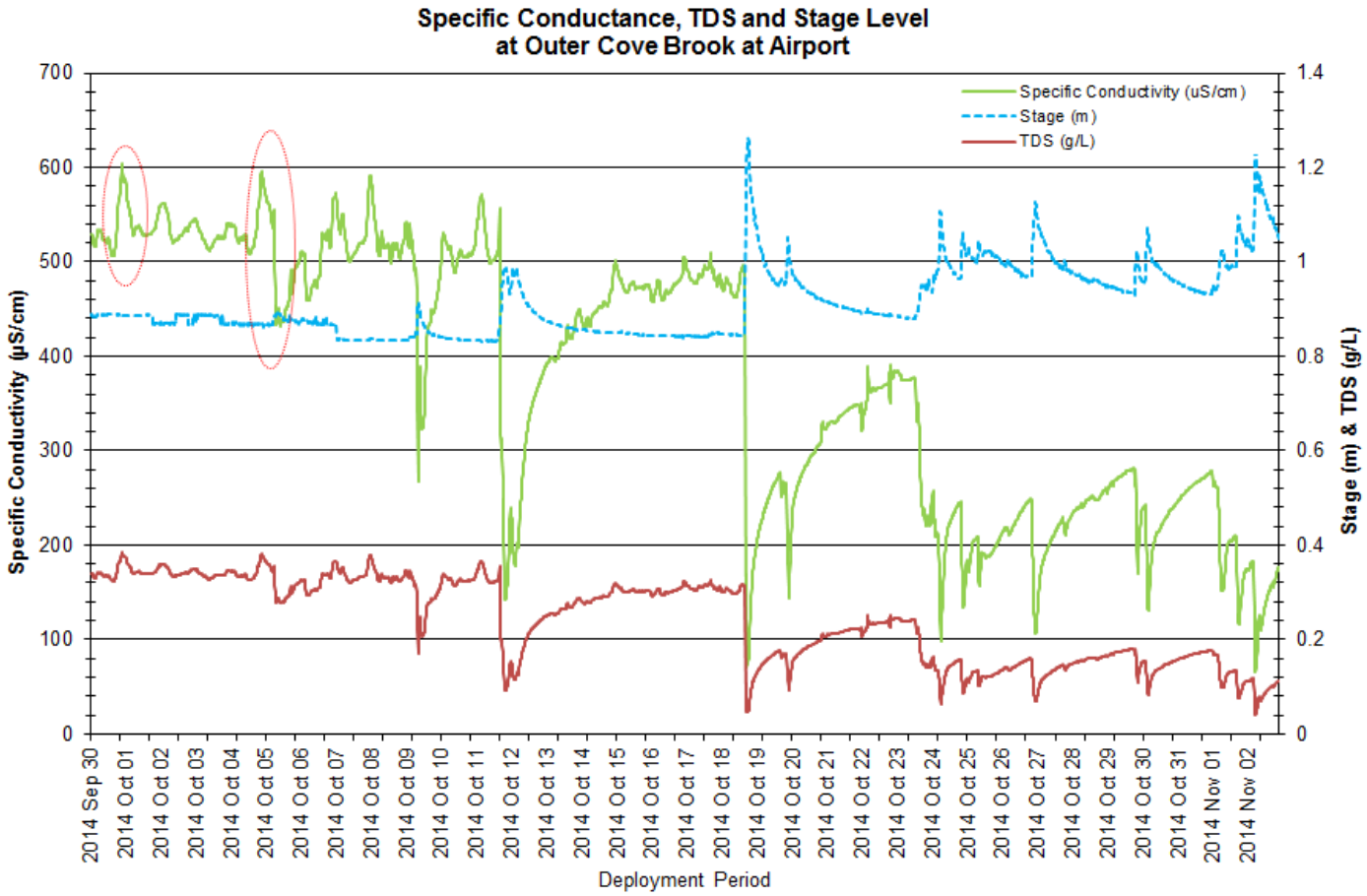

Figure 4: Specific conductivity (µS/cm), TDS (g/L) and stage (m) values at Outer Cove Brook below Airport.

Dissolved Oxygen

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

The Dissolved Oxygen % Sat levels within this deployment period were within 78.9% Sat to 87.0% Sat. Dissolved Oxygen (mg/L) measured 8.42 mg/L to 10.14 mg/L.

During this deployment the dissolved oxygen levels were reasonably consistent. The circled data on Figure 5 indicates the relationship between water temperature and dissolved oxygen. As water temperature increases the level of dissolved oxygen consumed increases, which means there is less dissolved oxygen in the brook during these temperatures. This is the opposite with cooler water temperatures.

There are several small events noted on Figure 5, on October 6th-7th, October 9th – 10th, October 15th and October 18-20th and on October 30th. These events also correspond with some of the warmer air temperatures during the deployment period (depicted on Figure 2).

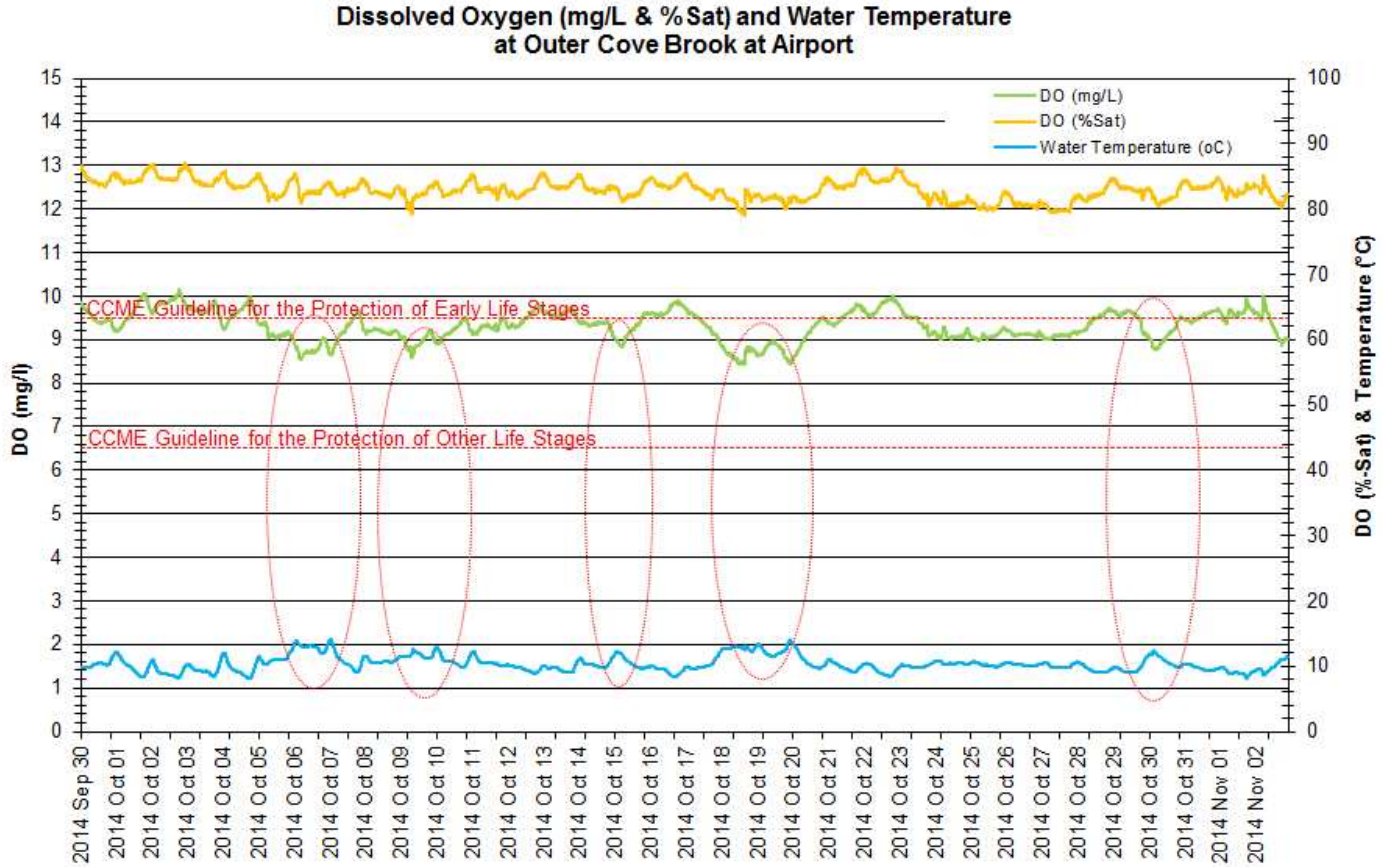

Figure 5: Dissolved oxygen (mg/L & % sat) and water temperature (°C) values at Outer Cove Brook below Airport.

