Real-Time Water Quality Deployment Report

Voisey's Bay Network

August 20, 2014 to September 23, 2014

Newfoundland Labrador

Government of Newfoundland & Labrador
Department of Environment and Conservation
Water Resources Management Division

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Contents

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Real Time Water Quality Monitoring

Department of Environment and Conservation staff monitors the real-time web pages regularly.

This deployment report discusses water quality related events occurring at four stations in the Voisey's Bay Network; Upper Reid Brook, Camp Pond Brook, Tributary to Lower Reid Brook, and Lower Reid Brook.

On August 20, 2014, Vale Environment staff deployed real-time water quality monitoring instruments at the four real time stations in the Voisey's Bay network for a period of 35 days. Instruments were removed by Vale Environment staff on September 23, 2014.

Quality Assurance and Quality Control

As part of the Quality Assurance and Quality Control protocol (QAQC), 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 QAQC Instrument is temporarily deployed along side the Field Instrument. Values for temperature, pH, conductivity, dissolved oxygen and turbidity are compared between the two instruments**.** Based on the degree of difference between parameters recorded by the Field Instrument and QAQC Instrument at deployment and at removal, a qualitative statement is made on the data quality (Table 1).

Table 1: Ranking classifications for deployment and removal

	Rank				
Parameter	**Excellent**	**Good**	**Fair**	**Marginal**	**Poor**
Temperature (oC)	<=+/-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 instrument is the most important. All other parameters can be broken down into three groups: temperature dependant, temperature compensated and temperature independent. Because the temperature sensor is not isolated from the rest of the instrument the entire instrument must be at the same temperature before the 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 comparison rankings for the Voisey's Bay Network stations are summarized in Table 2.

Table 2: Comparison rankings for Voisey's Bay Network stations

Station Voisey's Bay	Date	Action	Comparison Ranking				
			Temperature	pH	Conductivity	Dissolved Oxygen	Turbidity
Reid Brook at Outlet (62884)	Aug 20, 2014	Deployment	-	-	-	-	-
	Sept 23 2014	Removal	Excellent	Good	Excellent	Good	Excellent
Camp Pond Brook (62885)	Aug 20 2014	Deployment	Excellent	Good	Excellent	Excellent	Excellent
	Sept 23 2014	Removal	Excellent	Excellent	Excellent	Fair	Excellent
Tributary to L. Reid B. (62886)	Aug 20 2014	Deployment	Excellent	Excellent	Excellent	Excellent	Excellent
	Sept 23 2014	Removal	Excellent	Fair	Excellent	Excellent	Good
Lower Reid Brook (62887)	Aug 20 2014	Deployment	Excellent	Excellent	Excellent	Excellent	Excellent
	Sept 23 2014	Removal	Excellent	Good	Excellent	Fair	Good

During the deployment portion of the calibration and maintenance for Reid Brook at Outlet of Reid Pond, there was no QAQC instrument available to compare the field instrument against therefore there is no ranking for comparisons of field and QAQC instruments for the deployment section of the data. However for the removal ranking the data ranked 'Excellent' for temperature, specific conductivity and turbidity. With pH and dissolved oxygen data ranking against the QA instrument as 'good' readings.

At the station on Camp Pond Brook, temperature, specific conductivity, dissolved oxygen and turbidity all ranked as 'Excellent' with pH data ranking as 'good'. During removal the field instrument ranked as 'Excellent' for all water quality parameters, except dissolved oxygen which ranked as 'fair'.

At Tributary to Lower Reid Brook station, all water quality parameters when compared to the QA instrument ranked as 'excellent' at deployment. The comparison rankings of the data during removal were, 'excellent' for temperature, conductivity and dissolved oxygen, with pH ranking as 'fair' and turbidity ranking as 'good' The differences between the QA reading and the field readings at removal were not great enough to cause concern that the instrument was not performing accurately. These rankings may have been a result of biofouling on the sensors after a month in the water.

At the station on Lower Reid Brook, all water quality parameters when compared to the QA instrument ranked as 'excellent' at deployment. During removal the temperature and specific conductivity data ranked as 'excellent', the pH and turbidity data was ranked as 'good' and the dissolved oxygen data ranked as 'fair' against the QA instrument. There is the possibility that the rankings other than 'excellent' may have been a result of the biofouling that can occur on the instruments after being deployed for extended periods of time.

Data Interpretation

- The following graphs and discussion illustrate significant water quality-related events from August 20th to September 23rd 2014 in the Voisey's Bay Real Time Water Quality Monitoring Network.

- 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 QAQC protocol. Water Survey of Canada is responsible for QAQC of water quantity data. Corrected data can be obtained upon request.
- Reid Brook at Outlet of Reid Pond had technical issues with the communication capability of the station during this deployment. The station was unable to transmit quality and quantity real-time data. The instrument was able to log all water quality data internally and the data was downloaded at the end of the deployment and used in this report. However there is no stage or flow data (quantity) to compare water quality parameters against. No other stations were affected.
- Camp Pond Brook below Camp Pond had technical issues on September 17th that stopped the streamflow transmission at that time. There is no streamflow data from September 17th to September 23rd for this deployment report.
- Tributary to Lower Reid Brook had technical issues and streamflow data came in spotty and inconsistently during this deployment period. There is only a small amount of streamflow data available for this station. What was there was submitted in this report.
- Lower Reid Brook below Tributary had technical issues on September 17th that stopped the streamflow transmission at that time. There is no streamflow data from September 17th to September 23rd for this deployment report.

<u>Reid Brook at Outlet from Reid Pond</u>

Water Temperature

During this deployment period water temperature ranged from a minimum of 7.20°C to a maximum of 18.08°C (Figure 1). Air temperature had a high of 15.8°C with a low of 2.1°C which was right at the end of deployment. Both sets of minimums and maximum temperatures occur at the same time frame.

The median water temperature is 12.20°C for the deployment period, slightly lower than last deployment. This trend is expected given the cooling of the ambient air temperatures as the summer months come to an end and the cooler fall temperatures start (Figure 1).

There is one noticeable dip in water temperature on August 26th to 11.58°C; this reading was taken at 9:59pm, this dip in water temperature also corresponds with a dip in air temperature during the same time frame.

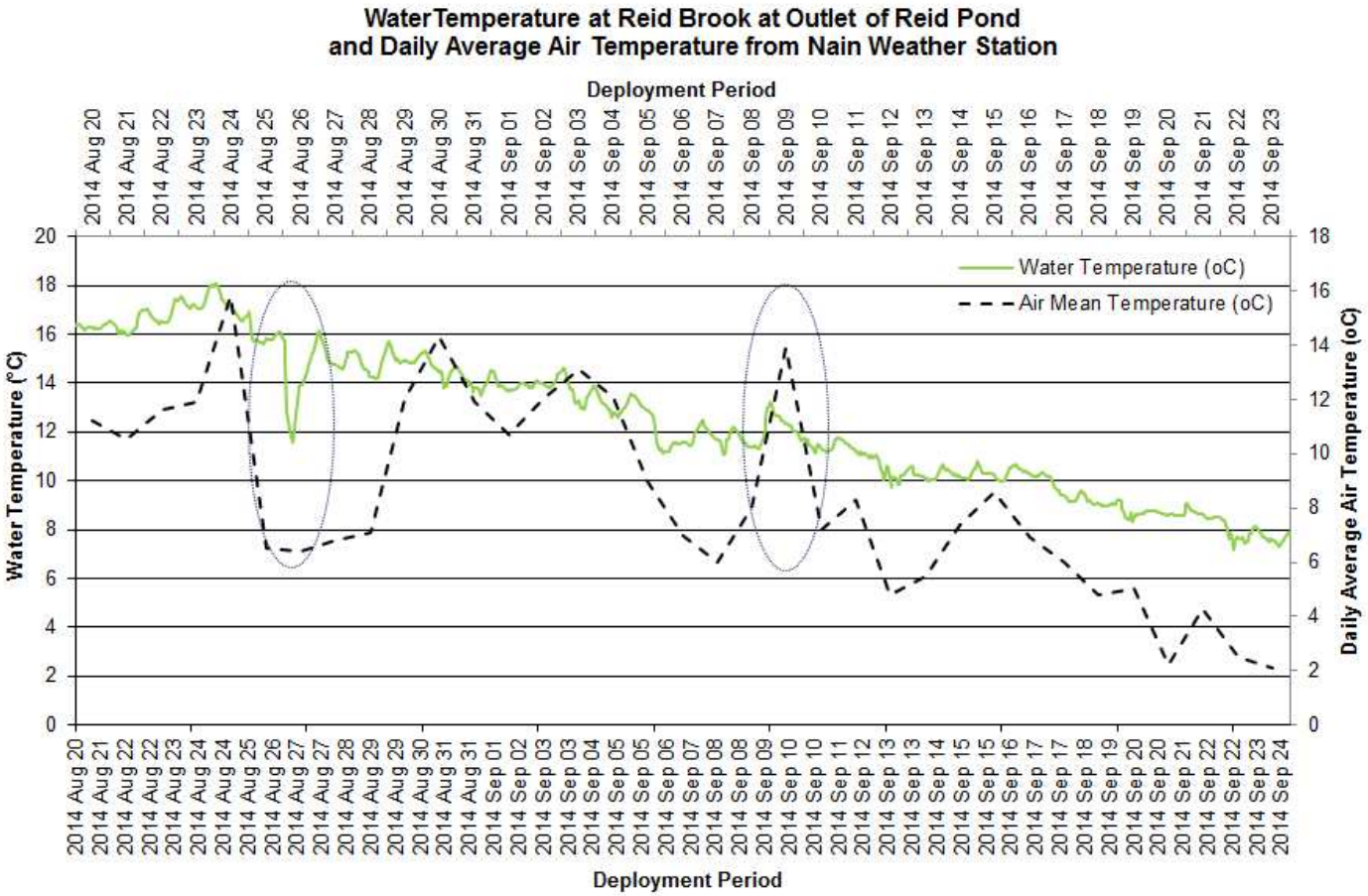

Figure 1: Water temperature at Reid Brook at Outlet of Reid Pond and Air Temperature from Nain Weather Station

pH Levels

During the deployment pH ranges were between a minimum of 5.38 and a maximum of 8.96 pH units (Figure 2).

At the beginning of deployment the pH data dips to 5.38 pH units and on August 22nd the pH climbs up to 7.42 pH units were it stabilizes for a while before peaking on August 25th to 8.25 pH units. It is unclear why the pH data fluctuated. A similar occurrence is evident on August 15th – 16th, as pH values climb to as high as 8.96 pH units. It is unclear what may have influenced these values.

Precipitation data was included on this graph to indicate how it can influence a change in pH values. Generally rainfall will increase the pH acidity (decrease values) for a short span of time. This is not as evident on this graph. Reid Brook at Outlet of Reid Pond is a larger body of water and generally isn't has influenced from environmental factors as smaller brooks.

Outside of the drop in pH early in deployment the rest of the pH values are within the recommended range as suggested by the CCME Guidelines for the Protection of Aquatic Life (> 6.5 and <9.5 pH units). Guidelines are indicated in red on Figure 2.

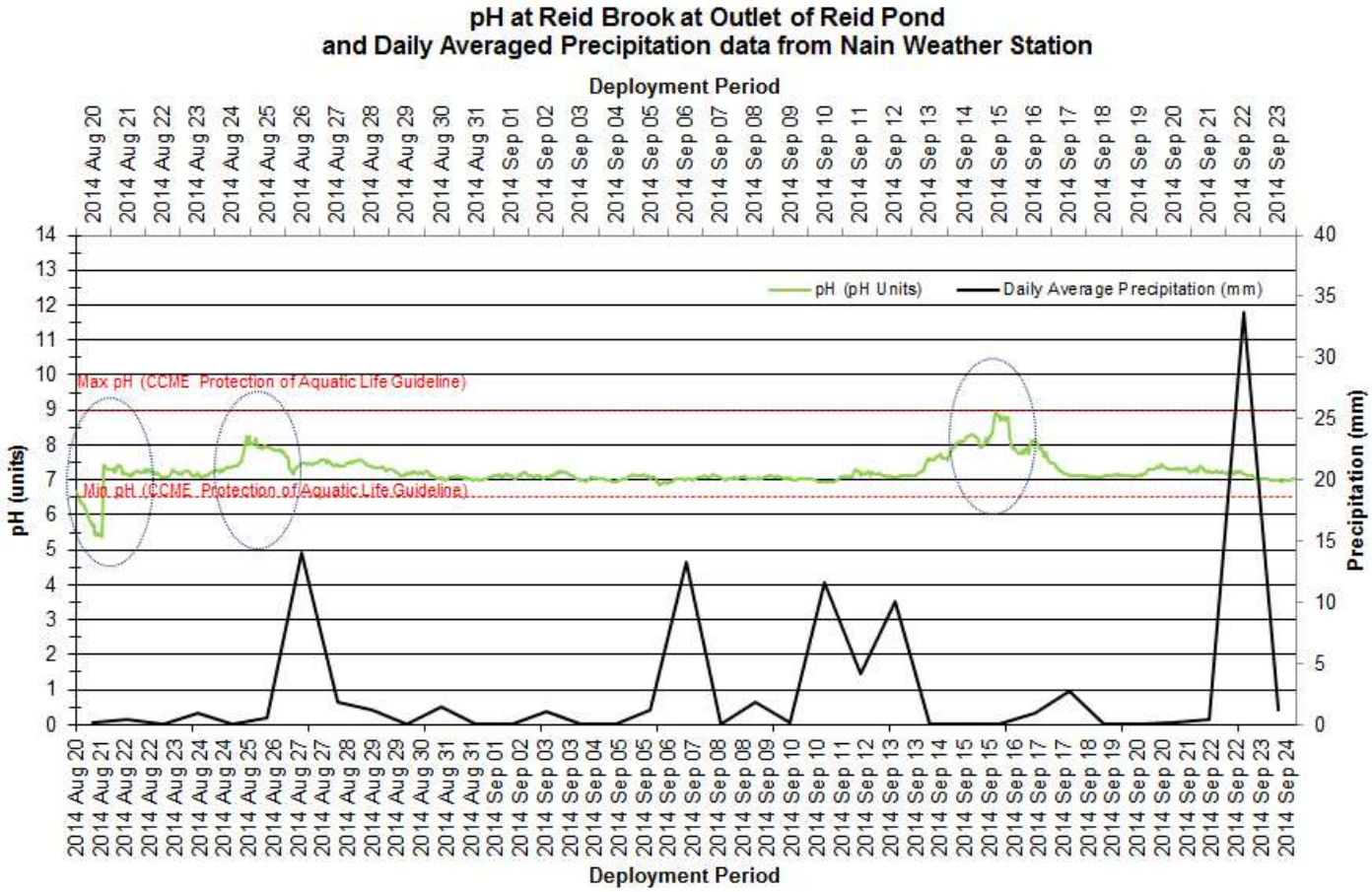

Figure 2: pH level at Reid Brook at Outlet of Reid Pond

Specific Conductivity

Specific conductivity values range from 12.0µS/cm to 13.0µS/cm during the deployment period, with a median of 12.0µS/cm (Figure 3). There is not much movement in the conductivity at this site.

Total Dissolved Solid data was not included on this graph as the readings were all 0.00 g/L and not high enough to graph.

Specific conductivity remains low throughout the deployment period at Reid Brook. This is expected at this site as it is pristine in nature and a larger distance from any anthropogenic disturbances that could affect water parameters.

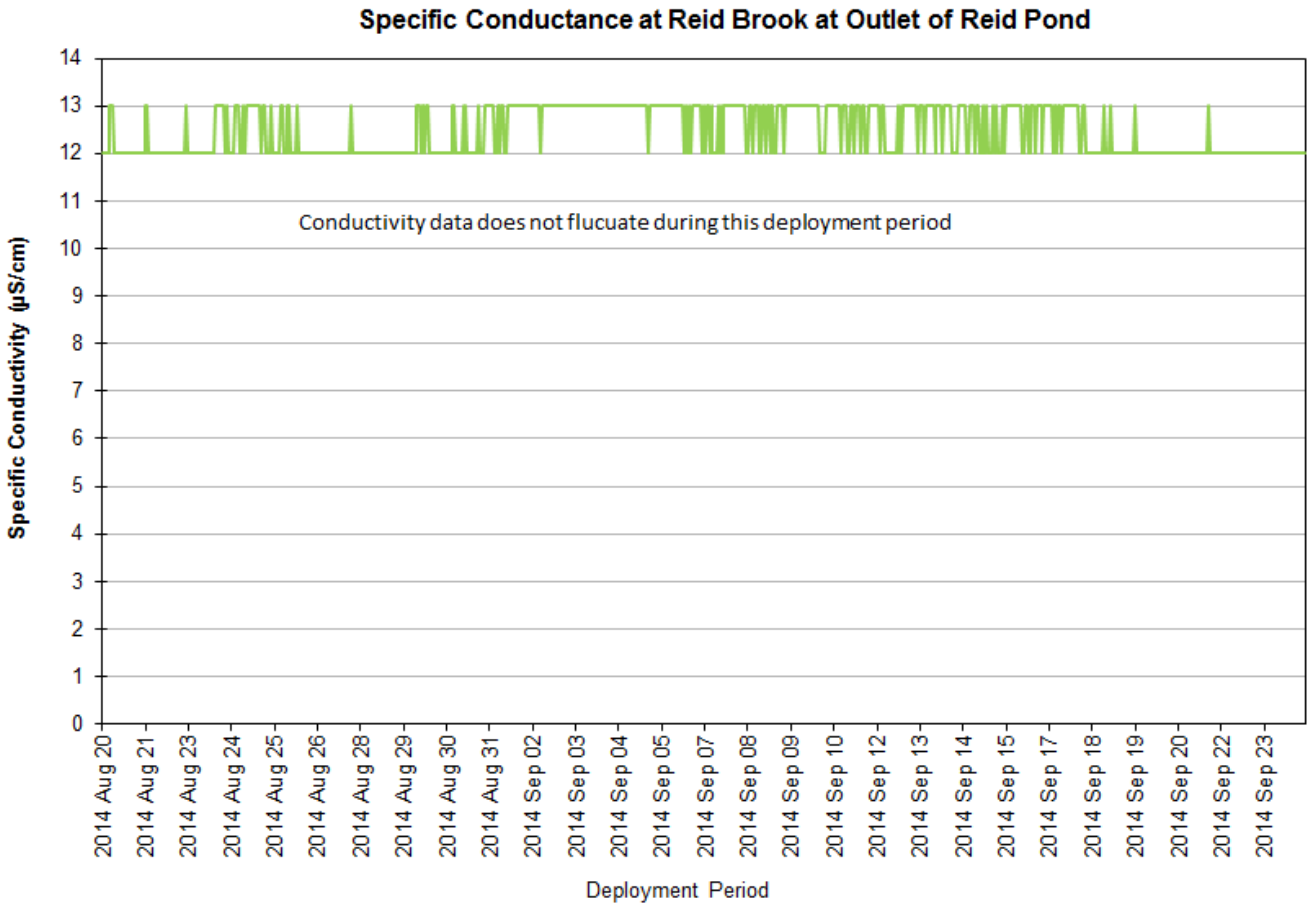

Figure 3: Specific conductivity at Reid Brook at Outlet of Reid Pond

Dissolved Oxygen

During this deployment period the dissolved oxygen content ranges between 9.54mg/l and 11.46mg/l. The saturation of dissolved oxygen ranges from 91.4% to 104.2% (Figure 4).

