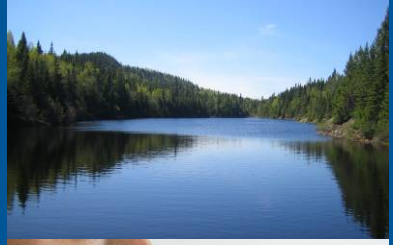







Real-Time Water Quality Report

Outer Cove Brook Network

Deployment Period
November 8 to December 7, 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 30-day period from deployment on November 8, 2012 until removal on December 7, 2012.

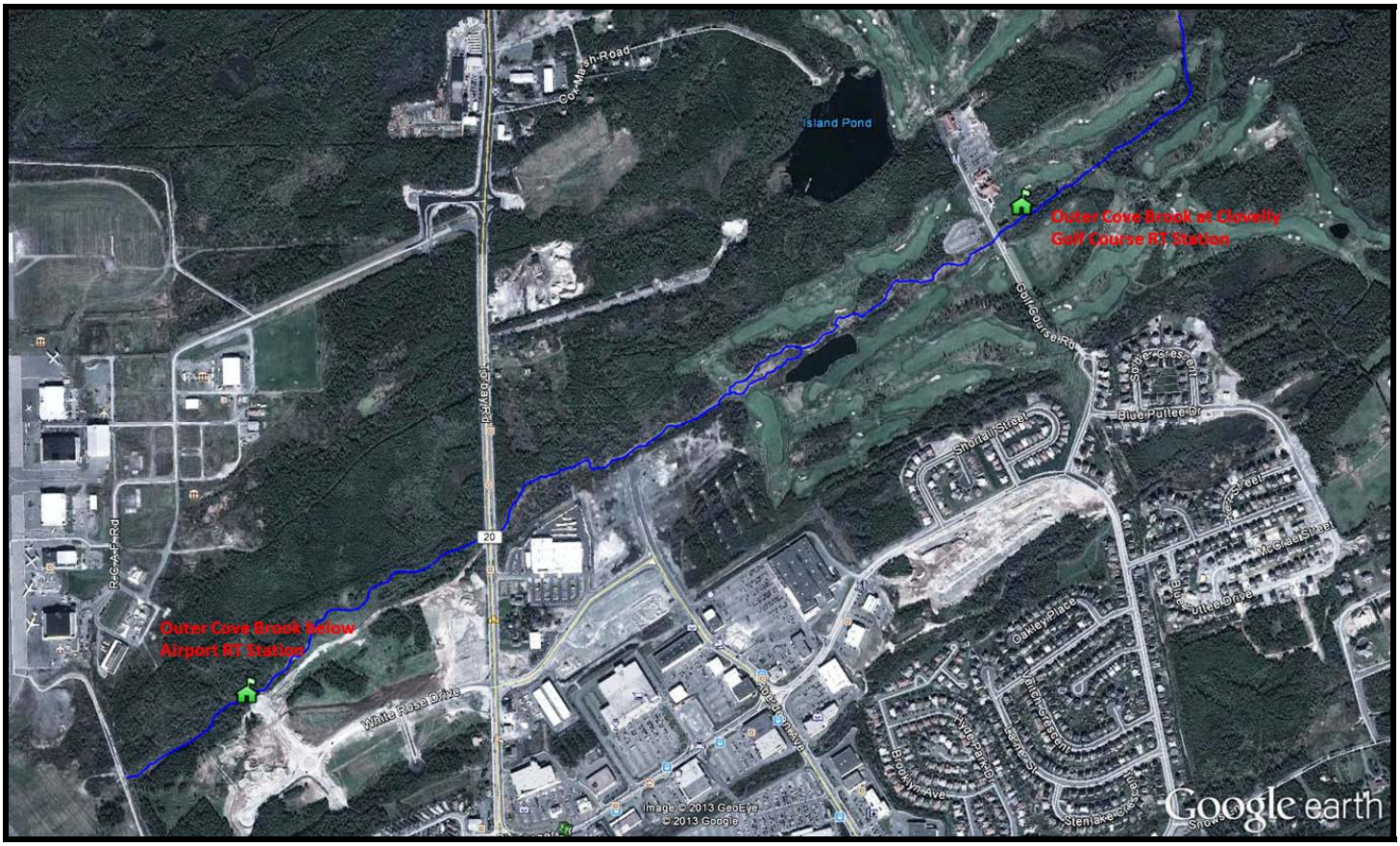

Figure 1: Outer Cove Brook Real-Time Water Quality and Quantity Stations.

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 November 8 through to December 7, 2012 is summarized in Table 2.

Table 2: Instrument performance rankings for Outer Cove Brook below Airport November 8 – December 7, 2012

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

- During the Outer Cove Brook below Airport station deployment, temperature, pH, dissolved oxygen and turbidity sensors ranked 'good' to 'excellent'. The specific conductivity sensor's 'fair' ranking indicates there may have been a calibration error or the sensor is slow responding to the cold river environment. Overall, the data being produced was reliable and accurate at the start of deployment.

- During removal, specific conductivity, dissolved oxygen and turbidity ranked as 'excellent', while temperature was 'marginal' and pH ranked as 'fair'. The temperature and pH sensors on the QA/QC sonde may have been slow stabilizing in the cold river environment, giving inaccurate readings. The improvement in the performance rankings of turbidity and specific conductivity indicate that the initial low performance sensor rankings may indeed have been due to unstabilized parameter readings at deployment. Overall, the data at the end of deployment was reliable.
- Deployment and removal instrument performance rankings for **Outer Cove Brook at Clovelly Golf Course** for the period of November 8 through to December 7, 2012 is summarized in Table 3.

Table 3: Instrument performance rankings for Outer Cove Brook at Clovelly Golf Course November 8 – December 7, 2012

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

- At the Outer Cove Brook Clovelly Golf Course station, temperature, pH and dissolved oxygen ranked 'excellent' to 'good' at deployment on the instrument. Turbidity ranked 'poor', likely due to an issue with the QA/QC sonde's sensor. The specific conductivity sensor ranked 'fair' during deployment at both stations. Analysis of the data from both stations indicates that there may have been a calibration issue with the QA/QC sonde's specific conductivity sensor as readings taken with this sonde were consistently off from field readings at both stations by ~ 12 uS/cm. Overall, the data being produced was reliable and accurate at the start of deployment.
- At removal, pH and specific conductivity ranked 'good' and 'excellent'. The turbidity and dissolved oxygen sensors ranked as 'fair', while temperature ranked 'marginal'. The turbidity sensor was likely influenced by algae or leaf debris. The difference in temperature readings between the two sondes will affect the dissolved oxygen readings, explaining the issues with this sensor. The temperature sensor was likely not stabilized when the readings were taken as the water temperatures were very low and it can take some time for the sensors to adjust to a large drop in temperature between the laboratory and river environments. Overall, the data at the end of deployment was reliable.

- 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 sporadically throughout the deployment period at both stations, resulting in data gaps in the graphs shown in this report. Environment Canada has been notified of these transmission gaps, and will make adjustments to the setup as needed to minimize these errors.

Data Interpretation

- The following graphs and discussion illustrate water quality-related events from November 8 to December 7, 2012 at the Outer Cove Brook Stations.
- Due to the above mentioned transmission errors, 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.
- 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.
- 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.

Outer Cove Brook below Airport

Water Temperature

- Water temperature ranged from 2.01°C to 11.60°C during this deployment period (Figure 2).
- 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.