Turbidity

Turbidity levels during this deployment period ranged within 1.8 NTU and 906.0 NTU (Figure 6). With a median of 4.6 NTU.

The turbidity sensor on this instrument can read turbidity values between 0 NTU and 3000 NTU. However a turbidity reading of 3000 NTU is always identified as an error reading and should not be used as a valid reading or included in any statistical analysis.

Most of the turbidity events in the deployment period correlate with increases in stage potentially from precipitation (Figure 6). Precipitation can increase the presence of suspended material in water as seen on October 9th and 12th, October 19th, 20th and October 24th. There are rainfall events on October 27th, 30th and several at the end of the deployment period as well.

The circled turbidity peaks on October 8th, October 21st, 22nd and 23rd do not correspond with an increase in stage. The turbidity peaks that occurred on October 22nd where documented by Water Resources staff who happened to be out at the brook that day. They noted that the brook was chocolate brown, however by the time they were able to take some pictures the turbidity was starting to dissipate (Pictures Appendix I). Although the WRMD staff were unable to investigate where the turbidity was coming from it was assumed it was a result of construction work being completed upstream from the station at that time.

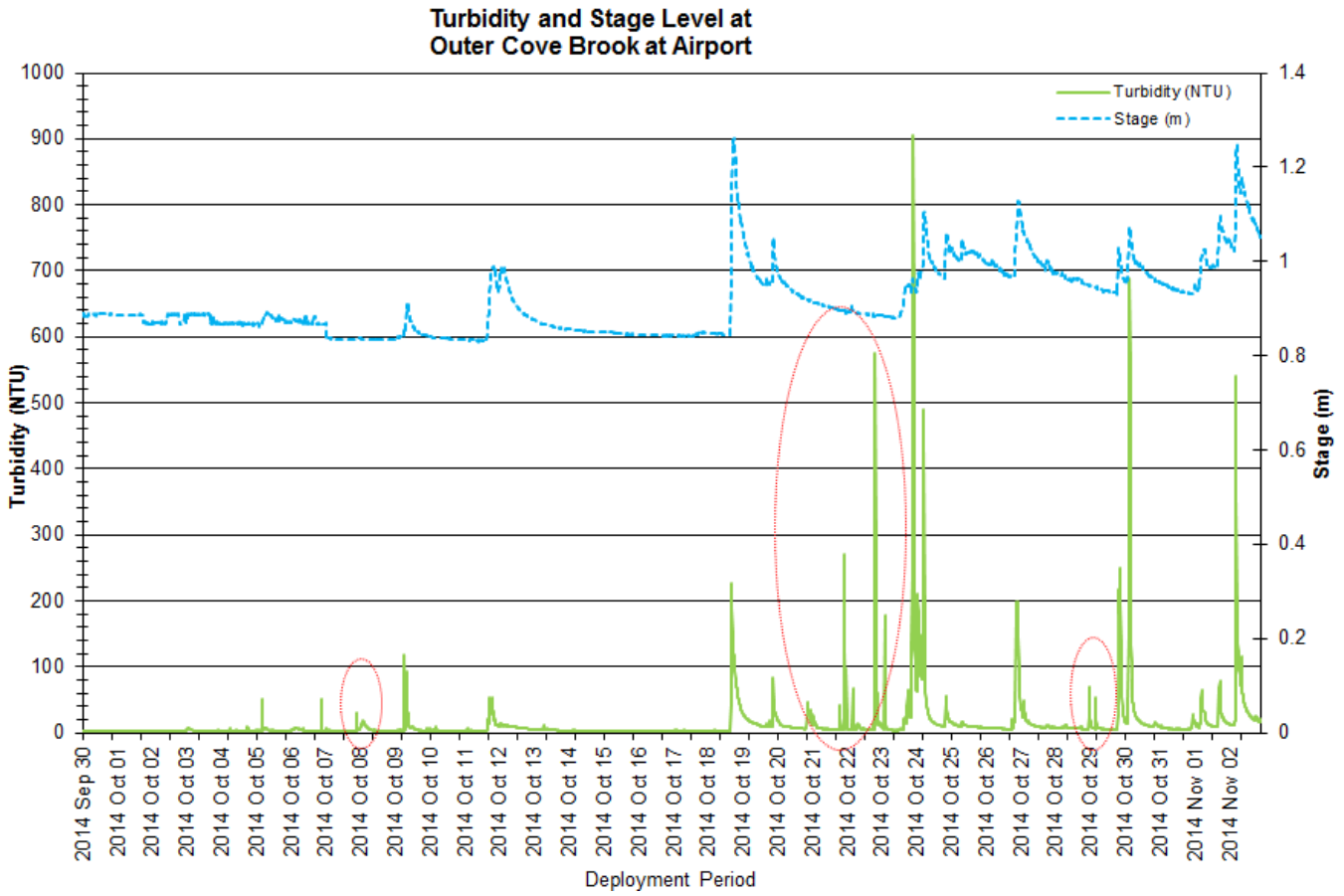

Figure 6: Turbidity (NTU) and stage level (m) values at Outer Cove Brook below Airport.

Stage & Stream Flow

Stage can be defined as the height or elevation of the stream's water surface above a reference elevation (sea level, gage level)**.** Stage is important to display as it provides 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).

Stream flow can be defined as the volume of water in a river at a specific location and time. It is measured in cubic meters per second.

Stage and Stream flow 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 them to rise significantly. During the deployment period, the stage values ranged from 0.83m to 1.26m. The stream flow values ranges from 0.07m to 2.49m .The larger peaks in stage and stream flow do correspond with substantial rainfall events as noted on Figure 7.

Precipitation and Air Temperature data was obtained from Environment Canada's St. John's Airport weather station. Precipitation ranges for the deployment period were a minimum of 0.0 mm and a maximum of 43.2 mm on November 2nd.

