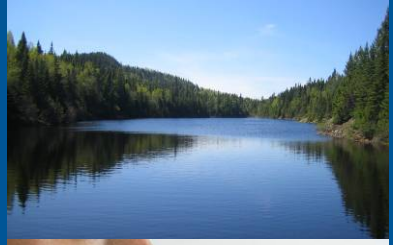







Real-Time Water Quality Report

Outer Cove Brook Network

Deployment Period
August 27 to September 24, 2012

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 27-day period from deployment on August 27 until removal on September 24, 2012.

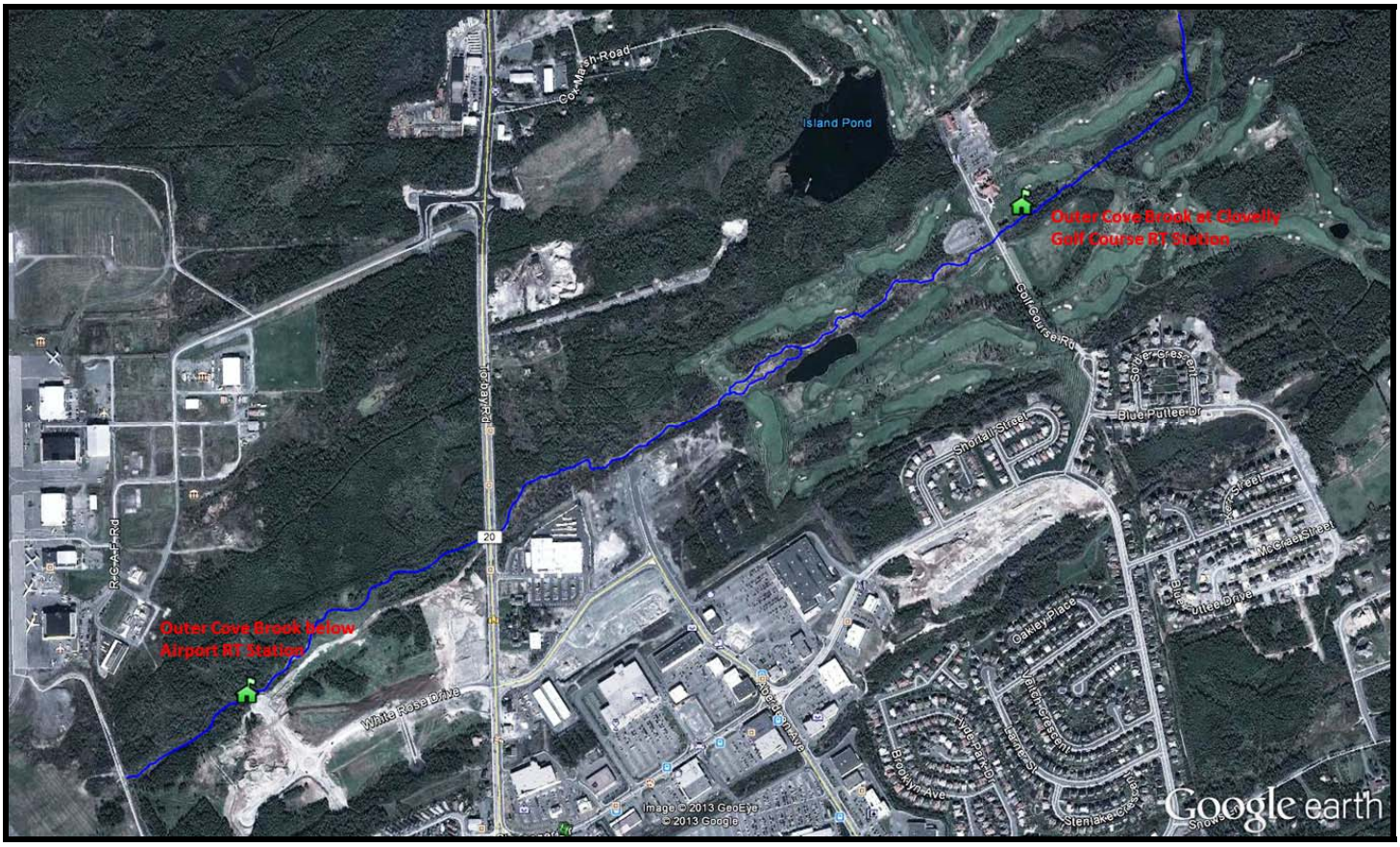

Figure 1: Outer Cove Brook Real-Time Water Quality and Quantity Stations.

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 August 27, 2012 through to September 24, 2012 are summarized in Table 2.

Table 2: Instrument performance rankings for Outer Cove Brook below Airport Aug. 27, 2012 – Sept. 24, 2012

Station	**Date**	**Action**	**Comparison Ranking**				
			Temperature	**pH**	**Conductivity**	**Dissolved Oxygen**	**Turbidity**
Below Airport	Aug 27 2012	Deployment	Excellent	Good	Excellent	Excellent	Good
	Sept 24 2012	Removal	Excellent	Good	Good	Excellent	Poor

- At the Outer Cove Brook below Airport station at the point of deployment, all sensors ranked 'good' to 'excellent'. Overall, the data being produced was reliable and accurate at the start of deployment.

- At removal, temperature and dissolved oxygen ranked as 'excellent', while pH and conductivity ranked as 'good. The turbidity sensor ranked as 'poor', indicating biofouling or debris blockage as the values had been rising constantly near the end of the deployment.

- Deployment and removal instrument performance rankings for **Outer Cove Brook at Clovelly Golf Course** for the period of August 27, 2012 through to September 24, 2012 are summarized in Table 3.

Table 3: Instrument performance rankings for Outer Cove Brook at Clovelly Golf Course Aug 27, 2012 - Sept 24, 2012

Station	Date	Action	Comparison Ranking				
			Temperature	pH	Conductivity	Dissolved Oxygen	Turbidity
Clovelly Golf Course	Aug 27 2012	Deployment	Excellent	Good	Good	Excellent	Excellent
	Sept 24 2012	Removal	Excellent	Excellent	Excellent	Excellent	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.

- At removal, all sensors ranked 'excellent' when compared to the QA/QC sonde. This indicates the sensors were all reading accurately at the end of the deployment.

- 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

- Brief transmission errors occurred during the deployment period at both stations, resulting in data gaps in the graphs shown in this report.

Data Interpretation

- The following graphs and discussion illustrate water quality-related events from August 27 to September 24, 2012 at the Outer Cove Brook Stations.
- As the above mentioned transmission errors for the Outer Cove Brook stations were short in duration, the transmitted water quality data and its synchronous stage data were analyzed instead of the internally stored data.
- 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.

Outer Cove Brook below Airport

Water Temperature

- Water temperature ranged from 11.6°C to 20.0°C during this deployment period (Figure 2).
- Water temperatures fluctuate around 15°C, decreasing into the fall. This is consistent with ambient air temperatures over this time period.
- 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.

