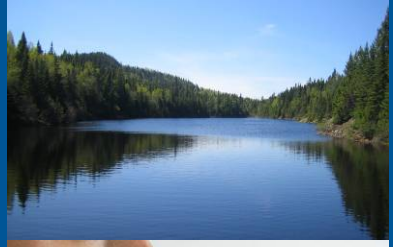
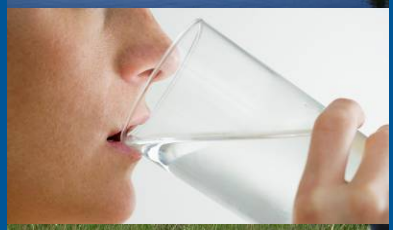






Real-Time Water Quality Report

Outer Cove Brook Network

Deployment Period
January 21, 2015 to March 4, 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 43-day period from deployment on January 21, 2014 until removal on March 4, 2015.

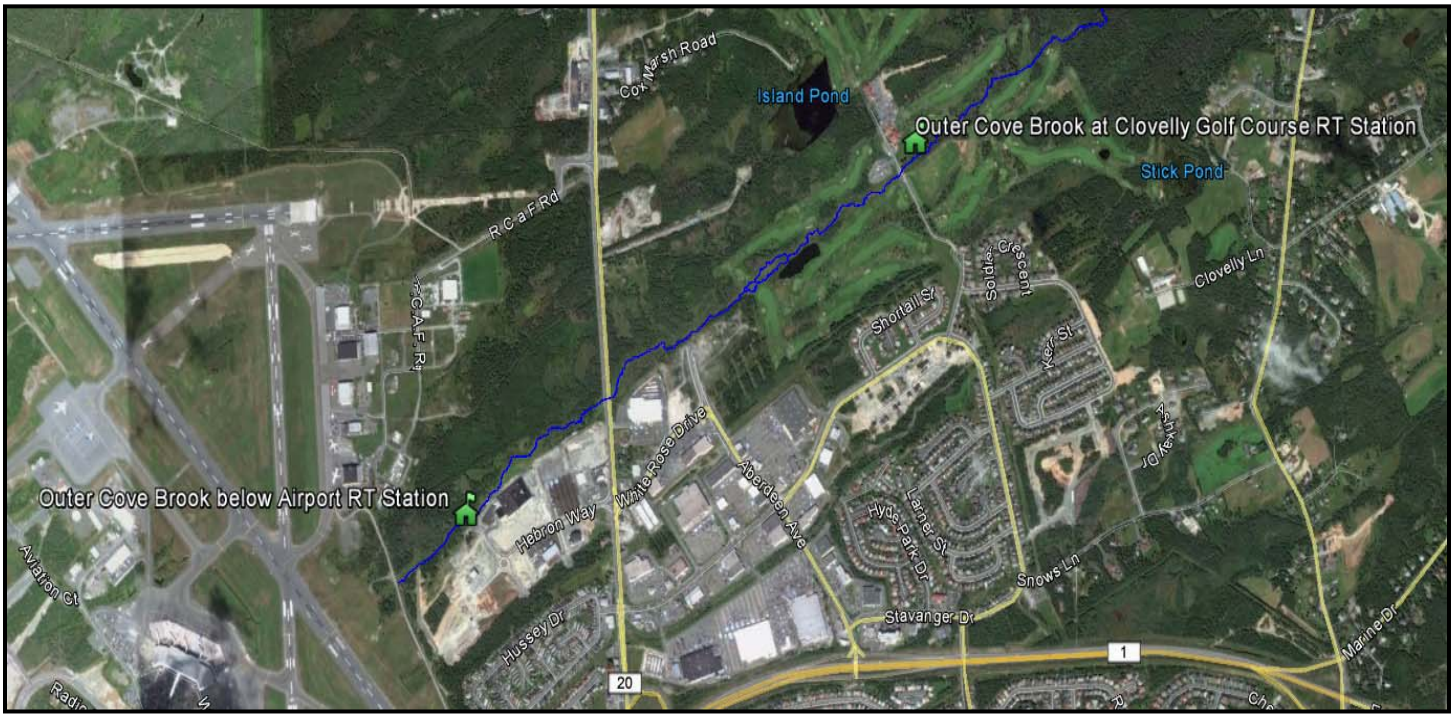

Figure 1: Outer Cove Brook Real-Time Water Quality and Quantity Stations.

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

Aside from several spotty data periods during the beginning of the deployment period, there were no outstanding issues or problems at these stations during deployment.

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	Jan 21 2015	Deployment	Excellent	Excellent	Good	Fair	Good
	Mar 4 2015	Removal	Good	Good	Marginal	Poor	Poor

- During the Outer Cove Brook below Airport station deployment, most of the water quality parameter data ranked as 'Excellent' or 'Good'. Dissolved oxygen data ranked as 'Fair' at deployment
- At removal of the instrument, the water temperature and pH data ranked as 'Good', with conductivity data ranking as 'Marginal'. The dissolved oxygen and turbidity data ranked as 'Poor' which may have been a result of the fouling present on the sensors at the time of removal. The lower ranking may have be a result of the slime like substance inhibiting the sensor, at removal the instrument and the instrument protective casing was covered with the substance.

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	Jan 21 2015	Deployment	Excellent	Good	Excellent	Good	Excellent
	Mar 4 2015	Removal	Excellent	Excellent	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, conductivity and turbidity comparison data all ranked as 'excellent'. pH data and 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 ranked as 'Good'. The data for turbidity ranked as 'Poor' at removal. At this time, there was a large amount of ice in the brook. It is likely that frazzle ice had built up around the turbidity sensor. This inference can cause the data to rank poorly.

Outer Cove Brook below Airport

Water Temperature

Water temperature ranged from -0.10°C to 3.90°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. 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 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. WSC is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request to WSC.

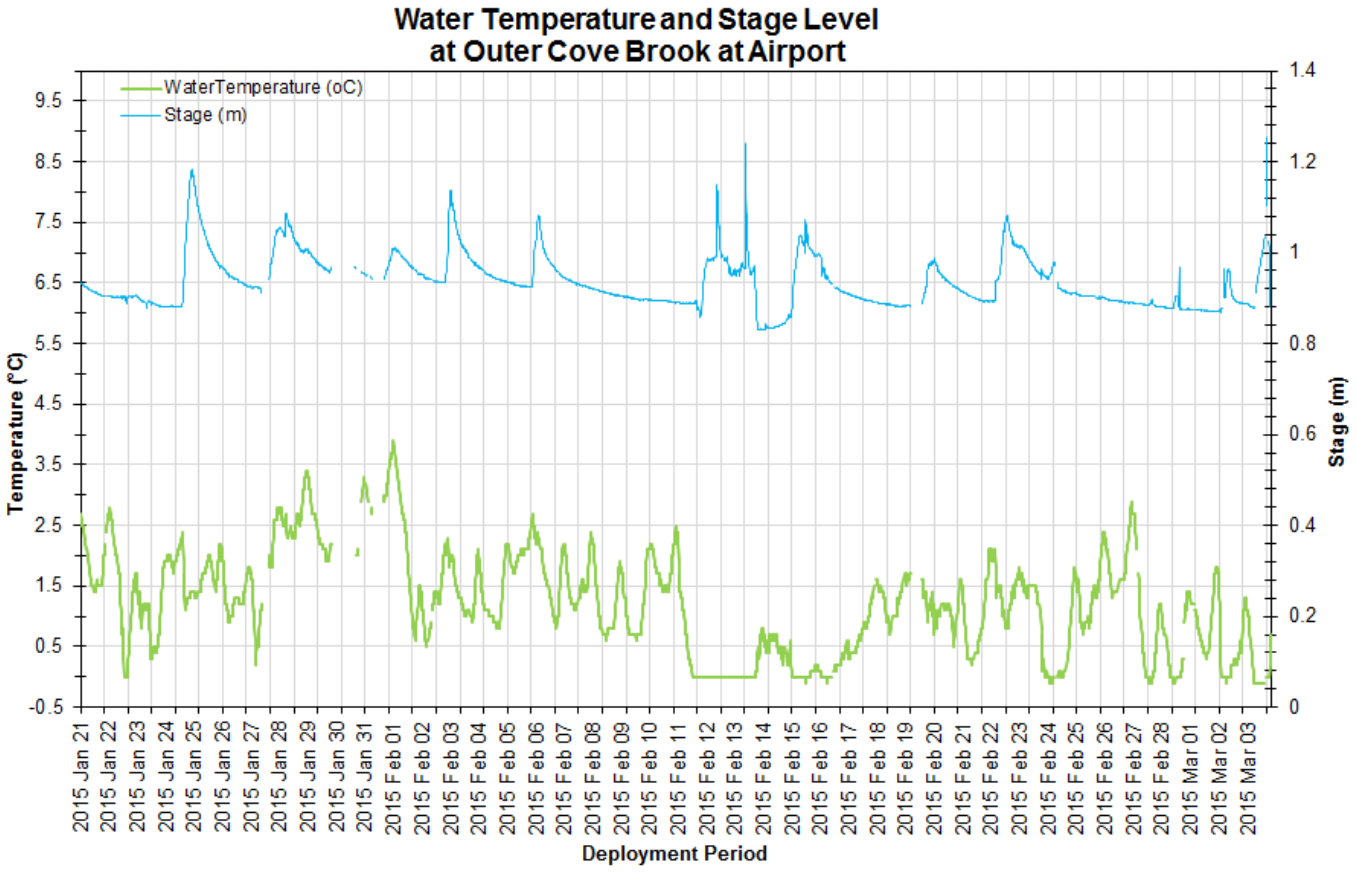

Figure 2: Water temperature (°C) and Stage (m) values at Outer Cove Brook below Airport

pH

Throughout the deployment period, pH values ranged between 6.50 pH units and 7.43 pH units (Figure 3).

During this deployment, the majority of pH values at this station were within the CCME Guidelines for the Protection of Aquatic Life (6.5 pH units and 9.0 pH units).

All black circled increases 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 pH events circled in red are increases in pH that don't correspond with an increase in stage event.

Please note the stage data is raw data that is published on our web page. 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.

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 6.76 pH units.