Dissolved Oxygen (DO) in mg/L is directly recorded by the water quality instrument. Dissolved oxygen percent saturation is a calculated value derived from DO mg/L and water temperature. Dissolved Oxygen is directly influenced by the temperature of the water; therefore as water temperatures in Figure 4 decrease the Dissolved Oxygen concentration increases slightly in the water column. This is a normal reaction between the two parameters.

The DOmg/L levels are above the minimum CCME Guidelines for the Protection of Cold Water Biota at Other Life Stages (6.5mg/l) and Early Life Stages (9.5mg/l). The guidelines are indicated in red on Figure 4.

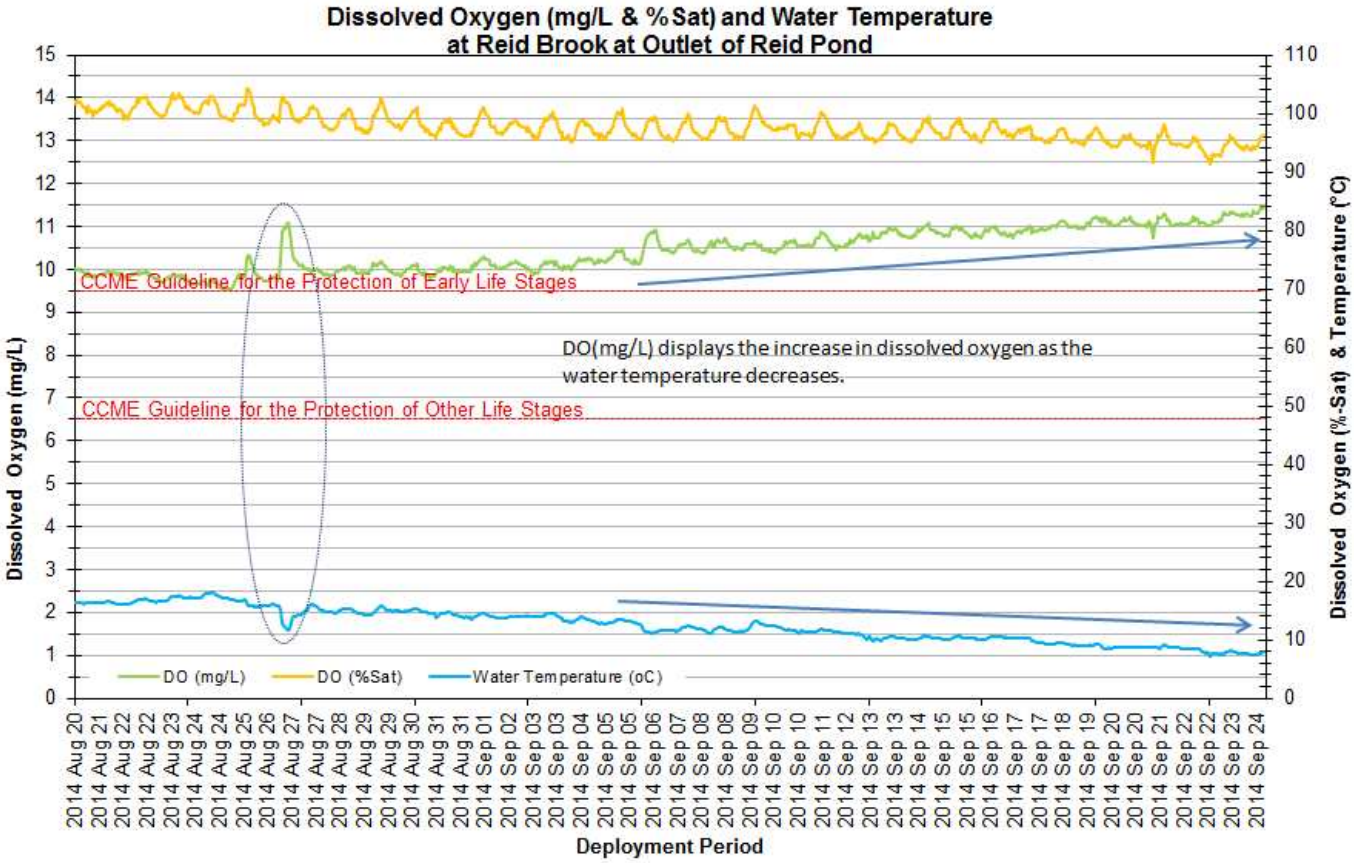

Figure 4: Dissolved Oxygen (mg/L & %sat) and Water Temperature at Reid Brook at Outlet of Reid Pond

Turbidity

The turbidity levels at during this deployment did not get beyond 0 NTU. It is not unusual for this station to have low turbidity readings, as the water flowing from the lake is typically very clean; clear and cold (Figure 5). However the turbidity data used in this report was from the recorded logfile that the instrument stores over the deployment period. This logfile does not provide numerical data with decimal places, therefore the readings were just values of 0 NTU.

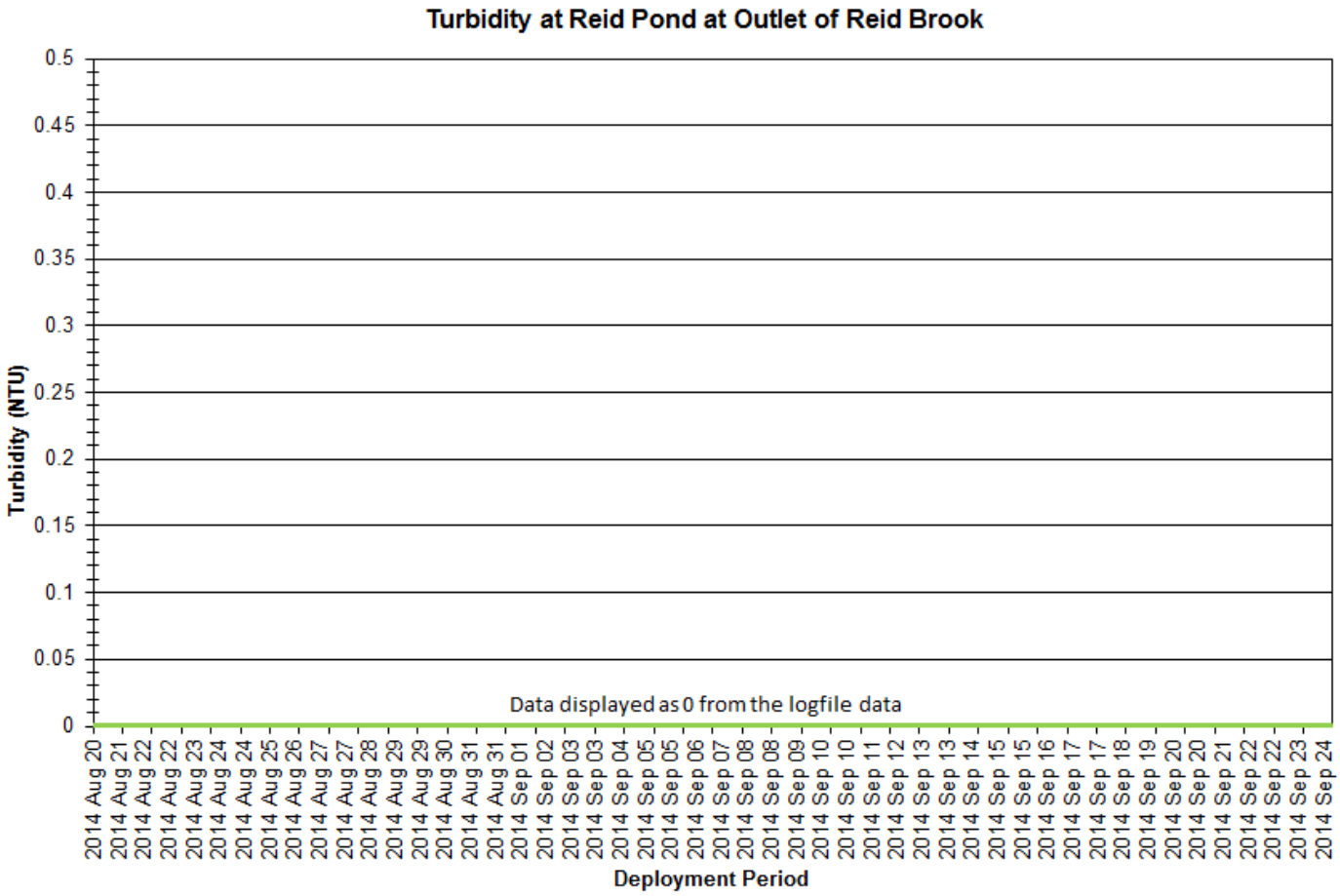

Figure 5: Turbidity and Precipitation at Reid Brook at Outlet of Reid Pond

Daily Average Air Temperature & Precipitation

Daily Average Air Temperature and precipitation are graphed below to show the weather behaviour over this deployment period (Figure 6). The weather data used in this report came from the weather station in Nain.

During deployment the highest averaged air temperature was 15.8 °C with an average low of 2.1°C at the end of the deployment period. Total precipitation had a minimum of 0 mm to a maximum of 33.7 mm on September 22nd, 2014.

The data graphed below displays some of the weather factors that could be influencing the water quality parameters over the deployment period.

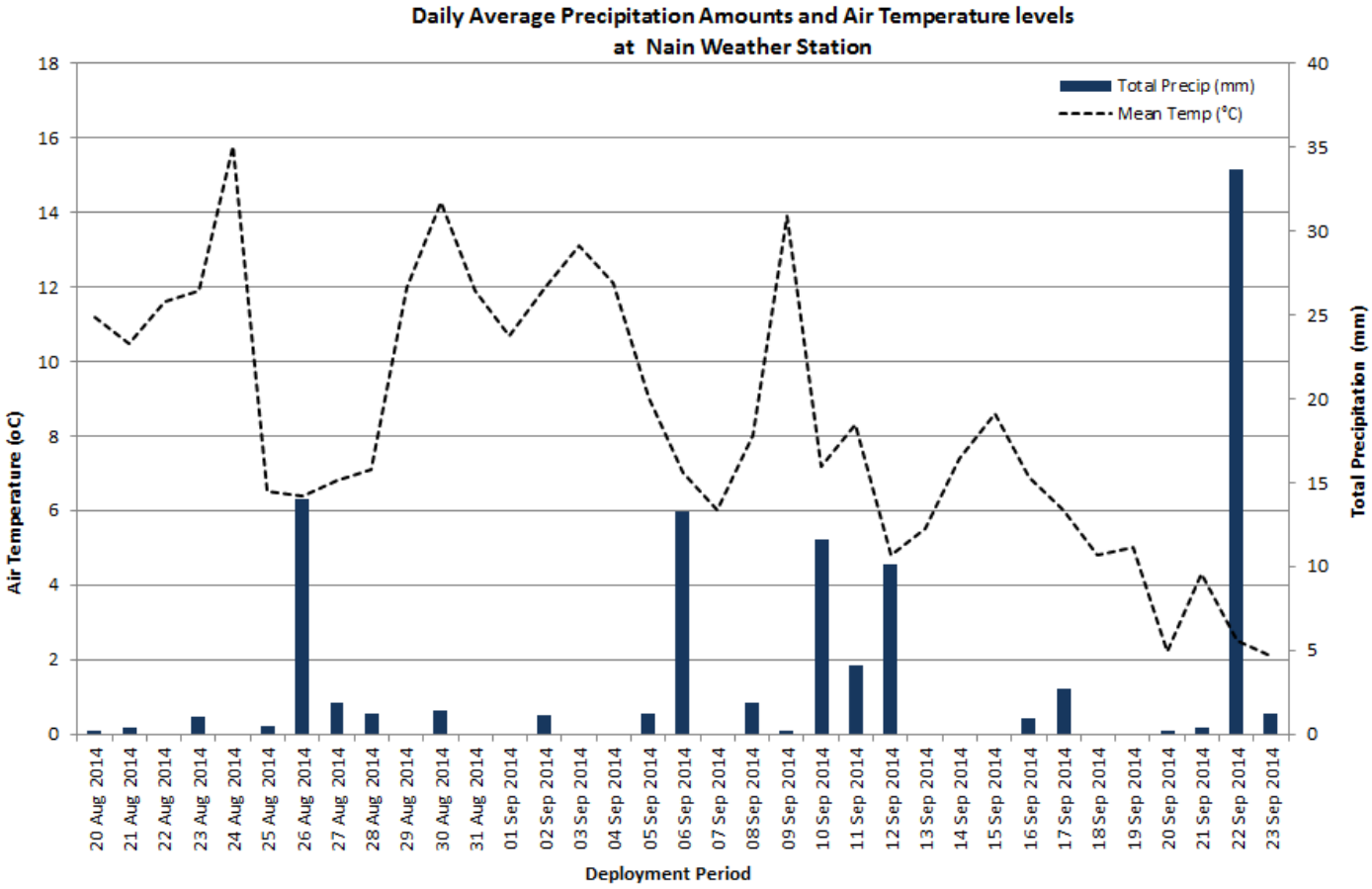

Figure 6: Daily Averaged precipitation and air temperatures in Nain at Reid Brook at Outlet of Reid Pond

Camp Pond Brook

Water Temperature

Water temperature ranges from 2.53°C to 22.82°C during the deployment period (Figure 7).

Water temperature has started to decrease during this deployment period. The trend is expected as the air temperatures decrease with the onset of fall months. The median water temperature is 11.73°C for the deployment period.

This stream is sensitive to changes in the ambient air temperature and fluctuates considerably depending on the weather and time of day. As the stage level increases on August 26th, September 6th and September 12th the water temperatures dip in response.

The trend line on Figure 7 displays the gradual water temperature decrease as the surrounding air temperatures start to cool as the temperatures adjusts to a fall climate. This station typically has the highest water temperatures and greatest fluctuations when compared to the other stations in the network.

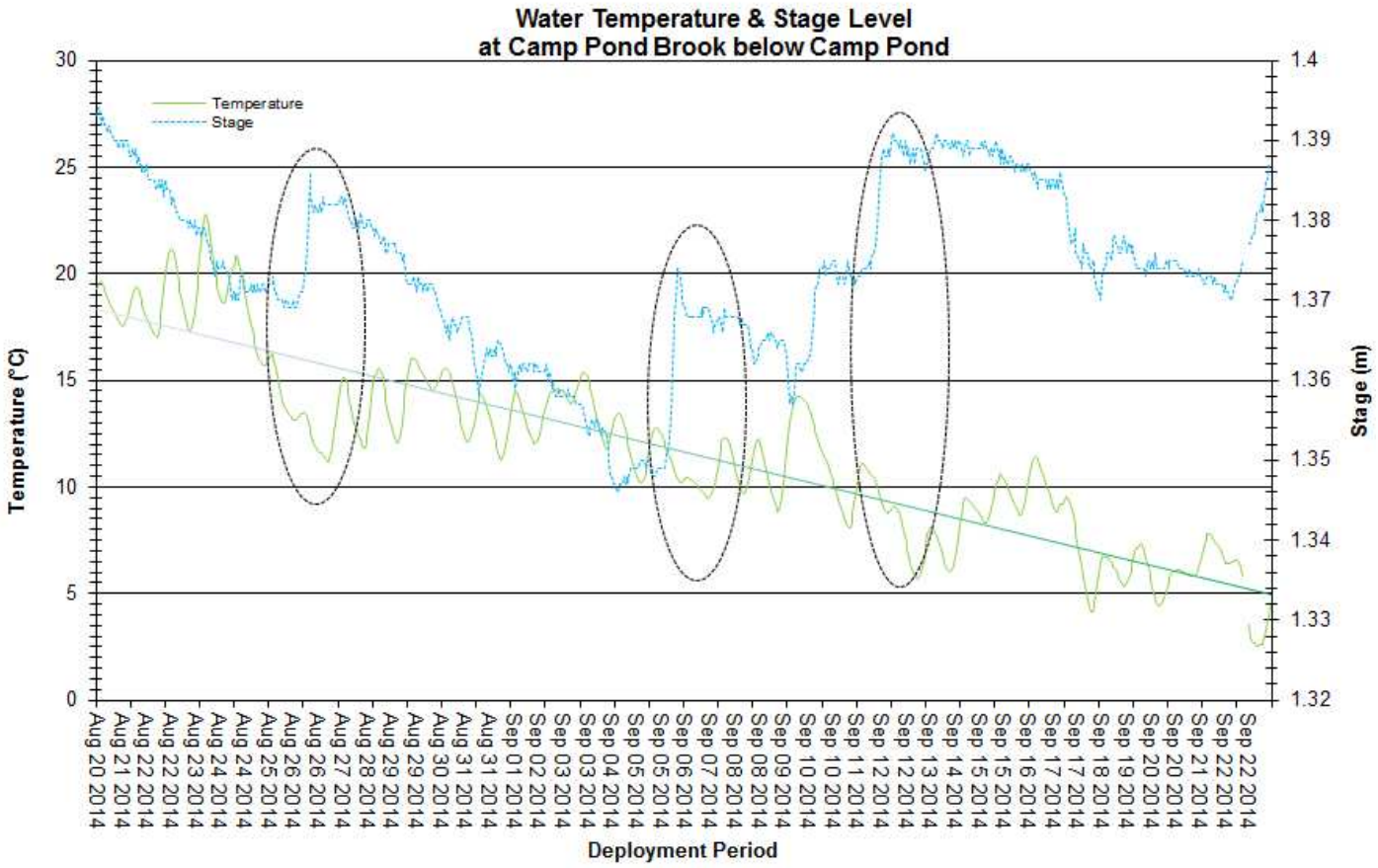

Figure 7: Water Temperature & Stage Level at Camp Pond Brook

pH

During this deployment period the pH ranged between a minimum of 6.40 and a maximum of 7.08 pH units (Figure 8).

The pH values are very stable at this station, only fluctuating diurnally during the deployment period. On September 18th, the pH values decrease slightly as the stage level dips for a couple of days.

At the beginning of deployment the pH values within the recommended guidelines for pH as suggested by the CCME Guidelines for the Protection of Aquatic Life (>6.5 and <9.0 pH units). As the stage levels increases the pH levels start to dip just below the minimum guideline. Guidelines are indicated in red on Figure 8.