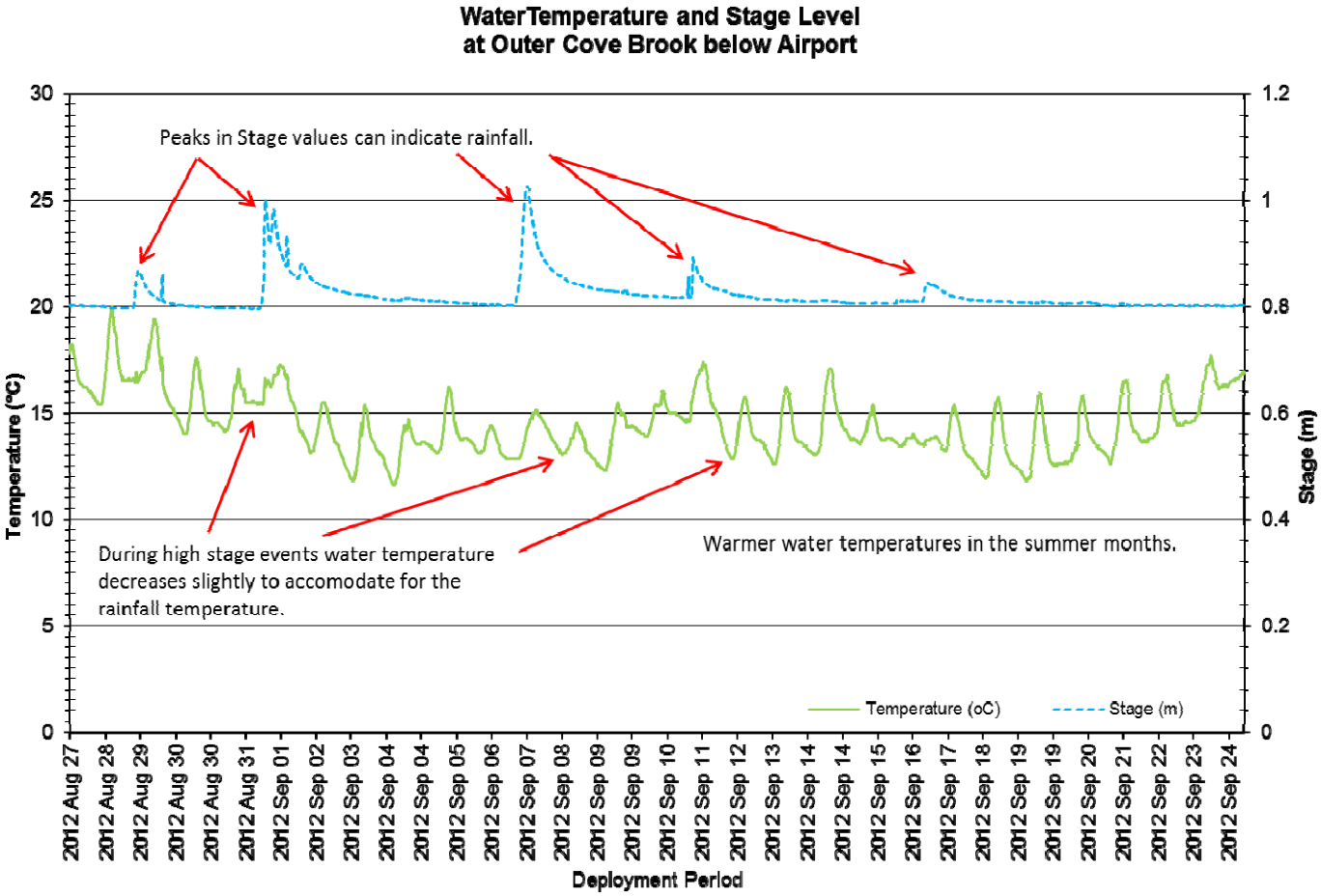

Figure 2: Quarter-hourly water temperature (°C) and stage level (m) values at Outer Cove Brook below Airport for the deployment period August 27, 2012 to September 24, 2012.

pH

- Throughout this deployment period pH values ranged between 6.18 pH units and 6.71 pH units (Figure 3).
- During the deployment, the pH values at this station hover just below the minimum CCME Guideline for the Protection of Aquatic Life (between 6.5 and 9 pH units). Several precipitation events cause drops in the pH values. 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.

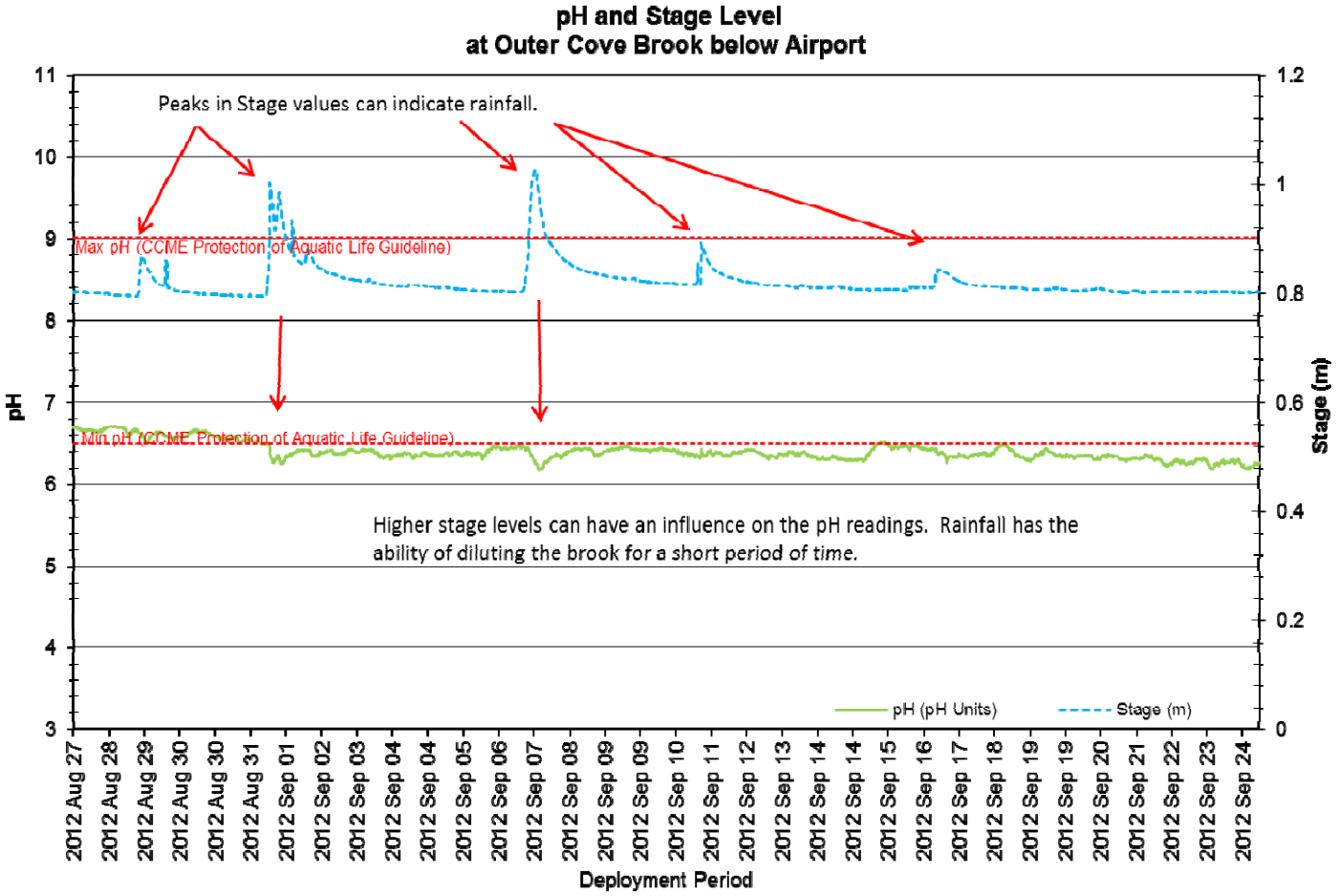

Figure 3: Quarter-hourly pH (pH units) and stage level (m) values at Outer Cove Brook below Airport for the deployment period August 27, 2012 to September 24, 2012.

Specific Conductivity & TDS

- The conductivity levels were within 156.5 µS/cm and 574 µS/cm during this deployment period. TDS ranged from 0.1001 g/L to 0.3670 g/L.
- Generally, rainfall events, indicated in Figure 4 by increased stage levels, 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 freshwater in the river system dilutes the solids present there, thus generally decreasing the specific conductivity readings.
- A spike in conductivity and TDS on September 4th without a rise in stage may indicate an input of solids into the river system or resuspension of the solids already present by some mechanism other than the addition of precipitation.
- 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.