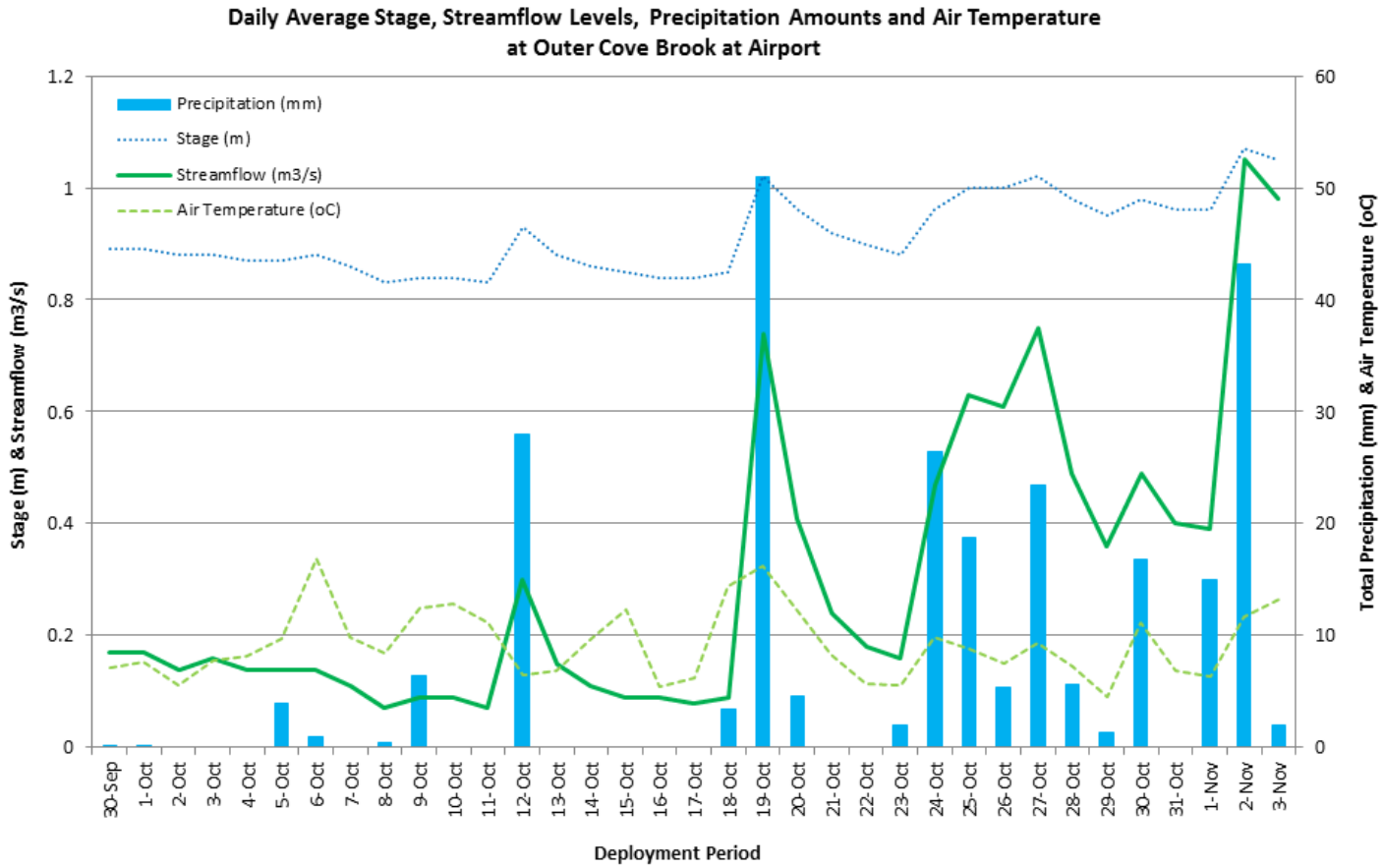

Figure 7: Daily average stage & stream flow values at Outer Cove Brook below Airport and daily total precipitation & Air Temperature values from Environment Canada's St. John's Airport Station.

Conclusion

- As with many shallow brooks and streams, precipitation events play a role in influencing the parameters within the water body. This brook also flows through significant developed areas, including residential zones and within the boundaries of heavily used road ways, which can influence the parameter levels that are recorded.

- It is evident by the parameter data recorded that precipitation events during this deployment period have influenced fluctuations in stage. When reviewing the graphs as a whole it is evident that the precipitation events on October 5th, October 9th, October 19th, October 24th to 28th, October 30th and November 1st and 2nd created varying effects with the water quality parameters. An influx of rainfall will dilute conductivity and TDS, and increase turbidity. pH values dropped (acidity increases) after an increase in runoff from the surrounding natural environment that can increase dissolved substances in the water column.

- Ambient air temperatures influenced the water temperature during this deployment period with some of the higher water temperatures coinciding with higher air temperatures. In turn, water temperature directly affects the amount of dissolved oxygen present in the brook and it is common to see mirroring trends in dissolved oxygen.

- On October 21st, 22nd and 23rd there is unexplained turbidity events that are also evident slightly on the conductivity graphs for the same dates. On October 22nd Water Resources staff was at the site to capture the turbidity event occurring upstream from the station. However we can only speculate that the other two turbidity events (October 21st and October 23rd) were likely related to the same upstream disturbance. (Pictures in Appendix I)

Outer Cove Brook at Clovelly Golf Course

Water Temperature

Water temperature ranged from 6.49 ^{o}C to 14.08 ^{o}C during this deployment period (Figure 8).

Water temperature in this brook displays a typical variation in pattern over the deployment period. Water temperature is influenced by air temperature. The air temperature displayed on Figure 8 is from the weather station at St. John's International Airport.

It is evident on the graph that the high air temperatures influence the water temperatures, as both sets of data have increases and decreases around the same time frame.

Water temperature on these water quality instruments is a very important parameter and it has the ability to influence other parameters.

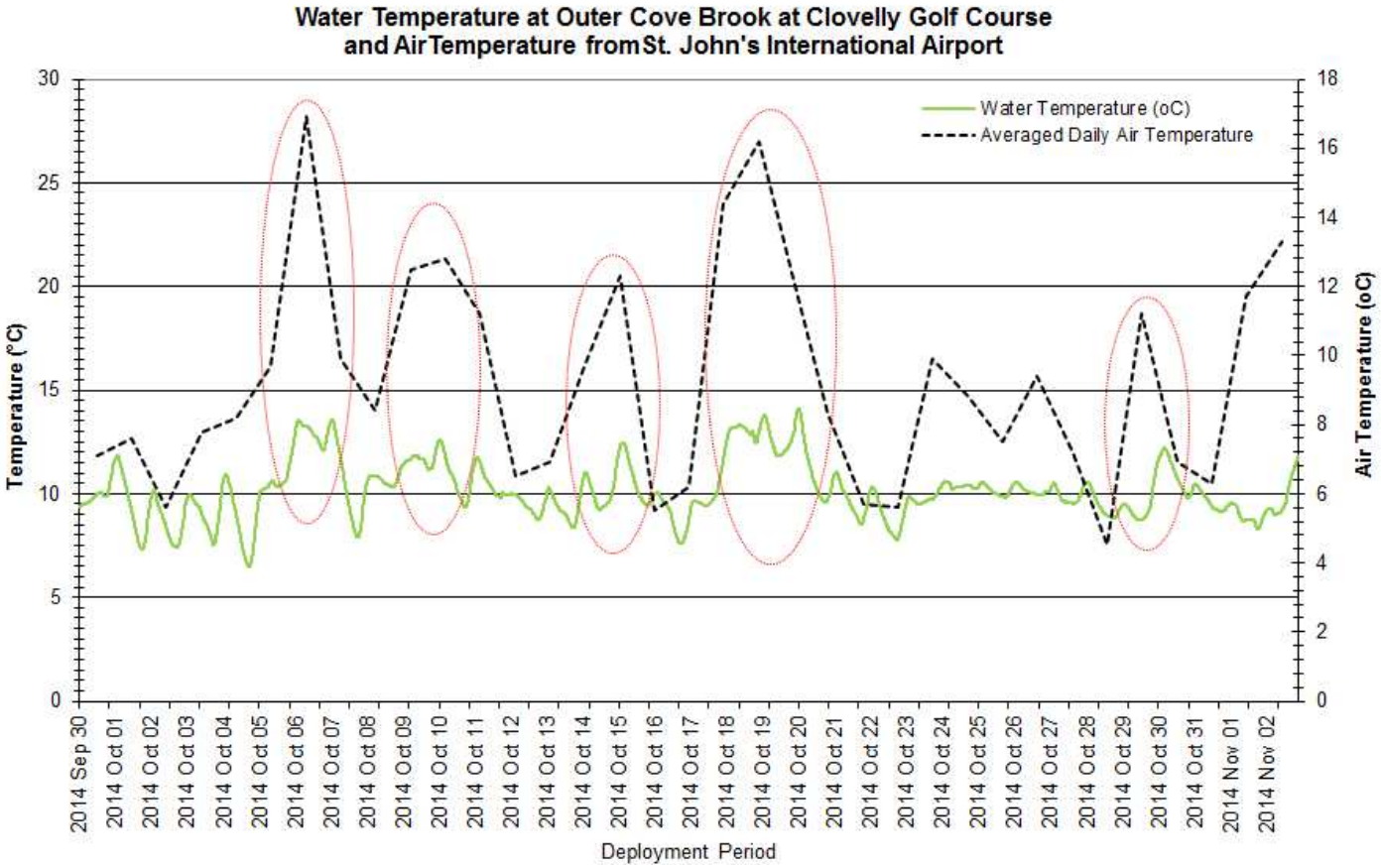

Figure 8: Water temperature (℃) values at Outer Co ve Brook at Clovelly Golf Course and Air Temperature (℃) from St. John's International Airport.

pH

Throughout this deployment period pH values ranged between 6.06 pH units and 6.70 pH units (Figure 9).

During the deployment, the pH values at this station recorded just below the minimum CCME Guideline for the Protection of Aquatic Life for the majority of deployment period.

From September 30th through to October 7th, the pH data that was being recorded was inaccurate and it was determined that the pH data should be removed for this time frame. In response the pH bulb was cleaned and recalibrated and for the remainder of deployment the pH data was accurate for the brook.

