Real-Time Water Quality Report

Outer Cove Brook Network

Deployment Period
November 3, 2014 to December 3, 2014

Newfoundland Labrador

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

Outer Cove Brook, Newfoundland and Labrador

Prepared by:

Tara Clinton
Environmental Scientist
Water Resources Management Division
Department of Environment & Conservation
4th Floor, Confederation Building, West Block
PO Box 8700, St. John's NL A1B 4J6
Ph. No.: (709) 729 - 5925
Fax No.: (709) 729 - 0320
taraclinton@gov.nl.ca

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 37-day period from deployment on November 3, 2014 until removal on December 3, 2014.

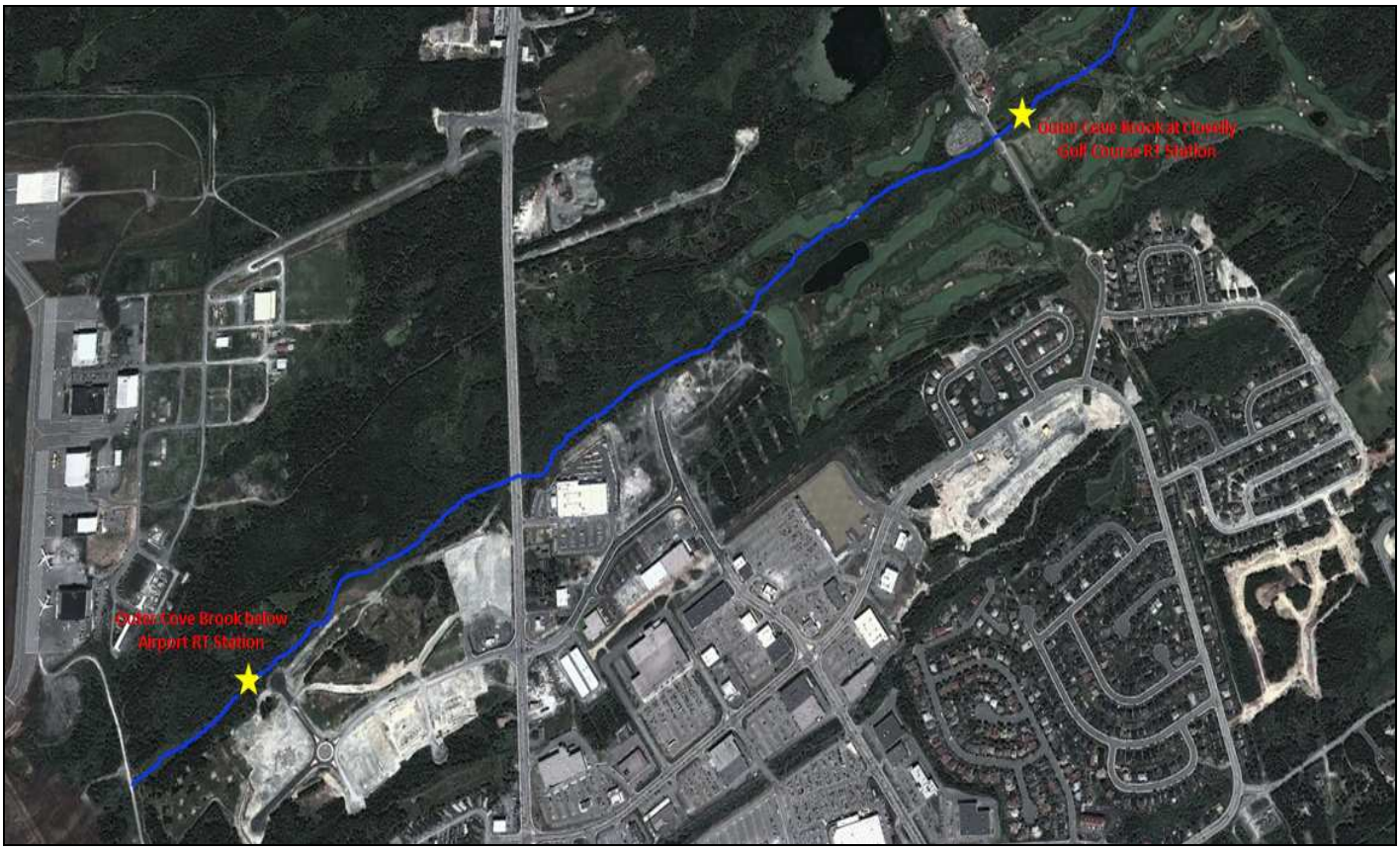

Figure 1: Outer Cove Brook Real-Time Water Quality and Quantity Stations.

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.

Concerns or Issues during the deployment period

During this deployment period Outer Cove Brook below Airport station lost transmission from November 26th through to December 2nd, 2014. Therefore the data on the online graphs and the data graphed for comparisons in Appendix I will have missing data for that time frame.

However the individual parameter data in the body of this report is from the log file that the instrument internally logs during the deployment period. There are no gaps in this data.

Outer Cove Brook, Newfoundland and Labrador

Deployment and removal instrument performance rankings for **Outer Cove Brook below Airport** 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	Nov 3 2014	Deployment	Excellent	Good	Excellent	Fair	Marginal
	Dec 3 2014	Removal	Excellent	Excellent	Excellent	Excellent	Excellent

- During the Outer Cove Brook below Airport station deployment, water temperature and conductivity ranked as 'Excellent'. With pH ranking as 'Good'. Dissolved oxygen ranked as 'Fair' during deployment and turbidity ranked as 'Marginal'. The turbidity ranking may have been a result of debris or sediment from the stream bed interfering with the reading taken at that time.
- At removal, water temperature, pH and conductivity, dissolved oxygen and turbidity all ranked as 'Excellent'.

Deployment and removal instrument performance rankings for **Outer Cove Brook at Clovelly Golf Course** 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	Nov 3 2014	Deployment	Excellent	Excellent	Excellent	Excellent	Poor
	Dec 3 2014	Removal	Excellent	Excellent	Excellent	Excellent	Excellent

- 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 dissolved oxygen comparison data all ranked as 'excellent'. Turbidity data ranked as 'Poor' 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 11.4 NTU between the field sonde and the QAQC sonde.

- At removal the comparison between the field sonde and QAQC sonde indicated that, water temperature, pH, conductivity, dissolved oxygen and turbidity ranked as 'excellent'.

Outer Cove Brook below Airport

Water Temperature

Water temperature ranged from 3.34°C to 11.4°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 peaks in water temperature correspond with higher stage levels, this is displayed on Figure 2 by the black circled events. 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.

This deployment period the water temperature is also decreasing, this is evident by the linear regression line across the data. This decrease is to be expected with the cooler air temperatures coming into winter.

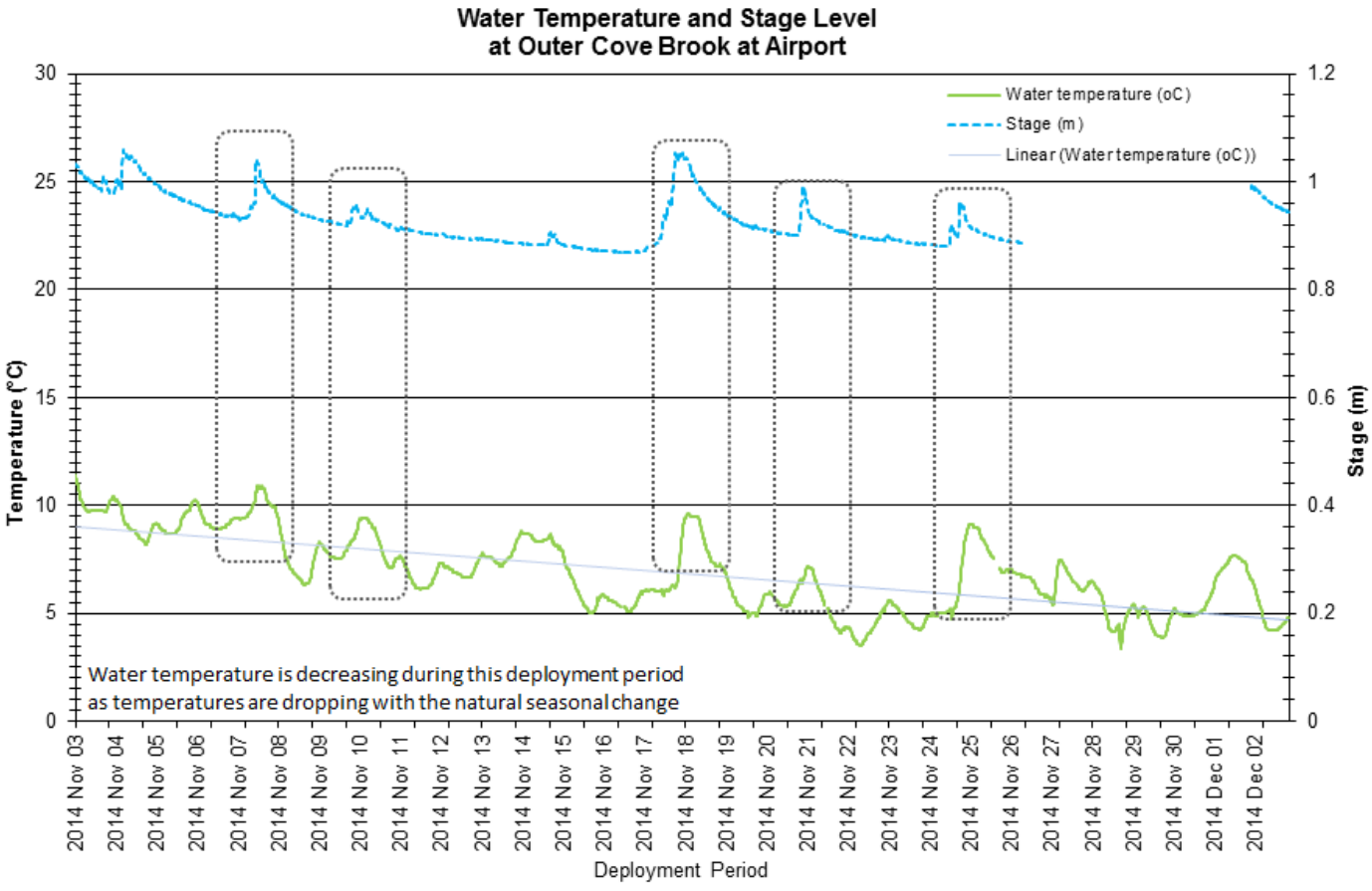

Figure 2: Water temperature (°C) and Stage (m) values at Outer Cove Brook below Airport

pH

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Throughout this deployment period pH values ranged between 6.22 pH units and 8.27 pH units (Figure 3). The maximum value is unusually high for this brook.