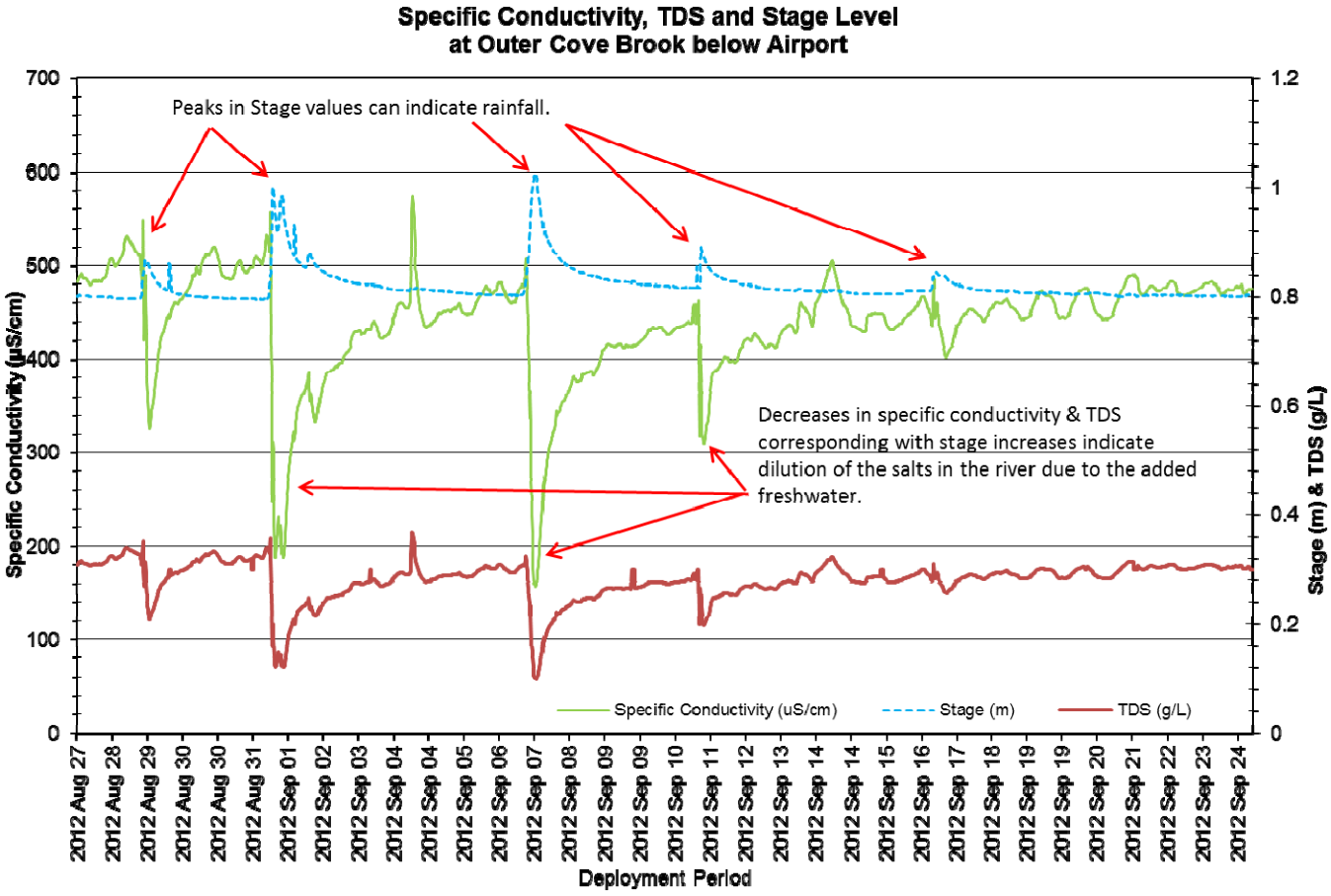

Figure 4: Quarter-hourly specific conductivity (µS/cm), TDS (g/L) and stage (m) values at Outer Cove Brook below Airport for the deployment period August 27, 2012 to September 24, 2012.

Dissolved Oxygen

- The instrument measures percent saturation directly, then calculates dissolved oxygen (mg/L) using the percent saturation and water temperature values.
- The Dissolved Oxygen % Sat levels within this deployment period were within 84.9 % Sat–96.1% Sat. Dissolved Oxygen (mg/L) measured 8.21 mg/L to 9.99 mg/L. The DO mg/L values hover around the minimum DO CCME guideline for early life stages, dipping below the guideline when water temperatures rise as warmer water can hold less oxygen. The large amount of algae in this river may contribute to the depleted oxygen levels.
- Dissolved Oxygen percent saturation remains constant during the deployment period. 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. This trend was observed during the deployment period as evident in Figure 5 on August 28, 2012.

