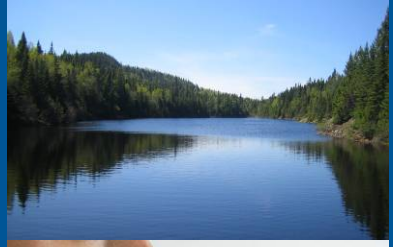
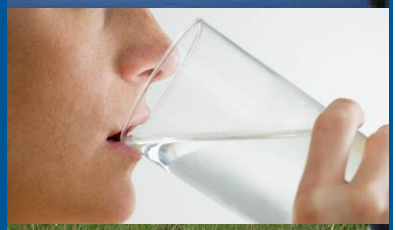






Real-Time Water Quality Report

Outer Cove Brook Network

Deployment Period includes:

Outer Cove Brook below Airport
August 28, 2015 to October 7, 2015

Outer Cove Brook at Clovelly Golf Course
September 2, 2015 to October 7, 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 August 28th, 2015 to October 7th, 2015 for the Outer Cove Brook below Airport station and the deployment period of September 2nd, 2015 to October 7th, 2015 for Outer Cove Brook at Clovelly Golf Course station. Due to weather conditions and time constraints the scheduled field visits for deployment of the instruments had to be separate.

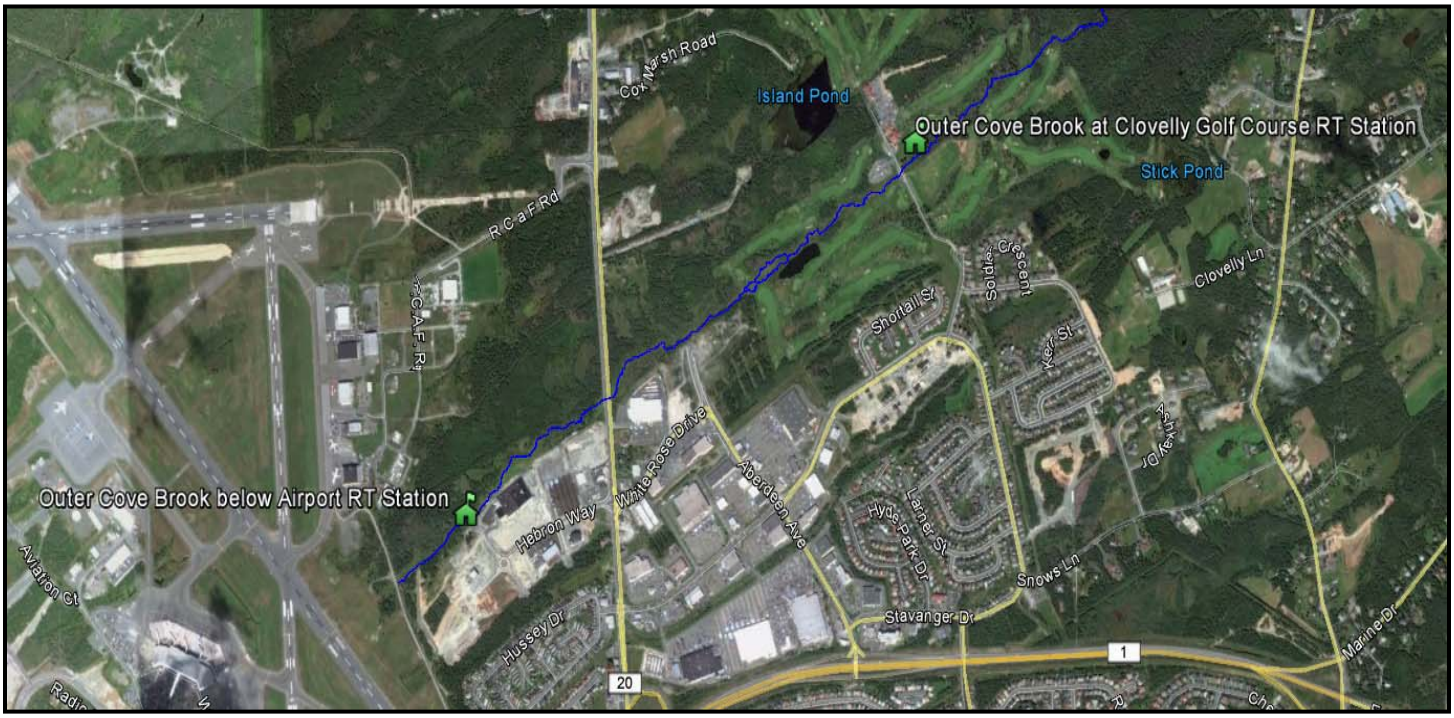

Figure 1: Outer Cove Brook Real-Time Water Quality and Quantity Stations.

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 Division (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

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	August 28	Deployment	Excellent	Good	Good	Excellent	Good
	October 7	Removal	Poor	Poor	Good	Good	Excellent

During the Outer Cove Brook below Airport station deployment, the water quality parameter data ranked as 'Excellent' for water temperature and dissolved oxygen comparisons. The pH, conductivity and turbidity data all ranked as 'Good'. These were acceptable rankings for deployment.

During the Outer Cove Brook below Airport station removal, the data collected displayed that the water quality parameters for turbidity comparisons ranking as 'Excellent'. The conductivity and dissolved oxygen data comparisons ranked as 'Good'. The water temperature and pH data ranked as 'Poor', the ranking may be a result of the QAQC instrument not being left to stabilize as long as it should have before the values were recorded.

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	September 2	Deployment	Excellent	Excellent	Excellent	Excellent	Excellent
	October 7	Removal	Poor	Good	Excellent	Good	Excellent

Comparison of the field sonde and QAQC sonde data during the deployment at Outer Cove Brook Clovelly Golf Course indicated the following: water temperature, pH, conductivity, dissolved oxygen and turbidity comparison data all ranked as 'Excellent'.

At removal the comparison between the field sonde and QAQC sonde indicated that, pH and dissolved oxygen ranked as 'Good', while conductivity and turbidity data ranked as 'Excellent' for data comparisons. Water temperature ranked as 'Poor'. This ranking may be a result of the QAQC instrument not being left to stabilize as long as it should have before the temperature values were recorded.

Outer Cove Brook below Airport

Water Temperature

Water temperature ranged from 8.00°C to 16.80°C during this deployment period (Figure 2). There were noticeable increases and decreases in the water temperature. This is consistent with ambient air temperatures over this time period, generally increasing during daylight hours and cooling overnight.

Increases in stage influenced the water temperatures to decrease slightly for a short period of time. For example, the stage increase on October 2nd, 2015 influenced the water temperature to decrease during this event which indicates that the air temperatures may be cooling.

As the deployment period came to an end, the water temperature starts to decrease. Shallow streams and ponds are highly influenced by natural diurnal variations in the surrounding air temperatures (Appendix I) and precipitation events.

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.

