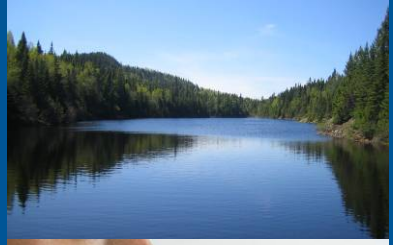







Real-Time Water Quality Report

Outer Cove Brook Network

Deployment Period
June 5 to July 3, 2013

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 mitigative measures can be taken.
- The purpose of these real-time stations is to monitor, process and publish hydrometric (water quantity) and real-time water quality data at the real-time stations. Outer Cove Brook is in the vicinity of the Torbay Road North Commercial Development Area and the real-time stations allow for assessment and management of the water body.
- This report covers the 28-day period from deployment on June 5, 2013 until removal on July 3, 2013.

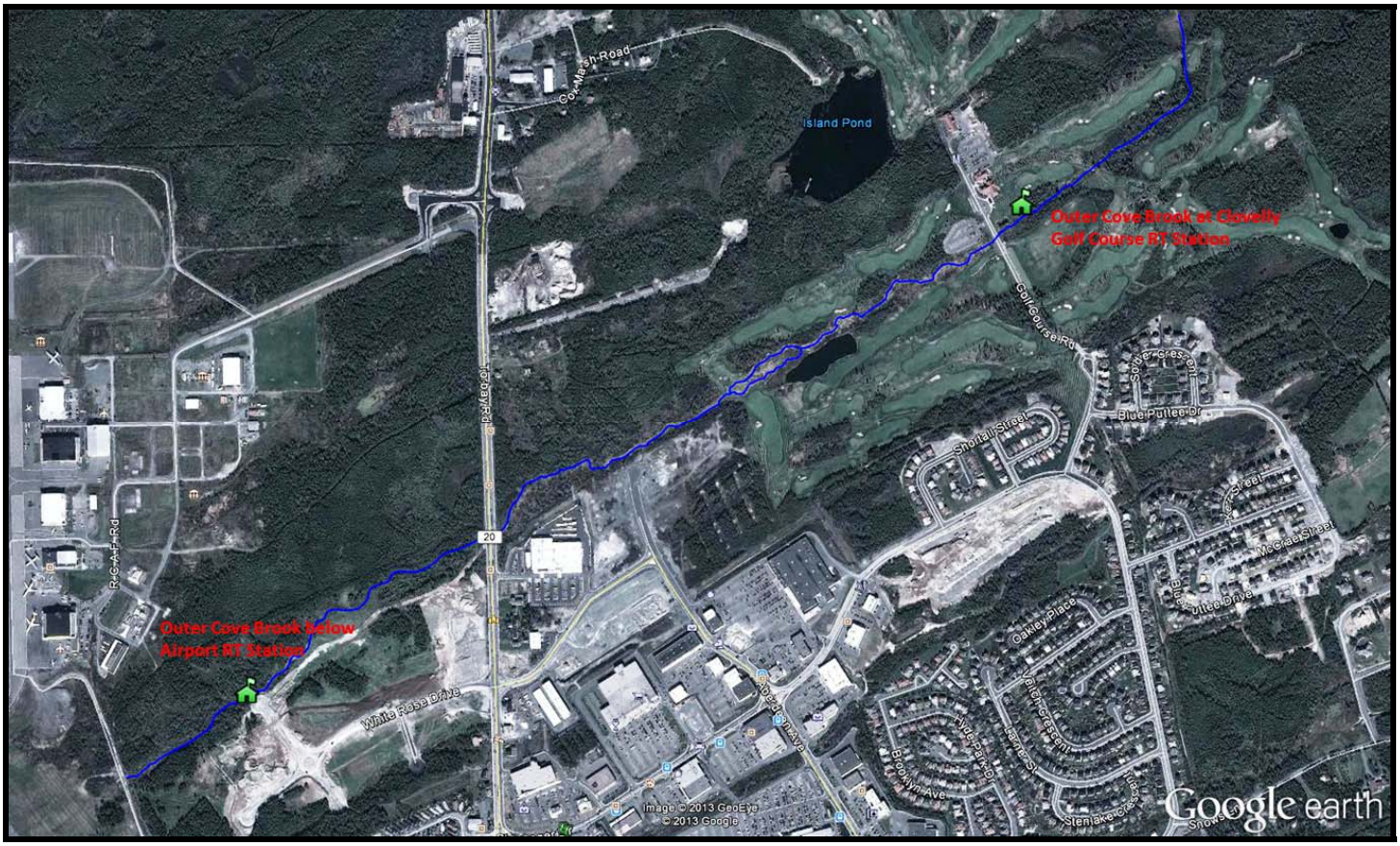


Figure 1: Outer Cove Brook Real-Time Water Quality and Quantity Stations.

Quality Assurance and Quality Control

- As part of the Quality Assurance and Quality Control protocol (QA/QC), an assessment of the reliability of data recorded by an instrument is made at the beginning and end of the deployment period. The procedure is based on the approach used by the United States Geological Survey.
- At deployment and removal, a QA/QC Sonde is temporarily deployed alongside the Field Sonde. Values for temperature, pH, conductivity, dissolved oxygen and turbidity are compared between the two instruments**.** Based on the degree of difference between the parameters on the Field Sonde and QA/QC Sonde at deployment and at removal, a qualitative statement is made on the data quality (Table 1).

Table 1: Instrument Performance Ranking classifications for deployment and removal

	Rank				
Parameter	**Excellent**	**Good**	**Fair**	**Marginal**	**Poor**
Temperature (°C)	<=+/-0.2	>+/-0.2 to 0.5	>+/-0.5 to 0.8	>+/-0.8 to 1	<+/-1
pH (unit)	<=+/-0.2	>+/-0.2 to 0.5	>+/-0.5 to 0.8	>+/-0.8 to 1	>+/-1
Sp. Conductance (µS/cm)	<=+/-3	>+/-3 to 10	>+/-10 to 15	>+/-15 to 20	>+/-20
Sp. Conductance > 35 µS/cm (%)	<=+/-3	>+/-3 to 10	>+/-10 to 15	>+/-15 to 20	>+/-20
Dissolved Oxygen (mg/L) (% Sat)	<=+/-0.3	>+/-0.3 to 0.5	>+/-0.5 to 0.8	>+/-0.8 to 1	>+/-1
Turbidity <40 NTU (NTU)	<=+/-2	>+/-2 to 5	>+/-5 to 8	>+/-8 to 10	>+/-10
Turbidity > 40 NTU (%)	<=+/-5	>+/-5 to 10	>+/-10 to 15	>+/-15 to 20	>+/-20

- It should be noted that the temperature sensor on any sonde is the most important. All other parameters can be divided into subgroups of: temperature dependant, temperature compensated and temperature independent. Due to the temperature sensor's location on the sonde, the entire sonde must be at a constant temperature before the temperature sensor will stabilize. The values may take some time to climb to the appropriate reading; if a reading is taken too soon it may not accurately portray the water body.
- Deployment and removal instrument performance rankings for **Outer Cove Brook below Airport** for the period of June 5, 2013 through to July 3, 2013 are summarized in Table 2.

Table 2: Instrument performance rankings for Outer Cove Brook below Airport Jun. 5, 2013 – July 3, 2013

Station	**Date**	**Action**	**Comparison Ranking**				
			Temperature	**pH**	**Conductivity**	**Dissolved Oxygen**	**Turbidity**
Below Airport	June 5 2013	Deployment	Good	Excellent	Excellent	Good	Excellent
	July 3 2013	Removal	Good	Excellent	Excellent	Fair	Poor

- At the Outer Cove Brook below Airport station at the point of deployment, the turbidity, conductivity and pH sensors ranked 'excellent' while the temperature and dissolved oxygen sensors ranked 'good'.

- At removal, pH and conductivity ranked as 'excellent' while temperature ranked as 'good'. Dissolved oxygen ranked 'fair' and turbidity ranked 'poor', as was to be expected after observing a constant rise in turbidity values over the month, indicating biofouling of the sonde. The thick 'slime' substance found in previous months was not as prolific during sonde removal. The streambed and sonde were coated in a 'scaling' substance, about 2mm thick.

- Deployment and removal instrument performance rankings for **Outer Cove Brook at Clovelly Golf Course** for the period of June 5, 2013 through to July 3, 2013 are summarized in Table 3.

Table 3: Instrument performance rankings for Outer Cove Brook at Clovelly Golf Course Jun. 5, 2013 – July 3, 2013

Station	Date	Action	Comparison Ranking				
			Temperature	pH	Conductivity	Dissolved Oxygen	Turbidity
Clovelly Golf Course	June 5 2013	Deployment	Good	Good	Excellent	Fair	Excellent
	July 3 2013	Removal	Excellent	Excellent	Good	Good	Excellent

- During the Outer Cove Brook Clovelly Golf Course station deployment, all sensors ranked 'excellent' or 'good' when compared to the freshly calibrated QA/QC sonde, with the exception of the dissolved oxygen sensor. The QA/QC readings for dissolved oxygen were slightly lower than the field sonde readings. This may be due to the placement of the sonde during its reading or an issue with its calibration.

- At removal, temperature pH and turbidity ranked 'excellent', while conductivity and dissolved oxygen ranked 'good'. As the dissolved oxygen ranking of the field sonde was 'good' on removal, the 'fair' ranking on deployment was likely due to inaccurate reading by the QAQC sonde at this time.

- Outer Cove Brook has a large amount of algae growing and it was very hard to select a location for the sonde where the probes wouldn't be influenced by the long hair-like algae. The algae may cause issues periodically if it becomes tangled around the turbidity sensor or block the sensors on the conductivity probe.

Deployment Notes

- There were several short transmission errors during this deployment period at the below airport station, but none occurred at the Clovelly Golf Course station.
- At the end of this deployment period, the prolific 'slime' is no longer present in the large quantities of the previous deployments. However, there is a thin layer of a substance with a 'scaling' or 'peeling' appearance present on the equipment and streambed where the slime was previously. This is likely a remnant of the 'slime'.

Data Interpretation

- The following graphs and discussion illustrate water quality-related events from June 5 to July 3, 2013 at the Outer Cove Brook Stations.
- With the exception of water quantity data (stage), all data used in the preparation of the graphs and subsequent discussion below adhere to this stringent QA/QC protocol. Water Survey of Canada is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request from Water Survey of Canada.
- Precipitation data from the deployment period was retrieved from Environment Canada's weather station at St. John's Airport and supplemented with information from 'The Weather Network' when EC data was not available.

Outer Cove Brook below Airport

Water Temperature

- Water temperature ranged from 7.20°C to 17.30°C during this deployment period (Figure 2).
- There are noticeable increases and decreases in the water temperature during the deployment period. This is consistent with ambient air temperatures over this time period, generally increasing as summer approaches.
- Water temperatures display diurnal variations, typical of shallow streams and ponds which are highly influenced by natural diurnal variations in ambient air temperatures.
- Water temperature is a very important parameter and it has the ability to influence other parameters that are measured by the water quality instrument.