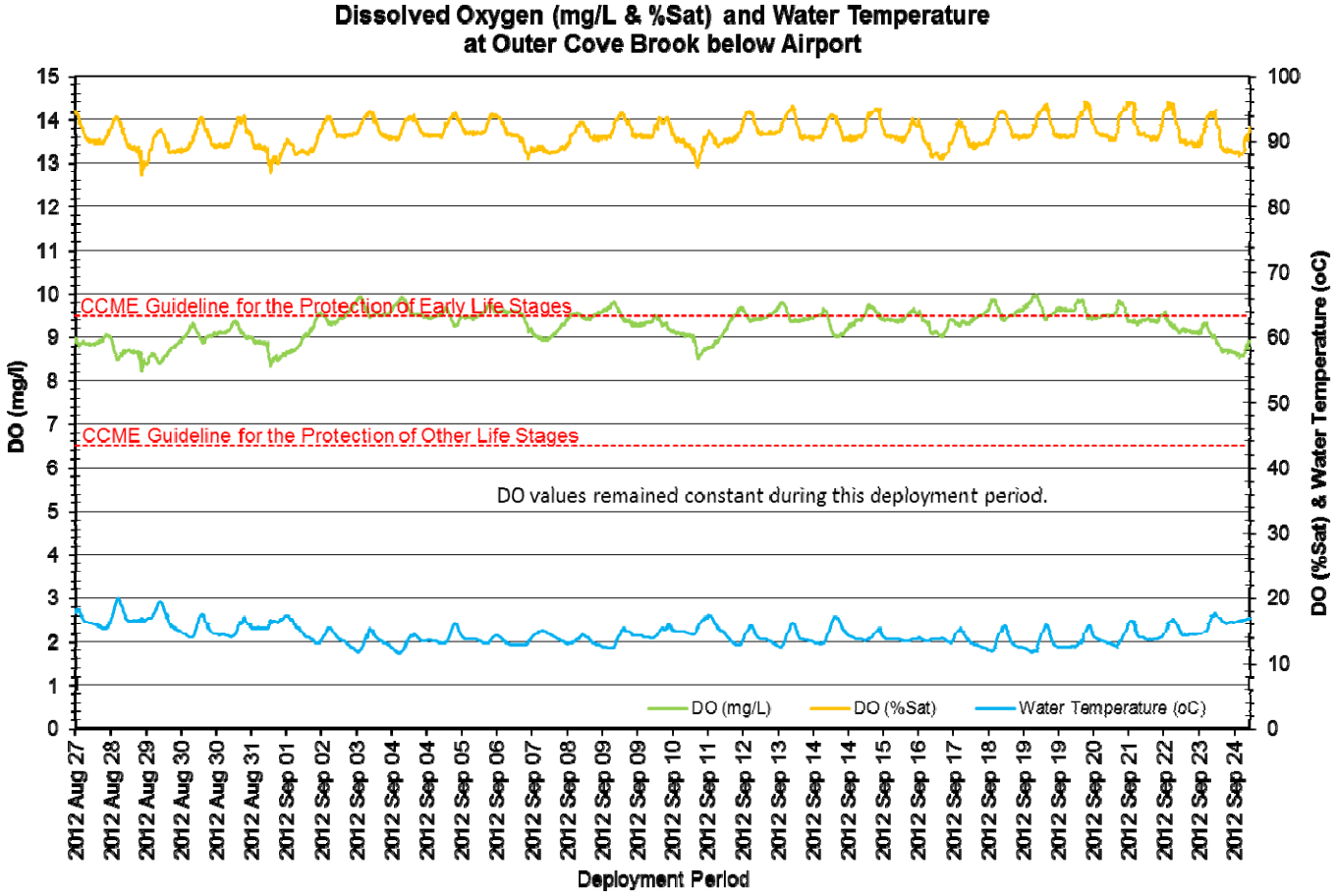

Figure 5: Quarter-hourly dissolved oxygen (mg/L & % sat) and water temperature (°C) values at Outer Cove Brook below Airport for the deployment period August 27, 2012 to September 24, 2012.

Turbidity

- Outer Cove Brook below Airport contains a significant amount of algae. High algal growth or leaf and grass debris can interfere with turbidity measurements as they block the sensor. Biofouling of the sensor is also common at this site.
- 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 this deployment ranged within 0 NTU to 300.9 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.
- This sensor received a 'poor' performance ranking at removal and there is a notable constant increase in values near the end of deployment, indicating biofouling or a sensor blockage.

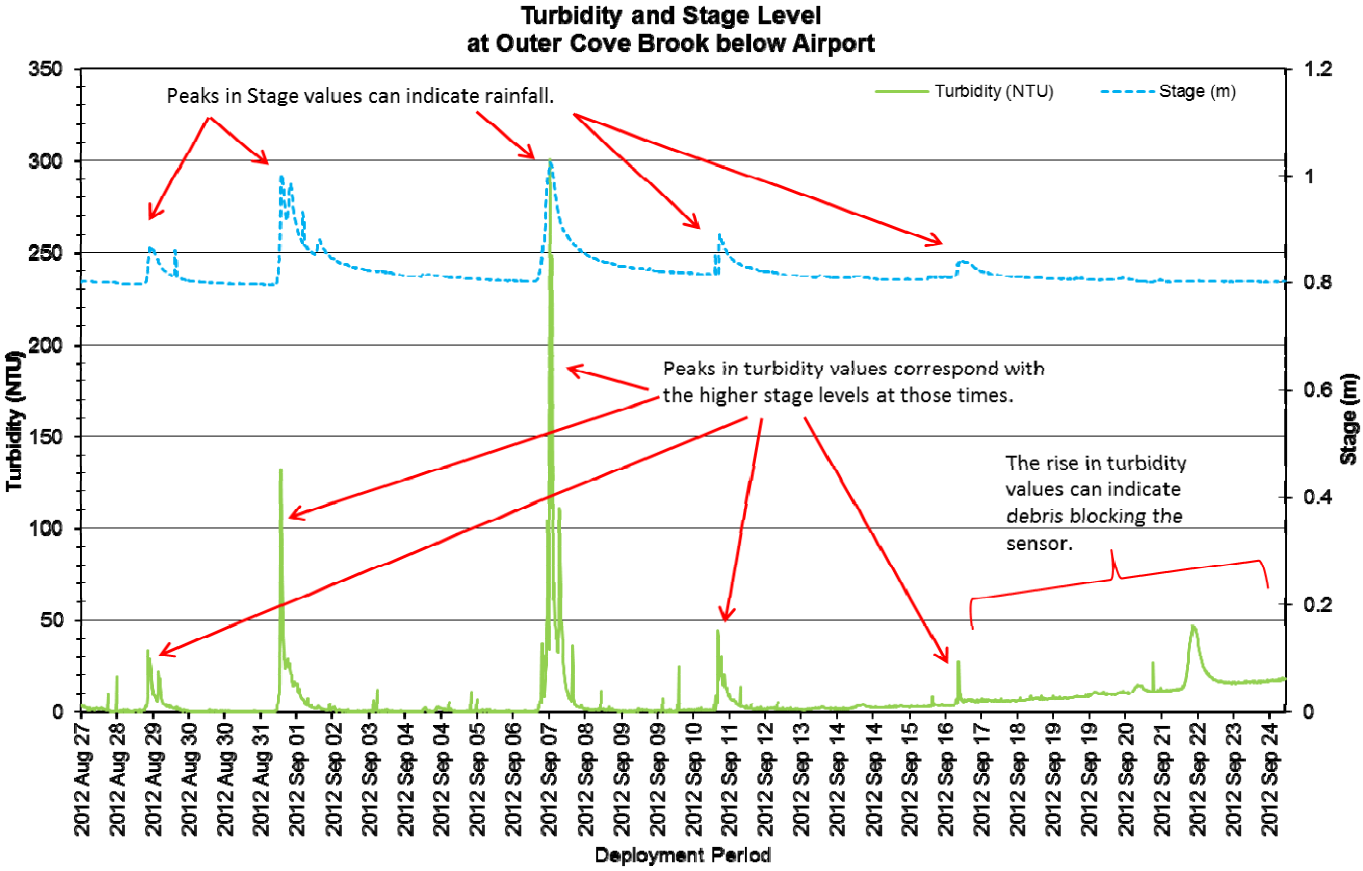

Figure 6: Quarter-hourly turbidity (NTU) and stage level (m) values at Outer Cove Brook below Airport for the deployment period August 27, 2012 to September 24, 2012.

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.
- During the deployment period, the stage ranged from 0.80m to 1.03m.