During this deployment, the majority of 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 several dips in pH values below the CCME Guideline for the Protection of Aquatic Life during the deployment period.

The pH dipped below the CCME guideline on a number of occasions. All circled dips in pH 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 peak in pH on November 27th is likely a result of road salting at that time. It is around this date that both turbidity and conductivity have an event.

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 6.48 pH units, which was slightly lower than last month.

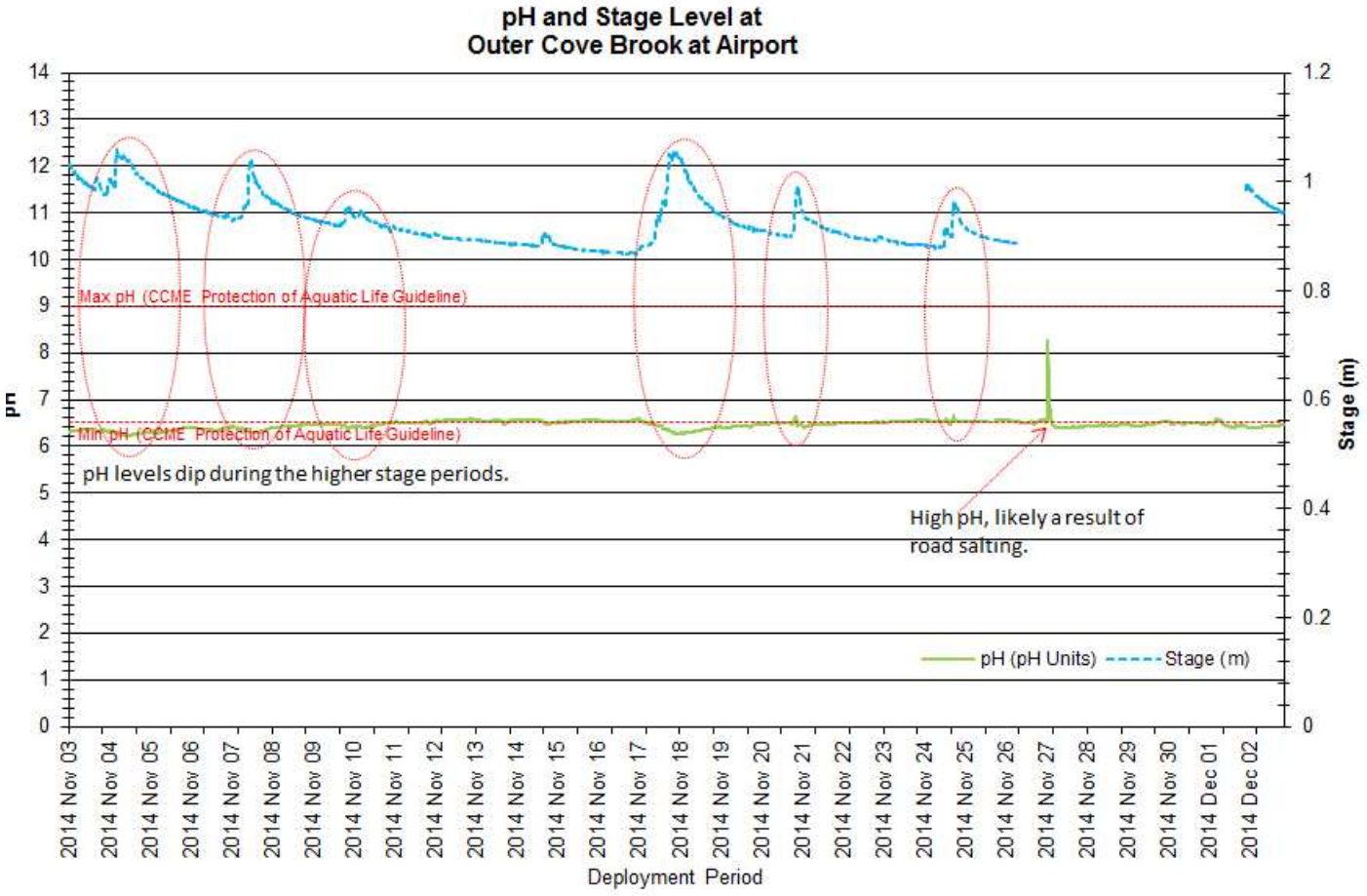

Figure 3: pH (pH units) and stage level (m) values at Outer Cove Brook below Airport

Specific Conductivity & TDS

The conductivity levels were within 114.2 µS/cm and 1192.0 µS/cm during this deployment period. TDS ranged from 0.0731 g/L to 0.7630 g/L.

Naturally 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 the dips in conductivity up to November 18th.

Around November 20th the conductivity levels start to peak periodically. This is likely a result of salting on the roadways around the brook. Figure 14 shows the air temperatures for November 20th onwards and indicates low and below 0 temperatures. During these frosty and icy road conditions, the roadways are salted and the conductivity levels increase as the residual salt is flushed into the brook through rainfall/runoff.

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.

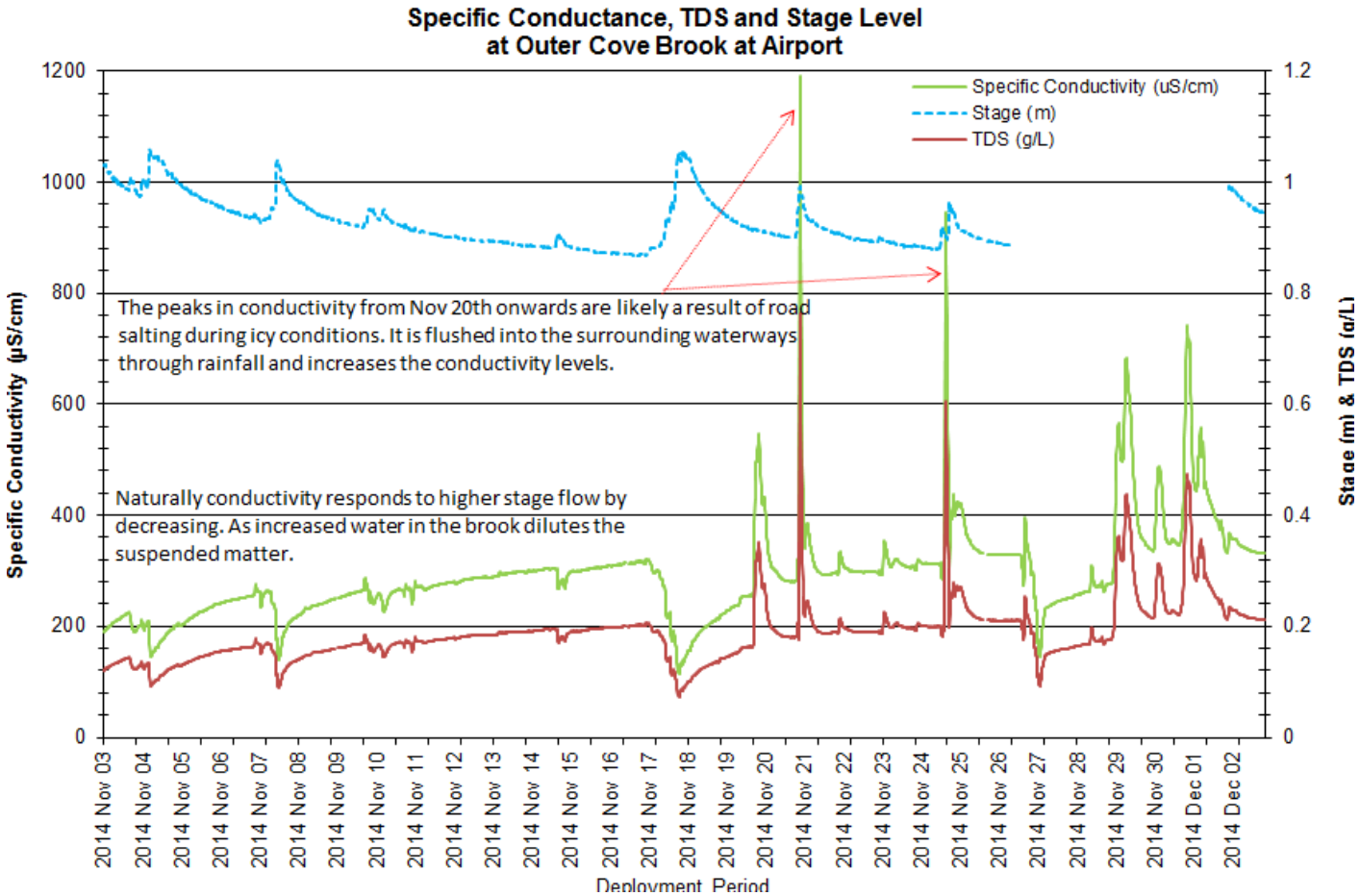

Figure 4: Specific conductivity (µS/cm), TDS (g/L) and stage (m) values at Outer Cove Brook below Airport.

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% Sat to 86.5% Sat. Dissolved Oxygen (mg/L) measured 8.58 mg/L to 10.80 mg/L.

During this deployment the dissolved oxygen levels were reasonably consistent. There is an evident relationship between water temperature and dissolved oxygen. As water temperature decreases the level of dissolved oxygen consumed decreases, which means there is slightly more dissolved oxygen in the brook during these cooler temperatures. This is displayed by the trend line on the dissolved oxygen (mg/L) data.

There are several small events noted on Figure 5, on November 7th, November 15th, November 18th and November 25th. These events correspond with some of the warmer water temperatures during the deployment period.

