Real-Time Water Quality Deployment Report

Voisey's Bay Network

July 16, 2014 to August 20, 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 July 16, 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 36 days. Instruments were removed by Vale Environment staff on August 20, 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.

During the removal portion of the calibration and maintenance for Reid Brook at Outlet of Reid Pond, there was no QAQC readings taken therefore there is no ranking for comparisons of field and QAQC.

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)	July 16 2014	Deployment	Good	Excellent	Excellent	Excellent	Excellent
	Aug 20 2014	Removal	-	-	-	-	-
Camp Pond Brook (62885)	July 16, 2014	Deployment	Excellent	Excellent	Excellent	Excellent	Excellent
	Aug 20 2014	Removal	Excellent	Excellent	Excellent	Excellent	Excellent
Tributary to L. Reid B. (62886)	July 16 2014	Deployment	Fair	Excellent	Excellent	Good	Excellent
	Aug 20 2014	Removal	Excellent	Excellent	Excellent	Excellent	Excellent
Lower Reid Brook (62887)	July 16 2014	Deployment	Fair	Excellent	Excellent	Good	Excellent
	Aug 20 2014	Removal	Excellent	Excellent	Excellent	Excellent	Excellent

During deployment at Reid Brook at outlet to Reid Pond station, the field instrument ranked against the QAQC as 'Good' for temperature. The data ranked 'Excellent' for pH, specific conductivity, dissolved oxygen and turbidity readings. There was no QAQC comparison done at removal of the instruments for this deployment period. Therefore there is no ranking for removal.

At the station on Camp Pond Brook, all parameter data when compared to the QAQC instrument's data ranked as 'Excellent'. This was also the case during the field instruments removal after a month of deployment, the data recorded continued to rank 'Excellent' against that of the freshly calibrated QAQC instrument. This ranking allows for high confidence in the data for Camp Pond Brook Station.

At the station on the Tributary to Lower Reid Brook, temperature ranked as 'fair' while pH, specific conductivity and turbidity value comparisons ranking as 'excellent'. Dissolved oxygen data comparison ranked as 'good'. The comparison rankings of the data for water temperature and dissolved oxygen were likely a result of the instrument not being given enough time to acclimatize to the water temperature before the reading was recorded. The differences between the QA reading and the field reading were not great enough to cause concern that the instrument was not performing accurately. All the data ranked at removal was rated as "excellent'.

At the station on Lower Reid Brook, water temperature values ranked as 'Fair'. pH, specific conductivity, and turbidity values ranked as 'Excellent'. With Dissolved Oxygen values ranking as 'Good'. These readings are considered reasonable for initial deployment. Water temperature may have needed additional time stabilizing before a comparison reading was taken hence the ranking of 'Fair'. These parameters at removal all ranked as 'Excellent' when the data was compared to that of the QAQC instrument.

Data Interpretation

- The following graphs and discussion illustrate significant water quality-related events from July 16th to August 20th 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 did not have stage or flow data for this deployment period. There were technical issues with the Water Survey of Canada's water quantity instrument. Therefore there is no stage or flow data to compare the water quality parameters against. No other stations were affected.

Reid Brook at Outlet from Reid Pond

Water Temperature

During this deployment period water temperature ranged from a minimum of 7.77°C to a maximum of 19.25°C (Figure 1). Air temperature had a high of 20.9°C with a low of 6.3°C which was right at the beginning of deployment. Both sets of minimums and maximum temperatures occur at the same time frame.

The median water temperature is 13.58°C for the deployment period, considerably higher than last deployment. This trend is expected given the warming ambient air temperatures as the summer months approach (Figure 1).

There is one noticeable dip in water temperature on August 13th to 8.99 °C; this reading was taken at 12:30am, this dip in water temperature also corresponds with a slight dip in air temperature during the same time frame.