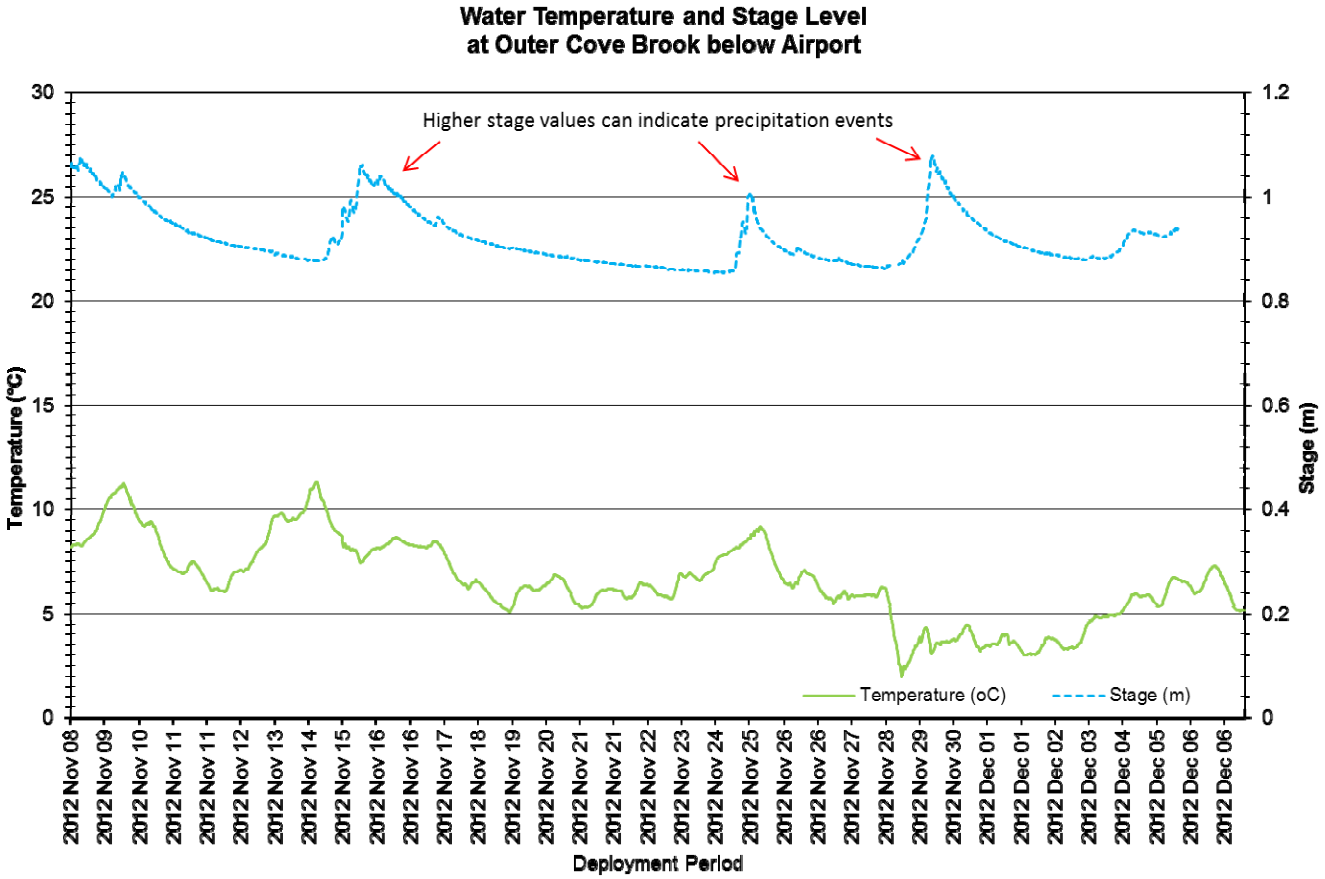

Figure 2: Quarter-hourly water temperature (°C) and Stage Level (m) values at Outer Cove Brook below Airport for the deployment period November 8 to December 7, 2012.

pH

- Throughout this deployment period pH values ranged between 6.10 and 6.66 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) with visible drops in pH corresponding to precipitation events. This is a natural occurrence between precipitation and pH levels. However there may also be some sensor drift issues as the pH values did not increase further after the precipitation event on November 30 and the sensor ranked 'fair' upon removal.
- 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.

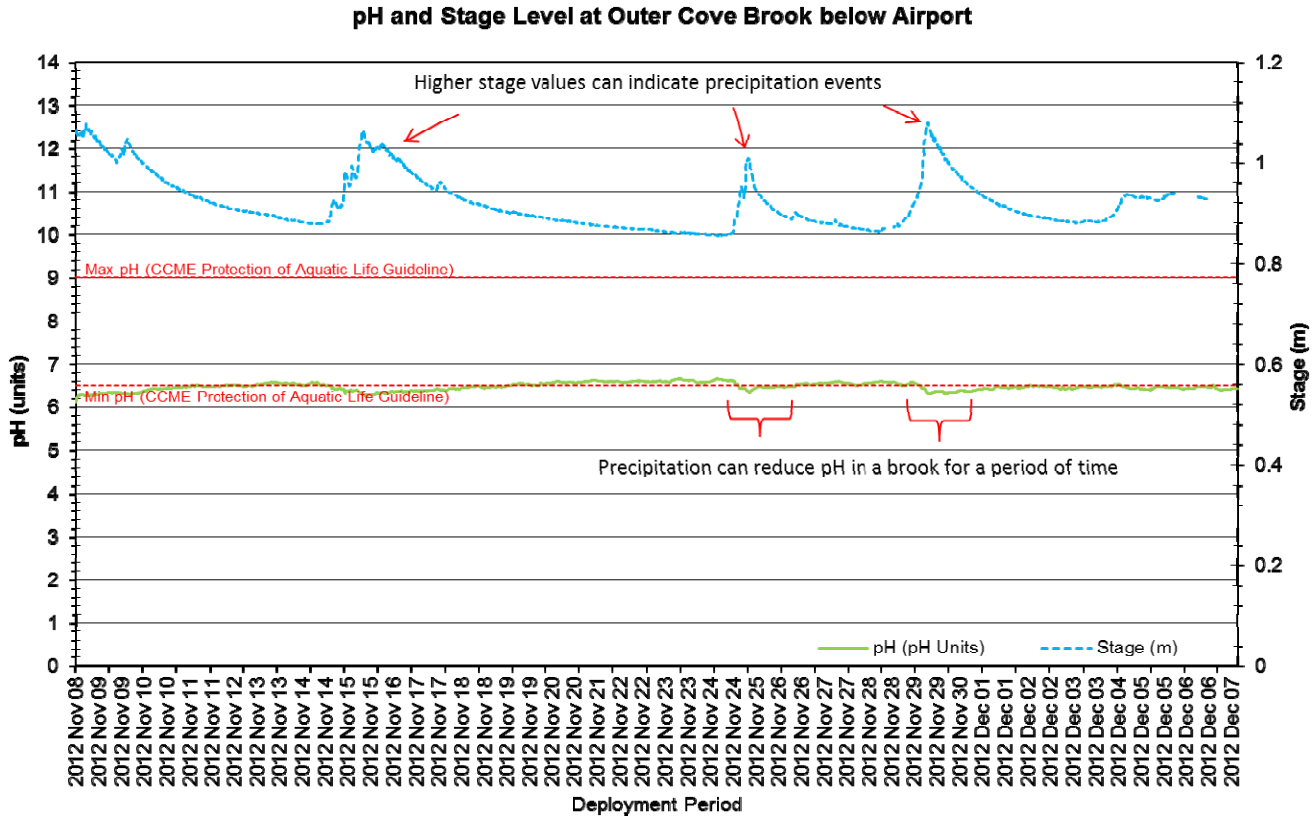

Figure 3: Quarter-hourly pH (pH units) and Stage Level (m) values at Outer Cove Brook below Airport for the deployment period November 8 to December 7, 2012.