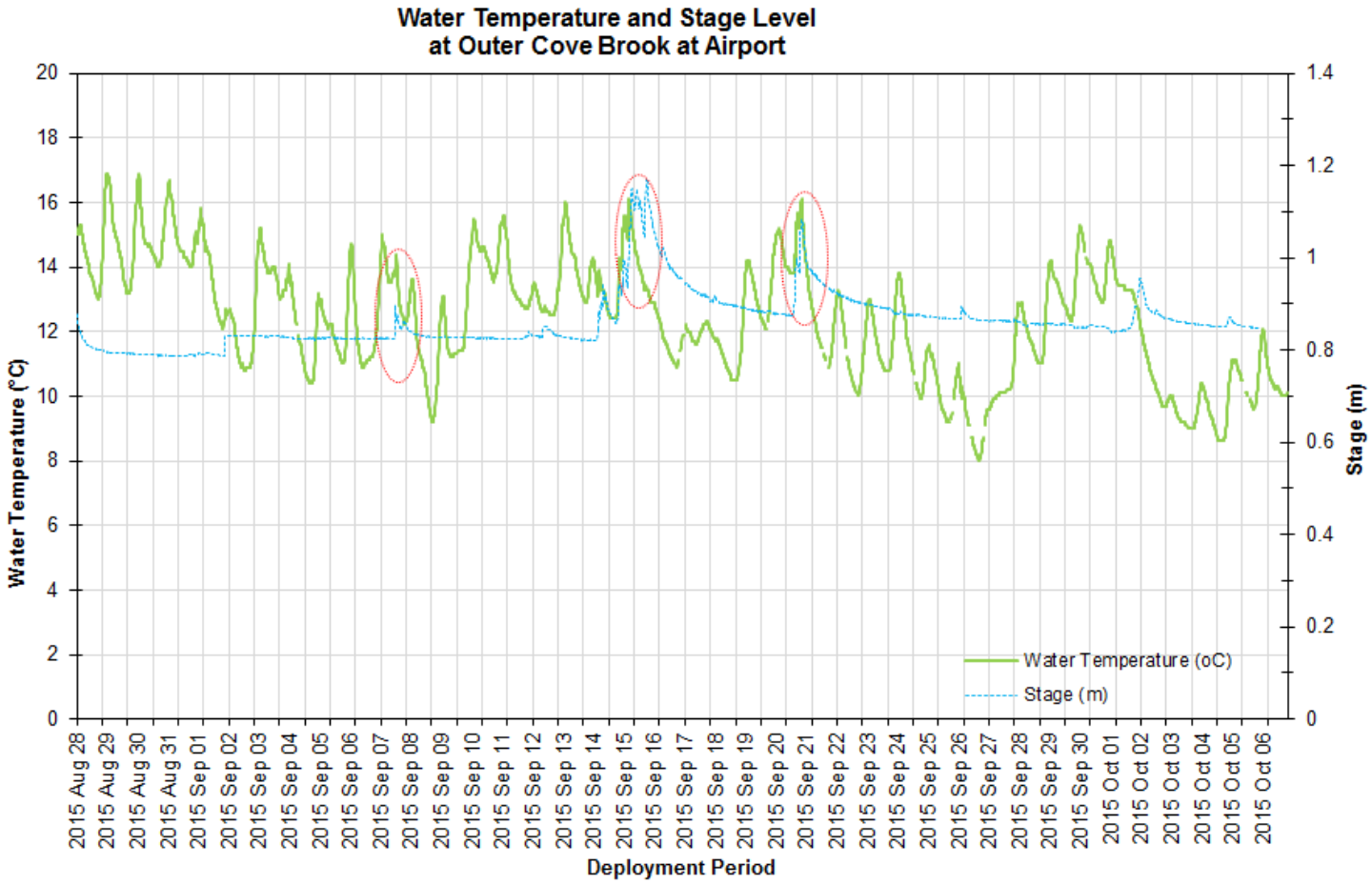

Figure 2: Water temperature (°C) and Stage (m) values at Outer Cove Brook below Airport

pH

Throughout the deployment period, pH values ranged between 5.75 pH units and 6.78 pH units (Figure 3).

During this deployment, the pH values dipped below the minimum CCME Guidelines for the Protection of Aquatic Life (6.5 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 increases the pH data decreases for a short period of time. During the deployment period, the median pH level was 6.22 pH units. The pH data decreases gradually over the deployment period.

It is likely that the stage event on September 2nd may have altered the sensor however it is still capturing the data events. It is likely that the 'Poor' ranking at removal was a result of the greater variability in the readings from this 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.

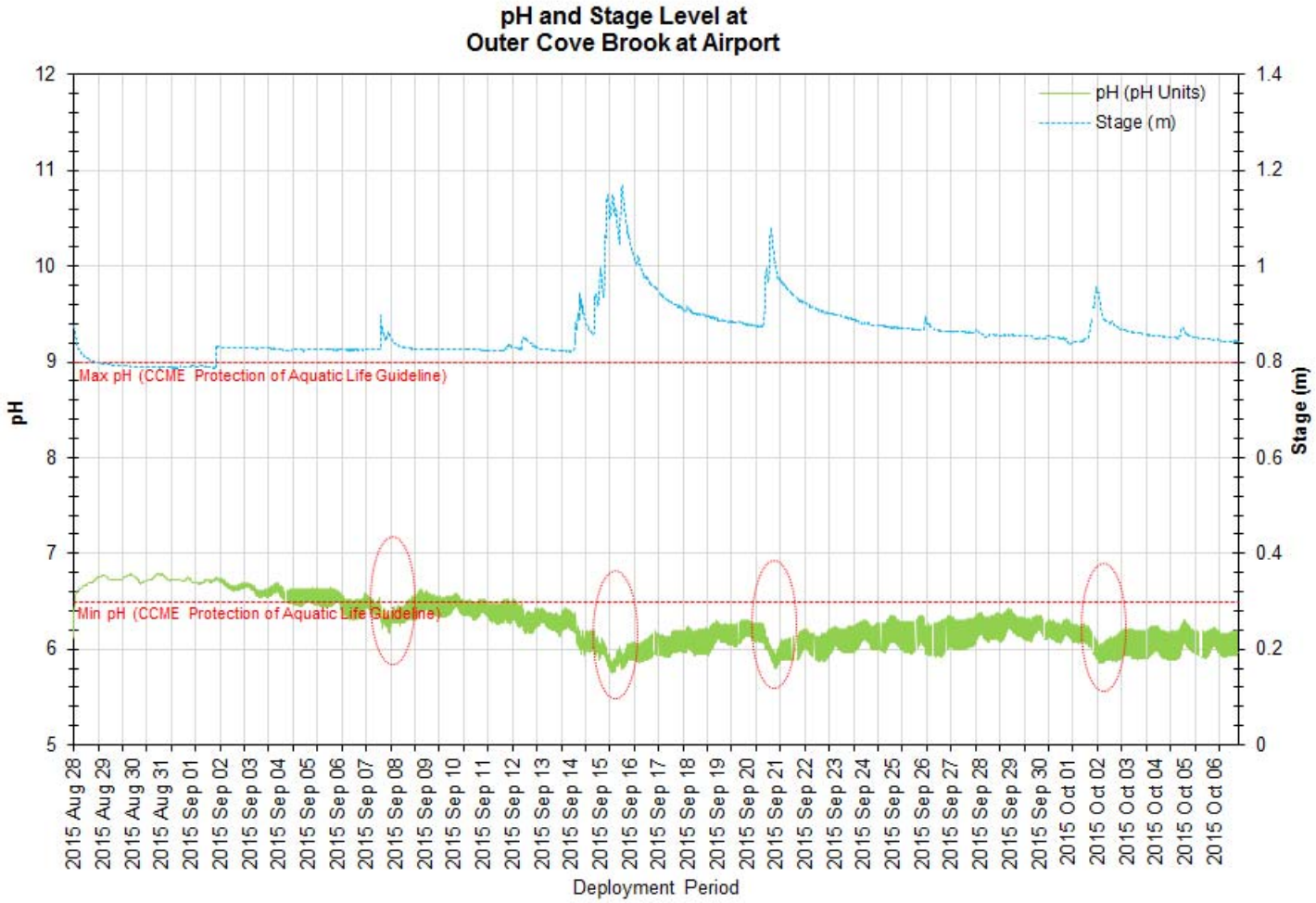

Figure 3: pH (pH units) and stage level (m) values at Outer Cove Brook below Airport

Specific Conductivity

The conductivity levels were within 80.0 µS/cm and 660.0 µS/cm during this deployment period.

Figure 4 displays the inverse relationship between conductivity and stage level. 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.

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.

