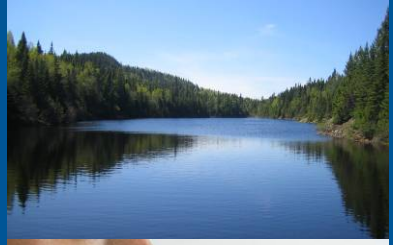







Real-Time Water Quality Report

Outer Cove Brook Network

Deployment Period
December 3, 2014 to January 21, 2015

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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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 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 49-day period from deployment on December 3, 2014 until removal on January 21, 2015.

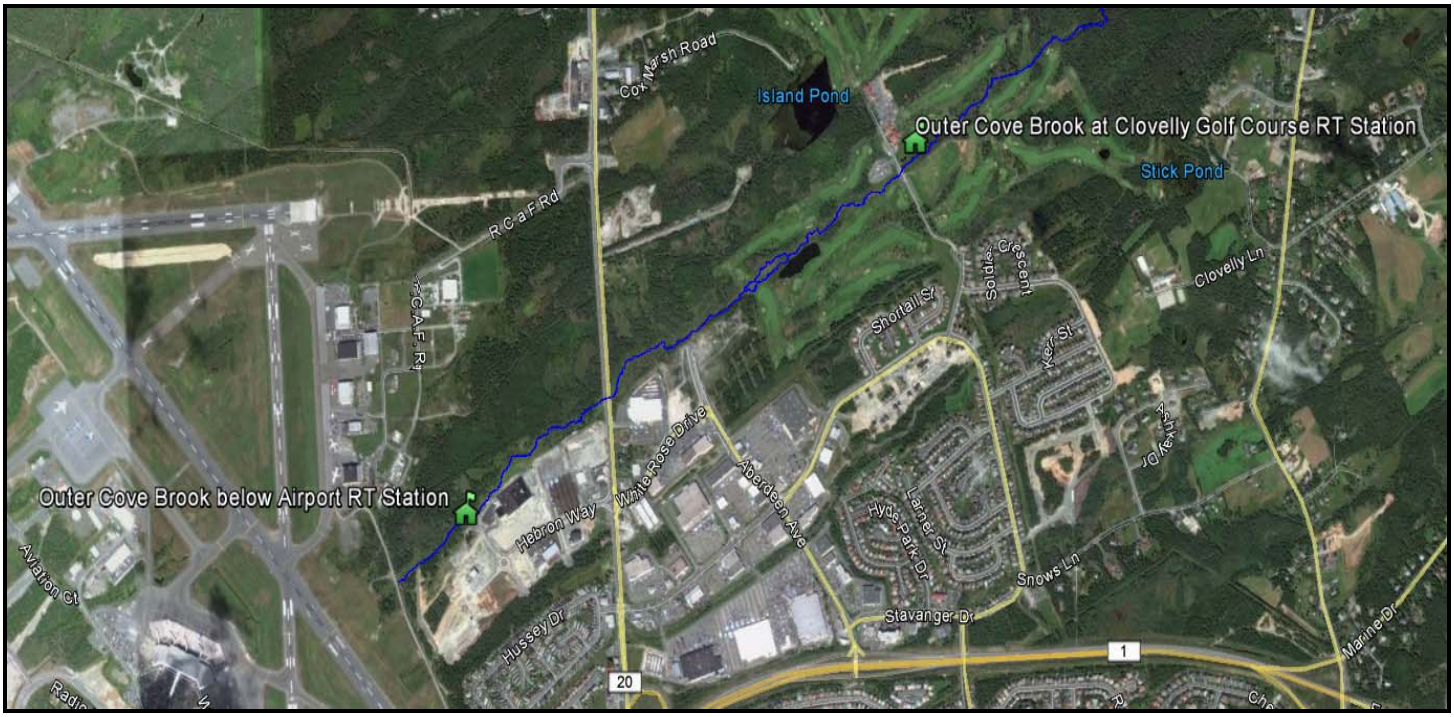

Figure 1: Outer Cove Brook Real-Time Water Quality and Quantity Stations.

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).

Water Resources Management (WRMD) staff (Environment and Conservation (ENVC)) is responsible for maintenance of the real-time water quality monitoring equipment, as well as recording and managing the water quality data. Tara Clinton, under the supervision of Renee Paterson, is ENVC's main contact for the real-time water quality monitoring operations at Outer Cove Brook, and is responsible for maintaining and calibrating water quality instruments, as well as grooming, analyzing and reporting on water quality data recorded at the stations during the deployment year.

Water Survey of Canada (WSC) staff (Environment Canada (EC) under the management of Howie Wills, play an essential role in the data logging/communication aspect of the network and the maintenance of the water quantity monitoring equipment. EC-WSC staff visit the sites regularly to ensure the data logging and data transmitting equipment are working properly. WSC is responsible for handling stage and streamflow issues. The quantity data is raw data that is transmitted via satellite and published online with the quality data on the Real-Time Stations website. 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 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 at Clovelly Golf Course station was having intermittent transmission issues and data was coming through spotty and irregular. On December 16 & 17, 2014 it was decided to replace the field cable to the instrument to see if the connection improves. Therefore there is a gap in the water quality data for that time frame. There is an improvement in the data transmissions since the field cable was replaced. This station still has intermittent data although not as much as before.

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	Dec 3 2014	Deployment	Excellent	Excellent	Excellent	Excellent	Excellent
	Jan 21 2015	Removal	Excellent	Good	Good	Marginal	Fair

- During the Outer Cove Brook below Airport station deployment, all parameters ranked as 'Excellent'.
- At removal of the instrument, the water temperature data ranked as 'Exellent', with pH and conductivity, data ranking as 'Good'. The dissolved oxygen data ranked as 'Marginal' which may have been a result of the fouling present on the sensor at the time of removal. Turbidity data ranked as 'Fair' at removal, the lower ranking may have also been a result of the slime like algae inhibiting the sensor, as the instrument and the instrument protective casing was covered in algae at removal.

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	Dec 3 2014	Deployment	Excellent	Excellent	Excellent	Good	Excellent
	Jan 21 2014	Removal	Excellent	Excellent	Good	Excellent	Good

- 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 'Good' during initial deployment.
- At removal the comparison between the field sonde and QAQC sonde indicated that, water temperature, pH and dissolved oxygen data ranked as 'Excellent', while the data for conductivity and turbidity ranked as 'Good'. Overall acceptable rankings for data after its deployment period.

Outer Cove Brook below Airport

Water Temperature

Water temperature ranged from -0.10°C to 9.10°C during this deployment period (Figure 2). There were noticeable increases and decreases in the water temperature during this 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 corresponded with higher stage levels; this is displayed on Figure 2 by the black circled events. The water temperatures at this station do display diurnal variations although slightly exaggerated due to the climatic conditions during this deployment period. Shallow streams and ponds are highly influenced by natural diurnal variations in the surrounding air temperatures and precipitation events (Appendix I).

As the deployment period came to an end the water temperature decreased to almost freezing. The spikes in stage levels highlighted in red were likely a result of ice buildup or even freezing over of the brook. Please note, the stage data is raw data that is published on our web page. It has not been corrected for backwater effect. Water Survey of Canada is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request to Water Survey of Canada.

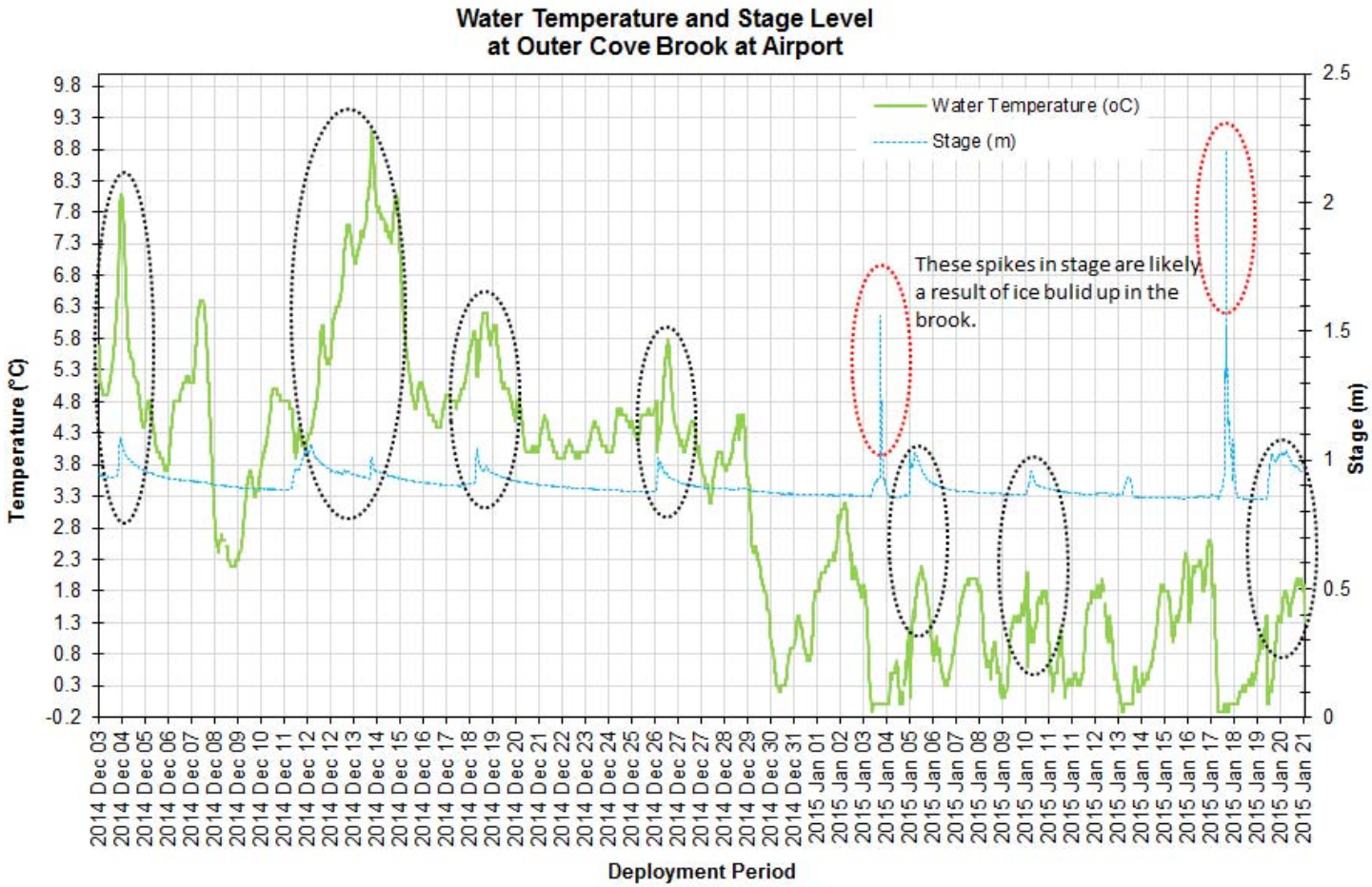

Figure 2: Water temperature (°C) and Stage (m) values at Outer Cove Brook below Airport

pH

Throughout the deployment period, pH values ranged between 6.39 pH units and 7.12 pH units (Figure 3).