Specific Conductivity & TDS

- The conductivity levels were within 140 µS/cm and 1238 µS/cm during this deployment period. TDS ranged from 0.1 to 0.8 g/L.
- Rainfall events (indicated by increased stage levels) can have the effect of diluting and lowering conductance levels, as is evident on Figure 4. 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 and runways at the airport. As the snow melts or rainfall occurs, these salts are washed into the water system, increasing the specific conductance. The increase on December 3 is in response to a snowfall event a few days prior.
- 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.

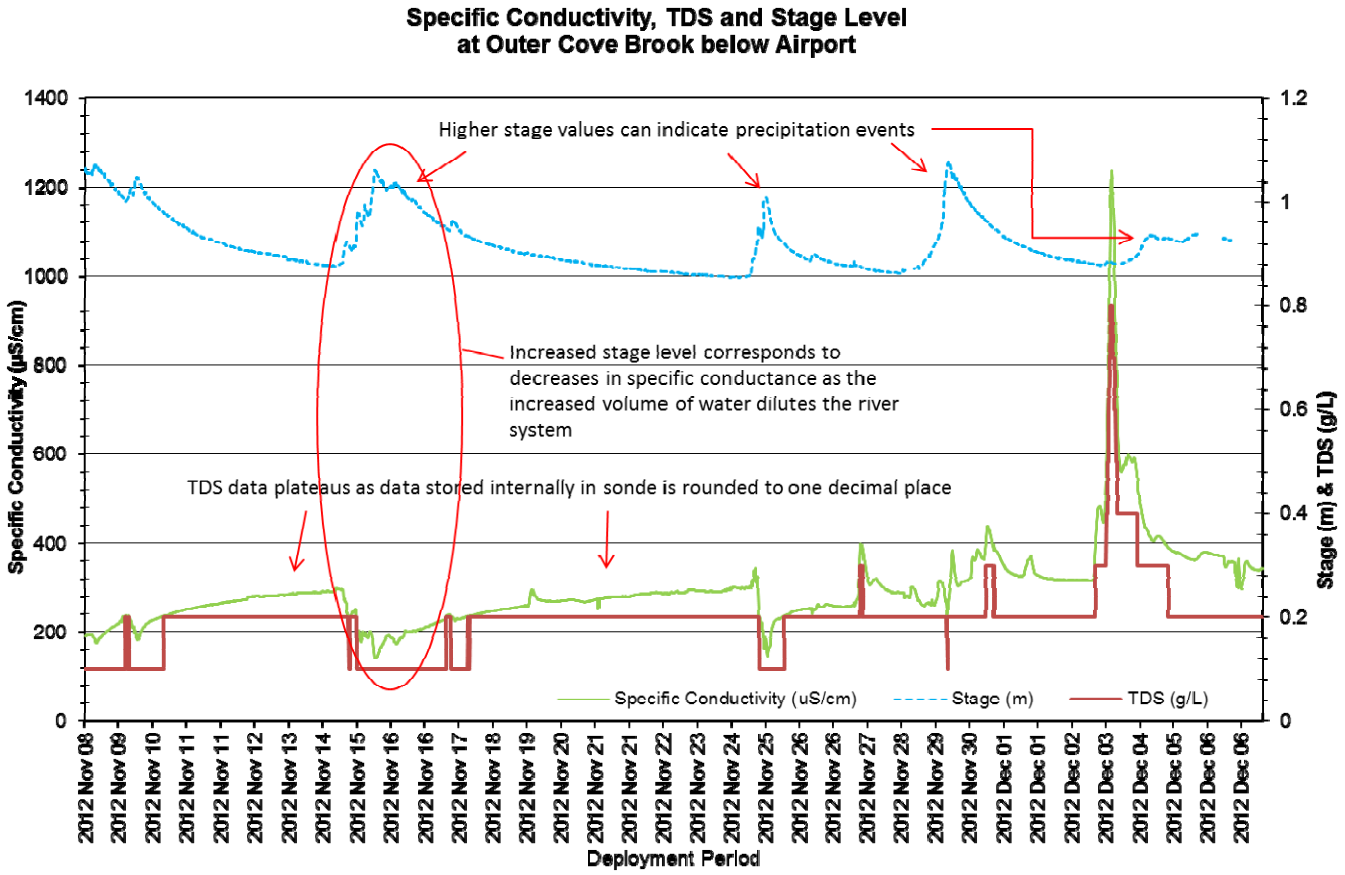

Figure 4: Quarter-hourly specific conductivity (uS/cm), TDS (g/L) and stage (m) values at Outer Cove Brook below Airport for the deployment period November 8 to December 7, 2012.

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 85.7–94.8% Sat. Dissolved Oxygen (mg/L) measured 9.66–12.48 mg/L. The DO mg/L values are above the minimum DO CCME guideline for early life stages throughout the deployment period.
- Dissolved Oxygen percent saturation remains constant during 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, particularly on November 28, 2012.

