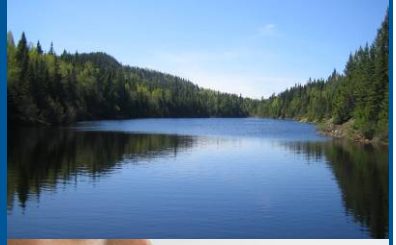







Real-Time Water Quality Report

Outer Cove Brook Network

Deployment Period
December 7, 2012 to January 8, 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 32-day period from deployment on December 7, 2012 until removal on January 8, 2013.

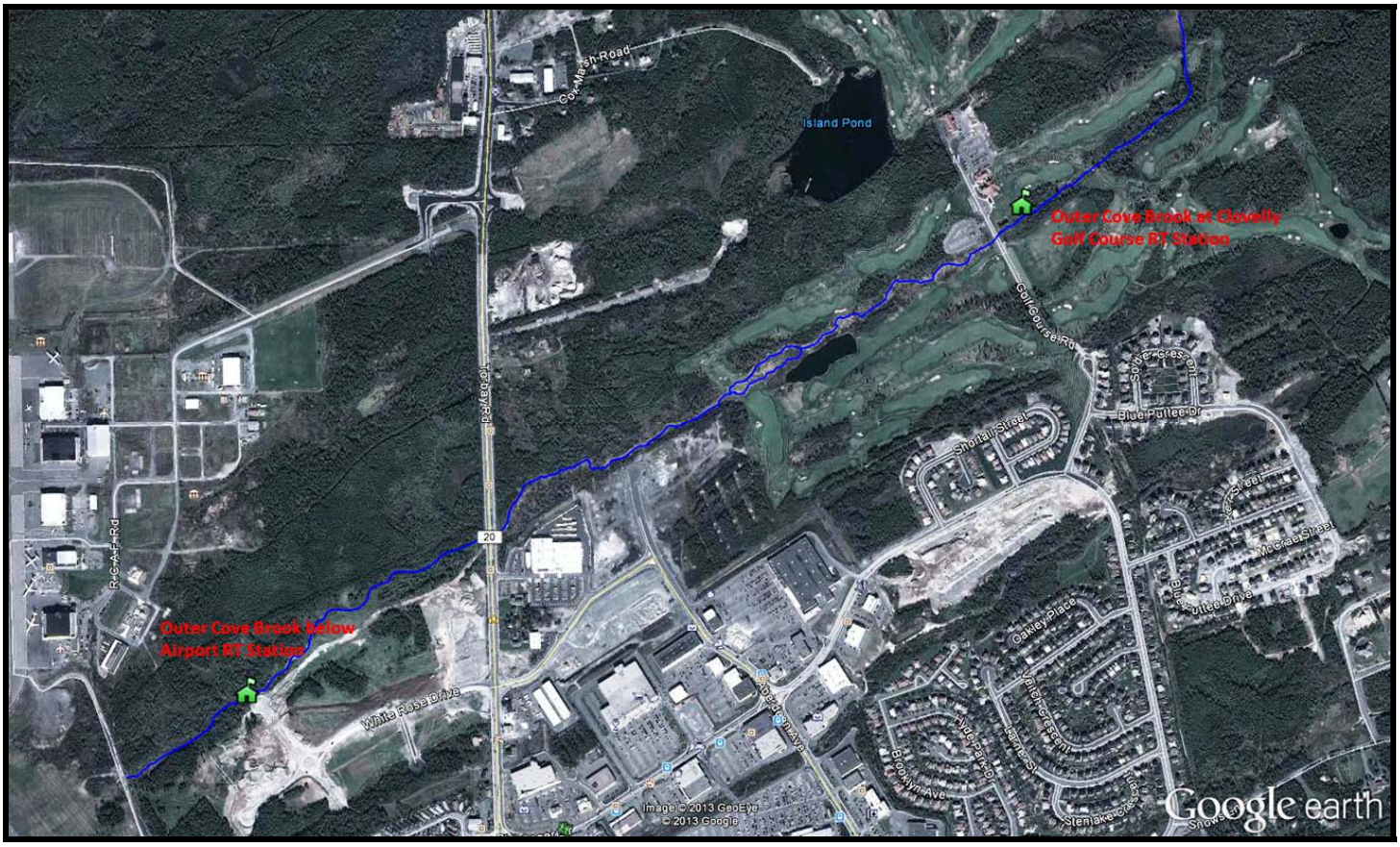

Figure 1: Outer Cove Brook Real-Time Water Quality and Quantity Stations.

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 December 7, 2012 through to January 8, 2013 are summarized in Table 2.

Table 2: Instrument performance rankings for Outer Cove Brook below Airport Dec. 7, 2012 – Jan. 8, 2013

Station	**Date**	**Action**	**Comparison Ranking**				
			Temperature	**pH**	**Conductivity**	**Dissolved Oxygen**	**Turbidity**
Below Airport	Dec 7 2012	Deployment	Marginal	Excellent	Good	Excellent	Good
	Jan 8 2013	Removal	Fair	Excellent	Good	Poor	Poor

- During the Outer Cove Brook below Airport station deployment, pH, conductivity, dissolved oxygen and turbidity sensors ranked 'good' to 'excellent'. The temperature sensor's 'marginal' ranking indicates that the QA/QC sonde may not have stabilized when the reading was taken due to the change in temperature between the laboratory and river. Overall, the data being produced was reliable and accurate at the start of deployment.

- During removal, pH ranked as 'excellent' while specific conductivity ranked as 'good'. The temperature sensor ranked as 'fair', indicating that the QA/QC readings may have been taken before the sensor stabilized in the cold environment. Dissolved oxygen and turbidity ranked as 'poor', which was expected as the sensors were encrusted in ice and biofouling slime upon removal, affecting the sensor's ability to function.

- Deployment and removal instrument performance rankings for **Outer Cove Brook at Clovelly Golf Course** for the period of December 7, 2012 through to January 8, 2013 are summarized in Table 3.

Table 3: Instrument performance rankings for Outer Cove Brook at Clovelly Golf Course Dec 7, 2012 - Jan 8, 2013

Station	Date	Action	Comparison Ranking				
			Temperature	pH	Conductivity	Dissolved Oxygen	Turbidity
Clovelly Golf Course	Dec 7 2012	Deployment	Marginal	Excellent	Marginal	Excellent	Excellent
	Jan 8 2013	Removal	Good	Good	Marginal	Good	Poor

At the Outer Cove Brook Clovelly Golf Course station, pH, dissolved oxygen and turbidity ranked 'excellent' at deployment. Temperature and specific conductivity ranked 'marginal', likely due to the 'shock' of being placed in the cold river and possibly a calibration error with the specific conductance sensor.

- At removal, temperature, pH, and dissolved oxygen all ranked 'good'. The turbidity sensor ranked as 'poor', the result of biofouling and debris stuck to the sensor as observed during removal. The specific conductivity sensor ranked as 'marginal', the same as during deployment, with an ~ 60 uS/cm difference at both deployment and removal, indicating a calibration issue with the field sonde's sensor.

- 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

- Transmission errors occurred during the first two weeks of the deployment period at both stations, resulting in data gaps in the graphs shown in this report. Both stations were visited by Environment Canada technicians, and transmissions were restored.

Data Interpretation

- The following graphs and discussion illustrate water quality-related events from December 7, 2012 to January 8, 2013 at the Outer Cove Brook Stations.
- Due to the above mentioned transmission errors, for Outer Cove Brook below Airport, water quality data was retrieved from the sonde's internal memory in order to minimize data gaps, and combined with the correlated stage data. Gaps in stage data remain as this information is not stored internally in the sonde. It should be noted that TDS data stored internally in the sonde is rounded to one decimal place instead of four decimal places as with the satellite transmission data.
- As there were few transmission errors at Outer Cove Brook at Clovelly Golf Course, the transmitted water quality data and its synchronous stage data were analyzed for this station.
- 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 -0.04°C to 7.02°C during this deployment period (Figure 2). Upon removal, ice had to be broken from around the deployment cable.
- The higher stage levels near the end of deployment are related to the backwater effect caused during ice cover.
- An overall decrease in water temperatures is evident from the graph and consistent with ambient air temperatures over this time period as winter approaches.
- Water temperatures display large 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 instruments.