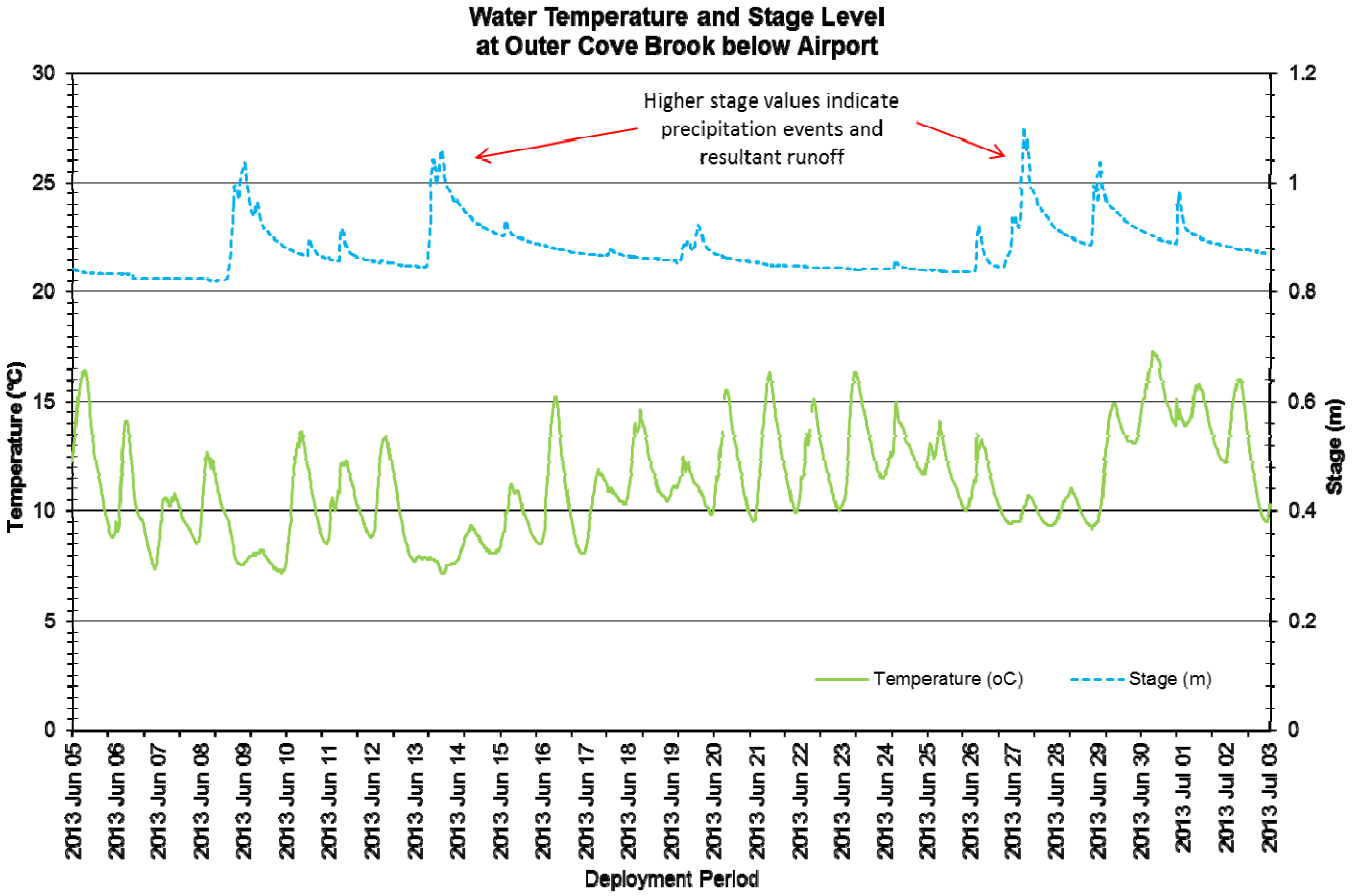


Figure 2: Quarter-hourly water temperature (°C) and stage level (m) values at Outer Cove Brook below Airport for the deployment period June 5, 2013 to July 3, 2013.

pH

- Throughout this deployment period pH values ranged between 6.19 pH units and 7.04 pH units (Figure 3). The maximum value of 7.04 pH units is higher than the 2012 maximum value at this station of 6.96 pH units.
- During the deployment, the pH values at this station hover around the minimum CCME Guideline for the Protection of Aquatic Life (between 6.5 and 9 pH units). There are notable drops in pH on June 9th and 29th, related to precipitation events (Figure 3). This is a natural occurrence between rainfall and pH levels.
- The CCME guideline provides a basis by which to judge the overall health of the brook. Naturally, all streams and brooks are different. In the case of Outer Cove Brook below Airport, pH is within the normal range for stream water in St. John's.

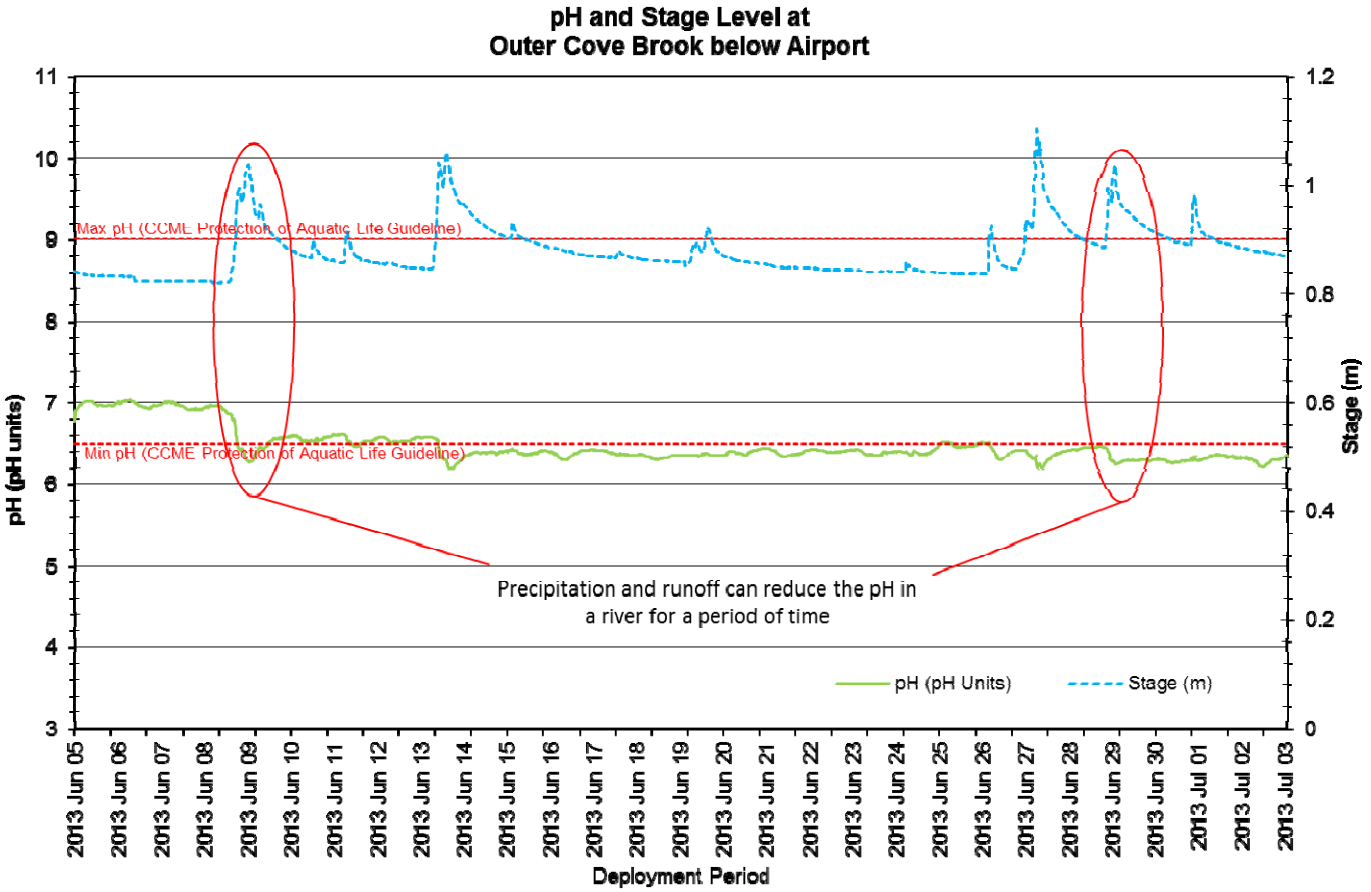


Figure 3: Quarter-hourly pH (pH units) and stage level (m) values at Outer Cove Brook below Airport for the deployment period June 5, 2013 to July 3, 2013.

Specific Conductivity & TDS

- The conductivity levels were within 135.6 µS/cm and 610 µS/cm during this deployment period. TDS ranged from 0.0868 g/L to 0.3900 g/L.
- Generally, rainfall events, such as that which occurred on June 13th and 27th (see Figure 4), can have the effect of diluting and lowering conductance levels. When stage levels rise, the specific conductance levels drop in correlation as the increased amount of water in the river system dilutes the solids present there, thus generally decreasing the specific conductivity readings.
- There is a small spike in conductivity and TDS on June 6th. This indicates some input or disturbance in the river at this time which may have led to resuspension of solids and salts.
- 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.