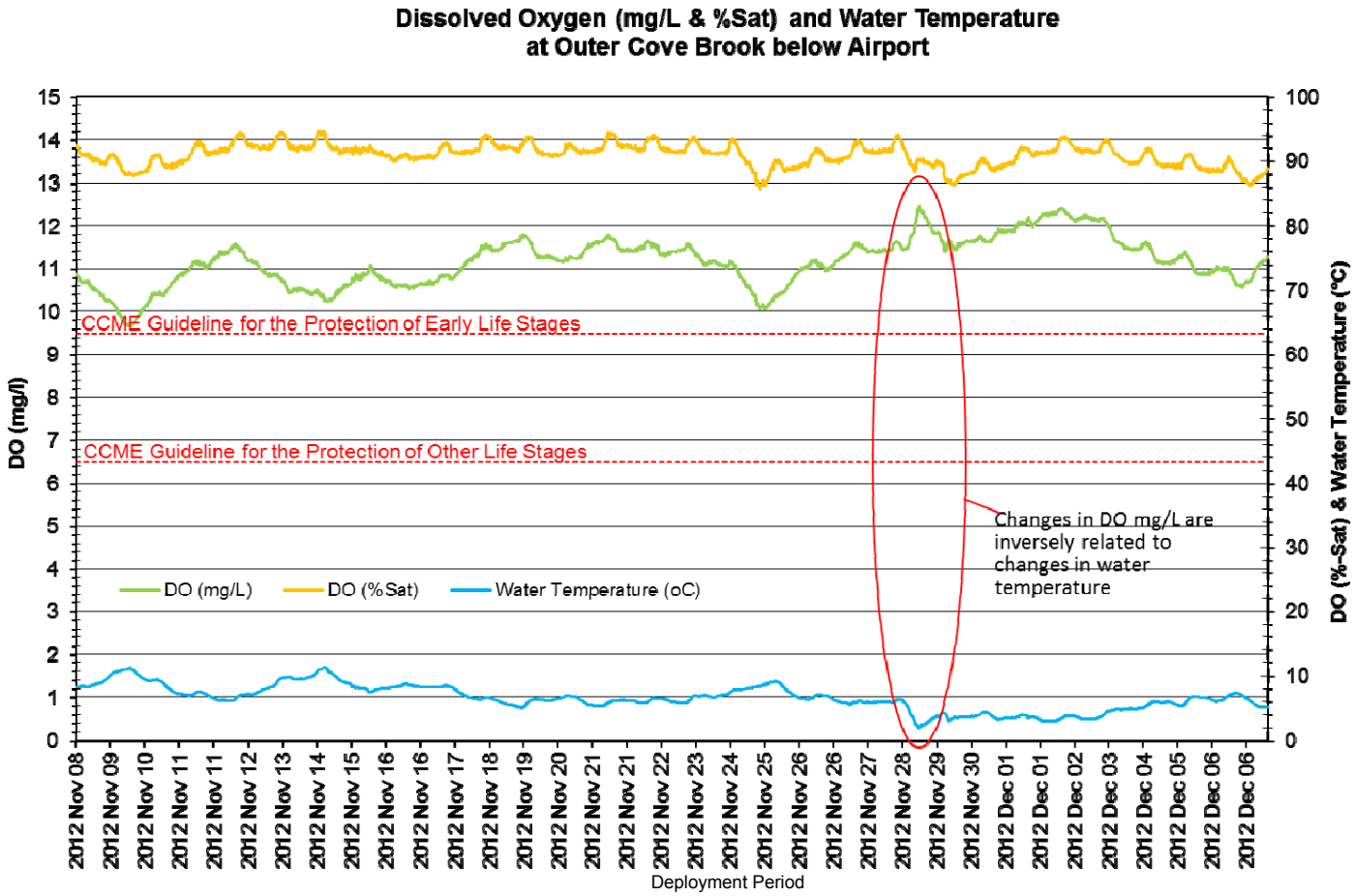

Figure 5: Quarter-hourly dissolved oxygen (mg/L & % sat) and water temperature values at Outer Cove Brook below Airport for the deployment period November 8 to December 7, 2012.

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 266.8 NTU (Figure 6).
- The majority of turbidity events during the deployment period coincide with precipitation events as runoff resuspends the river's sediments into the water column. The large amount of algae and leaf debris at this site may account for the increases in turbidity which do not correlate to precipitation events.

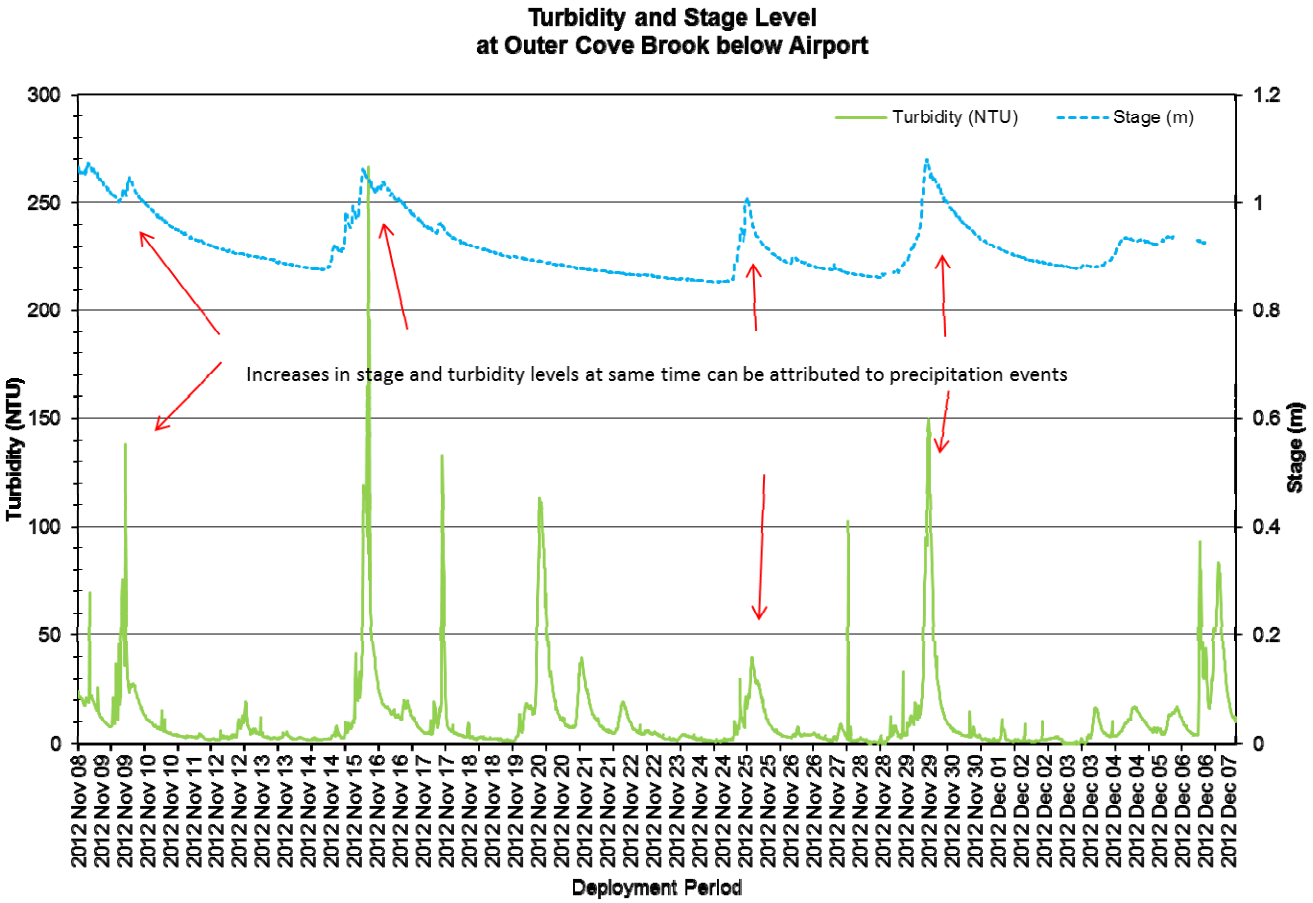

Figure 6: Quarter-hourly turbidity (NTU) and stage level (m) values at Outer Cove Brook below Airport for the deployment period November 8 to December 7, 2012.

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.
- 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 ranged from 0.85m to 1.08m.