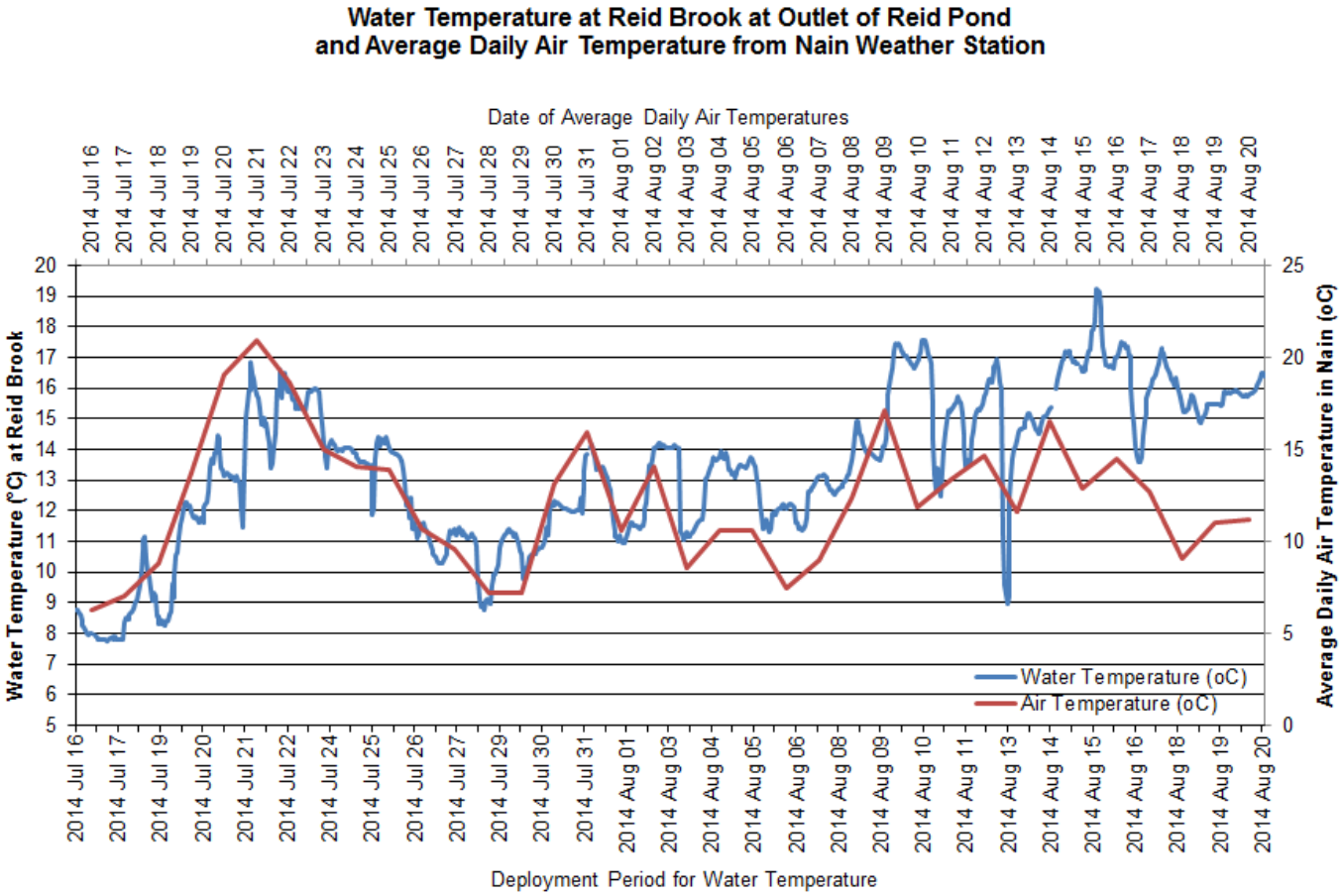

Figure 1: Water temperature at Reid Brook at Outlet of Reid Pond and Air Temperature from Nain Weather Station

pH Levels

During the deployment pH ranges were between a minimum of 6.74 and a maximum of 7.01 pH units (Figure 2).

At the beginning of deployment the pH sensor when compared to the QAQC instrument was ranked as 'Excellent', unfortunately the pH sensor failed on July 22, 2014 at 5:30pm. This was evident by the consistent logging of 14 which is the error reading for the pH sensor. Therefore the data was removed for the remainder of deployment.

The initial 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.