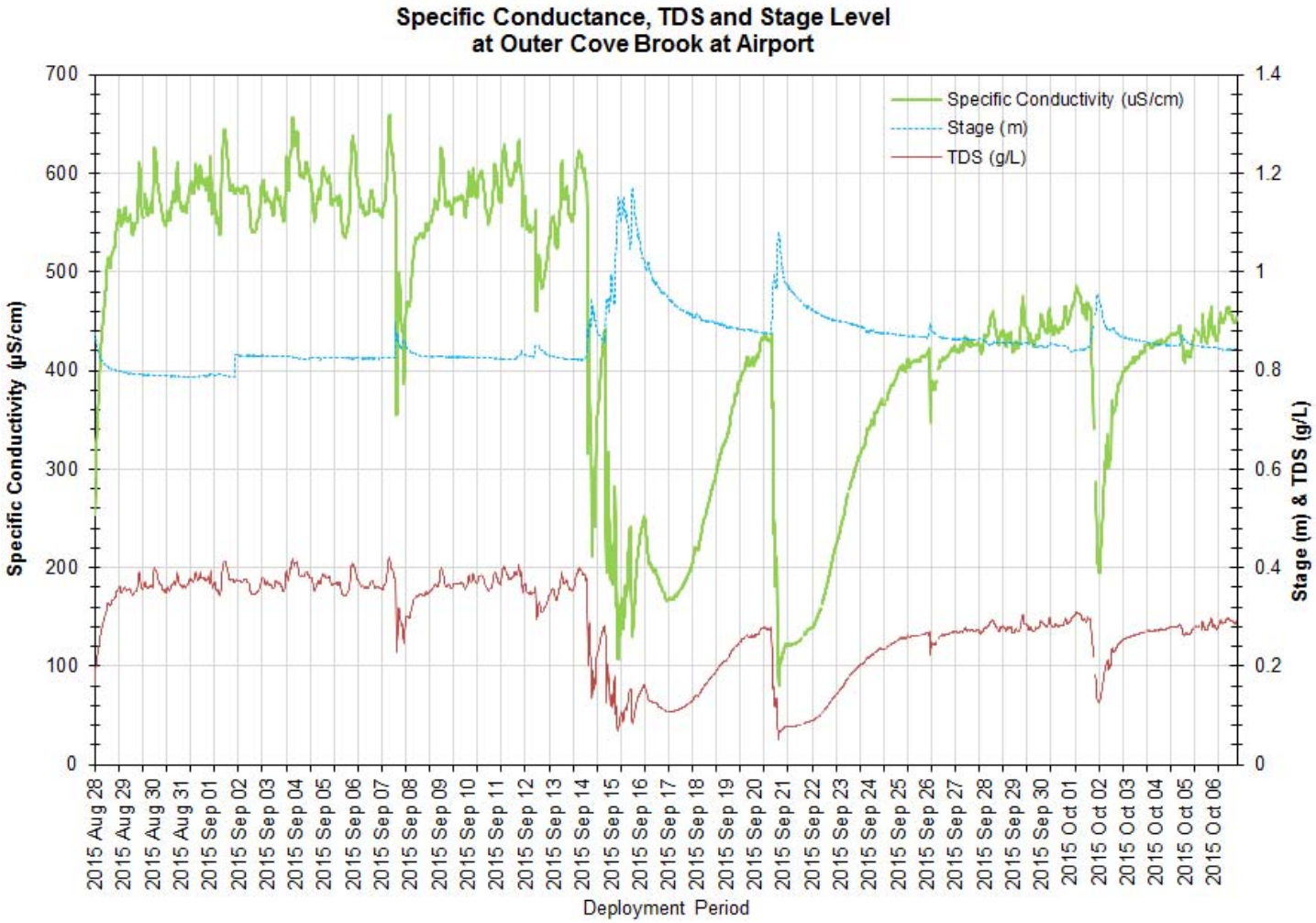

Figure 4: Specific conductivity (µS/cm) and stage (m) values at Outer Cove Brook below Airport.

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 82.8 %Sat to 93.2 %Sat. Dissolved Oxygen (mg/L) measured 8.44 mg/L to 10.74 mg/L (Figure 5).

The dissolved oxygen levels increased slightly as the deployment period continued. The cooler water temperatures utilized less dissolved oxygen present in the water body as the air temperatures start to drop. This is a normal occurrence in water as the winter season approaches.

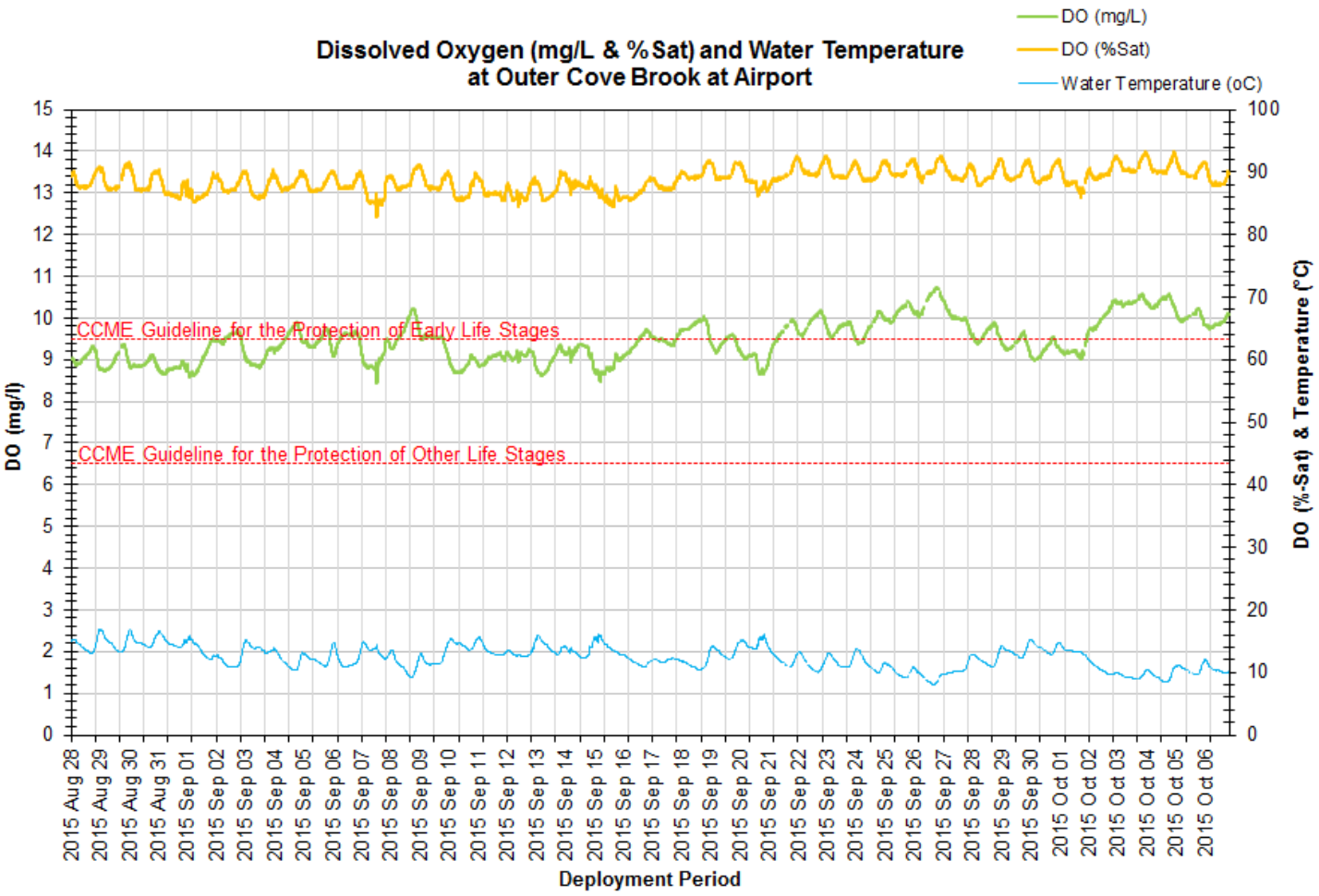

Figure 5: Dissolved oxygen (mg/L & % sat) and water temperature (°C) values at Outer Cove Brook below Airport.

Turbidity

Turbidity levels during the deployment ranged between 0.0 NTU and 894.0 NTU (Figure 6). The deployment data had a median of 7.3 NTU.

Most of the turbidity events (highlighted in red circles) in the deployment period correlate with increases in stage potentially from precipitation (Figure 6). Precipitation can increase the presence of suspended material in water.

The turbidity events over September 28th, 29th & 30th, 2015 do not link with any stage increases or precipitation events. It is unclear what influenced the turbidity during this time. During this same timeframe conductivity levels were slightly disrupted.

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.