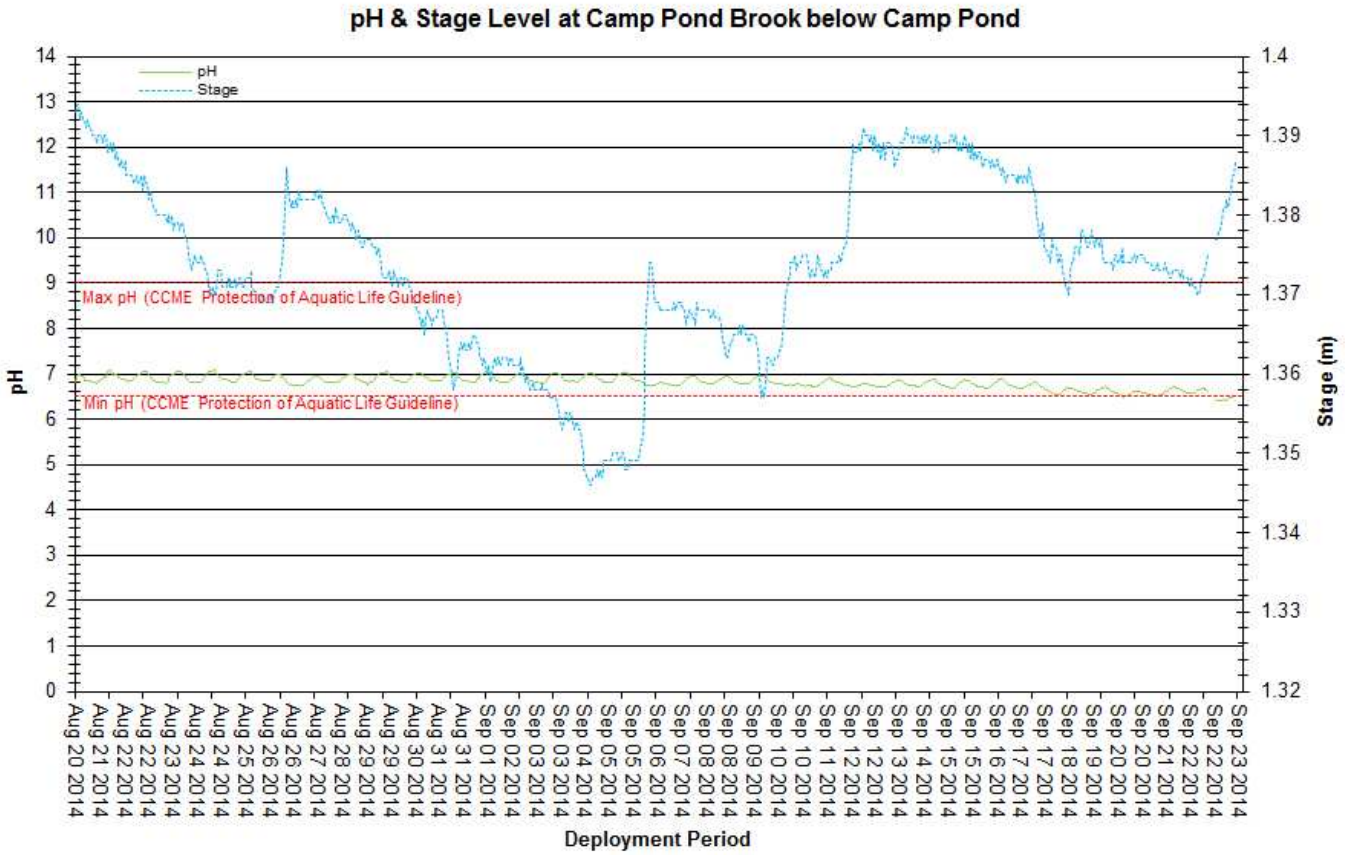

Figure 8: pH & Stage Level at Camp Pond Brook below Camp Pond

Specific Conductivity

During the deployment the specific conductivity data ranged between a minimum of 35.0µS/cm to a maximum of 56.7µS/cm, with a median of 37.8µS/cm (Figure 9).

There are a few peaks in conductivity on August 26th and September 6th and September 11th and 13th. The peaks in conductivity correspond with increases in stage level during those same time frames. It can be assumed that due to precipitation, stage increased and in turn increased the suspended matter in the water column which causes the increase in the conductivity.

Outside of the larger peaks, the remainder of the conductivity data was stable.

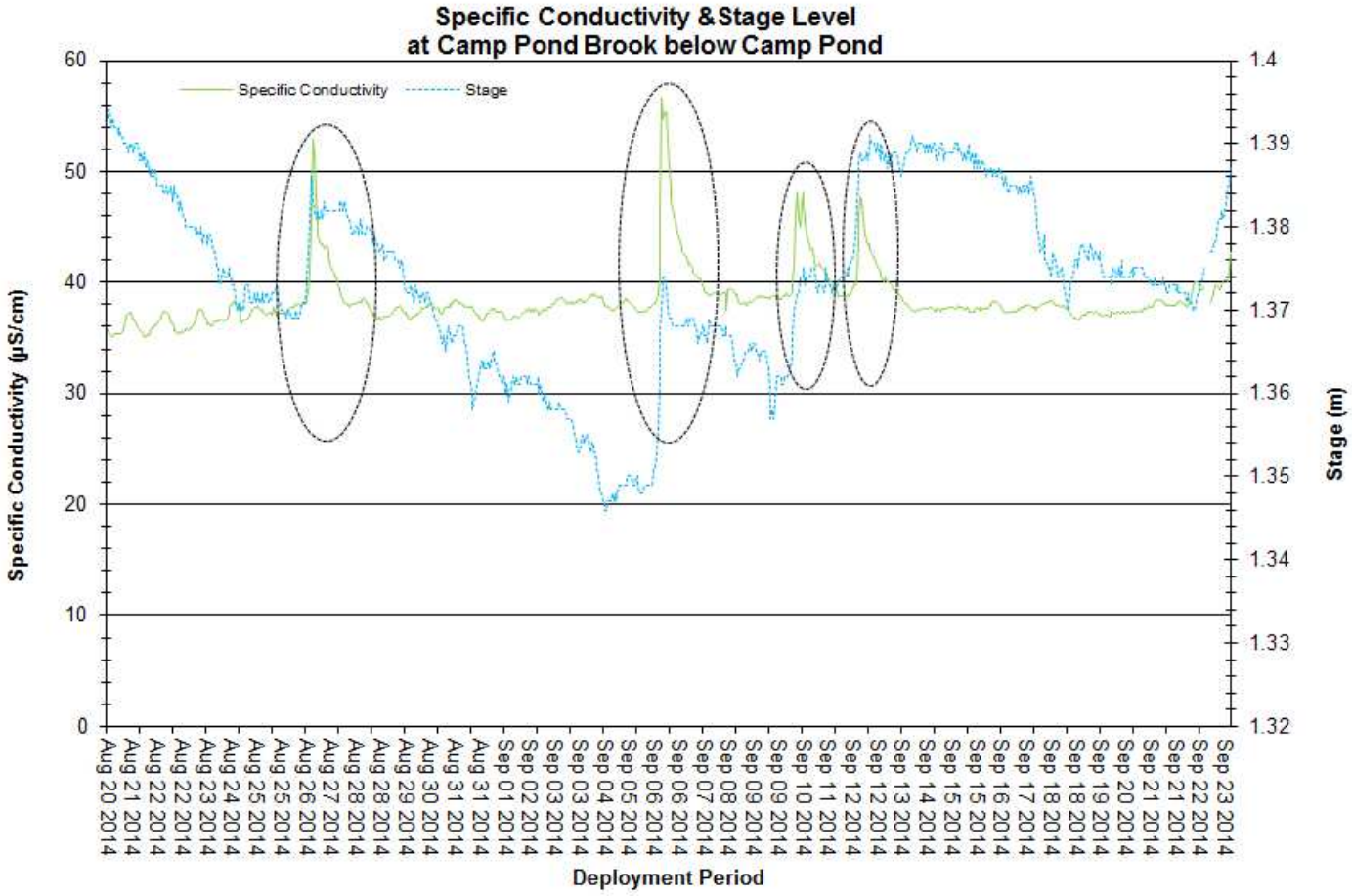

Figure 9: Specific Conductivity & Stage Level at Camp Pond Brook

Dissolved Oxygen (mg/L & % Saturation)

The water quality instrument measures dissolved oxygen (mg/L) with the dissolved oxygen probe and then the instrument calculates percent saturation (% Sat) with water temperature.

Dissolved oxygen content ranges between 8.08mg/l and 12.10mg/l. The saturation of dissolved oxygen ranges from 86.7% to 99.1% (Figure 10).

Dissolved Oxygen (%Sat) remains stable throughout this deployment period. Dissolved Oxygen mg/L is responding to the cooler water temperatures and over the deployment period the mg/L increases. This is indicated by the trend line as it slopes upward. This is to be expected as water temperature directly influences the level of dissolved oxygen present in a water column.

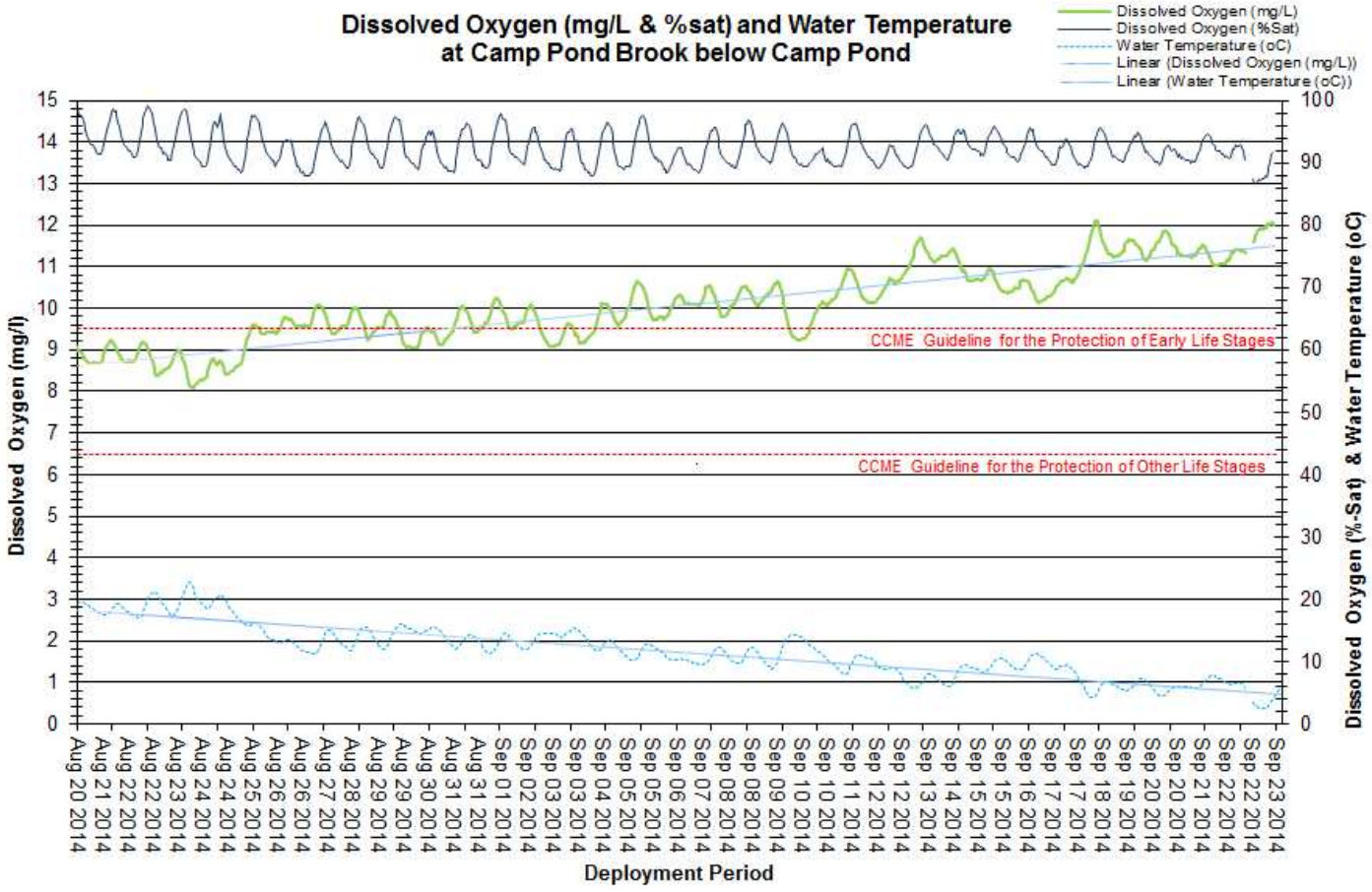

Figure 10: Dissolved Oxygen & Percent Saturation at Camp Pond Brook below Camp Pond

Turbidity

Turbidity values range between 0 NTU and 31.5 NTU (Figure 11). A median value of 0.0 NTU indicates there is very little natural background turbidity at this station during this deployment period.

There are a number of low - medium turbidity events at this station throughout the duration of this deployment. The larger turbidity events correspond with rainfall events (rainfall indicated on figure 12). Turbidity events on August 23rd, 28th and 30th are likely a result of increase suspended material in the water column after high rainfall.

The largest event of 31.5 NTU towards the end of September 22nd, 2014 corresponds with the beginning of a larger precipitation event (on Figure 11) right at the end of deployment. Only the beginning of the event was captured in this deployment period. It can be assumed that the turbidity value was a result of runoff and rainfall stirring up particles and substances in the brook.

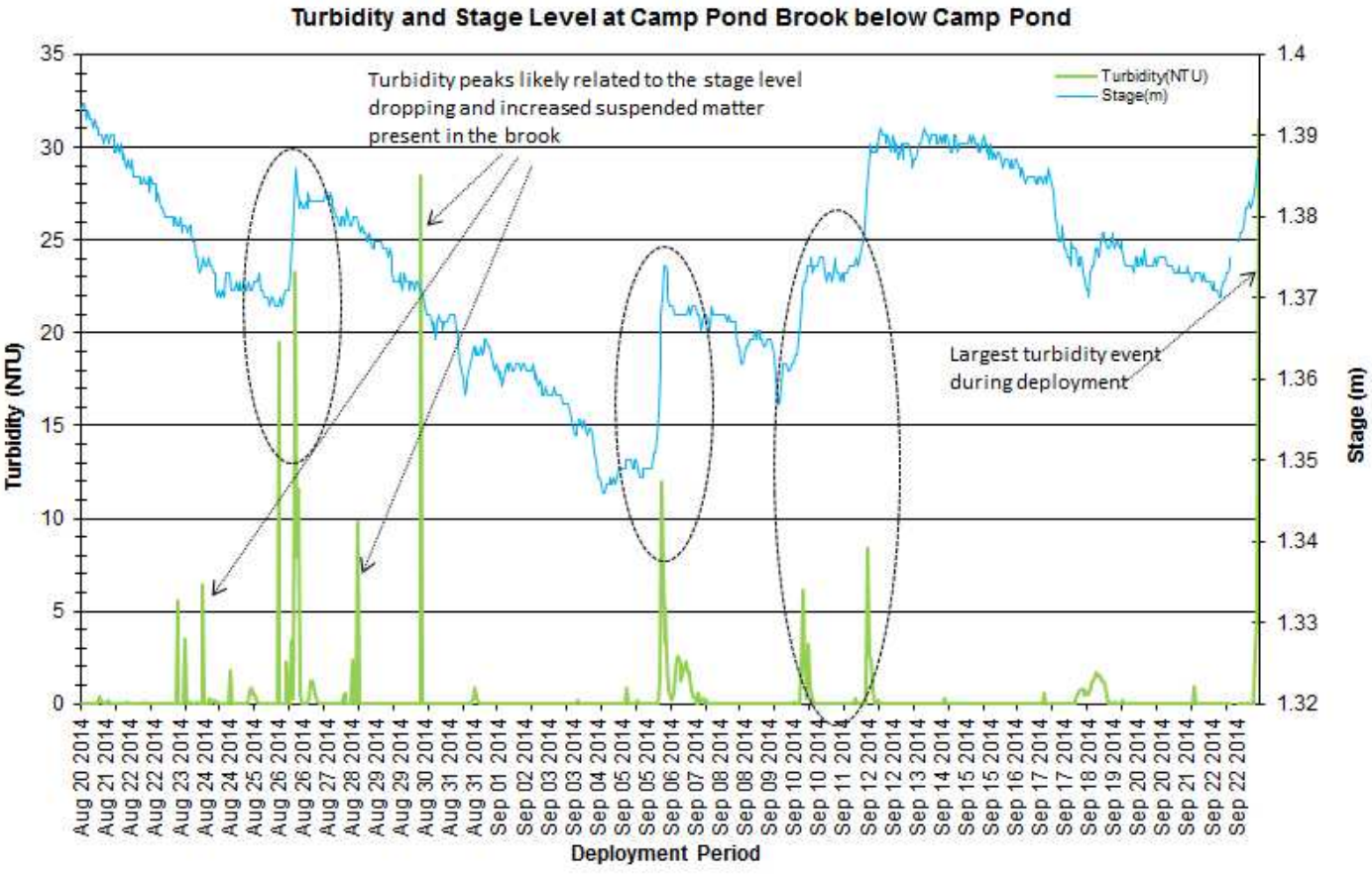

Figure 11: Turbidity & Stage Level at Camp Pond Brook

Stage, Streamflow and Precipitation

Stage can be defined as the height or elevation of the stream's water surface above a reference elevation (sea level, gage level)**.** Stage is important to display as it provides an estimation of water level at the station and can explain some of the events that are occurring with other parameters (i.e. Specific Conductivity, DO, turbidity). Stage will increase during rainfall events (Figure 12) and during any surrounding snow or ice melt as runoff will collect in the brooks. However, direct snowfall will not cause stage to rise significantly.

Precipitation data was obtained from the Environment Canada weather station at Nain. The highest recorded rainfall for this deployment was on September 22nd, with an average of 33.7mm that day.

During the deployment period, the stage values ranged from 1.35m to 1.39m. The larger peaks in stage correspond with substantial rainfall events as noted on Figure 12. Streamflow had a minimum amount of 0.19m^3/s and a maximum flow of 0.36m^3/s.

Stage, Streamflow and precipitation are graphed below to show the relationship between rainfall and water level (Figure 12). It is evident that the peaks in stage (m) and streamflow data are a result of precipitation.