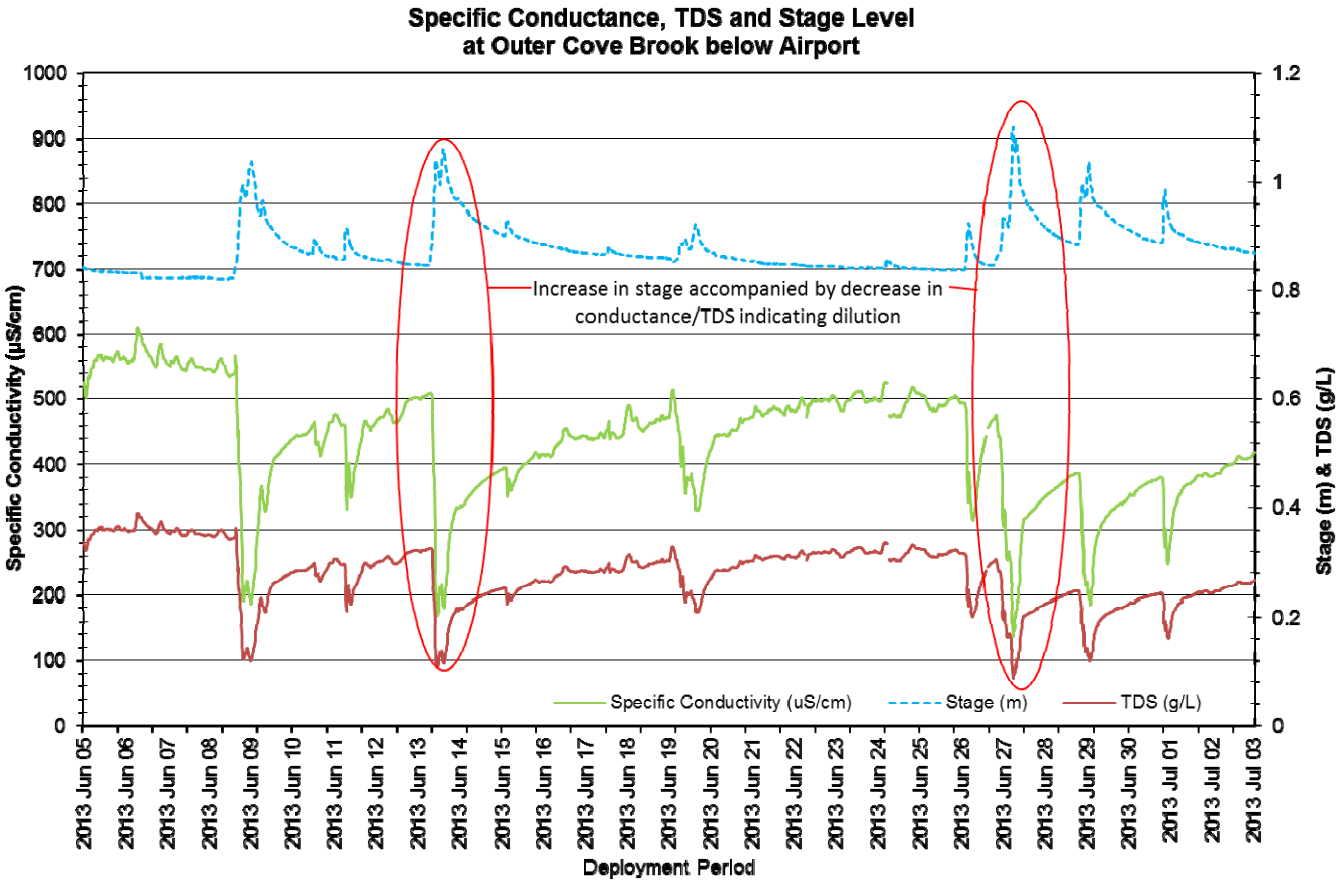


Figure 4: Quarter-hourly specific conductivity (µS/cm), TDS (g/L) and stage (m) values at Outer Cove Brook below Airport for the deployment period June 5, 2013 to July 3, 2013.

Dissolved Oxygen

- The instrument measures dissolved oxygen (mg/L) directly then calculates percent saturation (% Sat.).
- The Dissolved Oxygen % Sat levels within this deployment period were within 70.2% Sat–92.0% Sat. Dissolved Oxygen (mg/L) measured 7.62 mg/L to 10.45 mg/L.
- The DO mg/L values hover around the minimum DO CCME guideline for early life stages, dropping below the guideline when water temperatures increase, and rising again when water temperatures decrease (Figure 5). An unusual drop in DO values on June 20th is not correlated with a high water temperature, indicating a possible water quality event at this time.
- Dissolved Oxygen percent saturation remains relatively constant throughout the deployment period. Dissolved oxygen mg/L content fluctuates with the water temperature changes. Small decreases in dissolved oxygen values are inversely related to increases in water temperature as warmer water can hold less oxygen.

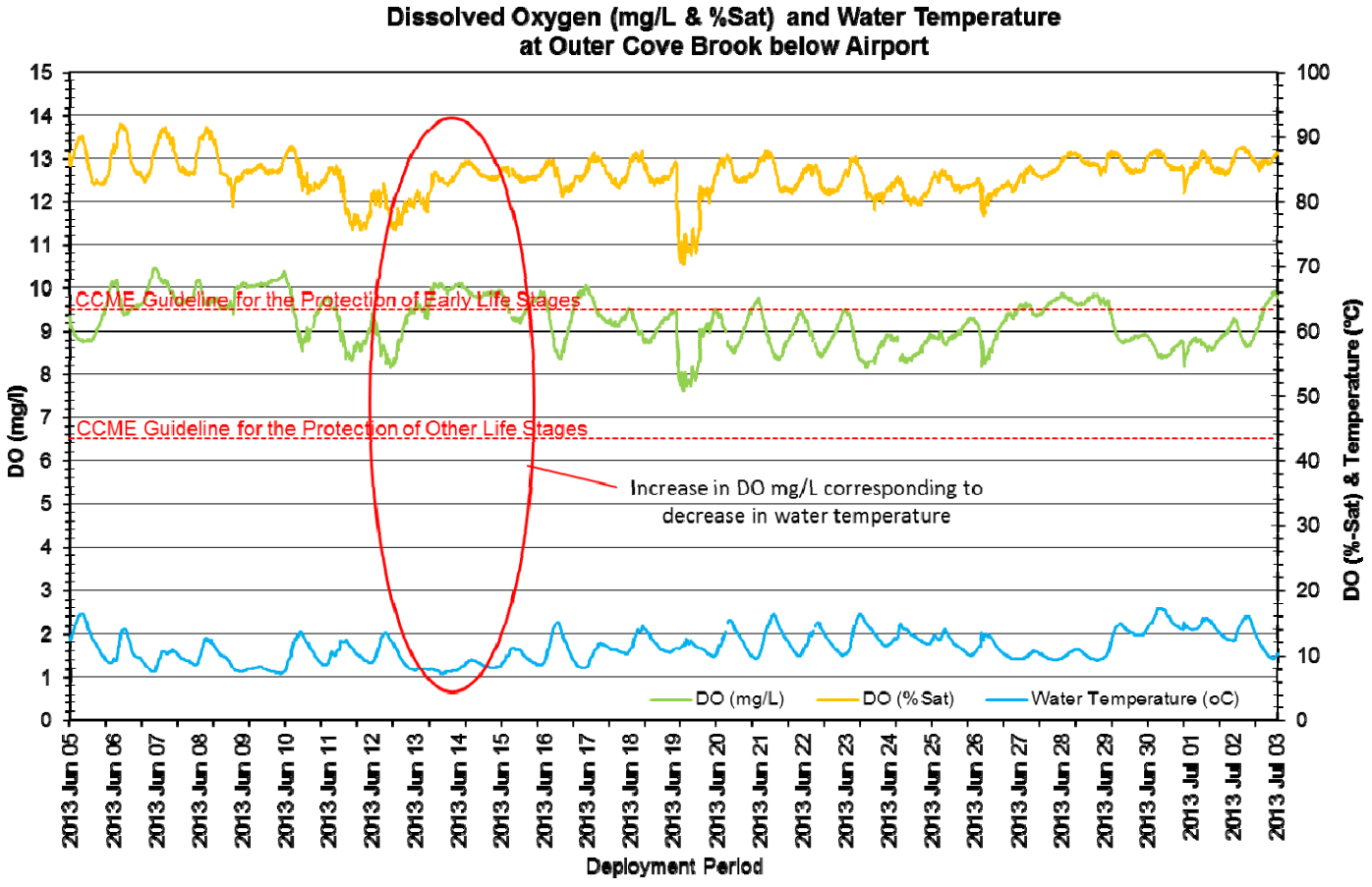


Figure 5: Quarter-hourly dissolved oxygen (mg/L & % sat) and water temperature (°C) values at Outer Cove Brook below Airport for the deployment period June 5, 2013 to July 3, 2013.

Turbidity

- Outer Cove Brook below Airport contains a significant amount of algae. High algal growth, biofouling, or leaf and grass debris can interfere with turbidity measurements as they block the sensor.
- The turbidity sensor can read a turbidity value between 0 NTU and 3000 NTU. If a reading hits 3000NTU it is identified as an error reading and thus is not a true turbidity value.
- The turbidity readings during deployment ranged within 1.8 NTU to 2373 NTU.
- Several precipitation events and corresponding stage increases led to fluctuating turbidity values (see Figure 6) as sediment and debris were resuspended into the water column.
- Biofouling is a known issue at this location, and likely caused several of the higher turbidity values during deployment as there is a large amount of debris in this river. The numerous precipitation events lead to 'flushing' of the river system, allowing debris to wash away from the sonde after a period of time. Some turbidity values spike with increased stage and are likely true values.
- This sensor received a 'poor' performance ranking at removal due to biofouling, which was evident on the sonde during removal as an orange-brown organic layer buildup.

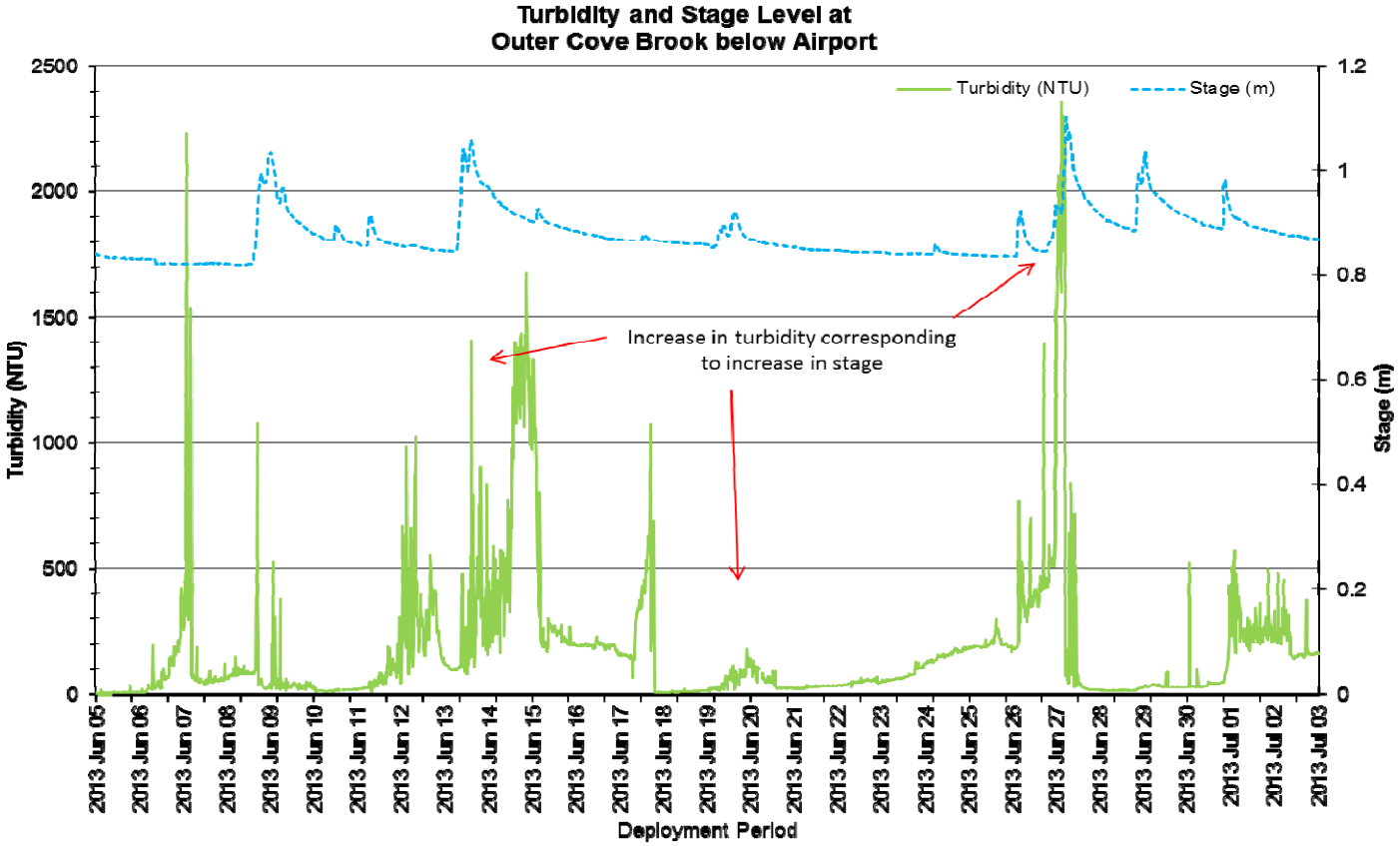


Figure 6: Quarter-hourly turbidity (NTU) and stage level (m) values at Outer Cove Brook below Airport for the deployment period June 5, 2013 to July 3, 2013.