During this deployment, the majority of pH values at this station were along the minimum CCME Guideline for the Protection of Aquatic Life (above and below 6.5 pH units).

All circled dips in pH corresponded with increases in stage level for similar time frames. During the deployment period the increased stage levels caused a sharp increase and then decrease in pH values.

The peak in stage on January 3rd and January 17th, were likely a result of ice buildup in the brook. The two stage events correspond with below 0.0 ^{0}C water temperatures. Please note the stage data is raw data that is published on our web page. It has not been corrected for backwater effect. Water Survey of Canada is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request to Water Survey of Canada.

The CCME guideline provides a basis by which to judge the overall health of the brook. Naturally, all streams and brooks are different. During the deployment period the median pH level was 6.62 pH units.

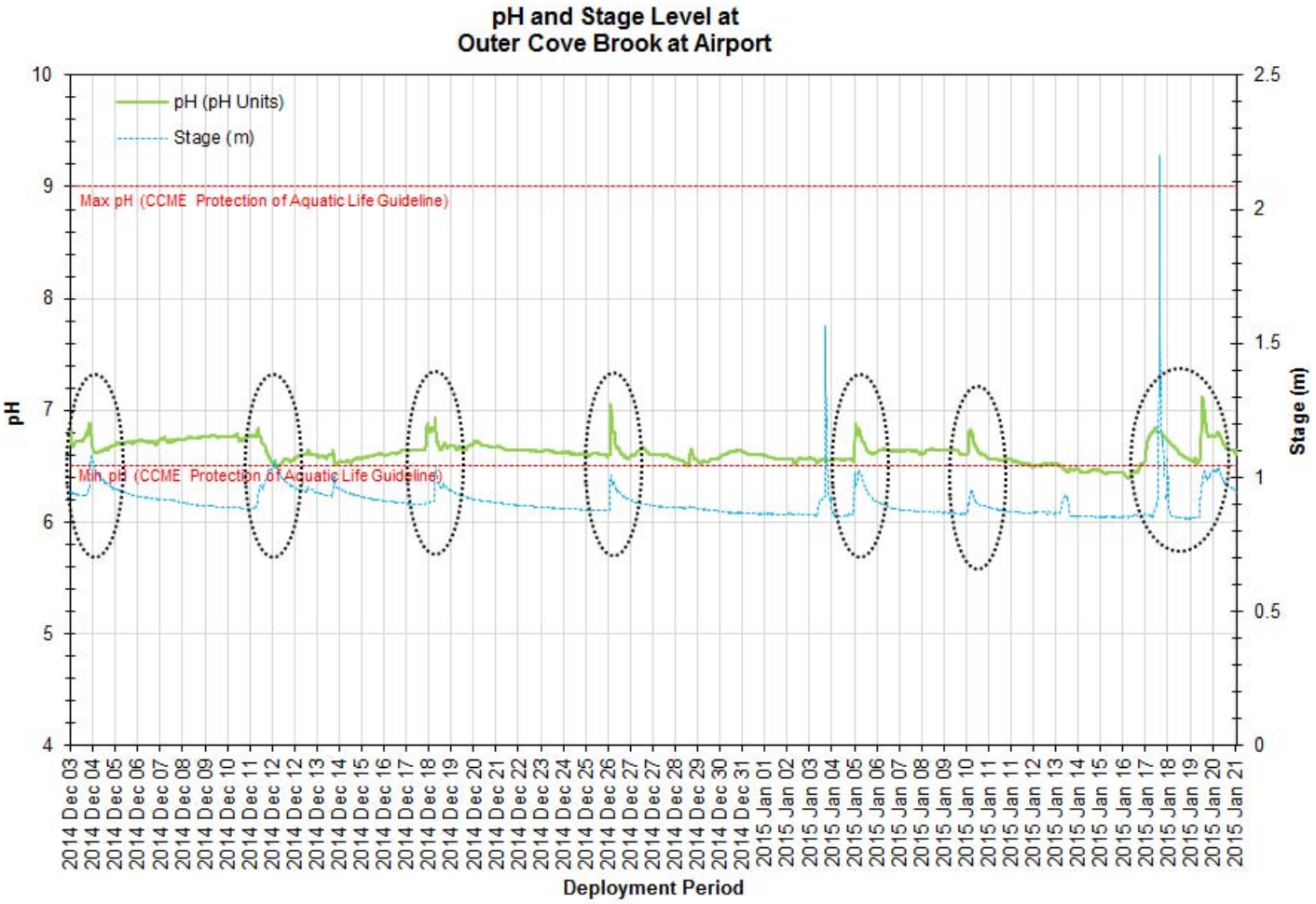

Figure 3: pH (pH units) and stage level (m) values at Outer Cove Brook below Airport

Specific Conductivity & TDS

The conductivity levels were within 192.9 µS/cm and 2823.0 µS/cm during this deployment period. TDS (a calculated value) ranged from 0.1235 g/L to 1.8100 g/L.

Commonly the relationship between conductivity and stage level is inversed. 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 was not the case during this deployment period.

Conductivity levels peaked alongside the increased stage levels. These events were likely a result of road salting of areas around the brook. 0°C or below 0°C temperatures (Appendix I) create frosty and icy road conditions, therefore the roadways are salted and the conductivity levels increase as the residual salt is flushed into the brook through rainfall/runoff.

December 12th and 14th had high stage levels (peaks highlighted in red circles) were the conductivity levels did decrease. The events are likely a result of rainfall on a mild air temperature day that did not require road salting during that time. Therefore the brook was flushed naturally (Appendix I).

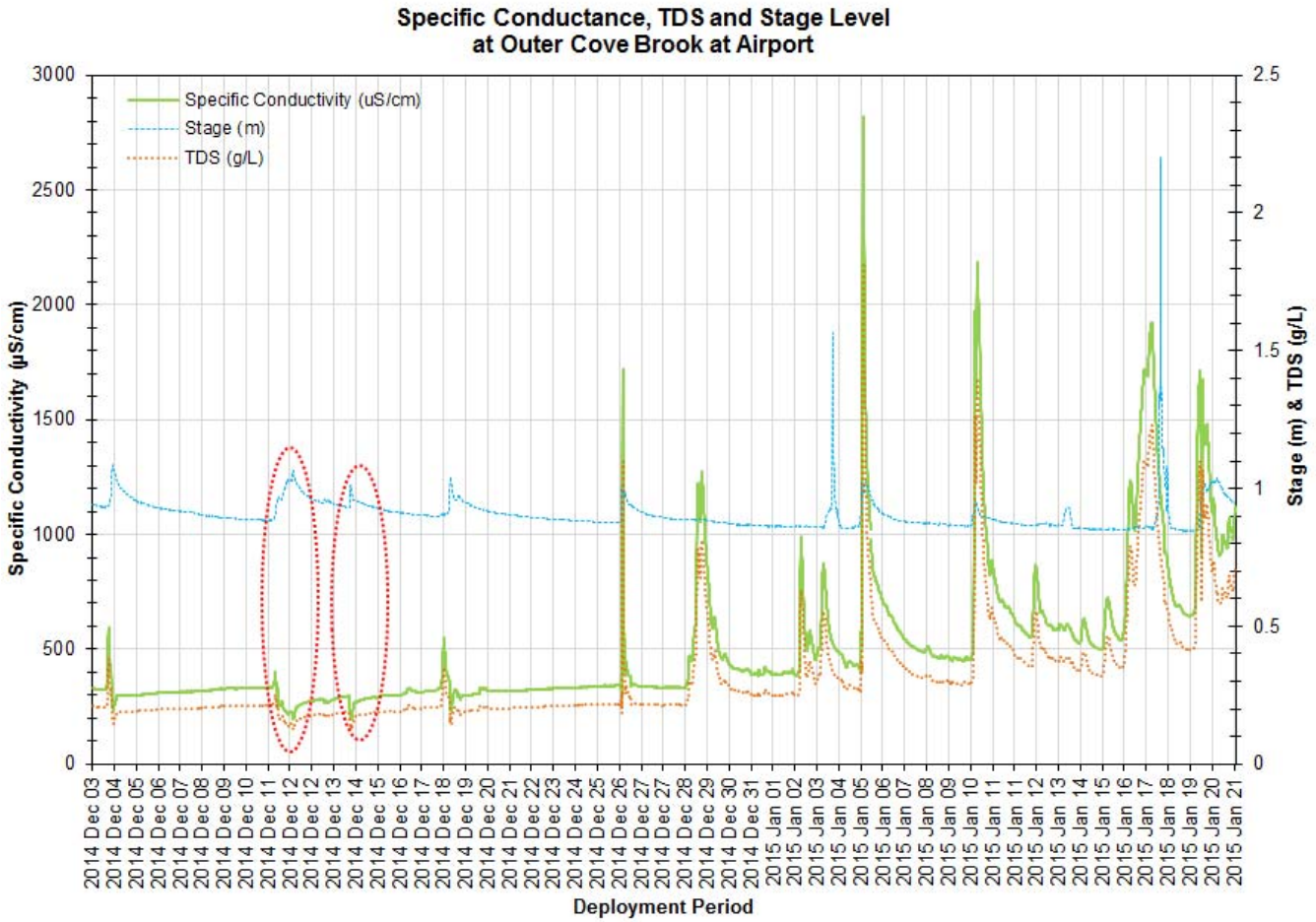

Figure 4: Specific conductivity (µS/cm), TDS (g/L) and stage (m) values at Outer Cove Brook below Airport.

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 78.1 %Sat to 91.0 %Sat. Dissolved Oxygen (mg/L) measured 9.62 mg/L to 12.65 mg/L.

During the deployment the dissolved oxygen levels were reasonably consistent. There was an evident relationship between water temperature and dissolved oxygen. As water temperature decreased the level of dissolved oxygen consumed decreased, which means there is slightly more dissolved oxygen in the brook during the 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 December 4th, December 7th and December 14th when the DO levels decrease. The events correspond with some of the warmer water temperatures during the deployment period.