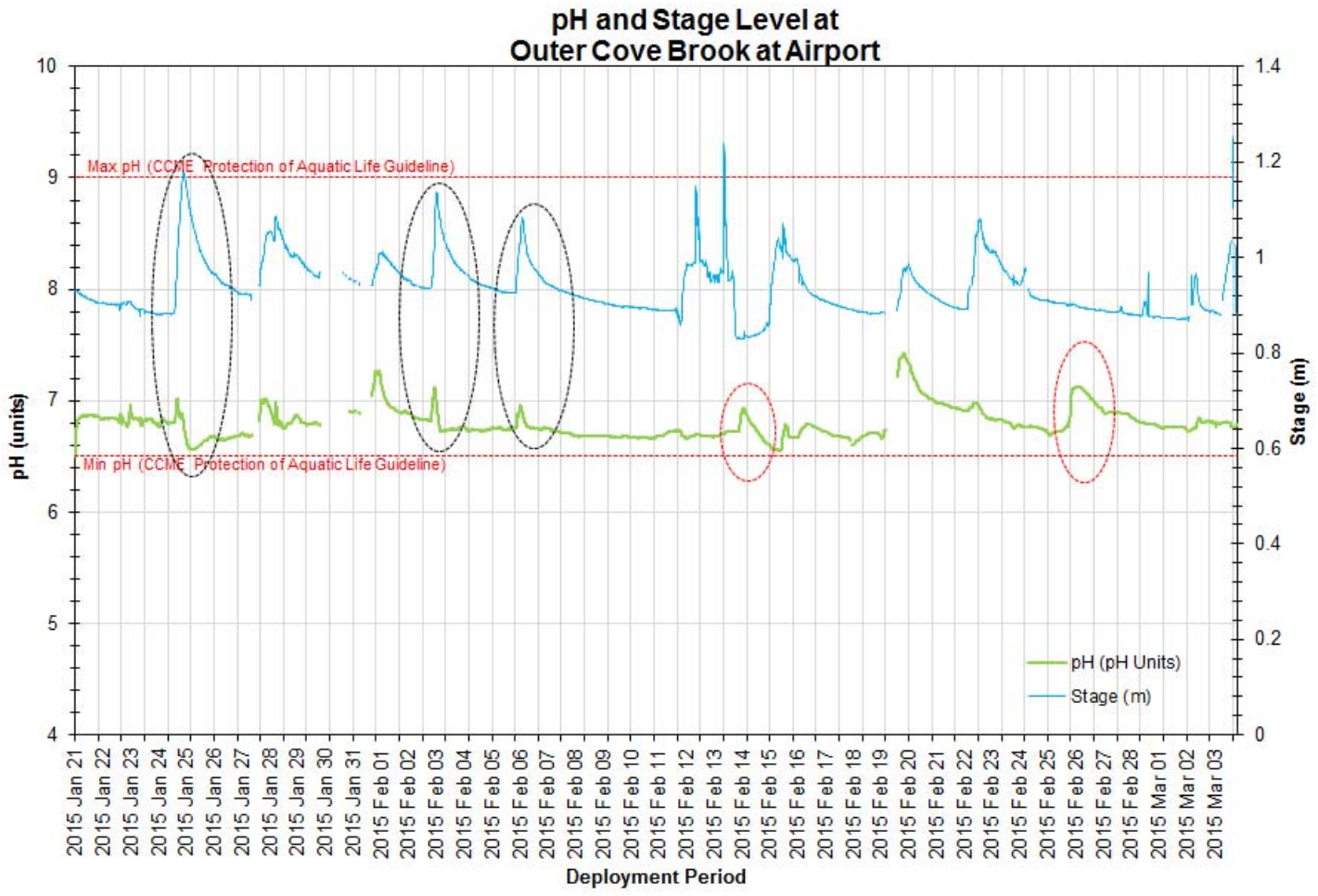

Figure 3: pH (pH units) and stage level (m) values at Outer Cove Brook below Airport

Specific Conductivity

The conductivity levels were within 477 µS/cm and 2359 µS/cm during this deployment period.

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.

The conductivity values that peaked together with stage levels were likely a result of road salt making its way into the brook after/during rainfall. 0°C or below 0°C air 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.

The other type of conductivity peak (peaks highlighted in black circles) that do not correspond with an increase in stage are likely a result of road salting during 0°C or below 0°C air temperatures that was not followed by a precipitation event. The salt made its way into the brook cause the levels to increase for a short period of time.

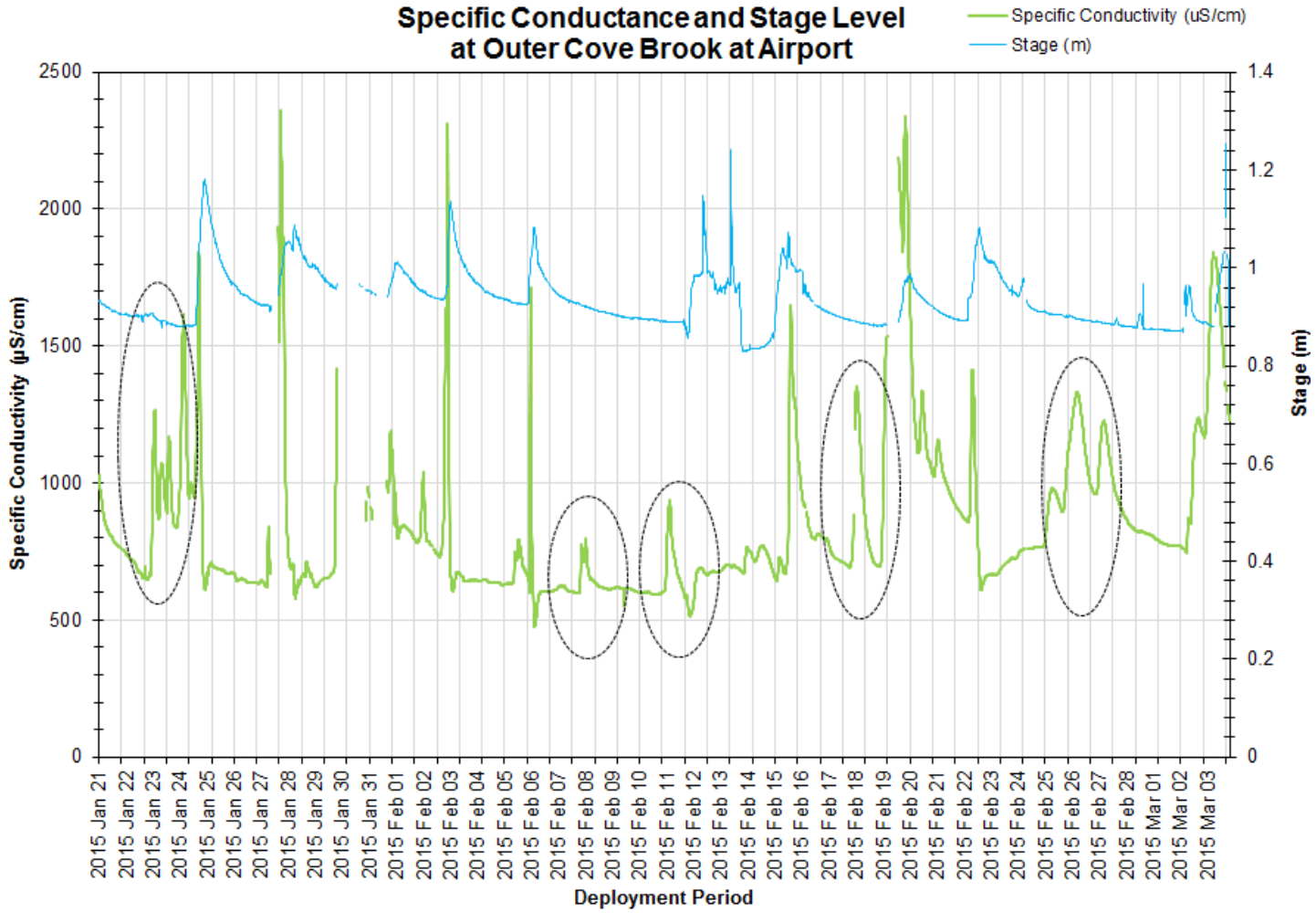

Figure 4: Specific conductivity (µS/cm) and stage (m) values at Outer Cove Brook below Airport.

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 51.0 %Sat to 84.7 %Sat. Dissolved Oxygen (mg/L) measured 7.35 mg/L to 11.59 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.

There is dip in dissolved oxygen around February 12th, 13th and 14th. It is not clear why the dissolved oxygen was low at that time. The dissolved oxygen levels do return to more normal levels after February 14th. During this time frame there was also 0^{o}C or below 0^{o}C water temperatures recorded.