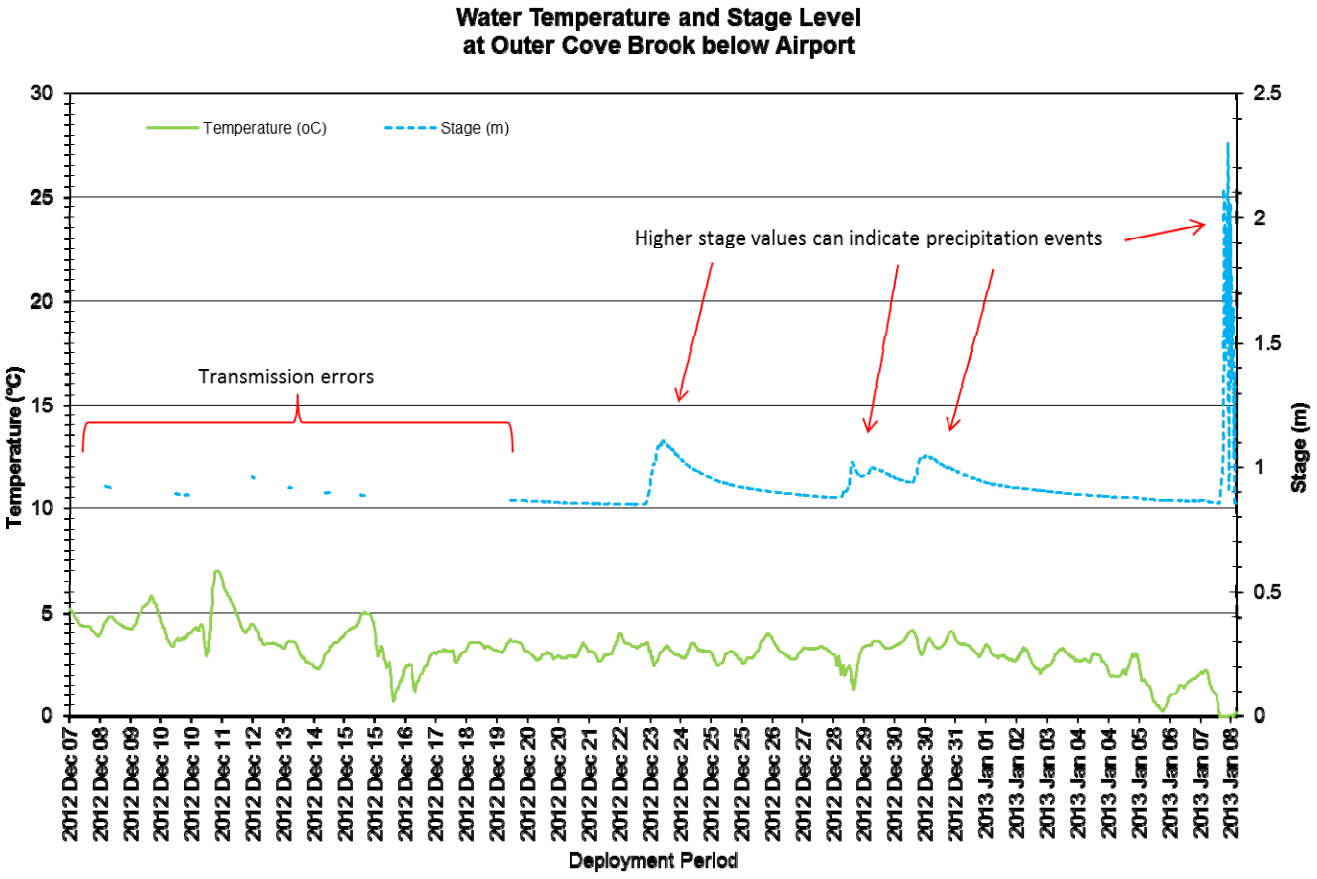

Figure 2: Quarter-hourly water temperature (°C) and stage level (m) values at Outer Cove Brook below Airport for the deployment period December 7, 2012 to January 8, 2012.

pH

- Throughout this deployment period pH values ranged between 6.29 and 6.82 pH units (Figure 3).
- 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). 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.

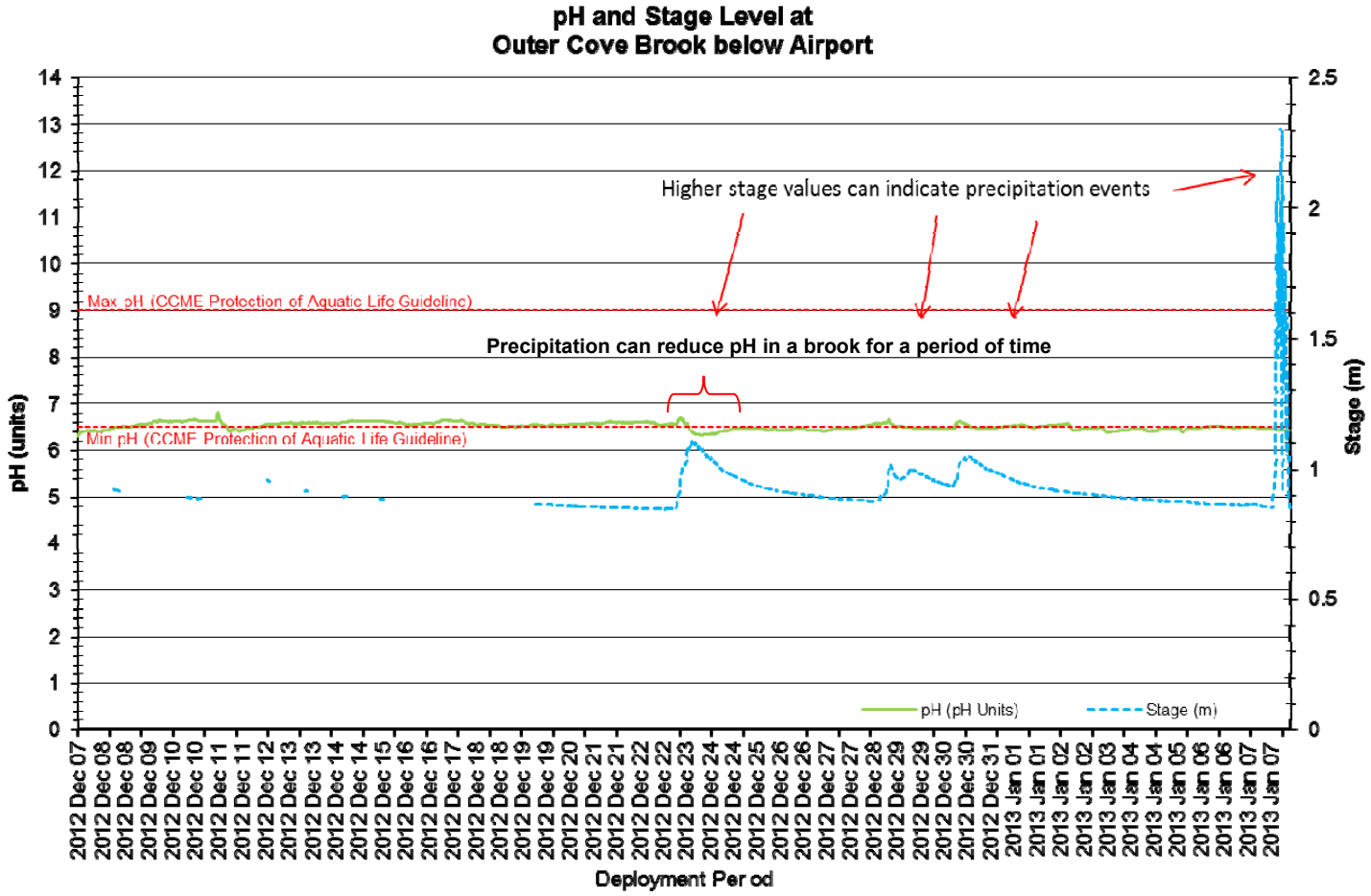

Figure 3: Quarter-hourly pH (pH units) and stage level (m) values at Outer Cove Brook below Airport for the deployment period December 7, 2012 to January 8, 2013.