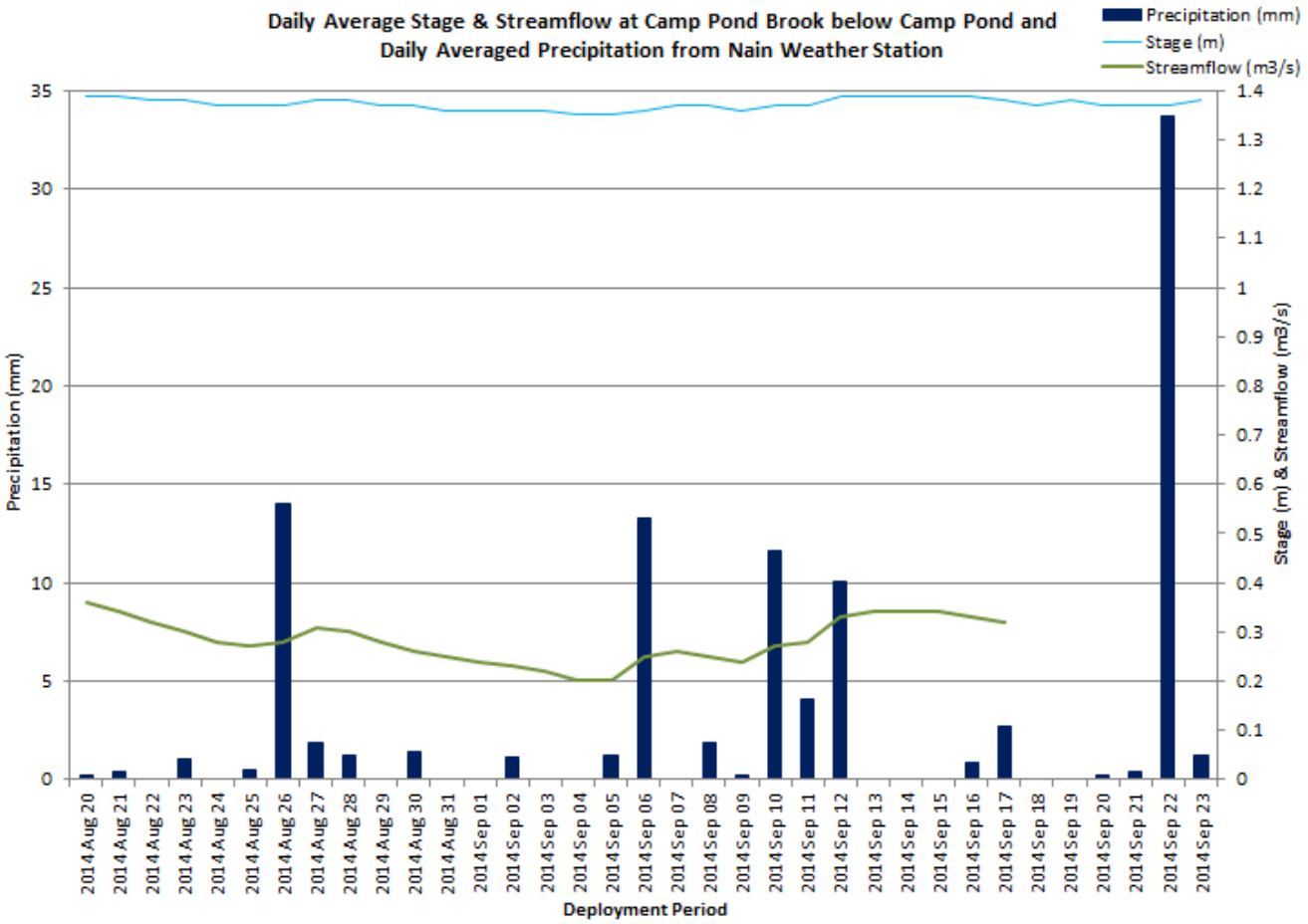

Figure 12: Daily Precipitation, Average Daily Stage & Flow level at Camp Pond Brook

(Weather data recorded at Nain)

Tributary to Lower Reid Brook

Water Temperature

At this station the water temperature ranged from 2.8°C to 14.40°C during the deployment period (Figure 13). The water temperature median for deployment was 9.30 °C.

The linear trend line shows that water temperature is decreasing throughout the deployment period. This trend is expected given the cooling ambient air temperatures as the fall season approaches (Figure 13).

The relationship between stage level and water temperature can be seen on Figure 13. As the stage level increases water temperature decreases. When the stage level dips between rainfall events the water temperature increases slightly during those times.

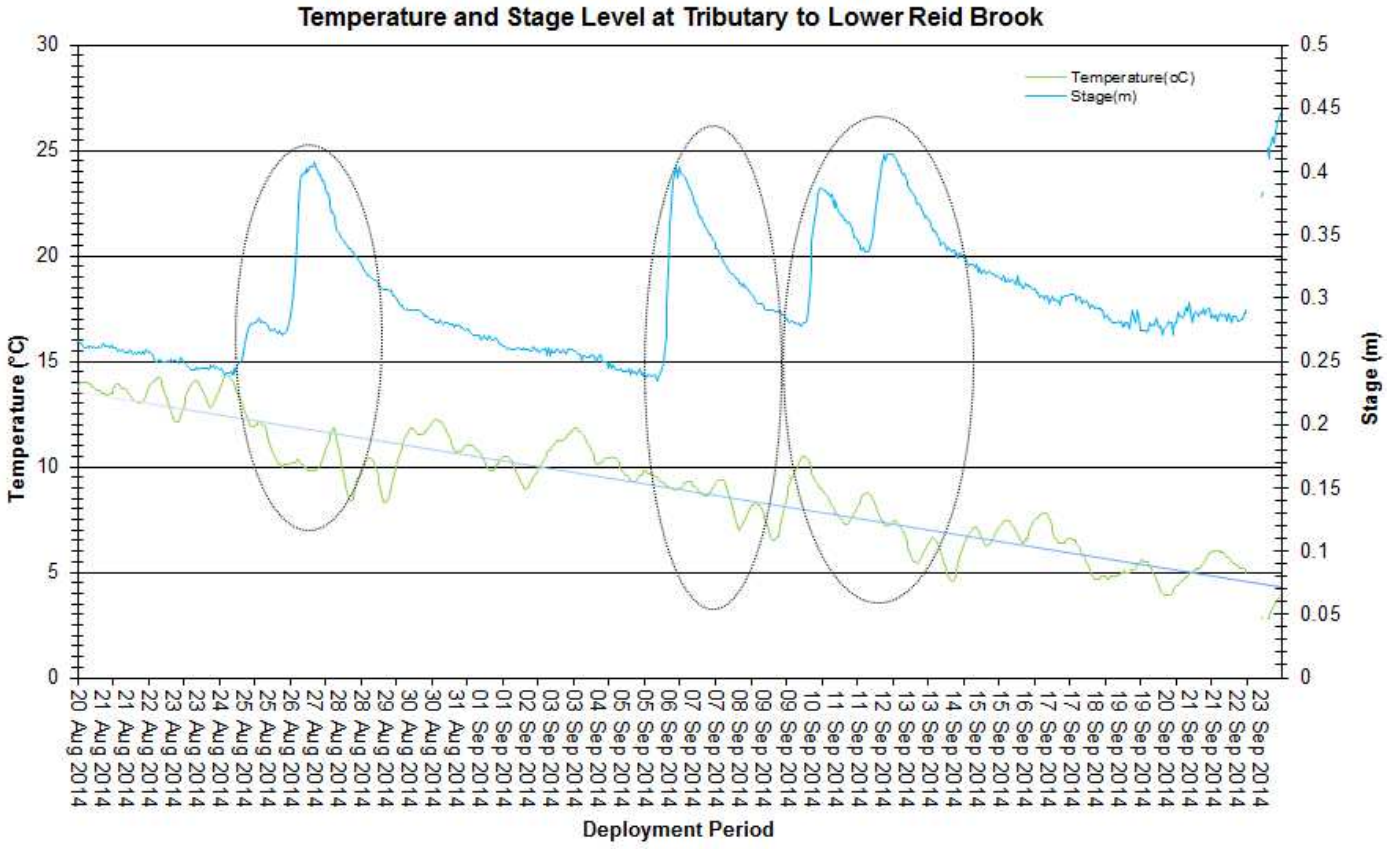

Figure 13: Water temperature at Tributary to Lower Reid Brook

pH

During this deployment period pH data ranged between a minimum of 6.65 and a maximum of 7.10 pH units (Figure 20). pH values had a median of 6.92 pH units for this deployment.

For the majority of this deployment period the pH data remains stable with small fluctuations diurnally. There is a relationship between pH and stage level, this is evident on Figure 14 as stage levels increase on several occasions (indicated by black arrows on Figure 14), the pH values drop slightly as a response.

During high peaks in stage level the pH dip slightly. This is a natural reaction between these two parameters.

The CCME guideline provides a basis by which to judge the overall health of the brook. Naturally, all streams and brooks are different.

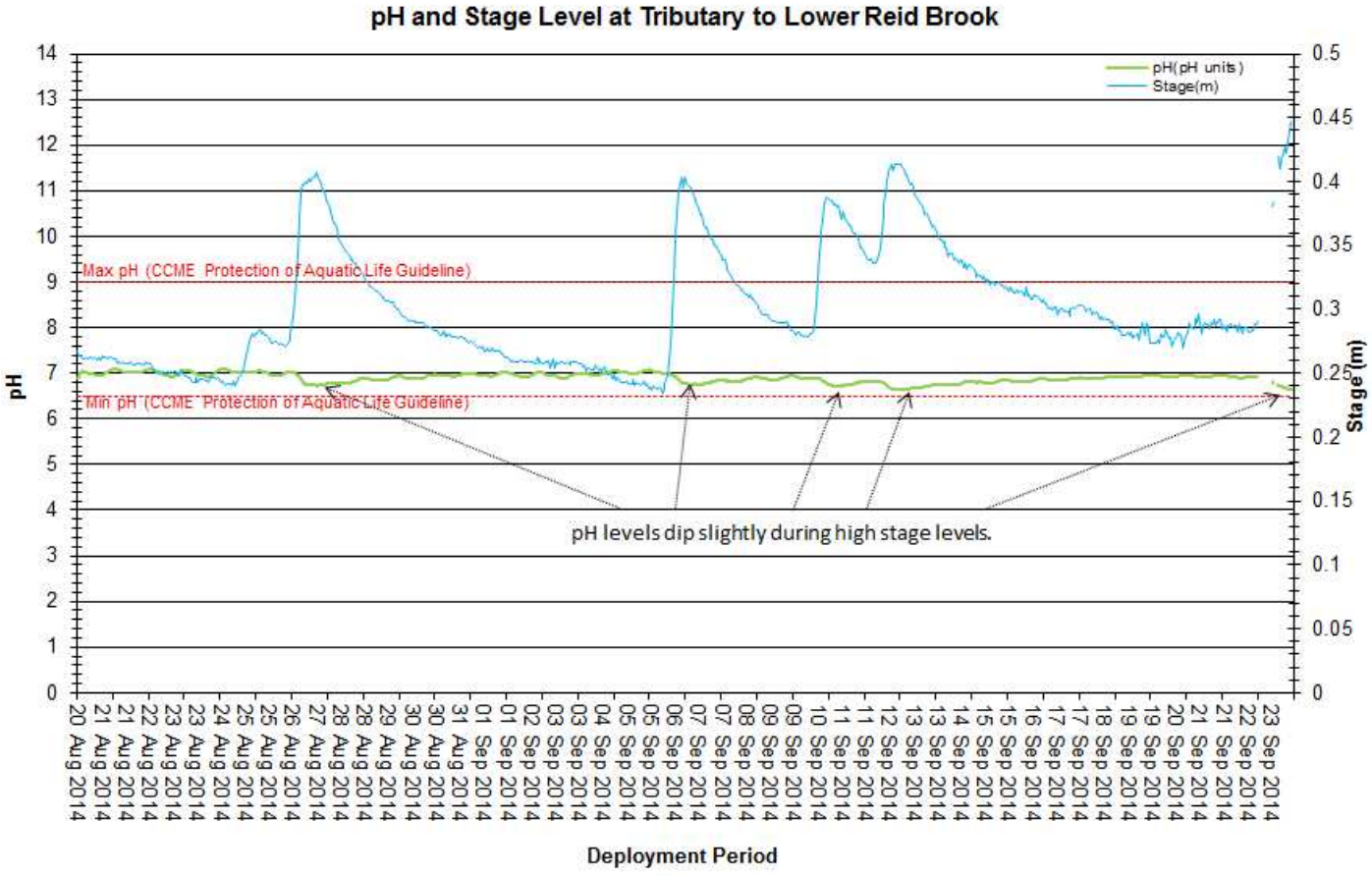

Figure 14: pH and stage level at Tributary to Lower Reid Brook

Specific Conductivity

Specific conductivity ranges between 32.2µS/cm and 42.6µS/cm during the deployment period, with a median for the deployment period of 39.2µS/cm (Figure 15).

Stage is included in Figure 15 to illustrate the inverse relationship between conductivity and water level. Specific conductivity changes with the varying water level. As stage decreases, specific conductivity generally increases due to the increase in concentration of dissolved solids in the water column. Inversely, as stage increases, specific conductivity decreases as the concentration of dissolved solids is diluted. This relationship is highlighted by how the data is displayed on Figure 15.

The linear trend line across specific conductivity data highlights that over this deployment period specific conductivity was decreasing.

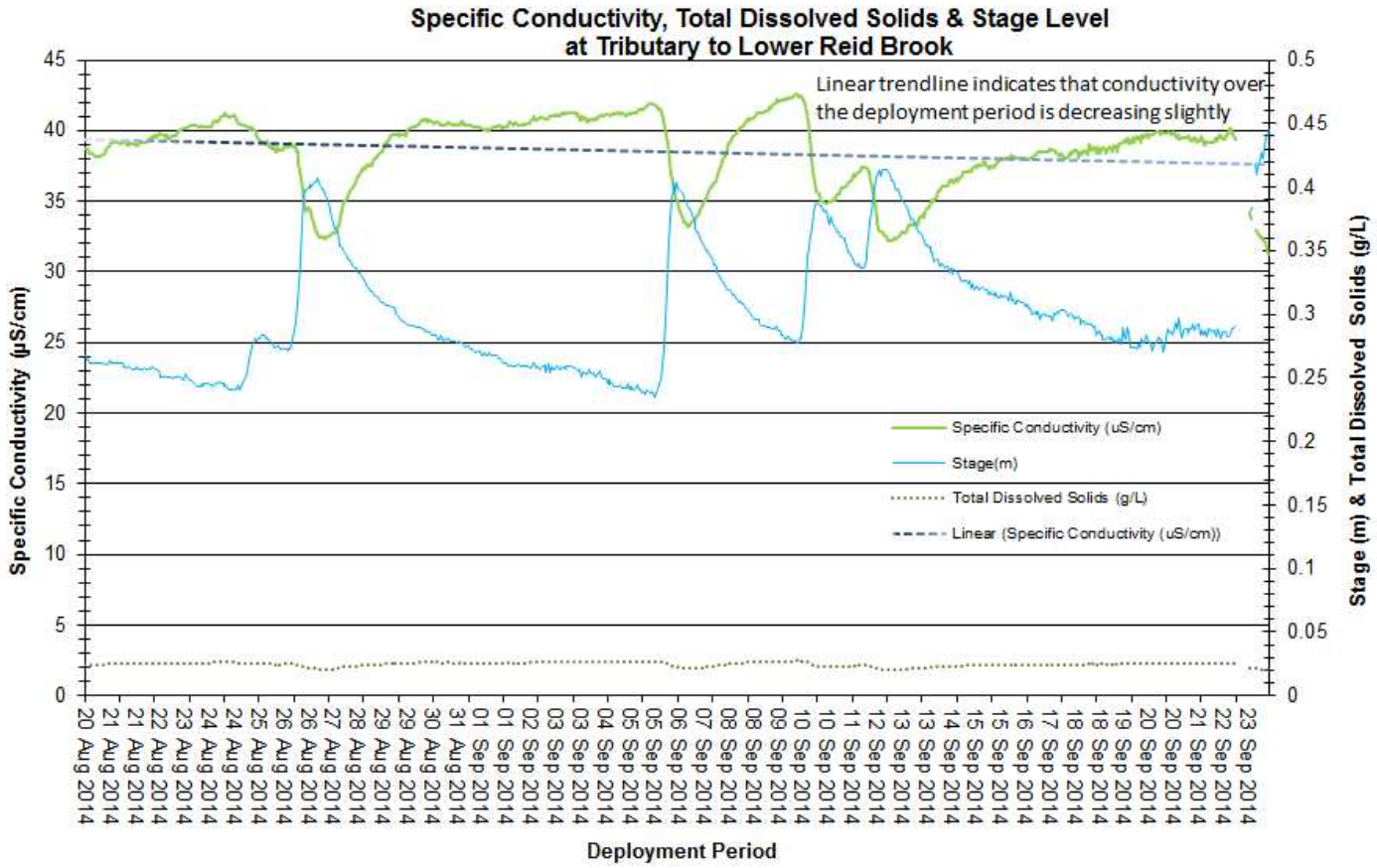

Figure 15: Specific conductivity and stage level at Tributary to Lower Reid Brook

Dissolved Oxygen

Dissolved oxygen content ranges between 9.89mg/l and 12.68mg/l. The saturation of dissolved oxygen ranges from 93.8% to 100.9% (Figure 16). The water quality instrument measures dissolved oxygen (mg/L) with the dissolved oxygen probe and then the instrument calculates percent saturation (% Sat) with water temperature.

The highlighted arrows on Figure 16 indicate the relationship between water temperature and dissolved oxygen. As water temperature decreases the level of dissolved oxygen consumed decreases, which means there is more available dissolved oxygen in the brook during the cooler temperatures. This relationship is indicated on Figure 16 by the arrows.

During this deployment the dissolved oxygen mg/L levels remained above both CCME guidelines for the protection of early/other life stages.

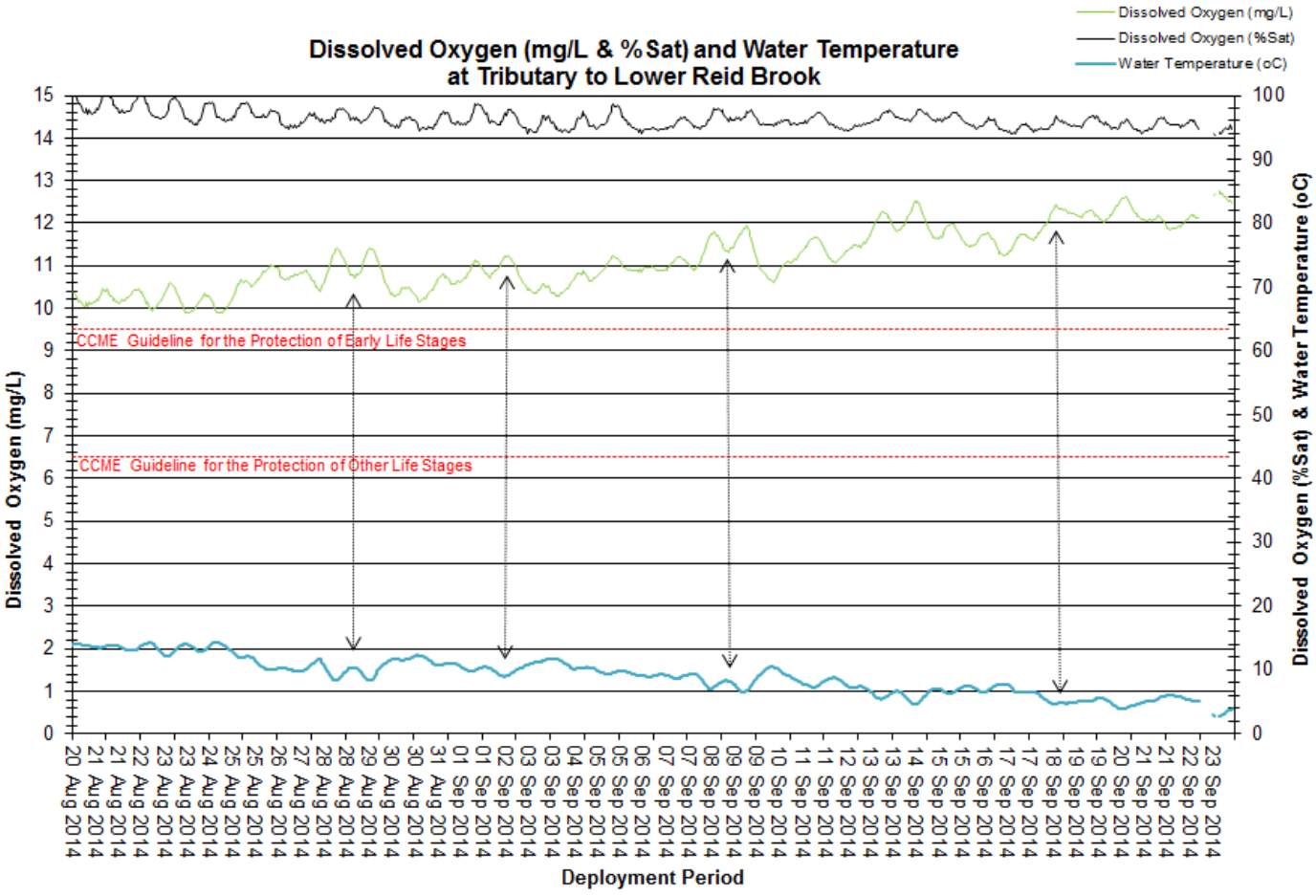

Figure 16: Dissolved oxygen and percent saturation at Tributary to Lower Reid Brook

Turbidity

During this deployment period the turbidity data for this deployment ranged within a minimum of 0.0NTU and a maximum of 40.2NTU (Figure 17). The median for this data set was 0.0NTU; indicating turbidity is generally quite low at this site.