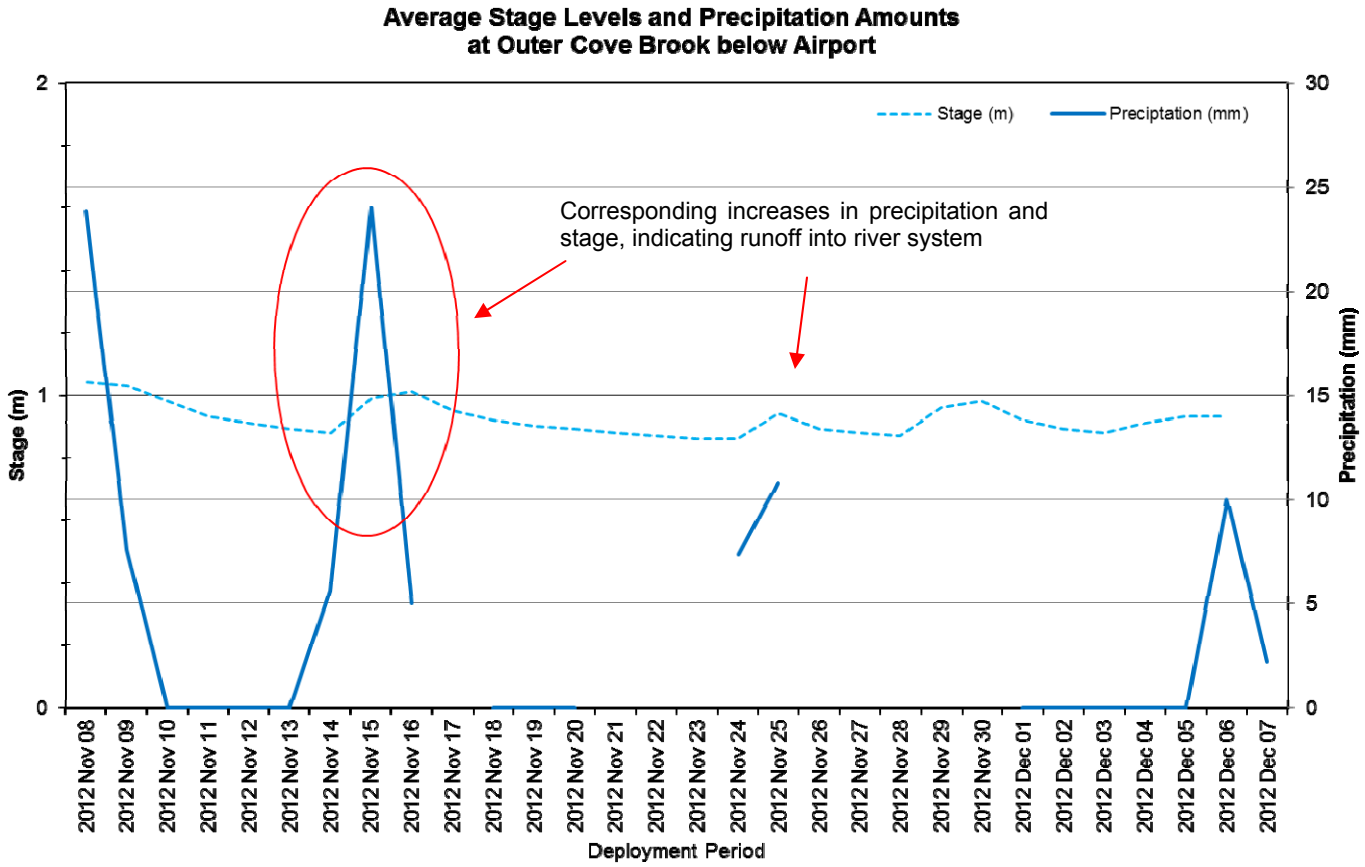

Figure 7: Daily average stage values (m) at Outer Cove Brook below Airport and daily total precipitation values (mm) from Environment Canada's St. John's Airport Weather Station for the deployment period November 8 to December 7, 2012.

Conclusions – Outer Cove Brook below Airport

- 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, were related to the intermittent precipitation events and small climatic changes of the seasons (i.e. temperature decreases).
- The precipitaiton 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 fall months, there was a corresponding decrease in water temperature, which in turn increased the amount of dissolved oxygen in the water.
- There may be an issue with the pH sensor on this instrument as there was some overall drift evident during the deployment period. This issue will be investigated further.
- The addition of road salts to roadways and runways during a period of snowfall and low ambient air temperatures led to an increase in specific conductance as the salts were washed into the river system. This indicates that this river is influenced by runoff upstream of the station.

Outer Cove Brook at Clovelly Golf Course

Water Temperature

- Water temperature ranged from 1.66°C to 11.58°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.

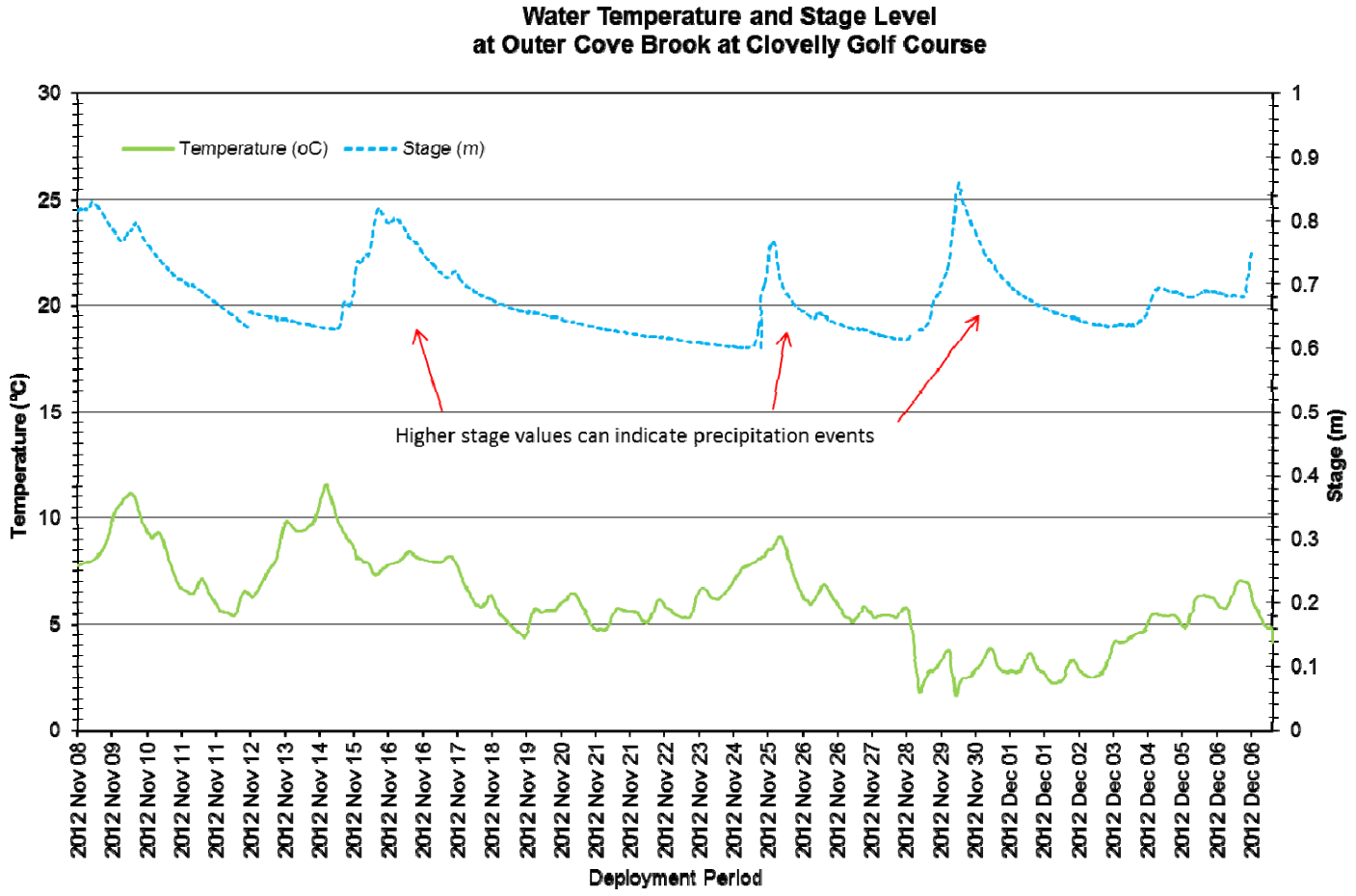

Figure 8: Quarter-hourly water temperature (°C) and Stage Level (m) values at Outer Cove Brook at Clovelly Golf Course for the deployment period November 8 to December 7, 2012.

pH

- Throughout this deployment period pH values ranged between 5.92 and 6.63 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) with precipitation events leading to pH value decreases. 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.