Specific Conductivity & TDS

- The conductivity levels were within 247µS/cm and 1241 µS/cm during this deployment period. TDS ranged from 0.2 to 0.8 g/L.
- Rainfall events (indicated 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 water in the river system dilutes the solids present there, thus decreasing the specific conductivity readings.
- Snowfall events can have the effect of increasing conductance levels. With snowfall and freezing air temperatures comes the addition of salt to roadways. Through wind, snowmelt and rainfall, these salts are carried into the water system, increasing the specific conductance. The increase on December 23 is in response to a snowfall event.
- 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.

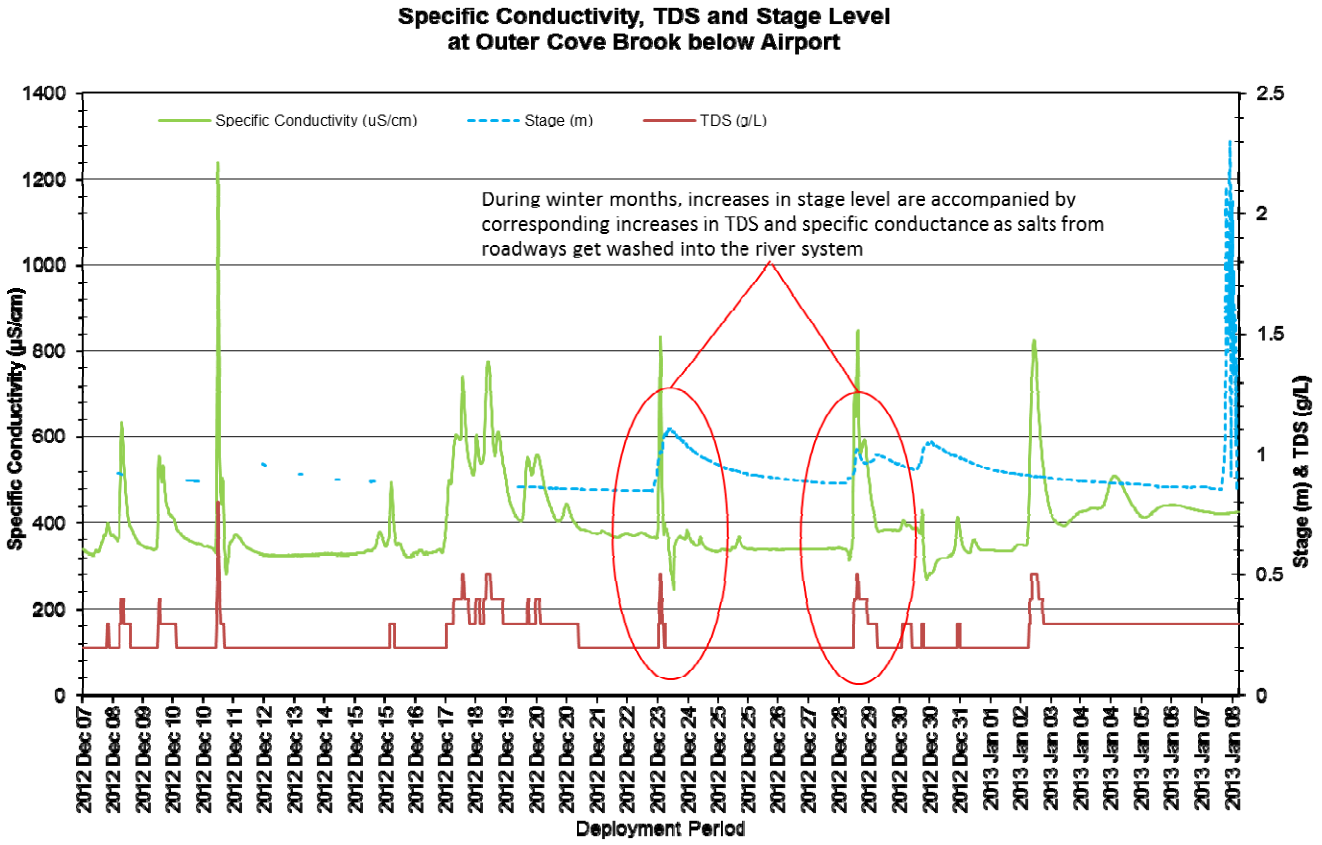

Figure 4: Quarter-hourly specific conductivity (µS/cm), TDS (g/L) and stage (m) values at Outer Cove Brook below Airport for the deployment period December 7, 2012 to January 8, 2013.

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 68.7–92.7% Sat. Dissolved Oxygen (mg/L) measured 10.03–12.73 mg/L. The DO mg/L values are above the minimum DO CCME guideline for early life stages and higher than in previous months as the colder water can hold more oxygen.
- Dissolved oxygen mg/L content fluctuates with the water temperature changes. Increases in dissolved oxygen values are inversely related to decreases in water temperature as colder water can hold more oxygen. This trend was observed during the deployment period as evident in Figure 5 on December 11, 2012.
- Dissolved Oxygen percent saturation decreases steadily throughout the deployment period, with a significant drop near the end of deployment, indicating an issue with the DO sensor, which resulted in the 'poor' performance ranking of this sensor upon removal.