Stage

- Stage values are based on a vertical reference that is unique to each station. As a result, absolute values of stage are not comparable between stations, but relative changes in stage are.
- Stage provides an estimation of water level at the station and can explain some of the changes that are occurring with other parameters (i.e. Specific Conductivity, DO, turbidity). Stage increases during precipitation events (Figure 7) due to increased runoff from the surrounding area.
- Precipitation data was obtained from Environment Canada's St. John's Airport weather station and supplemented with data from 'The Weather Network' when EC data was unavailable.
- During the deployment period, the stage ranged from 0.82m to 1.10m.

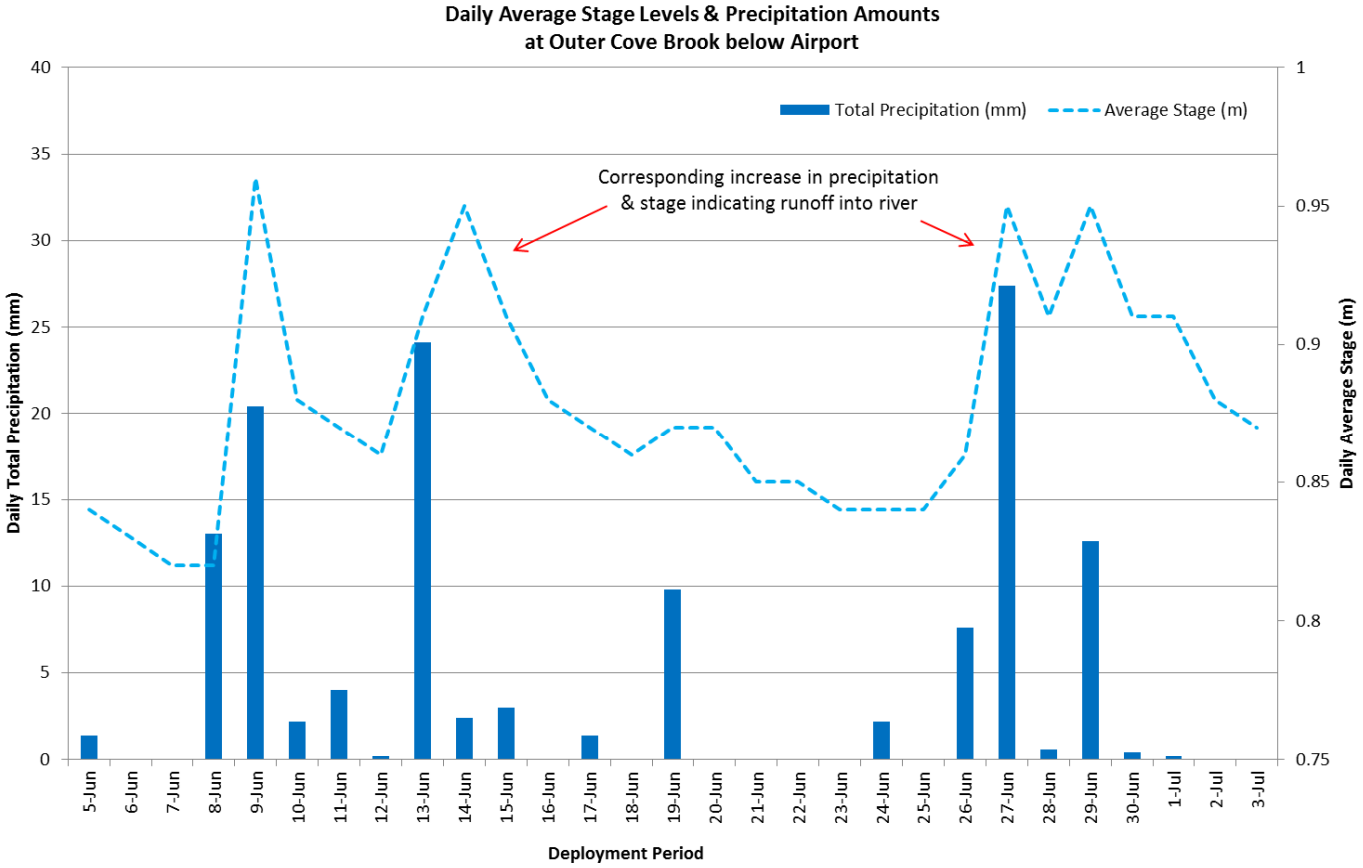


Figure 7: Daily average stage values (m) at Outer Cove Brook below Airport and daily total precipitation values (mm) from Environment Canada's St. John's Airport Station for the deployment period June 5, 2013 to July 3, 2013.

Conclusions

- Generally in natural environments, climate and weather conditions contribute in large part to the variation in water quality parameters. During this deployment it was evident that many of the changes in the parameter data displayed on the graphs, was related to the intermittent precipitation events and small climatic changes of the seasons (i.e. temperature increases).
- Precipitation events during the deployment period led to related fluctuations in stage, which thus influenced the values of turbidity, pH, specific conductance, and TDS. As ambient air temperatures rose, there were correspondingly warmer water temperatures, which in turn decreased the amount of dissolved oxygen in the water.
- The majority of turbidity events were correlated with increases in stage and thus precipitation events. Biofouling is still a factor contributing to the high turbidity values as a 'poor' sensor ranking was noted on sonde removal. Turbidity values fluctuated with stage increases and returned to zero after higher than normal values were recorded, indicating that the increased stage level was allowing the river system to be flushed, freeing the sonde of any debris or biofouling which accumulated and contributed to the increased the turbidity values.
- An unusual spike in conductivity an TDS on June 6th is due to some input or disturbance upstream of the station. A spike in turbidity was noted at the same time.
- A precipitation event on June 19th led to an expected decrease in conductance/ TDS and increase in turbidity. A prolonged drop in DO also occurred at this time, indicating an input or event which lowered the DO in the water and affected the water quality.
- The riverbed at this location is no longer covered in prolific 'slime', but instead is coated in a thin layer of a 'dried scaling/peeling' substance. The water quality event which took place several months ago is still affecting this section of the river, although its affects on the water quality parameters, in particular turbidity and dissolved oxygen, were much less pronounced during this deployment period.

Outer Cove Brook at Clovelly Golf Course

Water Temperature

- Water temperature ranged from 7.34°C to 18.69°C during this deployment period (Figure 8).
- There are noticeable increases and decreases in the water temperature during the deployment period. This is consistent with ambient air temperatures over this time period, generally increasing as summer approaches.
- Water temperatures display diurnal variations, typical of shallow streams and ponds which are highly influenced by natural diurnal variations in ambient air temperatures.
- Water temperature is a very important parameter and it has the ability to influence other parameters that are measured by the water quality instrument.

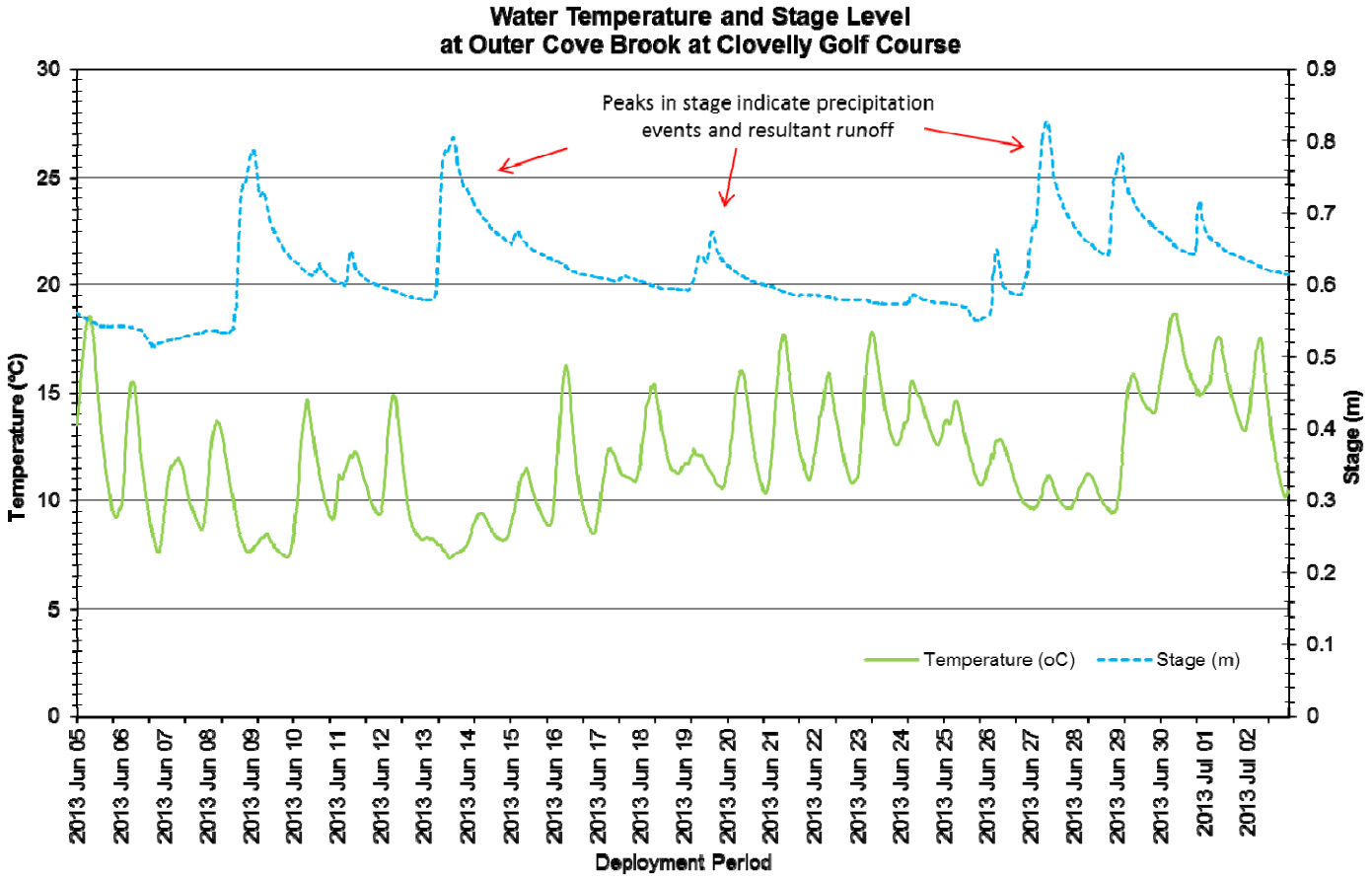


Figure 8: Quarter-hourly water temperature (°C) and stage level (m) values at Outer Cove Brook at Clovelly Golf Course for the deployment period June 5, 2013 to July 3, 2013.

pH

- Throughout this deployment period pH values ranged between 5.90 pH units and 6.82 pH units (Figure 9).
- During the deployment, the pH values at this station hover around the minimum CCME Guideline for the Protection of Aquatic Life (between 6.5 and 9 pH units) dropping below the guideline due to the addition of precipitation. There are notable drops on June 14th and 27th, related to precipitation events. This is a natural occurrence between rainfall and pH levels.
- The CCME guideline provides a basis by which to judge the overall health of the brook. Naturally, all streams and brooks are different. In the case of Outer Cove Brook at Clovelly Golf Course, pH is within the normal range for stream water in St. John's.