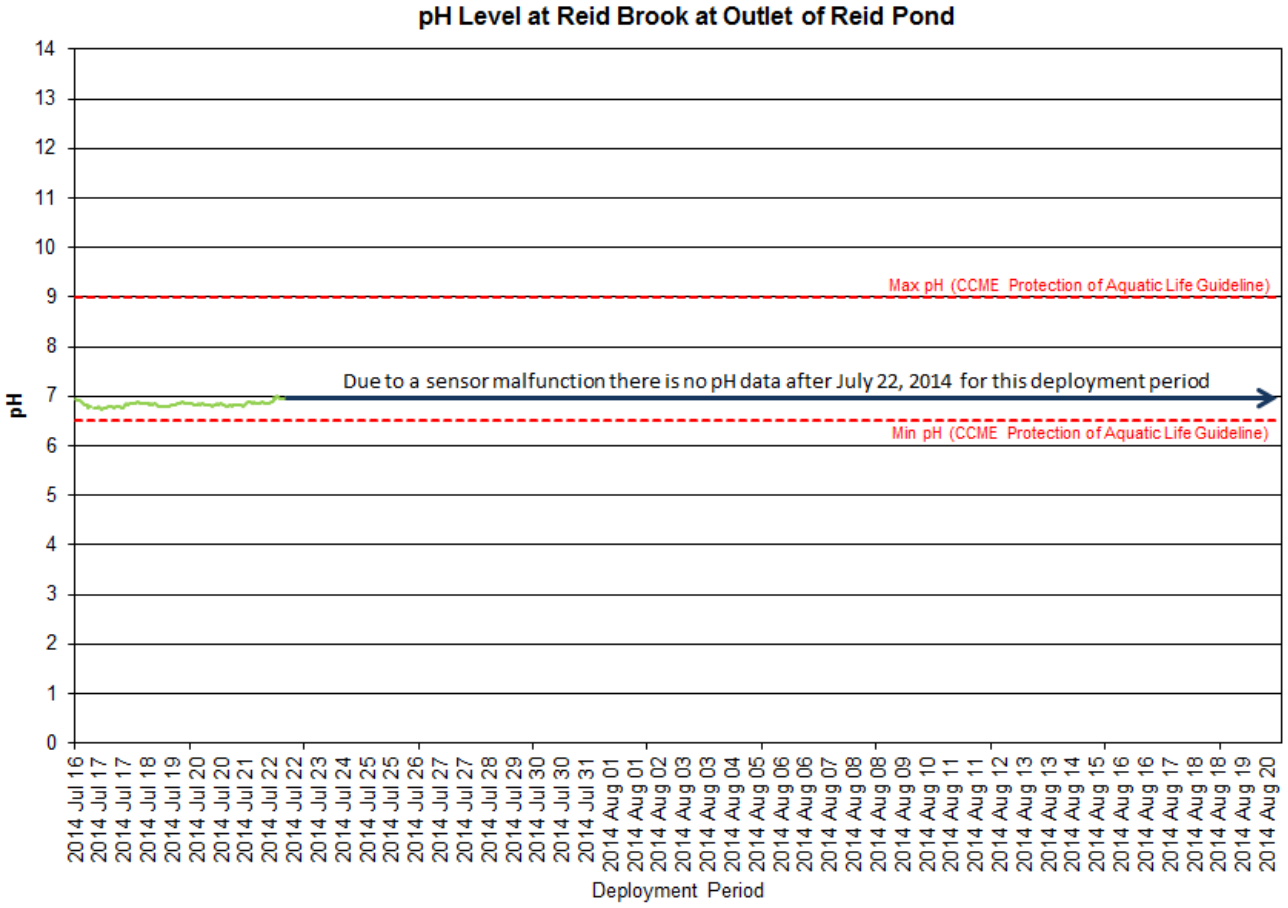

Figure 2: pH level at Reid Brook at Outlet of Reid Pond

Specific Conductivity

Specific conductivity values range from 10.6µS/cm to 11.6µS/cm during the deployment period, with a median of 11.0µS/cm (Figure 3). There is not much movement in the conductivity at this site besides a slight increase across the deployment period. This is noted by the trend line outlined on the graph.

Specific conductivity remains very 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.

