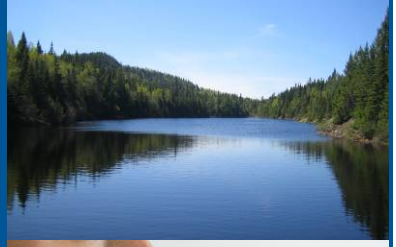
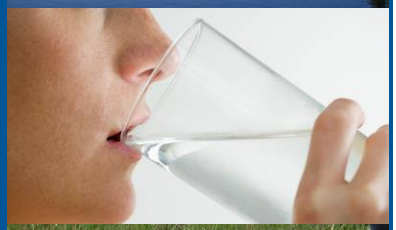






Real-Time Water Quality Report

Outer Cove Brook Network

Deployment Period
April 15, 2015 to June 2, 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 deployment period of April 15, 2015 until removal on June 2, 2015.

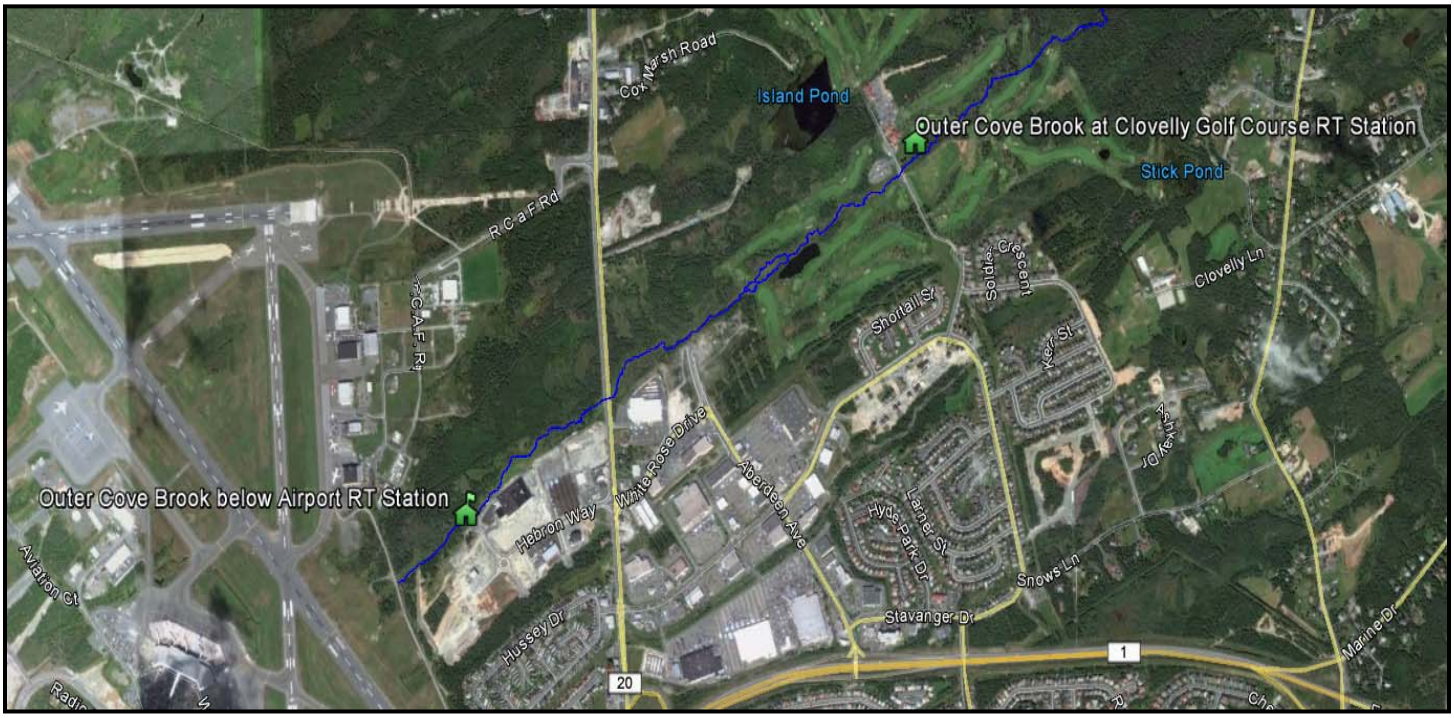

Figure 1: Outer Cove Brook Real-Time Water Quality and Quantity Stations.

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	April 15	Deployment	Excellent	Fair	Good	Excellent	Excellent
	June 2	Removal	Fair	Poor	Poor	Poor	Poor

- During the Outer Cove Brook below Airport station deployment, the water quality parameter data ranked as 'Excellent' for water temperature, dissolved oxygen and turbidity. The conductivity data ranked as 'Good'. pH data when compared to the QA ranked as 'Fair', this ranking may have been a result of a bubble on the pH probe at the time of the reading.
- At removal of the instrument, the water temperature data ranked as 'Fair' all other parameters on the instrument ranked as 'Poor'. This result may have been due to the fouling present on the sensors at the time of removal. At removal the instrument and the instrument protective casing was covered with a slime-like substance (similar to what has been seen in previous deployments) that completely covered the probes end inhibiting the sensors ability to read accurately.

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	April 15	Deployment	Excellent	Good	Excellent	Excellent	Excellent
	June 2	Removal	Good	Excellent	Excellent	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, dissolved oxygen and turbidity comparison data all ranked as 'excellent'. pH data ranked as 'Good' during initial deployment.
- At removal the comparison between the field sonde and QAQC sonde indicated that, water temperature ranked as 'Good'. With pH, conductivity and dissolved oxygen data ranked as 'Excellent', while the data for turbidity ranked as 'Poor'. At the time of removal the instrument was experiencing some biofouling by slime like substance. It is likely the fouling 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 0.50°C to 15.80°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.

As the deployment period came to an end, the water temperature starts to increase with the warmer air temperatures. 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).

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.

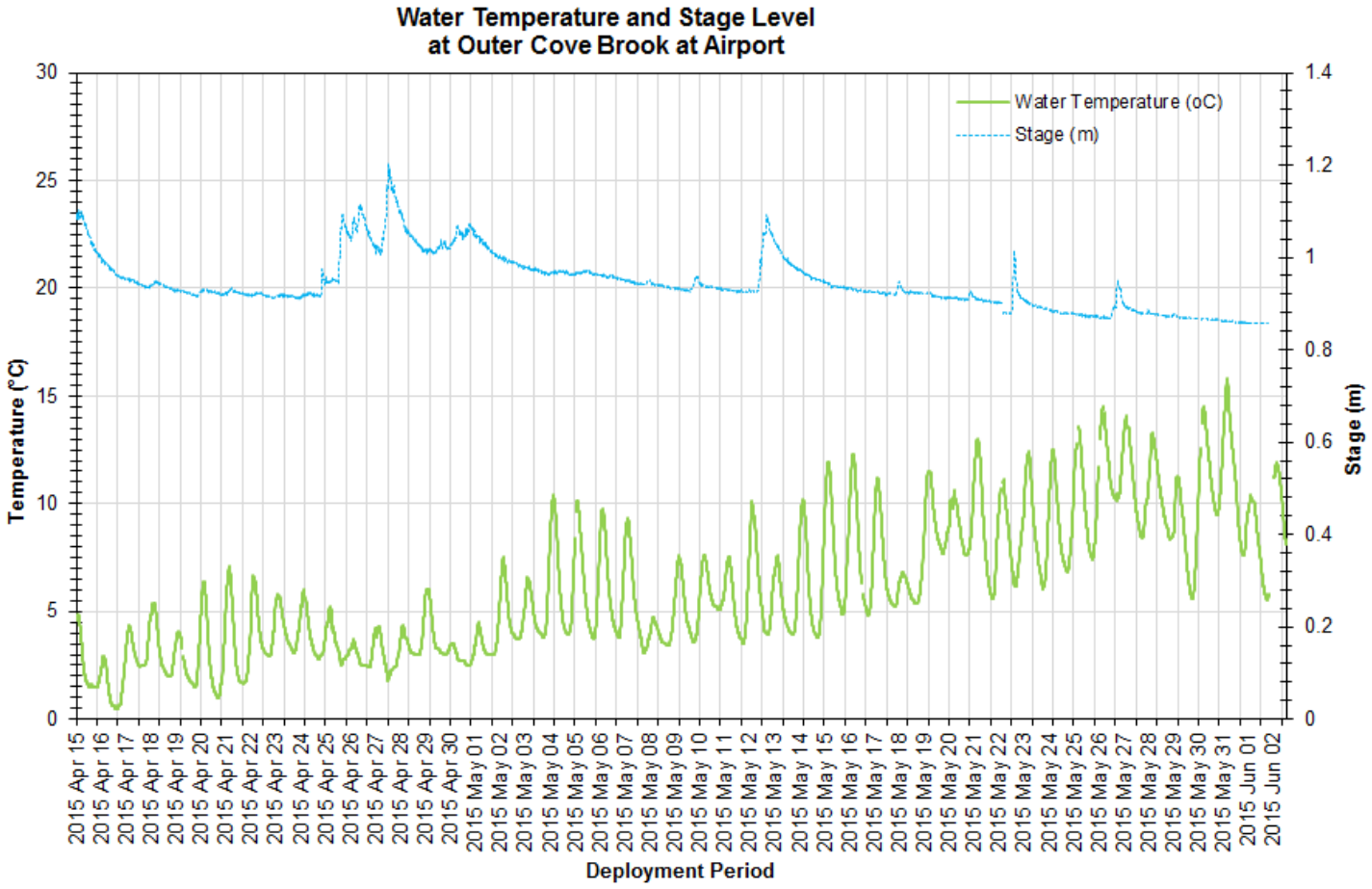

Figure 2: Water temperature (°C) and Stage (m) values at Outer Cove Brook below Airport

pH

Throughout the deployment period, pH values ranged between 6.28 pH units and 7.86 pH units (Figure 3).

During this deployment, the majority of the 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). The CCME guideline provides a basis by which to judge the overall health of the brook. Naturally, all streams and brooks are different.

The graph indicates that as the stage level decreases the pH data increases. During the deployment period the median pH level was 7.45 pH units. The pH data increases gradually over the deployment period. This could be due to the fouling on the sensor. The pH data was ranked as "Poor" for removal due to the sensor being covered in a slime-like substance.

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.