The pH levels dip slightly on October 12th, October 19th, October 24th, 27th and 30th and again on November 2nd -3rd. These dips in pH correspond with stage increases during the same time period. This is a natural occurrence and can be explained by the natural relationship between rainfall and pH levels.

The CCME guideline provides a basis by which to judge the overall health of the brook. Naturally, all streams and brooks are different. During this deployment period the median pH level was 6.38 units (slightly lower from last deployment).

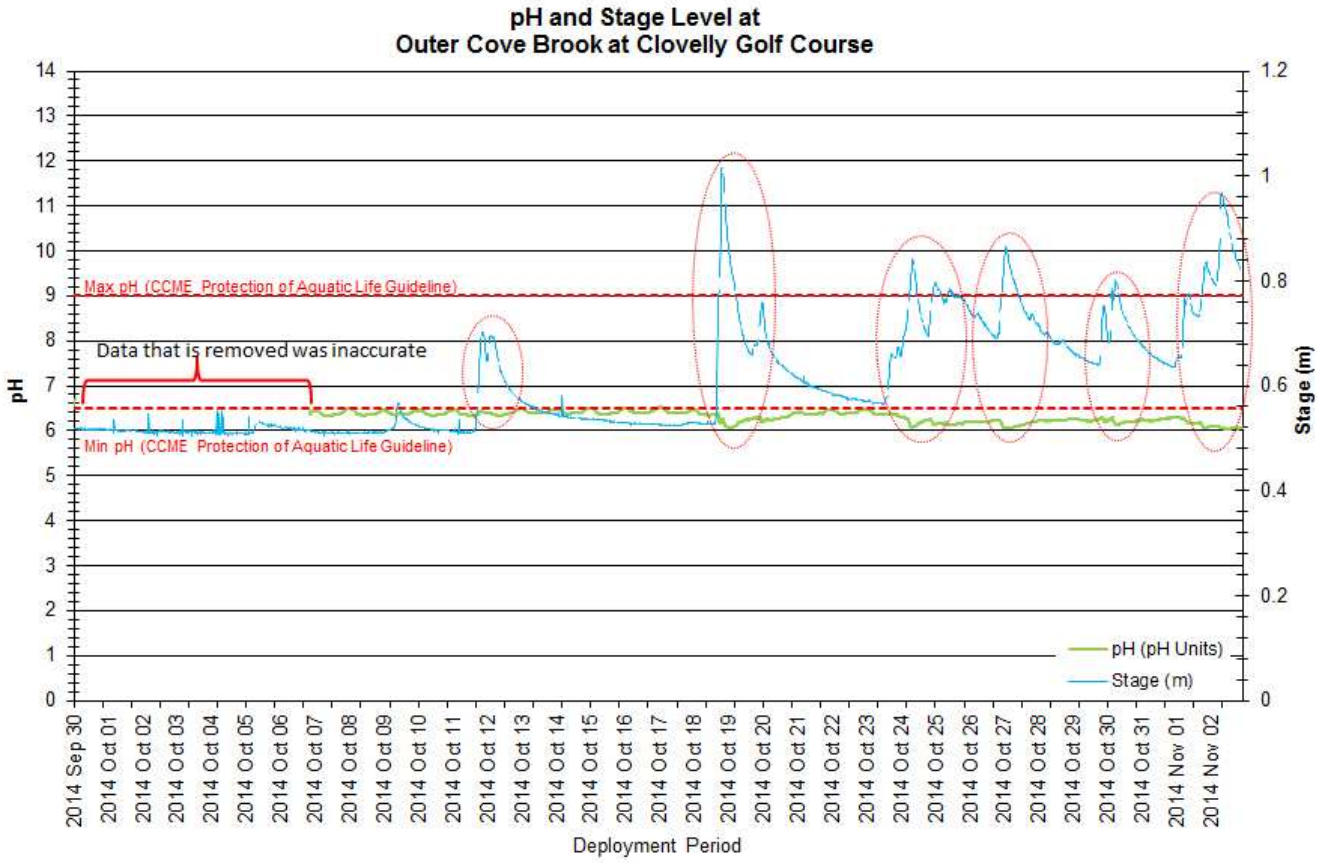

Figure 9: pH (pH units) and stage level (m) values at Outer Cove Brook at Clovelly Golf Course.

Specific Conductivity & TDS

The conductivity levels were within 127.0 µS/cm and 576.0 µS/cm during this deployment period. TDS ranged from 0.0818 g/L to 0.3690 g/L.

The dips in conductivity during the deployment period (see Figure 10) all correspond with an increase in stage level. The conductivity probe measures the dissolved particles present in a water body, when there is an increase in stage it can indicate that there was rainfall. Rainfall saturates the brook and flushes the dissolved particles from the water column diluting the conductivity levels for a short period of time.

Total Dissolved Solids (TDS), is a parameter that the instrument calculates by an algothrim that utilizes the data from specific conductivity and water temperature to produce a TDS value and generally always mirrors specific conductivity.

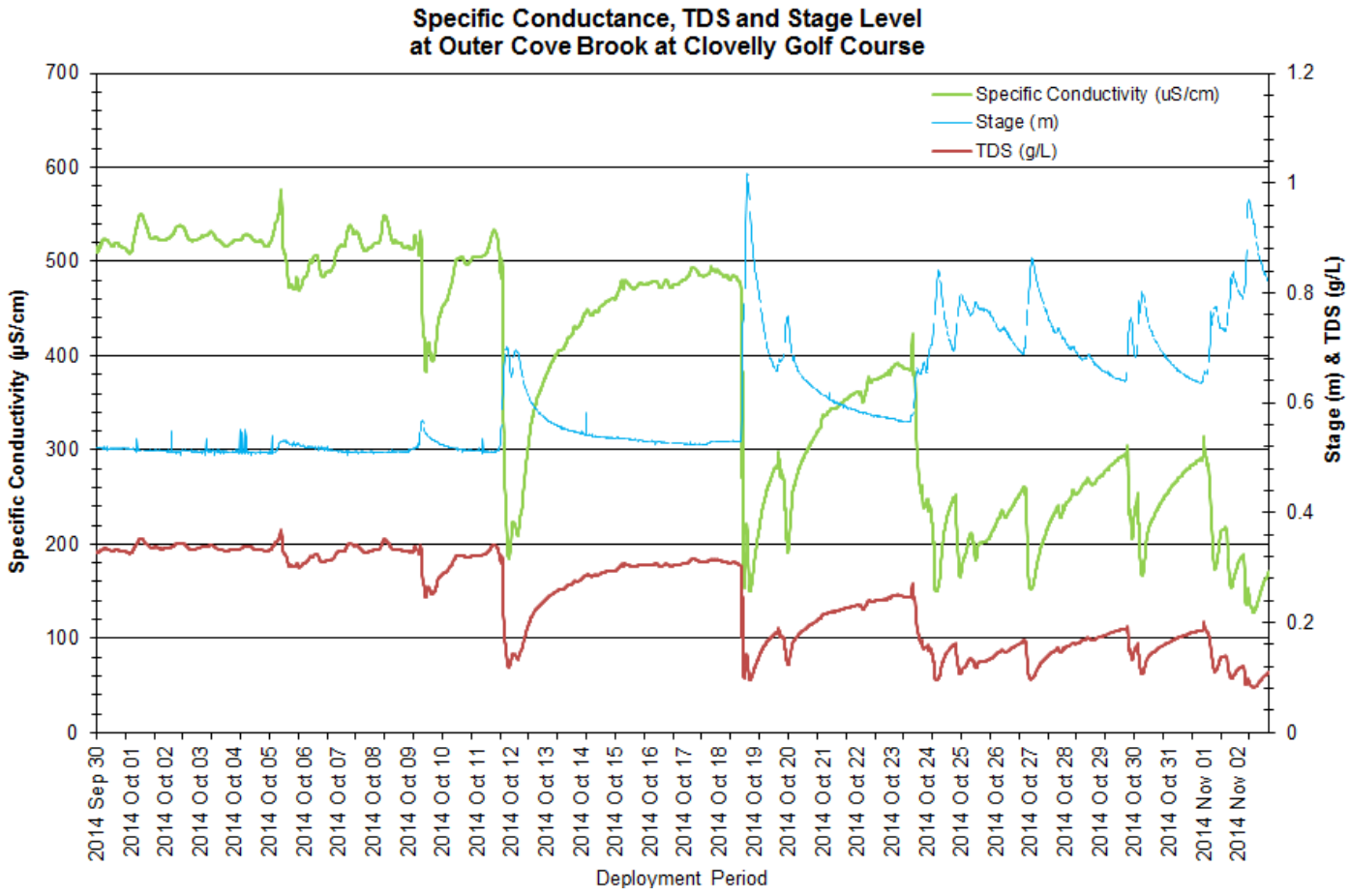

Figure 10: Specific conductivity (uS/cm), TDS (g/L) and stage (m) values at Outer Cove Brook at Clovelly Golf Course.