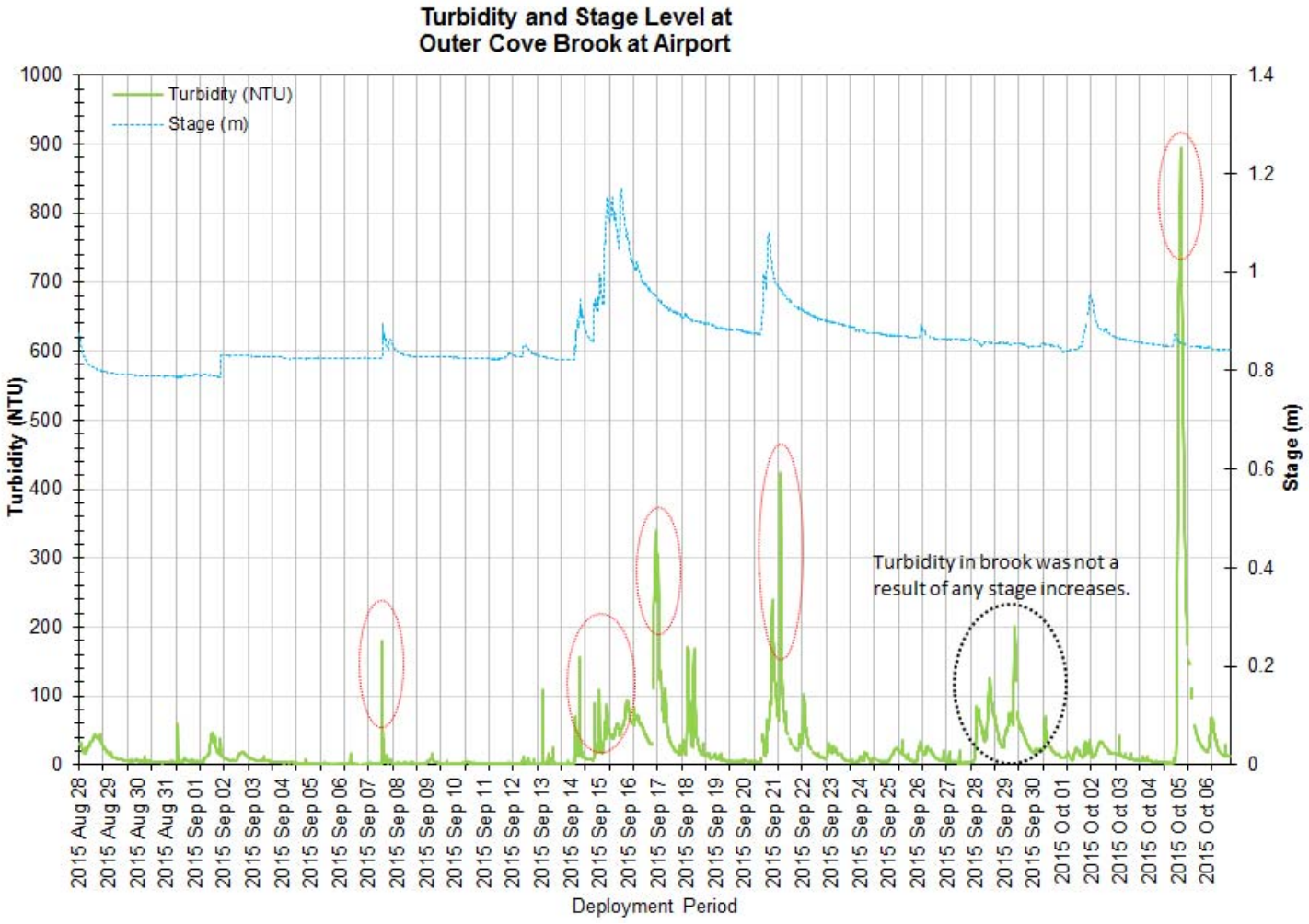

Figure 6: Turbidity (NTU) and stage level (m) values at Outer Cove Brook below Airport.

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 0.79m to 1.17m. Stream flow data ranged within 0.03 m^3/s to 2.19 m^3/s. 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 67 mm on September 15th, 2015 which increased both stage and stream flow on the same day.

Please note the stage and stream flow 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.

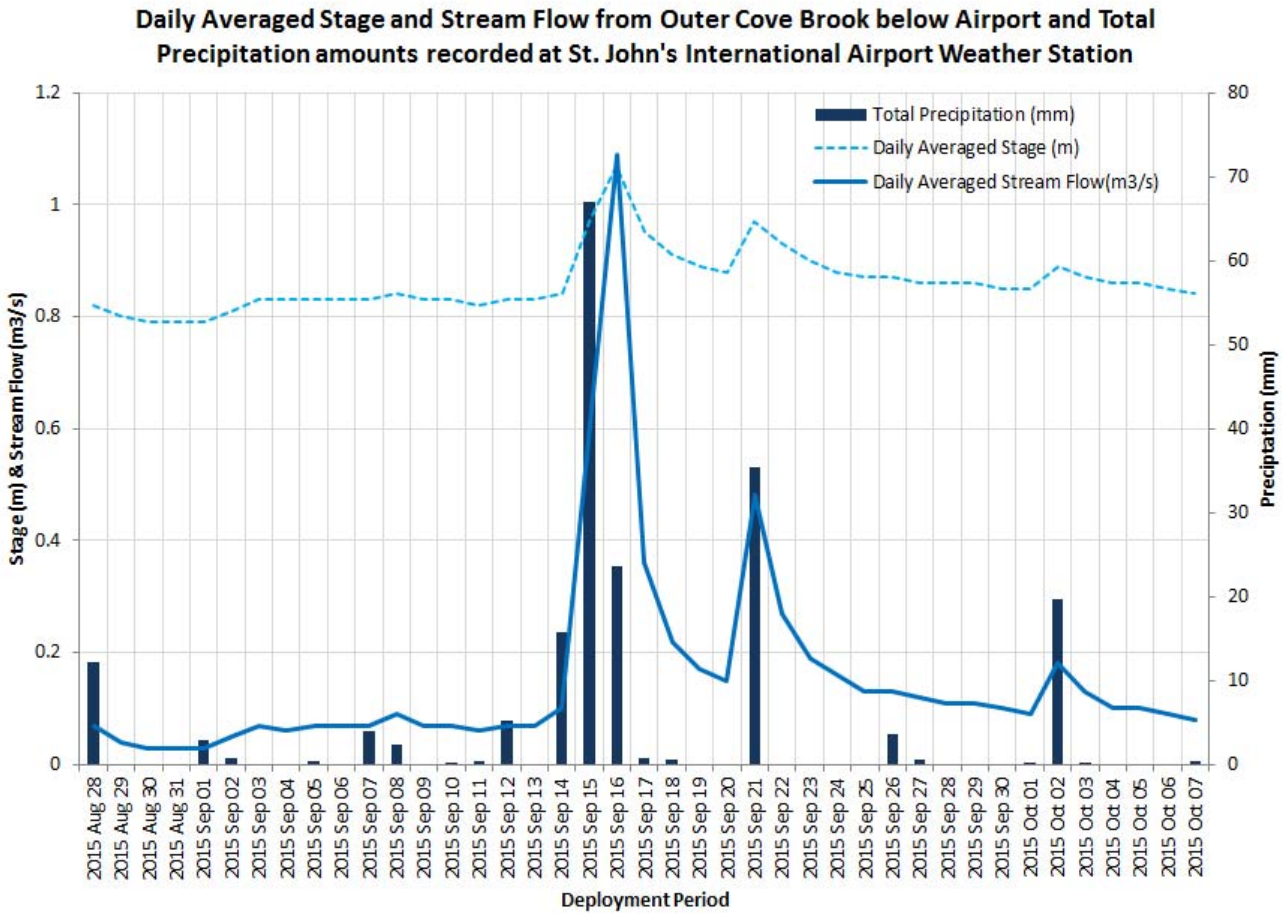

Figure 7: Daily average stage & stream flow values at Outer Cove Brook below Airport and daily total precipitation values from Environment Canada's St. John's Airport Station.

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 turbidity events on September 28th, 29th and 30th that could not be explained by stage increases or precipitation influences. Conductivity values also indicated a slightly change and dissolved oxygen levels dipped slightly during these same dates. It was not determined what could have influenced the water body.

The cooling ambient air temperatures (Appendix I) resulted in a lower dips 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.

Outer Cove Brook at Clovelly Golf Course

Water Temperature

Water temperature ranged from 7.72°C to 17.75°C during this deployment period (Figure 8).

During this deployment period the water temperature remains reasonably consistent. Water temperatures decreased slighting toward the end of the deployment (Figure 8). There are minor dips in water temperature during higher stage events; this can be noted on several occasions circled in red on Figure 8.

Water temperature recorded by the water quality instruments is a very important parameter 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.