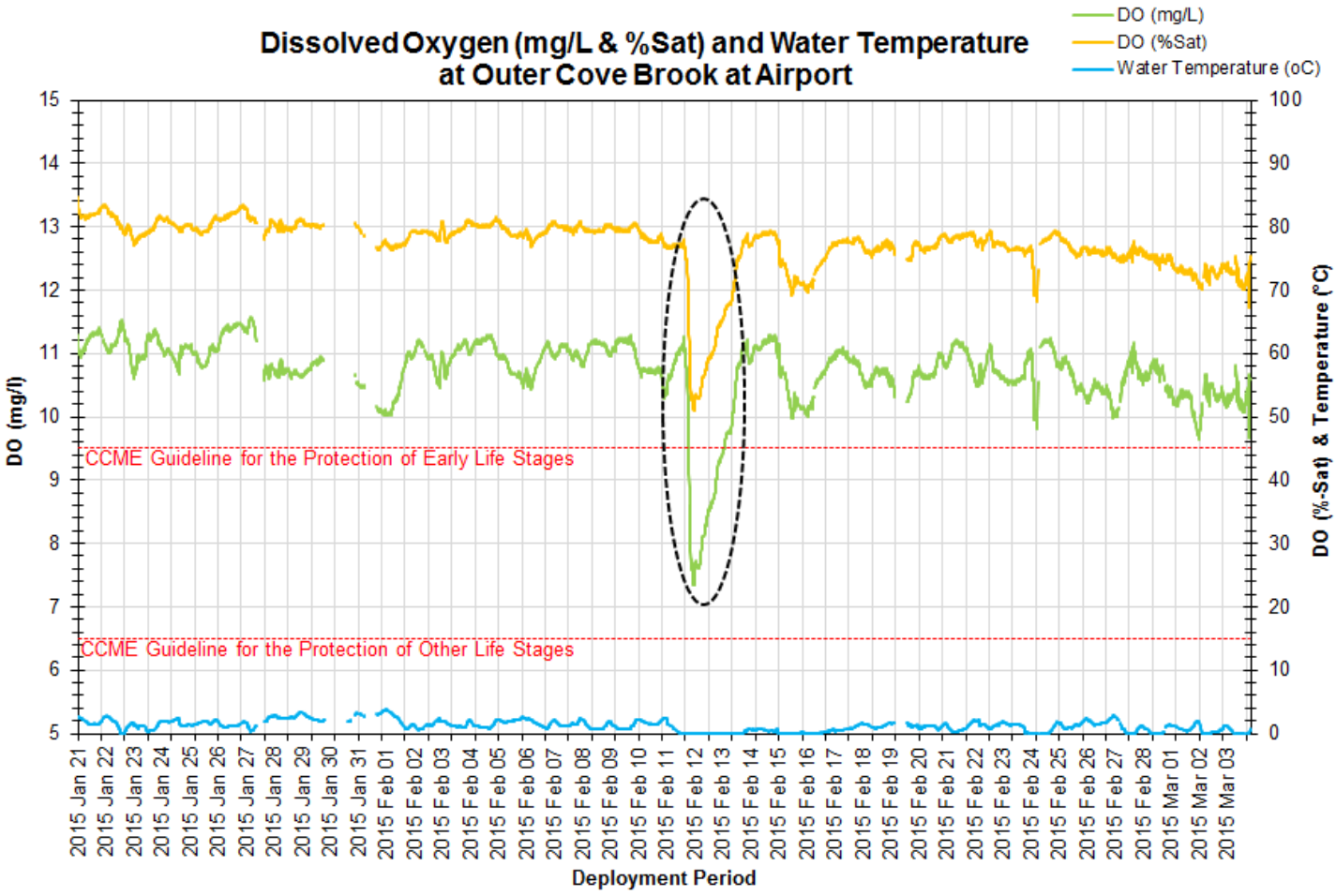

Figure 5: Dissolved oxygen (mg/L & % sat) and water temperature (°C) values at Outer Cove Brook below Airport.

Turbidity

Turbidity levels during the deployment ranged within 0.0 NTU and 60.8 NTU (Figure 6). The deployment data had a median of 1.7 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 March 2nd corresponds with a slight stage increase; however the data recorded after that event resembled that of interference from debris blocking the sensor. When the instrument was removed for cleaning it was covered in slime like algal growth completely inhibiting the sensor at this time. Therefore the data from March 3rd, 2015 onwards was removed.

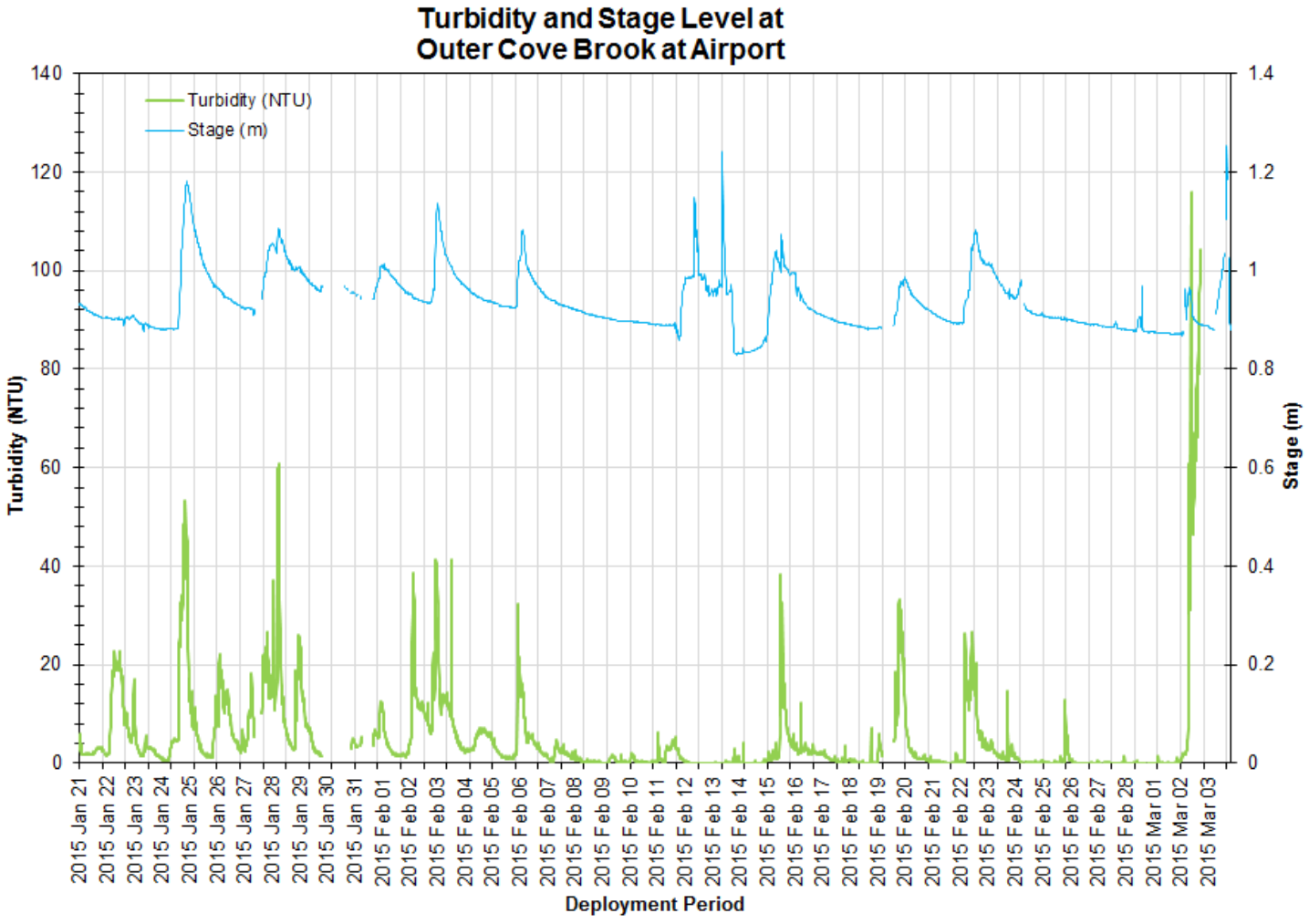

Figure 6: Turbidity (NTU) and stage level (m) values at Outer Cove Brook below Airport.

Stage

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).

During the deployment period, the daily averaged stage data ranged from 0.88m to 1.04m. The larger peaks in stage 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 27 mm on January 25th which increased both stage and streamflow at that time.

Please note the stage data graphed below is raw data that is published on WRMD web page. 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.

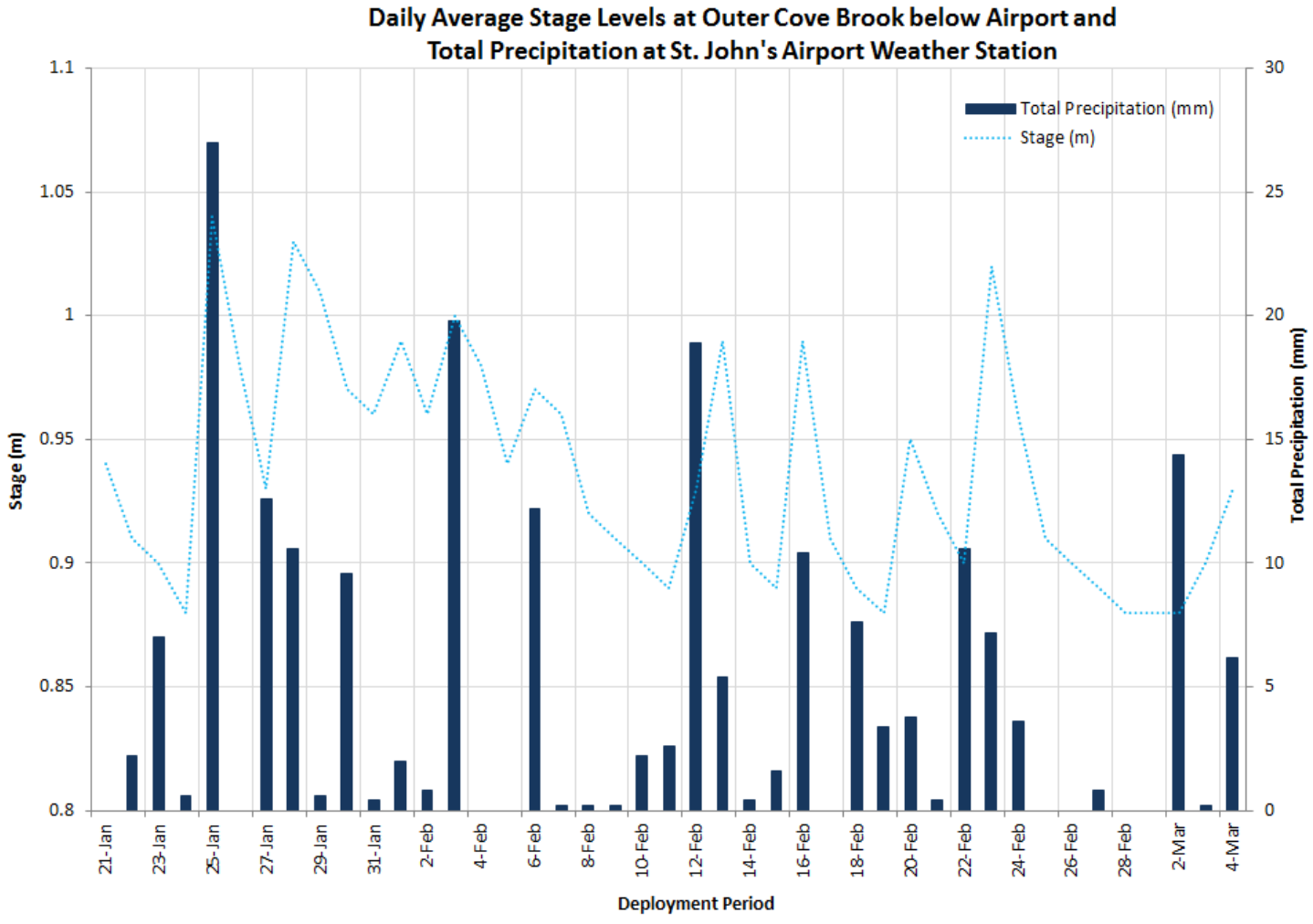

Figure 7: Daily average stage values at Outer Cove Brook below Airport and daily total precipitation values from Environment Canada's St. John's Airport Station.

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 significant dip in dissolved oxygen in February at Airport station is also evident at Clovelly station for the same time frame. It is not clear what caused the water quality to change so significantly. At both stations the dissolved oxygen improved after a couple of days.

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 -0.11 ^{o}C to 3.91 ^{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.