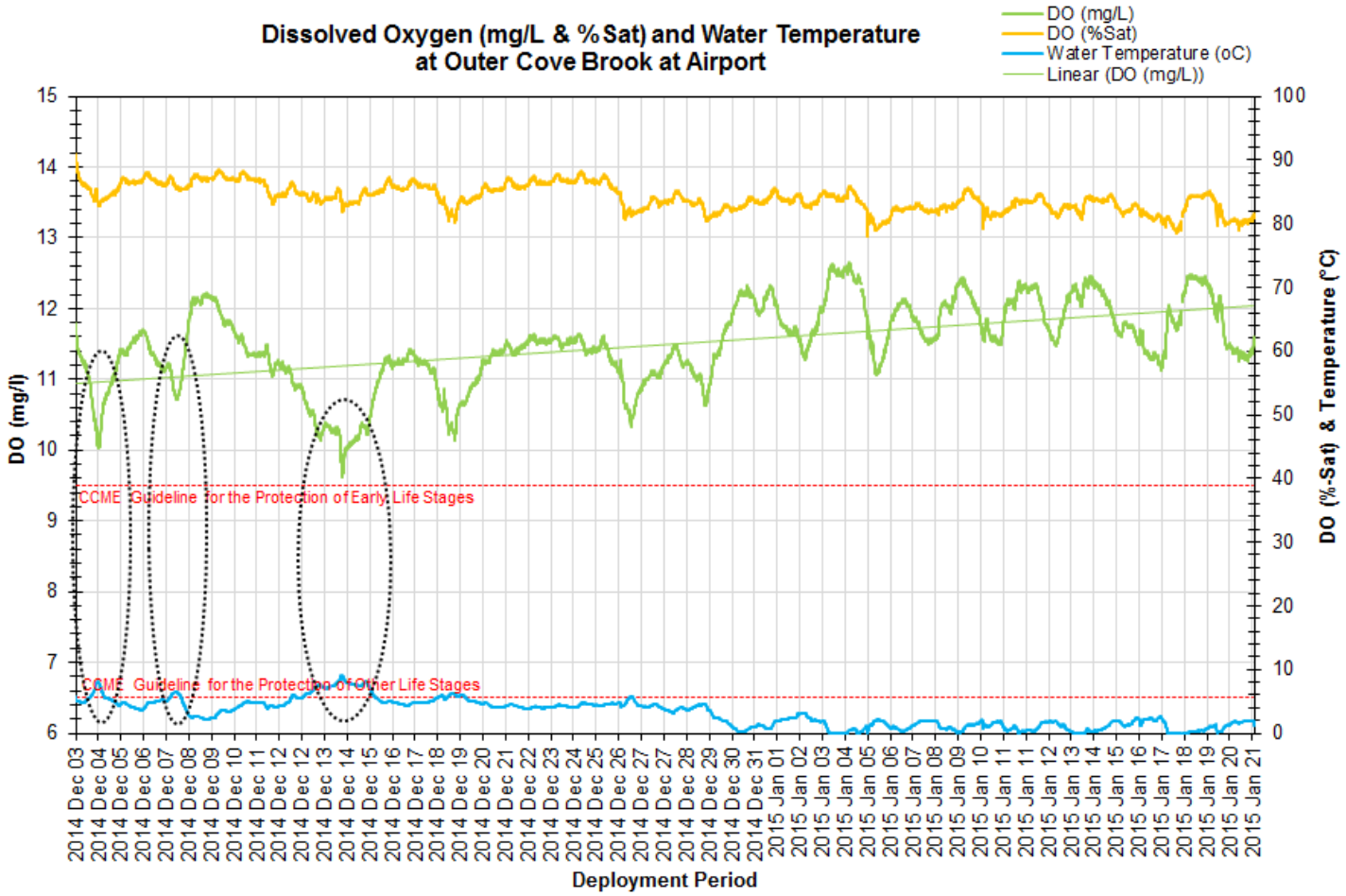

Figure 5: Dissolved oxygen (mg/L & % sat) and water temperature (°C) values at Outer Cove Brook below Airport.

Turbidity

Turbidity levels during the deployment ranged within 0.0 NTU and 1104.0 NTU (Figure 6). The deployment data had a median of 0.3 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 (Appendix I) can increase the presence of suspended material in water as seen on Figure 6 by the arrows. The large turbidity event on January 7th doesn't correspond with any stage increases therefore the spike is likely a result of debris passing over the sensor during the instrument taking a reading.

The circled cluster of turbidity data on January 19th to 21st is likely a result of the buildup of ice around the probes on the instrument. During removal, the instrument and protective casing was encased in slush and ice which can influence the turbidity data.

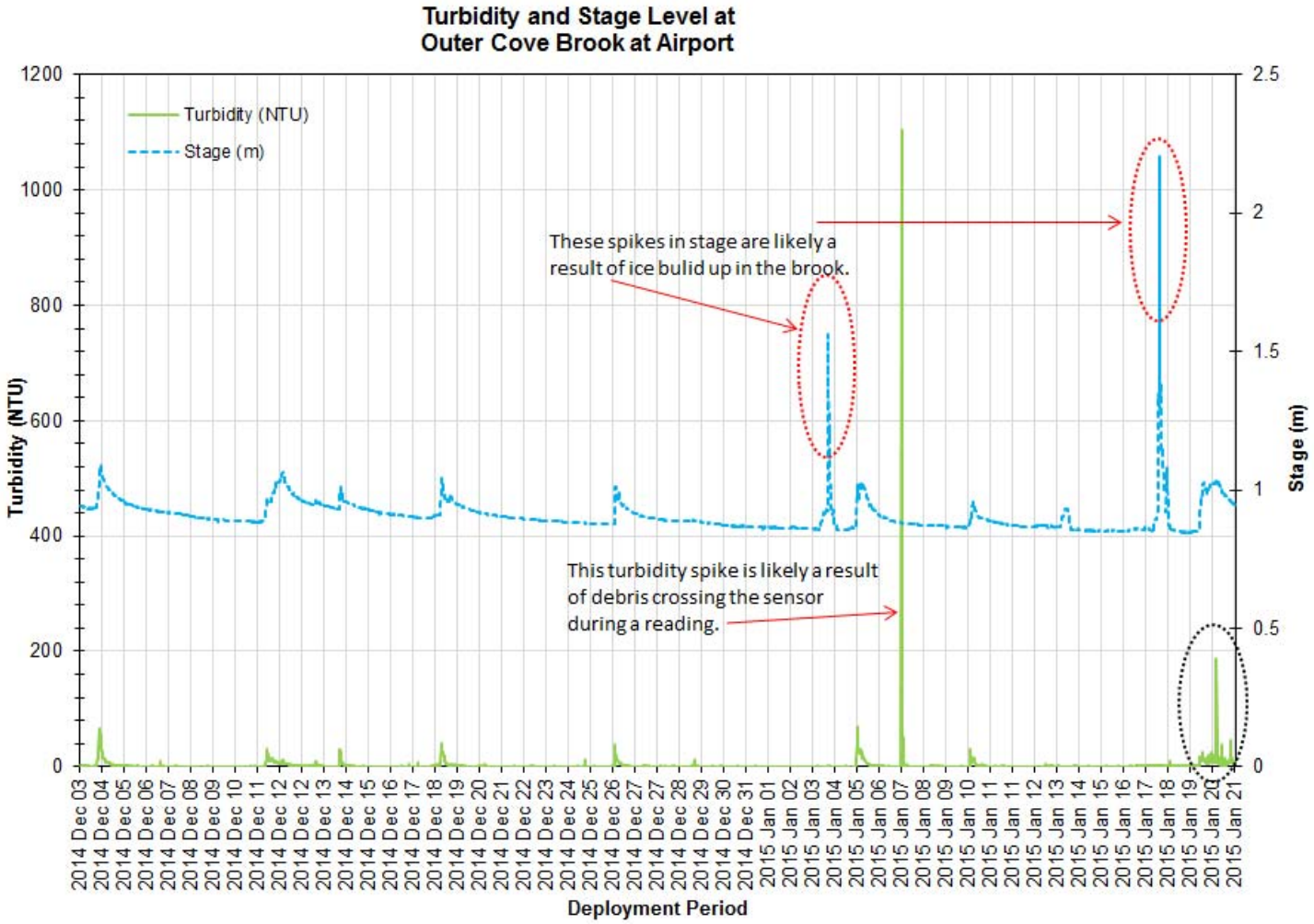

Figure 6: Turbidity (NTU) and stage level (m) values at Outer Cove Brook below Airport.

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 0.84m to 2.20m. The stream flow values ranges from 0.08 m^3/s to 2.49 m^3/s. The larger peaks in stage and stream flow do correspond with substantial rainfall events as noted on Figure 7.

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 26.4 mm on December 11th which increased both stage and streamflow at that time.

Please note the stage and streamflow data graphed below is raw data that is published on WRMD web page. It has not been corrected for backwater effect. Water Survey of Canada is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request to Water Survey of Canada.

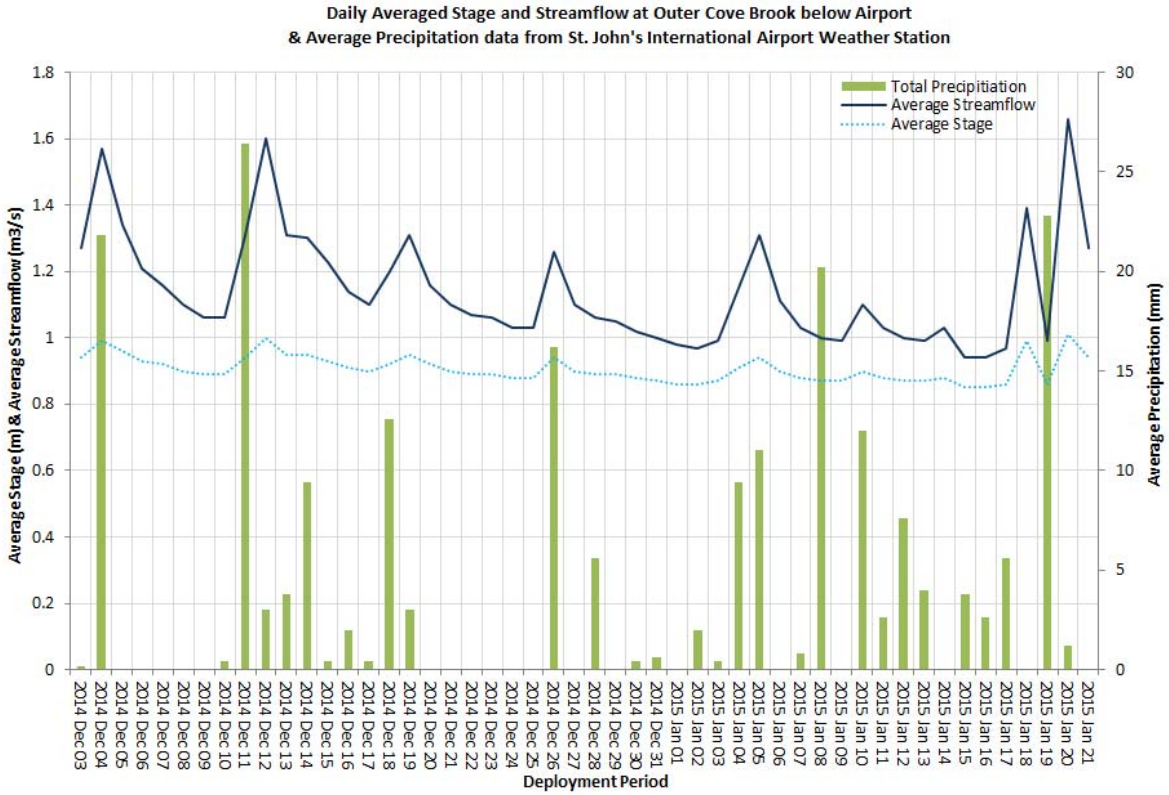

Figure 7: Daily average stage & stream flow values at Outer Cove Brook below Airport and daily total precipitation & Air Temperature values from Environment Canada's St. John's Airport Station.