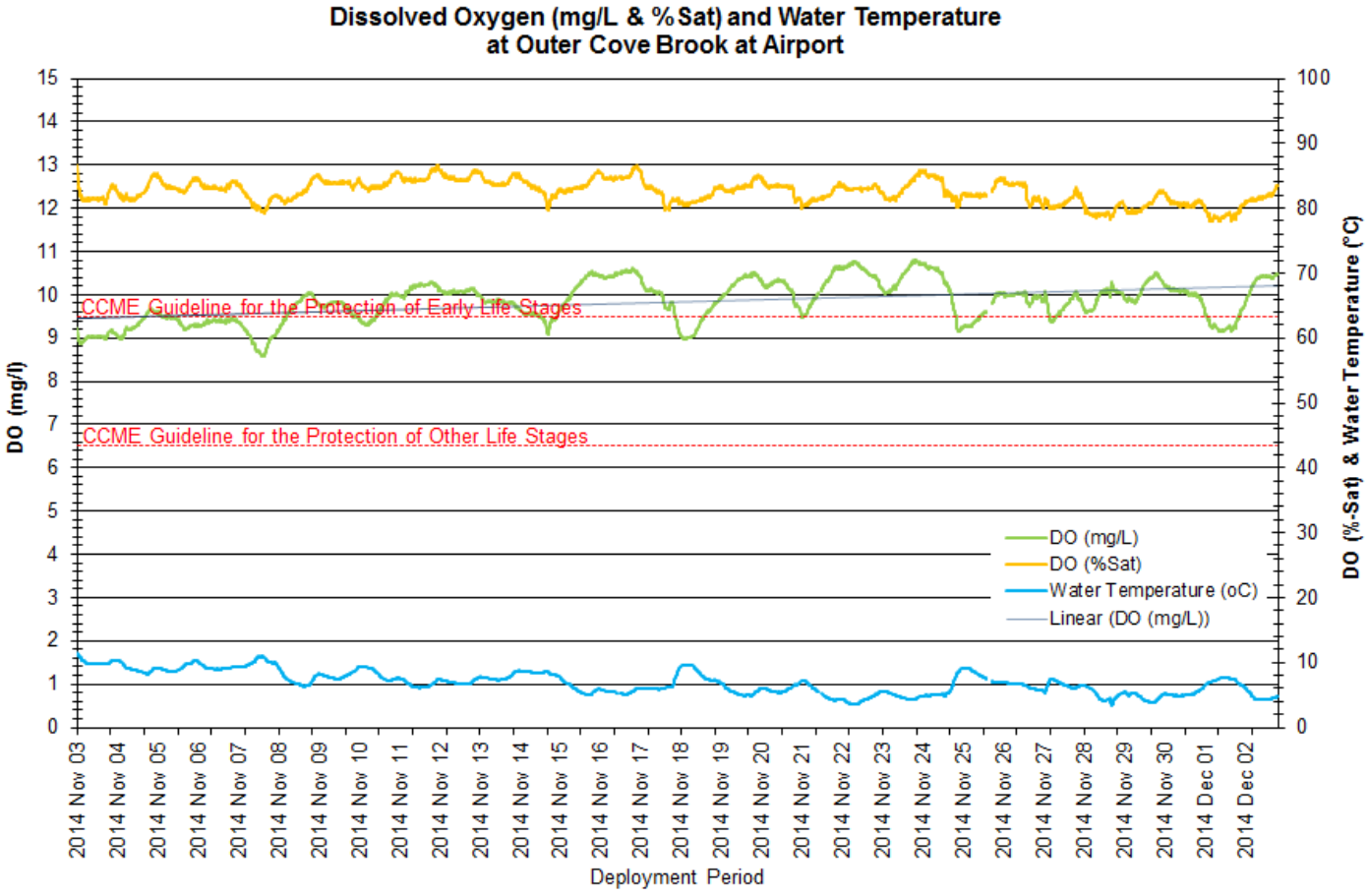

Figure 5: Dissolved oxygen (mg/L & % sat) and water temperature (°C) values at Outer Cove Brook below Airport.

Turbidity

Turbidity levels during this deployment period ranged within 0.9 NTU and 205.5 NTU (Figure 6). With a median of 3.3 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 Figure 6 by the arrows. The large turbidity event on November 27th corresponds with a rainfall amount of 23mm on the same day (see Figure 7).

The circled turbidity peaks on November 5th – 6th, November 11th – 13th, and November 19th – 20th and again on November 24th do not correspond with an increase in stage. It is unclear what the cause of the peaks in turbidity at these times, although they may be a result of road salting during below 0 temperatures see Figure 14 for ambient air temperatures in St. John's.

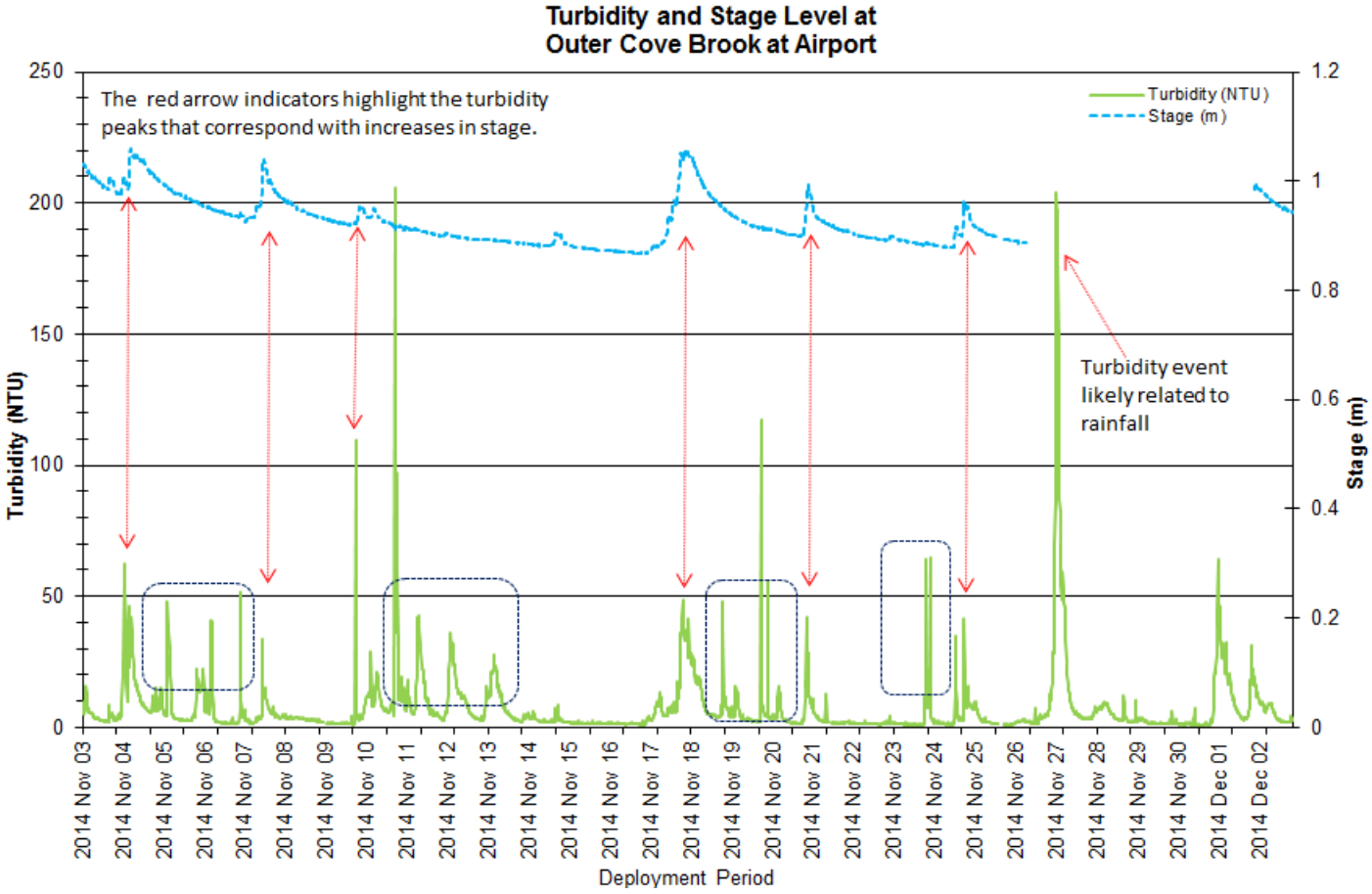

Figure 6: Turbidity (NTU) and stage level (m) values at Outer Cove Brook below Airport.

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 0.87m to 1.06m. The stream flow values ranges from 0.13m to 1.06m .The larger peaks in stage and stream flow do correspond with substantial rainfall events as noted on Figure 7. Please note that due to transmission issues there is a gap in data from November 26th to December 2nd with the stage and stream flow data.

Precipitation 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 30.0 mm on November 18th.

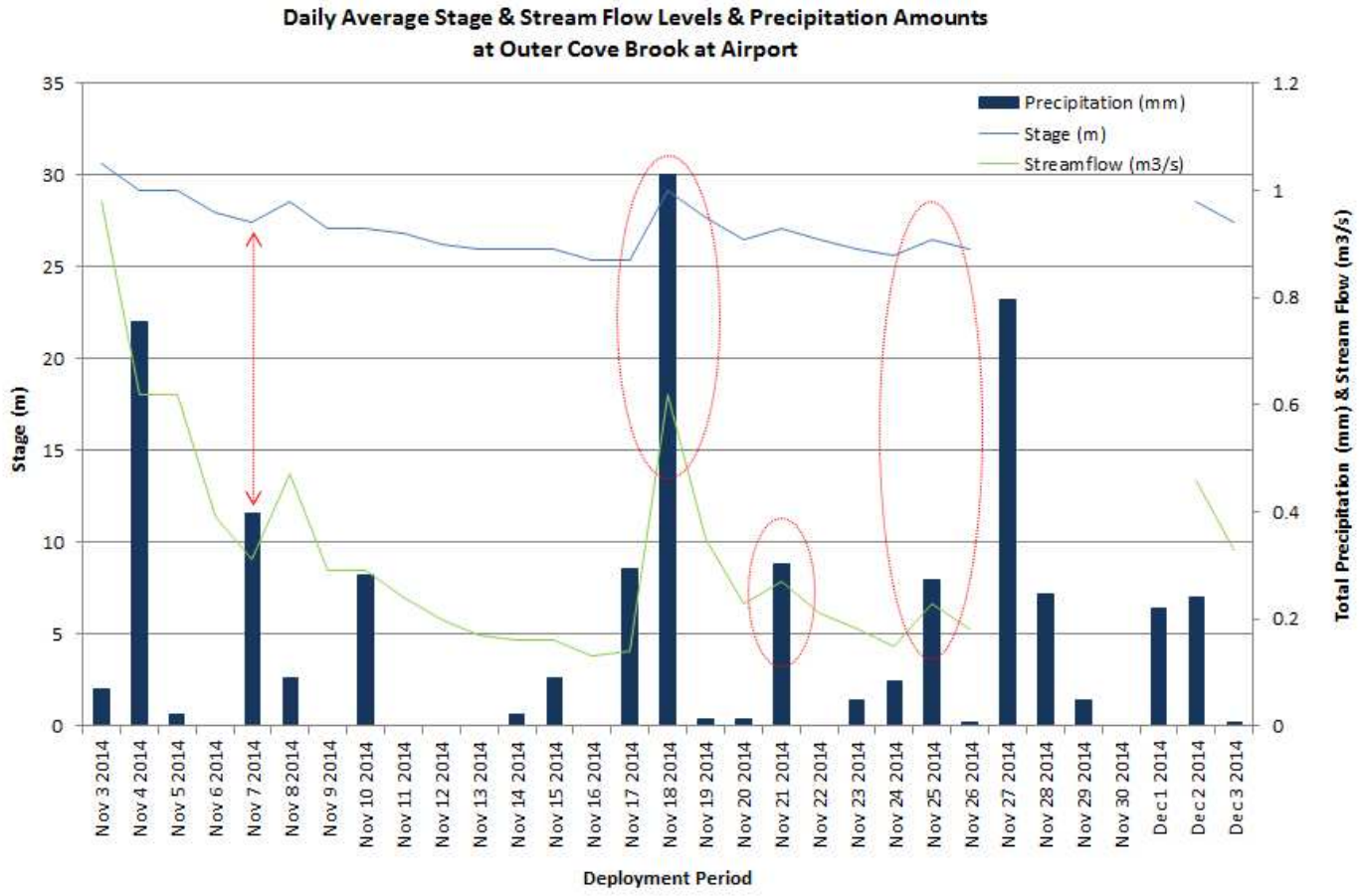

Figure 7: Daily average stage & stream flow values at Outer Cove Brook below Airport and daily total precipitation & Air Temperature values from Environment Canada's St. John's Airport Station.