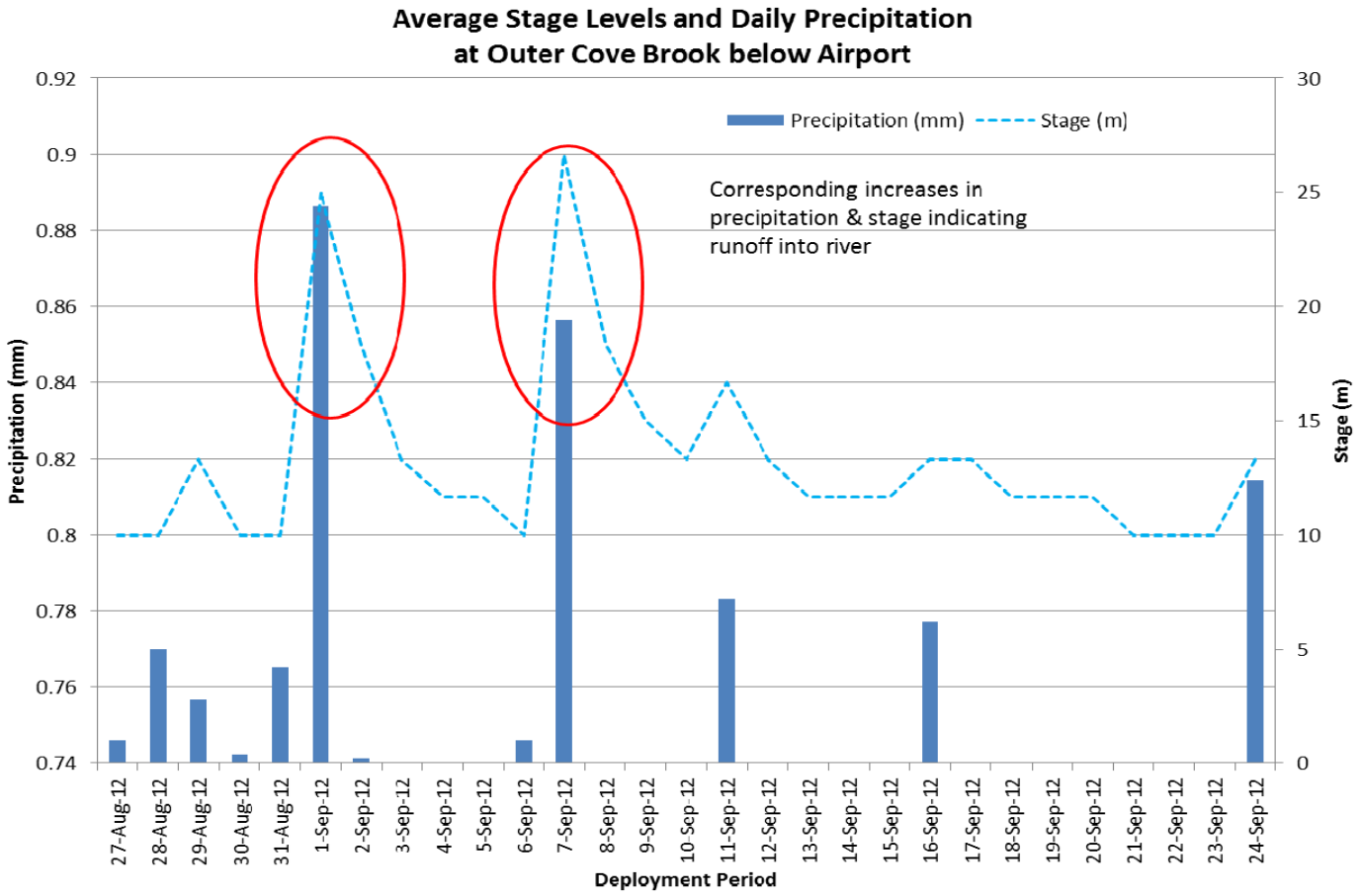

Figure 7: Daily average stage values (m) at Outer Cove Brook below Airport and daily total precipitation values (mm) from Environment Canada's St. John's Airport Station for the deployment period August 27, 2012 to September 24, 2012.

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 decreases).
- 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 began to decrease in the early fall, there were correspondingly lower water temperatures, which in turn increased the amount of dissolved oxygen in the water.
- The majority of turbidity events were correlated with increases in stage and thus precipitation events. High turbidity values at removal and a 'poor' sensor ranking, indicate that either biofouling or sensor drift was an issue during this deployment period.

Outer Cove Brook at Clovelly Golf Course

Water Temperature

- Water temperature ranged from 10.91°C to 19.42°C during this deployment period (Figure 8).
- Water temperatures fluctuate around 15°C, decreasing into the fall. This is consistent with ambient air temperatures over this time period.
- 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.

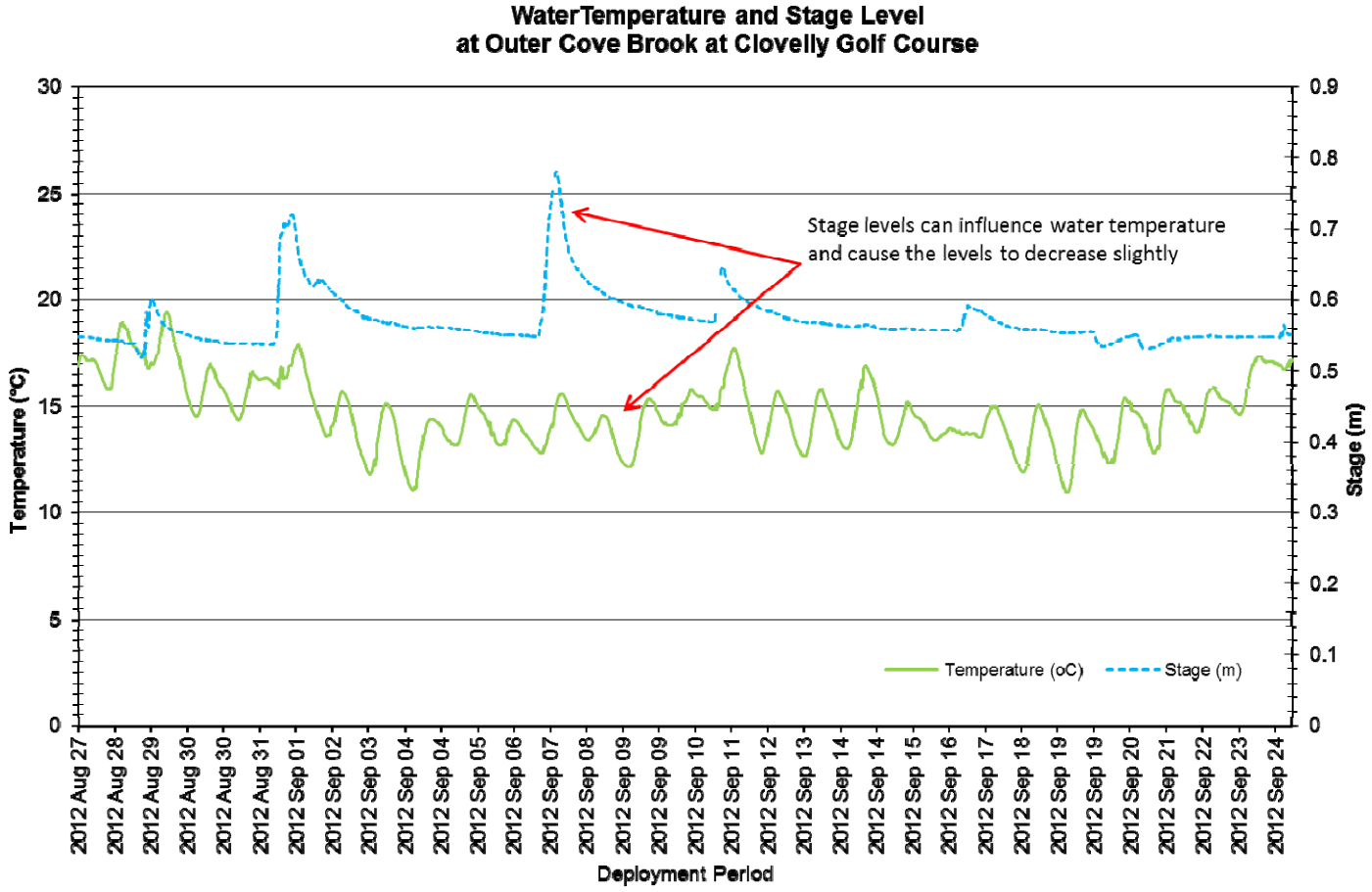

Figure 8: Quarter-hourly water temperature (°C) and stage level (m) values at Outer Cove Brook at Clovelly Golf Course for the deployment period August 27, 2012 to September 24, 2012.

pH

- Throughout this deployment period pH values ranged between 6.12 pH units and 6.59 pH units (Figure 9).
- During the deployment, the pH values at this station hover just below the minimum CCME Guideline for the Protection of Aquatic Life (between 6.5 and 9 pH units). Several precipitation events cause drops in the pH values. 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.