Dissolved Oxygen

The instrument measures dissolved oxygen (mg/L) then calculates percent saturation (% Sat).

The Dissolved Oxygen %Sat levels within this deployment period were within 72.8 %Sat to 99.5 %Sat. Dissolved Oxygen (mg/L) measured 7.91 mg/L to 11.18 mg/L.

It should be noted that the warmer water temperatures reduce the amount of dissolved oxygen a water body can hold. It can be seen on October 5th -7th, October 18th-20th, and October 30th, as the water temperatures increases (probably at the hottest time of the day) the water dissolved oxygen levels dip.

Rainfall can also have an influence on dissolved oxygen content, the movement in the data from October 23rd through to October 28th, is likely a result of the rainfall that occurred during that same time period (seen on Figure 13).

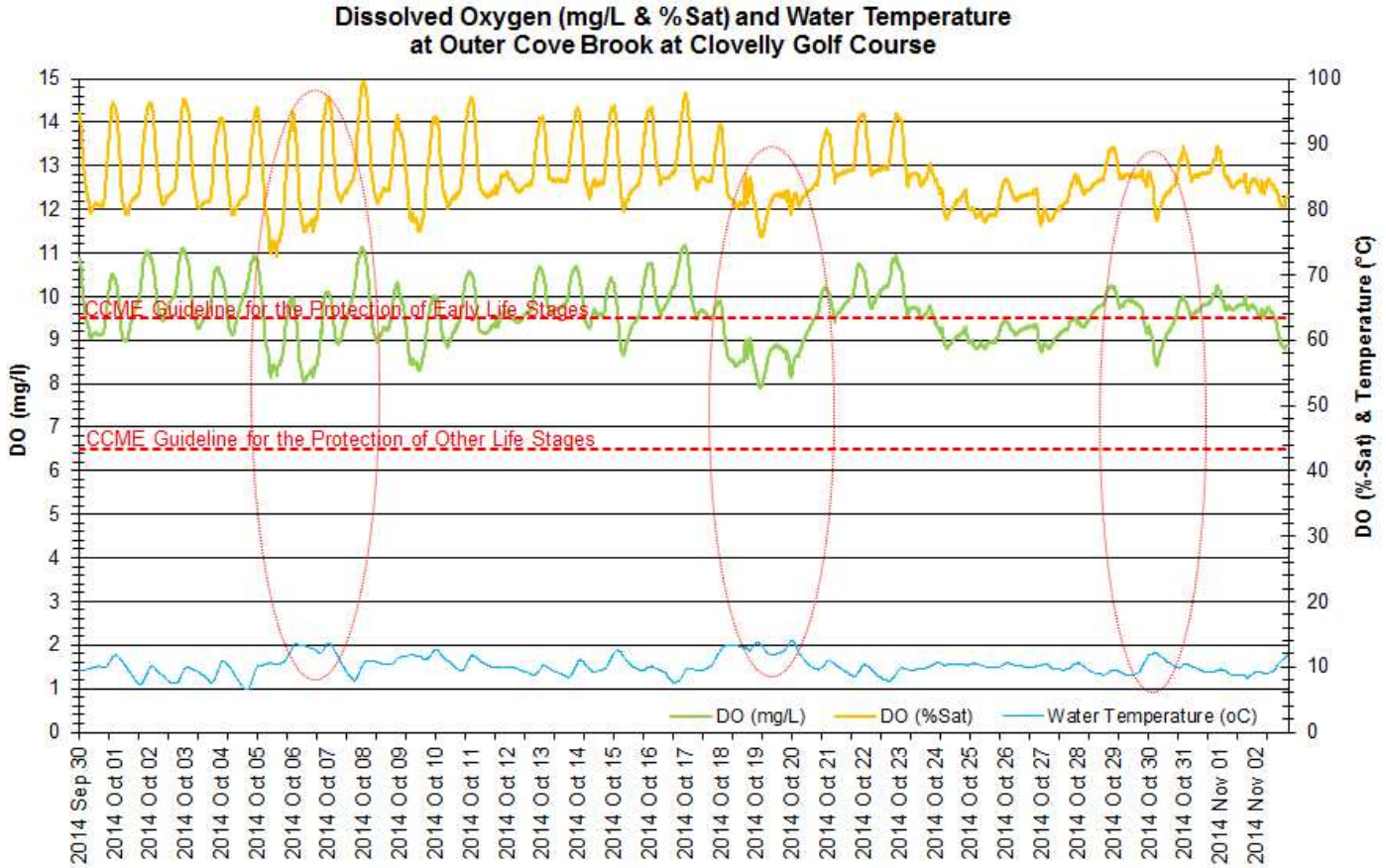

Figure 11: Dissolved oxygen (mg/L & % sat) and water temperature (℃) values at Outer Cove Brook at Clovelly Golf Course.

Turbidity

Turbidity levels during this deployment period ranged within 0.0 NTU and 108.8 NTU (Figure 12), with a median of 1.4 NTU.

High algal growth, biofouling, or leaf and grass debris can interfere with a turbidity sensor as particles block the sensor and affect the turbidity value. This is likely the cause of the peak on September 30th with a reading of 108 NTU. This peak is not linked to any other events or outside influences.

The turbidity sensor on this instrument can read turbidity values between 0.0 NTU and 3000 NTU. However a turbidity reading of 3000 NTU is always identified as an error reading and during data grooming will be removed from the data set so to ensure it is not included in any statistical analysis.

As depicted on the graph there were several turbidity events during deployment. All the turbidity increases highlighted on Figure 12 correspond with a large stage increase at the same time. However the turbidity events on October 21st, October 22nd and October 23rd are not a result of any rainfall or precipitation during those times. These dates also correspond with high turbidity at Outer Cove Brook below Airport, which indicates that the same event caused turbidity increases around the same time noted at both stations.