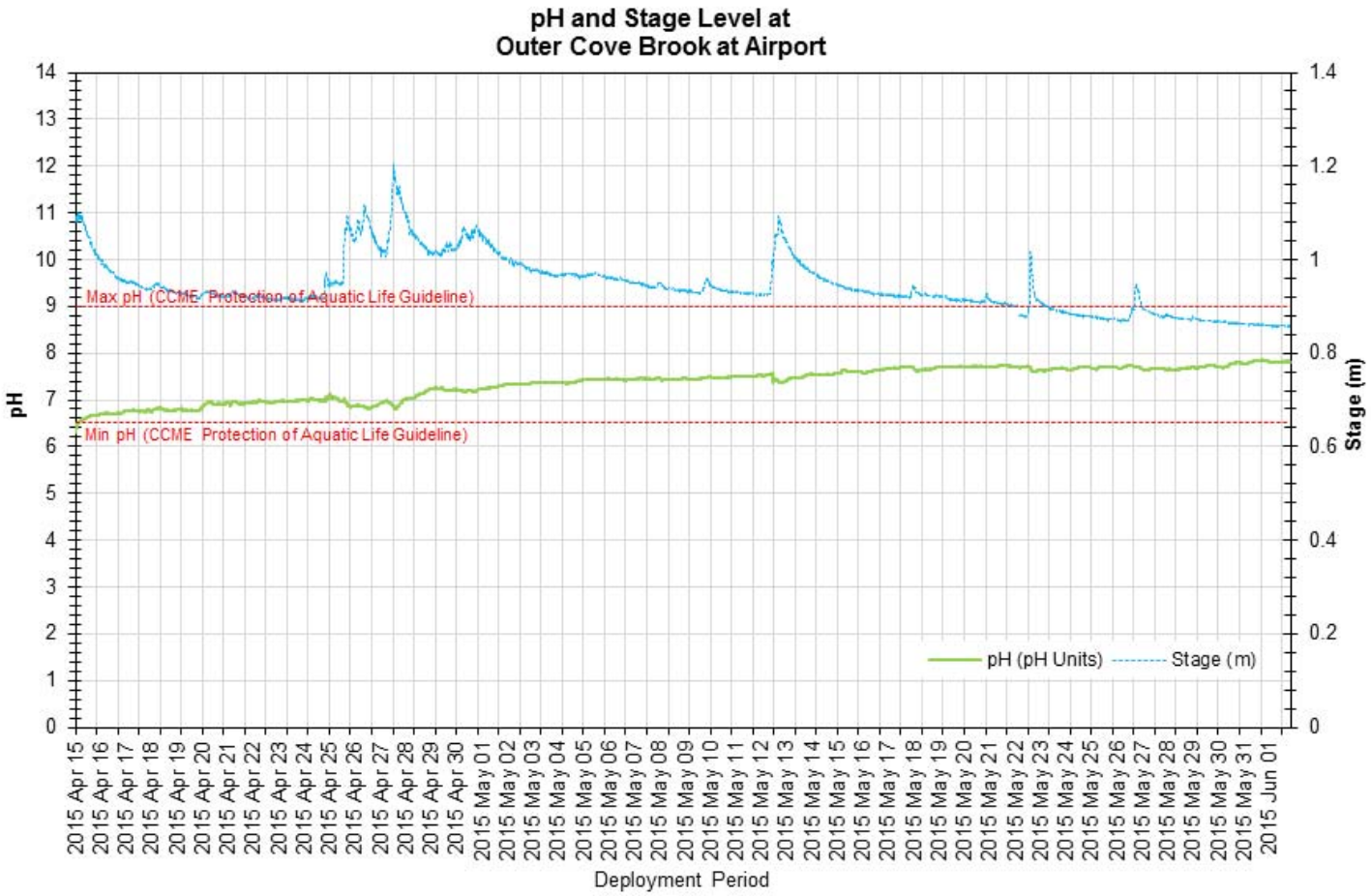

Figure 3: pH (pH units) and stage level (m) values at Outer Cove Brook below Airport

Specific Conductivity

The conductivity levels were within 177.1 µS/cm and 666.0 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 is evident on Figure 4.

The dips in conductivity data after increases in stage indicate that the brook is being flushed naturally, the suspended matter and dissolved substances in the brook are flushed for a short period of time with the higher flow. This is evident on several occasions during this deployment.

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.

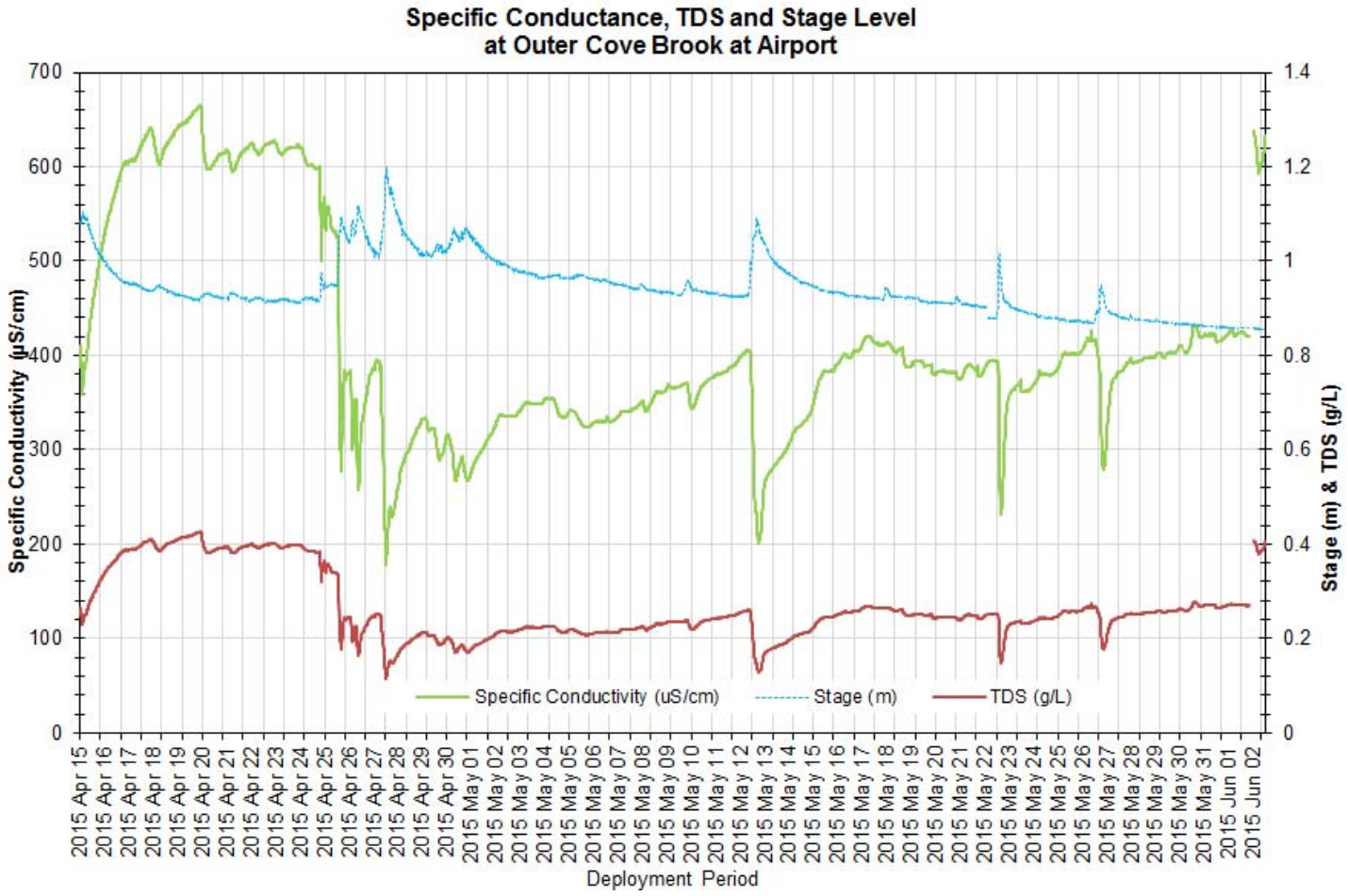

Figure 4: Specific conductivity (µS/cm) and stage (m) values at Outer Cove Brook below Airport.

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 were within 66.8 %Sat to 86.8 %Sat. Dissolved Oxygen (mg/L) measured 8.23 mg/L to 11.43 mg/L (Figure 5).

At the start of the deployment the dissolved oxygen data was inconsistent; this may be explained by the start of the die off from the slime like substance that was present in the brook. As the substance dies off the oxygen levels in the water are exhausted.

The dissolved oxygen data displayed inaccuracies starting May 20th; therefore the data was removed from the statistical analysis as it did not represent the brook at that time. This sensor also ranked as "Poor" during the comparison of data at removal due to the fouling on the sensor.

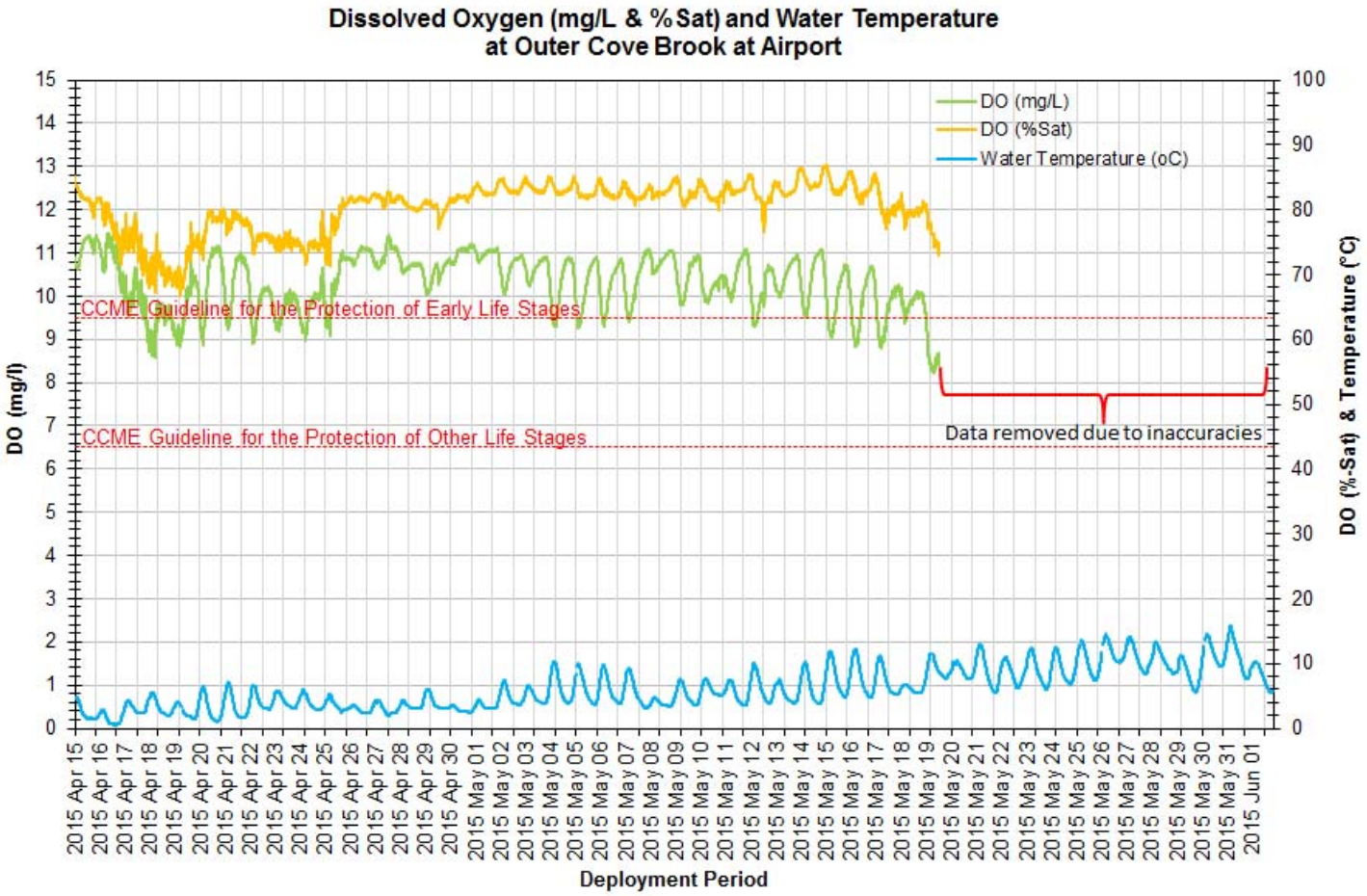

Figure 5: Dissolved oxygen (mg/L & % sat) and water temperature (°C) values at Outer Cove Brook below Airport.