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 November 4th, November 7th, November 17 -18th, November 21st and again on November 25th 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. There is one high pH reading on November 27th which may have been a combination of rainfall and road salting runoff during the below 0^{o}C temperatures during that time frame (see Figure 14).

- Cooler ambient air temperatures (Figure 14) influenced the water temperature during this deployment period. 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 November 5th – 6th, November 11th – 13th, and November 19th – 20th and again on November 24th there are unexplained turbidity events. The November 20th event is also evident on the conductivity graph (Figure 4) which can indicate that the turbidity was also influenced from the road salting during these time frames.

Outer Cove Brook at Clovelly Golf Course

Water Temperature

Water temperature ranged from 2.89 ^{o}C to 12.04 ^{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 generally influenced by ambient air temperature. Figure 8 indicates that stage level can also influence the water temperature for a short period of time.

It is evident on the graph that the water temperature is decreasing; trend line indicates the gradual slope of the water temperature values as the cooler temperatures start with the winter season.

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

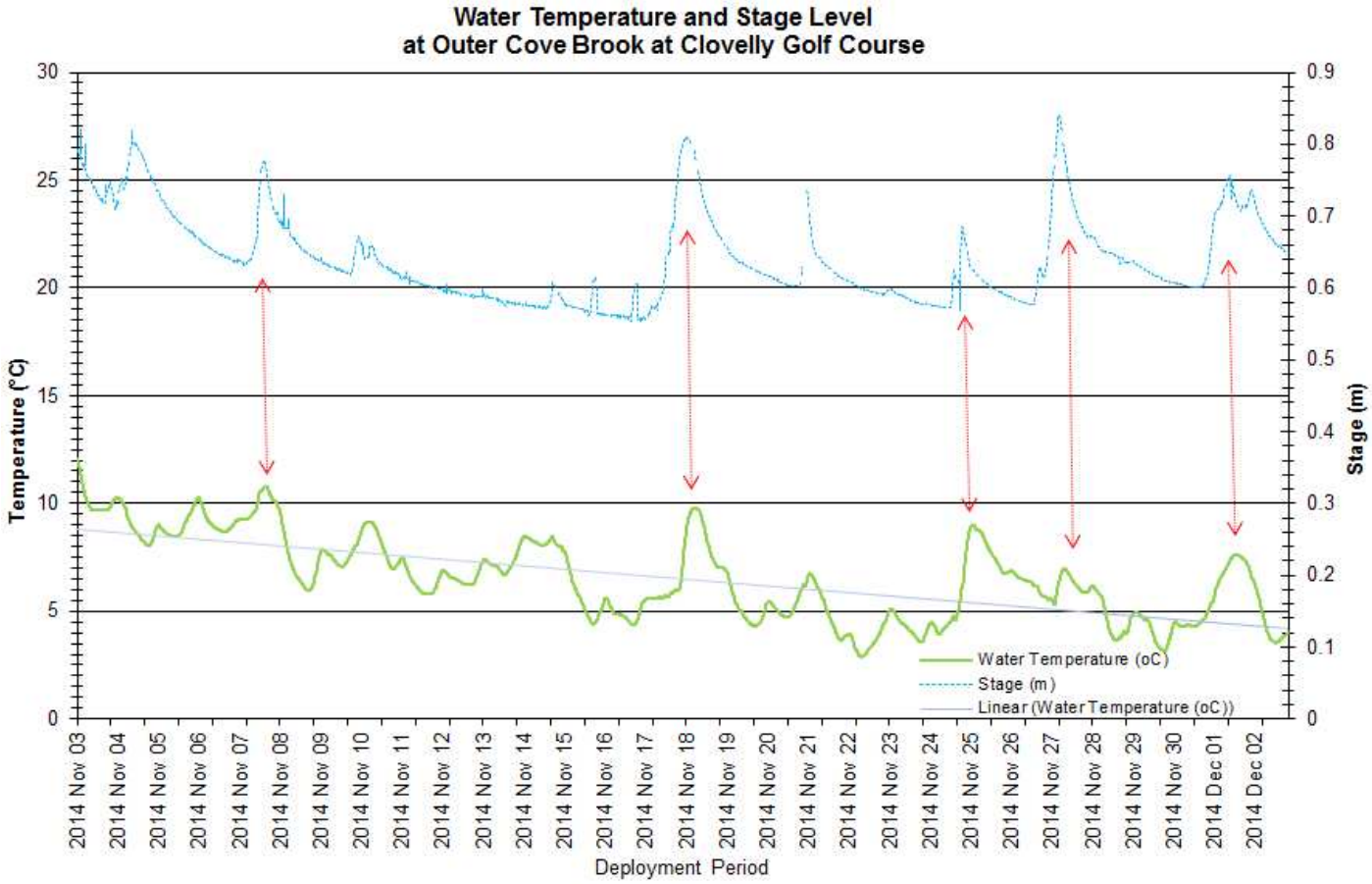

Figure 8: Water temperature (℃) and Stage (m) leve ls at Outer Cove Brook at Clovelly Golf Course.

pH

Throughout this deployment period pH values ranged between 6.17 pH units and 6.63 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.

The pH levels dip slightly on several occasions these events are highlighted on the graph by the arrows. The 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 6.46 units (slightly higher pH unit from last deployment).

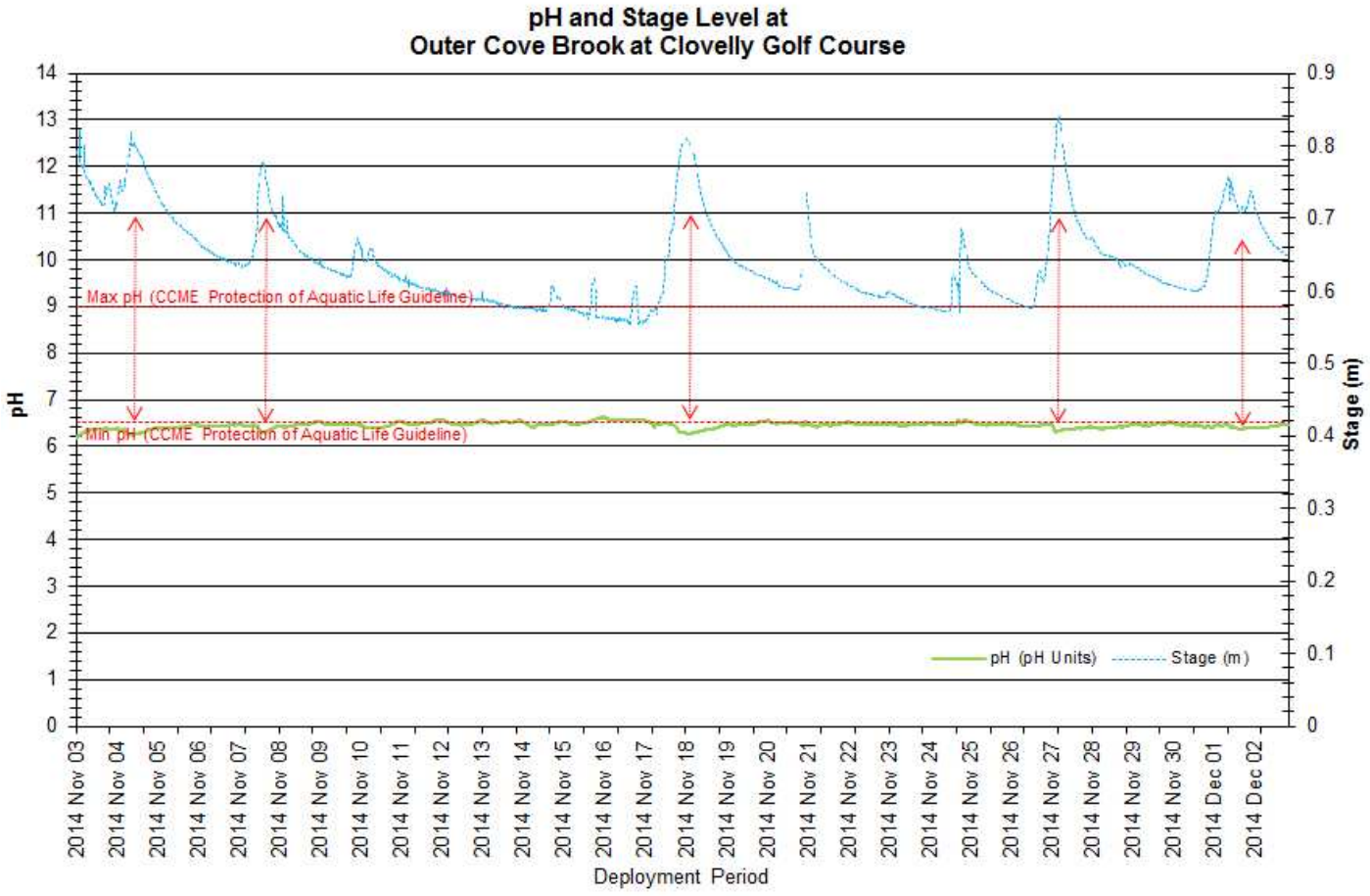

Figure 9: pH (pH units) and stage level (m) values at Outer Cove Brook at Clovelly Golf Course.