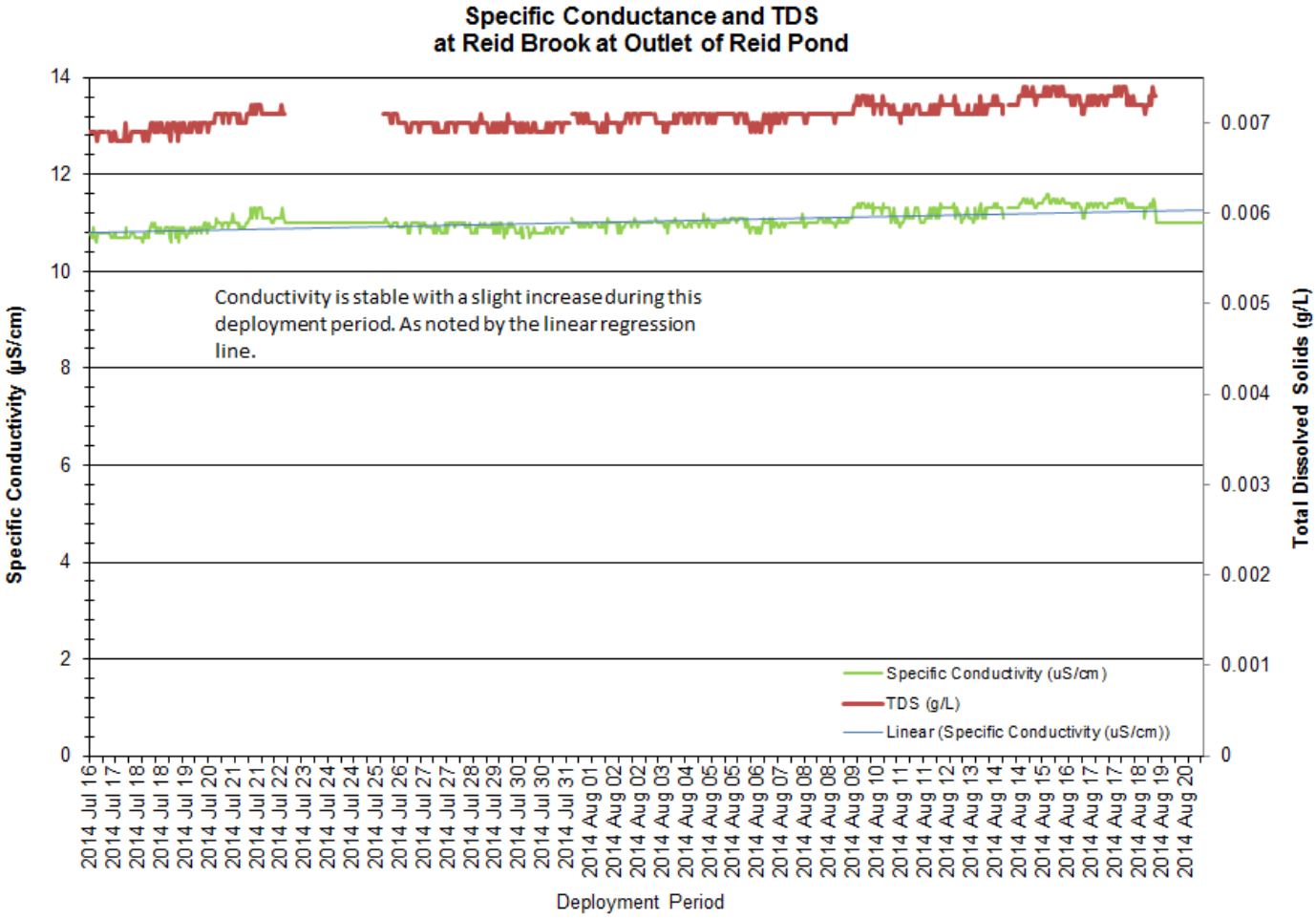

Figure 3: Specific conductivity at Reid Brook at Outlet of Reid Pond

Dissolved Oxygen

During this deployment period the dissolved oxygen content ranges between 9.93mg/l and 12.30mg/l. The saturation of dissolved oxygen ranges from 100.4% to 114.6% (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 increase the Dissolved Oxygen concentration decreases 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.