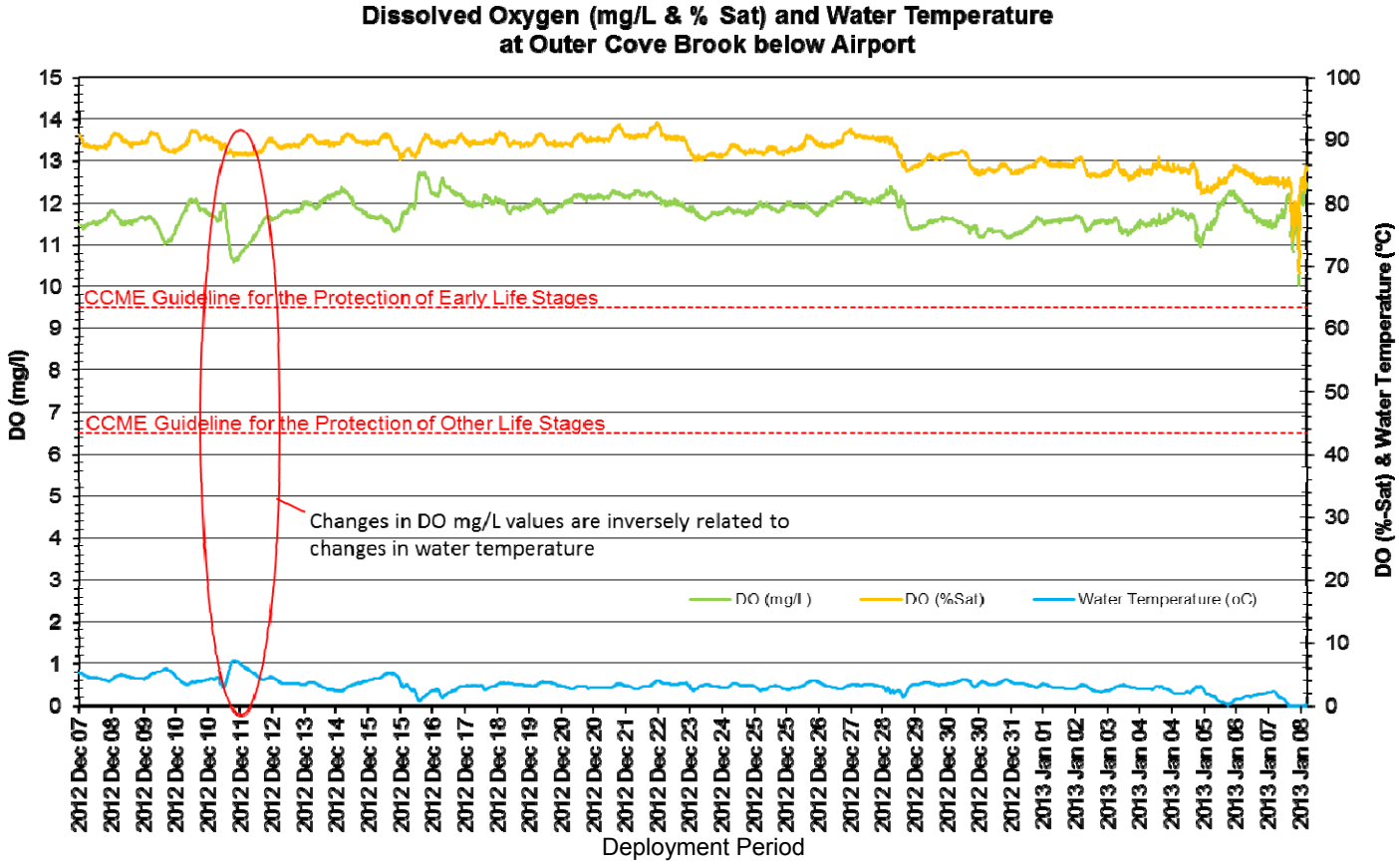

Figure 5: Quarter-hourly dissolved oxygen (mg/L & % sat) and water temperature (°C) values at Outer Cove Brook below Airport for the deployment period December 7, 2012 to January 8, 2013.

Turbidity

- Outer Cove Brook below Airport contains a significant amount of algae. High algal growth or leaf 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 this deployment ranged within 0 NTU to 2417.0 NTU.
- The persistently high turbidity values at the end of deployment indicate the sensor is blocked and not reading correctly. Upon removal, it was noted that algae and slush were removed from around the sensors. Other turbidity events during the deployment period coincide with precipitation events as runoff resuspends the river's sediments into the water column.

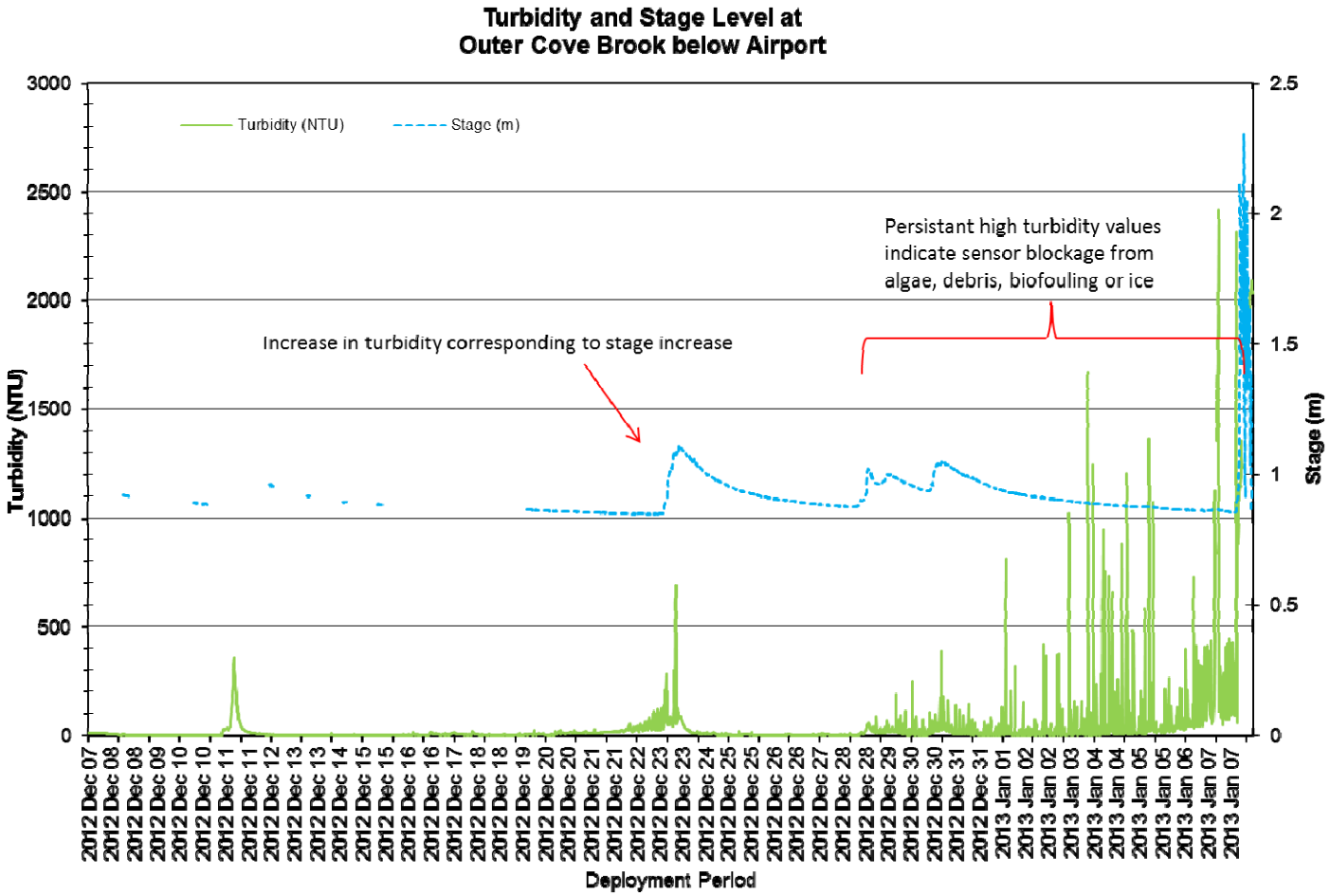

Figure 6: Quarter-hourly turbidity (NTU) and stage level (m) values at Outer Cove Brook below Airport for the deployment period December 7, 2012 to January 8, 2013.

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.
- Precipitation data was obtained from Environment Canada's St. John's Airport weather station. Gaps exist in the precipitation data as data for all days was not available.
- The higher stage levels near the end of deployment are related to the backwater effect caused during ice cover.
- 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.
- During the deployment period, the stage ranged from 0.85m to 1.11m. During removal, ice completely covered the sonde and deployment area, requiring the cables to be cut from the ice and the ice around the sonde to be broken up and removed.