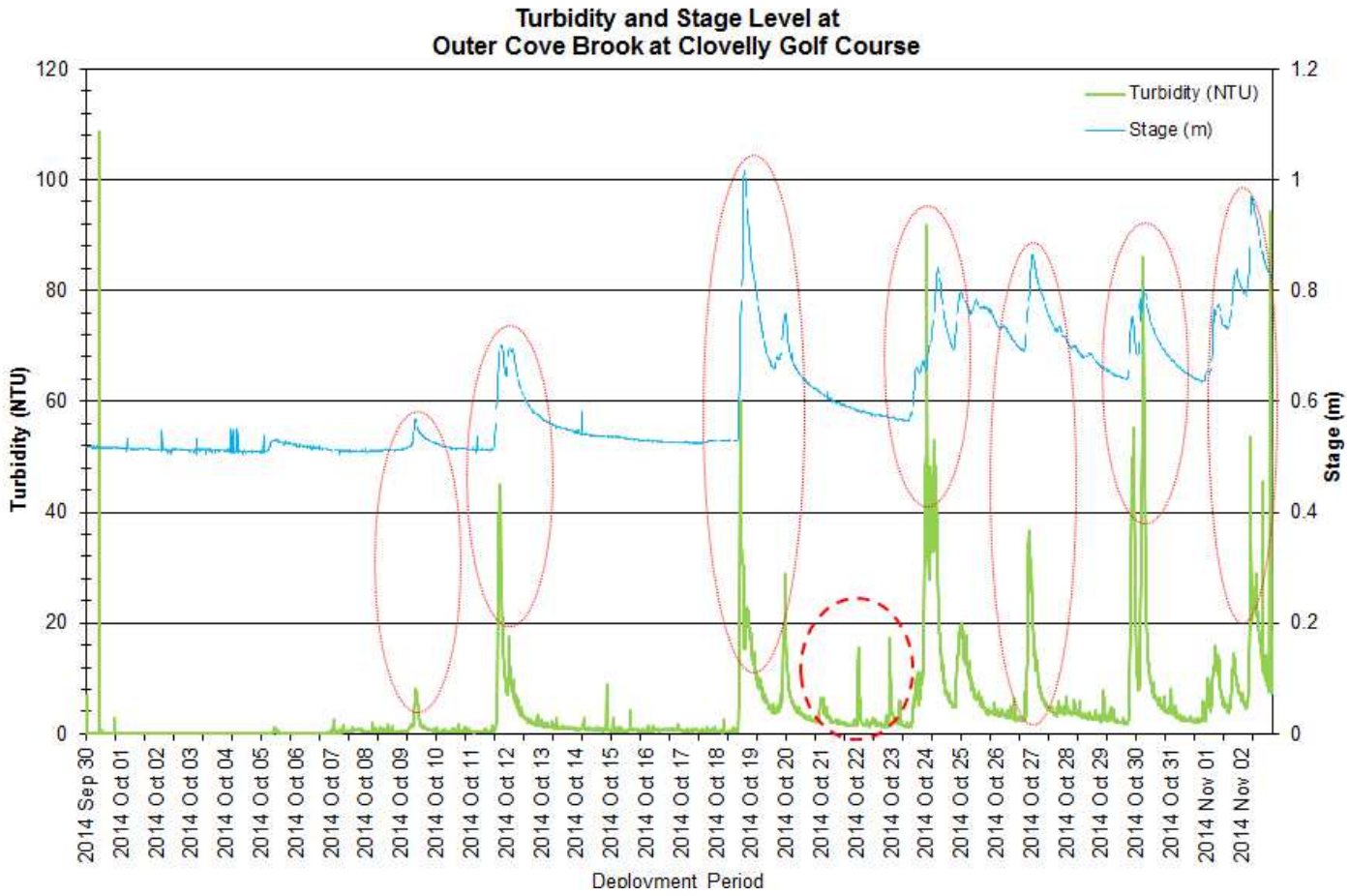

Figure 12: Turbidity (NTU) and stage level (m) values at Outer Cove Brook at Clovelly Golf Course.

Stage & Stream flow

The below graph includes precipitation data from St. John's International Airport weather station.

Stage can be defined as the height or elevation of the stream's water surface above a reference elevation (sea level, gauge level)**.** Stage is important to display as it provides 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). Stream flow can be defined as the volume of water in a river at a specific location and time. It is measured in cubic meters per second.

Stage levels during this deployment ranged within a minimum of 0.50m and a maximum of 1.02m. Stream flow ranged within minimum of 0.02 m^3/s and a maximum of 1.31 m^3/s. The precipitation averaged a minimum of 0.0 mm a day to a maximum of 43.2 mm which was on November 2nd, 2014.

It is not unusual to see Stage and Stream flow vary throughout the deployment period (Figure 13). Stage is directly influenced by rainfall and subsequent runoff from the surrounding environment. This is evident on October 12th, October 19th, October 24th to October 28th, October 30th and again on November 1st to 3rd.

Precipitation data was obtained from Environment Canada's St. John's Airport weather station.

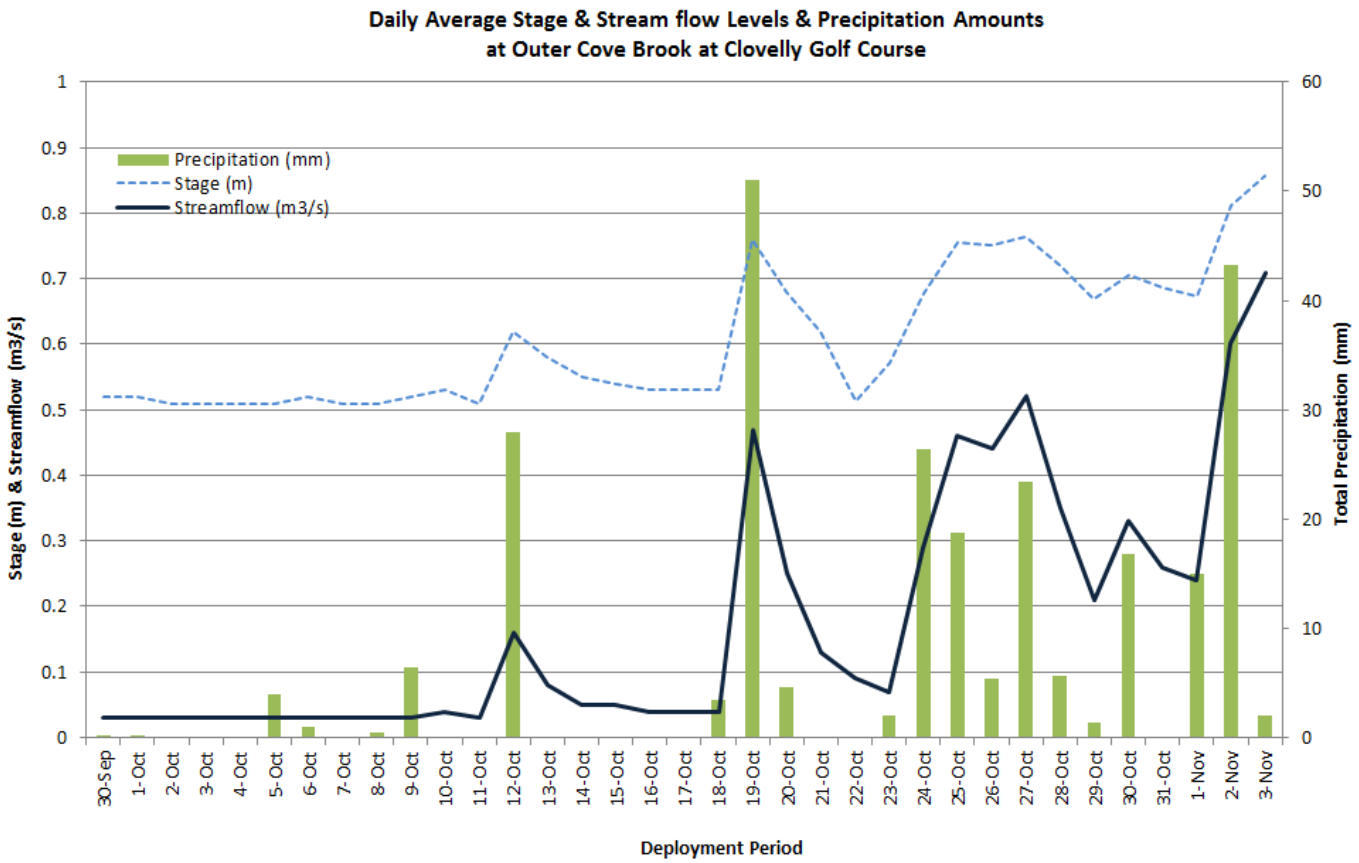

Figure 13: Daily average stage values (m) at Outer Cove Brook at Clovelly Golf Course and daily total precipitation values (mm) from Environment Canada's St. John's Airport Station.

Conclusion

- There is visual evidence that the large spikes in stage level were a result of several rainfall events as displayed on Figure 13. Rainfall events such as those displayed on Figure 13 can influence changes in water temperatures, conductivity, dissolved oxygen and turbidity in the water column.

- This brook flows through significant developed areas, including residential zones, golf courses and within the boundaries of heavily used road ways, which can influence the water quality parameters in the areas of turbidity increases or conductivity increases when runoff from residential areas is a factor.

- As ambient air temperatures increase with the seasonal changes it should reflect in the water temperature. Water temperature directly affects the amount of dissolved oxygen present in the brook and this is also evident on the graph in Figure 11.

- The increases and decrease in the water quality parameters can be explained by the natural relationship with rainfall and subsequent runoff. The only events for Outer Cove Brook at Clovelly Golf Course that is not linked to rainfall is the high turbidity peaks on October 21st, 22nd and 23rd, which were also evident in Outer Cove Brook below Airport (Appendix II). It is undetermined what caused the turbidity to peak during those dates although there is evidence that there was construction and work being conducted upstream from the station.