Specific Conductivity & TDS

The conductivity levels were within 146.6 µS/cm and 1769.0 µS/cm during this deployment period. TDS ranged from 0.0938 g/L to 1.1300 g/L.

The dips in conductivity up to November 18th (see Figure 10) correspond with an increase in stage level. The conductivity probe measures the dissolved particles present in a water body, generally an increase in stage can indicate rainfall. Rainfall saturates the brook and flushes the dissolved particles from the water column diluting the conductivity levels for a short period of time.

With the current cooler temperatures (see Figure 14), road salting has started on the roadways surrounding the brook. Road salting creates an opposite effect during high stage levels, the salt adds to the dissolved particles in the brook when it is flushed into the surrounding waterways.

On November 29th a high peak in conductivity was likely a result of road salting. The weather station at St. John's International airport indicated average air temperatures of -4 ^{o}C that day as well as ~3 cm in snow falls (Figure 14).

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.

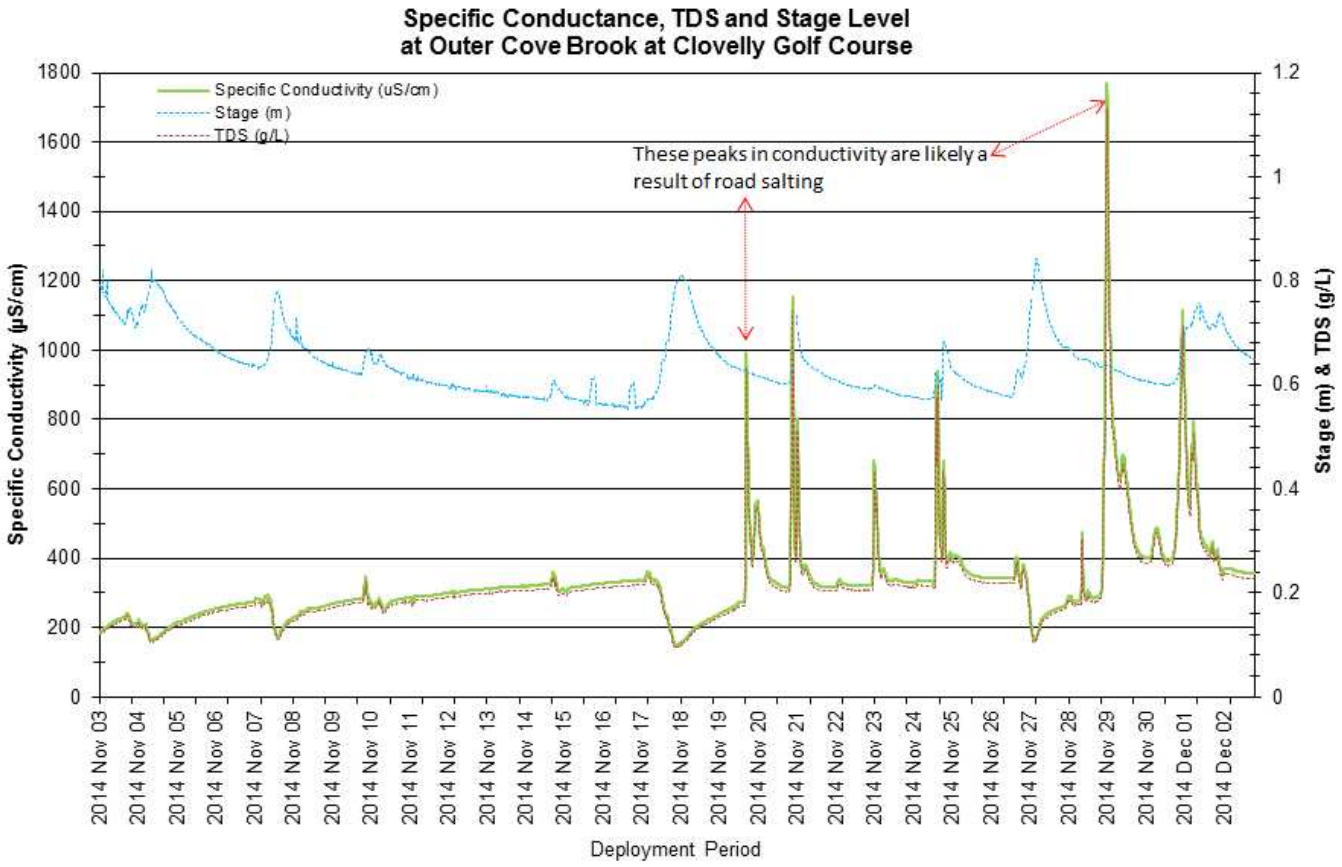

Figure 10: Specific conductivity (uS/cm), TDS (g/L) and stage (m) values at Outer Cove Brook at Clovelly Golf Course.

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 79.9 %Sat to 93.9 %Sat. Dissolved Oxygen (mg/L) measured 8.67 mg/L to 11.92 mg/L.

It should be noted that the cooler water temperatures increase the amount of dissolved oxygen a water body can hold. As water temperatures decrease (most likely overnight) the water dissolved oxygen levels increase.

Rainfall can also have an influence on dissolved oxygen content, the movement in the data on November 8th, November 14th, November 18th, November 25th and December 1st, is likely a result of the rainfall that occurred during that same time period (seen on Figure 13).

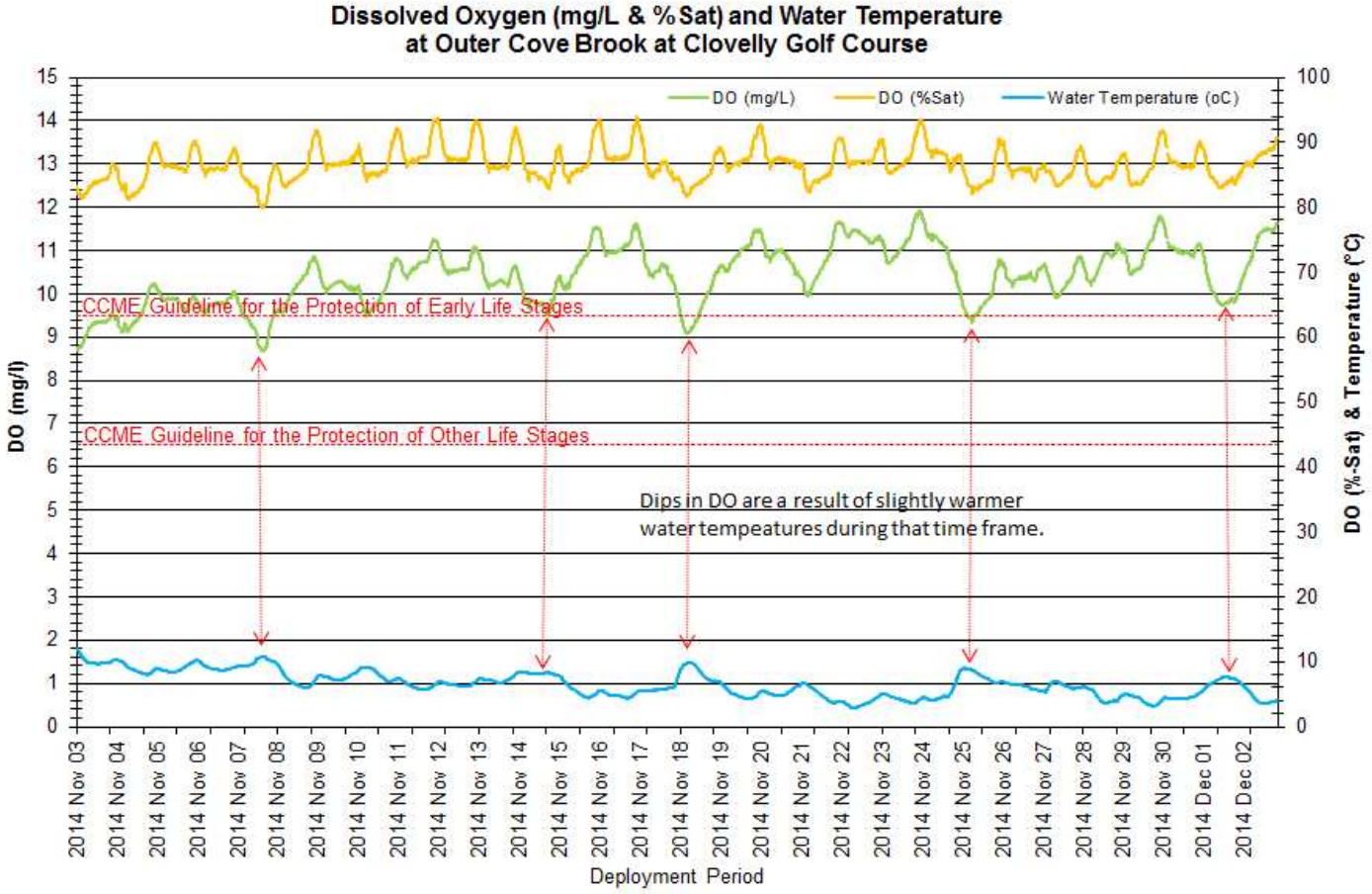

Figure 11: Dissolved oxygen (mg/L & % sat) and water temperature (℃) values at Outer Cove Brook at Clovelly Golf Course.

Turbidity

Turbidity levels during this deployment period ranged within 1.0 NTU and 97.9 NTU (Figure 12), with a median of 4.6 NTU.

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. The majority of turbidity increases on the turbidity graph correspond with stage increases at the same time. However the turbidity events on November 5th – 6th, November 11th - 13th, November 19th – November 20th and again around November 28th to 30th 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 events caused turbidity increases around the same time noted at both stations (Appendix I).