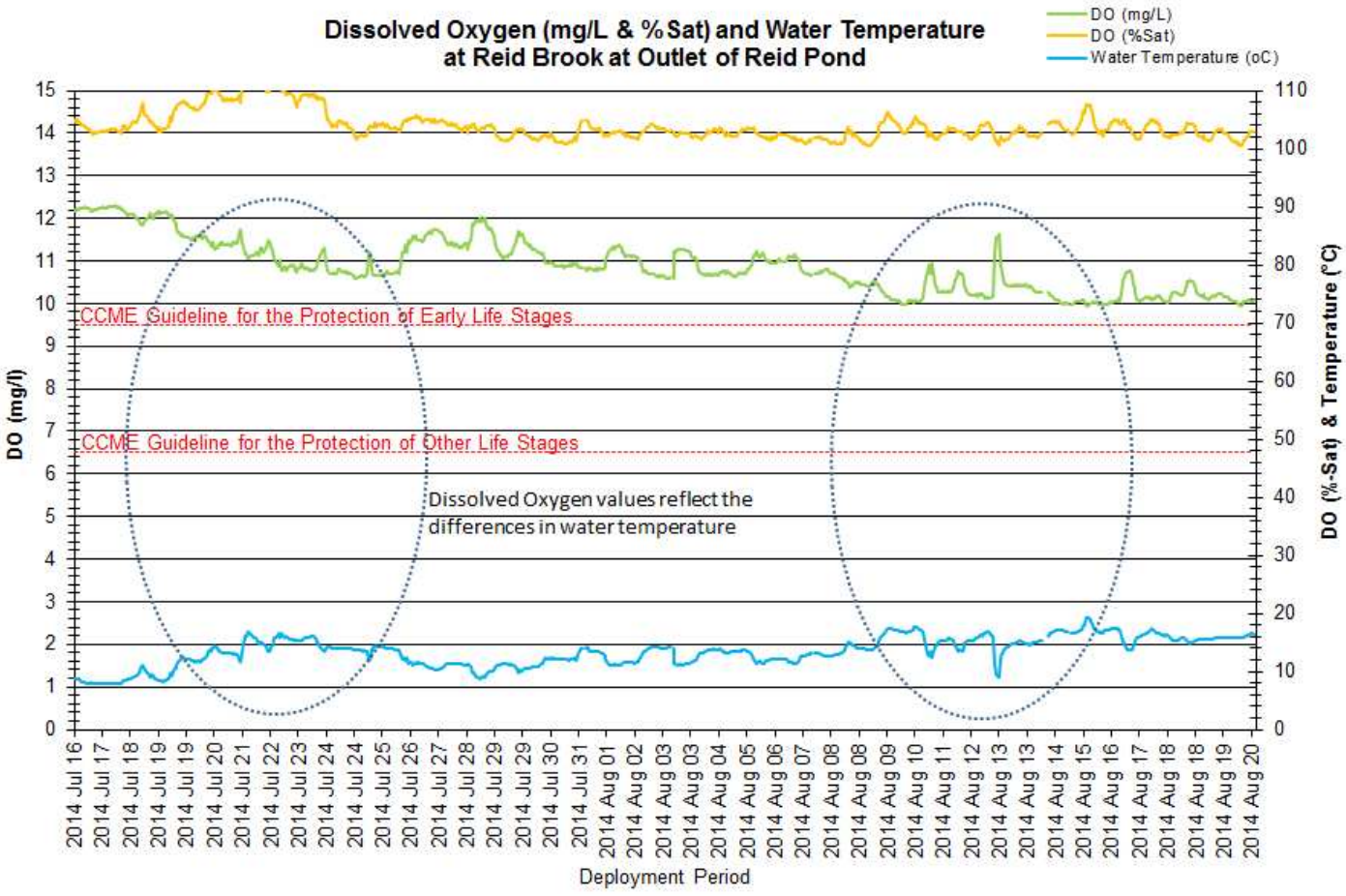

Figure 4: Dissolved Oxygen (mg/L & %sat) and Water Temperature at Reid Brook at Outlet of Reid Pond

Turbidity

Turbidity levels during this deployment period ranged between a minimum of 0.0 NTU to a maximum of 2.4 NTU.

The turbidity sensor on this instrument can record values between 0 NTU and 3000 NTU. However it should be noted that a turbidity reading of 3000 NTU is identified as an error reading and this data should not be included in any statistical analysis.

For the majority of the deployment period the turbidity levels at this station were relatively stable. The peaks that are evident on Figure 5 are actually very small events in turbidity. At its highest turbidity of 2.4 NTU the water in the pond would still look visually clear. This is not unusual for this station as the water flowing from the lake is typically very clean; clear and cold (Figure 5).