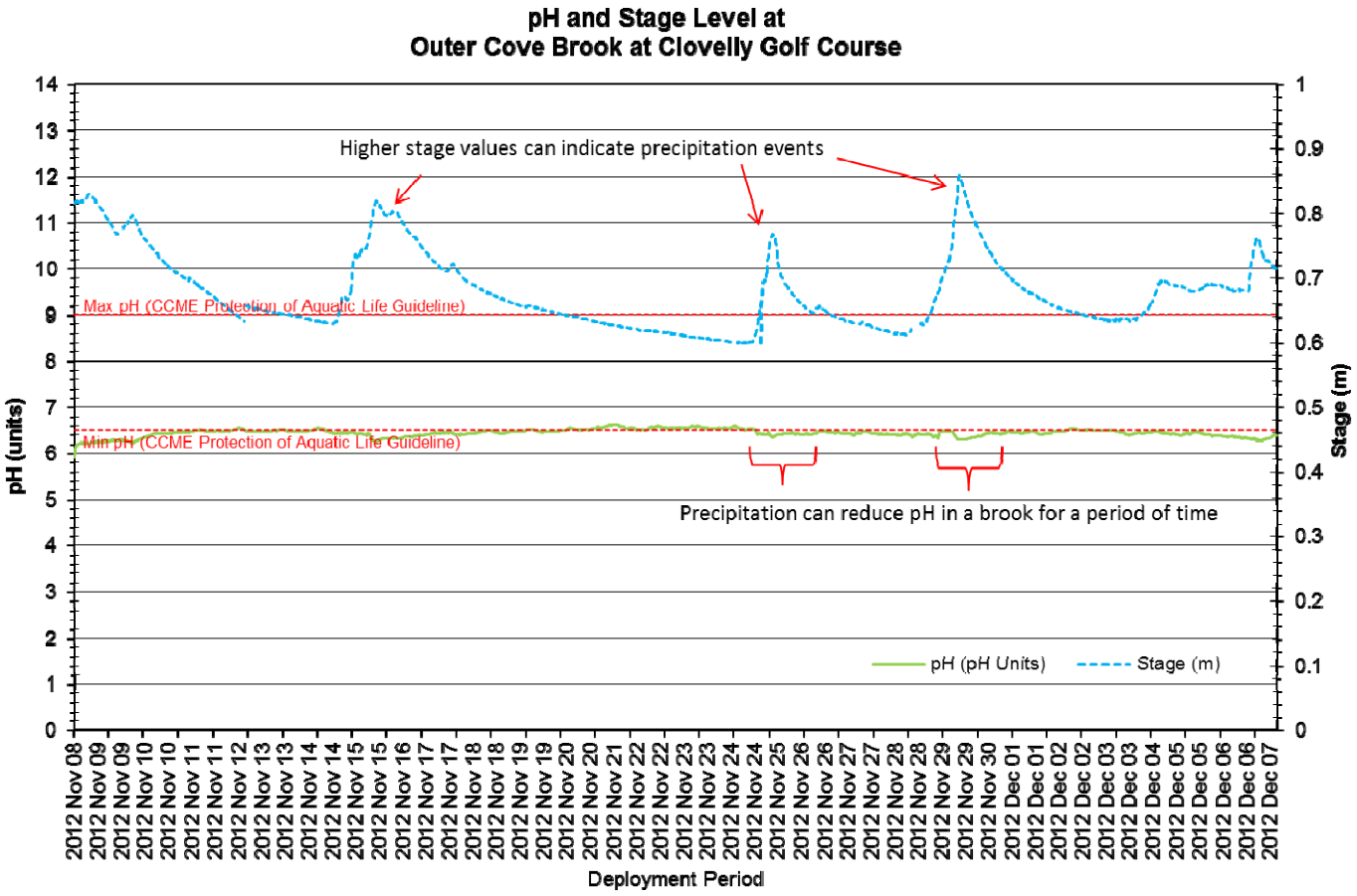

Figure 9: Quarter-hourly pH (pH units) and Stage Level (m) values at Outer Cove Brook at Clovelly Golf Course for the deployment period November 8 to December 7, 2012.

Specific Conductivity

- The conductivity levels were within 161.0µS/cm and 2134.0µS/cm during this deployment period. TDS ranged from 0.1 to 1.4 g/L.
- Rainfall events (indicated by increased stage levels) can have the effect of diluting and lowering conductance levels through dilution, as is evident on Figure 10. Snowfall events can have the effect of increasing conductance levels. With snowfall and freezing air temperatures comes the addition of salt to roadways and runways at the airport. As the snow melts or rainfall occurs, these salts are washed into the river system, increasing the specific conductance. The increases on November 29 and December 3 are responses to snowfall events in the preceding days.
- 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.

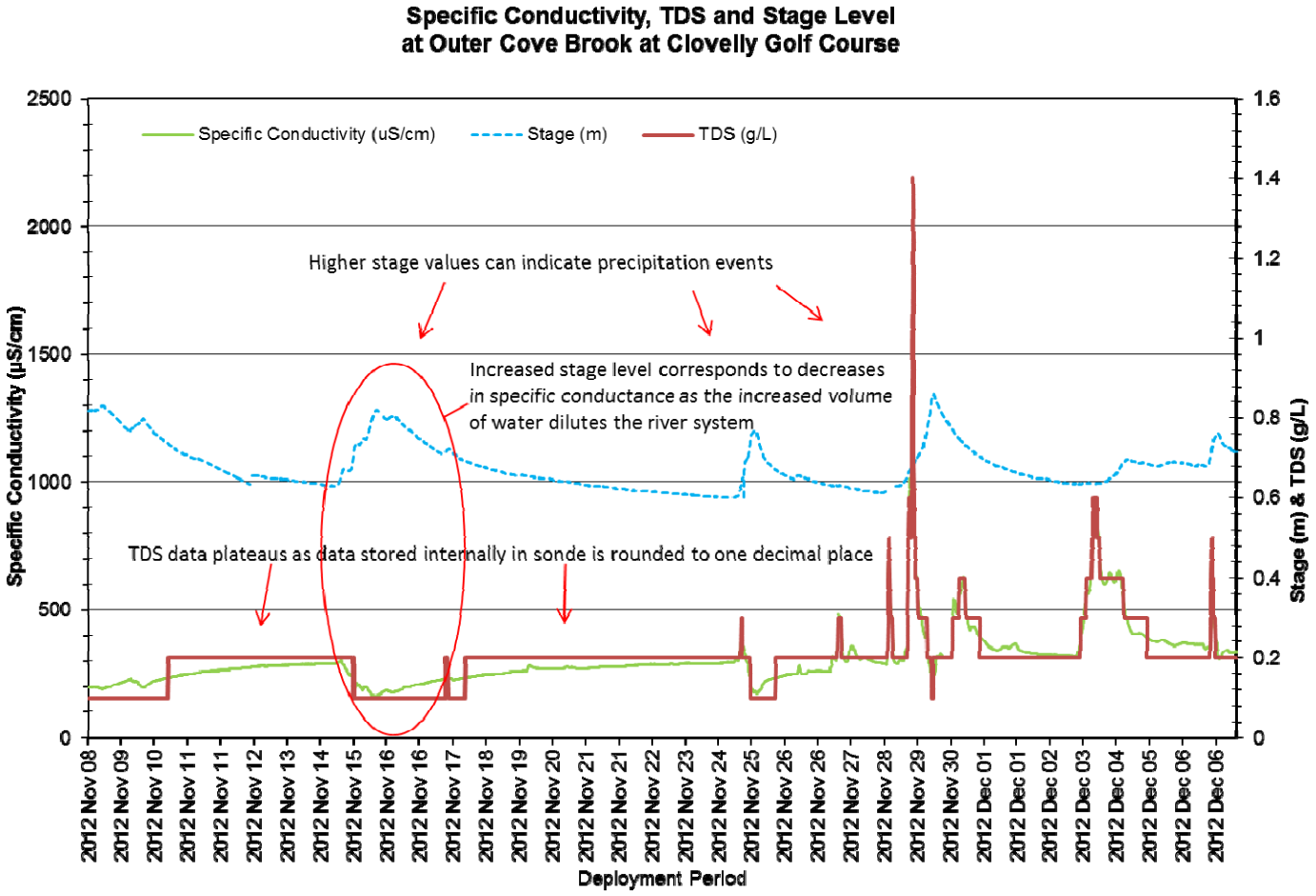

Figure 10: Quarter-hourly specific conductivity (uS/cm), TDS (g/L) and stage (m) values at Outer Cove Brook at Clovelly Golf Course for the deployment period November 8 to December 7, 2012.