Turbidity

Turbidity levels during the deployment ranged within 0.7 NTU and 220.7 NTU (Figure 6). The deployment data had a median of 3.6 NTU.

The turbidity data displayed inaccuracies starting May 20th; therefore the data was removed from the statistical analysis as it did not represent the brook at that time. This sensor also ranked as "Poor" during the comparison of data at removal due to the fouling on the sensor.

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. The large turbidity event around April 26 – 29th corresponds with stage increase at that time.

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.

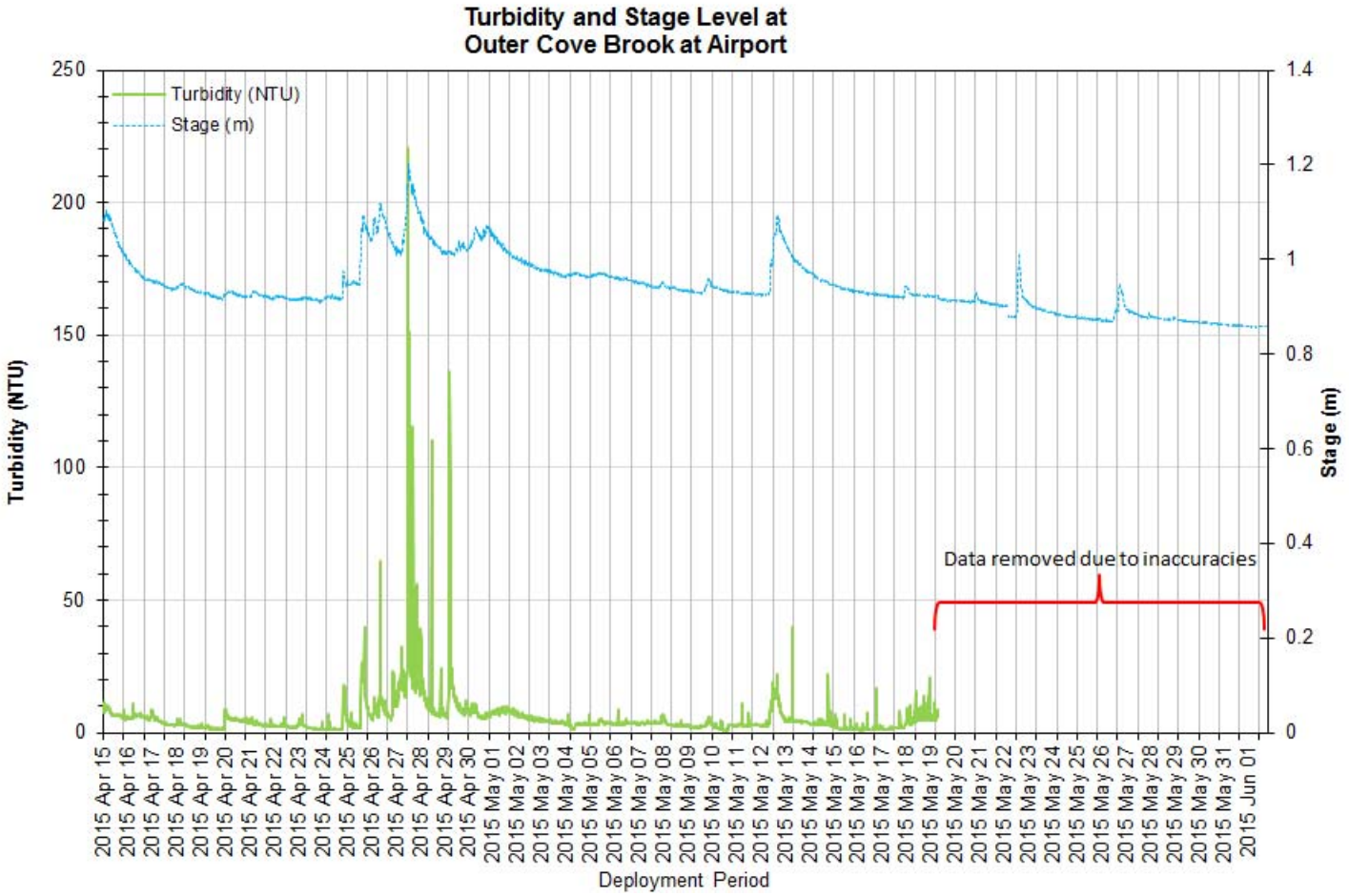

Figure 6: Turbidity (NTU) and stage level (m) values at Outer Cove Brook below Airport.

Stage, Stream Flow & Precipitation

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 0.84m to 1.19m. The larger peaks in stage 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 28.2 mm on March 16th 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.

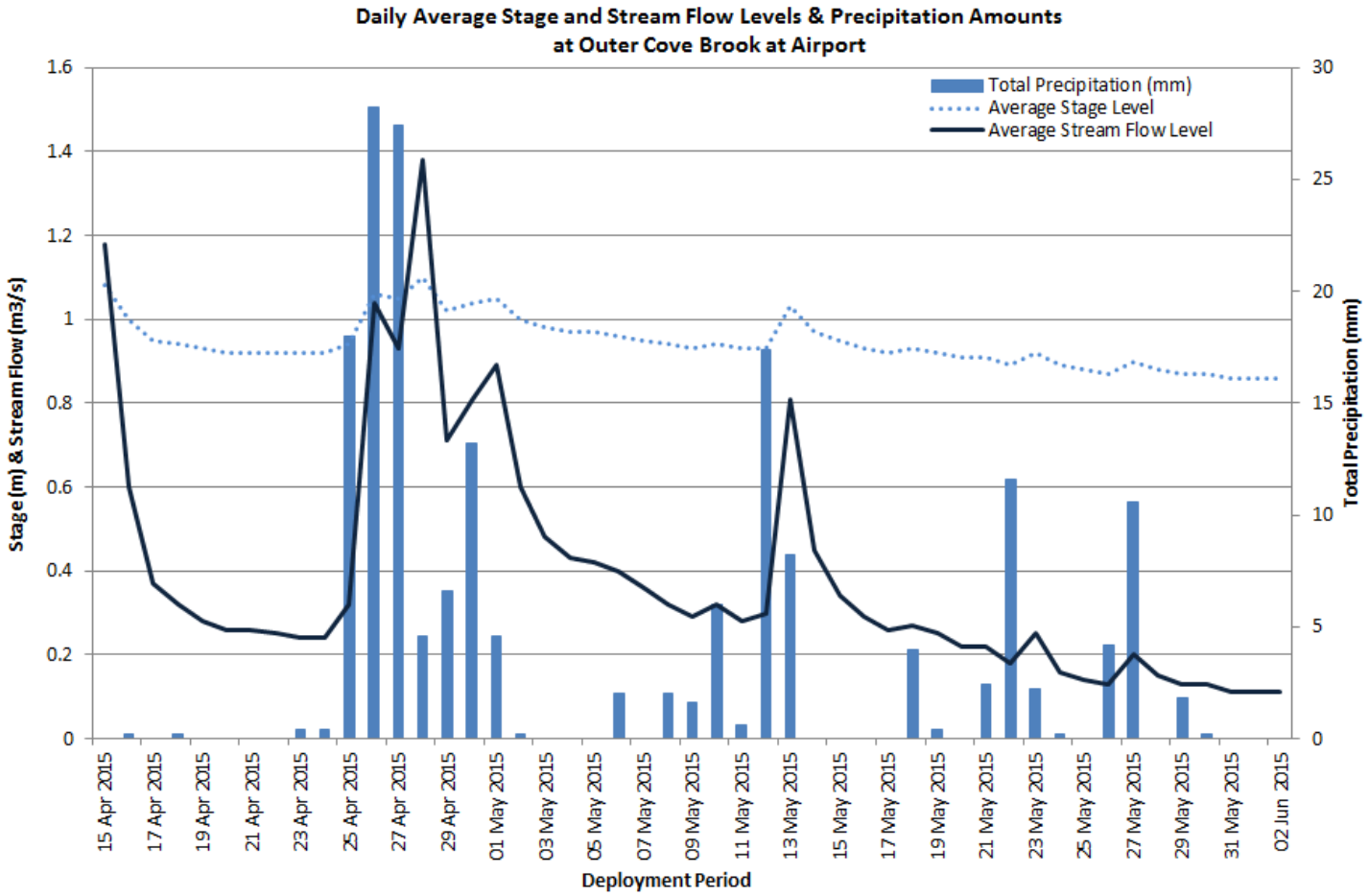

Figure 7: Daily average stage & stream flow values at Outer Cove Brook below Airport and daily total precipitation values from Environment Canada's St. John's Airport Station.

Conclusion

As with many shallow brooks and streams, precipitation events play a role in influencing the parameters within the water body. Outer Cove Brook at Airport 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.

Rainfall events decreased conductivity for short periods of time flushing the dissolved material through the brook. High stage levels reflecting rainfall, also contributed to bursts in turbidity readings for short periods of time. During the deployment there were inaccuracies with the turbidity data from May 19th onwards, this data was removed to ensure it was not used in any statistical analysis.

The warmer ambient air temperatures (Appendix I) resulted in a slight increase in water temperature over 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. During the deployment there were inaccuracies with the dissolved oxygen data from May 19th onwards, this data was removed to ensure it was not used in any statistical analysis.