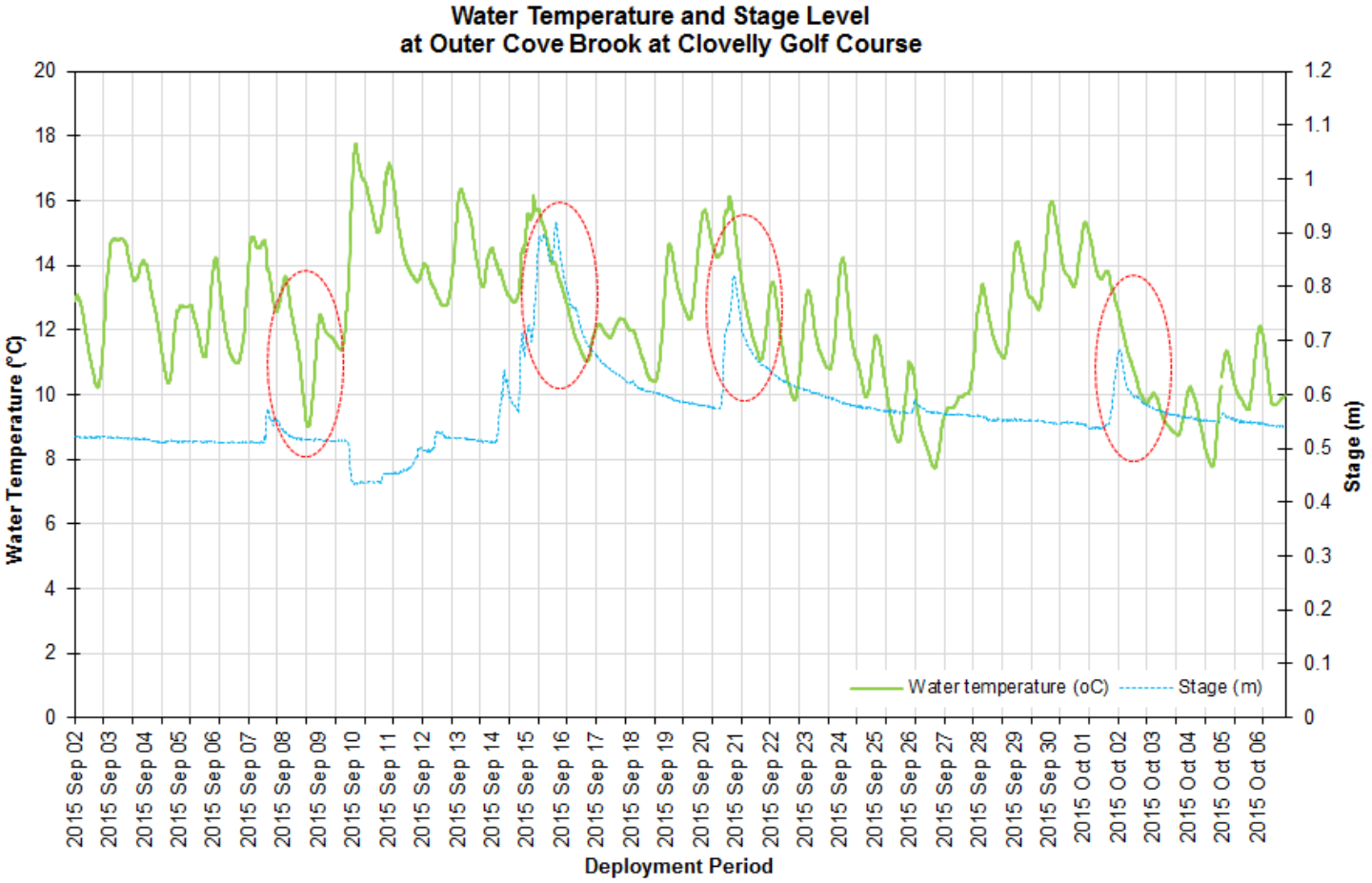

Figure 8: Water temperature (°C) and Stage (m) levels at Outer Cove Brook at Clovelly Golf Course.

pH

Throughout this deployment period pH values ranged between 5.77 pH units and 6.42 pH units (Figure 9).

The pH data remained below the minimum CCME guideline for the Protection of Aquatic Life during this deployment. There are very slight decreases in pH during higher stage events (for example September 16th and September 21st, 2015).

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 6.18 units (slightly higher than pH median from last deployment of 6.13 pH units).

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.

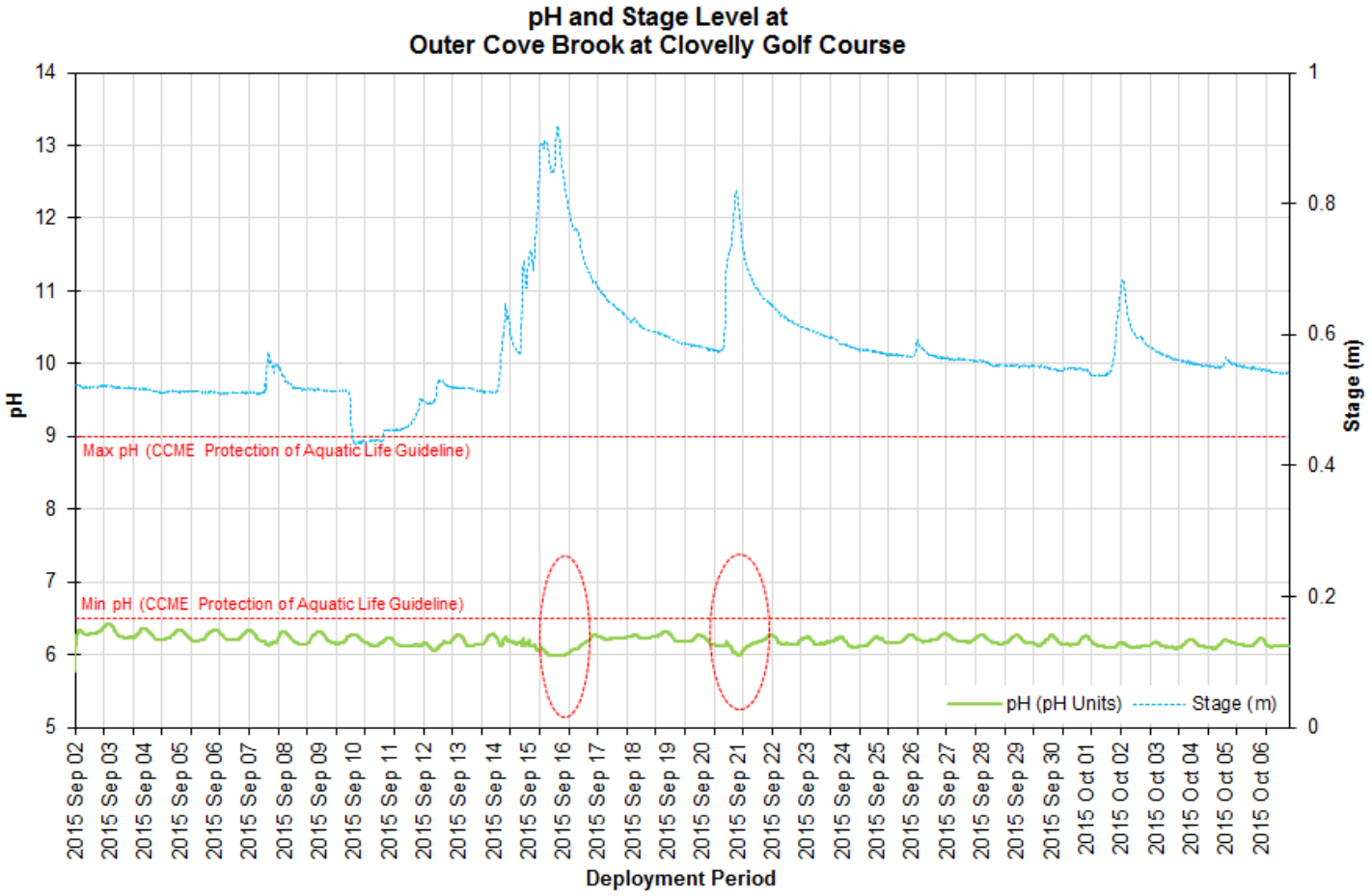

Figure 9: pH (pH units) and stage level (m) values at Outer Cove Brook at Clovelly Golf Course.

Specific Conductivity & TDS

The conductivity levels were within 173.6µS/cm and 644.0µS/cm during this deployment period. TDS ranged from 0.1111g/L to 0.4120g/L (Figure 10). The conductivity probe measures the dissolved particles present in a water body, an increase in stage can indicate rainfall.

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.

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.