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 larger precipitation events did create varying effects with the water quality parameters.

- At the station an influx of rainfall increased conductivity due to the dissolved salts from road salting being flushed into the brook. Rainfall also contributed to an increase in turbidity in the brook for short periods of time. pH values increased (alkalinity increased) after runoff from the surrounding environment flushed dissolved substances into the water column. The pH data is likely a combination of rainfall and road salting during the below 0^{o}C temperatures (Appendix I).

- The cooler ambient air temperatures (Appendix I) 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.

- The turbidity spikes mirror peaks in conductivity and pH occurring around the same dates. This can indicate that the turbidity in the brook was likely another factor from the road salting during these time frames.

Outer Cove Brook at Clovelly Golf Course

Water Temperature

Water temperature ranged from -0.10 ^{o}C to 8.25 ^{o}C during this deployment period (Figure 8).

Water temperature at the brook displayed somewhat of a typical variation in pattern for the beginning of the deployment. 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; toward the end of the deployment period the water temperatures get to 0.0^{o}C and below for several days. The stage data was indicating some interference on days that also have the coldest water temperatures, likely a built up of ice or even freezing of the brook for short periods of time. Please note the stage and streamflow data graphed below is raw data that is published on WRMD web page. It has not been corrected for backwater effect. Water Survey of Canada is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request to Water Survey of Canada.

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

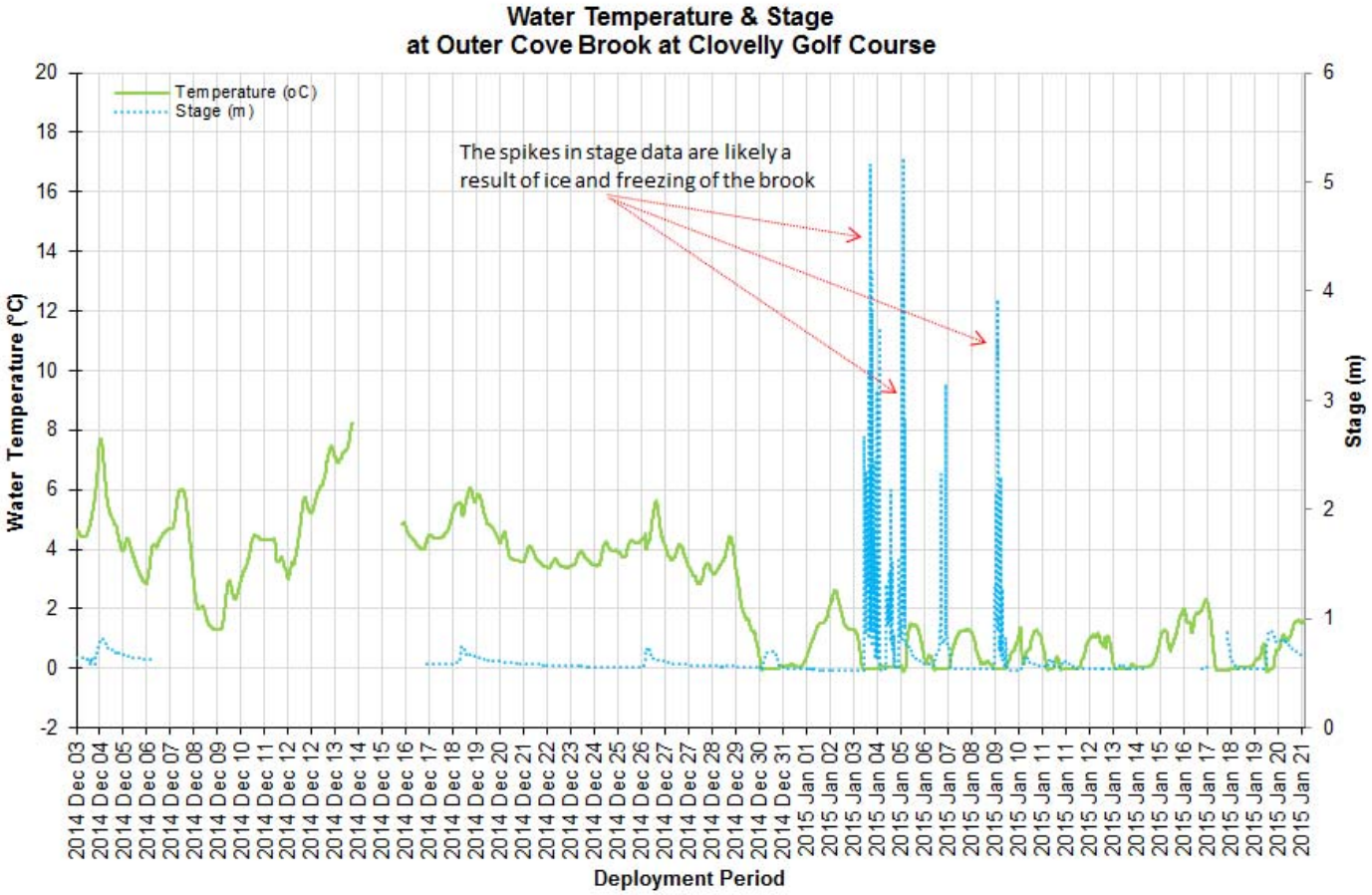

Figure 8: Water temperature (°C) and Stage (m) levels at Outer Cove Brook at Clovelly Golf Course.

pH

Throughout this deployment period pH values ranged between 6.39 pH units and 6.91 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 data corresponded with increases in stage level. Increases in stage resulted in sharp increases and then decreases in pH values. There is a natural occurrence between stage levels and pH values; however the sharp increases in pH may be a result of road salting in the cooler temperatures.

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 6.62 units (slightly higher pH unit from last deployment).

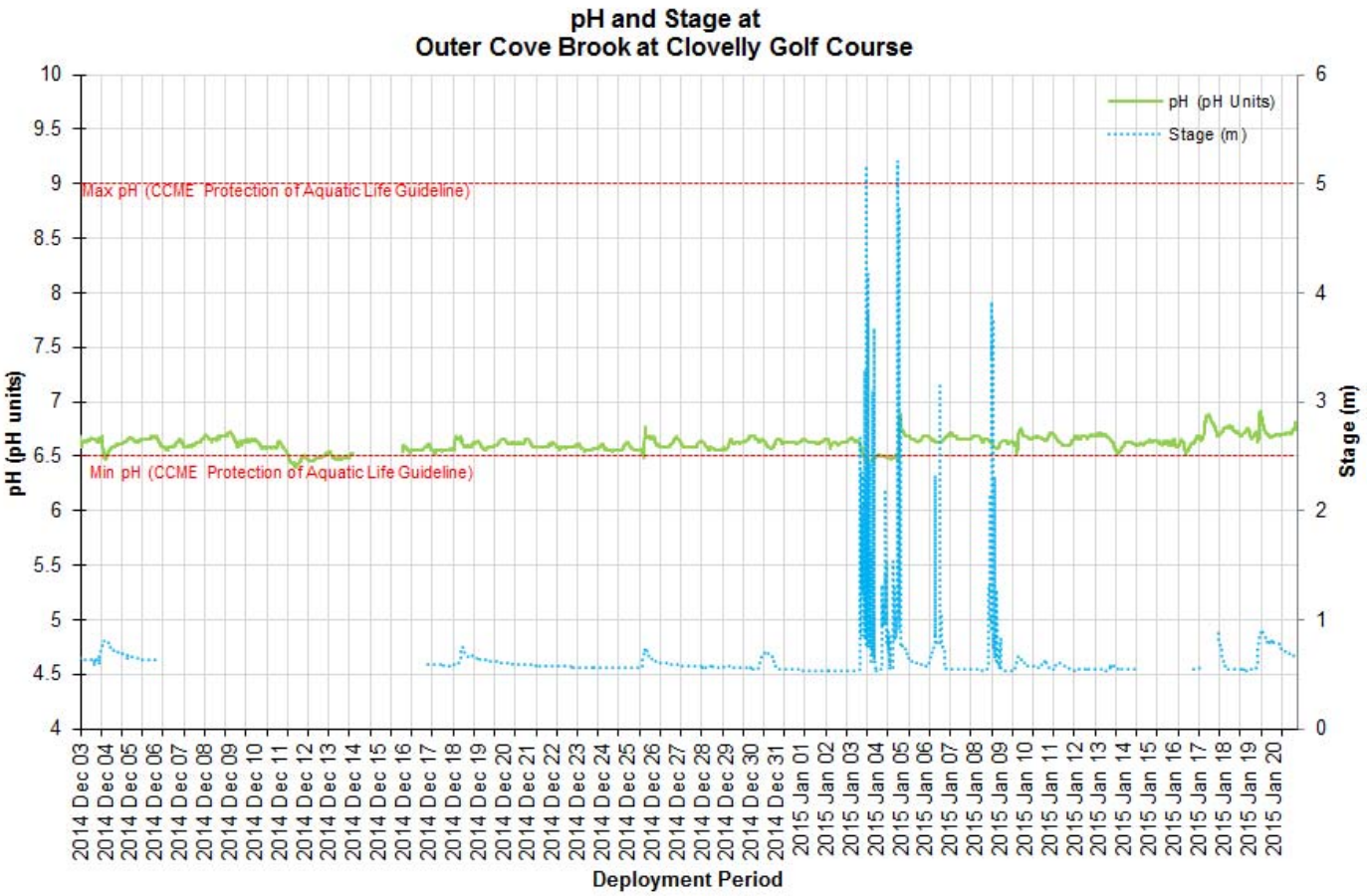

Figure 9: pH (pH units) and stage level (m) values at Outer Cove Brook at Clovelly Golf Course.

Specific Conductivity & TDS

The conductivity levels were within 205µS/cm and 5249µS/cm during this deployment period. TDS ranged from 0.1310g/L to 3.36g/L.

The conductivity probe measures the dissolved particles present in a water body, generally an increase in stage can indicate rainfall. Generally, 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 (Appendix I), 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.

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.