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APPENDIX I

Outer Cove Brook below Airport (October 21, 2014)

Figure A-1: Turbidity in brook at Outer Cove Brook below Airport (Oct 21, 2014)

Figure A-2: Turbidity in brook at Outer Cove Brook below Airport (Oct 21, 2014)

Outer Cove Brook below Airport (November 3, 2014)

Figure A-3: Picture of turbidity in brook during visit for monthly removal on November 3, 2014

Figure A-4: Picture of Outer Cove brook below Airport station on November 3, 2014

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Figure A-5: Downstream of Outer Cove brook below Airport station on November 3, 2014

Figure A-6: Fouling on sensors after monthly deployment at Outer Cove brook below Airport

Outer Cove Brook at Clovelly Golf Course (November 3, 2014)

Figure A-7: Turbidity at Outer Cove Brook at Clovelly Golf Course on November 3, 2014

Figure A-8: Downstream of Outer Cove brook at Clovelly Golf Course station on November 3, 2014

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Figure A-9: Fouling on sensors after monthly deployment at Outer Cove brook at Clovelly Golf Course

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APPENDIX II

Parameter comparisons between the two Outer Cove Brook stations

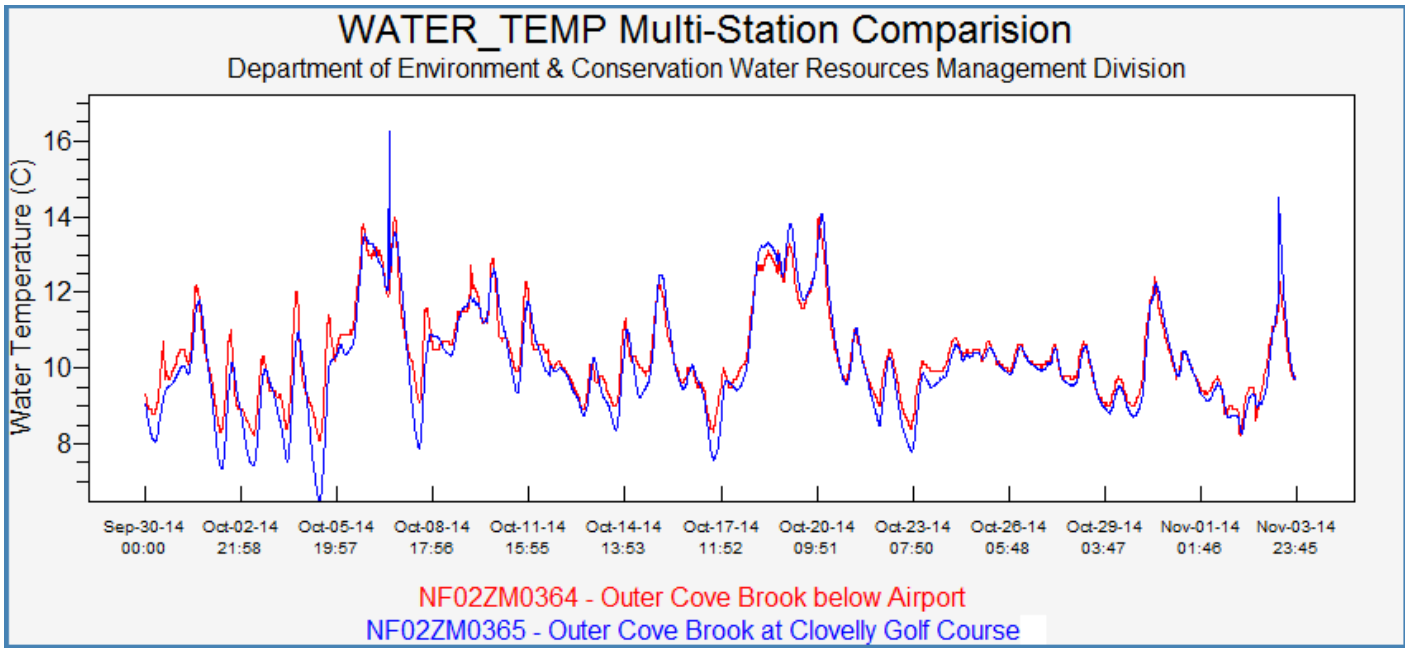

Figure A-10: Comparisons between Water Temperatures

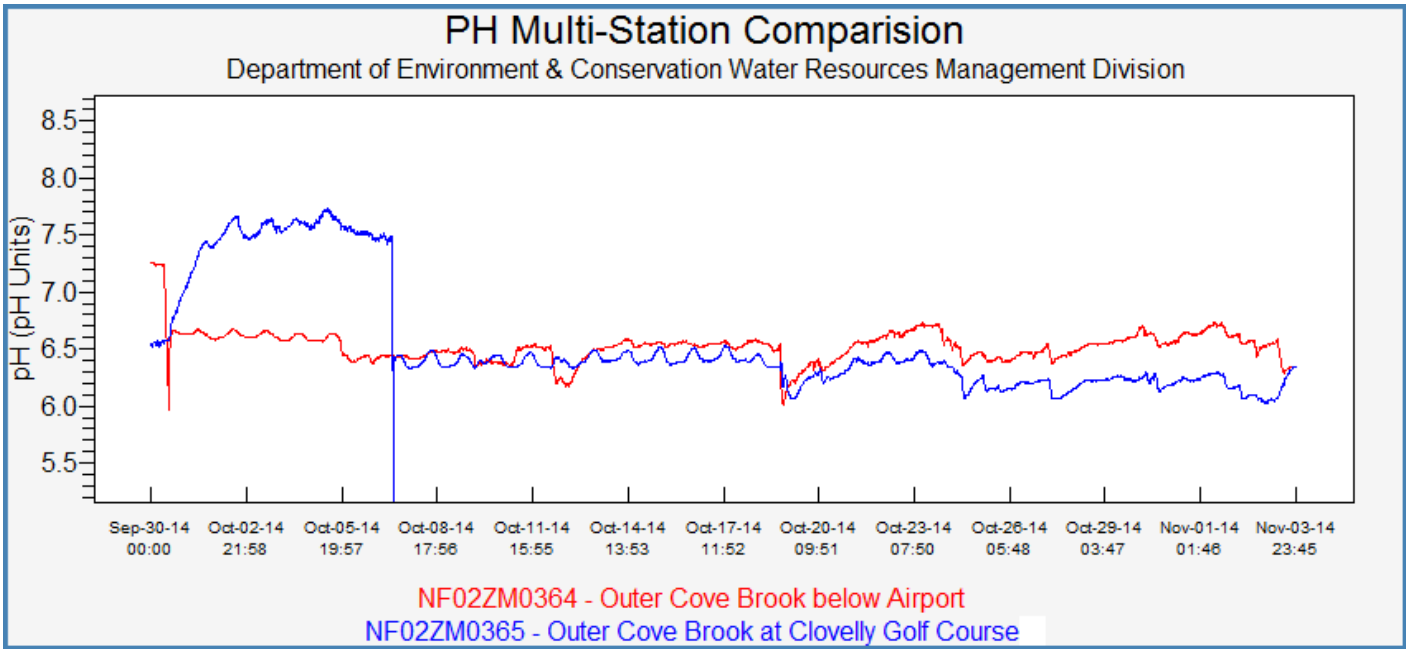

Figure A-11: Comparisons between pH

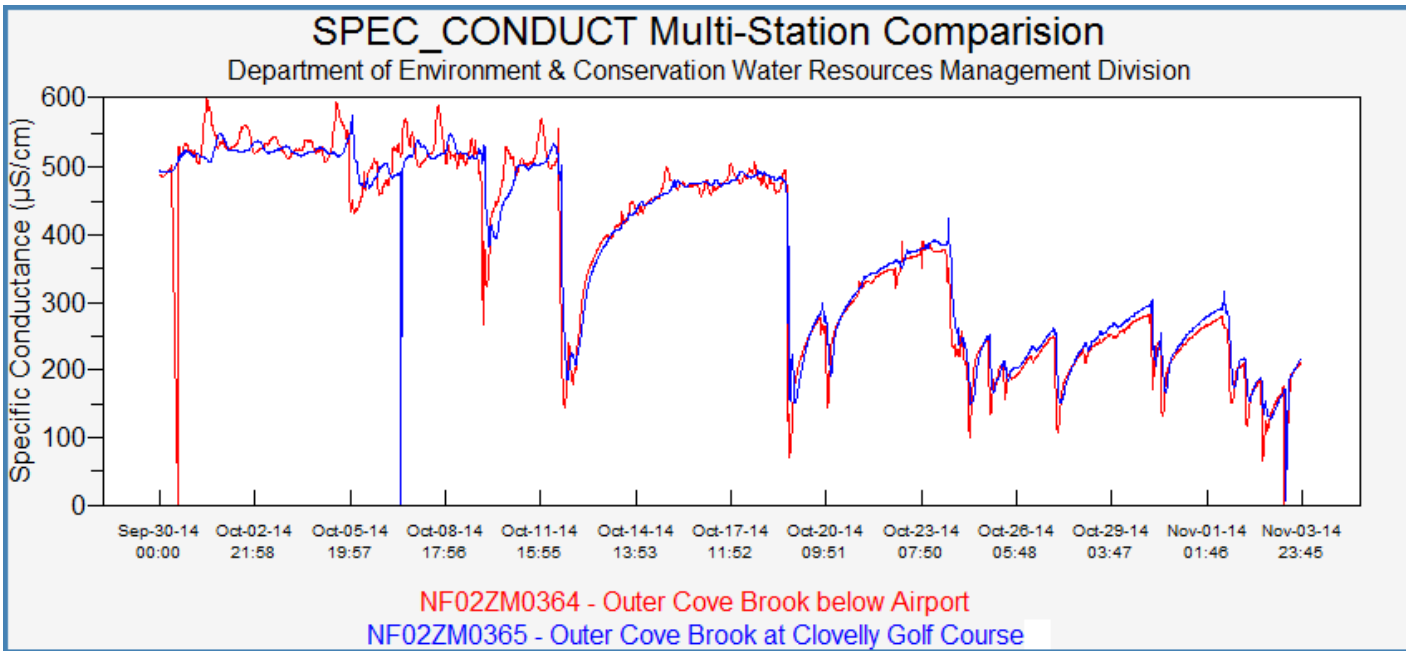

Figure A-12: Comparisons between Specific Conductivity

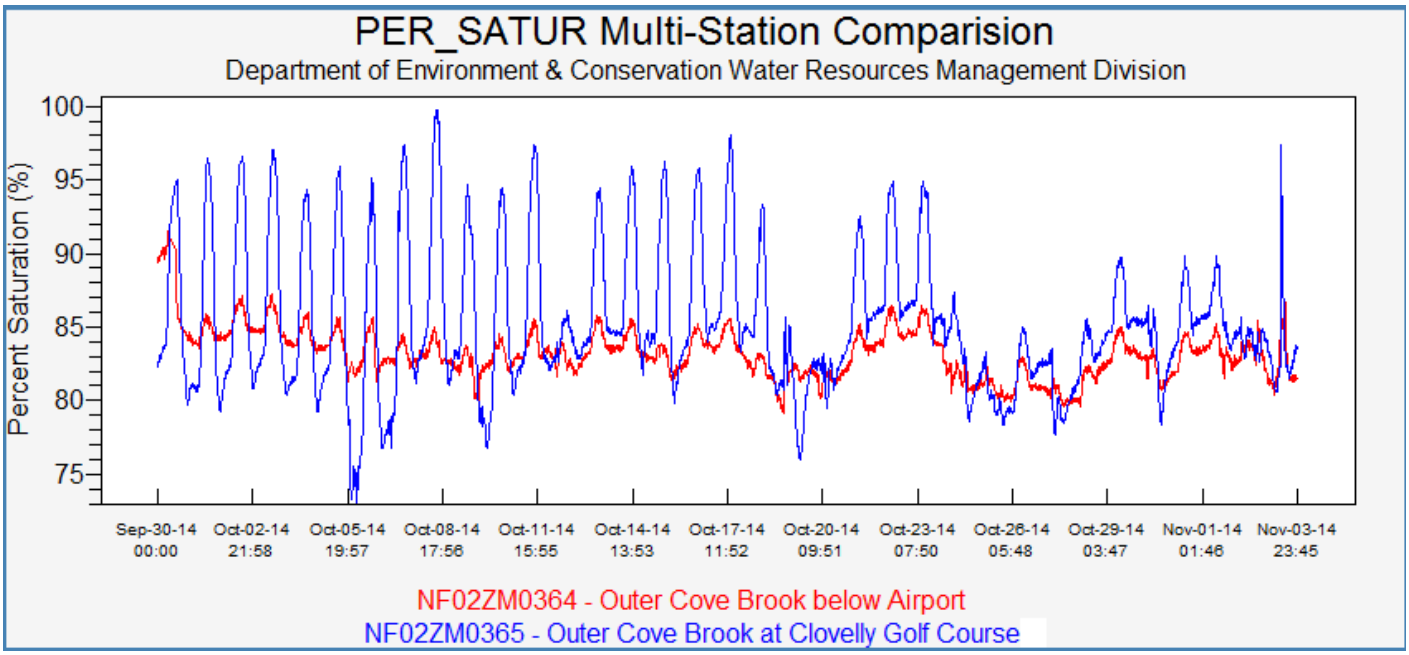

Figure A-13: Comparisons between Dissolved Oxygen (Percent Saturation)

Outer Cove Brook, Newfoundland and Labrador

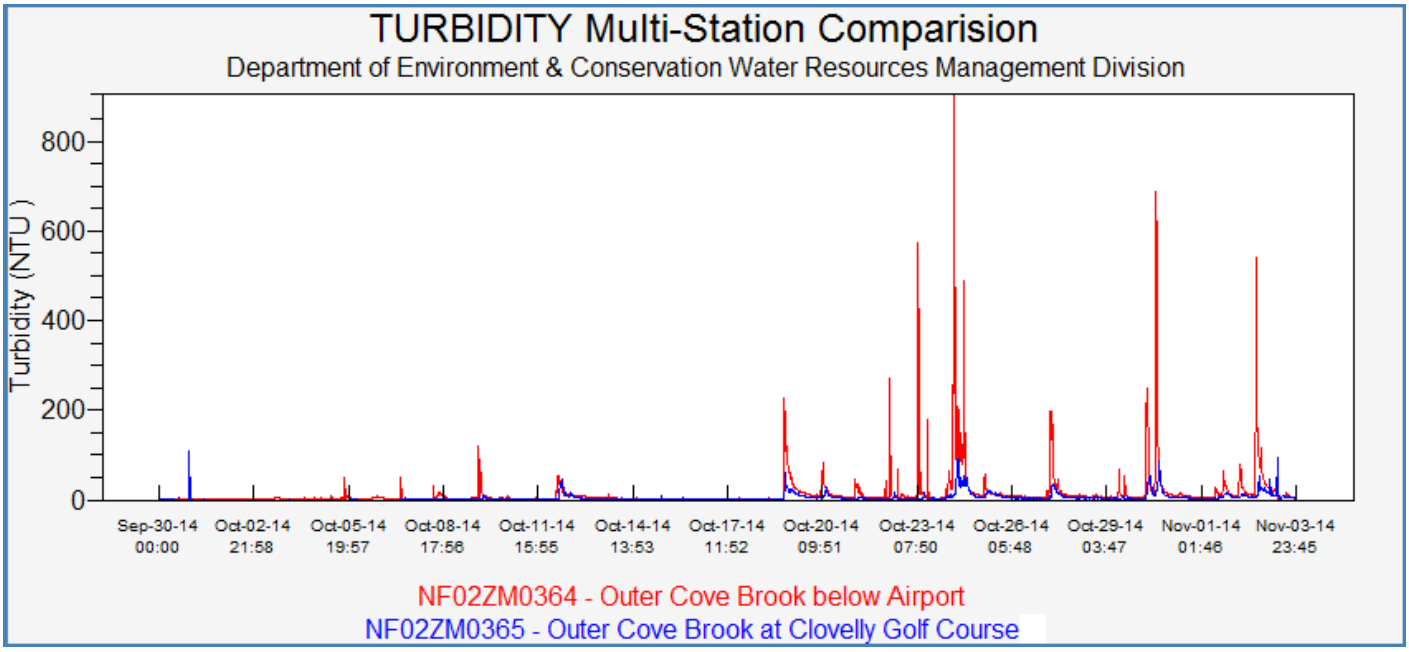

Figure A-14: Comparisons between Turbidity