Outer Cove Brook at Clovelly Golf Course

Water Temperature

Water temperature ranged from 0.07 °C to 17.61 °C during this deployment period (Figure 8).

During this deployment period the water temperature remains reasonably consistent until May. Water temperatures start to increase in May as the air temperatures warm up.

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

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.

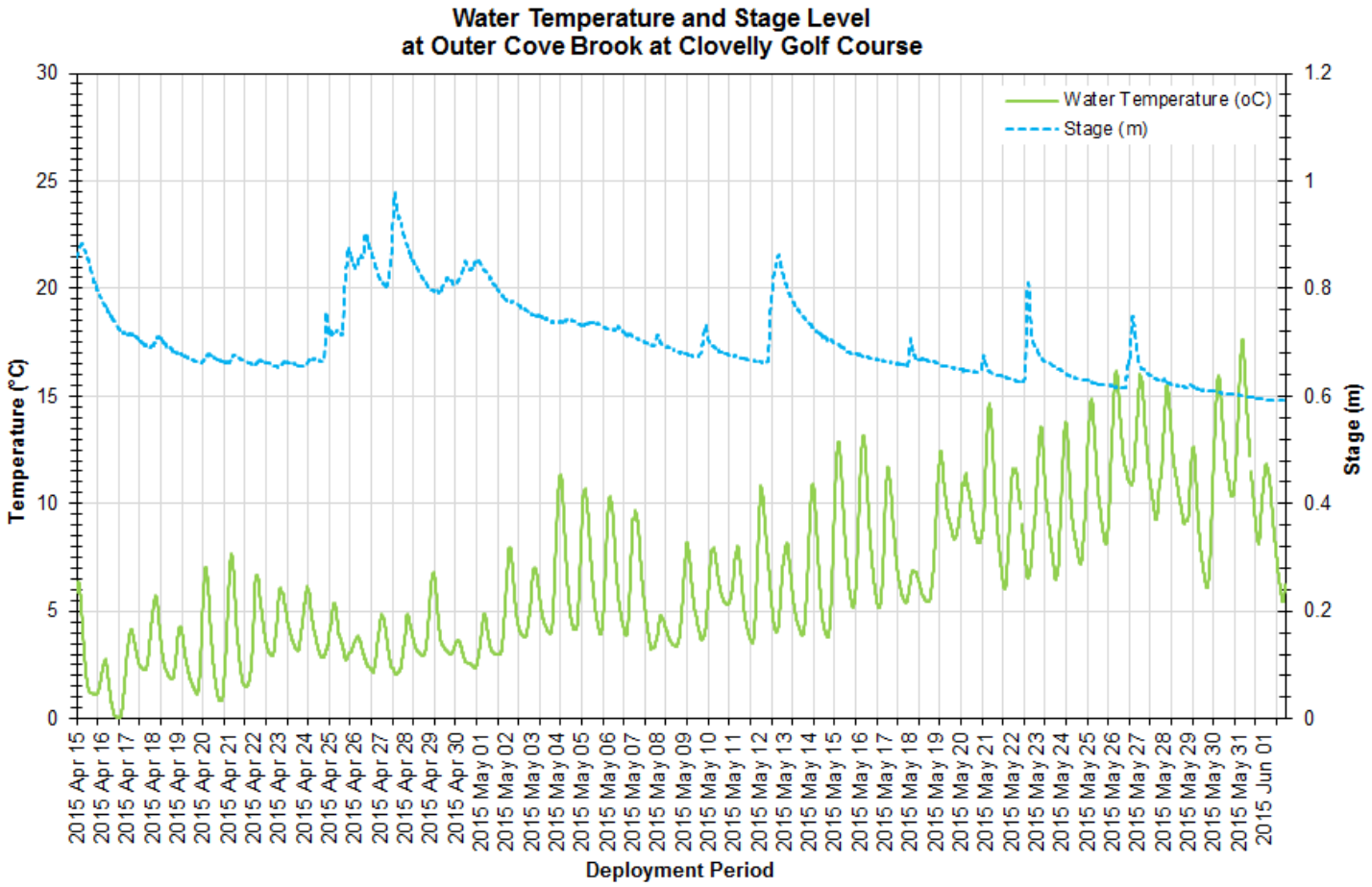

Figure 8: Water temperature (°C) and Stage (m) levels at Outer Cove Brook at Clovelly Golf Course.

pH

Throughout this deployment period pH values ranged between 5.73 pH units and 6.78 pH units (Figure 9).

During the deployment, the majority of the pH values at this station were on the lower limit of the 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 decreases in pH values.

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 6.49 units (a slightly lower pH median from last deployment).

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.

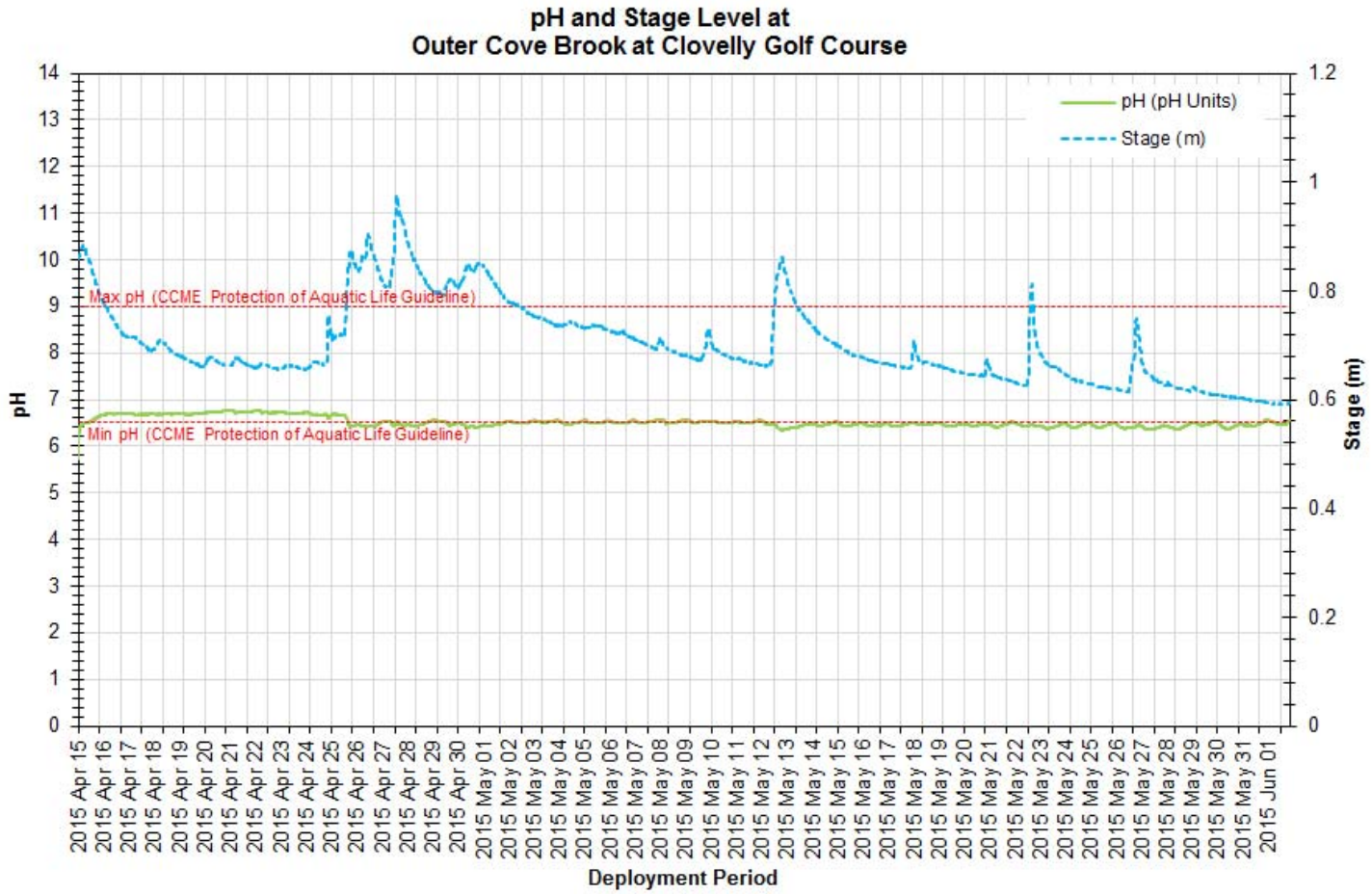

Figure 9: pH (pH units) and stage level (m) values at Outer Cove Brook at Clovelly Golf Course.

Specific Conductivity & TDS

The conductivity levels were within 241µS/cm and 778µS/cm during this deployment period. TDS ranged from 0.1540g/L to 0.4980g/L (Figure 10)

The conductivity probe measures the dissolved particles present in a water body, 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. This is evident on Figure 10, as the stage increases in the brook the conductivity levels dip for short periods of time.