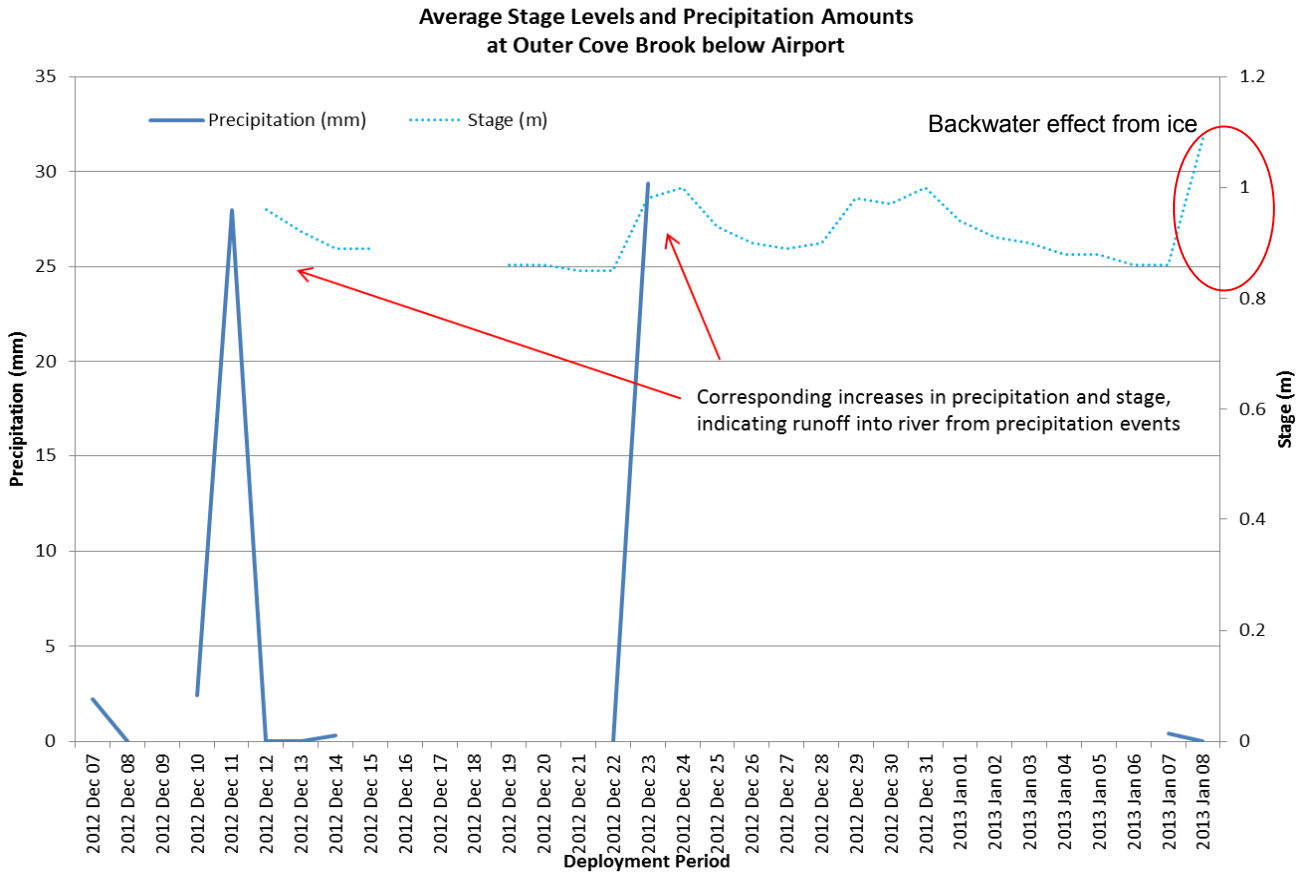

Figure 7: Daily average stage values (m) at Outer Cove Brook below Airport and daily total precipitation values (mm) from Environment Canada's St. John's Airport Station for the deployment period December 7, 2012 to January 8, 2013.

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 differences 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 decreased into the winter months, there was a corresponding decrease in water temperature, 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. During the end of the deployment period, a persistent increase in turbidity was evident. Inspection on removal noted that this was due to large amounts of debris and ice formed around the sensors.
- The addition of road salt to roadways and runways during periods of snowfall and low ambient air temperatures led to increases in specific conductance and TDS as the salts were washed into the river system. This indicates that this river is influenced by runoff upstream of the station.
- Due to the large amount of ice present around the sonde and cable and the noted low flow conditions, it was decided to not reinstall this station until ice conditions improve so as not to damage the cable and instrument.

Outer Cove Brook at Clovelly Golf Course

Water Temperature

- Water temperature ranged from -0.03°C to 6.31°C during this deployment period (Figure 8).
- An overall decrease in water temperatures is evident from the graph and consistent with ambient air temperatures over this time period as winter approaches.
- Water temperatures display large 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 instruments.

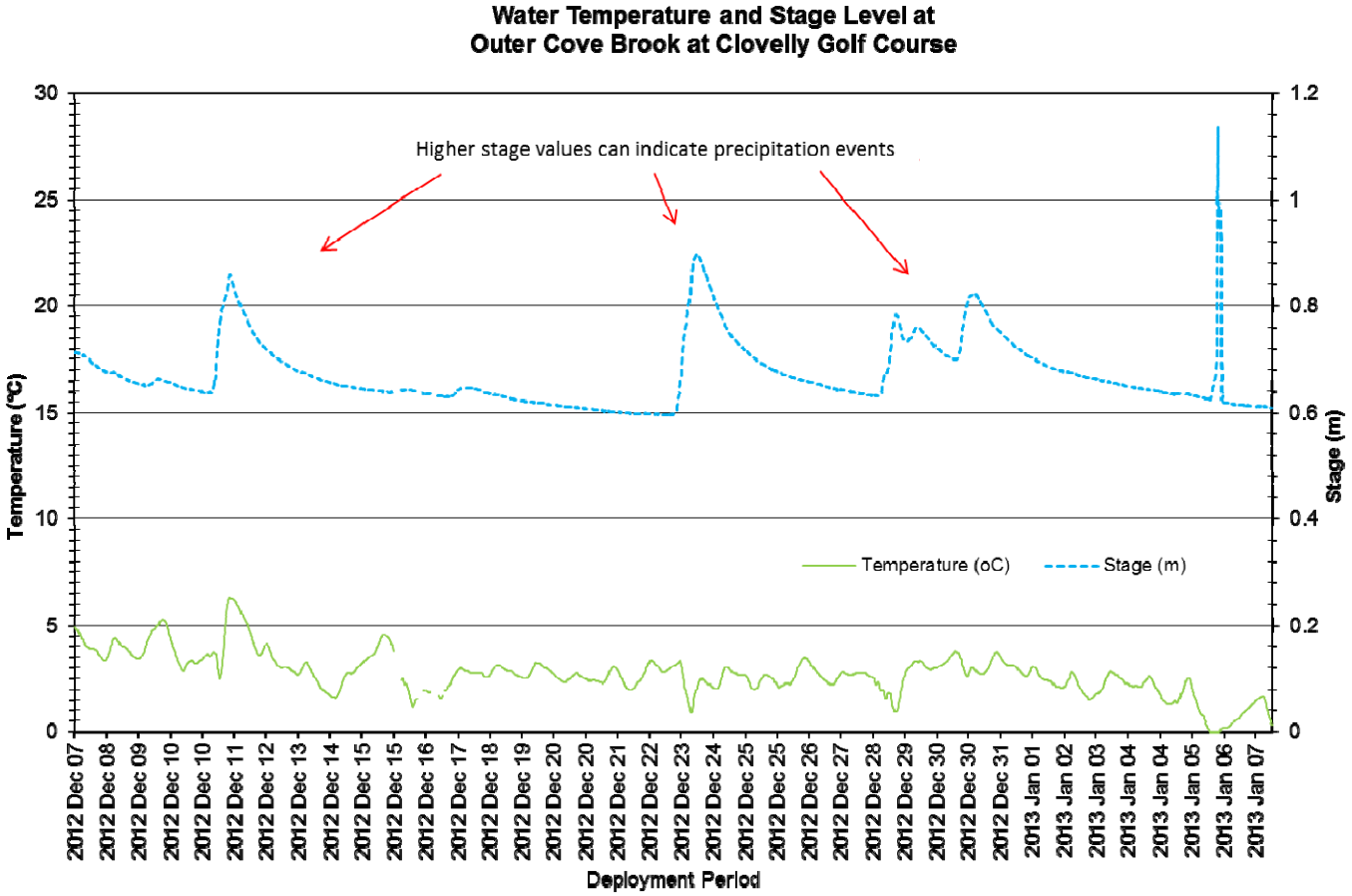

Figure 8: Quarter-hourly water temperature (°C) and stage level (m) values at Outer Cove Brook at Clovelly Golf Course for the deployment period December 7, 2012 to January 8, 2013.

pH

- Throughout this deployment period pH values ranged between 6.36 and 6.81 pH units (Figure 3).
- During deployment, the pH values hover just above the minimum CCME Guideline for the Protection of Aquatic Life (between 6.5 and 9 pH units), only falling below as two precipitation events increase the stage level resulting in lower pH values. This is a natural occurrence between precipitation 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.