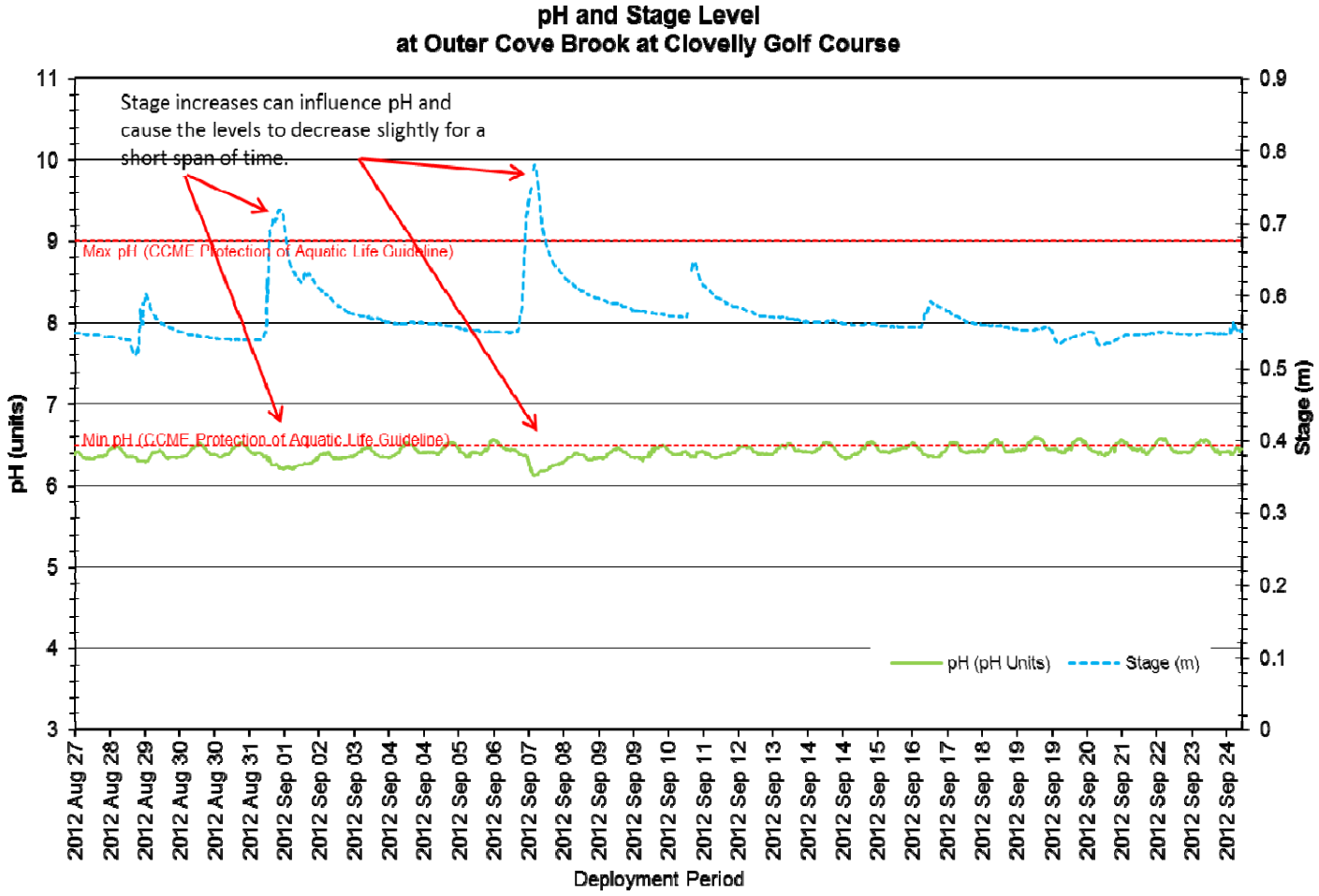

Figure 9: Quarter-hourly pH (pH units) and stage level (m) values at Outer Cove Brook at Clovelly Golf Course for the deployment period August 27, 2012 to September 24, 2012.

Specific Conductivity & TDS

- The conductivity levels were within 192.7 µS/cm and 466.0 µS/cm during this deployment period. TDS ranged from 0.1 g/L to 0.3 g/L.
- Generally, rainfall events, indicated in Figure 10 by increased stage levels, 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 freshwater in the river system dilutes the solids present there, thus generally decreasing the specific conductivity readings.
- A spike in conductivity and TDS on September 4th without a rise in stage may indicate an input of solids into the river system or resuspension of the solids already present by some mechanism other than the addition of precipitation.
- 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.

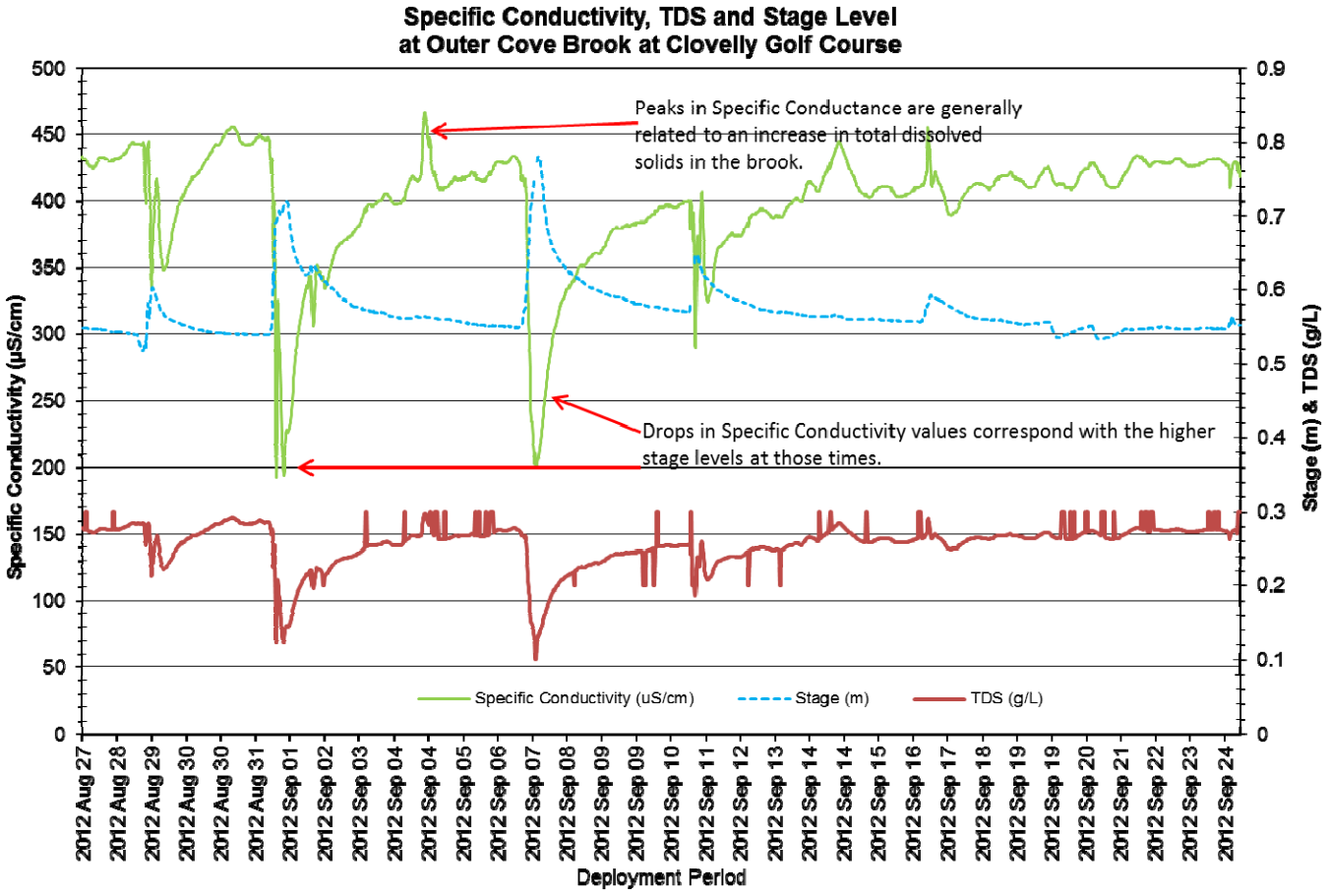

Figure 10: Quarter-hourly specific conductivity (uS/cm), TDS (g/L) and stage (m) values at Outer Cove Brook at Clovelly Golf Course for the deployment period August 27, 2012 to September 24, 2012.