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

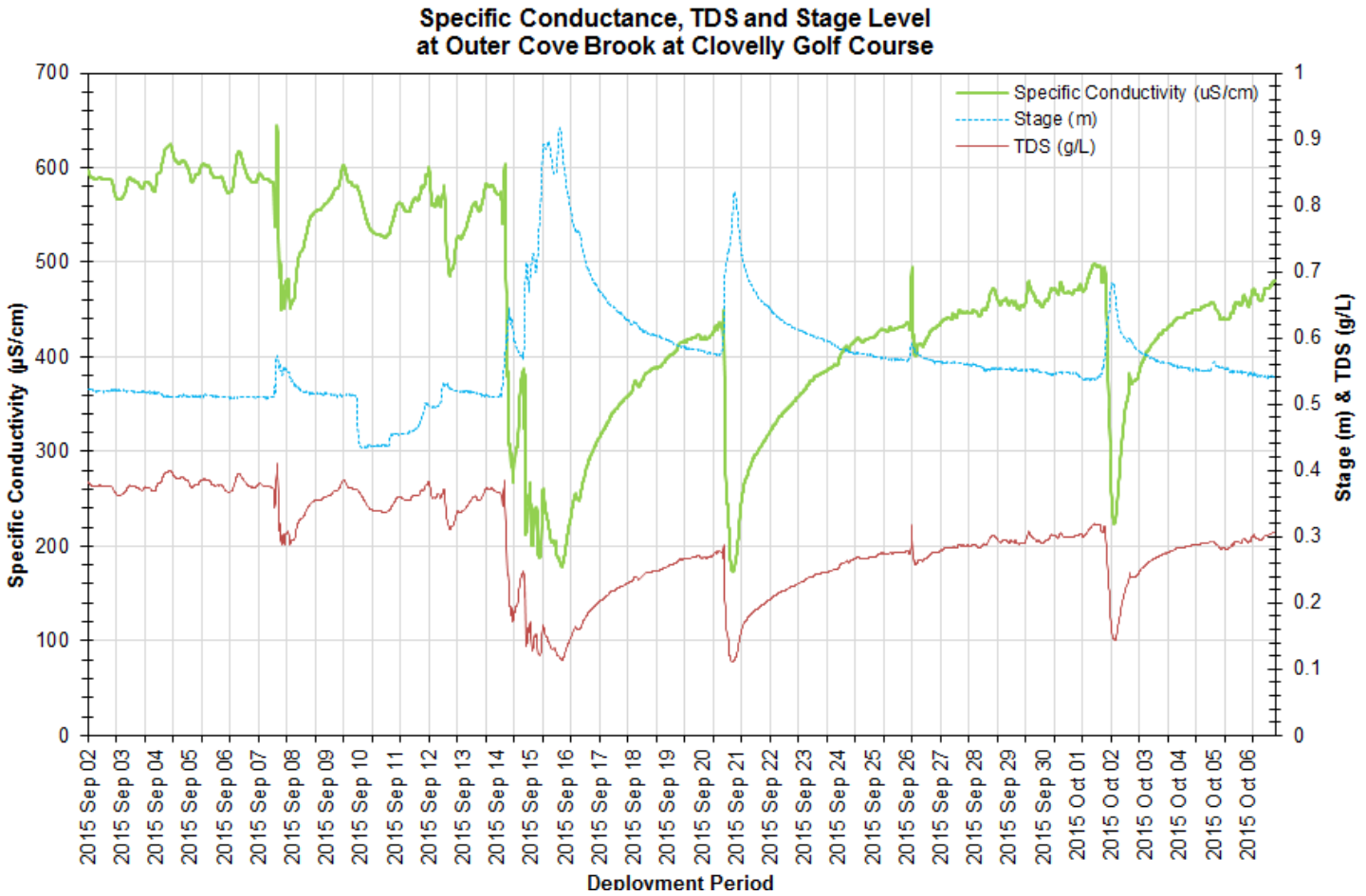

Figure 10: Specific conductivity (uS/cm) and stage (m) values at Outer Cove Brook at Clovelly Golf Course.

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 62.6 %Sat to 97.3 %Sat. Dissolved Oxygen (mg/L) measured 6.25 mg/L to 10.88 mg/L (Figure 11).

The majority of dissolved oxygen (mg/L) data level remained above the CCME Guideline for the Protection of Other Life Stages. 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 dissolved oxygen levels in the water decrease with consumption from the aquatic organisms and vegetation present in the brook.

The dissolved oxygen levels dipped below the guideline on September 10th and when compared to the mean air temperatures (Appendix I) for St. John's at those times it is during some of the warmest periods of this deployment.

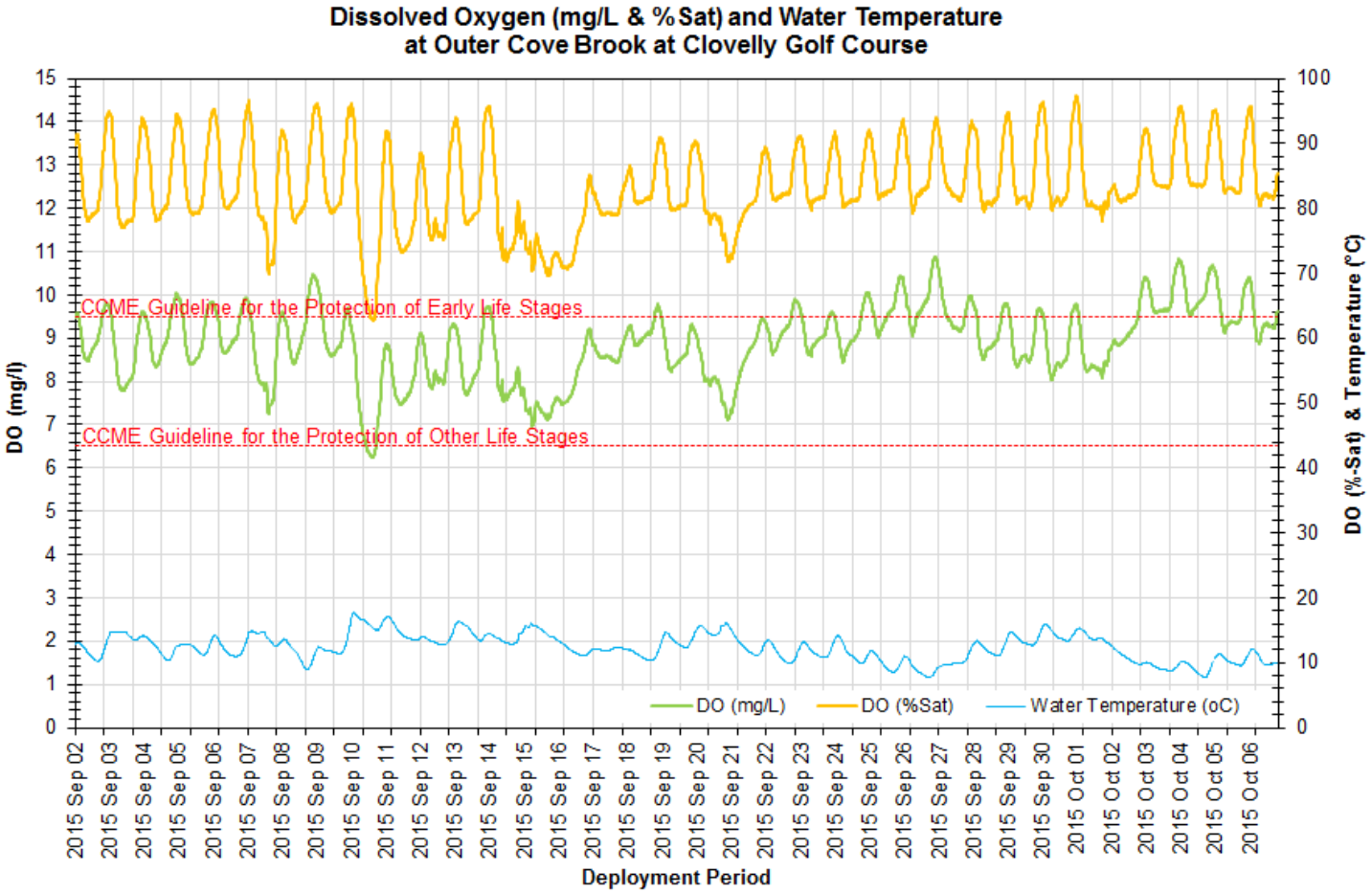

Figure 11: Dissolved oxygen (mg/L & % sat) and water temperature (°C) values at Outer Cove Brook at Clovelly Golf Course.

Turbidity

Turbidity levels during the deployment period ranged from 0.0 NTU to 196.4 NTU (Figure 12), with a median of 2.8 NTU.

As depicted on the graph there were several turbidity spikes during this deployment. The majority of turbidity increases on the turbidity graph correspond with stage increases at the same time (events are highlighted in red circles).

Turbidity events that occurred on September 28th, 29th and 30th as well as October 5th, 2015 did not coincide with stage increases or precipitation events. It cannot be determined what may have influenced the turbidity during this time. The turbidity events listed were also evident in the Outer Cove Brook below Airport turbidity data review (Figure 6).