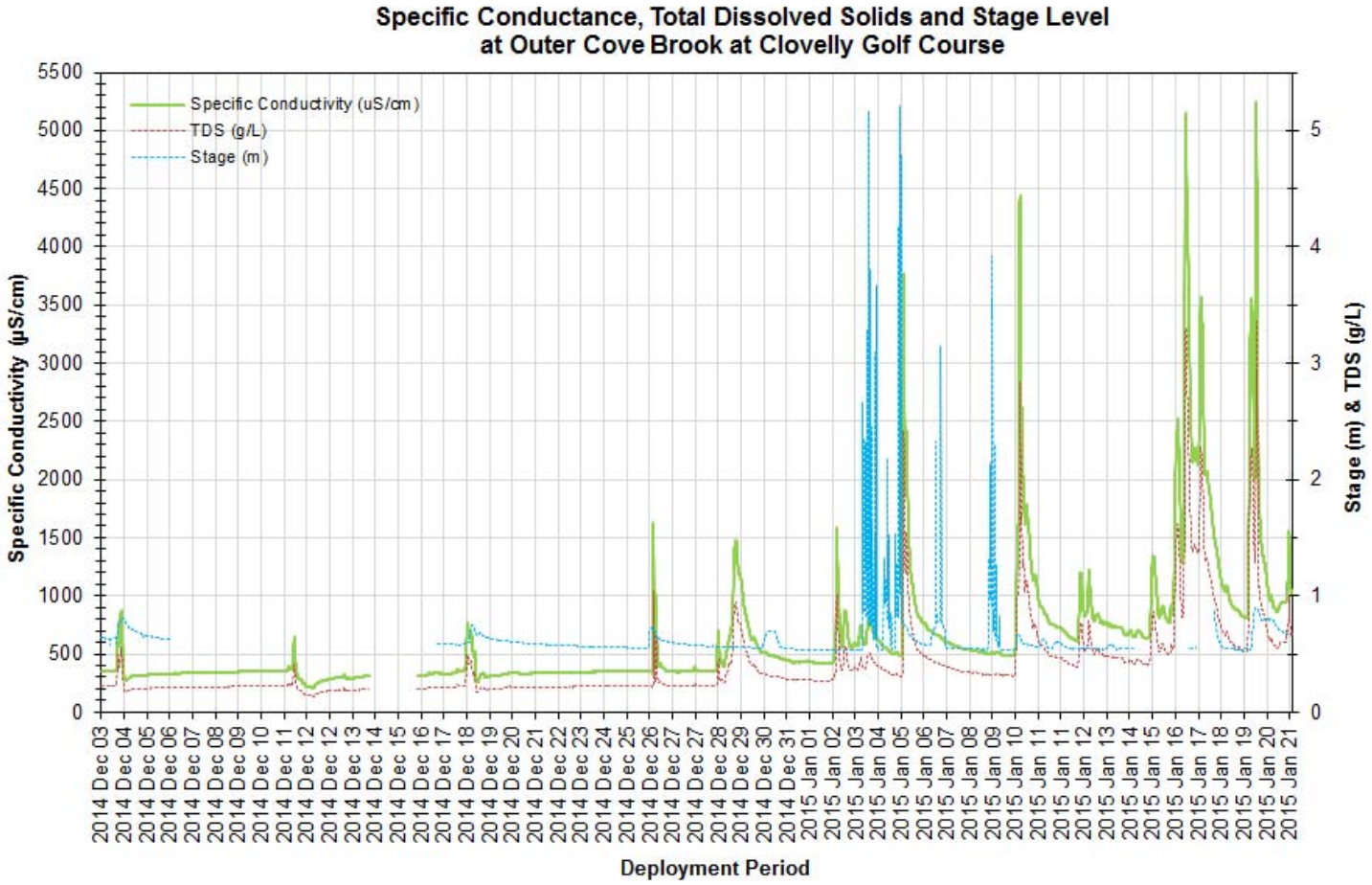

Figure 10: Specific conductivity (uS/cm), TDS (g/L) and stage (m) values at Outer Cove Brook at Clovelly Golf Course.

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 73.0 %Sat to 97.0 %Sat. Dissolved Oxygen (mg/L) measured 10.08 mg/L to 13.17 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.

Dissolved oxygen dips that are evident (circled in red) also corresponded with peaks in conductivity for the same time frames. The conductivity peaked due to road salt being present in the brook; it is likely the road salt caused the oxygen content (mg/L) to decrease as well.

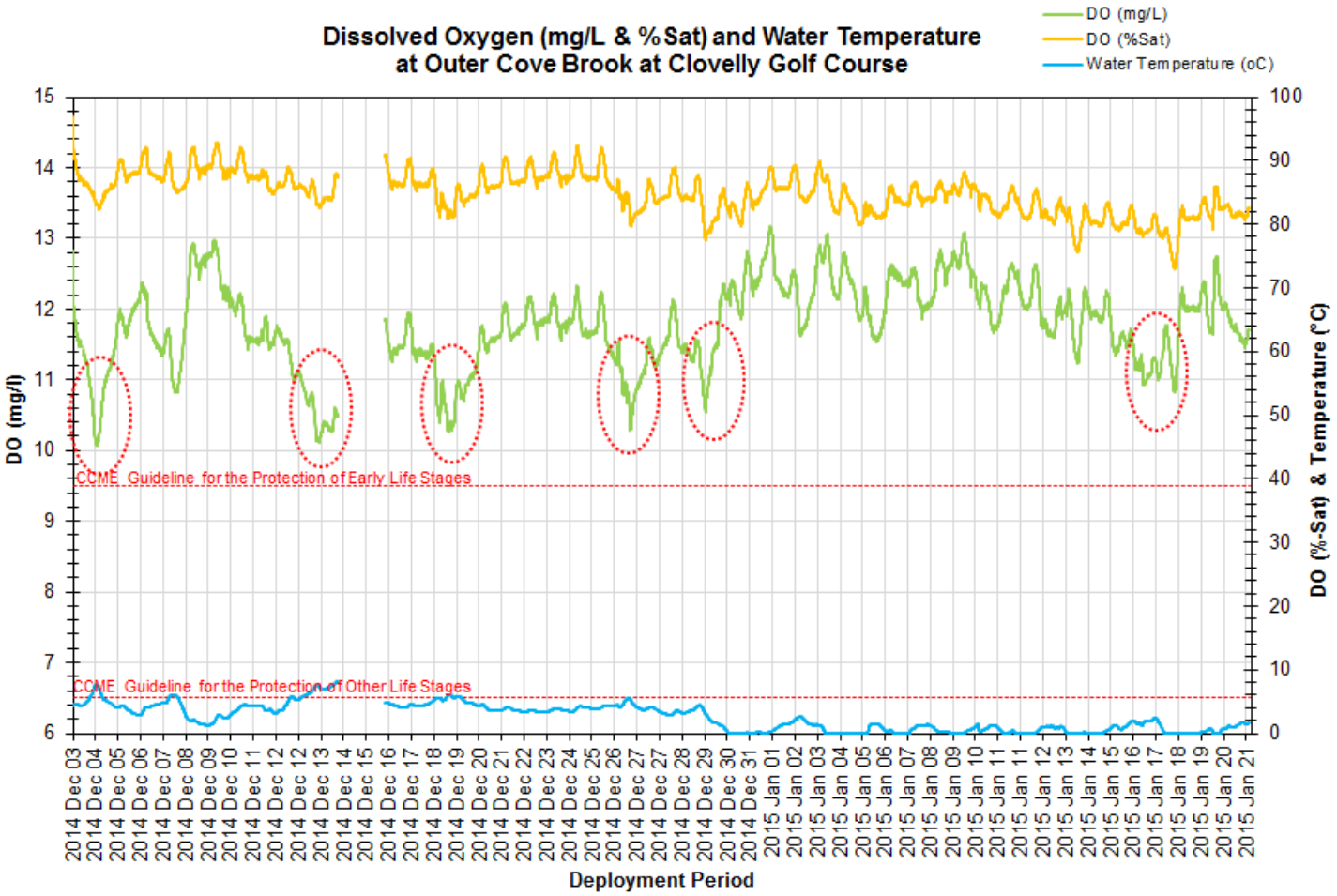

Figure 11: Dissolved oxygen (mg/L & % sat) and water temperature (°C) values at Outer Cove Brook at Clovelly Golf Course.

Turbidity

Turbidity levels during the deployment period ranged within 0.5 NTU and 429 NTU (Figure 12), with a median of 1.1 NTU.

The turbidity sensor on the water quality 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. The turbidity events at Clovelly station also correspond with high turbidity at Outer Cove Brook below Airport, which indicates that the same events caused these turbidity increases (Appendix II).

During removal of the instrument it was discovered to be encased in ice slush. Ice particles would have an effect on the turbidity sensor's ability to record accurate values.

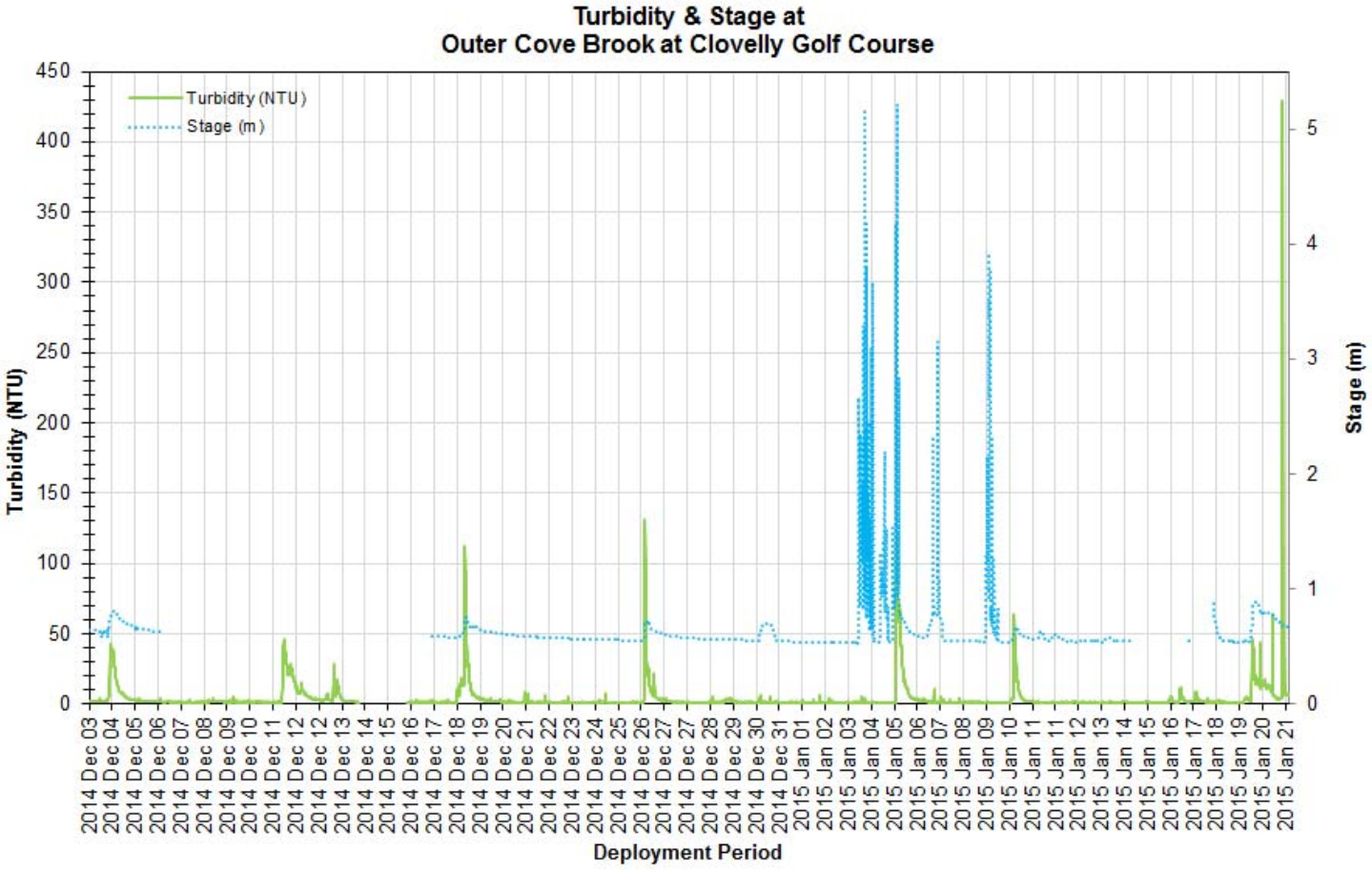

Figure 12: Turbidity (NTU) and stage level (m) values at Outer Cove Brook at Clovelly Golf Course.