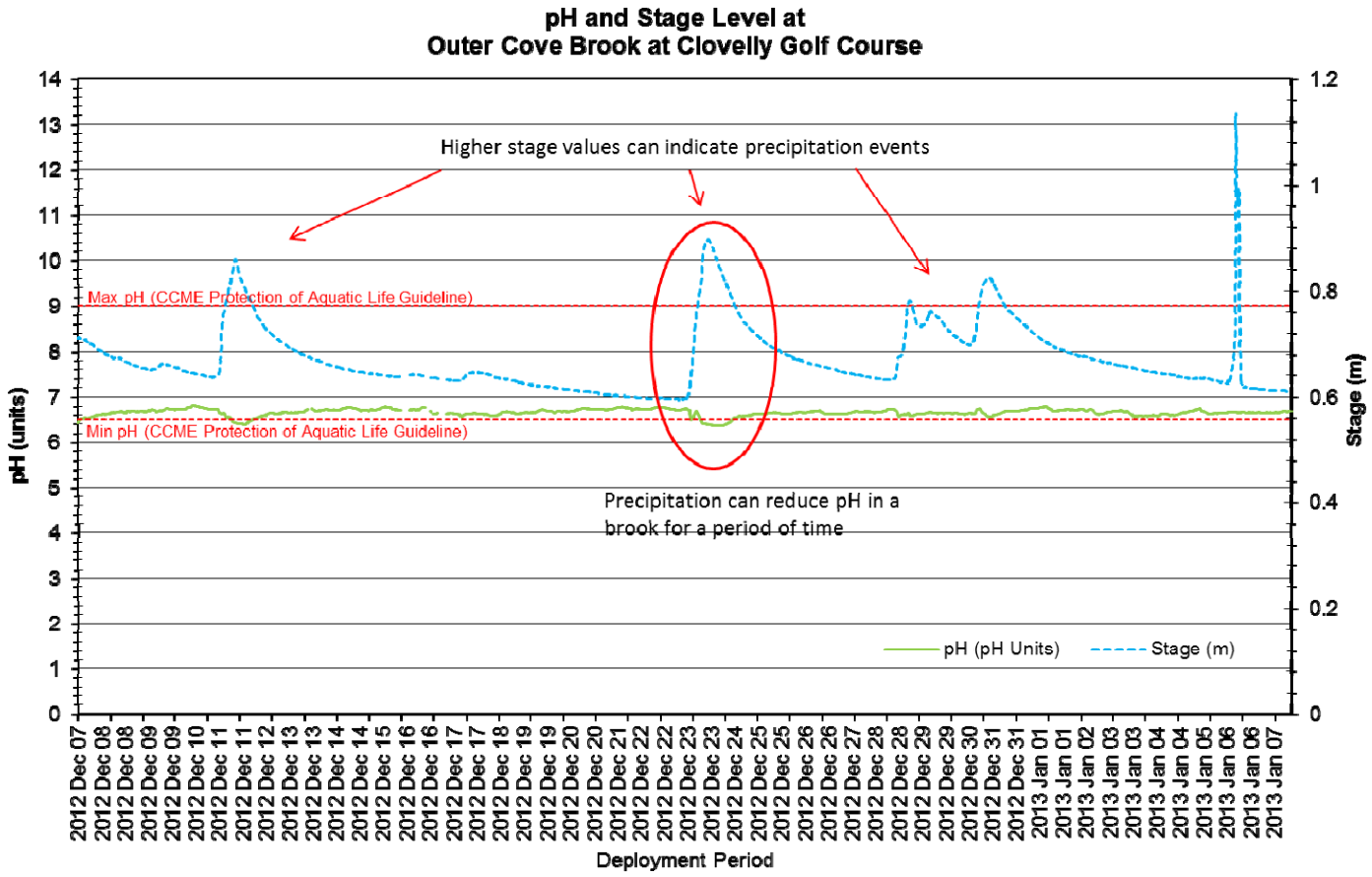

Figure 9: Quarter-hourly pH (pH units) and stage level (m) values at Outer Cove Brook at Clovelly Golf Course for the deployment period December 7, 2012 to January 8, 2013.

Specific Conductivity

- The conductivity levels were within 239 µS/cm and 2629 µS/cm during this deployment period. TDS ranged from 0.1530 to 1.6800 g/L. These values are notably higher than those of the previous deployment period.
- Snowfall events can have the effect of increasing conductance levels. With snowfall and freezing air temperatures comes the addition of salt to roadways. Through wind, snowmelt and rainfall, these salts are carried into the water system, increasing the specific conductance. The increase on December 28 is in response to a snowfall event.
- 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 mirrors specific conductivity.

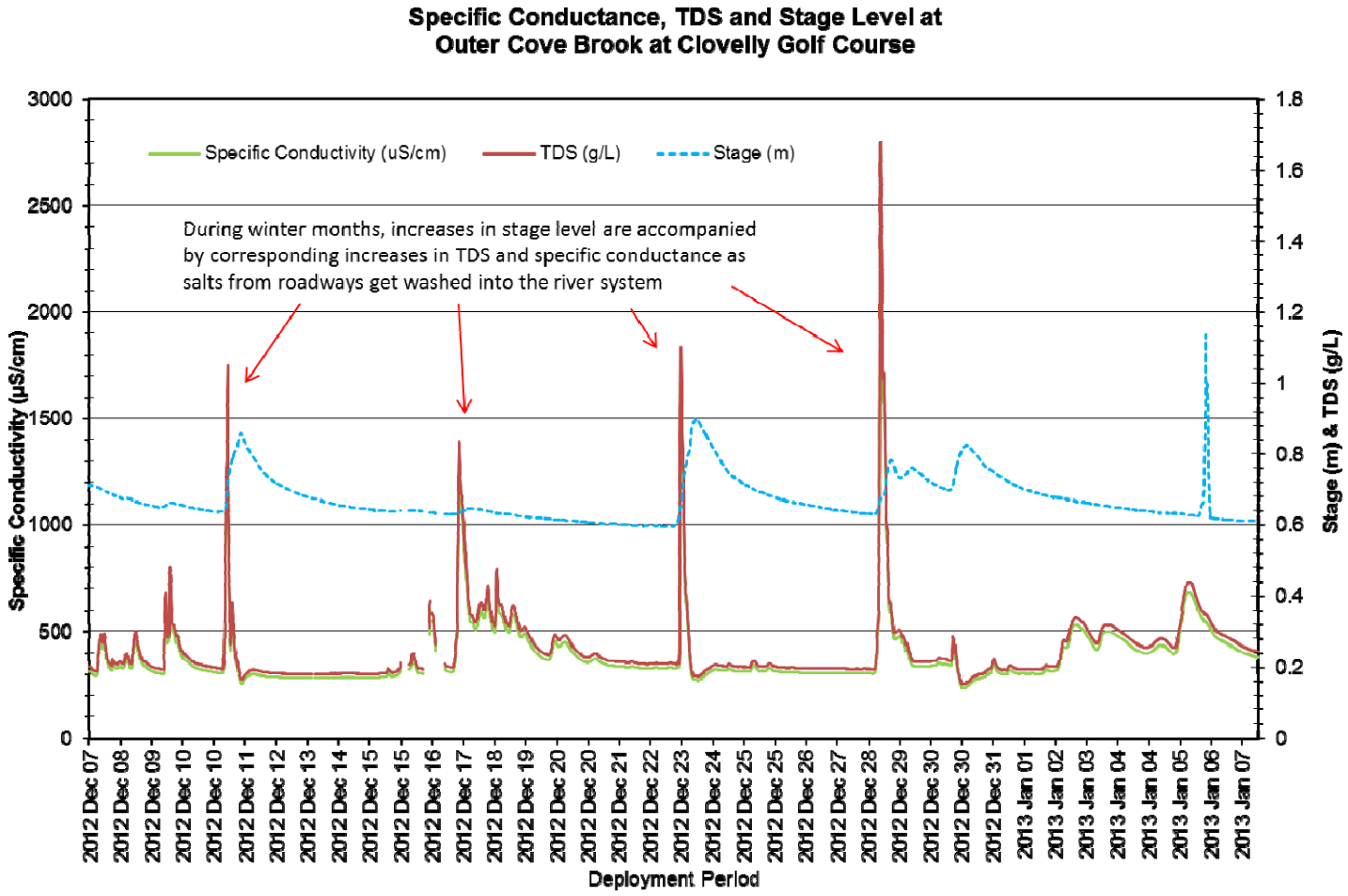

Figure 10: Quarter-hourly specific conductivity (uS/cm), TDS (g/L) and stage (m) values at Outer Cove Brook at Clovelly Golf Course for the deployment period December 7, 2012 to January 8, 2013.