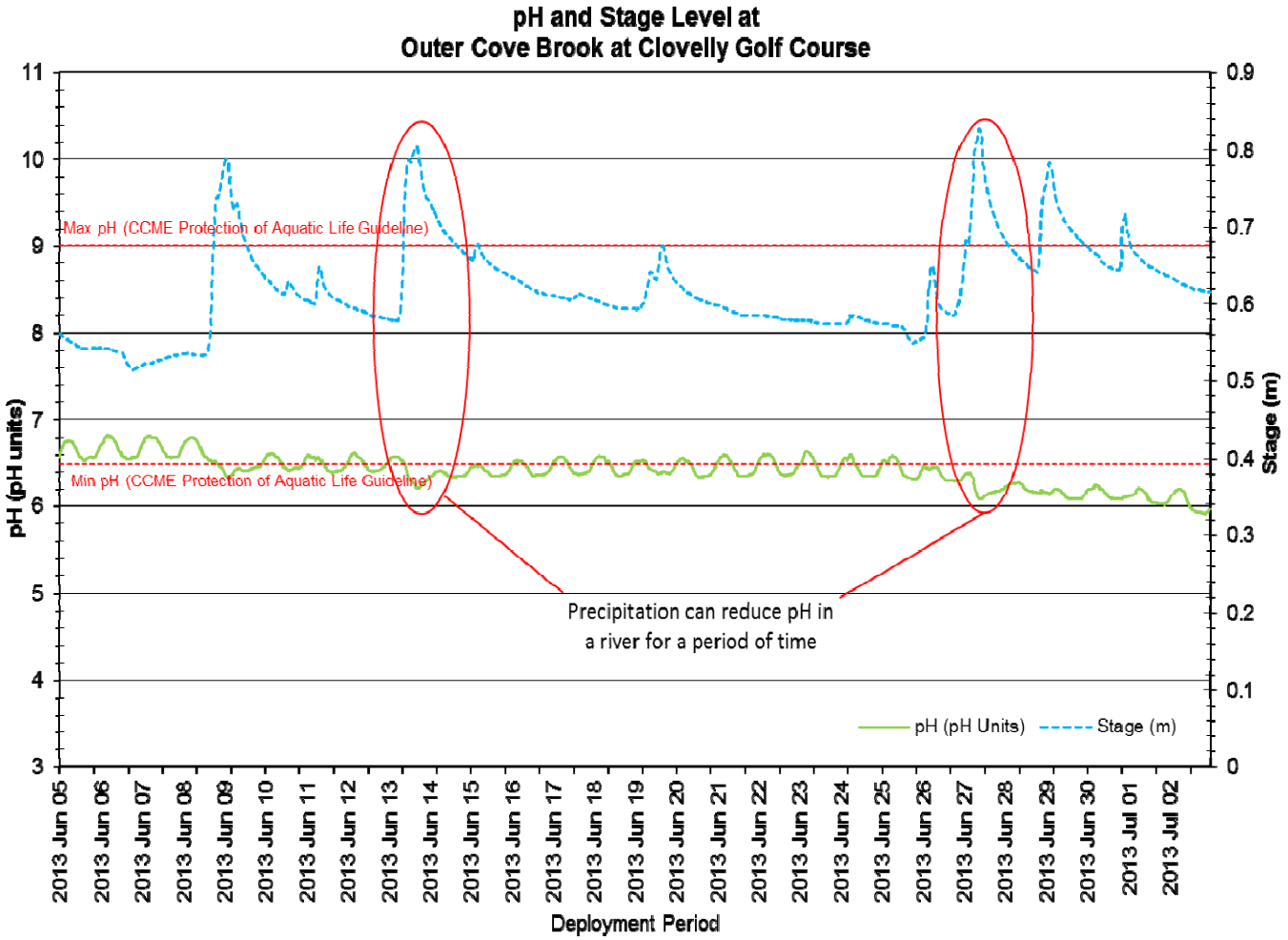


Figure 9: Quarter-hourly pH (pH units) and stage level (m) values at Outer Cove Brook at Clovelly Golf Course for the deployment period June 5, 2013 to July 3, 2013.

Specific Conductivity & TDS

- The conductivity levels were within 181.3 µS/cm and 538 µS/cm during this deployment period. TDS ranged from 0.1160 g/L to 0.3440 g/L. These values are notably lower than those of the previous deployment period.
- Generally, rainfall events, such as that which occurred on June 20th (see Figure 10), can have the effect of diluting and lowering conductance levels. When stage levels rise, the specific conductance levels drop in correlation as the increased amount of water in the river system dilutes the solids present there, thus generally decreasing the specific conductivity readings.
- The spike in conductivity/TDS which was noted at the below airport station on June 6th (Figure 4), also occurred at the Clovelly Golf Course site. This indicates some input or disturbance upstream of both stations at this 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.

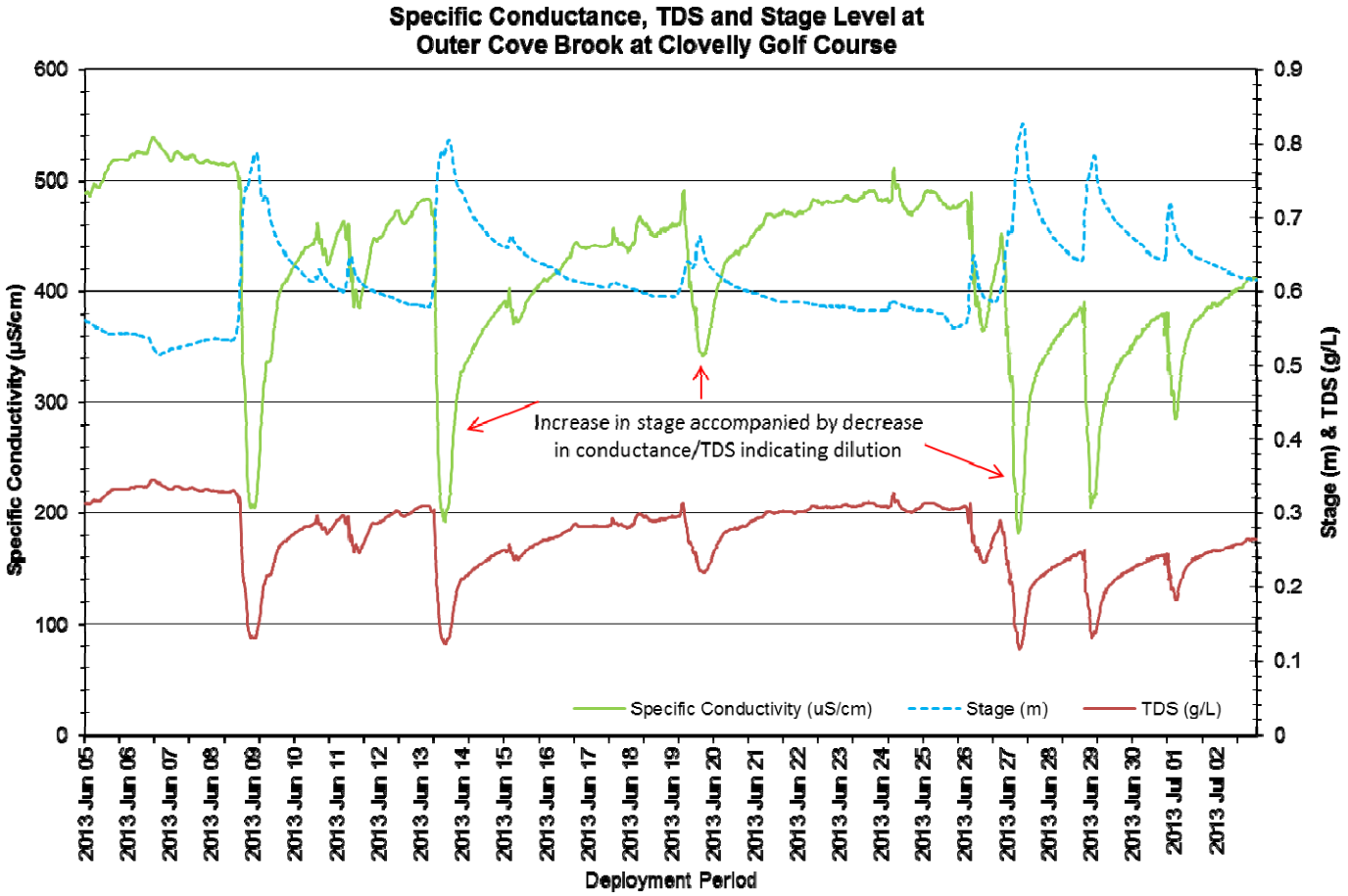


Figure 10: Quarter-hourly specific conductivity (uS/cm), TDS (g/L) and stage (m) values at Outer Cove Brook at Clovelly Golf Course for the deployment period June 5, 2013 to July 3, 2013.

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 65.4% Sat–102.3% Sat. Dissolved Oxygen (mg/L) measured 6.76 mg/L to 11.02 mg/L. The DO mg/L values are below the minimum DO CCME guideline for early life stages for the majority of the deployment, coinciding with the high water temperatures reported over this deployment period. A high water temperature on June 30th of 18.7°C lead to low oxygen levels in the water at this time (Figure 11).
- The drop in DO on June 19-20th which was noted at the below airport station is not evident at the Clovelly station.
- Dissolved Oxygen percent saturation remains relatively constant throughout the deployment period, with diurnal fluctuations. Dissolved oxygen mg/L content fluctuates with the water temperature changes. Decreases in dissolved oxygen values are inversely related to increases in water temperature as warmer water can hold less oxygen.