Stage & Stream flow

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 0.524m and a maximum of 5.216m. Stream flow ranged within minimum of 0.0m^3/s and a maximum of 1.314m^3/s. The precipitation ranged from a minimum of 0.0 mm a day to a maximum of 26.4 mm which was on December 11th, 2014. This rainfall event increased both stage and streamflow at Outer Cove Brook at Clovelly Golf Course.

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

Please note the stage and streamflow data graphed below is raw data that is published on WRMD web page. It has not been corrected for backwater effect. Water Survey of Canada is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request to Water Survey of Canada.

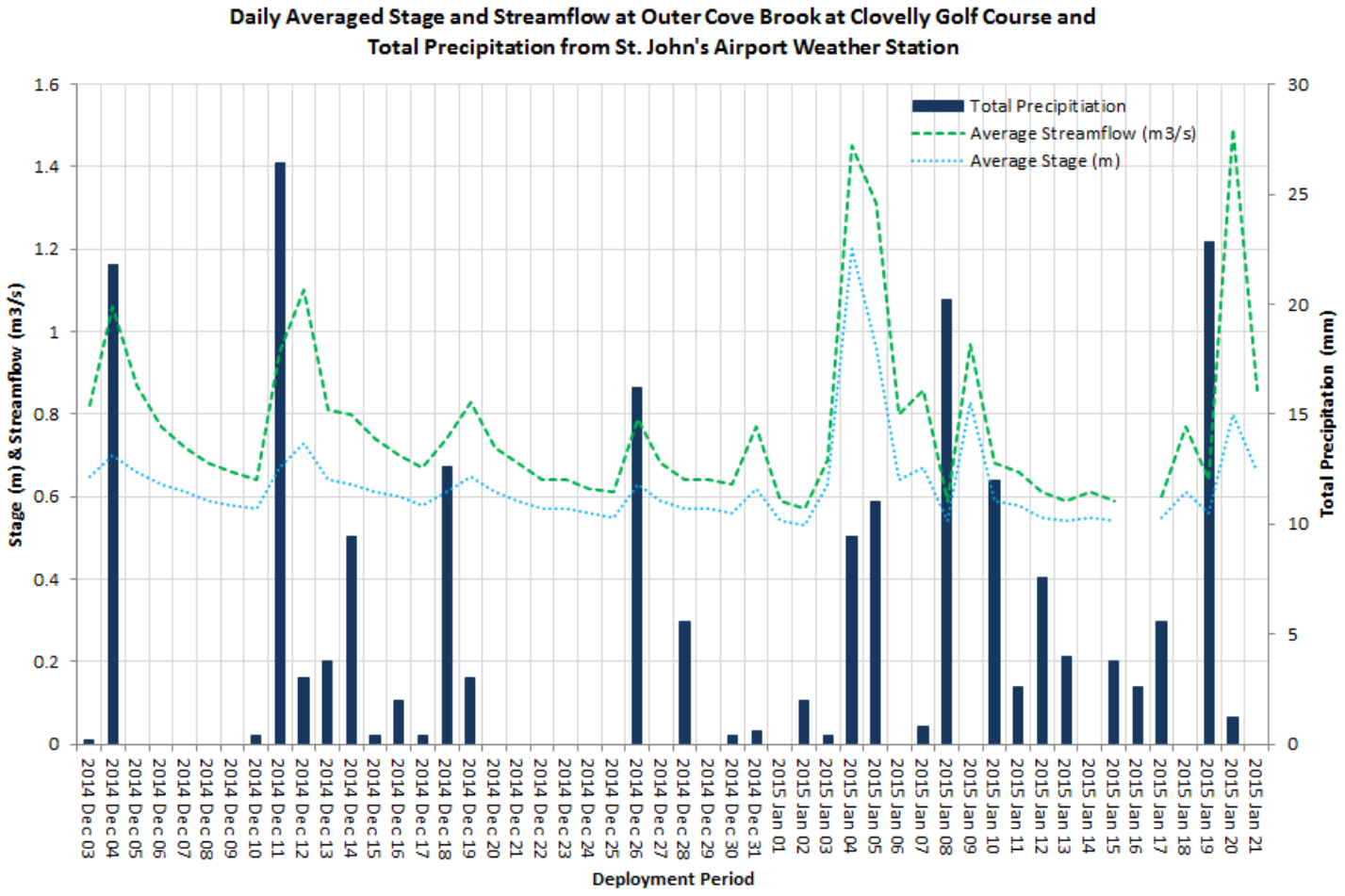

Figure 13: Daily average stage and stream flow values at Outer Cove Brook at Clovelly Golf Course and daily total precipitation values (mm) from Environment Canada's Weather Station at St. John's International Airport.

Conclusion

- There is visual evidence that the large spikes in stage level were a result of several rainfall events. 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 throughout the deployment as road salting continued with the colder winter weather. The peaks in conductivity, turbidity and pH are a result of road salt runoff when the air temperature was below 0^0C.

- 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.

- Several of the increases and decreases in the water quality parameters can be explained by the natural relationship with rainfall and the subsequent surrounding runoff. During the end of the deployment period the brook had started to freeze over, there was also ice slush around the sensors that take the water quality readings. This occurrence was captured by the 0^0C water temperatures in the brook and minus air temperatures at St. John's Airport.

Outer Cove Brook, Newfoundland and Labrador

APPENDIX I

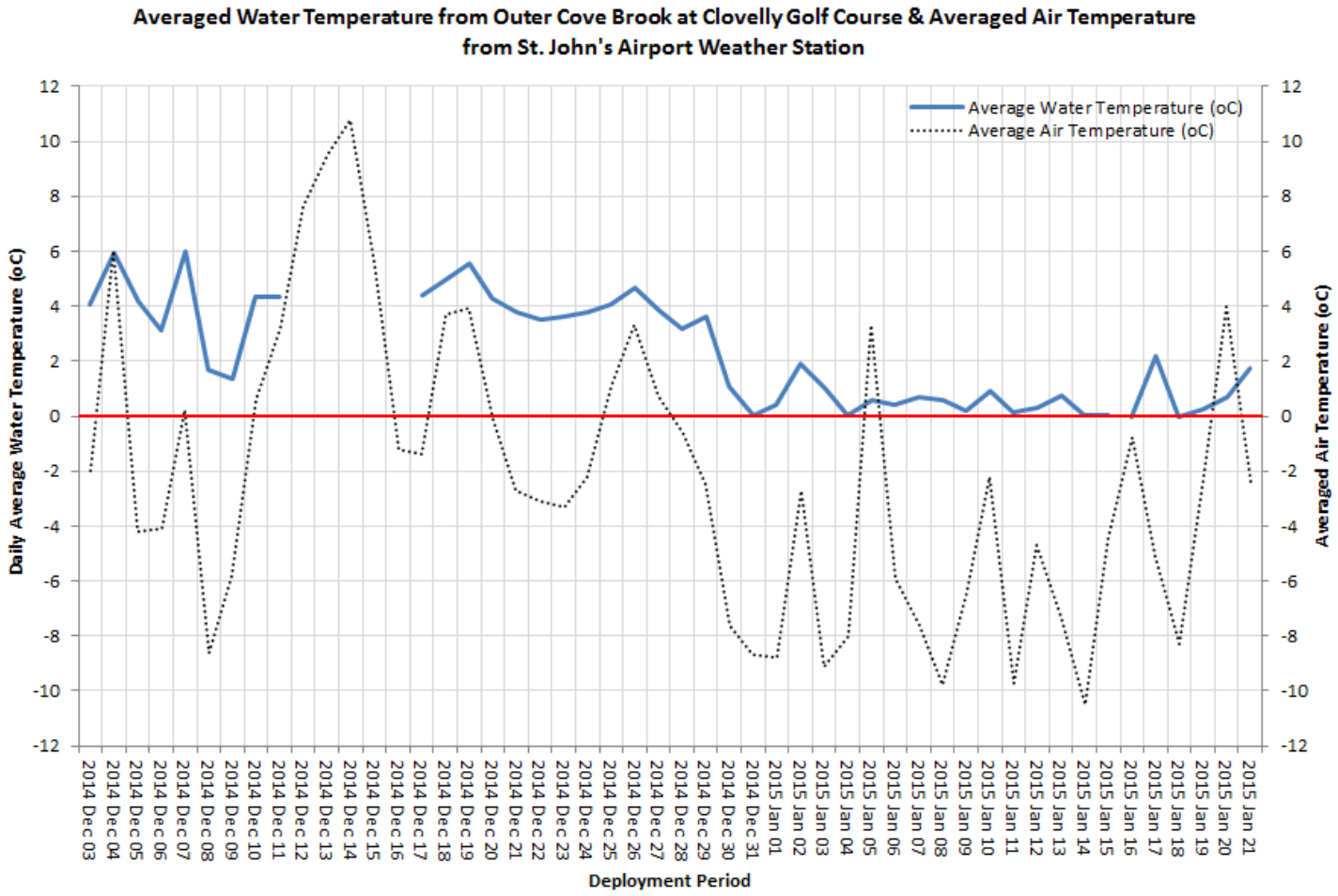

Figure 14: Daily average water temperature values from Outer Cove Brook at Clovelly Golf Course and air temperature values from Environment Canada's Weather Station at St. John's International Airport.