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 72.2–88.2% Sat. Dissolved Oxygen (mg/L) measured 7.95-11.78 mg/L.
- Dissolved Oxygen percent saturation remains relatively constant during 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 11, particularly on December 1.

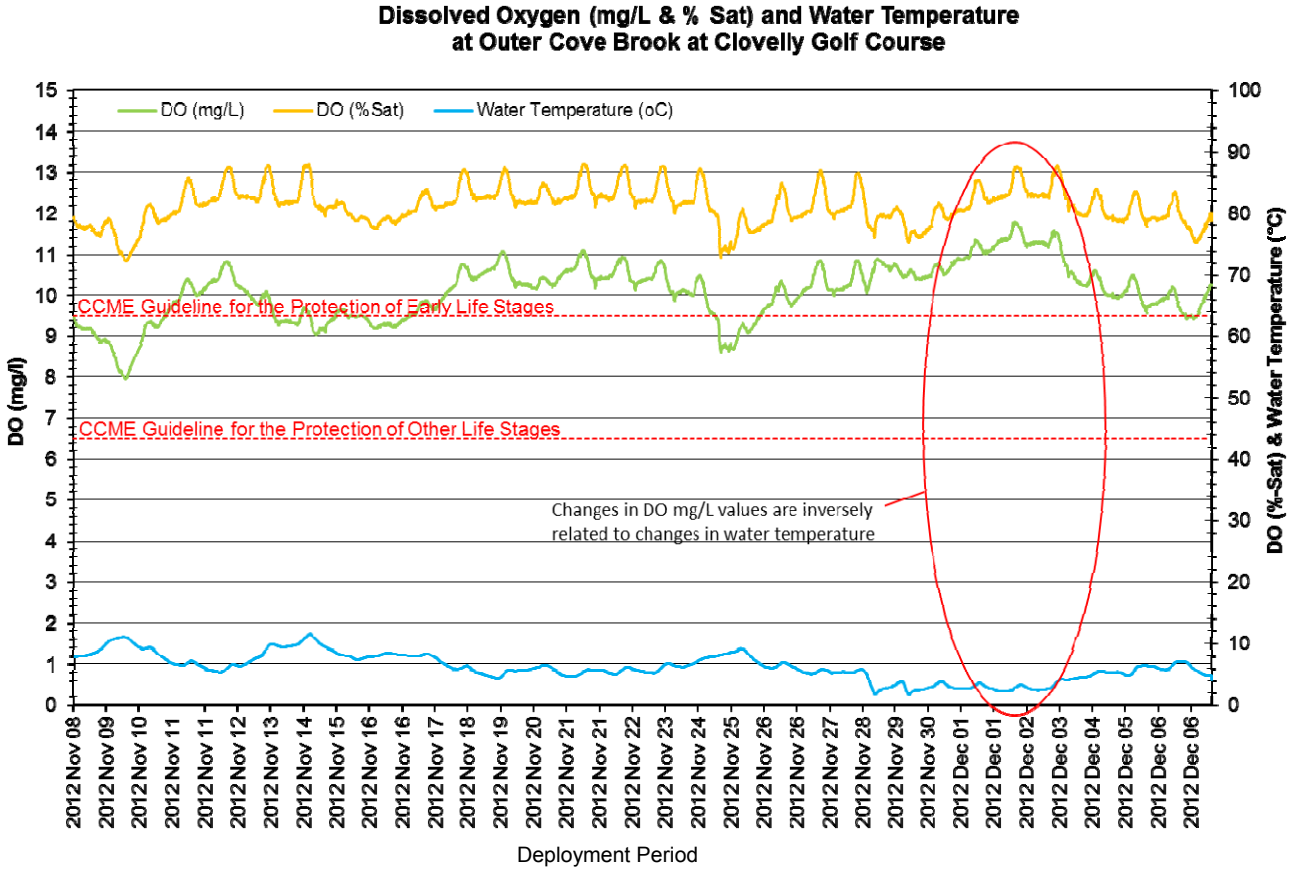

Figure 11: Quarter-hourly dissolved oxygen (mg/L & % sat) and water temperature values at Outer Cove Brook at Clovelly Golf Course for the deployment period November 8 to December 7, 2012.

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 4.3 NTU to 294 NTU.
- The majority of turbidity events during the deployment period coincide with precipitation events as runoff resuspends the river's sediments into the water column. The large amount of algae and lead debris at this site may account for the increases in turbidity which do not correlate to precipitation events.