During this deployment period the water temperature remains reasonably consistent. The warmer water temperatures during deployment coincide with higher stage levels. The higher stage levels are likely a result of rainfall. 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. WSC is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request to WSC.

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

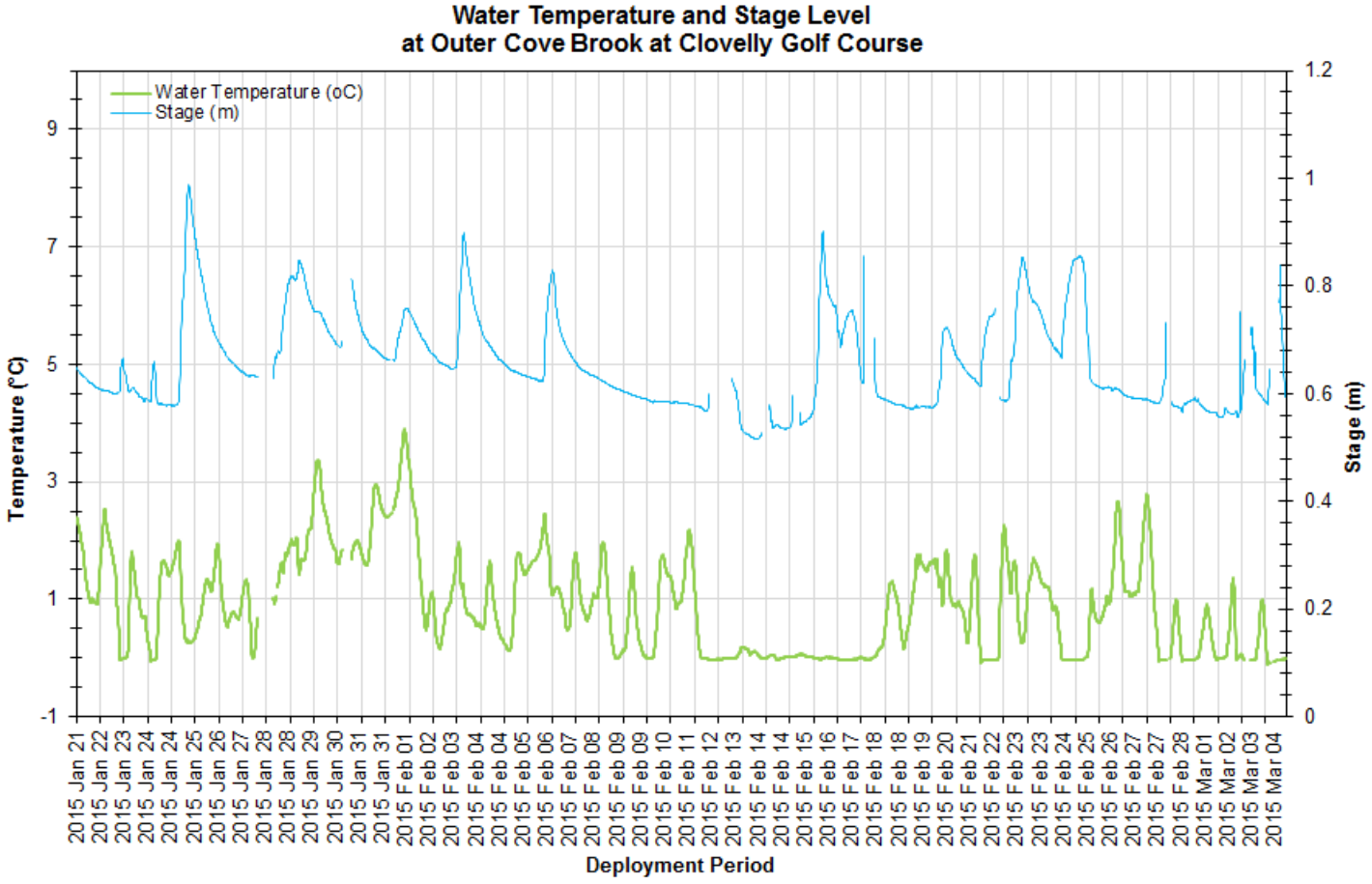

Figure 8: Water temperature (°C) and Stage (m) levels at Outer Cove Brook at Clovelly Golf Course.

pH

Throughout this deployment period pH values ranged between 6.33 pH units and 7.09 pH units (Figure 9).

During the deployment, the majority of the pH values at this station recorded within the minimum and maximum CCME Guideline for the Protection of Aquatic Life.

The pH data that did dip below the minimum guideline corresponded with increases in stage level. Increases in stage resulted in increases and then sharp 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 during the cooler icier 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 6.74 units (a slightly higher pH median from last deployment).

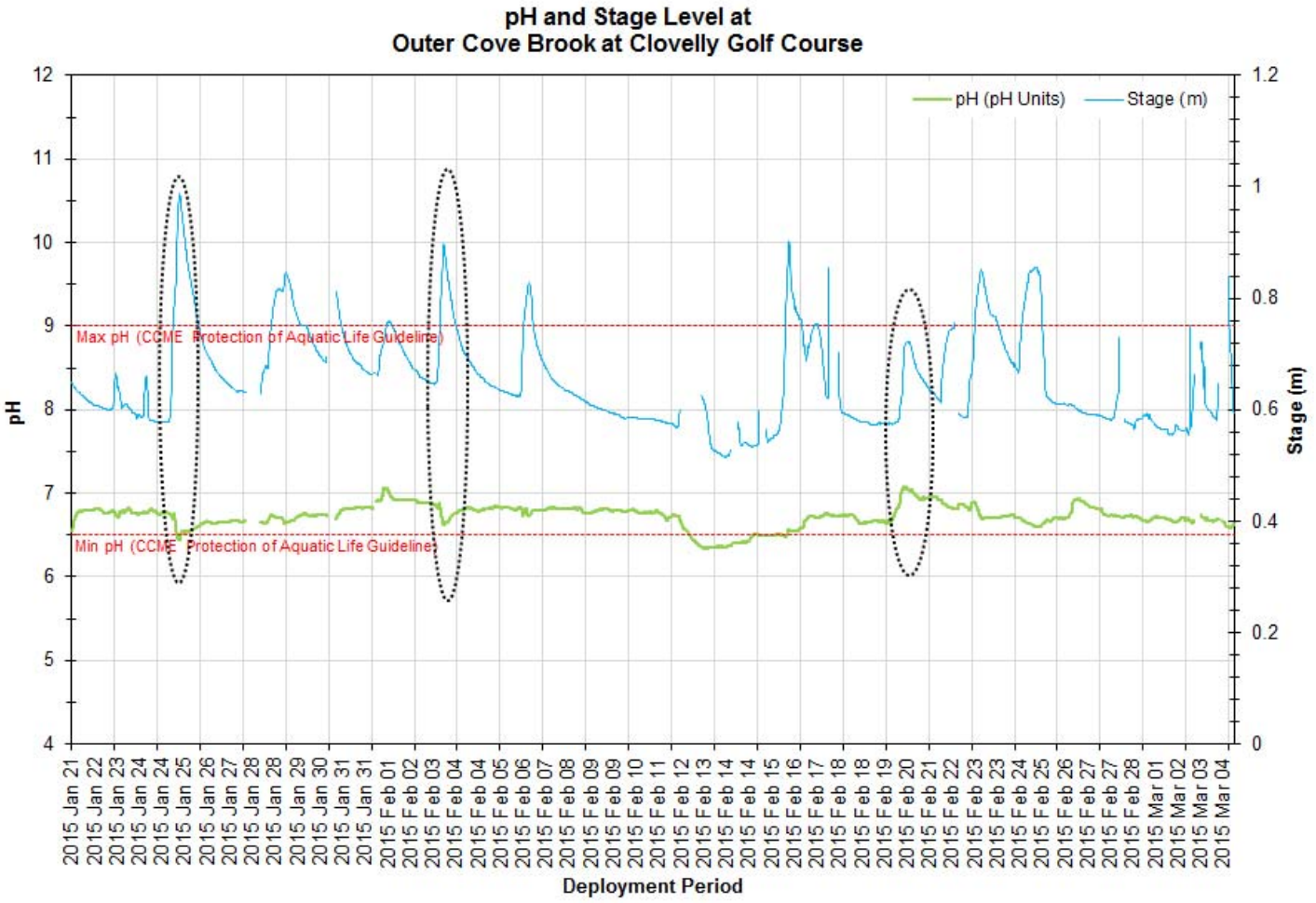

Figure 9: pH (pH units) and stage level (m) values at Outer Cove Brook at Clovelly Golf Course.

Specific Conductivity & TDS

The conductivity levels were within 517µS/cm and 3337µS/cm during this deployment period. TDS ranged from 0.331g/L to 2.14g/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 icier 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 and causes an increase in the conductivity values.

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.