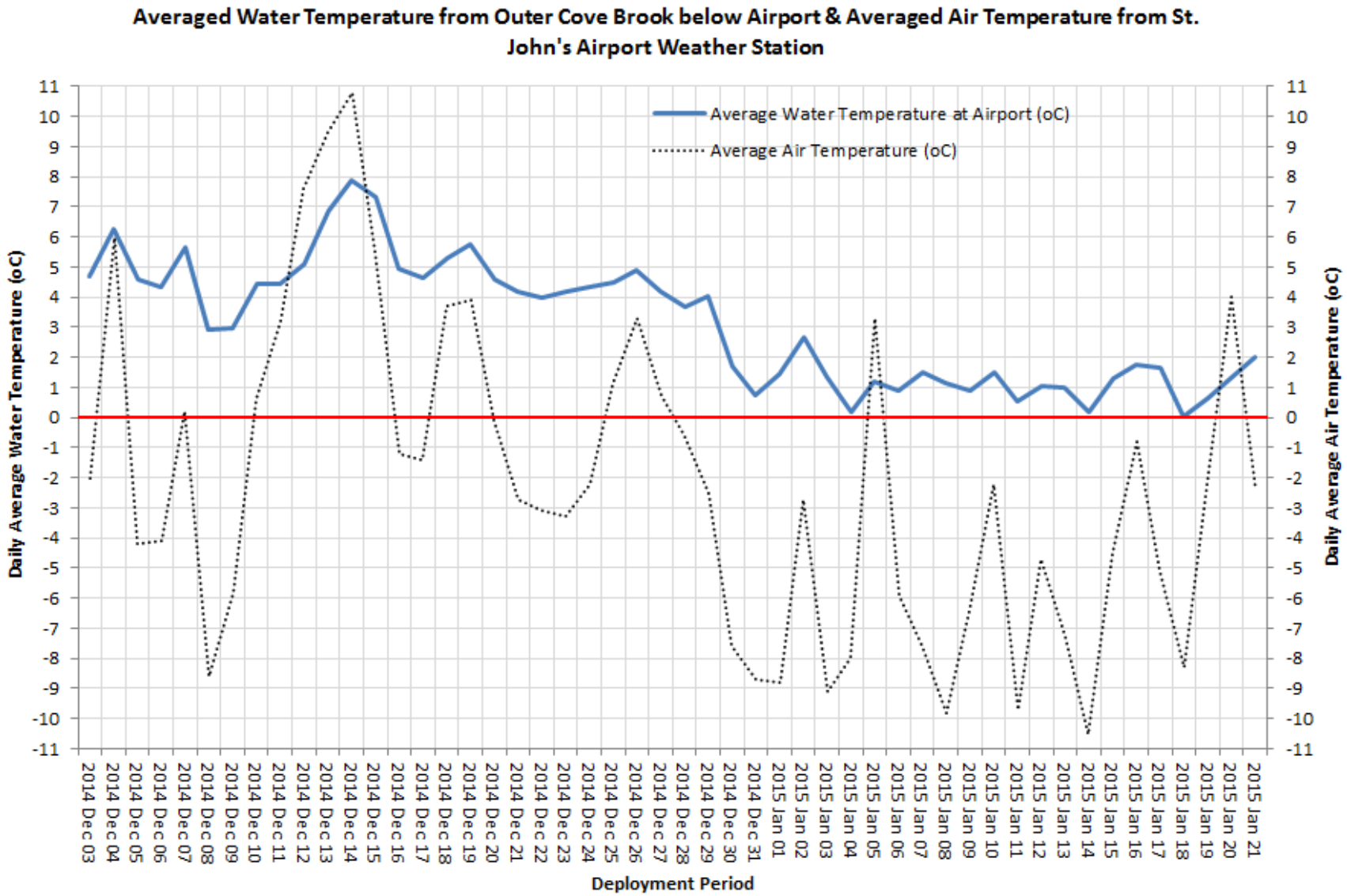

Figure 15: Daily average water temperature values from Outer Cove Brook below Airport and air temperature values from Environment Canada's Weather Station at St. John's International Airport.