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

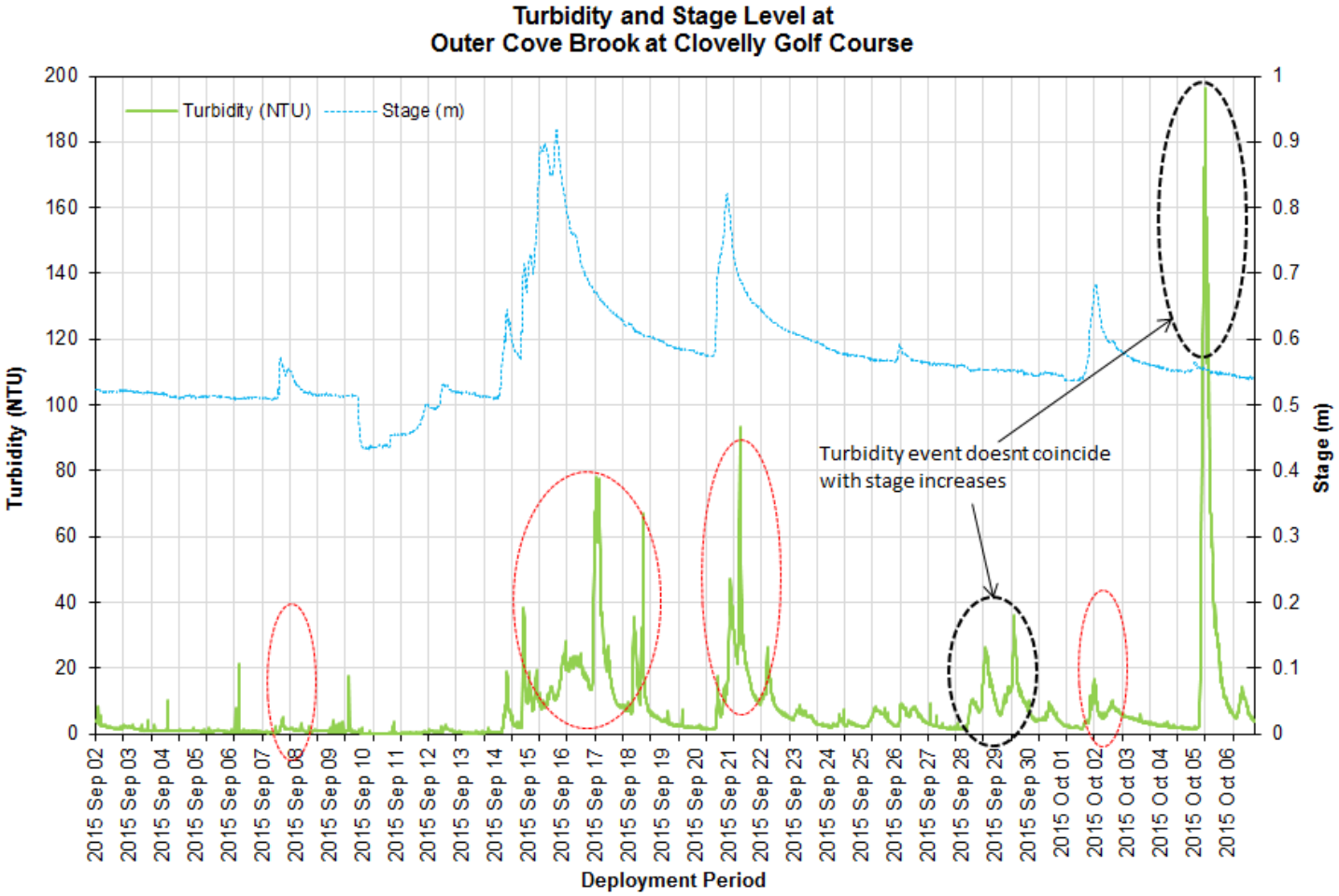

Figure 12: Turbidity (NTU) and stage level (m) values at Outer Cove Brook at Clovelly Golf Course.

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 0.43m to a maximum of 0.92m. Stream flow levels ranged from a minimum of 0.01m^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 67mm which was on September 15th, 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 stream flow 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.

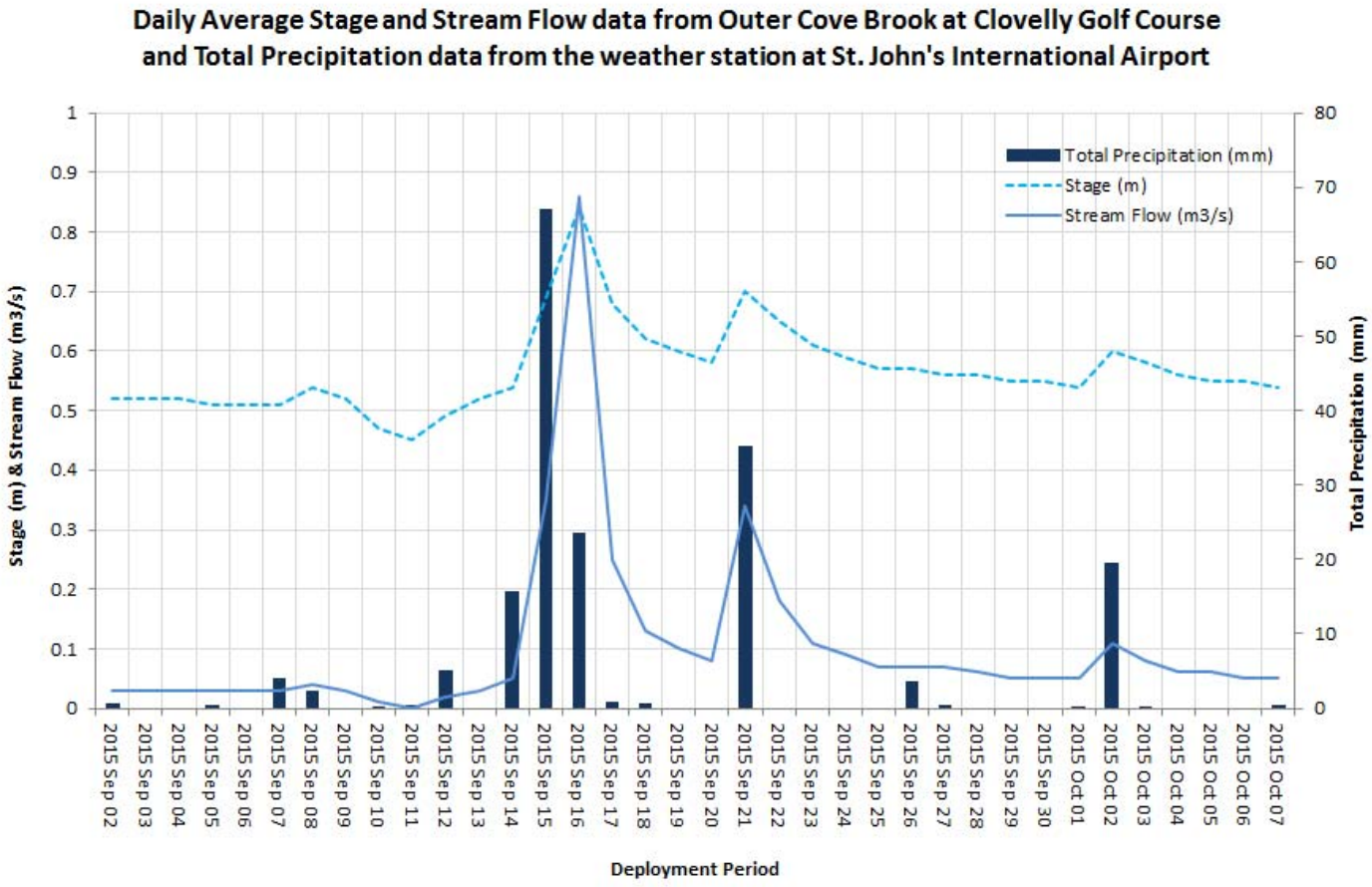

Figure 13: Daily average stage & stream flow values at Outer Cove Brook at Clovelly Golf Course and daily total precipitation values (mm) from Environment Canada's Weather Station at St. John's International Airport.

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.

Water temperature displayed data representative of an urban brook, with examples of small increases in water temperature during higher stage events. pH data indicated an influence from the higher stage event on September 16th and 21st , 2015. Increases in stage influenced the conductivity levels, the values decreased as the suspended minerals are flushed from the brook for a short period of time.

Dissolved oxygen levels remained relatively constant. The concentration levels of dissolved oxygen had a median of 8.94mg/L during deployment. The dissolved oxygen levels dropped below the CCME guideline for the Protection of Other Life Stages during a period of warmer water temperatures on September 10th 2015.