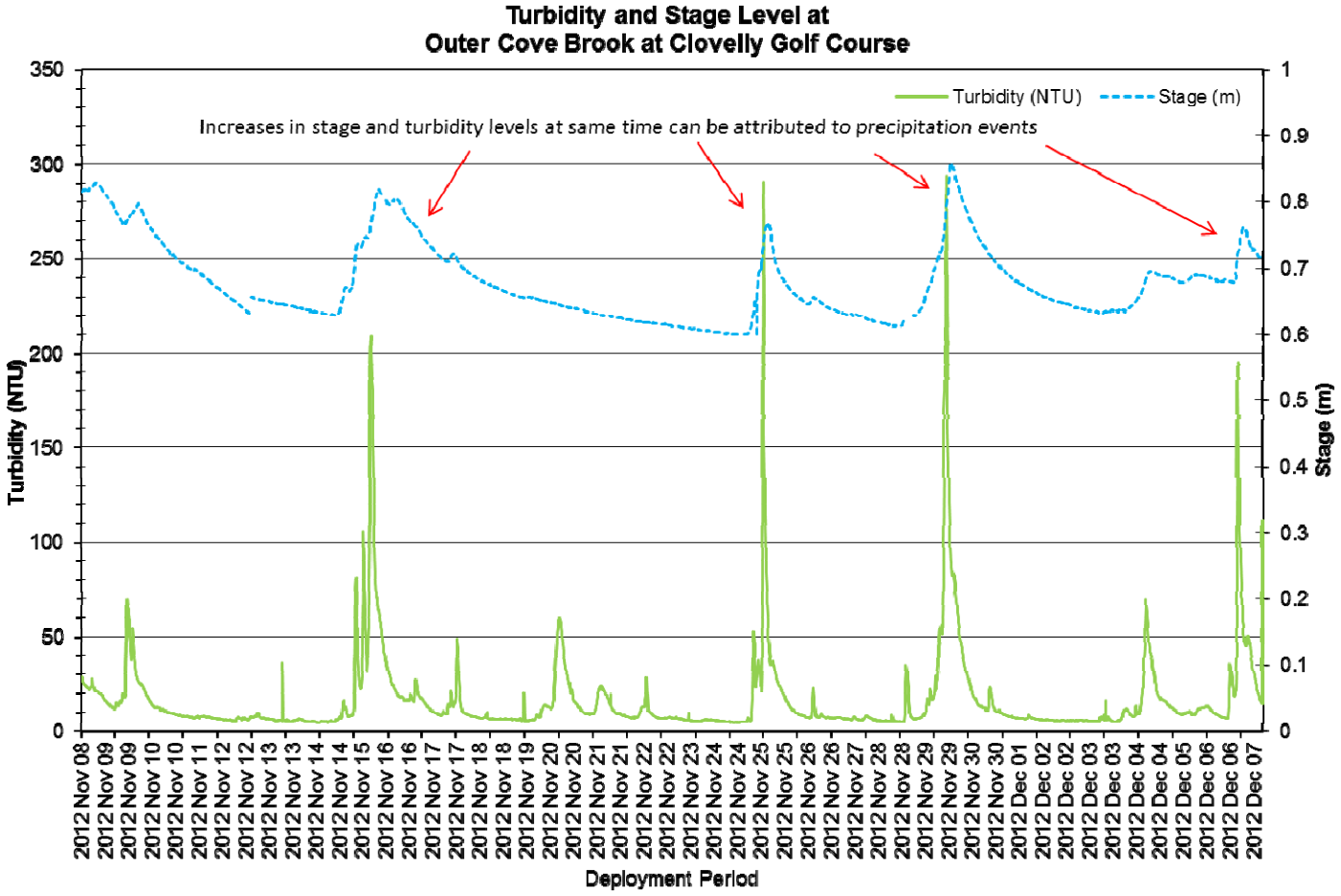

Figure 12: Quarter-hourly turbidity (NTU) and stage level(m) values at Outer Cove Brook at Clovelly Golf Course for the deployment period November 8 to December 7, 2012.

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.
- 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 ranged from 0.60m to 0.86m.
- The peaks in stage in Figure 13 directly correspond with the precipitation events that occurred during this deployment period, thus we know that these stage increases are due to natural water level fluctuations.

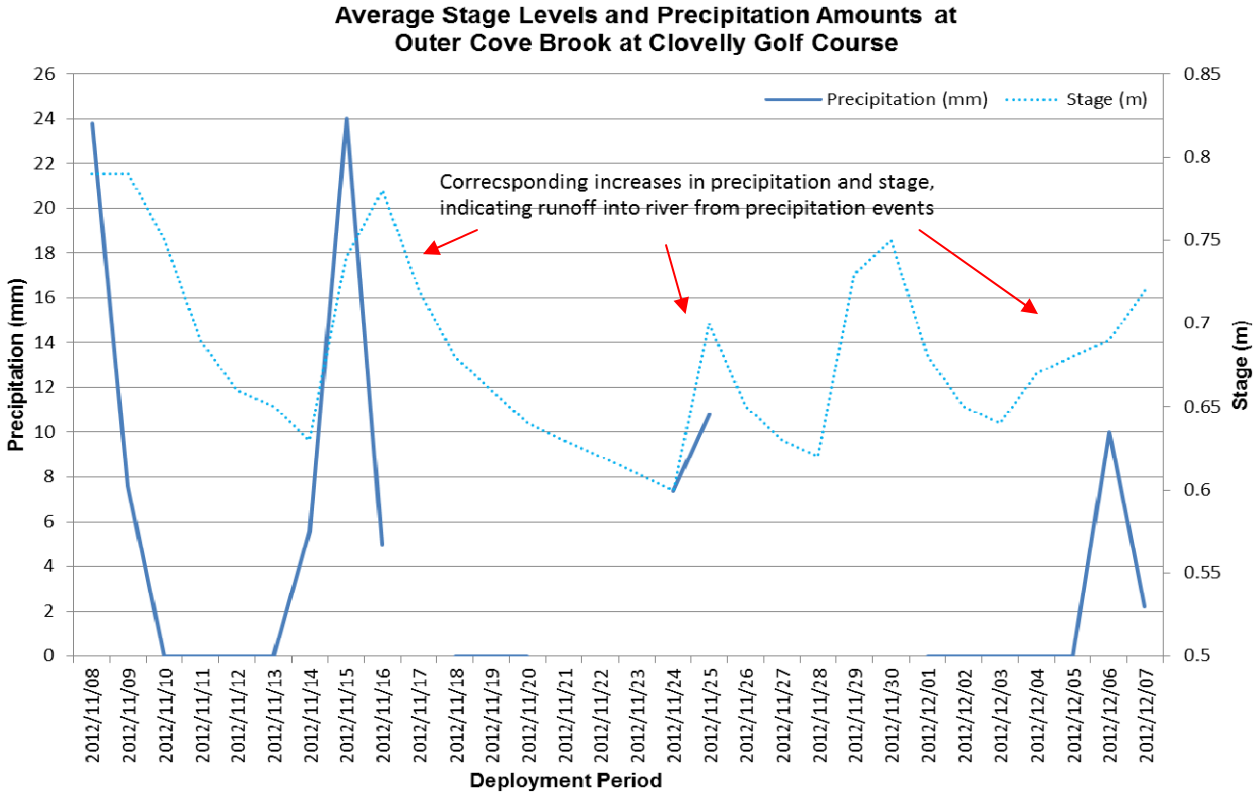

Figure 13: Daily average stage values (m) at Outer Cove Brook at Clovelly Golf Course and daily total precipitation values (mm) from Environment Canada's St. John's Airport Weather Station for the deployment period November 8 to December 7, 2012

Conclusions – Outer Cove Brook at Clovelly Golf Course

- During this deployment it is evident that many of the water quality events that occurred were related to the intermittent precipitation events, as shown throughout the figures. Generally in natural environments, climate and weather conditions account for the majority of variation in water quality parameters.
- Water Temperature steadily decreased during the deployment period, which would be expected as the ambient air temperature decreases during the fall season. There was some possible drift with the pH sensor over the deployment period. Dissolved Oxygen remains constant throughout the deployment period, increasing or decreasing in small increments as water temperatures rise and fall.
- Specific conductivity data displays intermittent drops in levels which accurately correlated to corresponding precipitation events. Periods of snowfall and low ambient air temperatures led to increases in specific conductance as road salts were washed into the river system, indicating that this river is influenced by runoff upstream of the station.
- Increases in stage level can explain the peaks in the turbidity values during the deployment period. As organic matter and natural minerals are washed into the brook the suspended matter in the water column will increase and the turbidity sensor and the specific conductivity sensor will pick up these additional changes in the water body. The turbidity sensors 'fair' performance ranking at removal is due to debris blocking the sensor on the field sonde, as evident in Figure 12.

Conclusions – Outer Cove Brook Network

During this deployment period the median water temperature at the upstream station (below Airport) of 6.38°C was very similar to that of the downstream station (at Clovelly Golf Course) of 5.96°C. The median pH values for both was also comparable with below Airport's median at 6.47 and Clovelly Golf Course reading 6.44, there was no significant change in pH from the upstream to the downstream station. The Specific Conductivity median at both stations was identical at 281 uS/cm, indicating no significant difference in specific conductivity as the water moves downstream. Dissolved Oxygen at the upstream station (below Airport) had a median of 91.3%Sat during the deployment period, while the downstream station (Clovelly Golf Course) had a lower median of 81.5%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 of 4.9 NTU below the Airport and 8.7 NTU at Clovelly Golf Course indicate that turbidity does increase slightly as the water moves downstream.