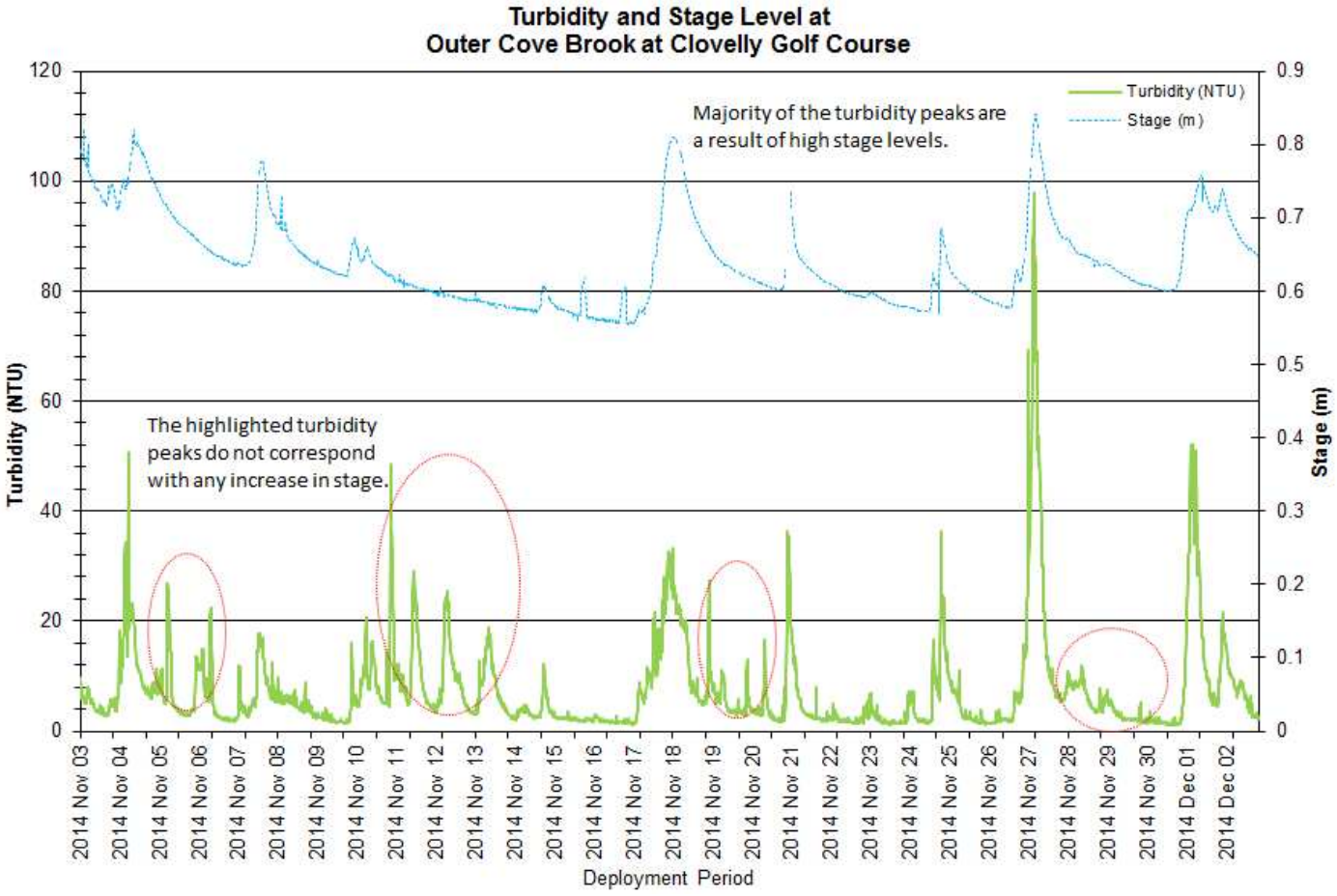

Figure 12: Turbidity (NTU) and stage level (m) values at Outer Cove Brook at Clovelly Golf Course.

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 0.55m and a maximum of 0.84m. Stream flow ranged within minimum of 0.05 m^3/s and a maximum of 0.84 m^3/s. The precipitation ranged from a minimum of 0.0 mm a day to a maximum of 30 mm which was on November 18th, 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. Precipitation data was obtained from Environment Canada's St. John's Airport weather station.

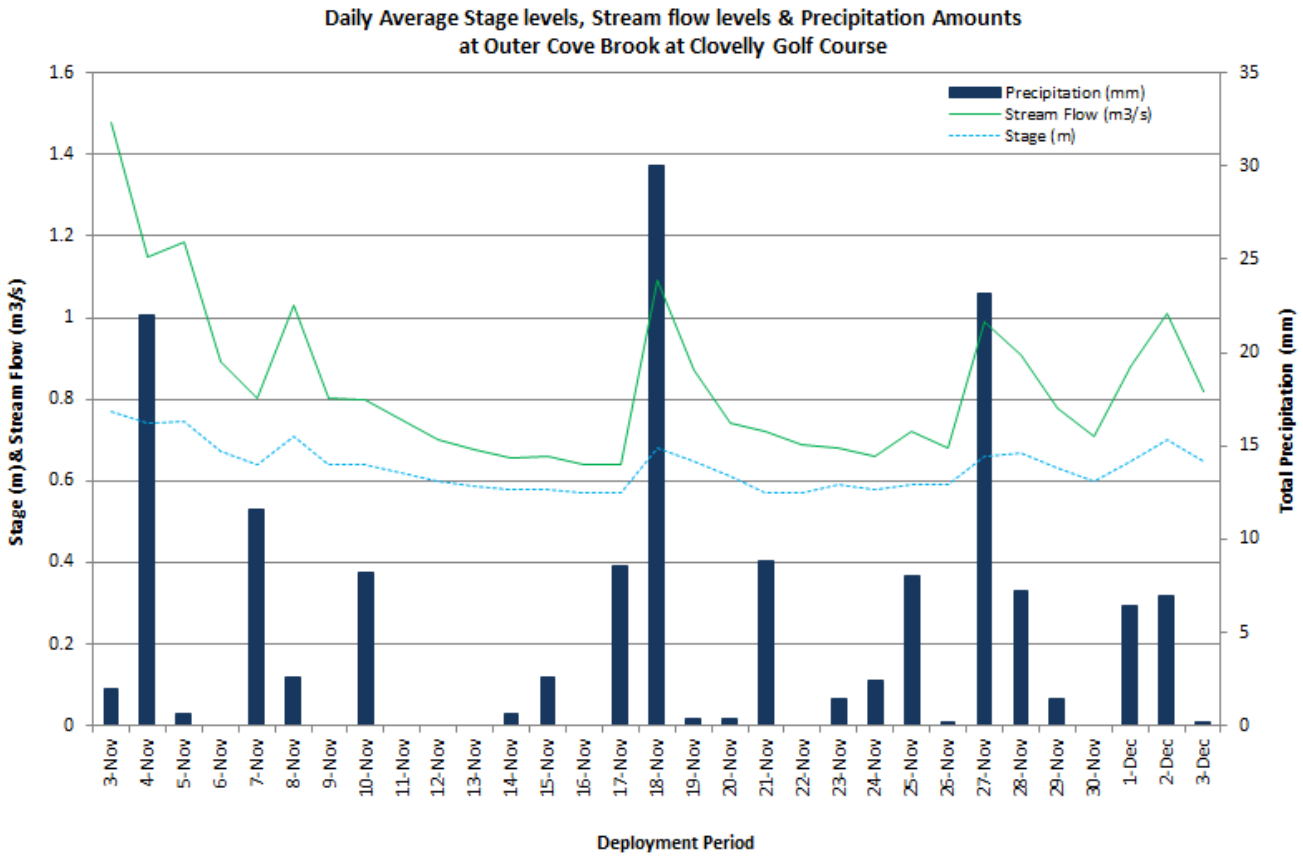

Figure 13: Daily average stage and stream flow values at Outer Cove Brook at Clovelly Golf Course and daily total precipitation values (mm) from Environment Canada's Weather Station at St. John's International Airport.

Outer Cove Brook, Newfoundland and Labrador

Daily Averaged Rainfall, Snowfall and Air Temperature

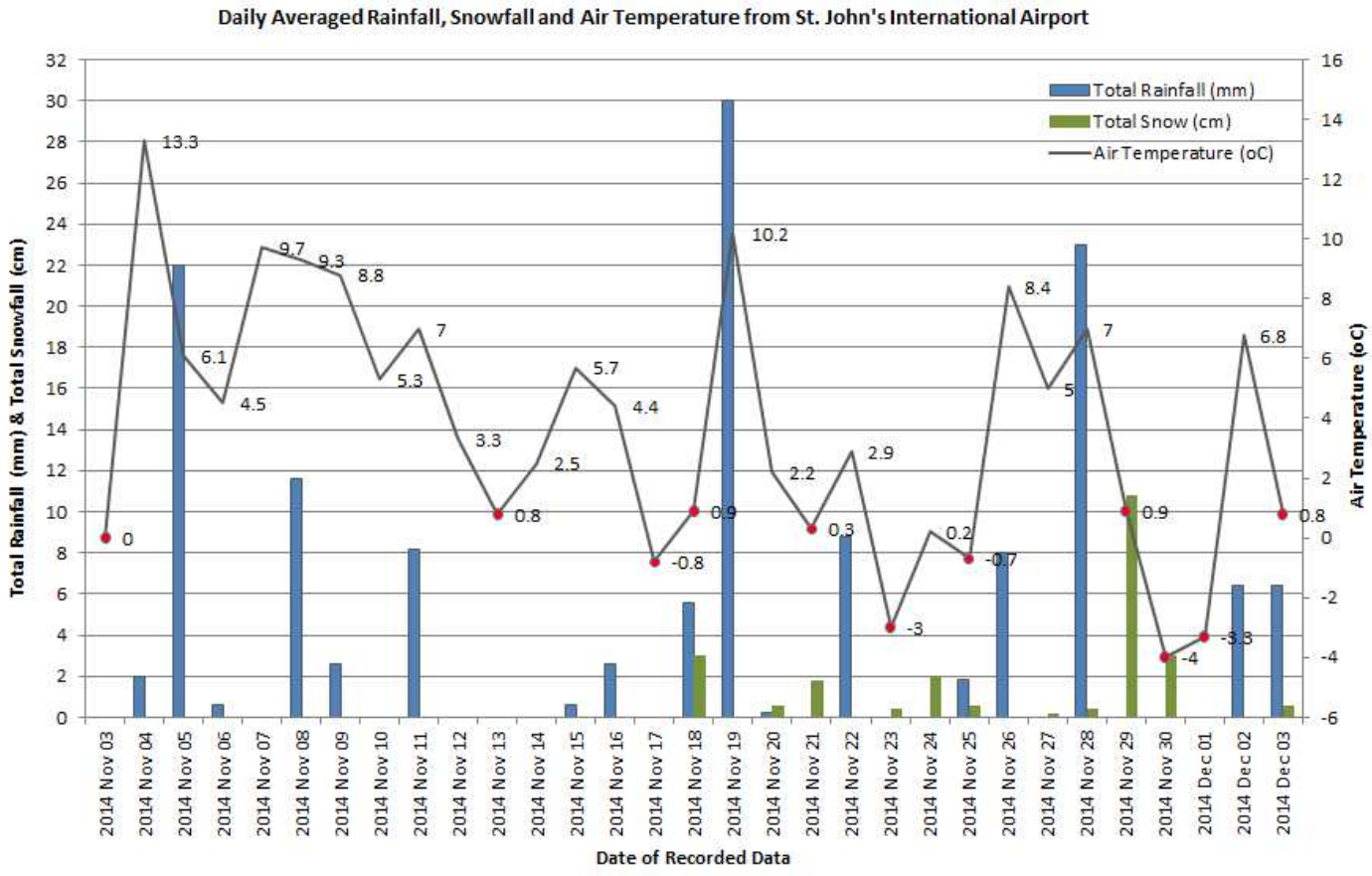

Figure 14: Daily average rainfall, snowfall and air temperature values from Environment Canada's Weather Station at St. John's International Airport.