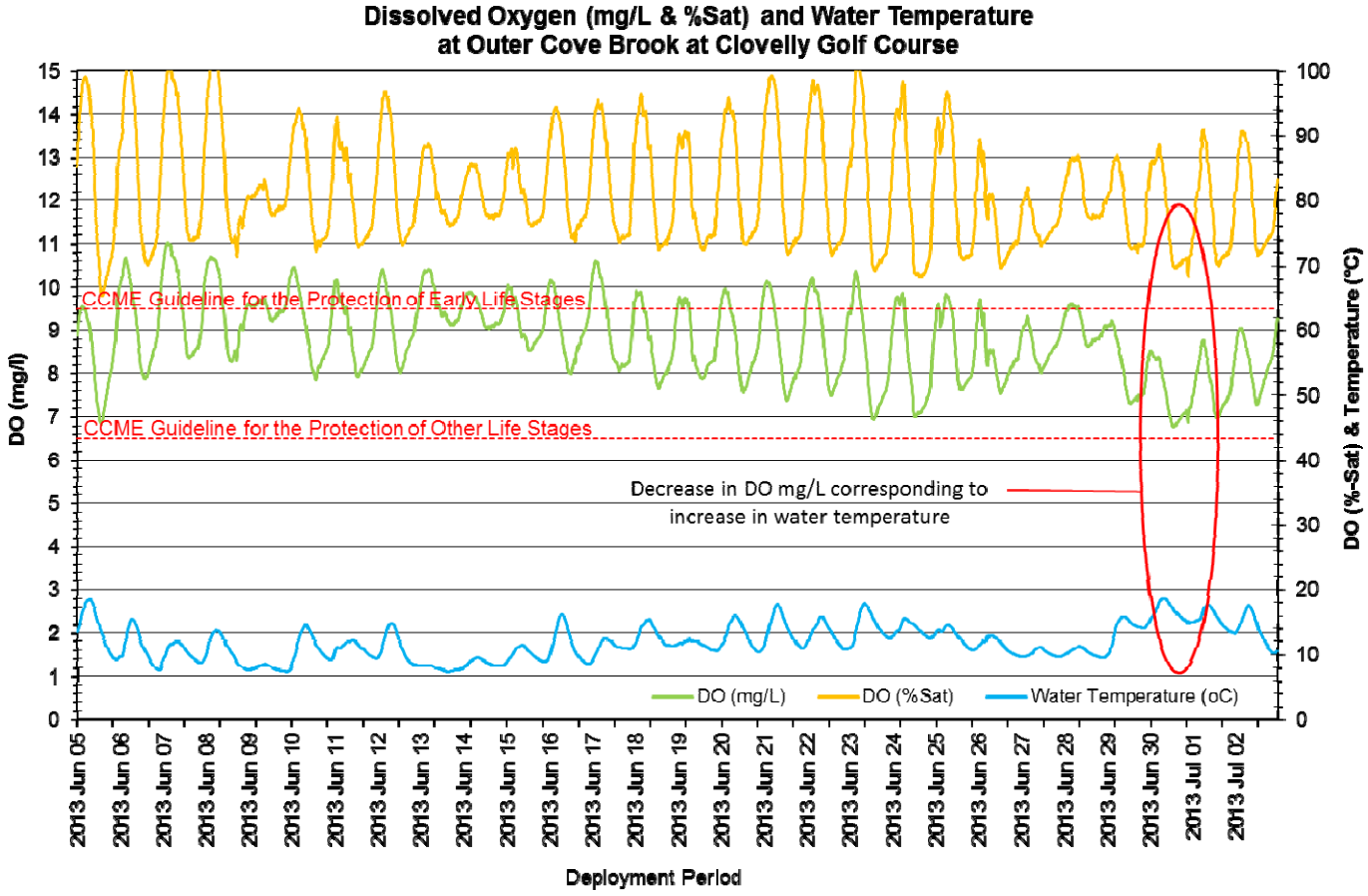


Figure 11: Quarter-hourly dissolved oxygen (mg/L & % sat) and water temperature (°C) values at Outer Cove Brook at Clovelly Golf Course for the deployment period June 5, 2013 to July 3, 2013.

Turbidity

- Outer Cove Brook contains a significant amount of algae. High algal growth in the summer or leaf debris during all seasons can interfere with turbidity measurements as they block the sensor.
- The turbidity sensor can read turbidity values between 0 NTU and 3000 NTU. If a turbidity reading hits 3000NTU it is always identified as an error reading and thus is not a valid turbidity reading.
- The turbidity readings during this deployment did not appear to be affected by biofouling, and ranged within 0.0 NTU to 270.1 NTU (Figure 12). Fluctuations in turbidity values were correlated with increases in stage and thus precipitation events.
- A thin layer of brown sediment & organic material was noted on the sonde during removal. However, the sensor ranked 'excellent' upon removal and the data was unaffected by biofouling during this deployment period.
- Several precipitation events and corresponding stage increases led to fluctuating turbidity values as sediment and debris were resuspended into the water column.

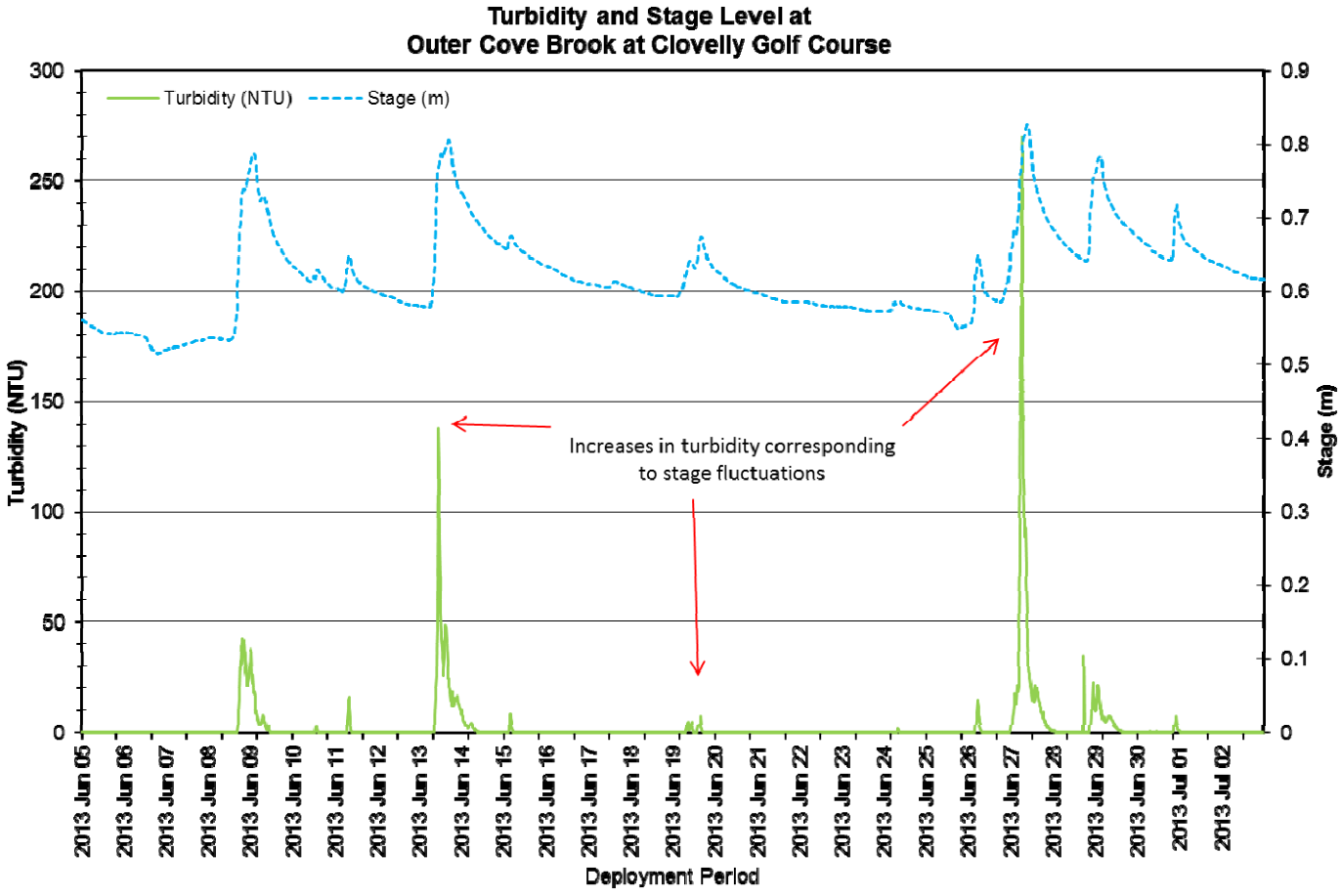


Figure 12: Quarter-hourly turbidity (NTU) and stage level (m) values at Outer Cove Brook at Clovelly Golf Course for the deployment period June 5, 2013 to July 3, 2013.

Stage

- Stage values are based on a vertical reference that is unique to each station. As a result, absolute values of stage are not comparable between stations, but relative changes in stage are.
- Stage 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 increases during precipitation events due to increased runoff from the surrounding area (see Figure 13).
- Precipitation data was obtained from Environment Canada's St. John's Airport weather station and supplemented with data from 'The Weather Network' when EC data was unavailable.
- During the deployment period, the stage values ranged from 0.52m to 0.83m.

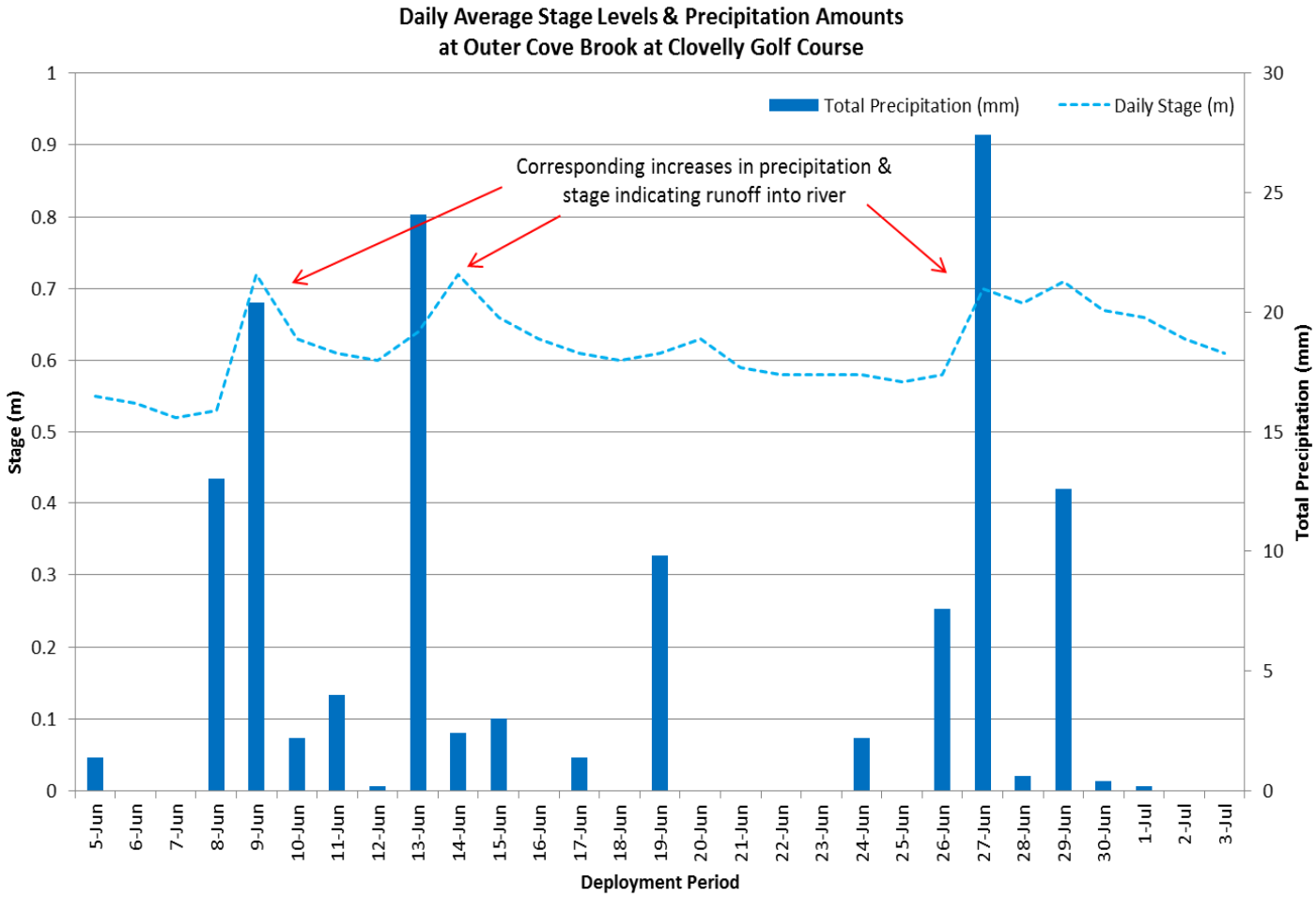


Figure 13: Daily average stage values (m) at Outer Cove Brook below Airport and daily total precipitation values (mm) from Environment Canada's St. John's Airport Station for the deployment period June 5, 2013 to July 3, 2013.