The majority of the turbidity peaks correspond with higher stage values during the same time frame. These are highlighted on Figure 17 by the black circles and arrows. As the stage level increases so does the presence of suspended solids and particles in the water column which is captured by the turbidity sensor.

On August 22nd there are two brief turbidity peaks. When the turbidity data was reviewed it indicated all 0.0NTU readings beside the two turbidity spikes, it is likely the turbidity was a result of debris passing over the sensor at the exact time the instrument is logging.

On September 22nd, 2015 there is a turbidity spike although there is no complete stage data to correspond with; the remaining stage data does indicate high turbidity is likely a result of high stage at that time.

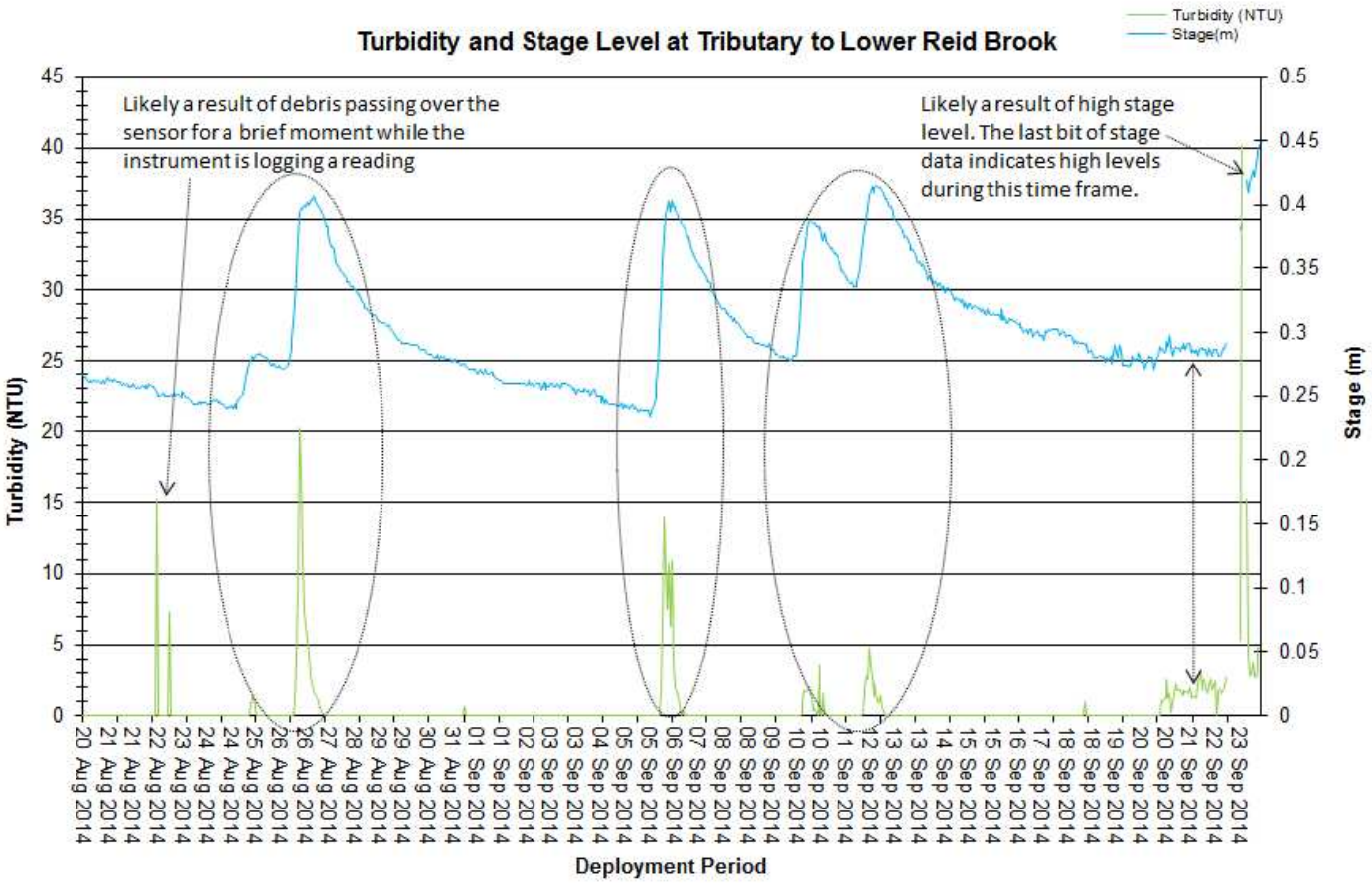

Figure 17: Turbidity and Stage level at Tributary to Lower Reid Brook

Stage, StreamFlow and Precipitation

Stage can be defined as the height or elevation of the stream's water surface above a reference elevation (sea level, gage level). Stage is important to display as it provides an estimation of water level at the station and can explain some of the events that are occurring with other parameters (i.e. Specific Conductivity, DO, turbidity). Streamflow can be defined as the volume of water in a river at a specific location and time. It is measured in cubic meters per second.

Stage and Streamflow will increase during rainfall events (Figure 18) and during any surrounding snow or ice melt as runoff will collect in the brooks. However, direct snowfall will not cause them to rise significantly. During the deployment period, the stage values ranged from 0.35m to 0.64m. Due to technical issues there wasn't a large amount of streamflow values recorded for this deployment.

Precipitation data was obtained from the Environment Canada weather station in Nain. Precipitation ranges for the deployment period were a minimum of 0.0 mm and a maximum of 33.7mm on September 22nd.

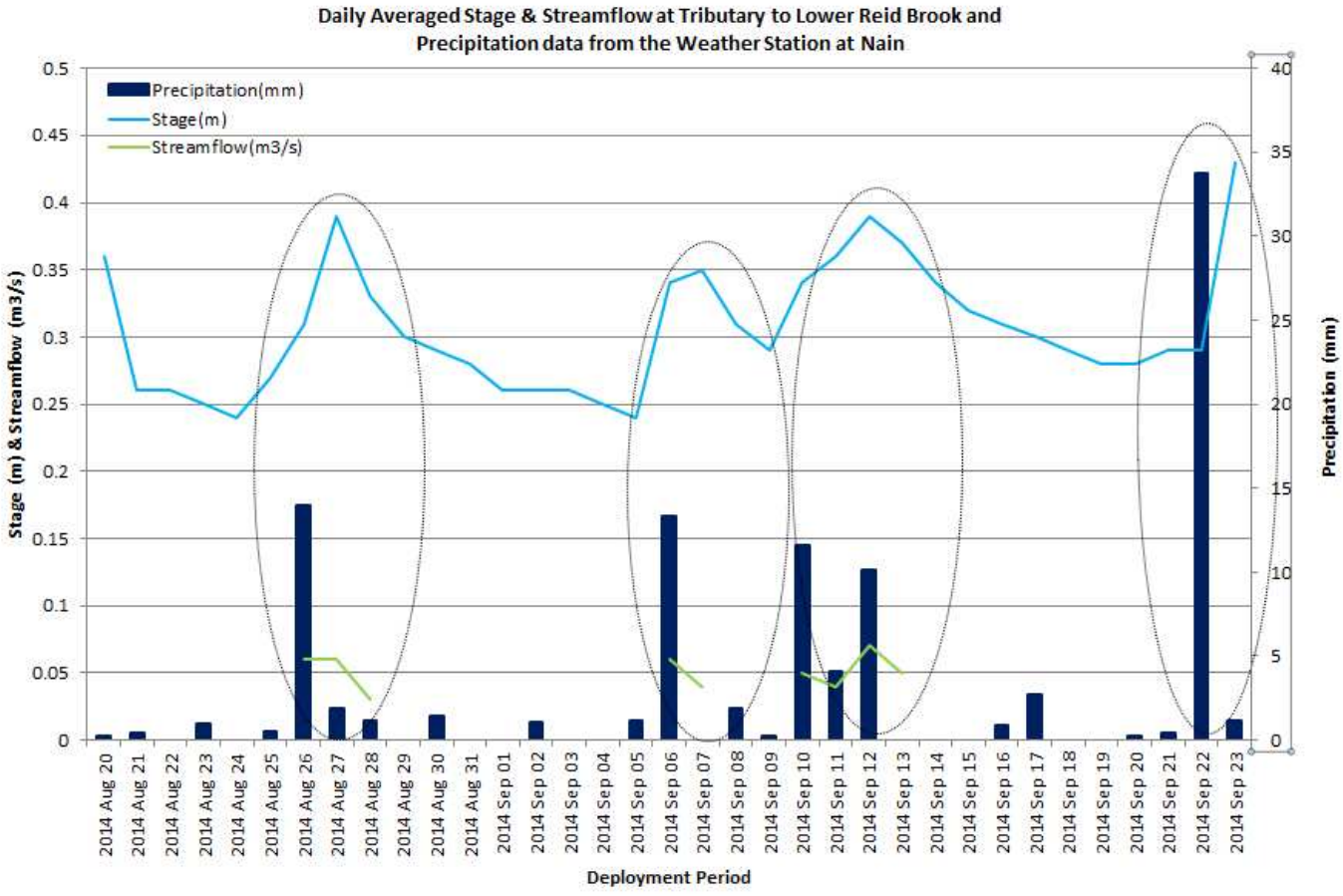

Figure 18: Daily precipitation and average daily stage and stream flow at Tributary to Lower Reid Brook (Weather data recorded at Nain)

Lower Reid Brook below Tributary

Water Temperature

Water temperature ranges from 2.95°C to 17.88°C during the deployment period (Figure 19). The data set for this deployment had a median of 9.55°C.

Water temperature is decreasing during this deployment period. This trend is expected as the ambient air temperatures decrease with the fall/winter season approaching (Figure 19). Streams and brooks are sensitive to changes in the ambient air temperature and water temperature will fluctuate considerably depending on the weather and the time of day.

The lower dips in water temperature correspond with higher stage values in the same time frame. Precipitation can cause the water temperature to lower slightly for a short period of time. This is evident on Figure 19 on August 26th, September 7th, September 12th and again towards the very end of deployment on September 22nd.

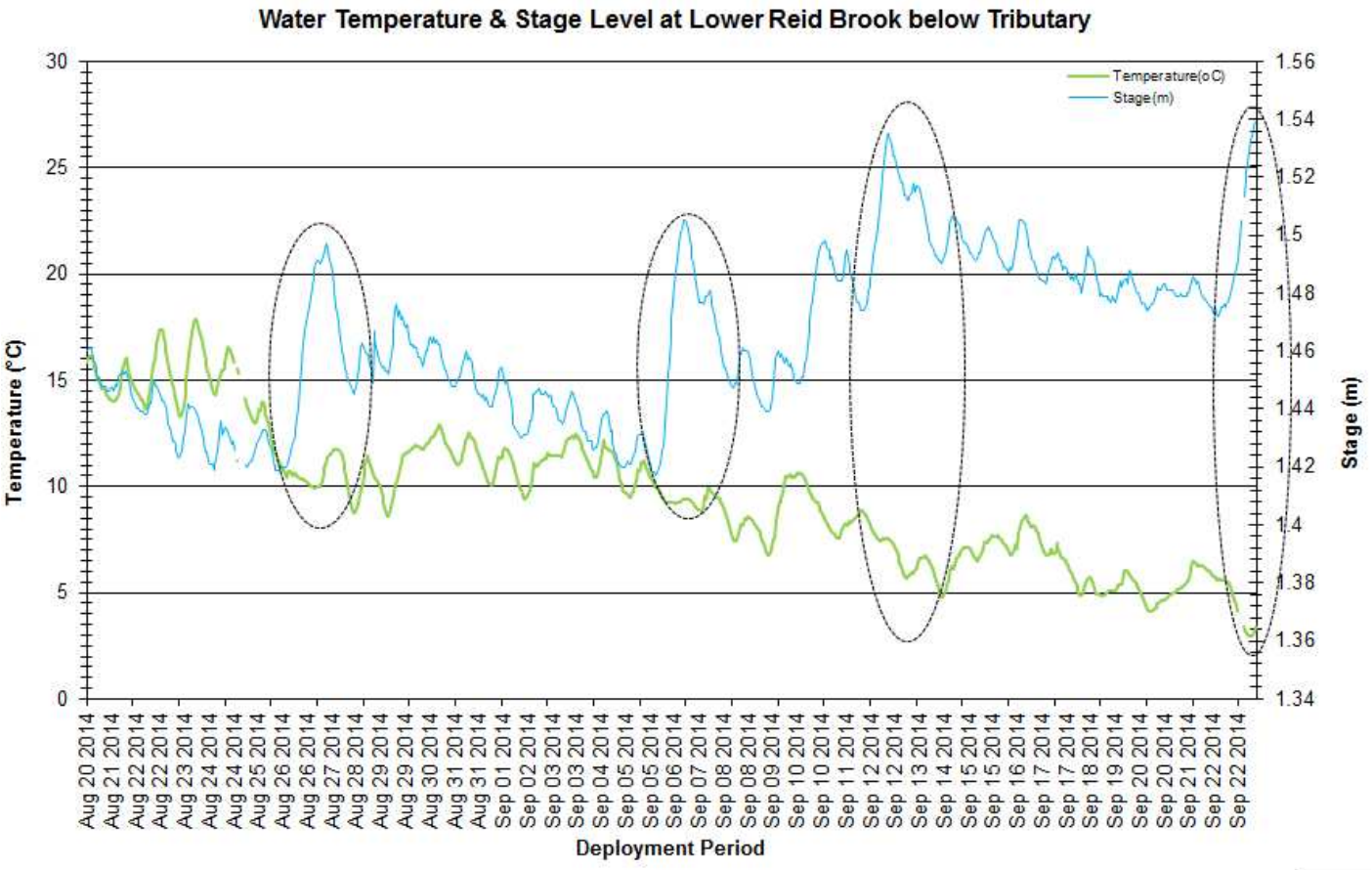

Figure 19: Water temperature and Stage levels at Lower Reid Brook below Tributary

pH

pH data at this station ranged within a minimum of 6.38 and a maximum of 7.13 pH units (Figure 14).

For the most part, pH is stable throughout the deployment period. There are slight decreases in pH during the higher stage periods, on August 27th, September 7th, September 11- 12th and September 22nd. These events are circled in black on Figure 20.

Initially the pH data sits just above the lower CCME guidelines until half way through the deployment period. As the stage level starts to fluctuate the pH values decrease slightly with each large stage increase.

The CCME guideline provides a basis by which to judge the overall health of the brook. Naturally, all streams and brooks are different. During this deployment period the median pH level was 6.66 pH units.

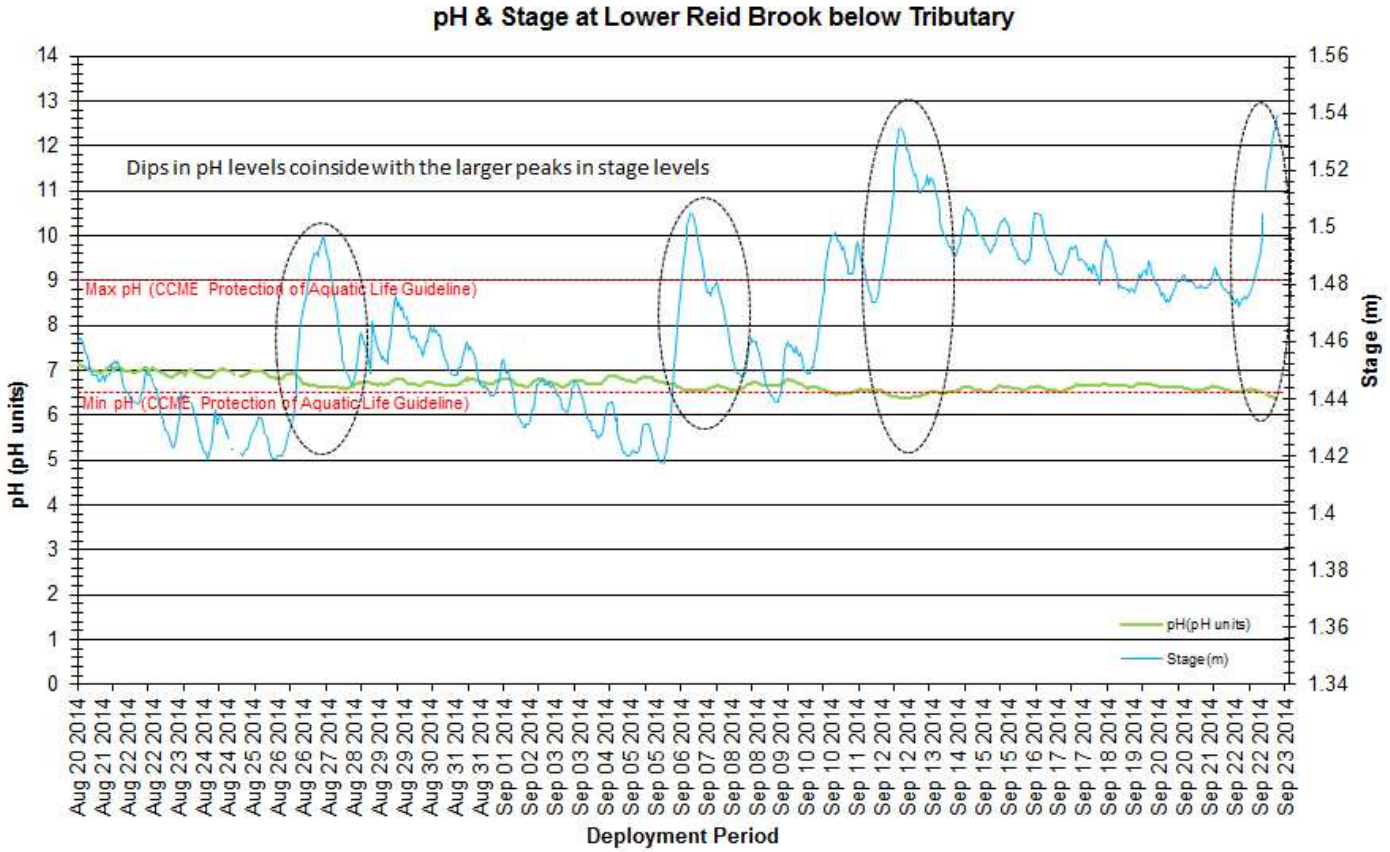

Figure 20: pH and stage level at Lower Reid Brook below Tributary

Specific Conductivity

During this deployment the specific conductivity data ranged between 32.3µS/cm and 41.5µS/cm, with a median of 37.2µS/cm (Figure 21). The median is slightly higher than the previous deployment.