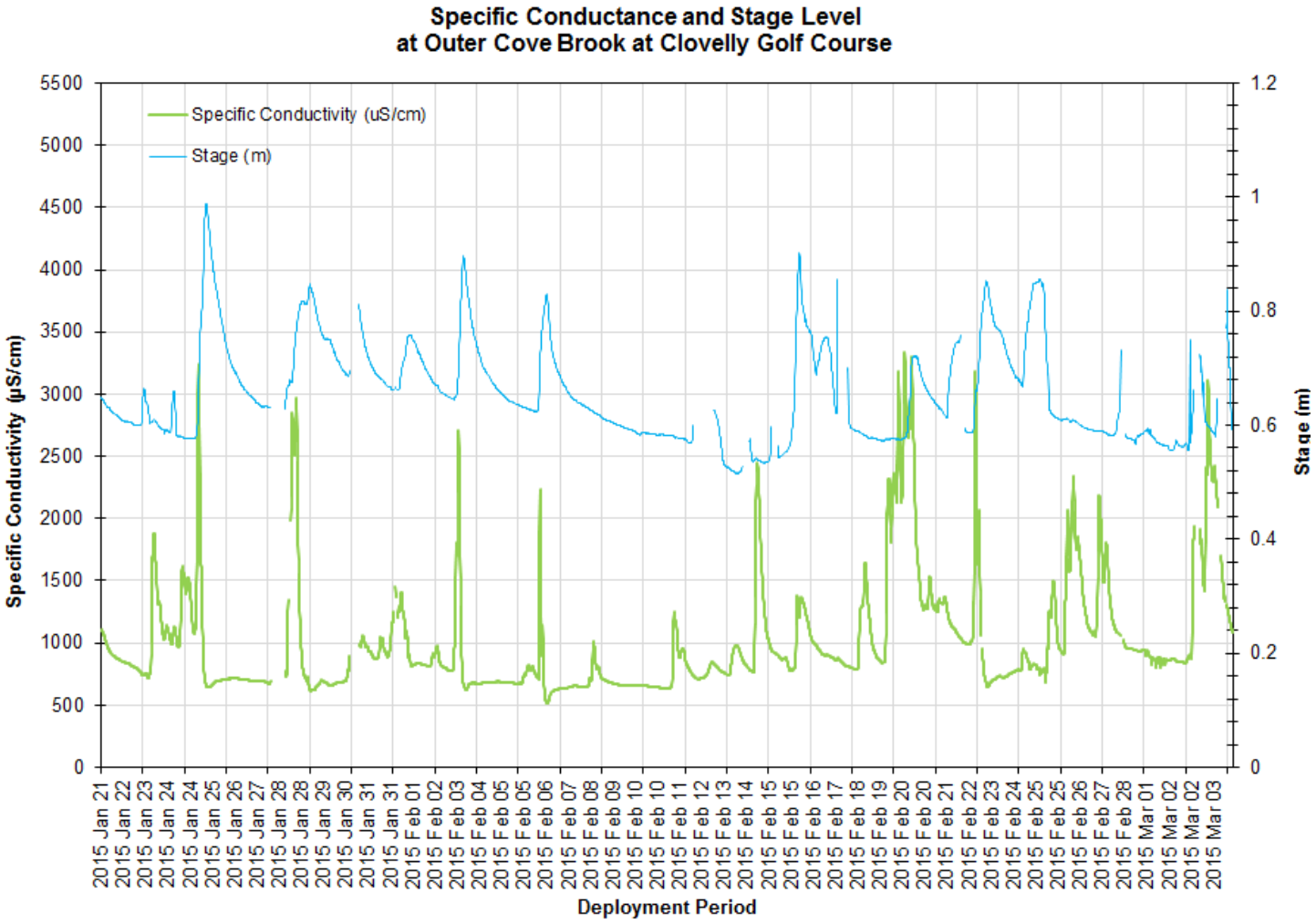

Figure 10: Specific conductivity (uS/cm) and stage (m) values at Outer Cove Brook at Clovelly Golf Course.

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 46.4%Sat to 87.3%Sat. Dissolved Oxygen (mg/L) measured 6.68mg/L to 12.18mg/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.

The large dissolved oxygen decrease (circled in black) was also evident on the dissolved oxygen graph for Outer Cove Brook below Airport for the same time frame. It is not clear what may have caused the dissolved oxygen levels at both stations to decrease at this time.

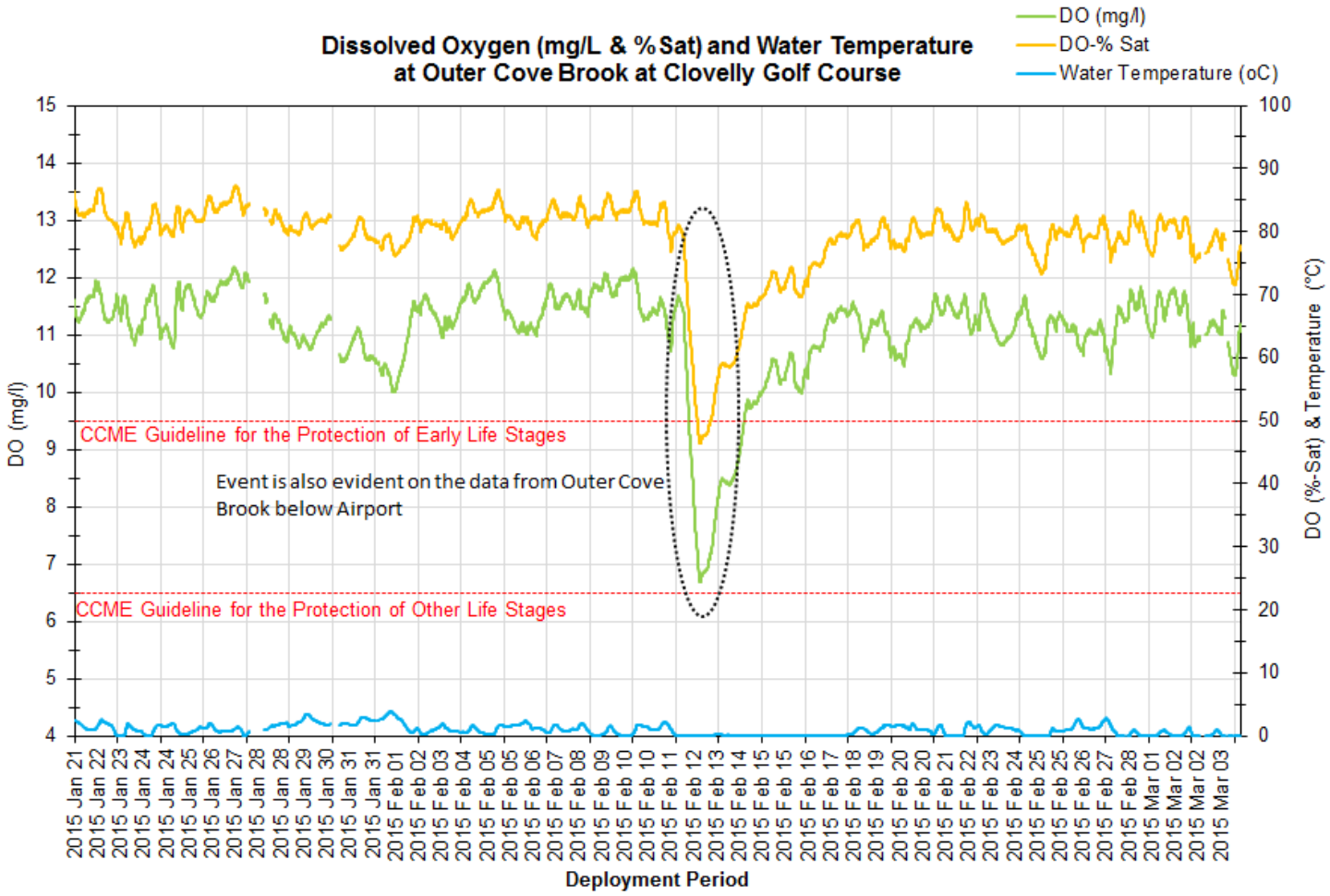

Figure 11: Dissolved oxygen (mg/L & % sat) and water temperature (°C) values at Outer Cove Brook at Clovelly Golf Course.

Turbidity

Turbidity levels during the deployment period ranged within 0.0 NTU and 67.4 NTU (Figure 12), with a median of 1.4 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.

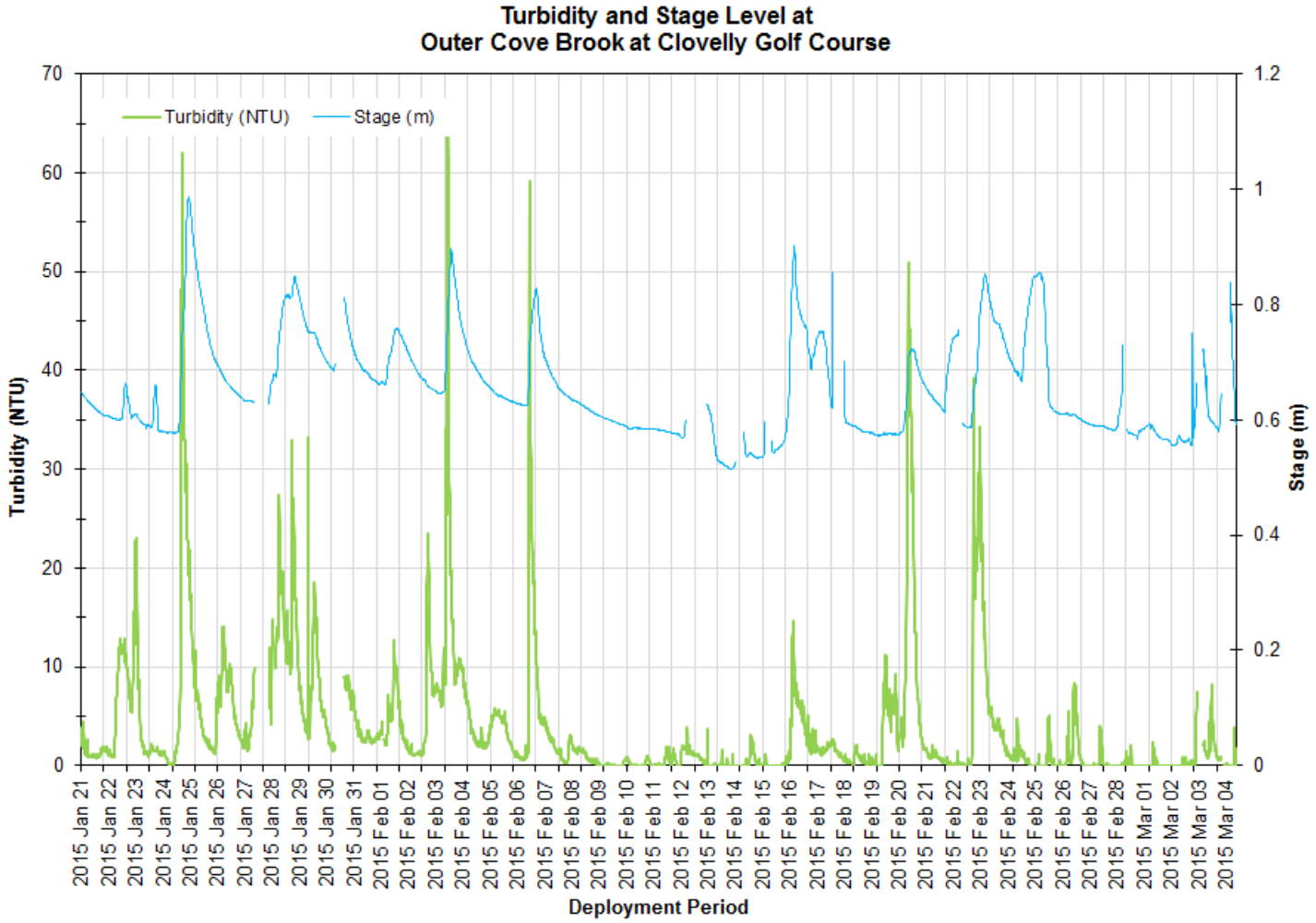

Figure 12: Turbidity (NTU) and stage level (m) values at Outer Cove Brook at Clovelly Golf Course.