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 75.5–90.1% Sat. Dissolved Oxygen (mg/L) measured 9.86-12.33 mg/L. The DO mg/L values are above the minimum DO CCME guideline for early life stages and higher than in previous months as the colder water can hold more oxygen.
- Dissolved Oxygen percent saturation decreases slightly over the deployment period. Dissolved oxygen mg/L content fluctuates with the water temperature changes. Increases in dissolved oxygen values are inversely related to decreases in water temperature as colder water can hold more oxygen. This trend was observed during the deployment period as evident in Figure 5 on December 11, 2012.

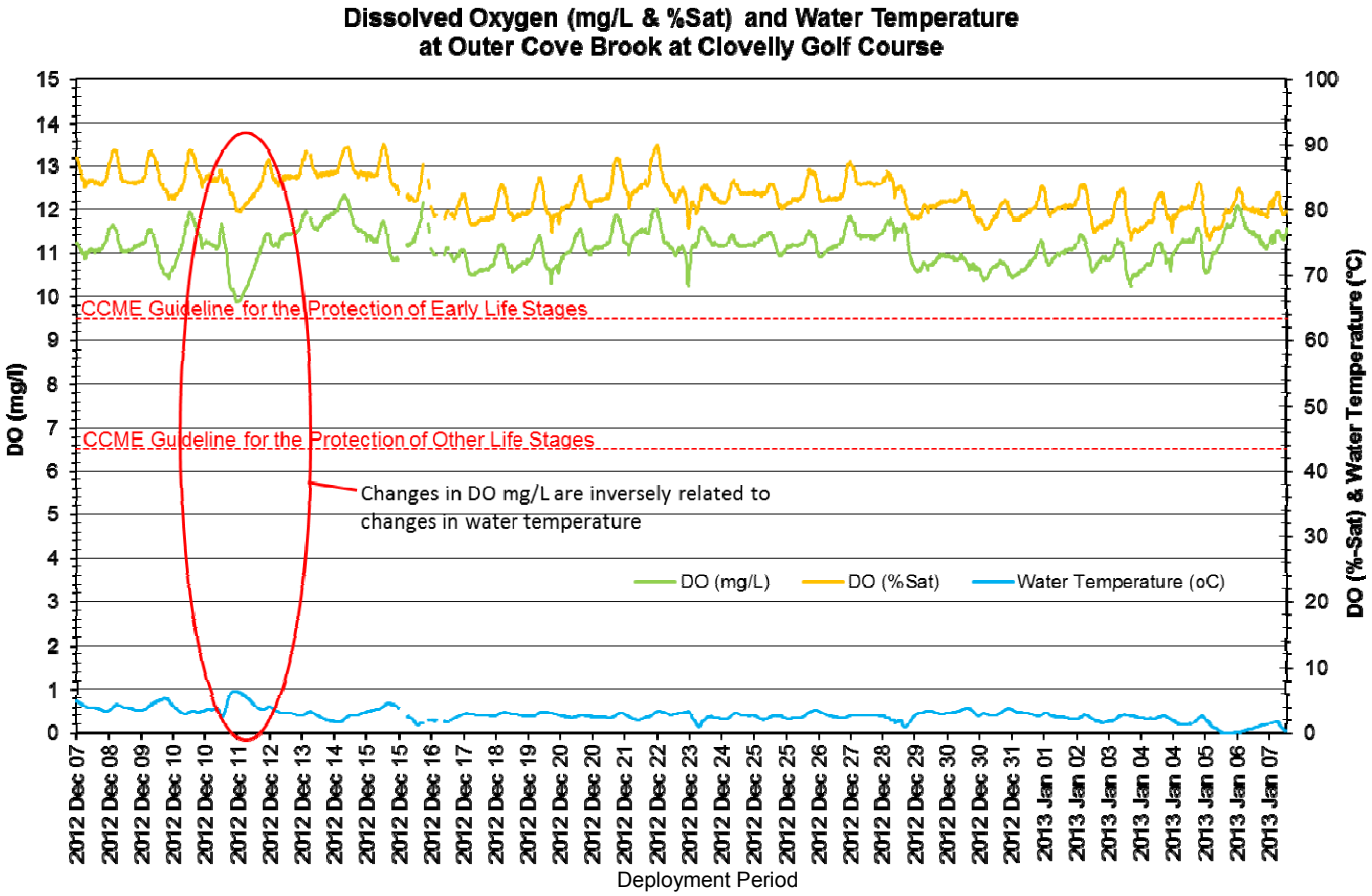

Figure 11: Quarter-hourly dissolved oxygen (mg/L & % sat) and water temperature (°C) values at Outer Cove Brook at Clovelly Golf Course for the deployment period December 7, 2012 to January 8, 2013.

Turbidity

- Outer Cove Brook contains a significant amount of algae. High algal growth or leaf debris 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, this is not a valid turbidity reading.
- The turbidity readings during this deployment ranged within 3 NTU to 375.8 NTU (Figure 12).
- The majority of turbidity events are the result of precipitation events. The constant increase in turbidity values at the end of deployment (January 4-8) indicates that there is either increasing interference with the sensor by debris or algae, or that there is an issue with this sensor.