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

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

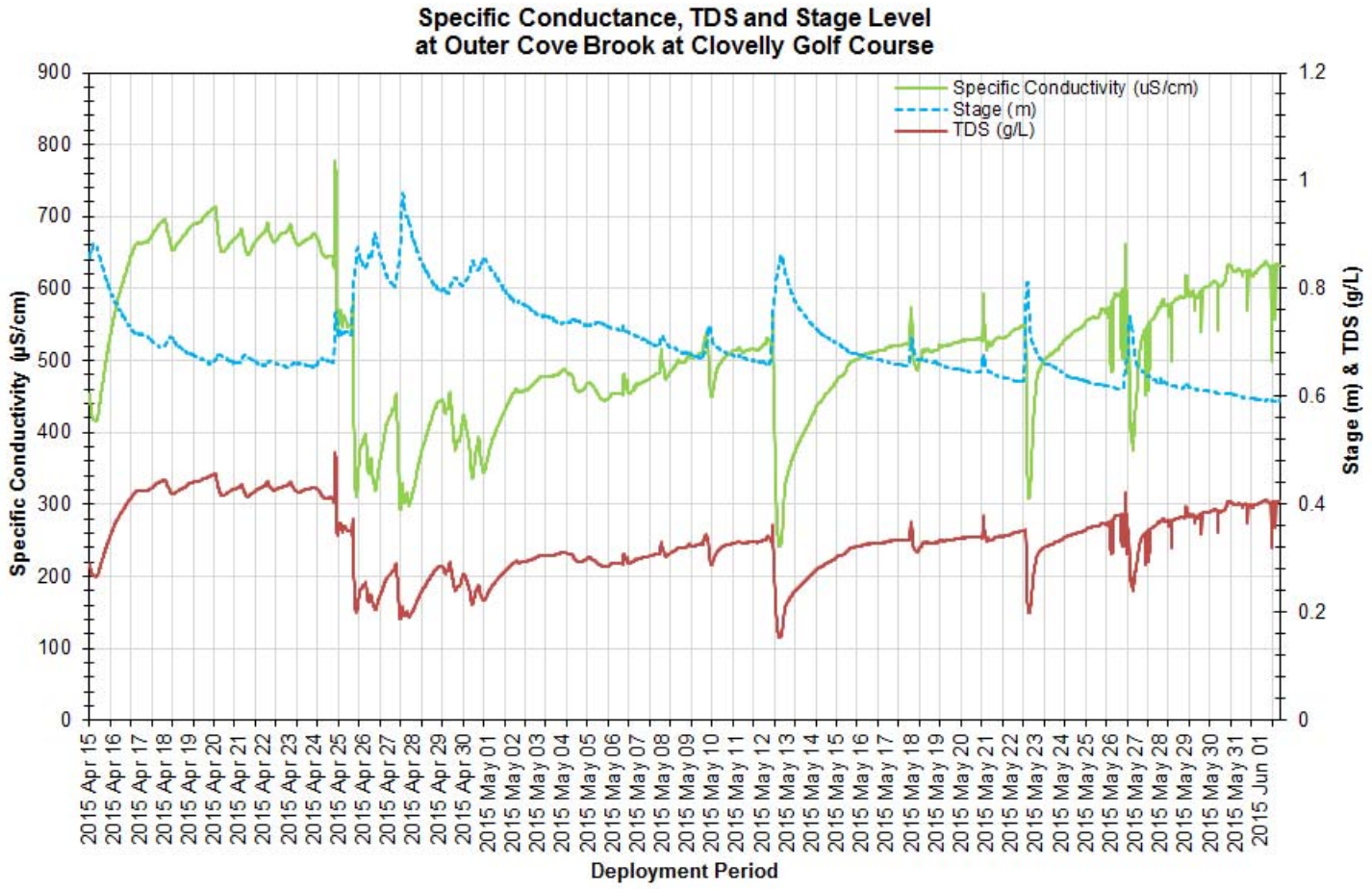

Figure 10: Specific conductivity (uS/cm) and stage (m) values at Outer Cove Brook at Clovelly Golf Course.

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 69.8 %Sat to 88.6 %Sat. Dissolved Oxygen (mg/L) measured 7.29 mg/L to 11.51 mg/L (Figure 11).

It should be noted that the warmer water temperatures decrease the amount of dissolved oxygen a water body can hold. As water temperatures increase (most likely during the day) the water dissolved oxygen levels decrease with consumption from the aquatic organisms and vegetation present in the brook.

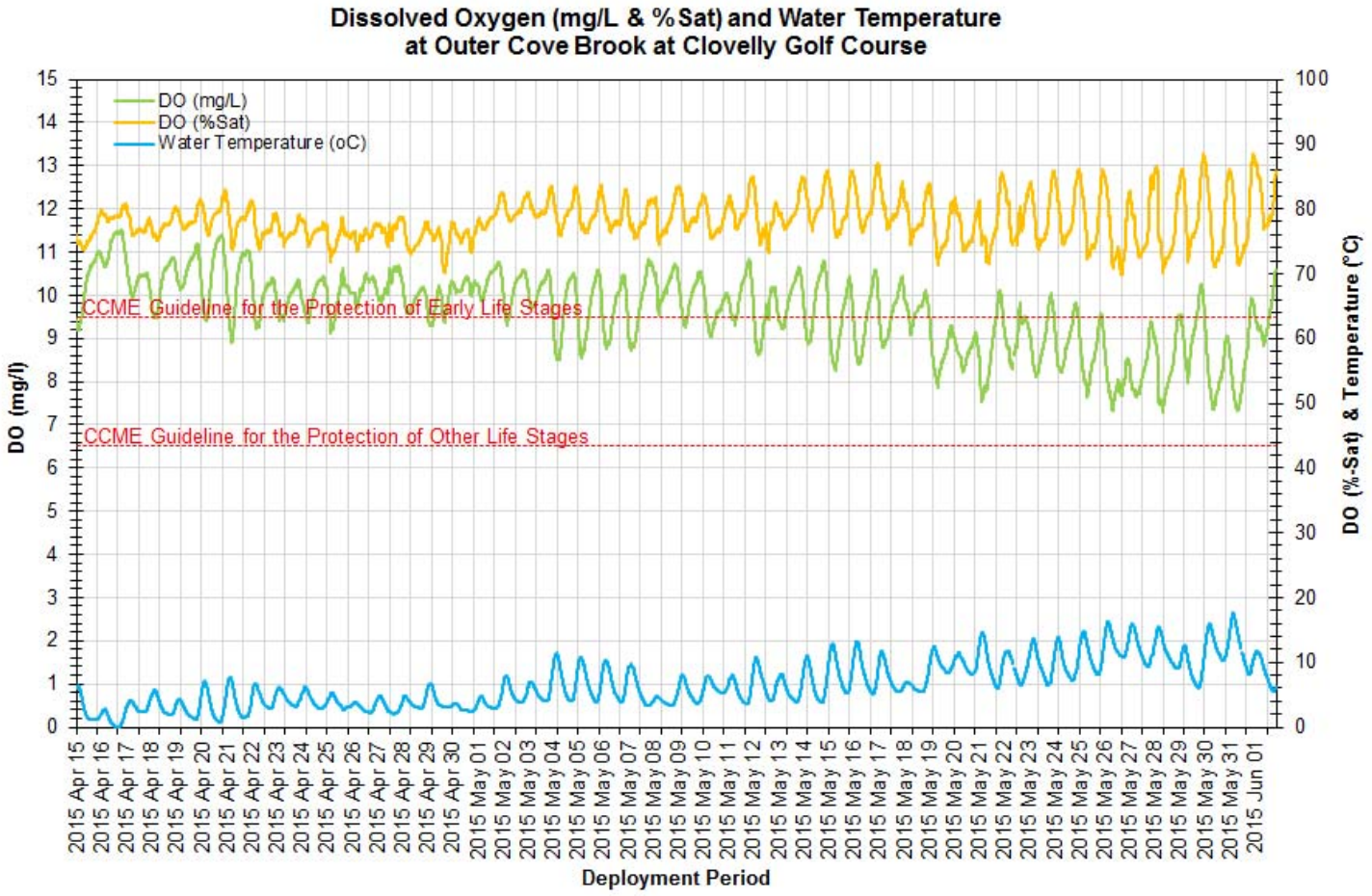

Figure 11: Dissolved oxygen (mg/L & % sat) and water temperature (°C) values at Outer Cove Brook at Clovelly Golf Course.

Turbidity

Turbidity levels during the deployment period ranged from 0.2 NTU to 72.4 NTU (Figure 12), with a median of 2.8 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 spikes during deployment. The majority of turbidity increases on the turbidity graph correspond with stage increases at the same time. The largest turbidity event on April 25th 2015 was likely a result of an increase in stage level. The total precipitation data indicates that there was 18 mm of rainfall which likely contributed to the increased turbidity.

During the data grooming process it was determined that the turbidity data from May 13th onwards was not accurate as during removal of the sonde the sensor was inhibited by fouling. Therefore the data at the end of deployment was removed.

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

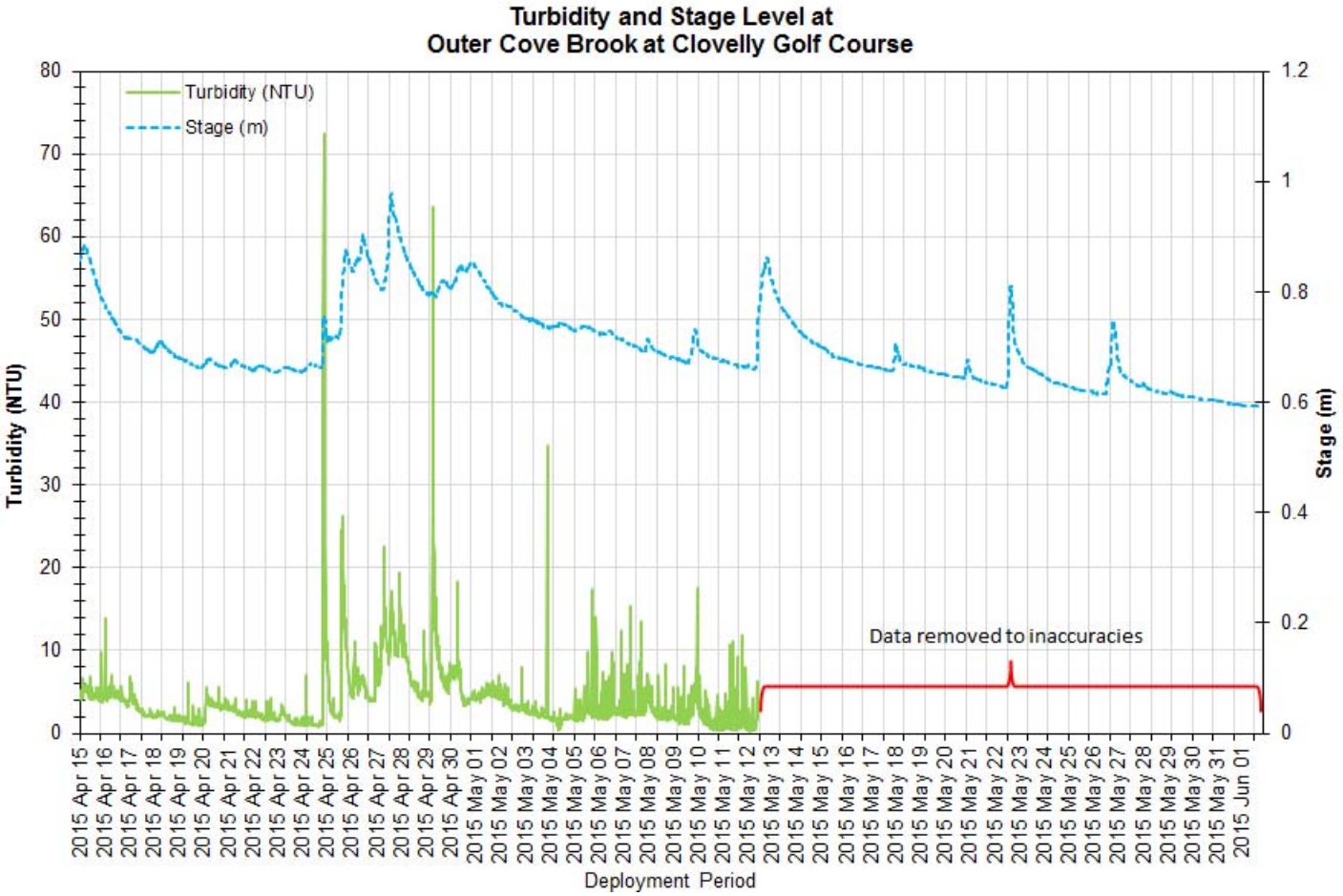

Figure 12: Turbidity (NTU) and stage level (m) values at Outer Cove Brook at Clovelly Golf Course.