Stage

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).

Stage levels during this deployment ranged within a minimum of 0.57m and a maximum of 1.03m. The precipitation ranged from a minimum of 0.0 mm a day to a maximum of 27 mm which was on January 25th, 2015. This rainfall event increased stage 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 data graphed below is raw data that is published on WRMD web page. 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.

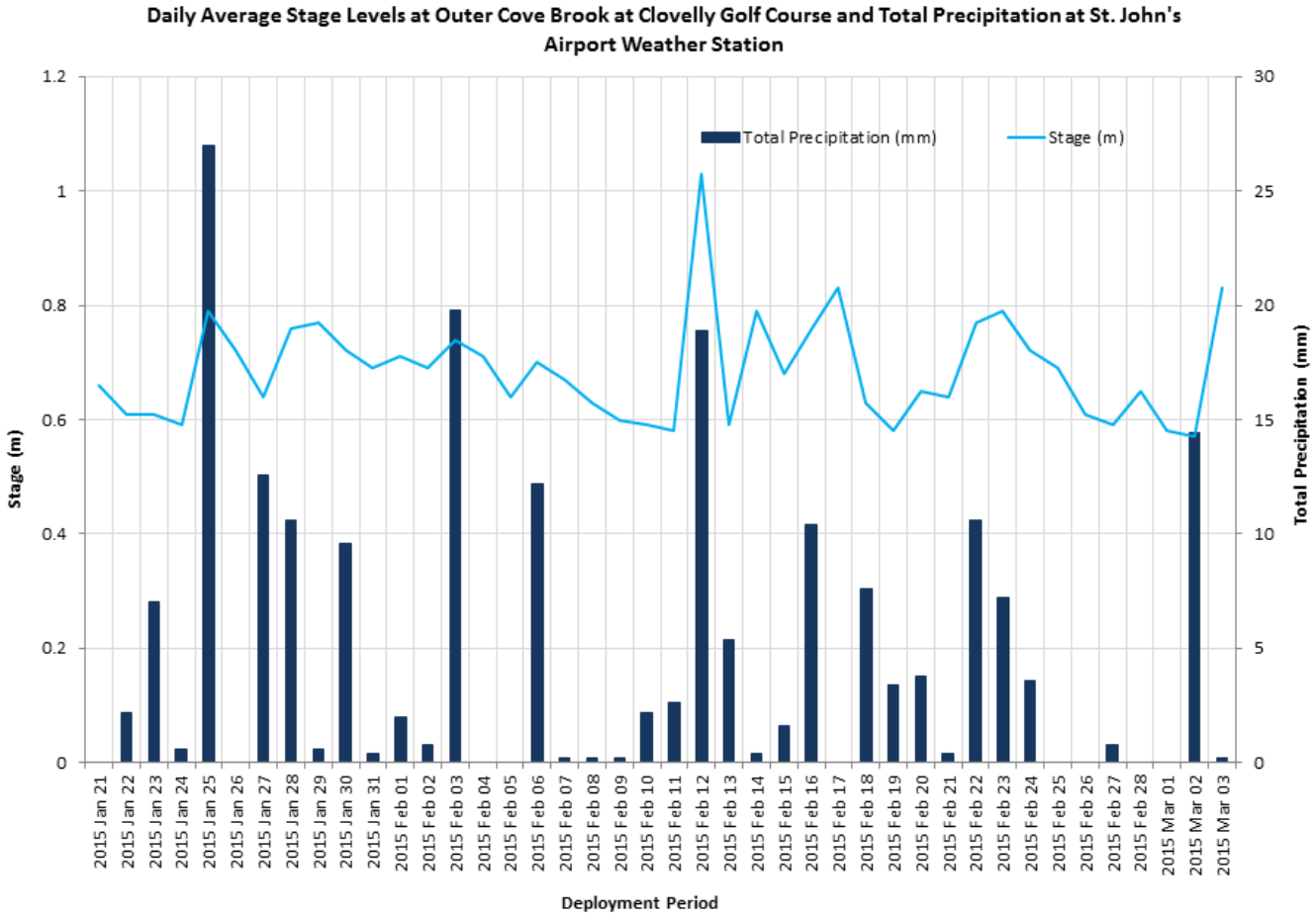

Figure 13: Daily average stage values at Outer Cove Brook at Clovelly Golf Course and daily total precipitation values (mm) from Environment Canada's Weather Station at St. John's International Airport.

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.

- The dissolved oxygen at Outer Cove Brook at Clovelly Golf Course displays the significant dip in February that is also evident on the Airport station dissolved oxygen graph. It is not evident on the cause of the dip however there was significant rainfall and a stage increase recorded at Outer Cove Brook at Clovelly Golf Course for the same time frame.

- 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.

APPENDIX I

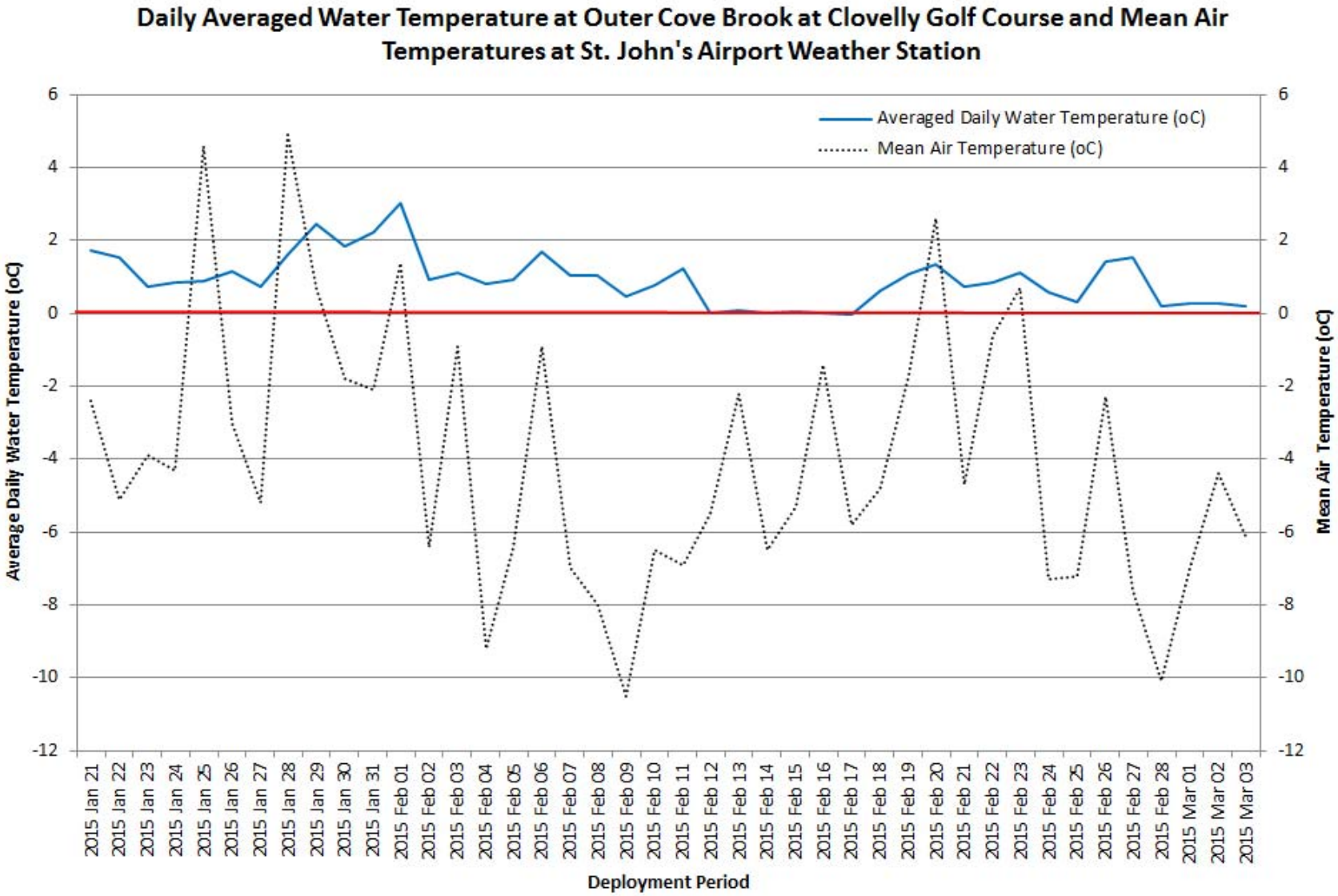

Figure 14: Daily average water temperature values from Outer Cove Brook at Clovelly Golf Course and air temperature values from Environment Canada's Weather Station at St. John's International Airport.