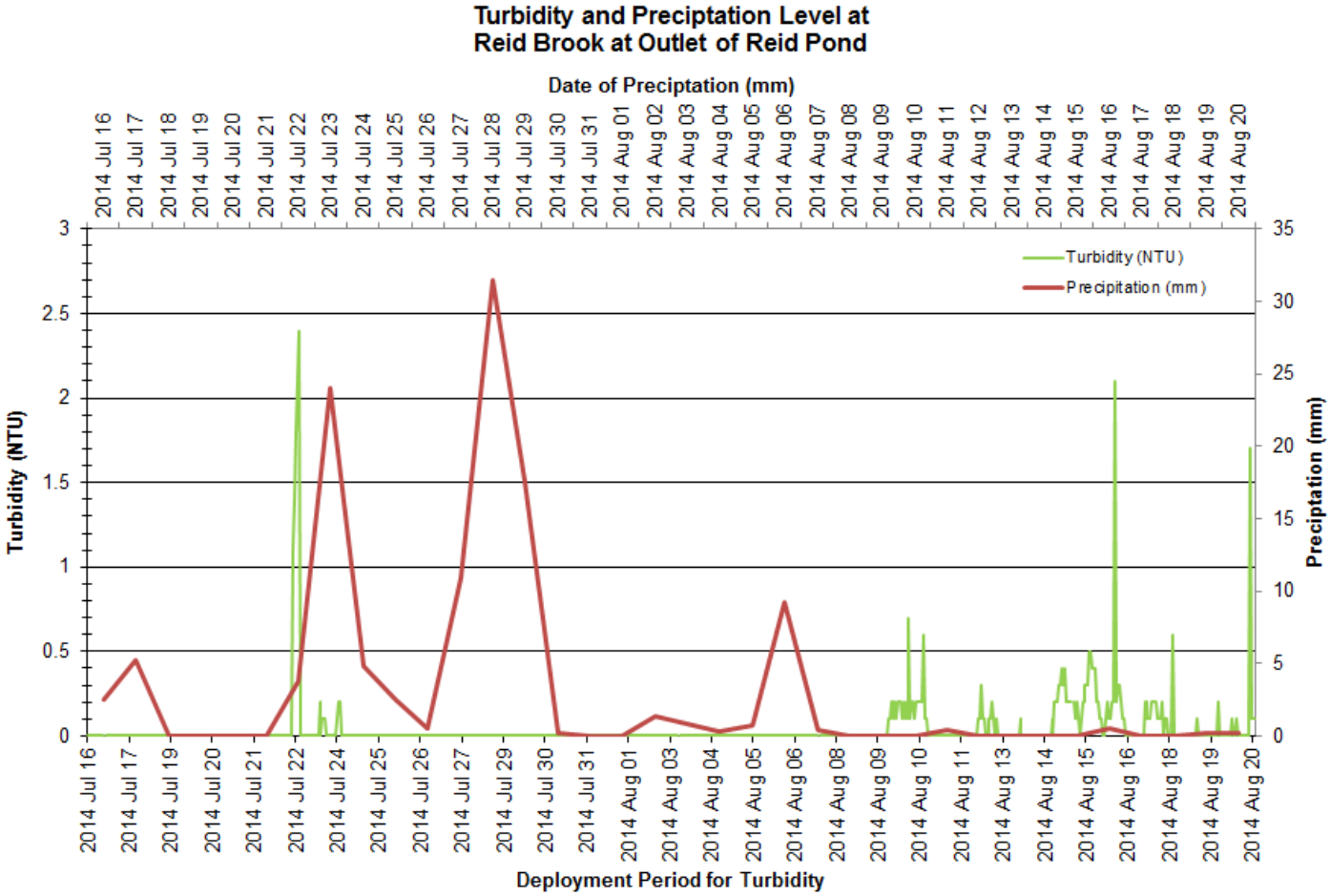

Figure 5: Turbidity and Precipitation at Reid Brook at Outlet of Reid Pond

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 20.9 °C with an average low of 6.3 °C at the beginning of the deployment period. Total precipitation had a minimum of 0 mm to a maximum of 31.5 mm on July 28th, 2014.

The data graphed just indicates some of the other weather factors that could be influencing the water quality parameters over the deployment period.