Dissolved Oxygen

- The instrument measures percent saturation directly, then calculates dissolved oxygen (mg/L) using the percent saturation and water temperature values.
- The Dissolved Oxygen % Sat levels within this deployment period were within 65.9 % Sat–99.2% Sat. Dissolved Oxygen (mg/L) measured 6.37 mg/L to 10.14 mg/L. The DO mg/L values hover around the minimum DO CCME guideline for early life stages, dipping below the guideline once on August 29th when water temperatures rise as warmer water can hold less oxygen. The large amount of algae in this river may contribute to the depleted oxygen levels at night.
- Dissolved Oxygen percent saturation remains constant during the deployment period. 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. This trend was observed during the deployment period as evident in Figure 11 on September 11, 2012.

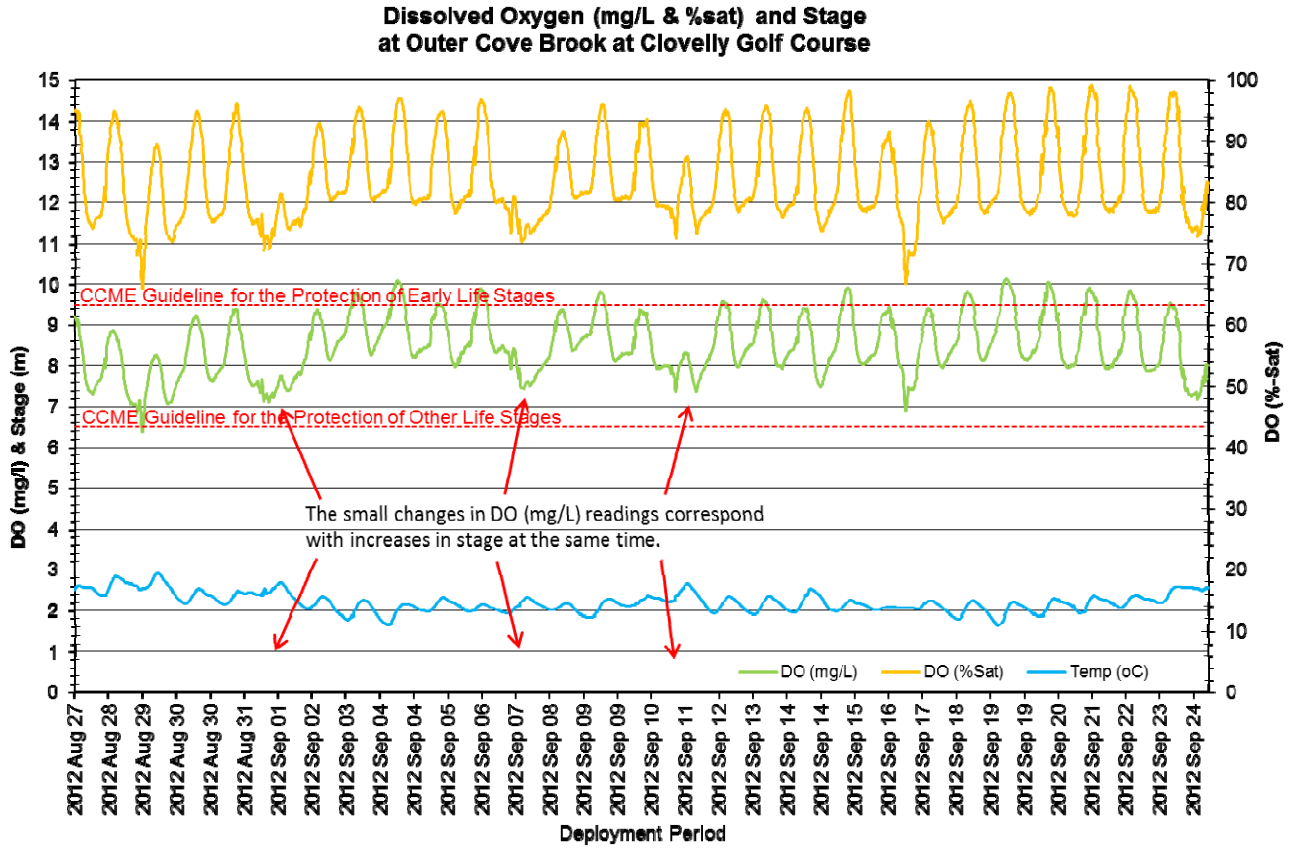

Figure 11: Quarter-hourly dissolved oxygen (mg/L & % sat) and water temperature (°C) values at Outer Cove Brook at Clovelly Golf Course for the deployment period August 27, 2012 to September 24, 2012.

Turbidity

- Outer Cove Brook at Clovelly Golf Course contains a significant amount of algae. High algal growth or leaf and grass debris can interfere with turbidity measurements as they block the sensor. Biofouling of the sensor is also common at this site.
- 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 this deployment ranged within 0.9 NTU to 466.0 NTU.
- Several precipitation events and corresponding stage increases led to fluctuating turbidity values (see Figure 12) as sediment and debris were resuspended into the water column.
- This sensor received an 'excellent' performance ranking at removal indicating that biofouling may not be an issue at this time of the year.