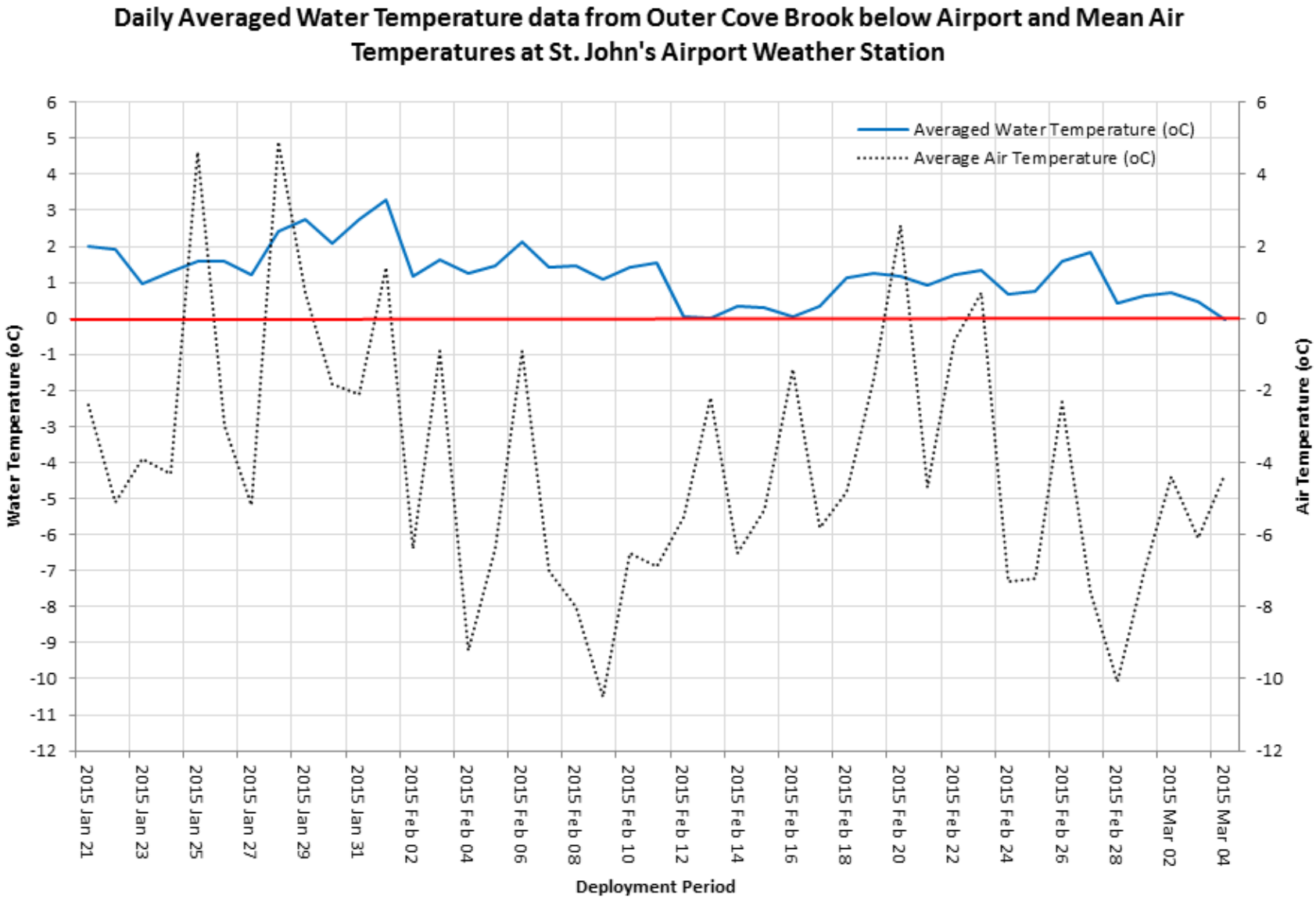

Figure 15: Daily average water temperature values from Outer Cove Brook below Airport and air temperature values from Environment Canada's Weather Station at St. John's International Airport.