Stage, Stream Flow and Total Precipitation

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 from a minimum of 0.59m to a maximum of 0.98m. Streamflow levels ranged from a minimum of 0.09m^3/s to a maximum of 1.31m^3/s. The precipitation ranged from a minimum of 0.0 mm a day to a maximum of 28.2 mm which was on April 26th, 2015. This rainfall event increased stage and stream flow at Outer Cove Brook at Clovelly Golf Course for a short period of time (Figure 13).

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

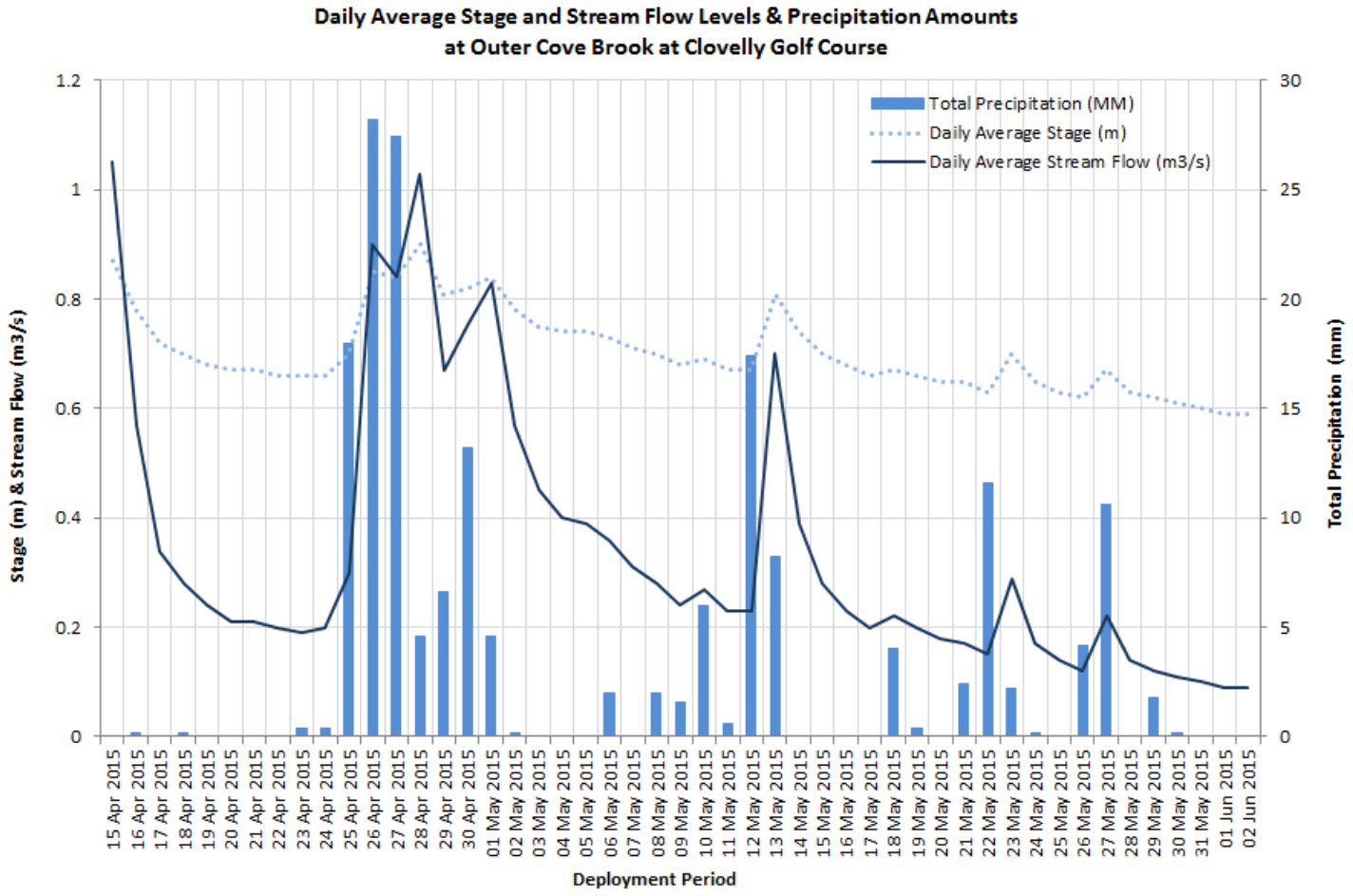

Figure 13: Daily average stage & stream flow values at Outer Cove Brook at Clovelly Golf Course and daily total precipitation values (mm) from Environment Canada's Weather Station at St. John's International Airport.

Conclusion

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 the natural flushing of the urban waterways during rainfall events. pH data remained relatively consistent throughout deployment.

As ambient air temperatures increase with slightly warmer temperatures it reflects slowly in the water temperature. In turn, the water temperatures present in the brook directly affects the amount of dissolved oxygen that is present in the waterbody.

Due to fouling on the turbidity sensor the data, from May 13th to the end of deployment, was removed.

APPENDIX I

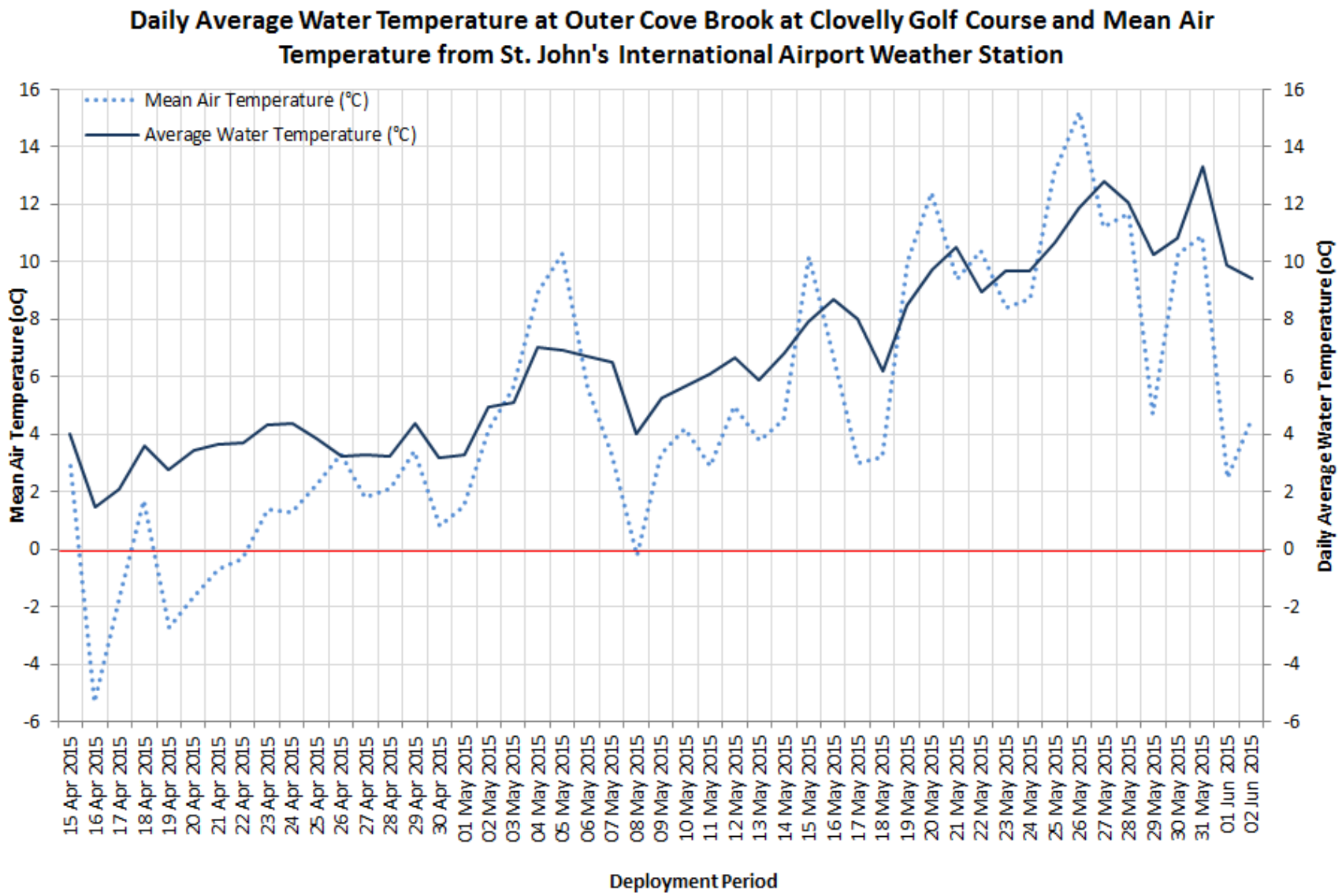

Figure 14: Daily average water temperature values from Outer Cove Brook at Clovelly Golf Course and air temperature values from Environment Canada's Weather Station at St. John's International Airport.