Stage is included in Figure 21 to illustrate the inverse relationship between conductivity and water level. As stage decreases, specific conductivity increases because of the increased concentration of dissolved solids.

Inversely, as stage increases, specific conductivity decreases due to the dilution of dissolved solids in the water column. This is evident on August 27th, September 6th -7th and again on September 12th -13th.

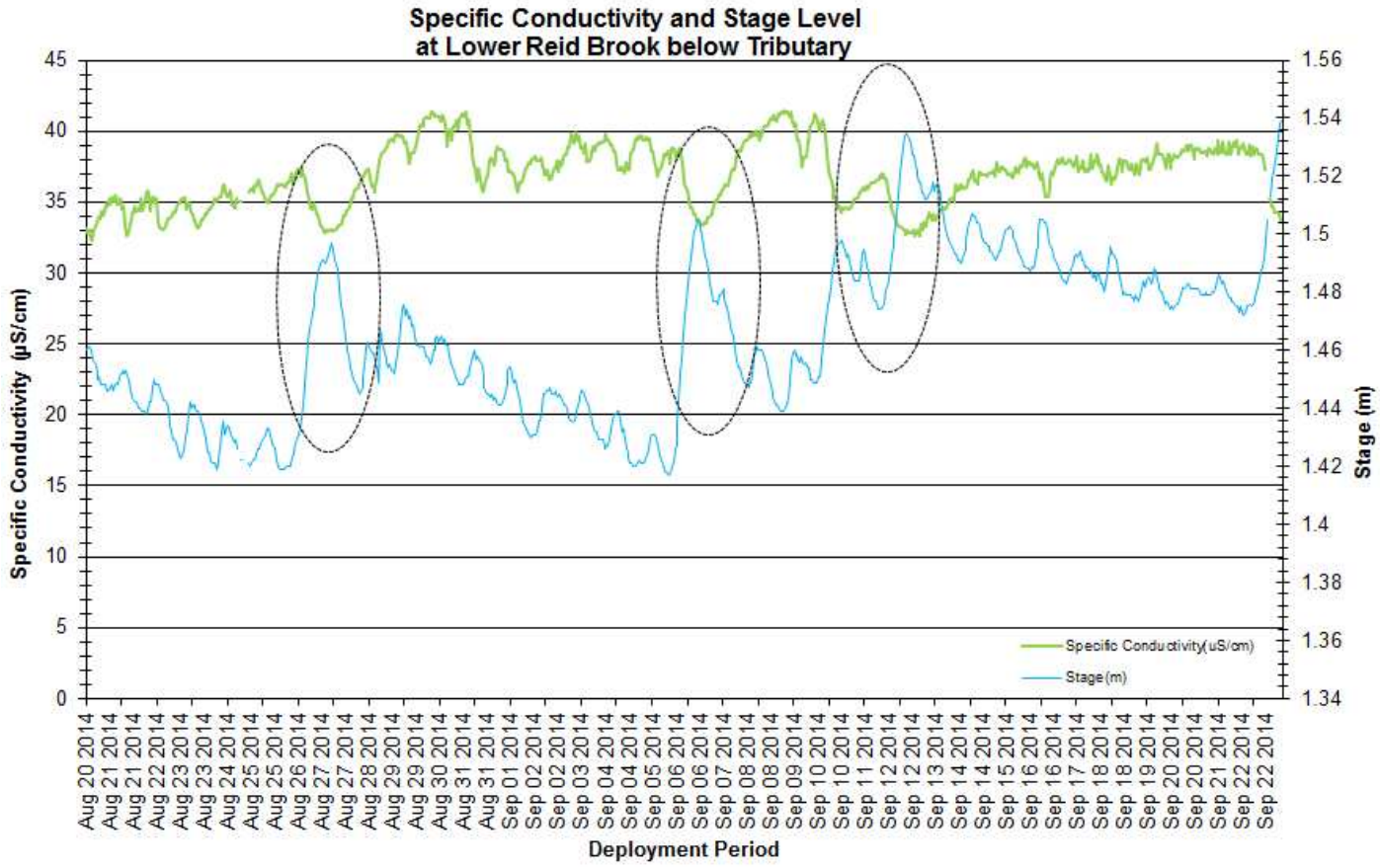

Figure 21: Specific conductivity and stage level at Lower Reid Brook below Tributary

Dissolved Oxygen

Dissolved oxygen content ranges between 9.30mg/l and 12.47mg/l. The saturation of dissolved oxygen ranges from 91.0% to 104.6% (Figure 22).

Dissolved oxygen percent saturation is relatively consistent throughout the deployment period. Dissolved oxygen mg/L increases throughout the deployment period as the water temperature decreases.

The dissolved oxygen levels are stable for this deployment period. The dissolved oxygen mg/L is just above the guideline for protection of early life stages for the majority of the deployment period.

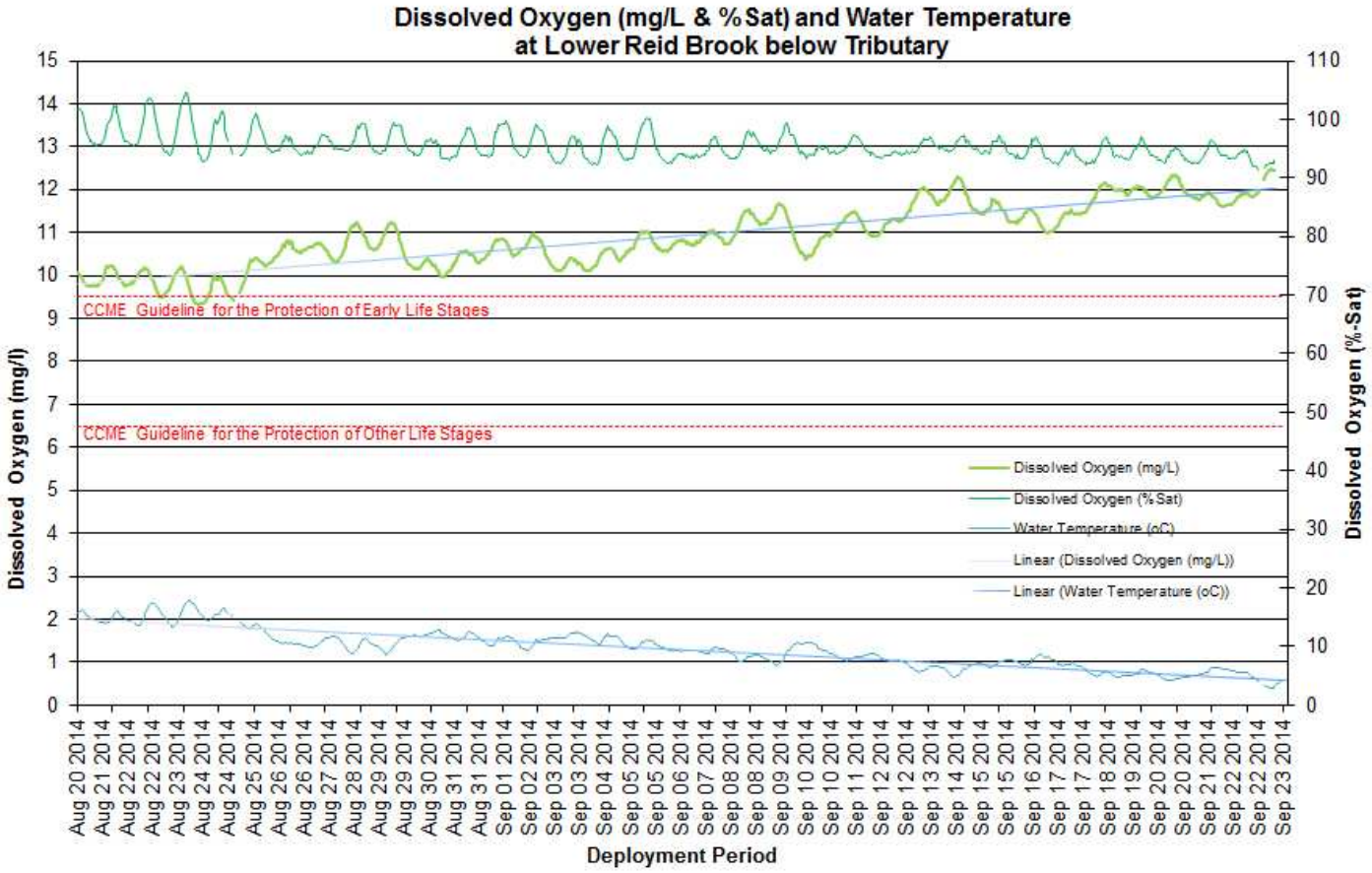

Figure 22: Dissolved oxygen (mg/L & %Sat) at Lower Reid Brook below Tributary

Turbidity

During the deployment period the turbidity values ranged between a minimum of 0 NTU and a maximum of 11.5 NTU (Figure 23). A median value of 0.0 NTU indicates there is no natural background turbidity data for this deployment period.

There are two turbidity increases captured during the deployment period, both correspond with high stage levels for the same timeframe. All other data for the deployment is stable.

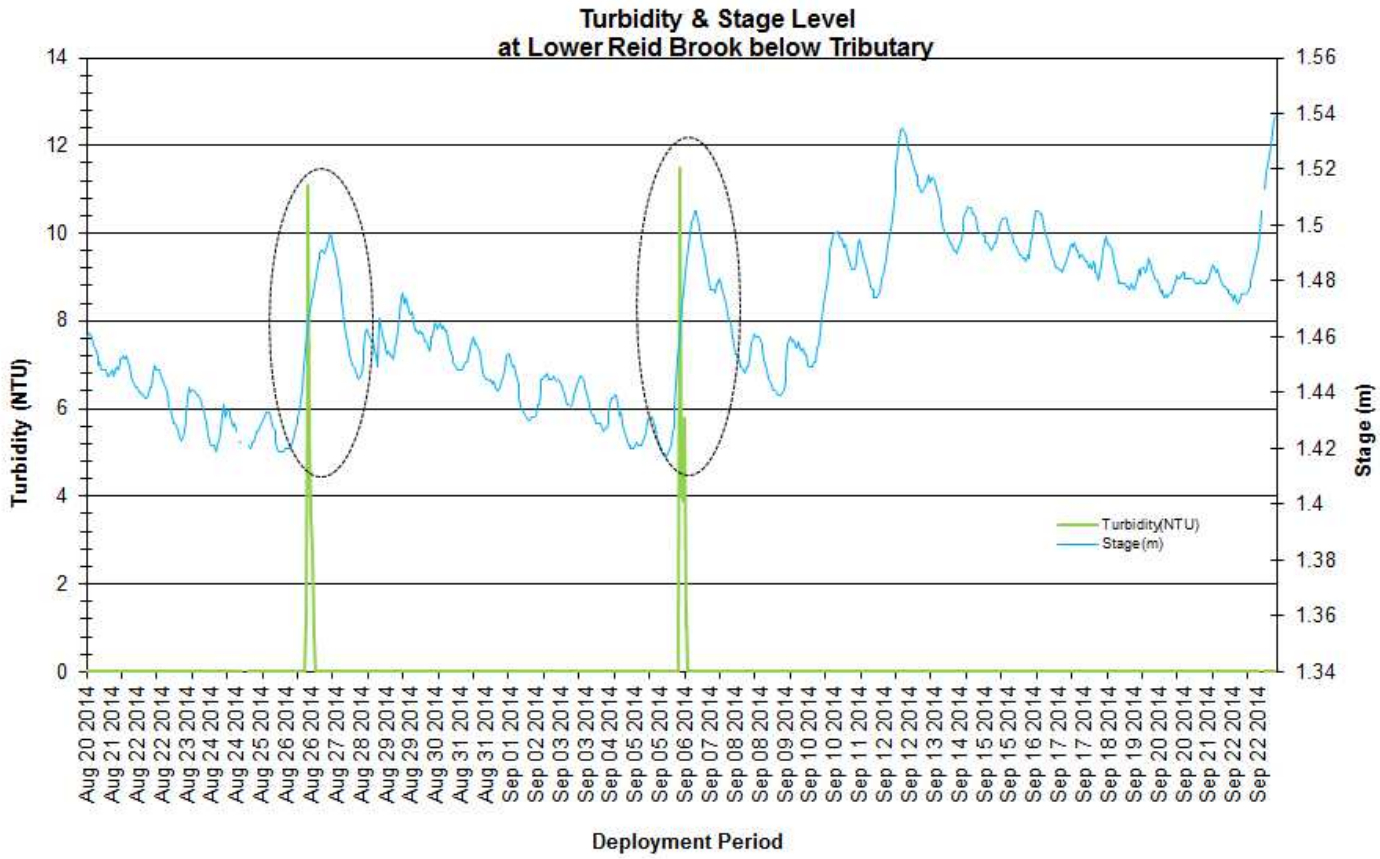

Figure 23: Turbidity and stage level at Lower Reid Brook below Tributary

Stage and Streamflow

Stage can be defined as the height or elevation of the stream's water surface above a reference elevation (sea level, gage level)**.** Stage is important to display as it provides an estimation of water level at the station and can explain some of the events that are occurring with other parameters (i.e. Specific Conductivity, DO, turbidity).

Streamflow can be defined as the volume of water in a river at a specific location and time. It is measured in cubic meters per second. The streamflow values ranged from 1.30 m^3/s to 3.10 m^3/s. The larger peaks in streamflow correspond with substantial rainfall events as highlighted by the black circles on Figure 24. There is no large movement in stage levels at this site.

During the deployment period, the stage values ranged from 1.42m to 1.54m. Precipitation data was obtained from the Environment Canada weather station at Nain. Precipitation ranges for the deployment period were a minimum of 0.0 mm and a maximum of 33.7 mm on September 22nd.

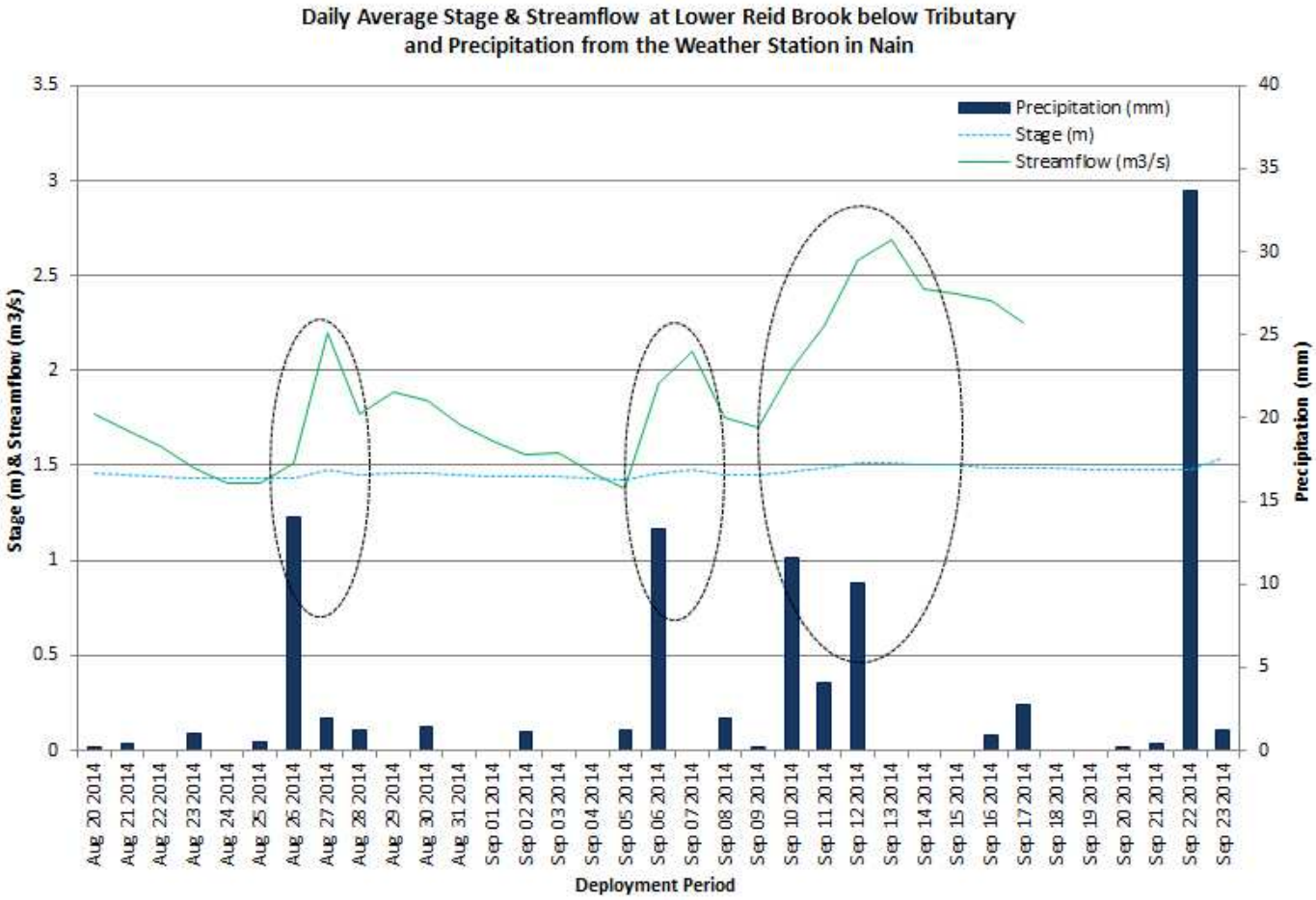

Figure 24: Daily precipitation and average daily stage and stream flow level at Lower Reid Brook below Tributary (Weather data recorded at Nain)

Conclusions

- The overall water temperatures across all stations were within a minimum of 2.53°C found at Camp Pond Brook below Camp Pond and a maximum of 22.82°C recorded again at Camp Pond Brook below Camp Pond. Overall the water temperature was decreasing across the network of stations. The stations on Camp Pond Brook, Tributary to Lower Reid Brook and Lower Reid Brook are more sensitive to changes in the ambient air temperatures. These three stations have the lowest minimum temperatures for this deployment period. Reid Brook at Outlet of Reid Pond is a large body of water and takes a longer time to adjust to the ambient air temperatures. Hence Reid Brook at Outlet of Reid Pond having the highest minimum water temperature during the deployment period at 7.20°C.
- The pH values for this deployment ranged between a minimum of 5.38 pH units at Reid Brook below Reid Pond and maximum of 8.96 pH units recorded again at Reid Brook below Reid Pond. Reid Pond below Reid Pond had some unusual pH data on August 25th and September 17th that cannot be linked to recorded precipitation events. The remaining stations pH graphs were similar with the larger decreases in pH occurring during precipitation events.
- The overall conductivity ranges within the four stations was a minimum of 12.0µS/cm at Reid Brook at Outlet of Reid Pond and a maximum value of 56.7µS/cm at Camp Pond Brook below Camp Pond. Conductivity values at Reid Brook at Outlet of Reid Pond has been the lowest all deployment season when compared to the other stations. Camp Pond Brook below Camp Pond maintains the highest median at 37.8µS/cm for August to September deployment period. This is to be expected with Camp Pond Brook being slightly closer to the mine site and the increased potential for roadway runoff and other influences. This is actually evident on August 26th, September 6th and September 10th – 12th, when all of the other stations indicate a lowering in conductivity from rainfall, Camp Pond Brook data actually increases.
- Dissolved oxygen levels for the deployment period ranged between a minimum of 8.08mg/l at Camp Pond Brook below Camp Pond and a maximum of 12.86mg/l found at Tributary to Lower Reid Brook. Dissolved oxygen content was increasing slightly at all stations. As the seasonal change from summer to fall starts there is a decrease in air temperatures and in turn water temperatures. Dissolved oxygen levels increase in cooler temperatures.
- Turbidity levels for the four real-time stations ranged within a minimum of 0.0NTU from all stations and a maximum of 40.2NTU at Tributary to Lower Reid Brook. Camp Pond brook below Camp Pond has the second highest maximum reading of 31.5NTU. The high turbidity readings for both stations occurred on the same day and it can be linked to the high precipitation event on September 22nd of 33.7mm. Rainfall events will cause disturbances to the water column and affect the turbidity values in the brooks for a short time frame.