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. The conductivity data displays potential runoff influences on November 20th – 21st, November 23rd, November 24th, 29th and December 1st. This was evident from the peaks in conductivity likely a result of road salt runoff when the air temperature was below 0^0C nights and mornings.

- As ambient air temperatures decrease with the seasonal changes it should reflect in the water temperature. In turn, 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. Events for Outer Cove Brook at Clovelly Golf Course that are not linked to rainfall are the turbidity peaks on November 5th – 6th, November 11th - 13th, November 19th – November 20th and again around November 28th to 30th, it was evident in turbidity data for Outer Cove Brook below Airport as well.

- Outer Cove Brook at Clovelly Golf Course had several peaks in conductivity from November 20th to 29th these peaks occurred without any recorded increases in stage level. Figure 14 indicated low air temperatures on these dates; this is important as the lower air temperatures may have resulted in frosting or icy road conditions and lead to the roads being salted for safety.

Outer Cove Brook, Newfoundland and Labrador

APPENDIX I

Outer Cove Brook, Newfoundland and Labrador

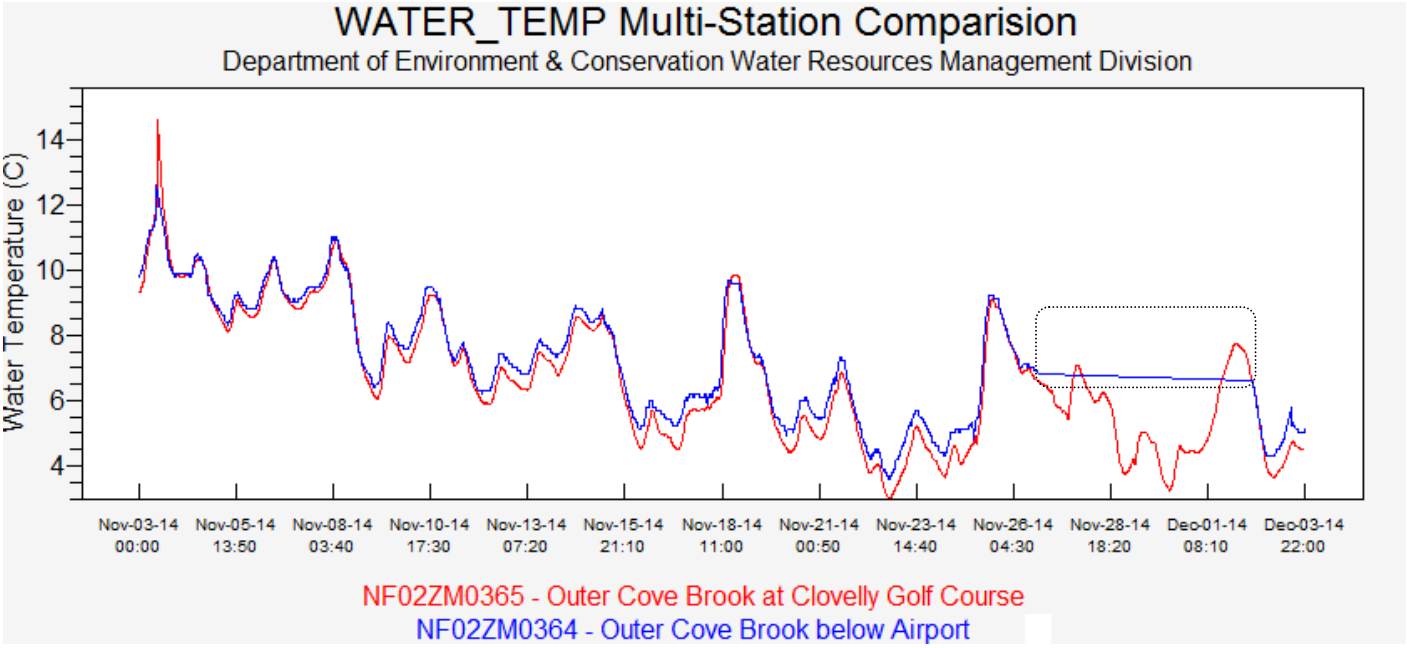

Figure A1: Comparison Water Temperature at the Outer Cove Brook Stations

Please note the area highlighted is data missing it is not representative of water temperature for Outer Cove Brook below Airport

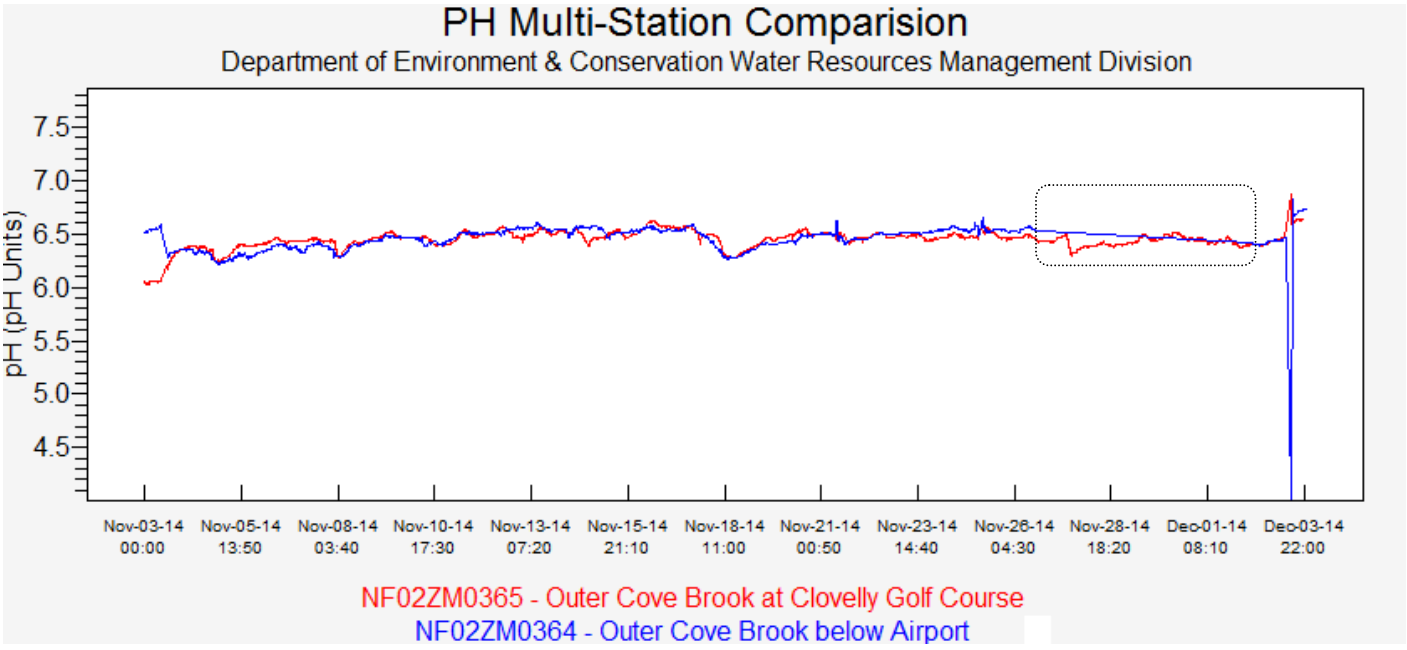

Figure A2: Comparison of pH units at the Outer Cove Brook Stations

Please note the area highlighted is data missing it is not representative of pH for Outer Cove Brook below Airport

Outer Cove Brook, Newfoundland and Labrador

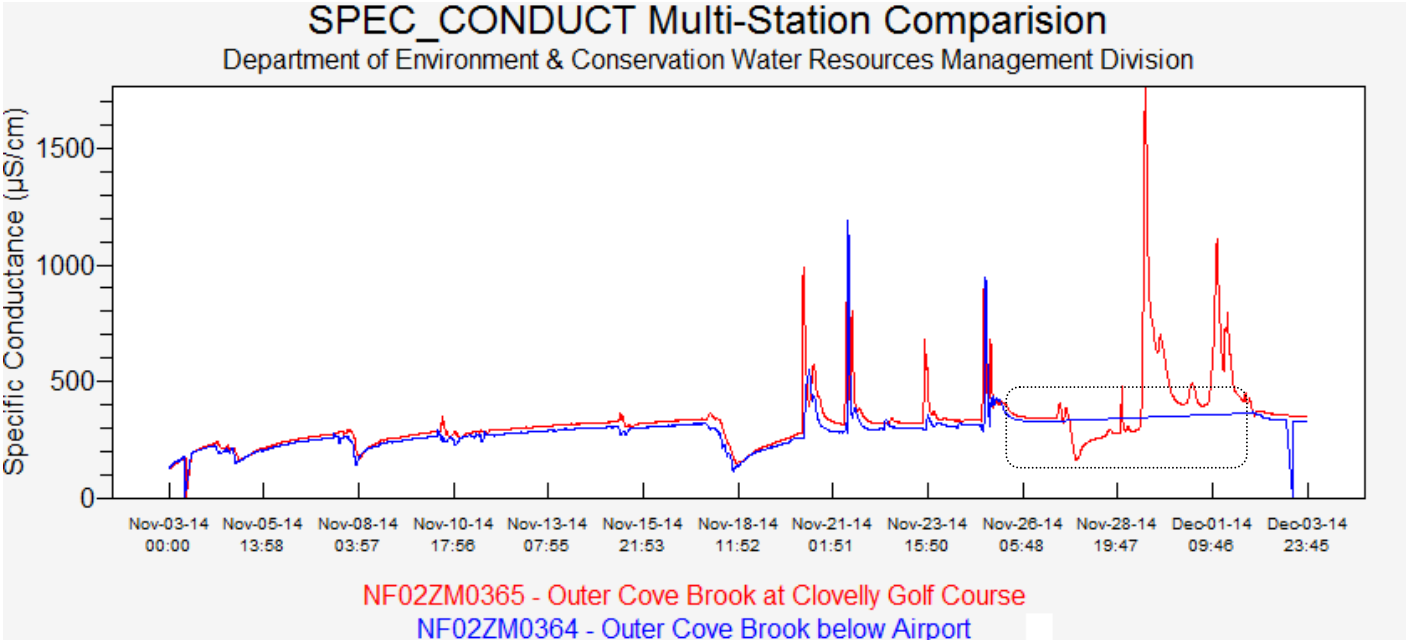

Figure A3: Comparison Specific Conductivity at the Outer Cove Brook Stations

Please note the area highlighted is data missing it is not representative of conductivity for Outer Cove Brook below Airport