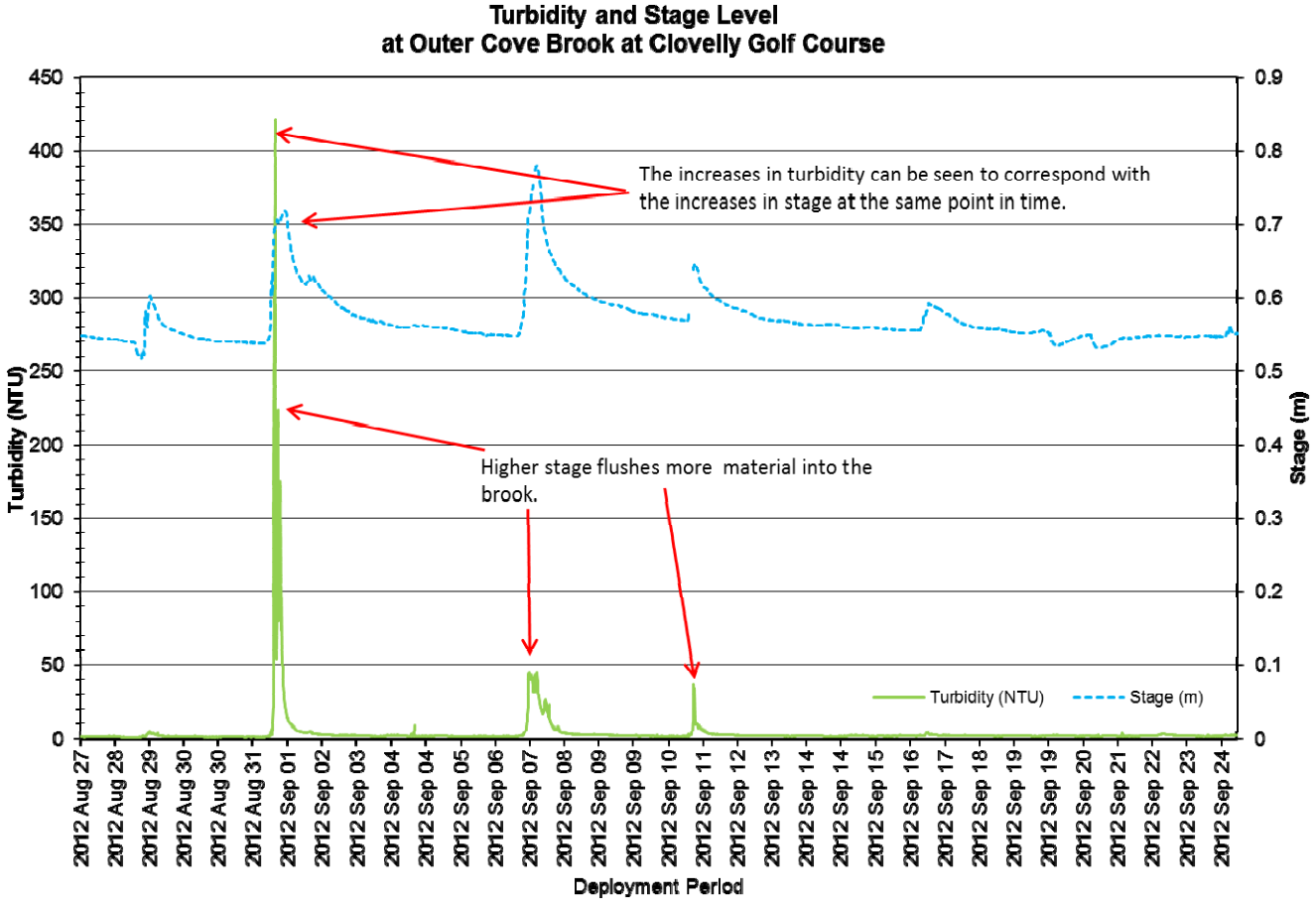

Figure 12: Quarter-hourly turbidity (NTU) and stage level (m) values at Outer Cove Brook at Clovelly Golf Course for the deployment period August 27, 2012 to September 24, 2012.

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.
- During the deployment period, the stage values ranged from 0.52m to 0.78m.

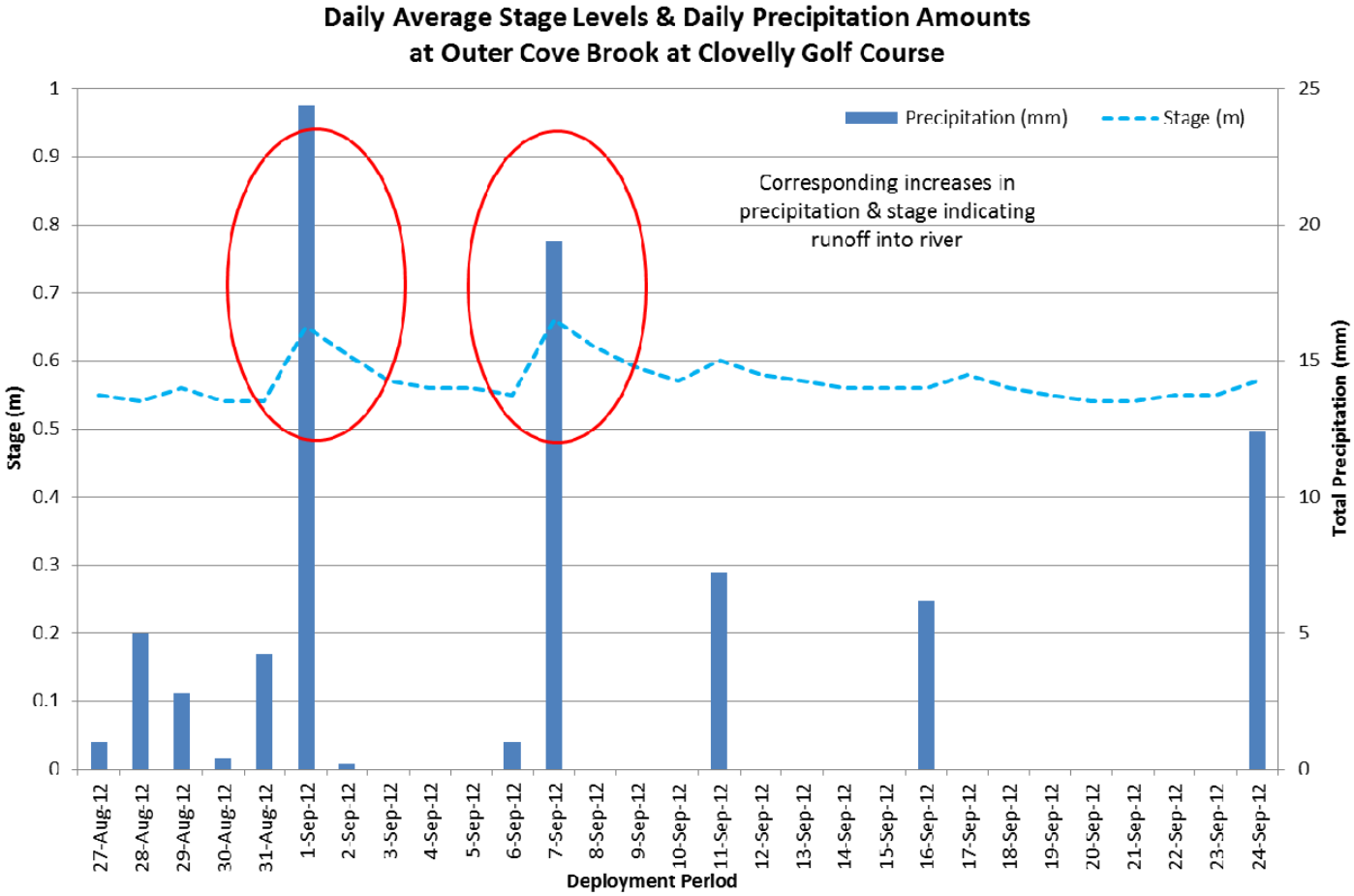

Figure 13: Daily average stage values (m) at Outer Cove Brook below Airport and daily total precipitation values (mm) from Environment Canada's St. John's Airport Station for the deployment period August 27, 2012 to September 24, 2012.

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 dropped in the early fall, so too did the water temperature, as is to be expected.
- Diurnal variations in DO values are much greater at this site than at below airport. This is likely due to the large quantity of grasses and vegetation in the river at the Clovelly site. The vegetation can create and give off oxygen only when the sun is present, resulting in high climbs in DO values during the daylight hours due to photosynthesis.
- The majority of turbidity events were correlated with increases in stage and thus precipitation events.
- Corresponding spikes in conductivity and TDS at both stations indicate that this river is influenced by runoff upstream of both stations.

Conclusions – Outer Cove Brook Network

During this deployment period, the median water temperature at the upstream station (below Airport) of 14.20°C was very similar to that of the downstream station (at Clovelly Golf Course) of 14.61°C. The median pH values for both stations were identical at 6.41 pH units, and thus there was no significant change in pH from the upstream to the downstream station. The specific conductivity medians were similar at both stations with 438.8 uS/cm reported below the airport and 411uS/cm reported at the golf course. It should be noted that higher specific conductivity values were recorded below the airport, reaching a maximum value of 574 uS/cm, compared to the maximum value of 466 uS/cm at Clovelly Golf Course. This indicates more influence or inputs of sediments at the below Airport station during this deployment period. Conductivity and TDS fluctuated regularly without the addition of precipitation, indicating that there may be some processes acting upstream of both stations which adds solids to the river or resuspends those already present. Dissolved oxygen at the upstream station (below Airport) had a median of 90.9%Sat during the deployment period, while the downstream station (Clovelly Golf Course) had a lower median of 81.2%Sat. The lower oxygen median is due to the large diurnal variations of oxygen at the Clovelly station. These large daily variations are due to the presence of more algae and vegetation at this station, which depletes oxygen from the water at night at a rapid rate but can only replenish the oxygen levels during daylight photosynthesis. Turbidity medians at both stations are identical: 2 NTU. This is an indication that turbidity did not increase significantly as the water in the brook moved downstream.