APPENDIX I

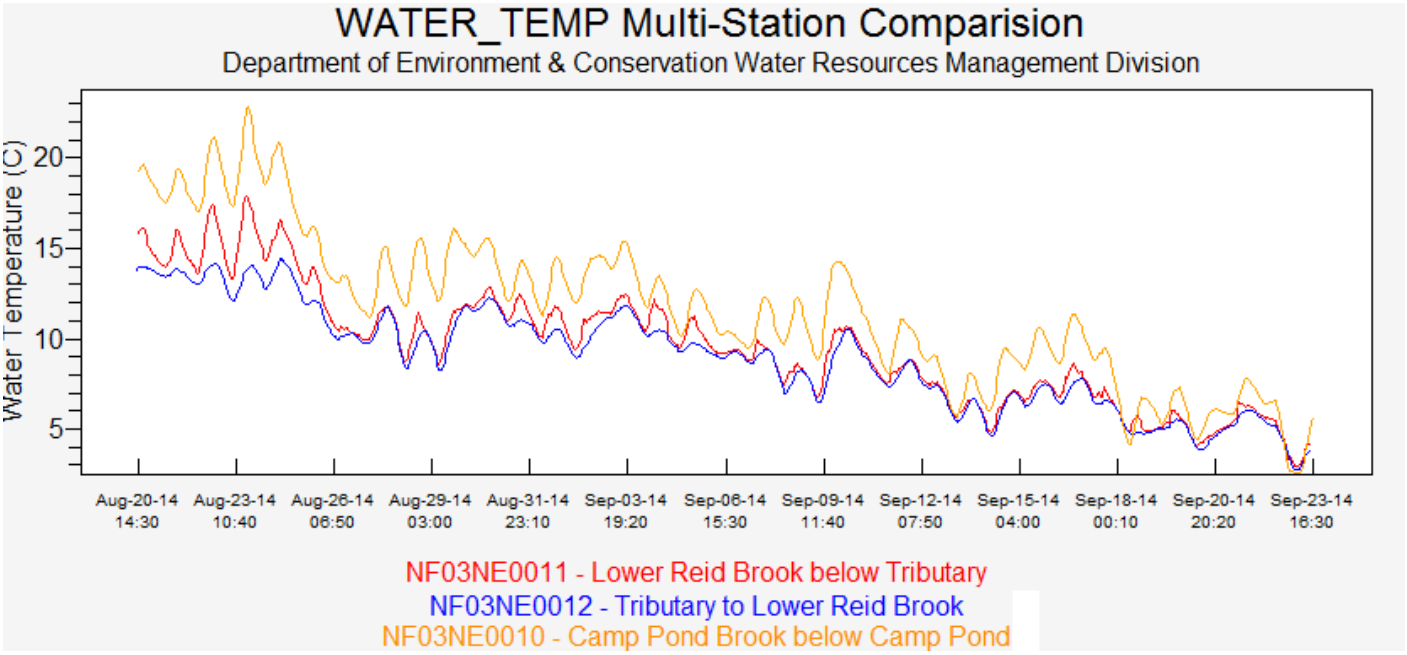

Figure A1: Comparison of Water Temperature at the Real-Time Stations in Voisey's Bay (due to transmission issues Reid Brook is not graphed alongside the other stations)

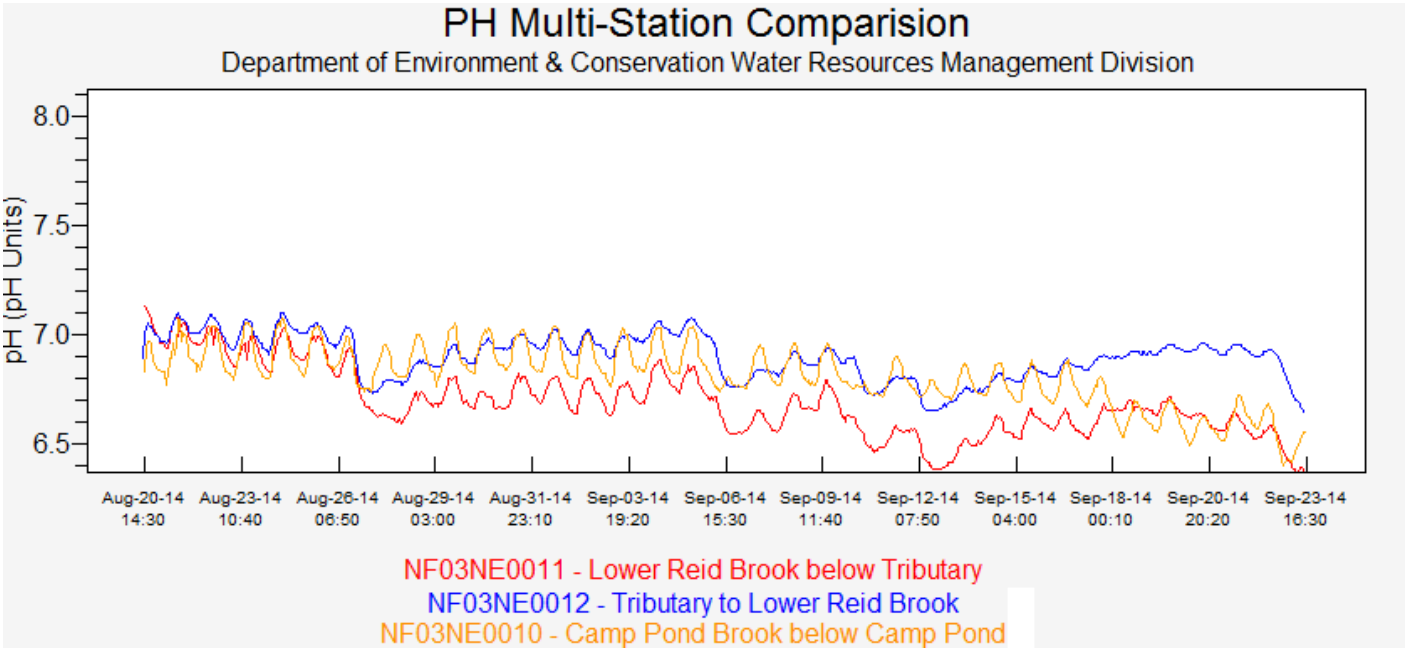

Figure A2: Comparison of pH at the Real-Time Stations in Voisey's Bay (due to transmission issues Reid Brook is not graphed alongside the other stations)

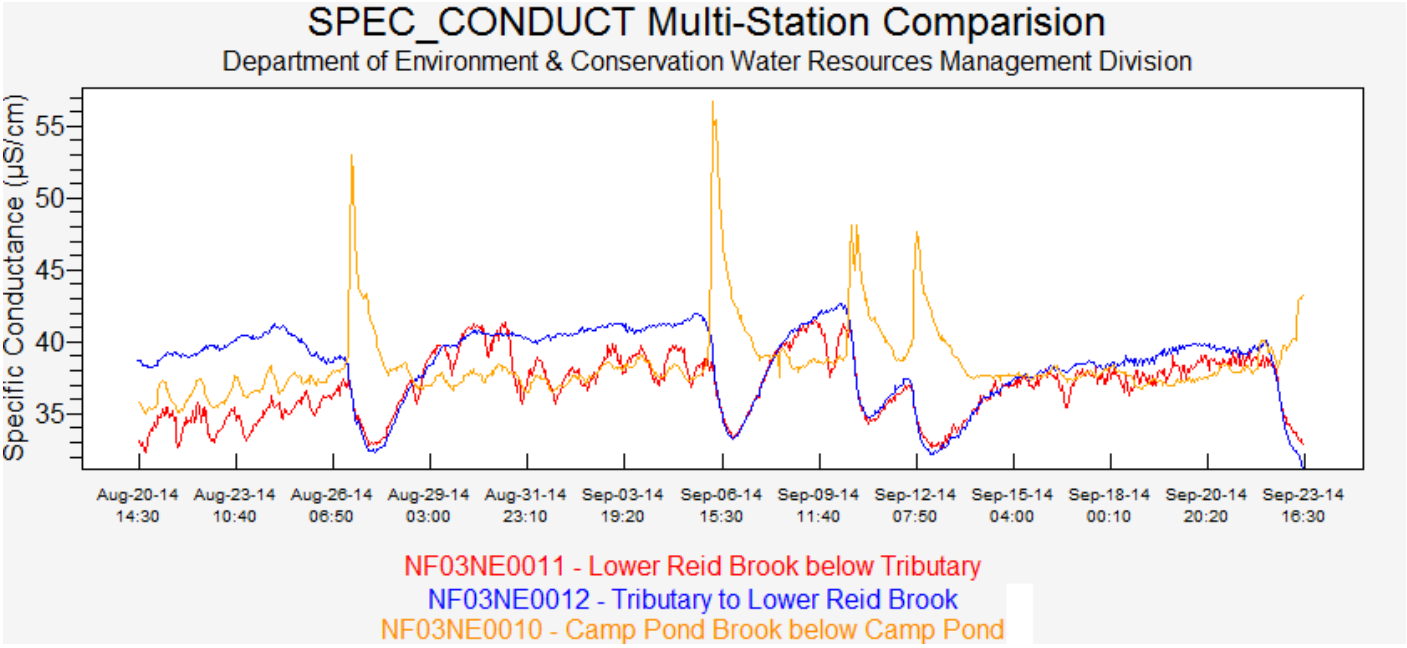

Figure A3: Comparison of Conductivity at the Real-Time Stations in Voisey's Bay (due to transmission issues Reid Brook is not graphed alongside the other stations)

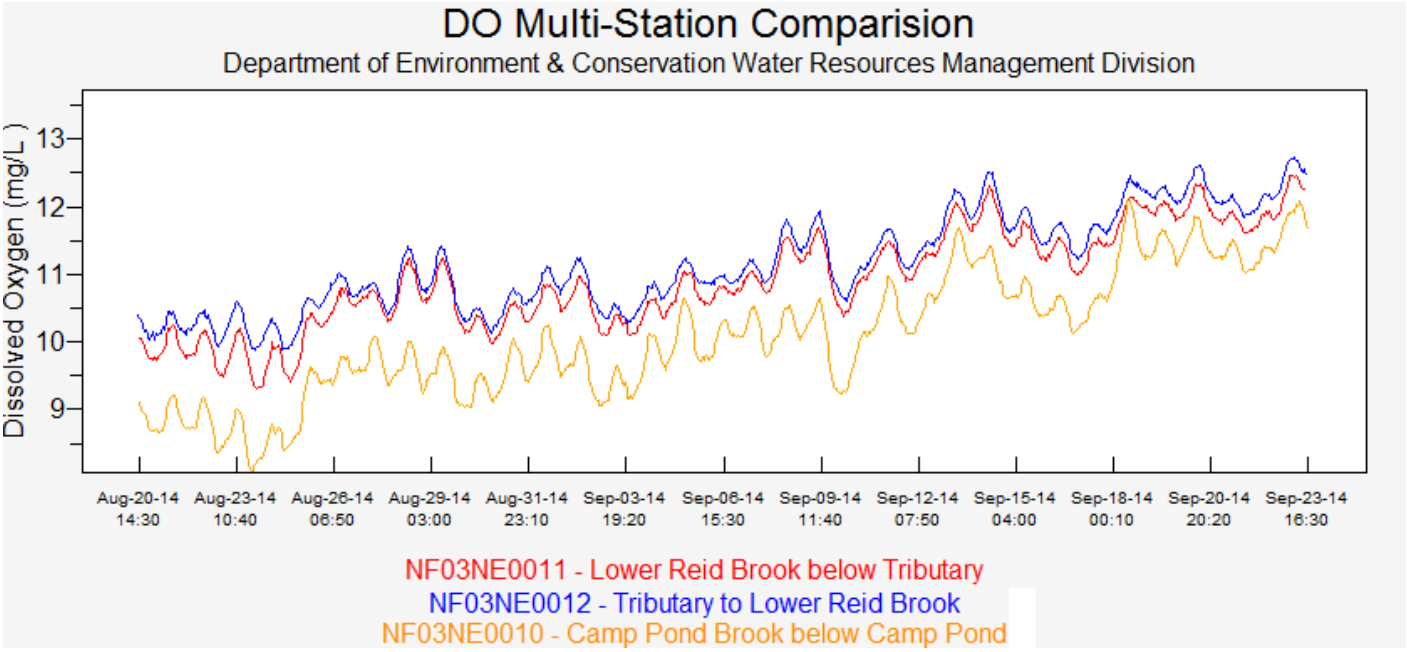

Figure A4: Comparison of Dissolved Oxygen (mg/L) at the Real-Time Stations in Voisey's Bay (due to transmission issues Reid Brook is not graphed alongside the other stations)

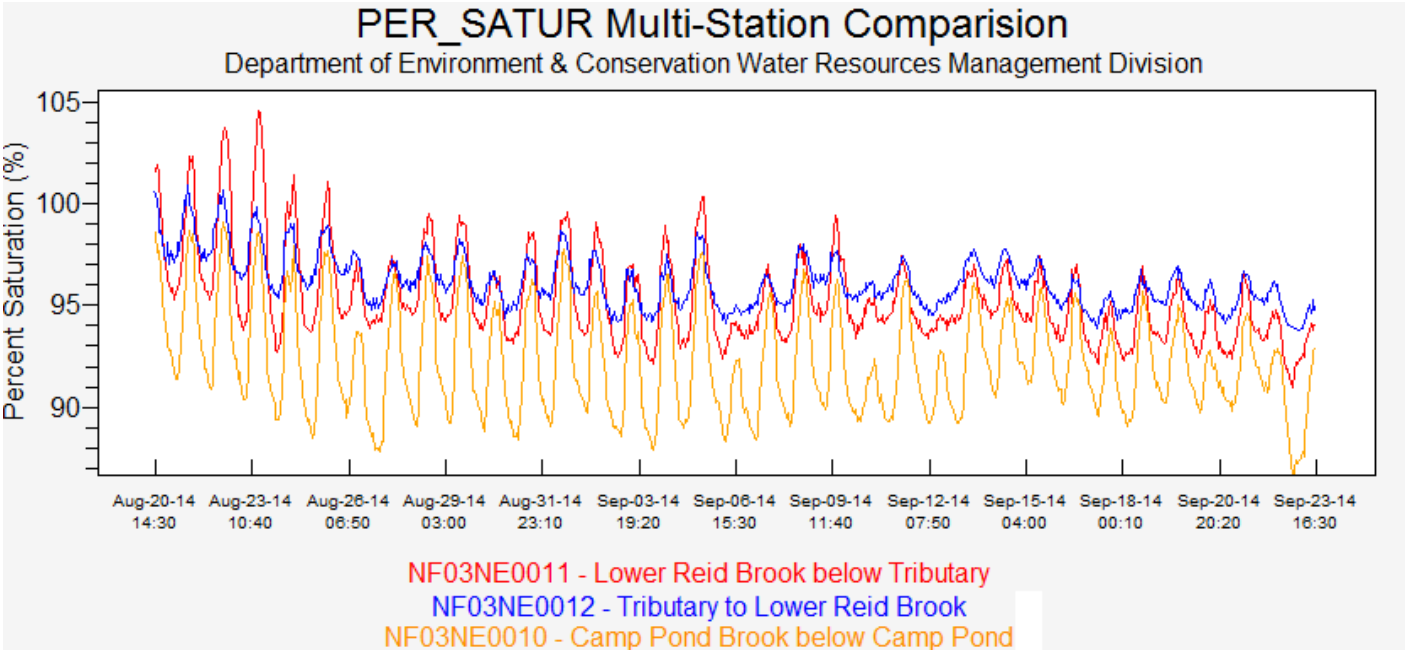

Figure A5: Comparison of Dissolved Oxygen (%Sat) at the Real-Time Stations in Voisey's Bay (due to transmission issues Reid Brook is not graphed alongside the other stations)