Conclusions – Outer Cove Brook at Clovelly Golf Course

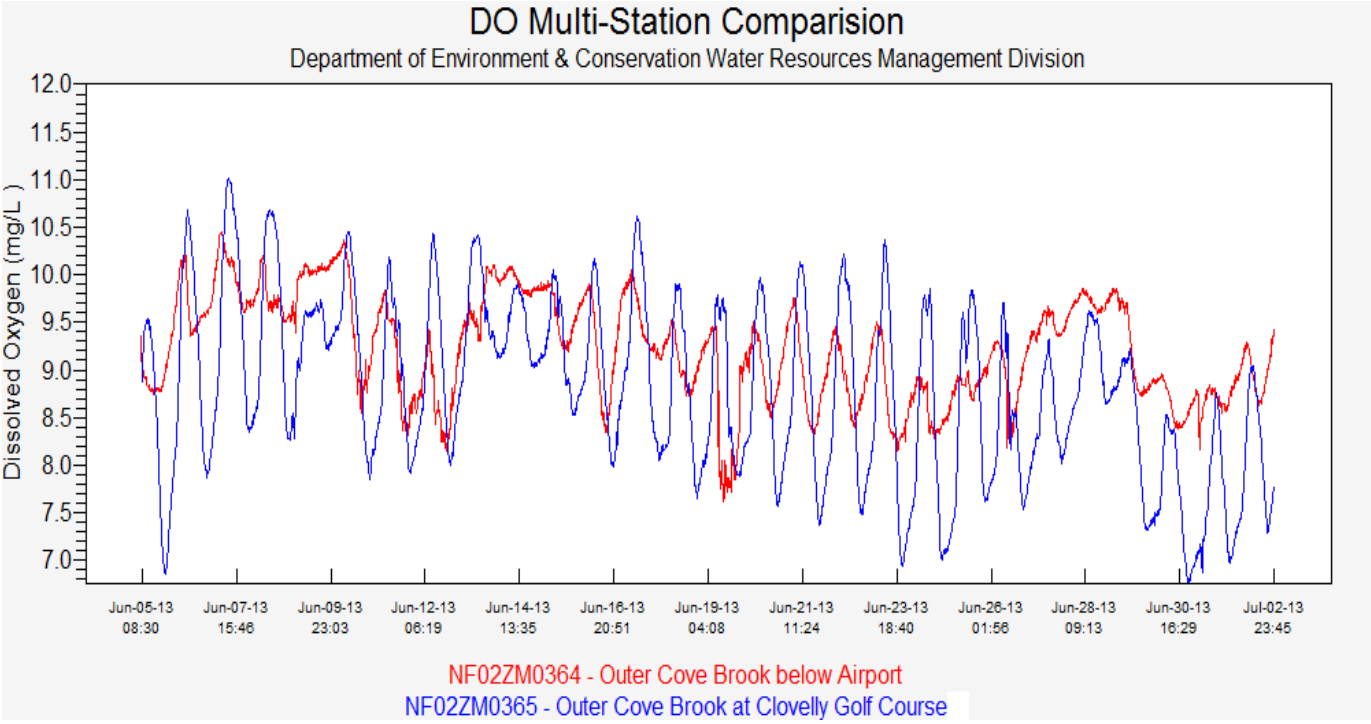
- Precipitation events during the deployment period led to related fluctuations in stage, which thus influenced the values of turbidity, pH, specific conductance, and TDS. As ambient air temperatures rose, there were correspondingly warmer water temperatures, which in turn decreased the amount of dissolved oxygen in the water.
- During this deployment, the turbidity sensor did not suffer from biofouling as it had in previous months, although there was a coating of a thin black organic layer noted on the sonde during removal.
- A drop in DO values during a precipitation event on June 19th was noted at the below airport station, but is not evident at this station over the same time period.
- A spike in TDS/conductance on June 6th occurred at the same time as an increase at the below airport station. There may therefore be an influence upstream of this station which is causing spikes in TDS and conductance values. This may be related to construction upstream of this station near Torbay Road, or some other disturbance of the river causing resuspension of solids present in the water.

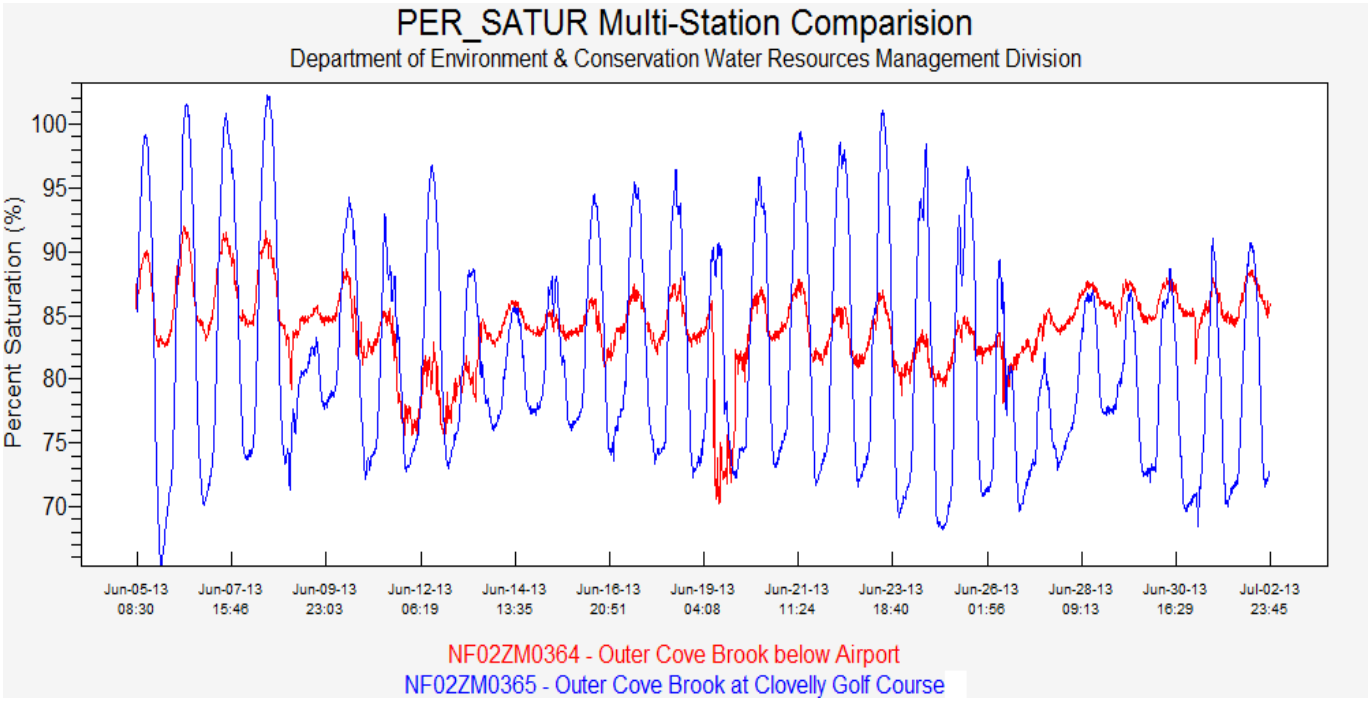
Conclusions – Outer Cove Brook Network

During this deployment period, the median water temperature at the upstream station (below Airport) of 10.90°C was slightly lower than that of the downstream station (at Clovelly Golf Course) of 11.54°C. The median pH values for both stations were comparable with below Airport's median at 6.40 and Clovelly Golf Course reading 6.42, and thus no significant change in pH from the upstream to the downstream station. The specific conductivity medians were similar at both stations with 446 uS/cm reported below the airport and 440 uS/cm reported at the golf course. Spikes in TDS and conductance on June 6th at both stations indicates a disturbance may have influenced this stream at this time upstream of both stations. Dissolved oxygen at the upstream station (below Airport) had a median of 84.3%Sat during the deployment period, while the downstream station (Clovelly Golf Course) had a lower median of 79.6%Sat. The lower oxygen levels at the downstream Clovelly station occur at night, indicating an interaction with the prolific aquatic grass growth which cannot synthesize oxygen and replenish the dissolved oxygen in the water at night. The median turbidity value at Clovelly Golf Course was 0 NTU. A comparison of turbidity values cannot be made as biofouling of the turbidity sensor at the below Airport station affected the data.