APPENDIX II

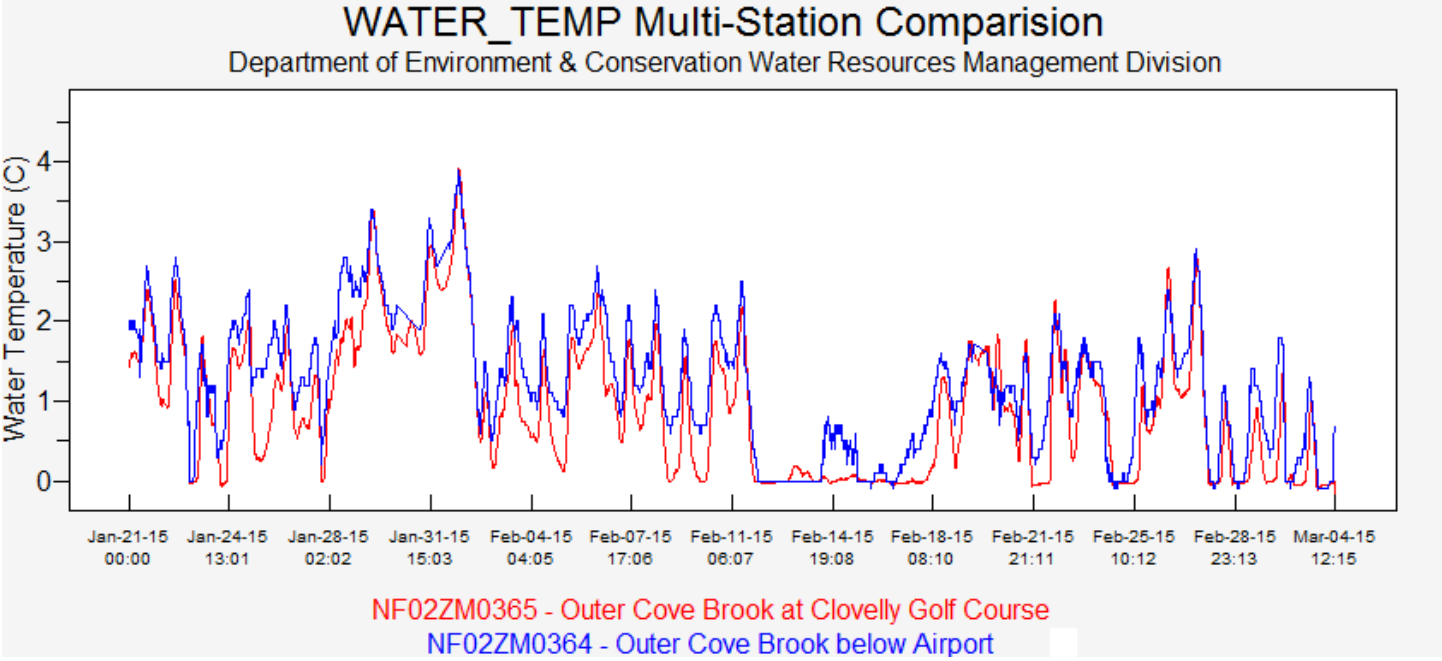

Figure 16: Comparison Water Temperature at the Outer Cove Brook Stations

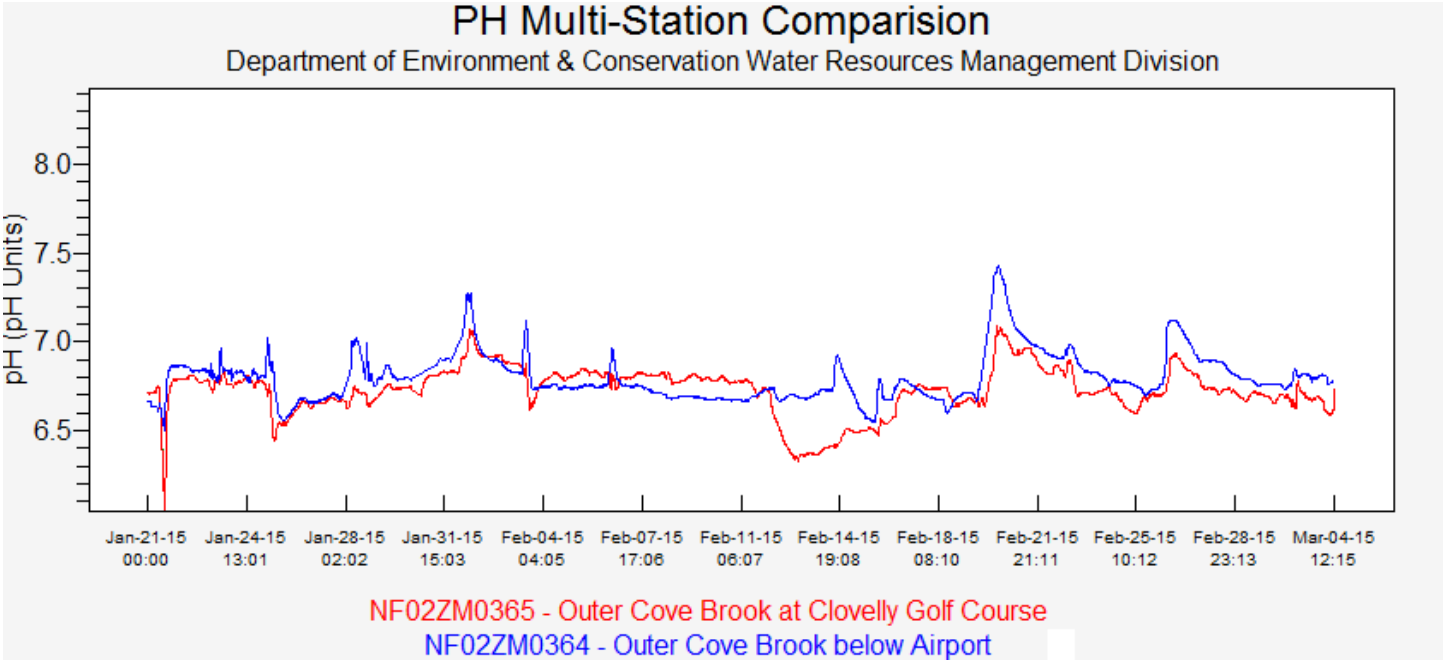

Figure 17: Comparison of pH units at the Outer Cove Brook Stations

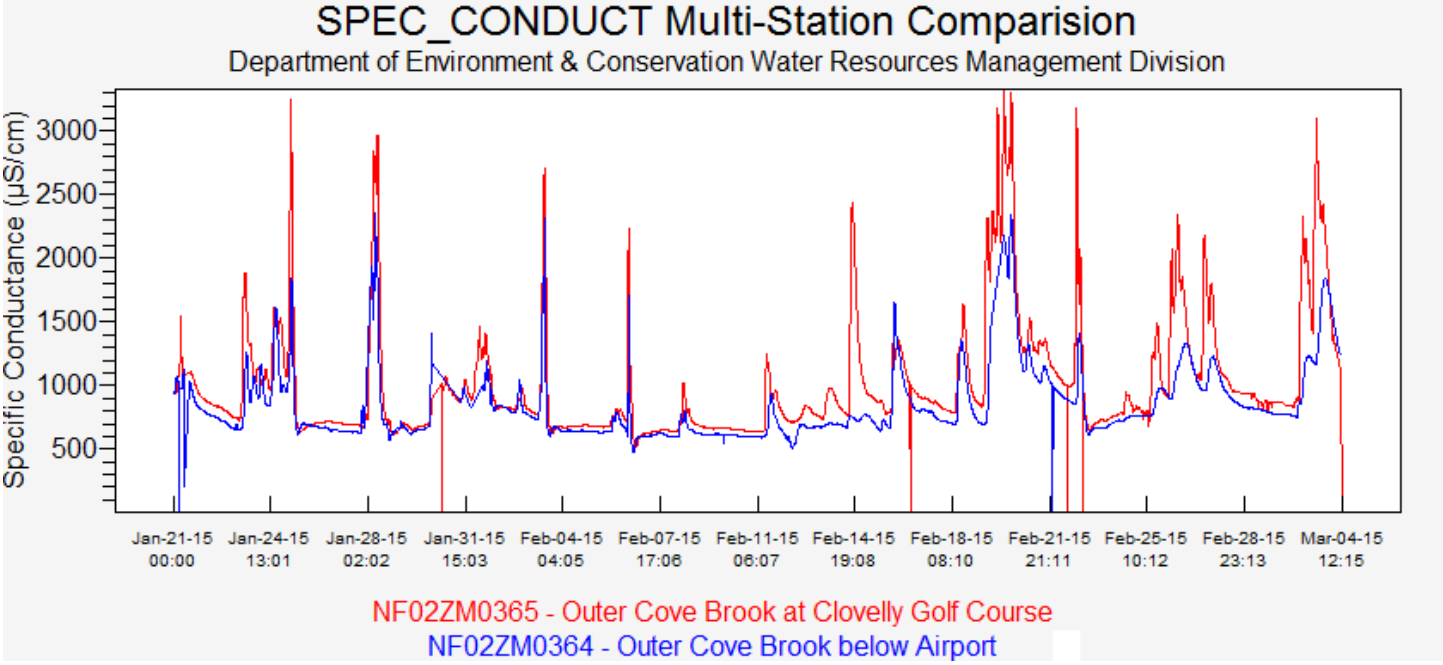

Figure 18: Comparison Specific Conductivity at the Outer Cove Brook Stations

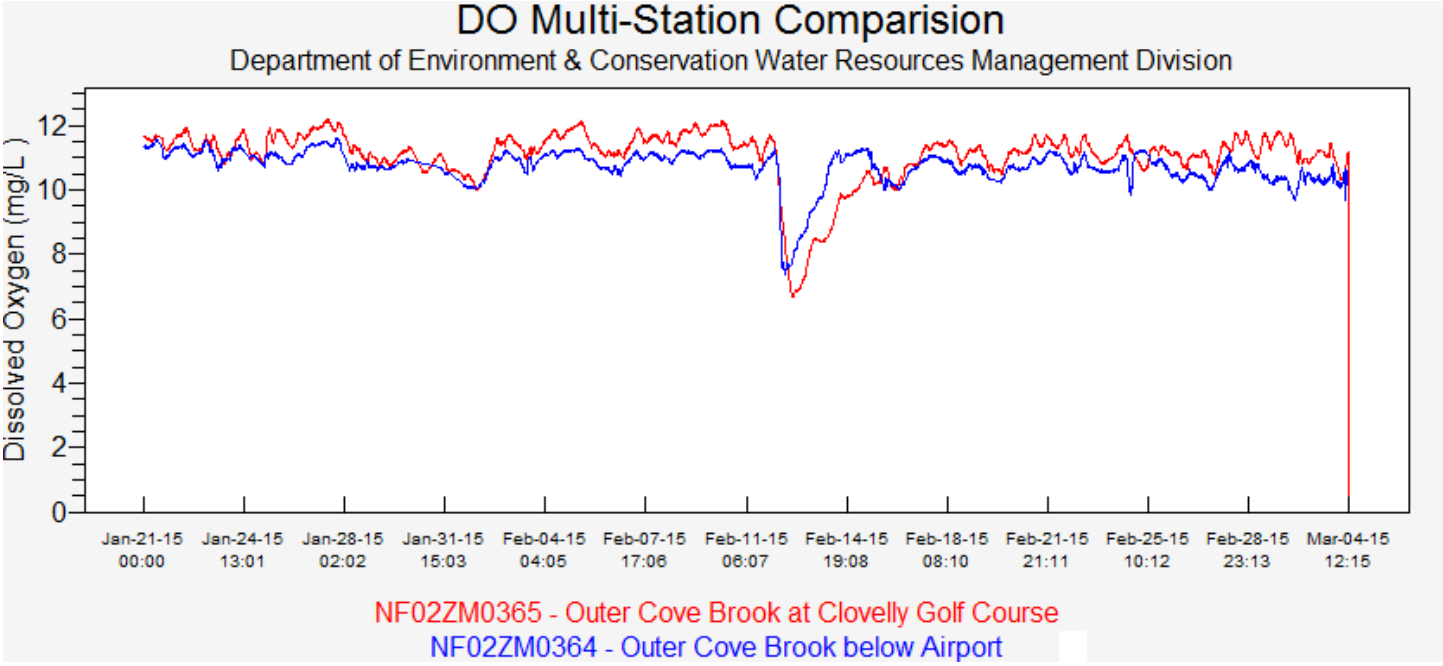

Figure 19: Comparison of Dissolved Oxygen (mg/L) at the Outer Cove Brook Station

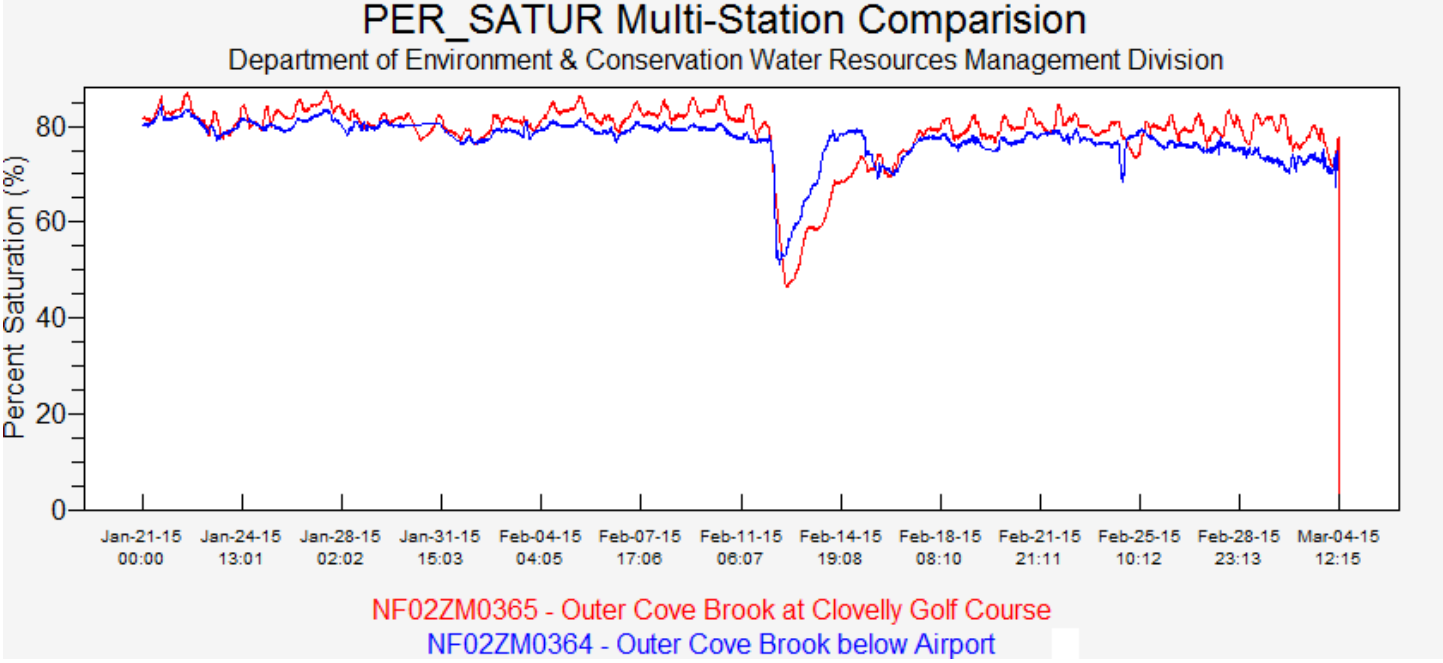

Figure 20: Comparison of Dissolved Oxygen (%Sat) of the Outer Cove Brook stations

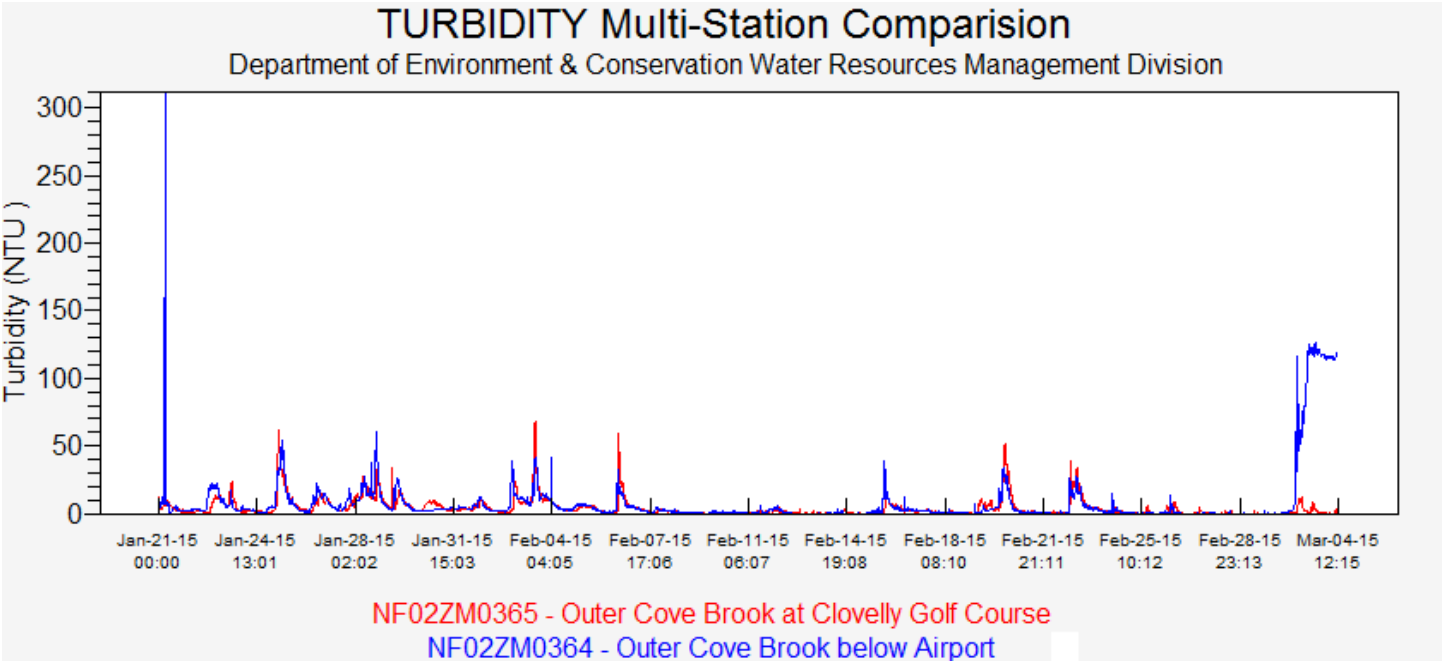

Figure 21: Comparison of Turbidity at the Outer Cove Brook stations