Turbidity levels fluctuated during deployment, with the majority of the higher turbidity values linked with high stage levels. There are several separate turbidity events that do not correspond with stage increases or precipitation at those times. These turbidity events are also evident on the turbidity data graphed for Outer Cove Brook below Airport. It is not determined what may have influenced the turbidity levels.

APPENDIX I

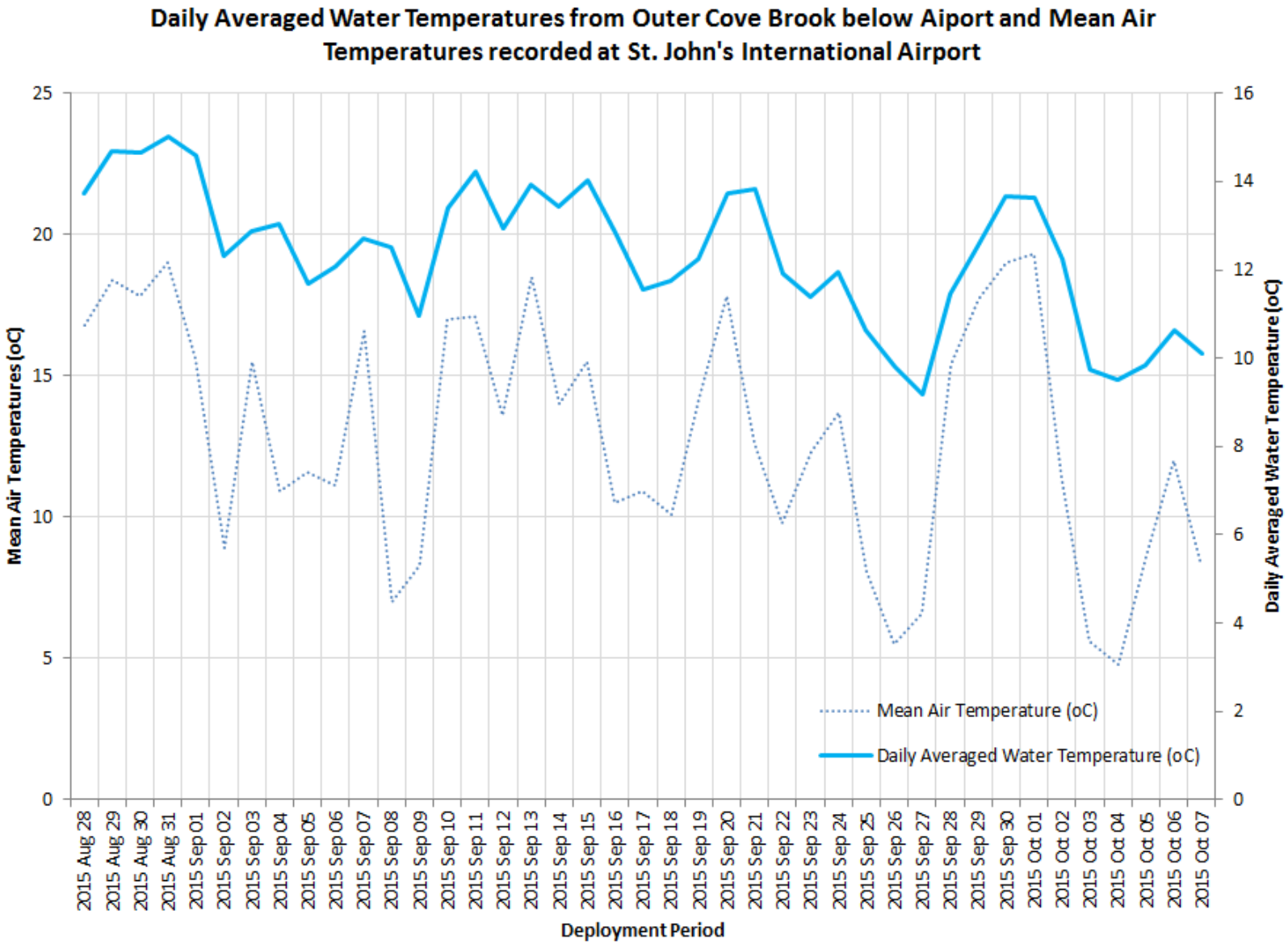

Figure 14: Daily average water temperature values from Outer Cove Brook below Airport and air temperature values from Environment Canada's Weather Station at St. John's International Airport.

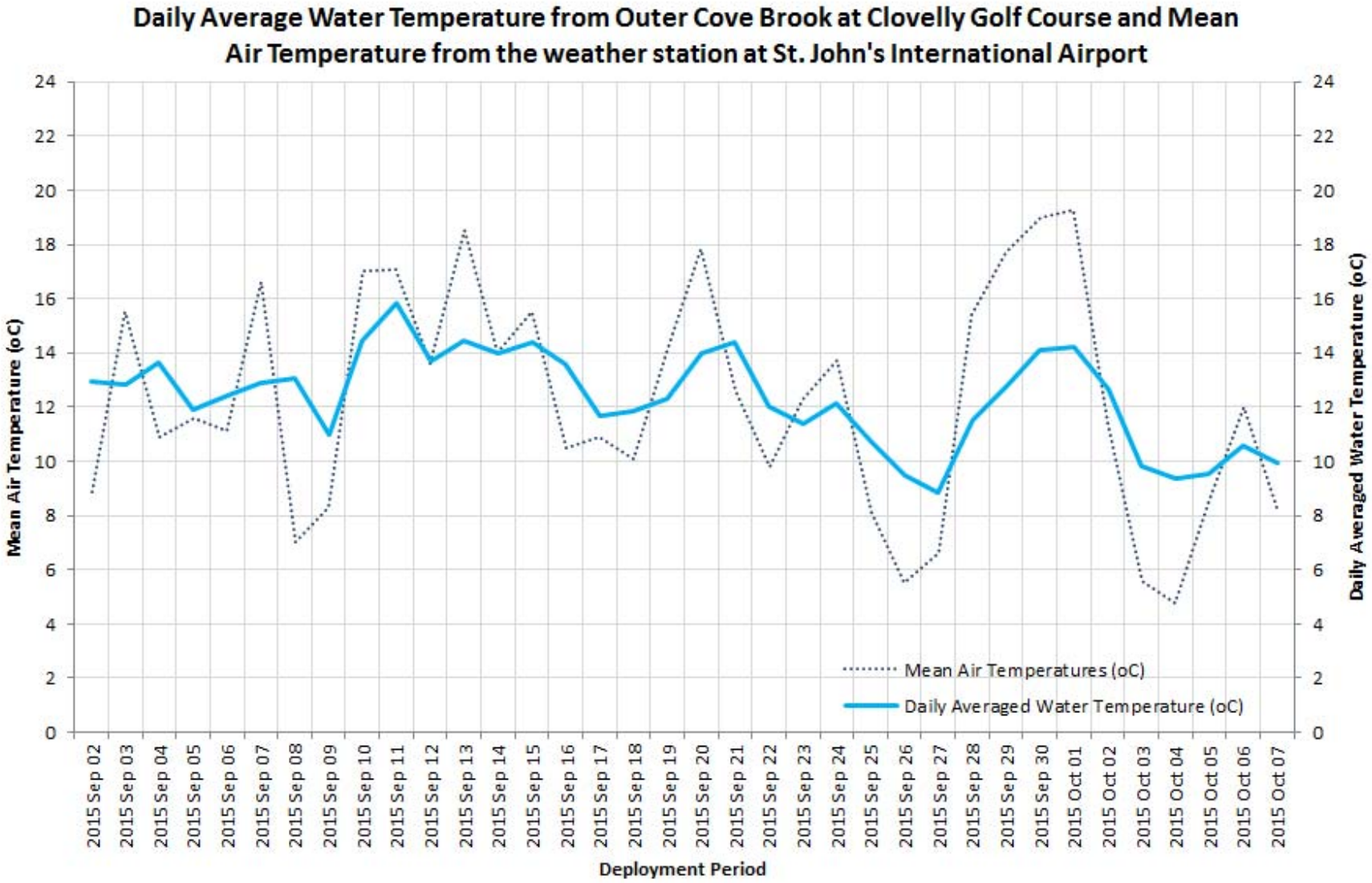

Figure 15: Daily average water temperature values from Outer Cove Brook at Clovelly Golf Course and air temperature values from Environment Canada's Weather Station at St. John's International Airport.

Outer Cove Brook, Newfoundland and Labrador