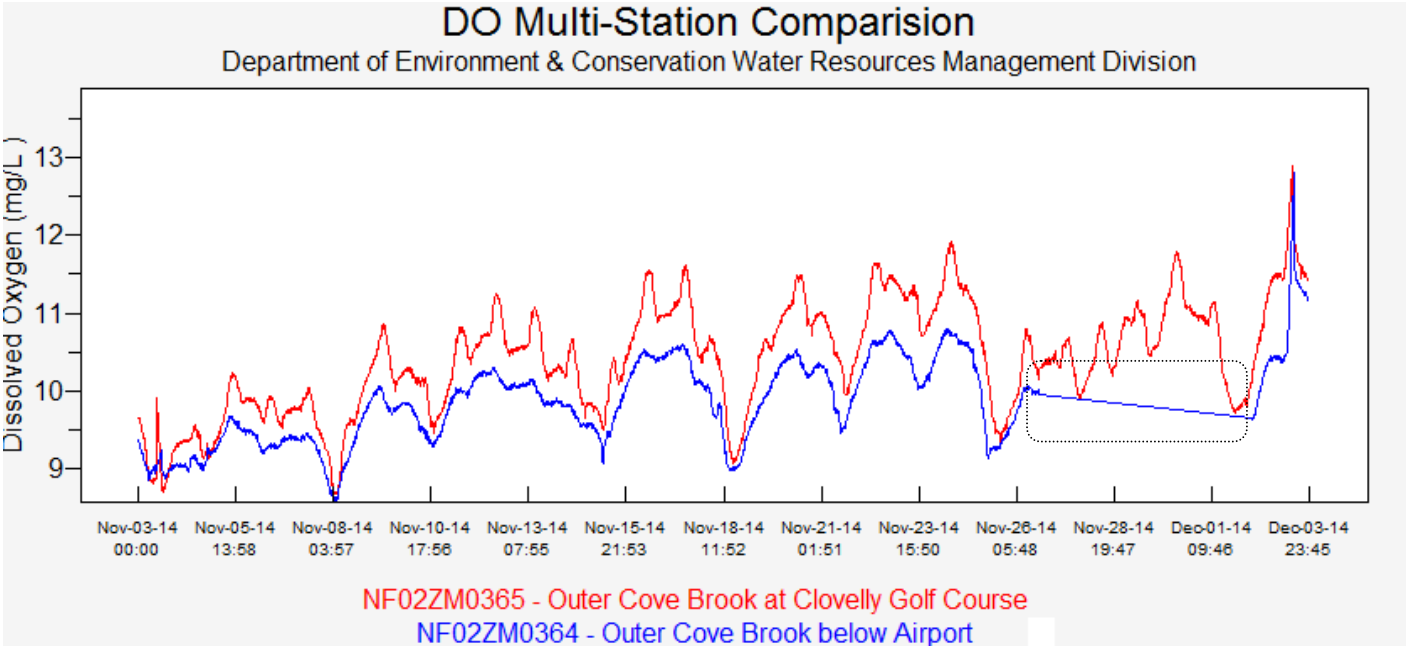

Figure A4: Comparison of Dissolved Oxygen (mg/L) at the Outer Cove Brook Station

Please note the area highlighted is data missing it is not representative of dissolved oxygen (mg/L) for Outer Cove Brook below Airport

Outer Cove Brook, Newfoundland and Labrador

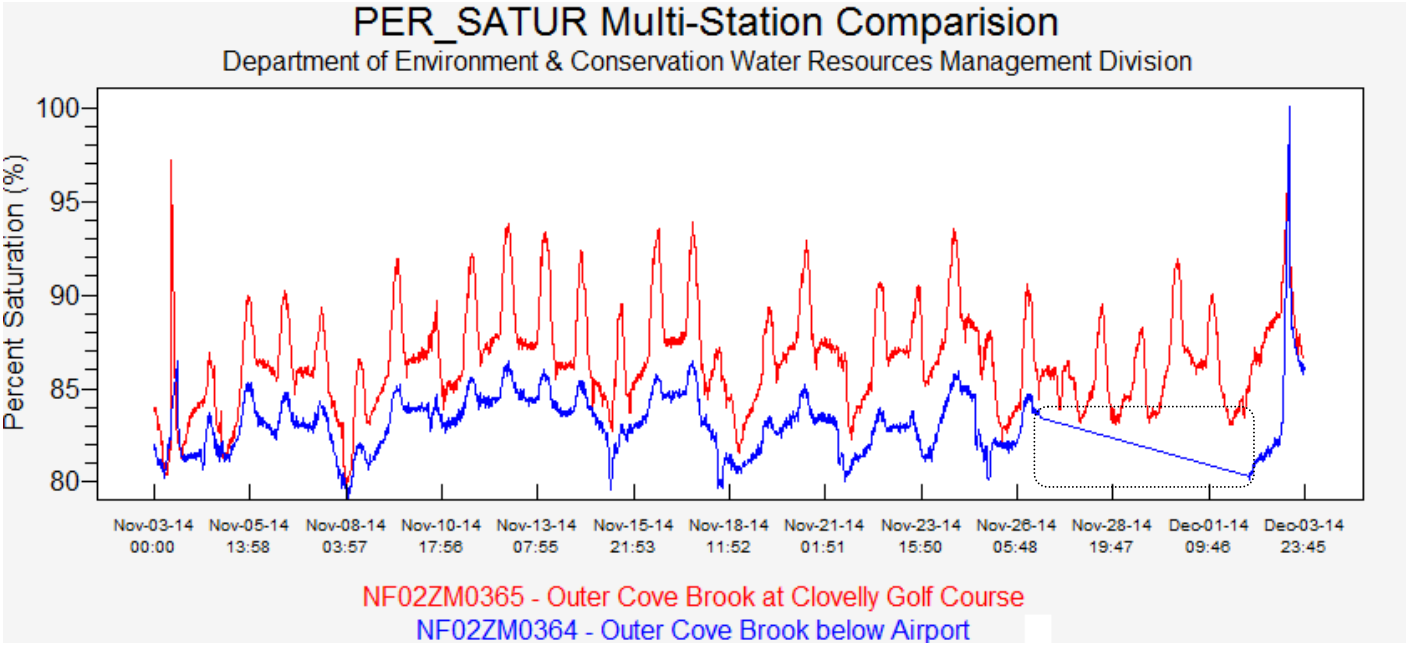

Figure A5: Comparison of Dissolved Oxygen (%Sat) of the Outer Cove Brook stations

Please note the area highlighted is data missing it is not representative of dissolved oxygen (%Sat) for Outer Cove Brook below Airport

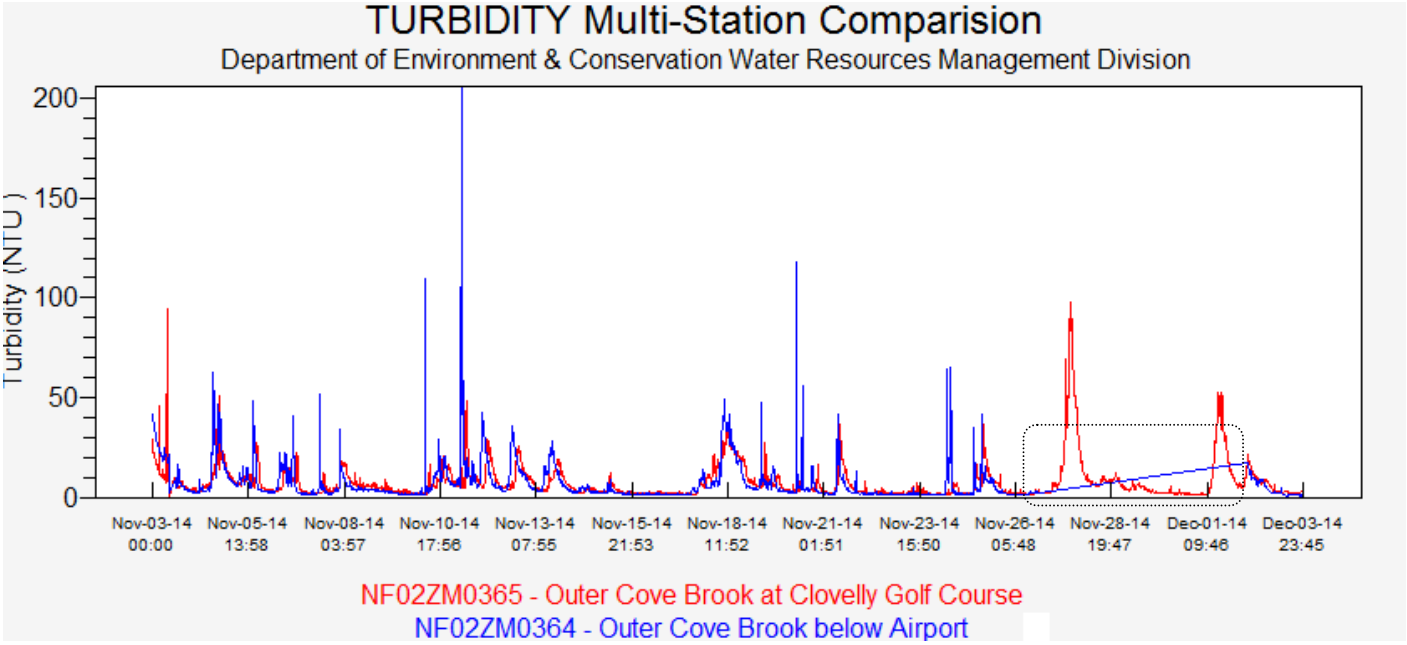

Figure A6: Comparison of Turbidity at the Outer Cove Brook stations

Please note the area highlighted is data missing it is not representative of turbidity for Outer Cove Brook below Airport