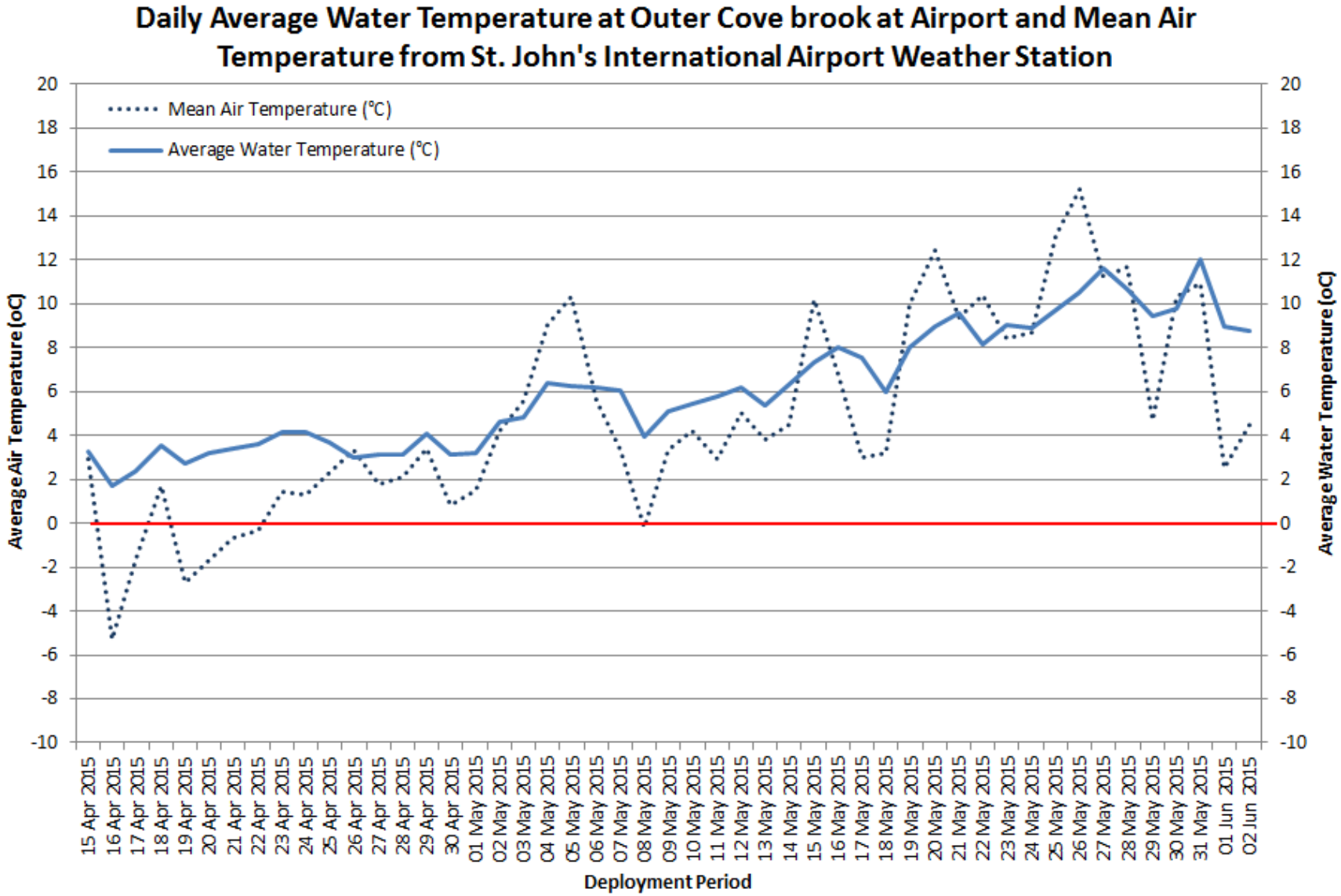

Figure 15: Daily average water temperature values from Outer Cove Brook below Airport and air temperature values from Environment Canada's Weather Station at St. John's International Airport.