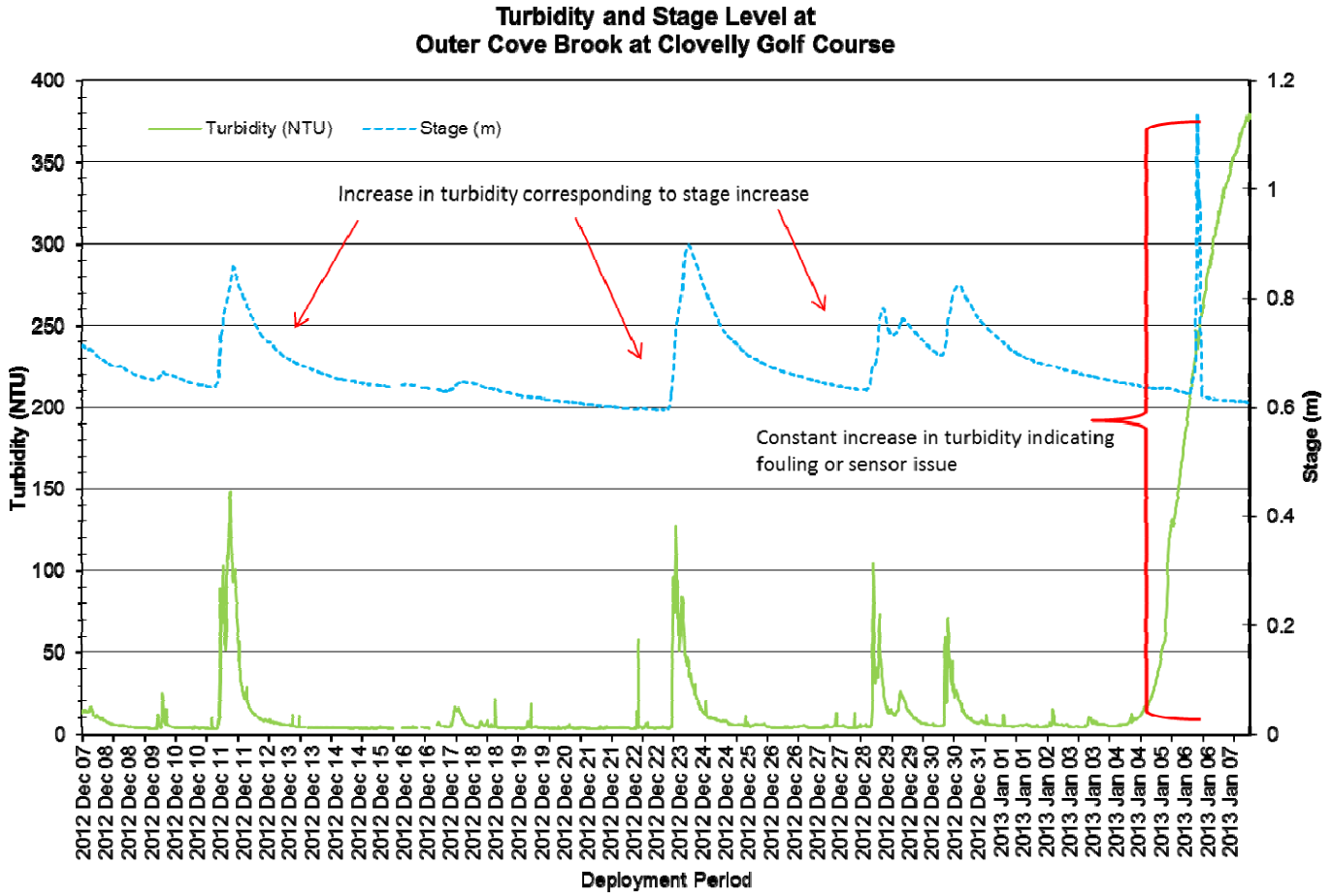

Figure 12: Quarter-hourly turbidity (NTU) and stage level (m) values at Outer Cove Brook at Clovelly Golf Course for the deployment period December 7, 2012 to January 8, 2013.

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.
- Precipitation data was obtained from Environment Canada's St. John's Airport weather station. Gaps exist in the precipitation data as data for all days was not available.
- 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.
- During the deployment period, the stage values ranged from 0.60m to 1.14m. The maximum value of 1.14m is the result of a backwater effect during ice cover. During removal, shorefast ice encased the deployment cable which had to be chopped free. Open water was running above the sonde.

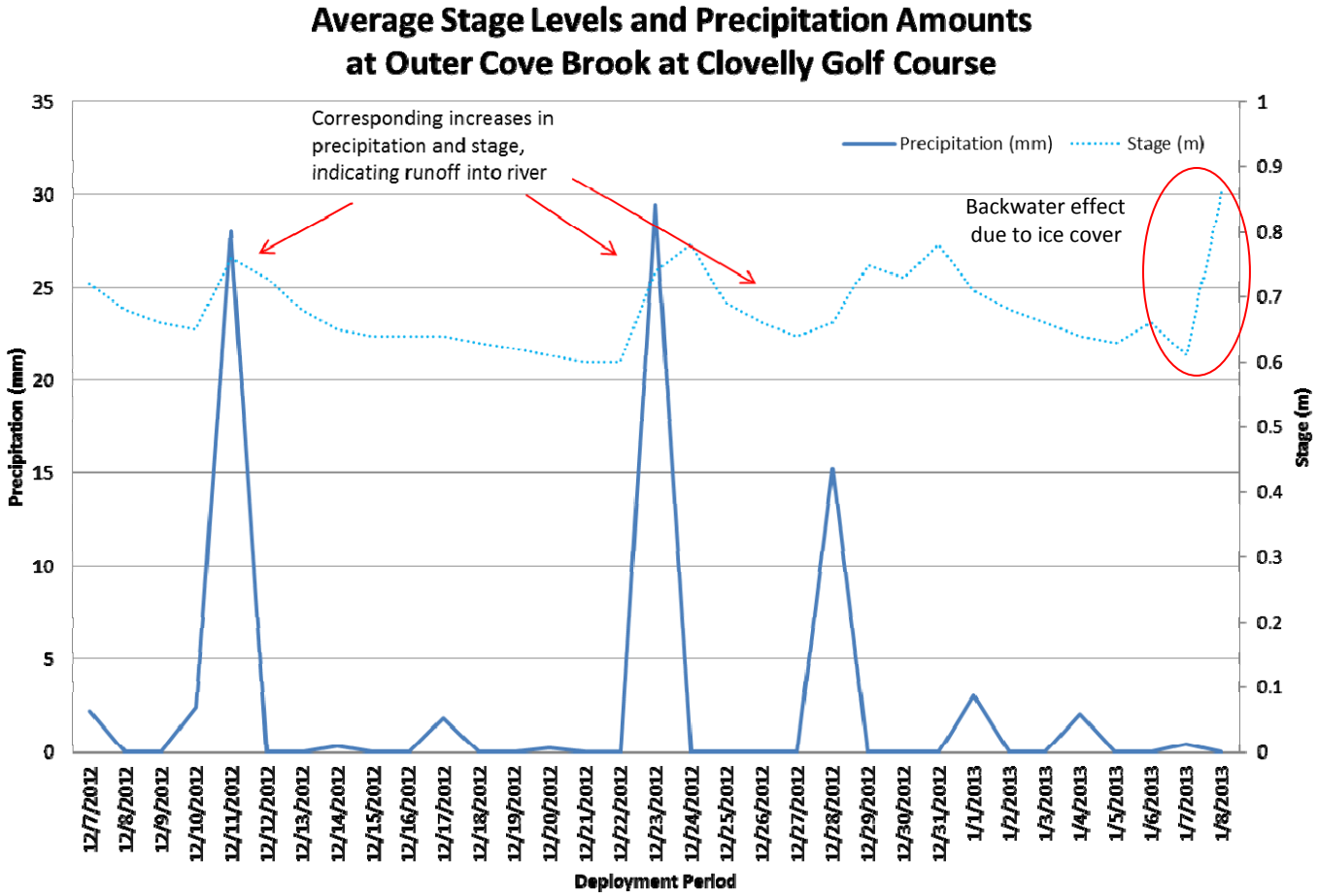

Figure 13: Daily average stage values (m) at Outer Cove Brook below Airport and daily total precipitation values (mm) from Environment Canada's St. John's Airport Station for the deployment period December 7, 2012 to January 8, 2013.

Conclusions – Outer Cove Brook at Clovelly Golf Course

- The 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 decreased into the winter months, there was a corresponding decrease in water temperature, 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. The constant increase in turbidity values at the end of deployment indicates either debris interfering or a malfunction with the sensor. This will be investigated further. Biofouling slime was noted around the sensors during removal.
- The addition of road salt to roadways and runways during periods of snowfall and low ambient air temperatures led to increases in specific conductance and TDS as the salts were washed into the river system. This indicates that this river is influenced by runoff upstream of the station.
- Due to the large amount of ice present around the sonde and cable and the noted low flow conditions, it was decide to not reinstall this station until ice conditions improved so as not to damage the cable and instrument.

Conclusions – Outer Cove Brook Network

During this deployment period the median water temperature at the upstream station (below Airport) of 3.16°C was very similar to that of the downstream station (at Clovelly Golf Course) of 2.72°C. The median pH values for both were also comparable with below Airport's median at 6.51 and Clovelly Golf Course reading 6.66, and thus no significant change in pH from the upstream to the downstream station. The specific conductivity medians were similar at both stations with 367 uS/cm reported below the airport and 332uS/cm reported at the golf course. It should be noted that higher values were recorded at the golf course, reaching a maximum value of 2629 uS/cm, compared to the maximum value of 1241 uS/cm below the Airport. This indicates more influence from road salts at the golf course station as it is downstream of a significantly developed commercial development area. Dissolved Oxygen at the upstream station (below Airport) had a median of 88.8%Sat during the deployment period, while the downstream station (Clovelly Golf Course) had a lower median of 82.2%Sat. Both stations have close DO medians and there is no significant difference between them, however, the downstream station does have considerably more aquatic growth in the stream which can increase the use of oxygen present in the water. The turbidity median values are almost identical at 5.2 NTU below the Airport and 5.0 NTU at Clovelly Golf Course, indicating that during this deployment period, turbidity did not vary significantly between upstream and downstream stations.