APPENDIX II

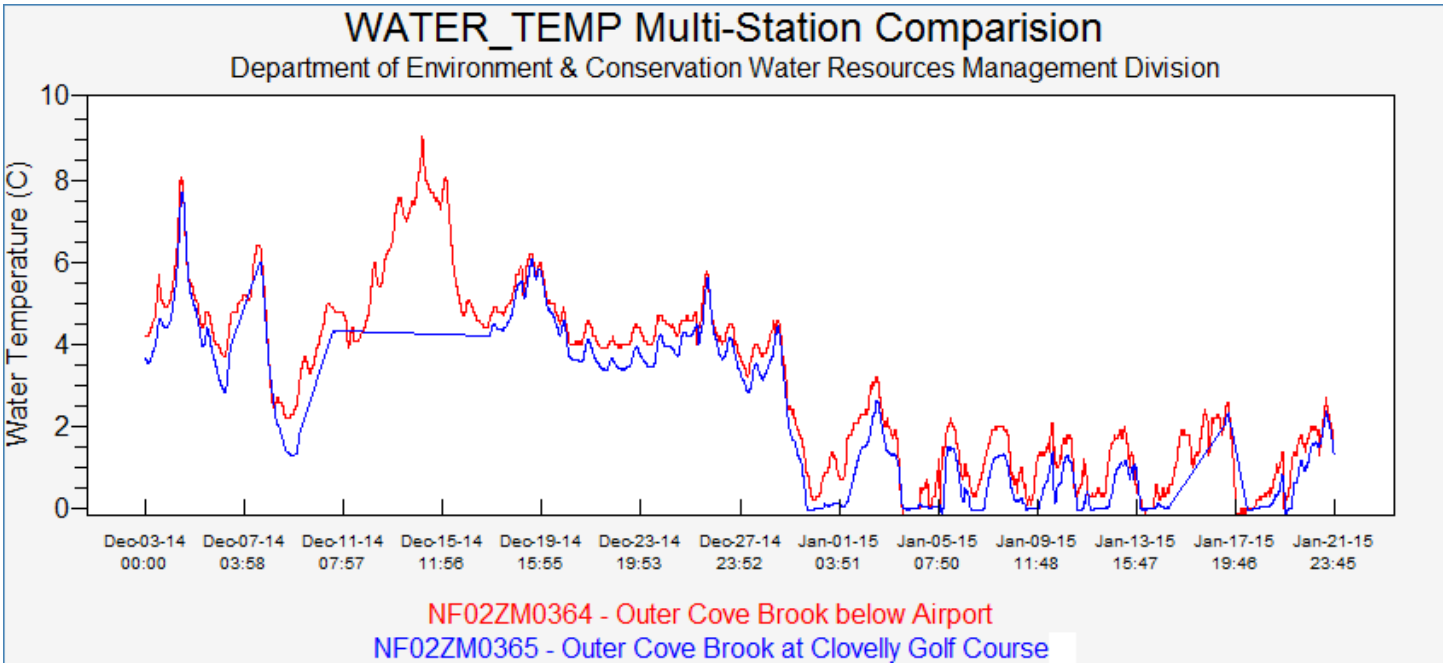

Figure 16: Comparison Water Temperature at the Outer Cove Brook Stations

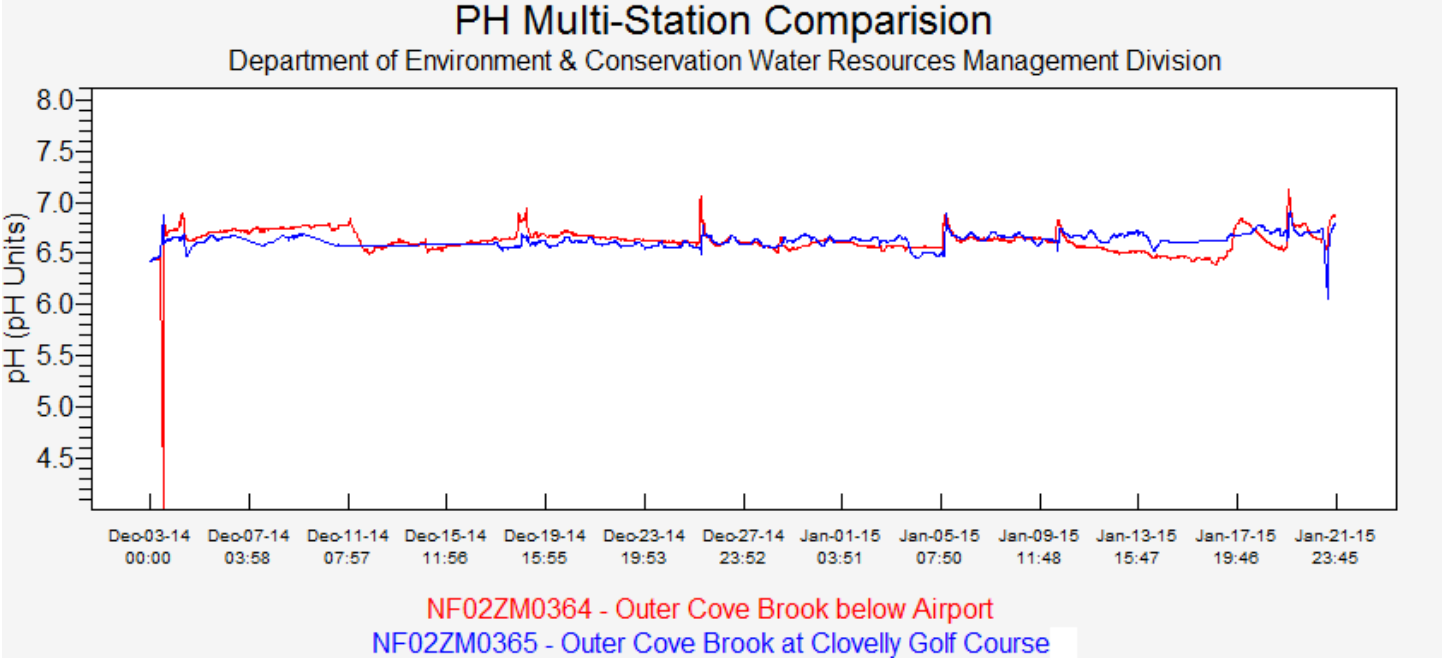

Figure 17: Comparison of pH units at the Outer Cove Brook Stations

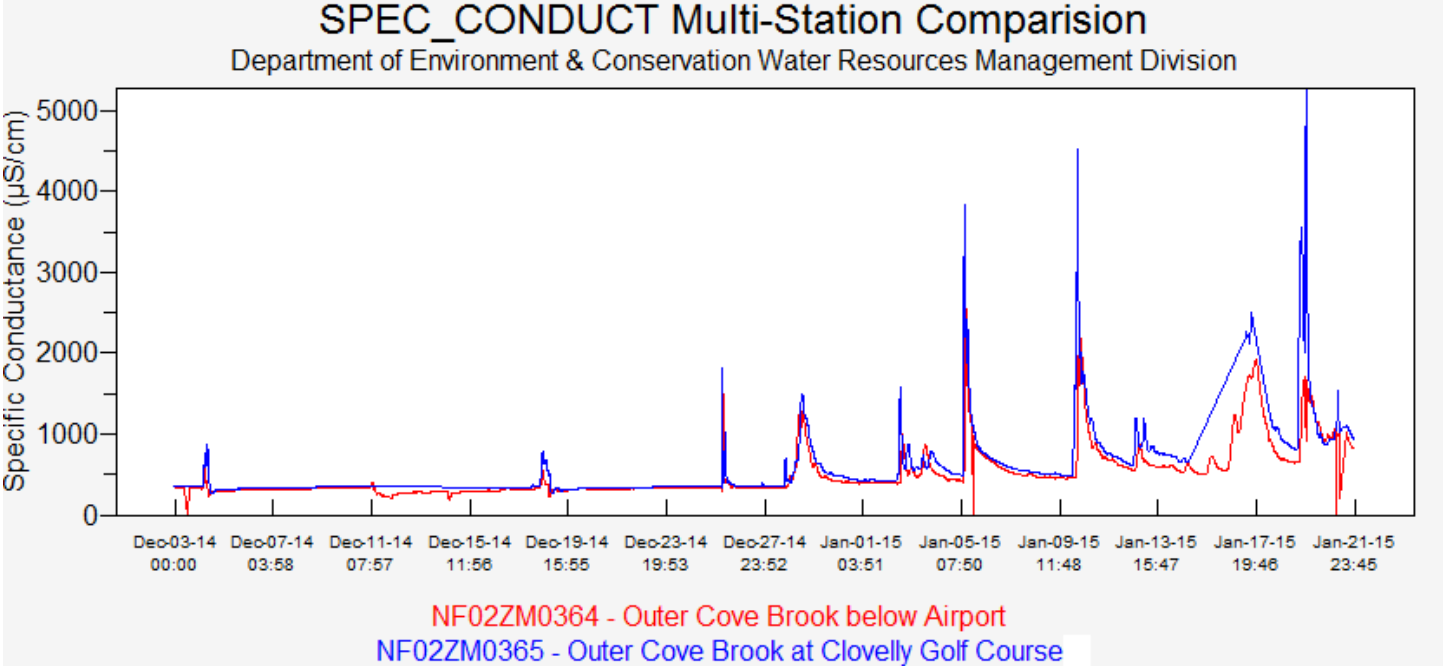

Figure 18: Comparison Specific Conductivity at the Outer Cove Brook Stations

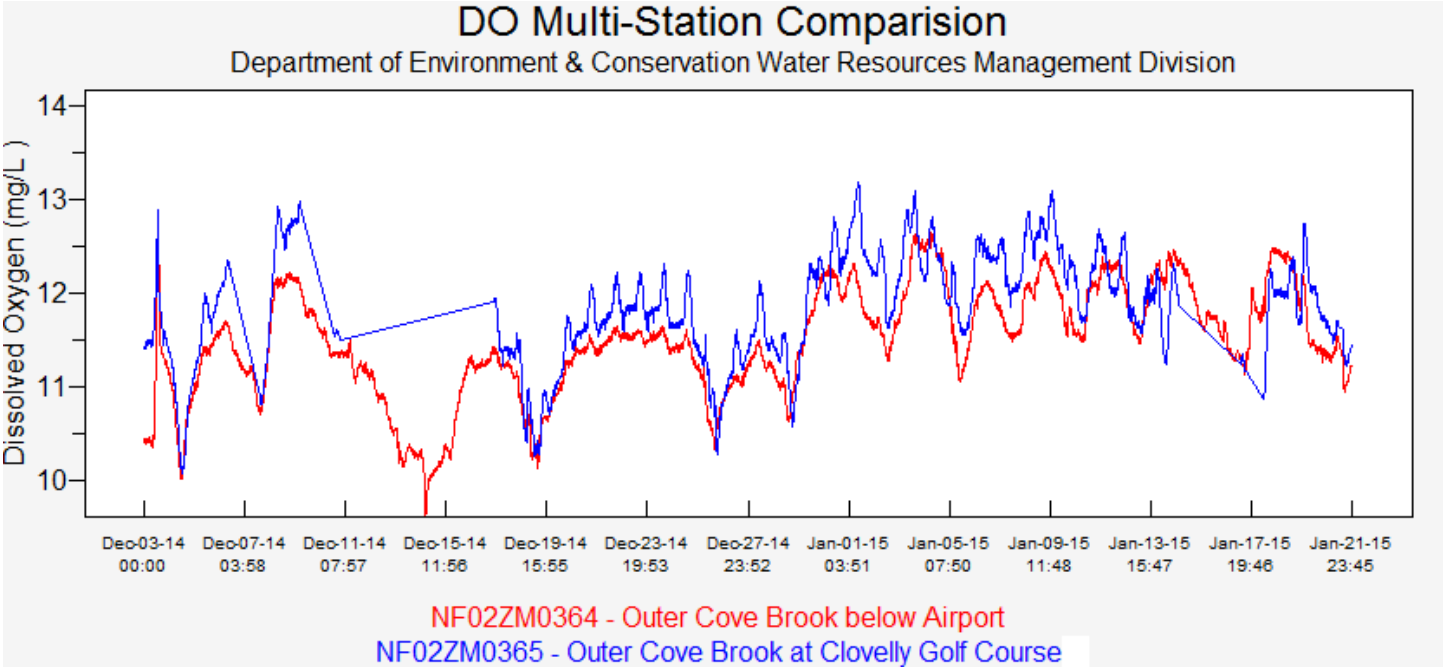

Figure 19: Comparison of Dissolved Oxygen (mg/L) at the Outer Cove Brook Station

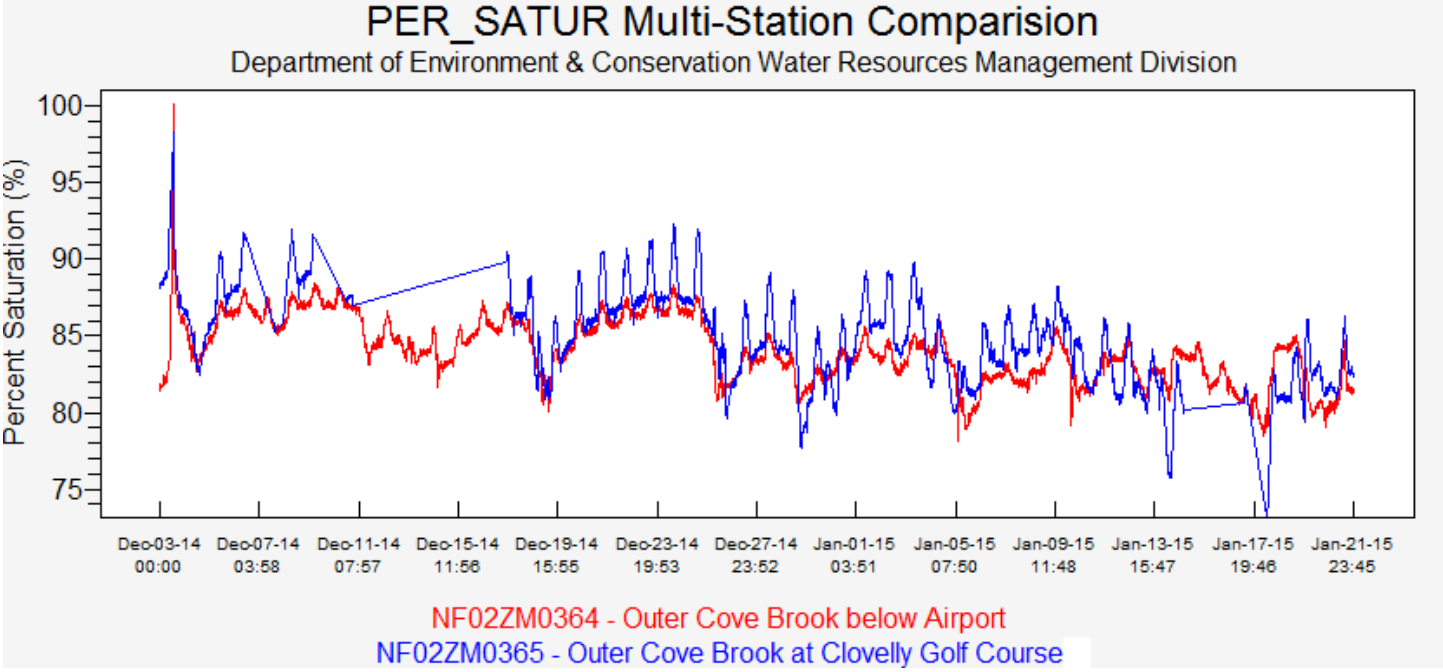

Figure 20: Comparison of Dissolved Oxygen (%Sat) of the Outer Cove Brook stations

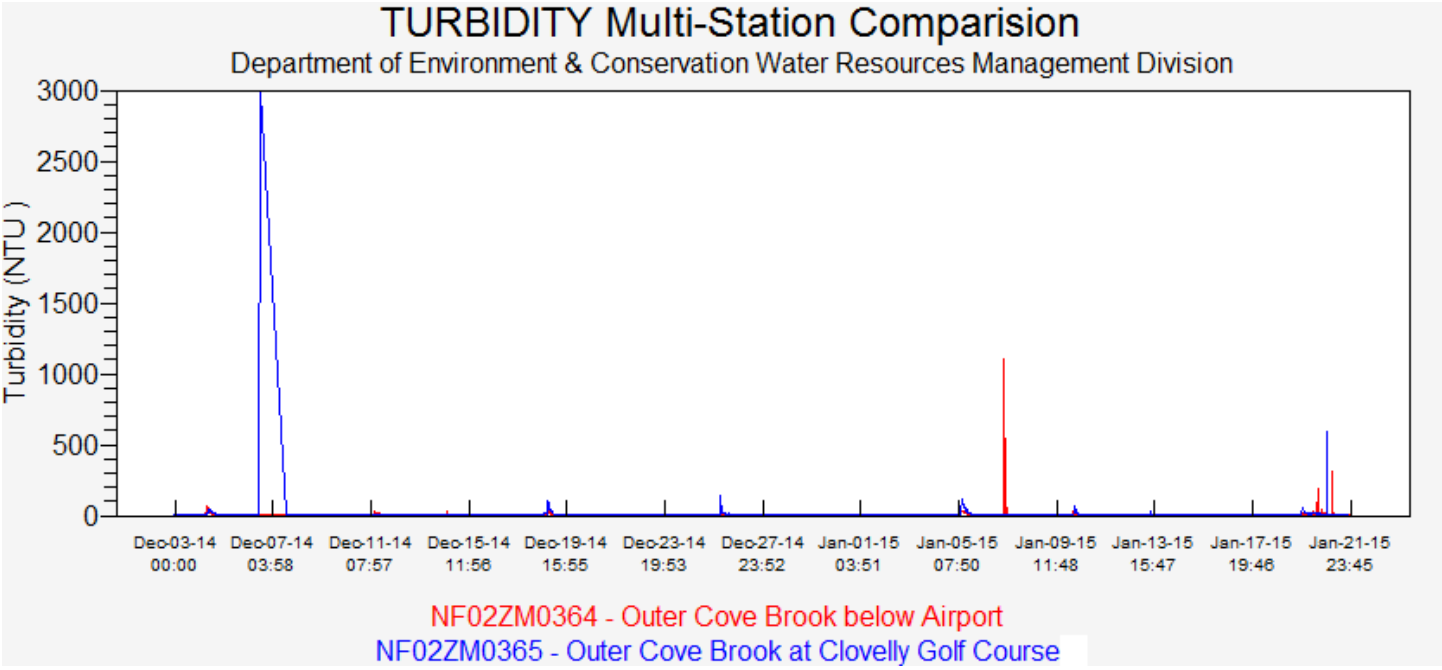

Figure 21: Comparison of Turbidity at the Outer Cove Brook stations

Please note: 3000NTU at Outer Cove Brook at Clovelly Golf Course is an inaccurate value.