APPENDIX II

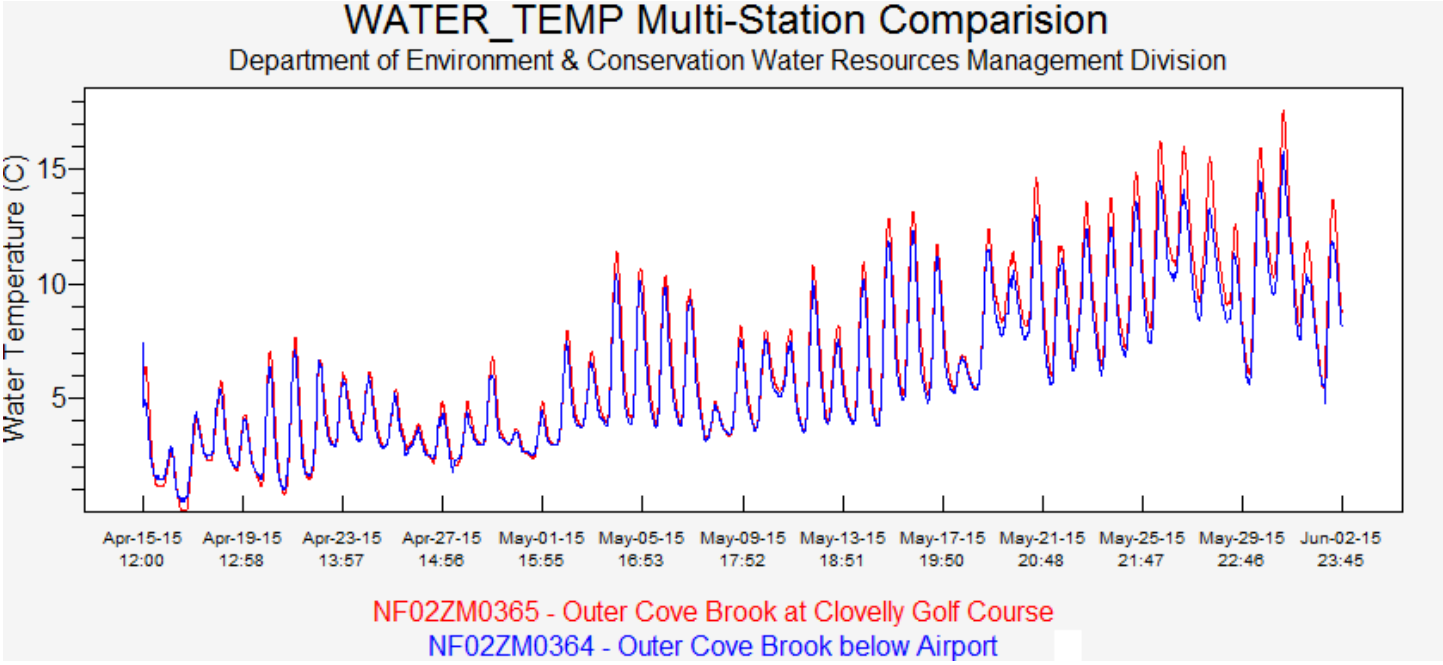

Figure 16: Comparison Water Temperature at the Outer Cove Brook Stations

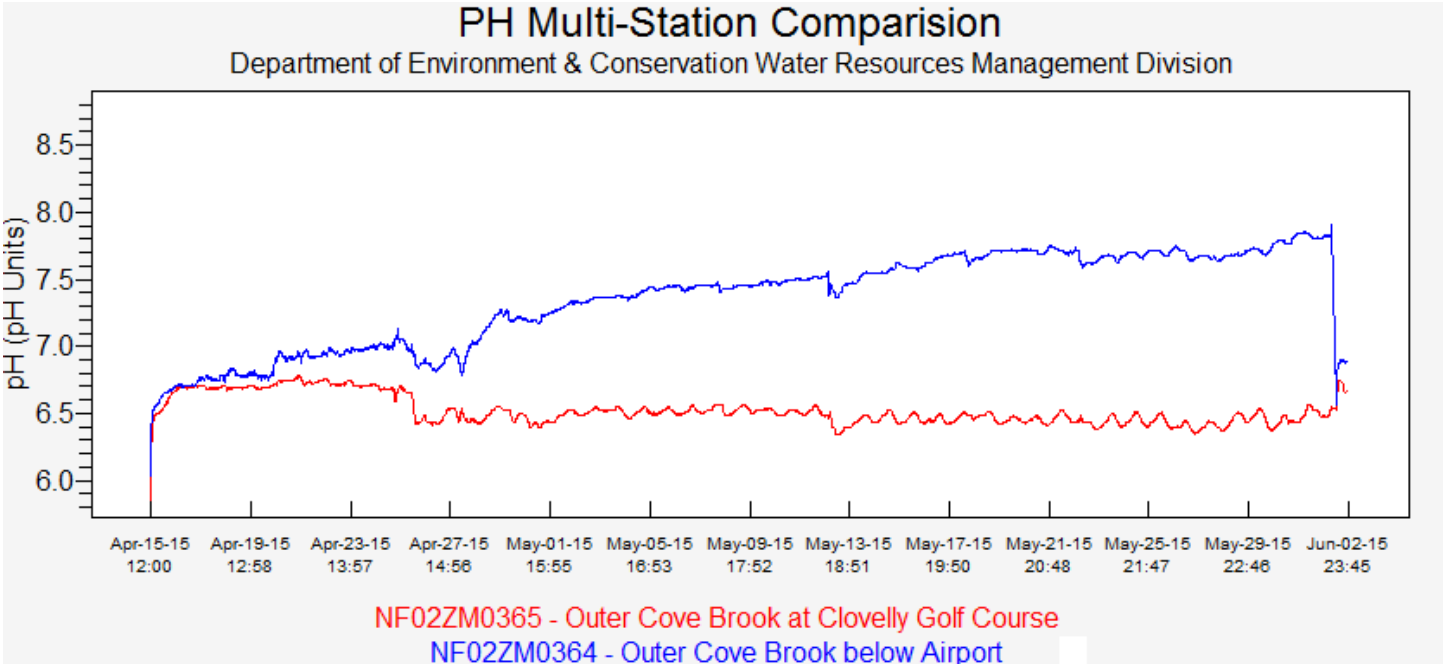

Figure 17: Comparison of pH units at the Outer Cove Brook Stations

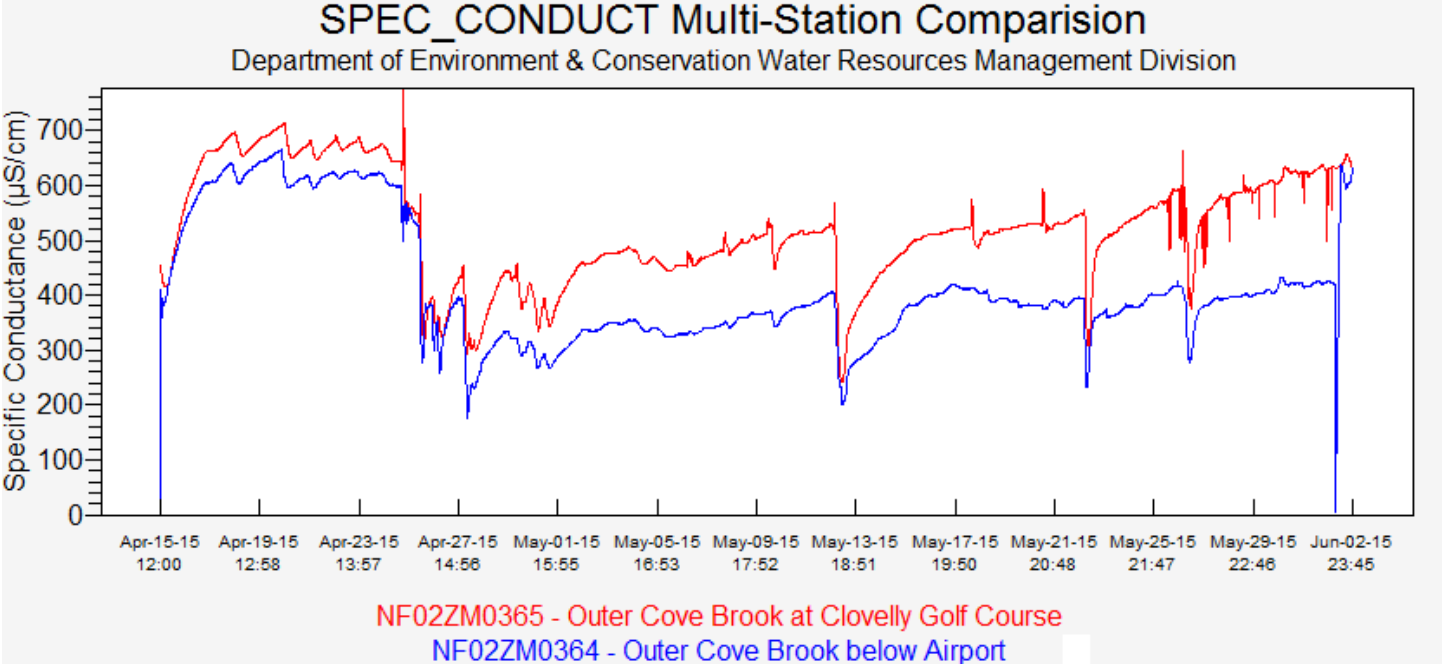

Figure 18: Comparison Specific Conductivity at the Outer Cove Brook Stations

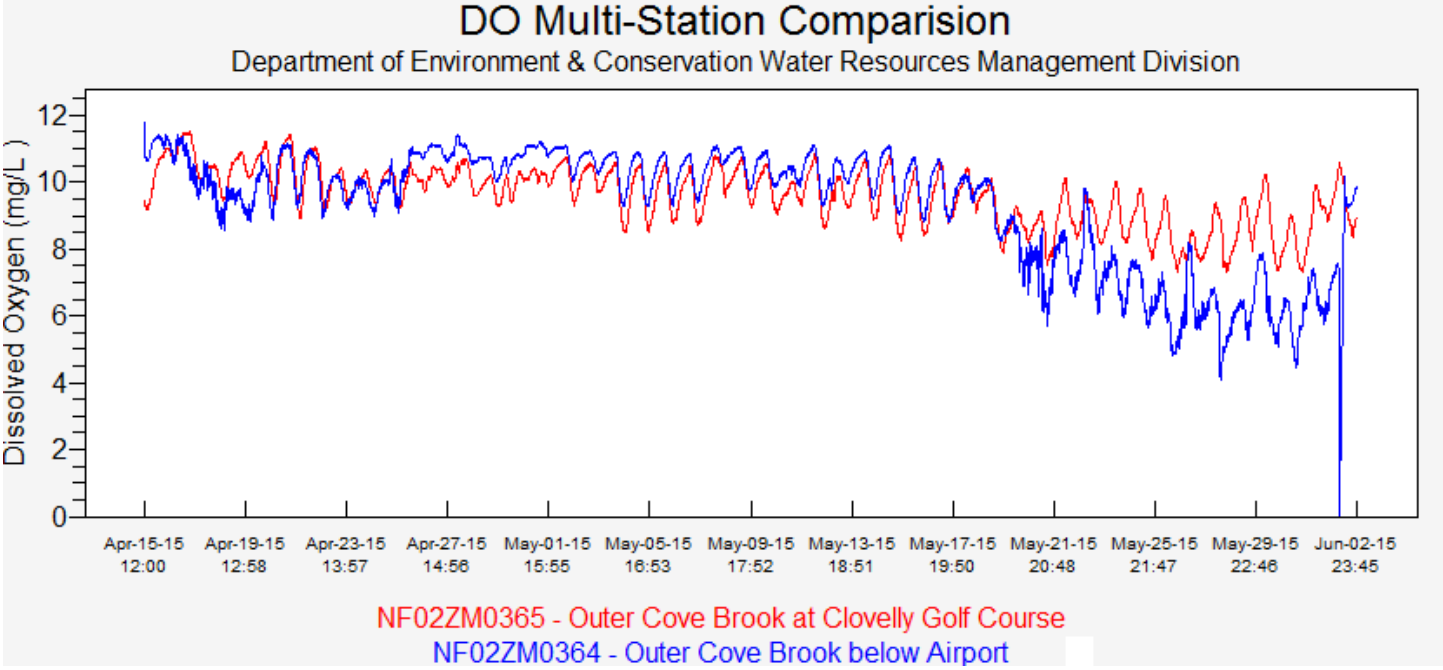

Figure 19: Comparison of Dissolved Oxygen (mg/L) at the Outer Cove Brook Station

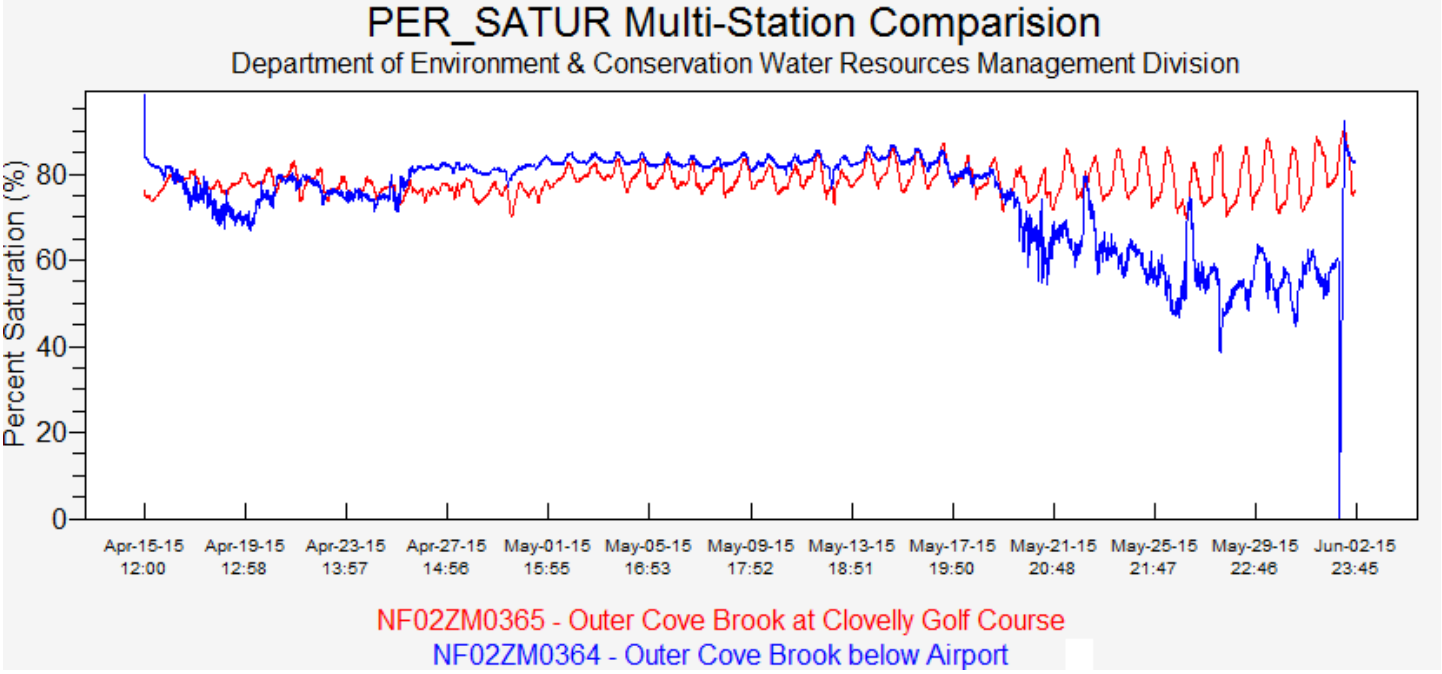

Figure 20: Comparison of Dissolved Oxygen (%Sat) of the Outer Cove Brook stations

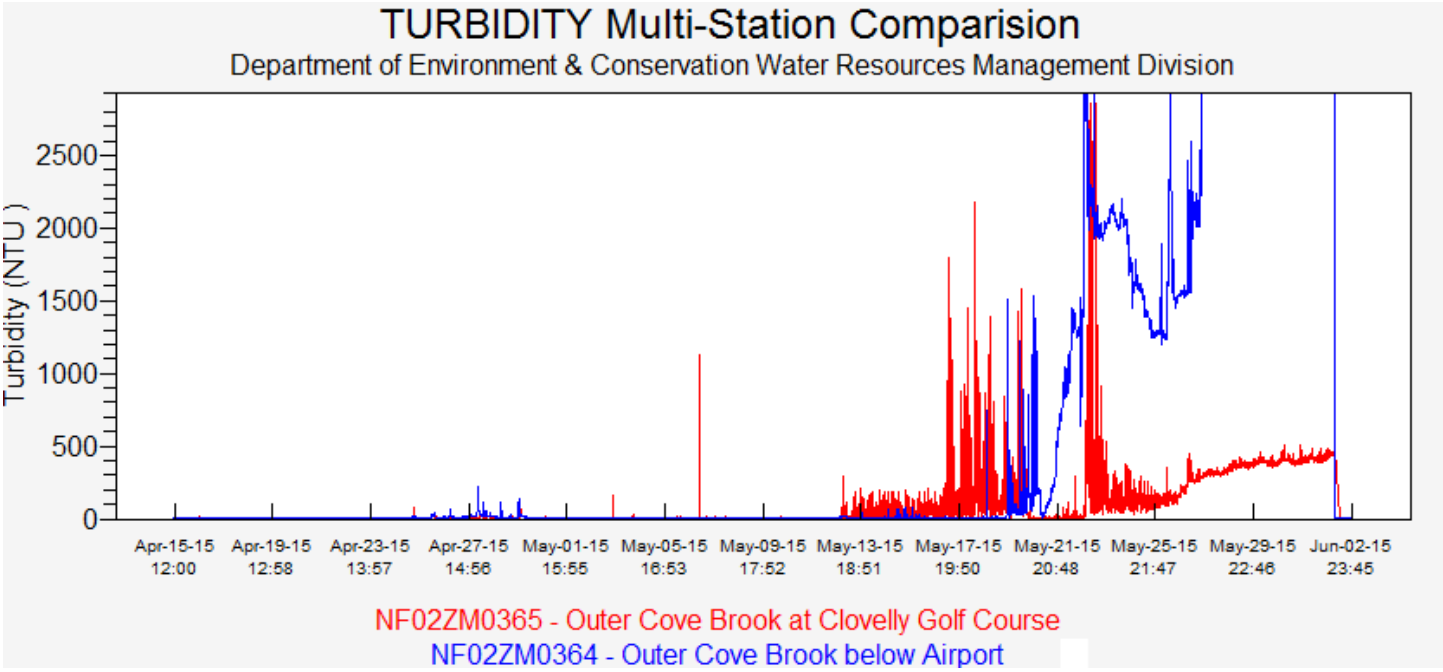

Figure 21: Comparison of Turbidity at the Outer Cove Brook stations

*Please note: Turbidity data that was removed for the report is evident in the graph above; this data does not represent the water body.