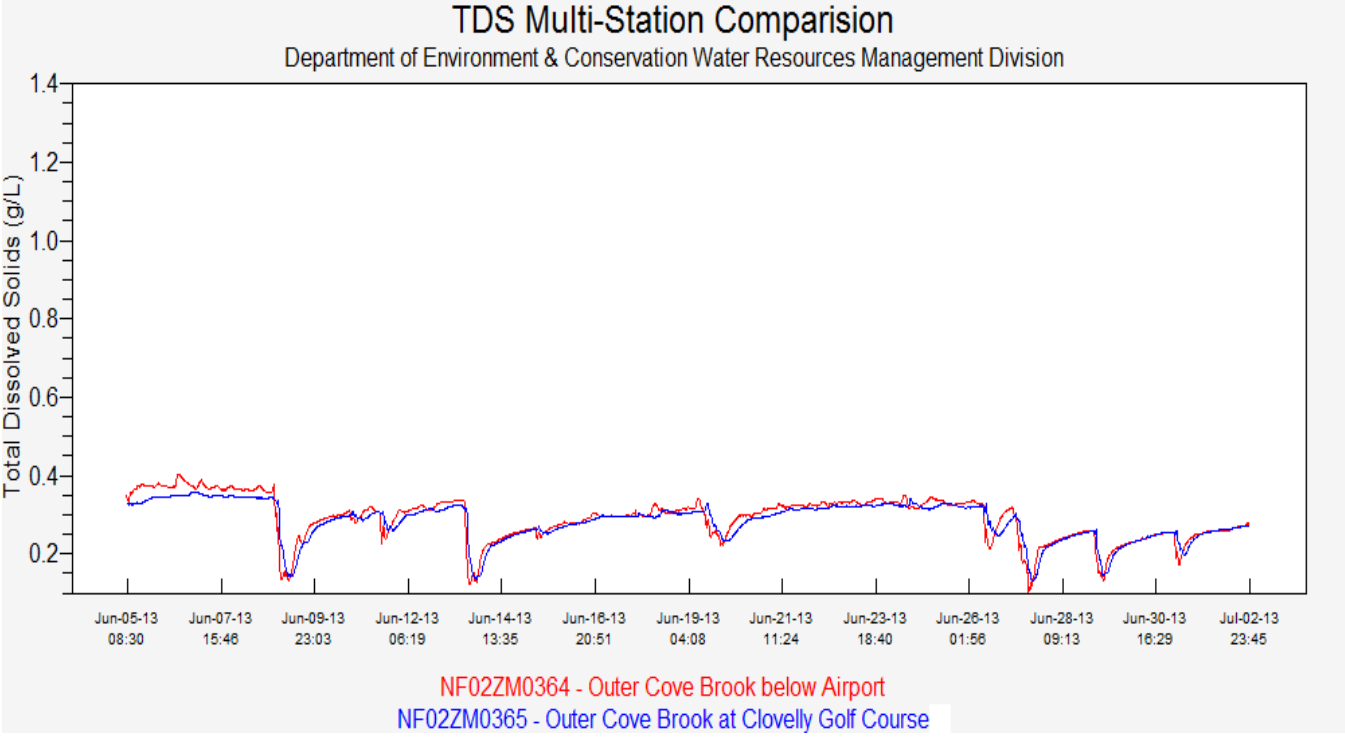
Appendix

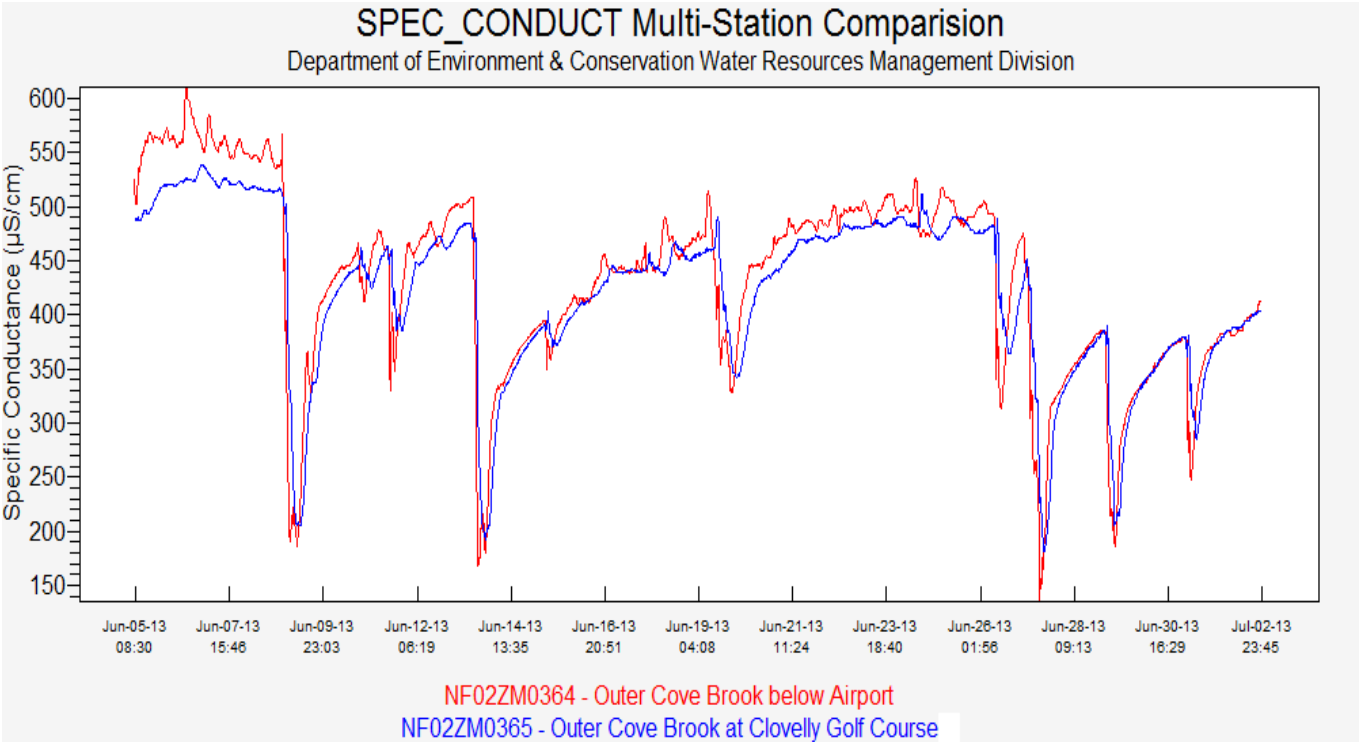
Parameter Station Comparison Graphs



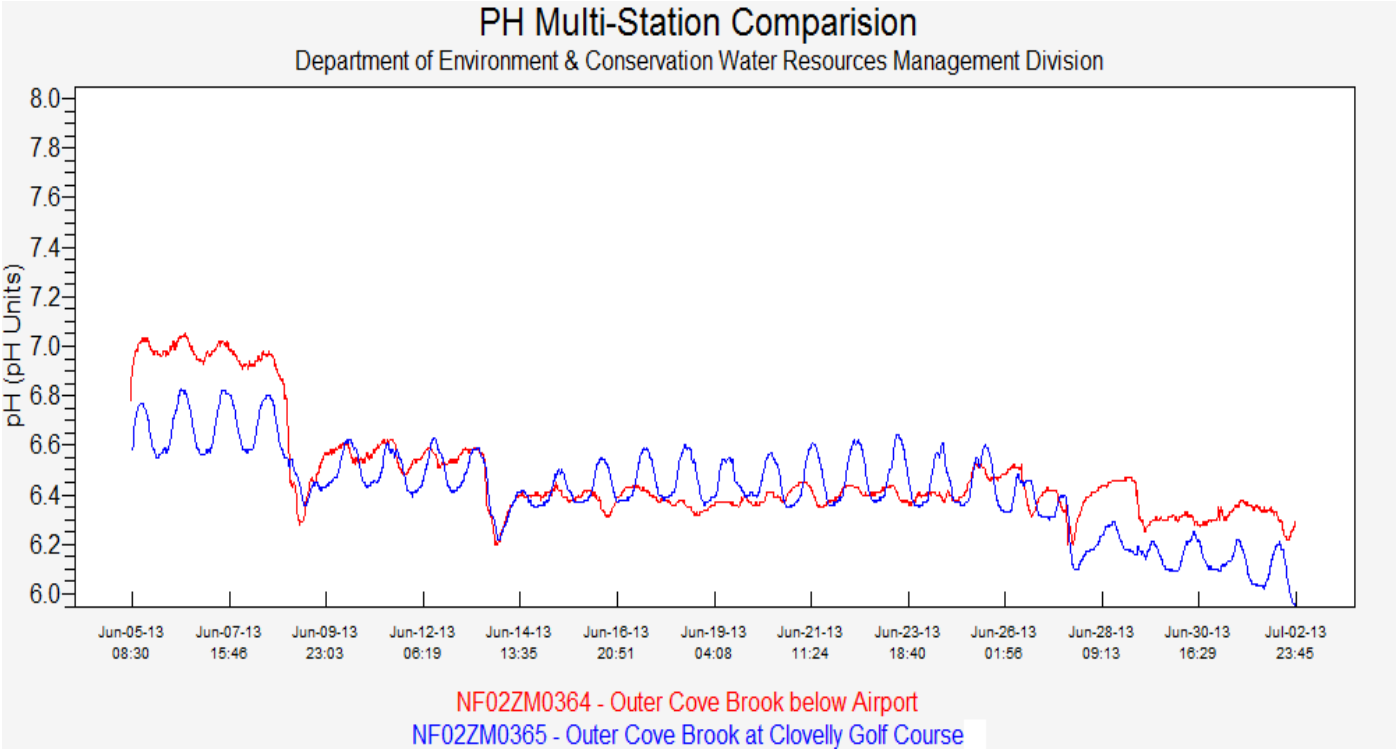


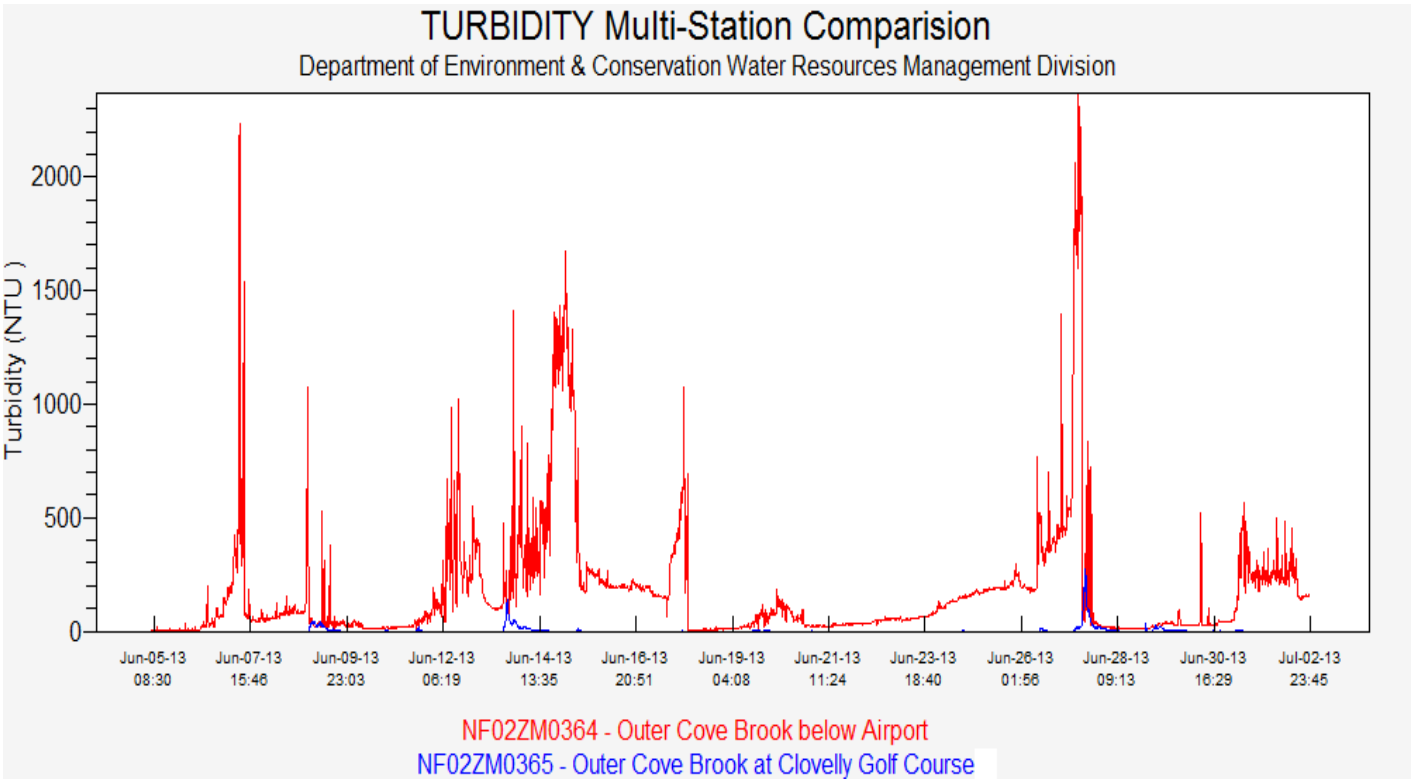
Outer Cove Brook, Newfoundland and Labrador





Outer Cove Brook, Newfoundland and Labrador





Outer Cove Brook, Newfoundland and Labrador