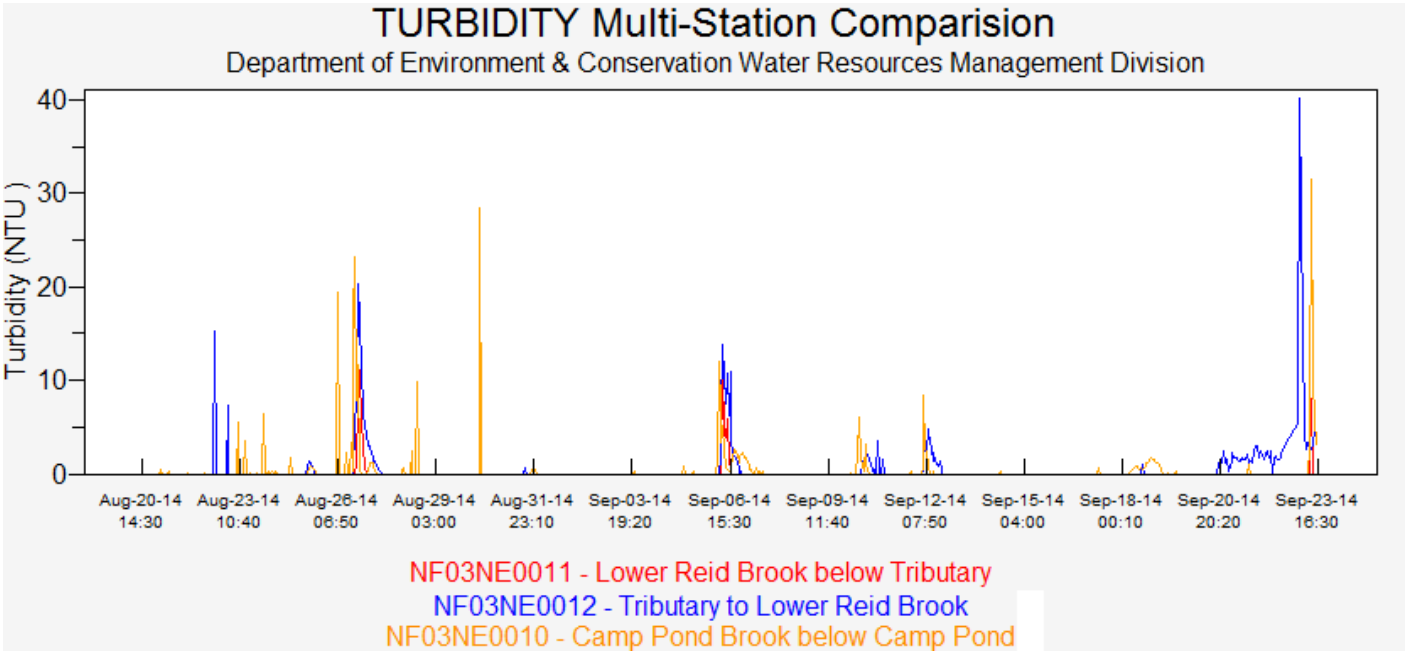

Figure A6: Comparison of Turbidity at the Real-Time Stations in Voisey's Bay (due to transmission issues Reid Brook is not graphed alongside the other stations)

APPENDIX II

REPORT OF ANALYSIS

Lab Report Number: **1417915**

Cient:	Department of Environment	**COC Number:**	2821
Attention:	Ms. Melissa McComiskey	**Date Reported:**	2014-09-02
Client Project:	St.Johns	**Date Submitted:**	2014-08-23
Purchase Order:	214004545	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date
1128171	WS-S-0000 Reid Brook at Outlet of Reid Pond	2014-6408-00-SI-SP	2014-08-20

Sample comment:

Report comment:

ANALYTE	UNIT	MRL	RESULT
Alkalinity as CaCO3	mg/L	5	<5
Bromide	mg/L	0.25	<0.25
Chloride	mg/L	1	1
Colour	TCU	2	6
Conductivity	uS/cm	5	14
Dissolved Organic Carbon	mg/L	0.5	2.3
Fluoride	mg/L	0.10	<0.10
Hardness as CaCO3	mg/L	1	2
N-NH3 (Ammonia)	mg/L	0.02	0.06
N-NO2 (Nitrite)	mg/L	0.10	<0.10
N-NO3 (Nitrate)	mg/L	0.10	<0.10
pH		1.00	6.69
Sulphate	mg/L	1	1
Total Dissolved Solids (COND - CALC)	mg/L	1	9
Total Kjeldahl Nitrogen	mg/L	0.10	<0.10
Total Organic Carbon	mg/L	0.5	2.9
Total Phosphorus	mg/L	0.01	<0.01
Turbidity	NTU	0.1	0.5
Aluminum	mg/L	0.01	0.06
Antimony	mg/L	0.0005	<0.0005
Arsenic	mg/L	0.001	<0.001
Barium	mg/L	0.01	<0.01
Boron	mg/L	0.01	<0.01
Calcium	mg/L	1	1
Cadmium	mg/L	0.0001	<0.0001
Chromium	mg/L	0.001	<0.001

Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

APPROVAL:

Lorna Wilson
Laboratory Supervisor, Inorganics

REPORT OF ANALYSIS

Lab Report Number: **1417915**

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Attention:	Ms. Melissa McComiskey	**Date Reported:**	2014-09-02
Client Project:	St.Johns	**Date Submitted:**	2014-08-23
Purchase Order:	214004545	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1128171	WS-S-0000	2014-6408-00-SI-SP	2014-08-20	Copper	mg/L	0.001	<0.001
	Reid Brook at Outlet of Reid Pond			Iron	mg/L	0.03	0.03
				Lead	mg/L	0.001	<0.001
Sample comment:				Magnesium	mg/L	1	<1
				Manganese	mg/L	0.01	<0.01
				Mercury	mg/L	0.0001	<0.0001
Report comment:				Nickel	mg/L	0.005	<0.005
				Potassium	mg/L	1	<1
				Selenium	mg/L	0.001	<0.001
				Sodium	mg/L	2	<2
				Strontium	mg/L	0.001	0.006
				Uranium	mg/L	0.001	<0.001
				Zinc	mg/L	0.01	<0.01
				Total Suspended Solids	mg/L	2	<2

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Methods references and/or additional QA/QC information available on request.

APPROVAL:

Lorna Wilson
Laboratory Supervisor, Inorganics

REPORT OF ANALYSIS

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Attention:	Ms. Melissa McComiskey	**Date Reported:**	2014-09-02
Client Project:	St.Johns	**Date Submitted:**	2014-08-23
Purchase Order:	214004545	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date
1128172	WS-S-0000 Camp Pond Brook below Camp Pond	2014-6409-00-SI-SP	2014-08-20

Sample comment:

Report comment:

ANALYTE	UNIT	MRL	RESULT
Alkalinity as CaCO3	mg/L	5	8
Bromide	mg/L	0.25	<0.25
Chloride	mg/L	1	2
Colour	TCU	2	24
Conductivity	uS/cm	5	37
Dissolved Organic Carbon	mg/L	0.5	4.1
Fluoride	mg/L	0.10	<0.10
Hardness as CaCO3	mg/L	1	7
N-NH3 (Ammonia)	mg/L	0.02	0.11
N-NO2 (Nitrite)	mg/L	0.10	<0.10
N-NO3 (Nitrate)	mg/L	0.10	<0.10
pH		1.00	7.18
Sulphate	mg/L	1	4
Total Dissolved Solids (COND - CALC)	mg/L	1	24
Total Kjeldahl Nitrogen	mg/L	0.10	0.24
Total Organic Carbon	mg/L	0.5	4.2
Total Phosphorus	mg/L	0.01	<0.01
Turbidity	NTU	0.1	0.9
Aluminum	mg/L	0.01	0.10
Antimony	mg/L	0.0005	<0.0005
Arsenic	mg/L	0.001	<0.001
Barium	mg/L	0.01	<0.01
Boron	mg/L	0.01	<0.01
Calcium	mg/L	1	3
Cadmium	mg/L	0.0001	<0.0001
Chromium	mg/L	0.001	<0.001

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Methods references and/or additional QA/QC information available on request.

APPROVAL:

Lorna Wilson
Laboratory Supervisor, Inorganics

REPORT OF ANALYSIS

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Client Project:	St.Johns	**Date Submitted:**	2014-08-23
Purchase Order:	214004545	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1128172	WS-S-0000	2014-6409-00-SI-SP	2014-08-20	Copper	mg/L	0.001	0.003
	Camp Pond Brook below Camp Pond			Iron	mg/L	0.03	0.25
				Lead	mg/L	0.001	<0.001
Sample comment:				Magnesium	mg/L	1	<1
				Manganese	mg/L	0.01	0.01
				Mercury	mg/L	0.0001	<0.0001
Report comment:				Nickel	mg/L	0.005	0.020
				Potassium	mg/L	1	<1
				Selenium	mg/L	0.001	<0.001
				Sodium	mg/L	2	<2
				Strontium	mg/L	0.001	0.020
				Uranium	mg/L	0.001	<0.001
				Zinc	mg/L	0.01	<0.01
				Total Suspended Solids	mg/L	2	<2

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Methods references and/or additional QA/QC information available on request.

APPROVAL:

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REPORT OF ANALYSIS

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Attention:	Ms. Melissa McComiskey	**Date Reported:**	2014-09-02
Client Project:	St.Johns	**Date Submitted:**	2014-08-23
Purchase Order:	214004545	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date
1128173	WS-S-0000 Tributary to Reid Brook	2014-6411-00-SI-SP	2014-08-20

Sample comment:

Report comment:

ANALYTE	UNIT	MRL	RESULT
Alkalinity as CaCO3	mg/L	5	10
Bromide	mg/L	0.25	<0.25
Chloride	mg/L	1	3
Colour	TCU	2	28
Conductivity	uS/cm	5	40
Dissolved Organic Carbon	mg/L	0.5	4.2
Fluoride	mg/L	0.10	0.14
Hardness as CaCO3	mg/L	1	14
N-NH3 (Ammonia)	mg/L	0.02	0.17
N-NO2 (Nitrite)	mg/L	0.10	<0.10
N-NO3 (Nitrate)	mg/L	0.10	<0.10
pH		1.00	7.22
Sulphate	mg/L	1	3
Total Dissolved Solids (COND - CALC)	mg/L	1	26
Total Kjeldahl Nitrogen	mg/L	0.10	0.26
Total Organic Carbon	mg/L	0.5	4.4
Total Phosphorus	mg/L	0.01	<0.01
Turbidity	NTU	0.1	1.3
Aluminum	mg/L	0.01	0.10
Antimony	mg/L	0.0005	<0.0005
Arsenic	mg/L	0.001	<0.001
Barium	mg/L	0.01	<0.01
Boron	mg/L	0.01	<0.01
Calcium	mg/L	1	4
Cadmium	mg/L	0.0001	<0.0001
Chromium	mg/L	0.001	<0.001

Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

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Client Project:	St.Johns	**Date Submitted:**	2014-08-23
Purchase Order:	214004545	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1128173	WS-S-0000	2014-6411-00-SI-SP	2014-08-20	Copper	mg/L	0.001	<0.001
	Tributary to Reid Brook			Iron	mg/L	0.03	0.55
				Lead	mg/L	0.001	<0.001
Sample comment:				Magnesium	mg/L	1	1
				Manganese	mg/L	0.01	0.01
				Mercury	mg/L	0.0001	<0.0001
Report comment:				Nickel	mg/L	0.005	0.006
				Potassium	mg/L	1	<1
				Selenium	mg/L	0.001	<0.001
				Sodium	mg/L	2	2
				Strontium	mg/L	0.001	0.024
				Uranium	mg/L	0.001	<0.001
				Zinc	mg/L	0.01	<0.01
				Total Suspended Solids	mg/L	2	<2

Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

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Client Project:	St.Johns	**Date Submitted:**	2014-08-23
Purchase Order:	214004545	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date
1128174	WS-S-0000 Lower Reid Brook Below Tributary	2014-6410-00-SI-SP	2014-08-20

Sample comment:

Report comment:

ANALYTE	UNIT	MRL	RESULT
Alkalinity as CaCO3	mg/L	5	10
Bromide	mg/L	0.25	<0.25
Chloride	mg/L	1	2
Colour	TCU	2	21
Conductivity	uS/cm	5	37
Dissolved Organic Carbon	mg/L	0.5	3.2
Fluoride	mg/L	0.10	0.13
Hardness as CaCO3	mg/L	1	7
N-NH3 (Ammonia)	mg/L	0.02	0.20
N-NO2 (Nitrite)	mg/L	0.10	<0.10
N-NO3 (Nitrate)	mg/L	0.10	<0.10
pH		1.00	7.29
Sulphate	mg/L	1	2
Total Dissolved Solids (COND - CALC)	mg/L	1	24
Total Kjeldahl Nitrogen	mg/L	0.10	0.34
Total Organic Carbon	mg/L	0.5	3.3
Total Phosphorus	mg/L	0.01	<0.01
Turbidity	NTU	0.1	1.2
Aluminum	mg/L	0.01	0.07
Antimony	mg/L	0.0005	<0.0005
Arsenic	mg/L	0.001	<0.001
Barium	mg/L	0.01	<0.01
Boron	mg/L	0.01	<0.01
Calcium	mg/L	1	3
Cadmium	mg/L	0.0001	<0.0001
Chromium	mg/L	0.001	<0.001

Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

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Attention:	Ms. Melissa McComiskey	**Date Reported:**	2014-09-02
Client Project:	St.Johns	**Date Submitted:**	2014-08-23
Purchase Order:	214004545	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1128174	WS-S-0000	2014-6410-00-SI-SP	2014-08-20	Copper	mg/L	0.001	<0.001
	Lower Reid Brook Below Tributary			Iron	mg/L	0.03	0.34
				Lead	mg/L	0.001	<0.001
Sample comment:				Magnesium	mg/L	1	<1
				Manganese	mg/L	0.01	<0.01
				Mercury	mg/L	0.0001	<0.0001
Report comment:				Nickel	mg/L	0.005	<0.005
				Potassium	mg/L	1	<1
				Selenium	mg/L	0.001	<0.001
				Sodium	mg/L	2	2
				Strontium	mg/L	0.001	0.019
				Uranium	mg/L	0.001	<0.001
				Zinc	mg/L	0.01	<0.01
				Total Suspended Solids	mg/L	2	<2

Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

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REPORT OF ANALYSIS

Lab Report Number: **1417915**

Cient:	Department of Environment	**COC Number:**	2821
Attention:	Ms. Melissa McComiskey	**Date Reported:**	2014-09-02
Client Project:	St.Johns	**Date Submitted:**	2014-08-23
Purchase Order:	214004545	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date
1128175	WS-S-0000 Outer Cove Bk below Airport	2014-1881-00-SI-SP	2014-08-22

Sample comment:

Report comment:

ANALYTE	UNIT	MRL	RESULT
Alkalinity as CaCO3	mg/L	5	9
Bromide	mg/L	0.25	<0.25
Chloride	mg/L	1	87
Colour	TCU	2	24
Conductivity	uS/cm	5	378
Dissolved Organic Carbon	mg/L	0.5	4.2
Fluoride	mg/L	0.10	<0.10
Hardness as CaCO3	mg/L	1	42
N-NH3 (Ammonia)	mg/L	0.02	0.97
N-NO2 (Nitrite)	mg/L	0.10	<0.10
N-NO3 (Nitrate)	mg/L	0.10	4.71
pH		1.00	6.90
Sulphate	mg/L	1	10
Total Dissolved Solids (COND - CALC)	mg/L	1	246
Total Kjeldahl Nitrogen	mg/L	0.10	1.37
Total Organic Carbon	mg/L	0.5	5.1
Total Phosphorus	mg/L	0.01	<0.01
Turbidity	NTU	0.1	2.8
Aluminum	mg/L	0.01	0.58
Antimony	mg/L	0.0005	<0.0005
Arsenic	mg/L	0.001	<0.001
Barium	mg/L	0.01	0.03
Boron	mg/L	0.01	0.01
Calcium	mg/L	1	12
Cadmium	mg/L	0.0001	<0.0001
Chromium	mg/L	0.001	<0.001

Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

APPROVAL:

Lorna Wilson
Laboratory Supervisor, Inorganics

REPORT OF ANALYSIS

Lab Report Number: **1417915**

Cient:	Department of Environment	**COC Number:**	2821
Attention:	Ms. Melissa McComiskey	**Date Reported:**	2014-09-02
Client Project:	St.Johns	**Date Submitted:**	2014-08-23
Purchase Order:	214004545	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1128175	WS-S-0000	2014-1881-00-SI-SP	2014-08-22	Copper	mg/L	0.001	0.003
	Outer Cove Bk below Airport			Iron	mg/L	0.03	0.44
				Lead	mg/L	0.001	<0.001
Sample comment:				Magnesium	mg/L	1	3
				Manganese	mg/L	0.01	1.00
				Mercury	mg/L	0.0001	<0.0001
Report comment:				Nickel	mg/L	0.005	<0.005
				Potassium	mg/L	1	2
				Selenium	mg/L	0.001	<0.001
				Sodium	mg/L	2	59
				Strontium	mg/L	0.001	0.043
				Uranium	mg/L	0.001	<0.001
				Zinc	mg/L	0.01	0.02
				Total Suspended Solids	mg/L	2	<2

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APPROVAL:

Lorna Wilson
Laboratory Supervisor, Inorganics

REPORT OF ANALYSIS

Lab Report Number: **1417915**

Cient:	Department of Environment	**COC Number:**	2821
Attention:	Ms. Melissa McComiskey	**Date Reported:**	2014-09-02
Client Project:	St.Johns	**Date Submitted:**	2014-08-23
Purchase Order:	214004545	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date
1128176	WS-S-0000 Outer Cove Bk at Clovelly Golf Course	2014-1882-00-SI-SP	2014-08-22

Sample comment:

Report comment:

ANALYTE	UNIT	MRL	RESULT
Alkalinity as CaCO3	mg/L	5	7
Bromide	mg/L	0.25	<0.25
Chloride	mg/L	1	92
Colour	TCU	2	23
Conductivity	uS/cm	5	386
Dissolved Organic Carbon	mg/L	0.5	4.6
Fluoride	mg/L	0.10	<0.10
Hardness as CaCO3	mg/L	1	45
N-NH3 (Ammonia)	mg/L	0.02	0.28
N-NO2 (Nitrite)	mg/L	0.10	<0.10
N-NO3 (Nitrate)	mg/L	0.10	4.31
pH		1.00	6.82
Sulphate	mg/L	1	10
Total Dissolved Solids (COND - CALC)	mg/L	1	251
Total Kjeldahl Nitrogen	mg/L	0.10	0.65
Total Organic Carbon	mg/L	0.5	5.2
Total Phosphorus	mg/L	0.01	<0.01
Turbidity	NTU	0.1	2.4
Aluminum	mg/L	0.01	0.30
Antimony	mg/L	0.0005	<0.0005
Arsenic	mg/L	0.001	<0.001
Barium	mg/L	0.01	0.04
Boron	mg/L	0.01	<0.01
Calcium	mg/L	1	13
Cadmium	mg/L	0.0001	<0.0001
Chromium	mg/L	0.001	<0.001

Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

APPROVAL:

Lorna Wilson
Laboratory Supervisor, Inorganics

REPORT OF ANALYSIS

Lab Report Number: **1417915**

Cient:	Department of Environment	**COC Number:**	2821
Attention:	Ms. Melissa McComiskey	**Date Reported:**	2014-09-02
Client Project:	St.Johns	**Date Submitted:**	2014-08-23
Purchase Order:	214004545	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1128176	WS-S-0000	2014-1882-00-SI-SP	2014-08-22	Copper	mg/L	0.001	0.002
	Outer Cove Bk at Clovelly Golf Course			Iron	mg/L	0.03	0.30
				Lead	mg/L	0.001	<0.001
Sample comment:				Magnesium	mg/L	1	3
				Manganese	mg/L	0.01	0.64
				Mercury	mg/L	0.0001	<0.0001
Report comment:				Nickel	mg/L	0.005	<0.005
				Potassium	mg/L	1	1
				Selenium	mg/L	0.001	<0.001
				Sodium	mg/L	2	59
				Strontium	mg/L	0.001	0.049
				Uranium	mg/L	0.001	<0.001
				Zinc	mg/L	0.01	0.02
				Total Suspended Solids	mg/L	2	<2

Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

APPROVAL:

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