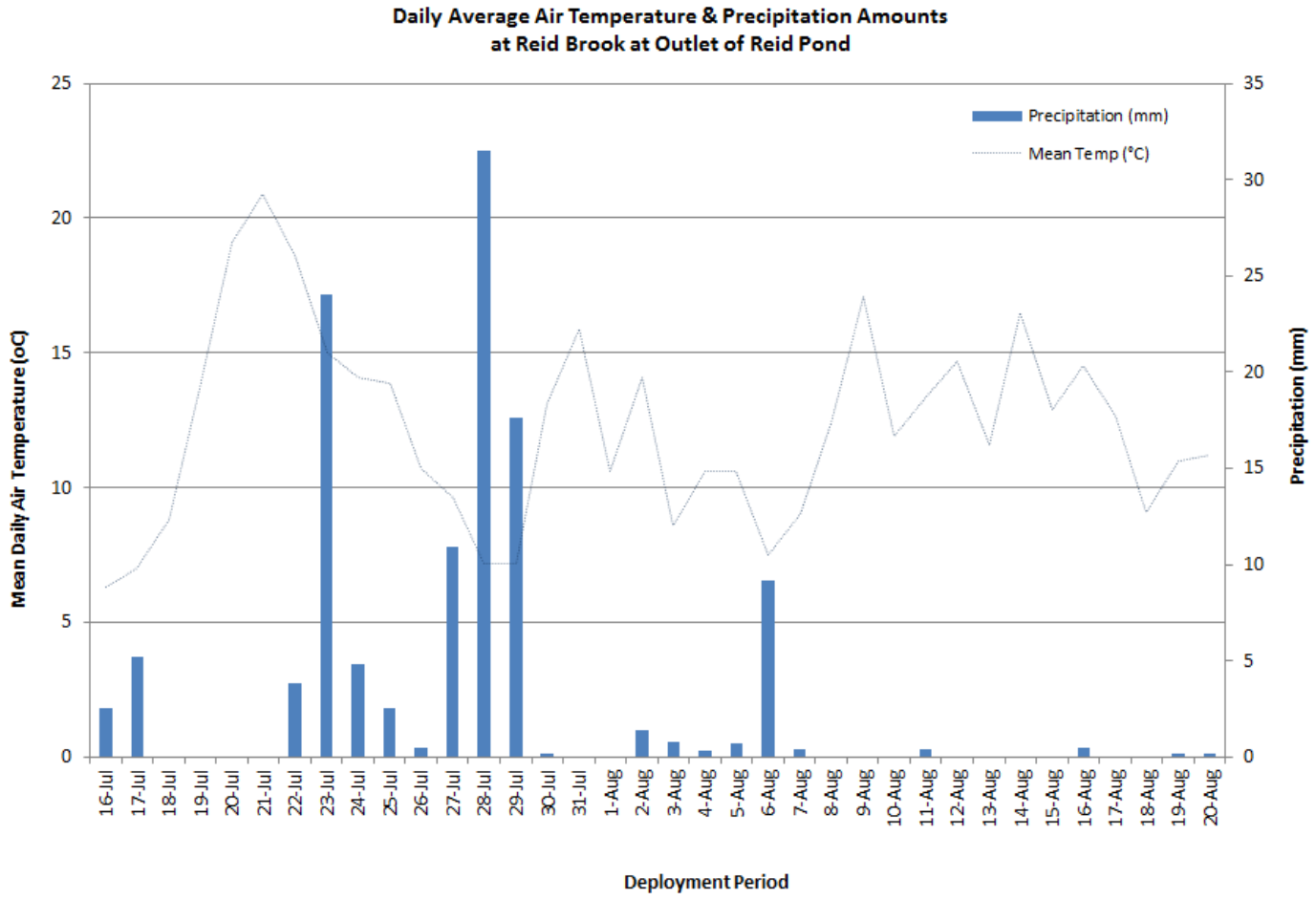

Figure 6: Daily precipitation in Nain and average daily stage & flow level at Reid Brook at Outlet of Reid Pond

Camp Pond Brook

Water Temperature

Water temperature ranges from 12.10°C to 22.90°C during the deployment period (Figure 7).

Water temperature is increasing during this deployment period. The trend is expected as the air temperatures increase with the onset of summer months. The median water temperature is 17.21°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 decreases toward the end of August the water temperatures peak to some of the higher temperatures for this deployment.

The trend line on Figure 7 displays the gradual water temperature increase as the surrounding air temperatures warm for the summer months. This station typically has the highest water temperatures and greatest fluctuations when compared to the other stations in the network.

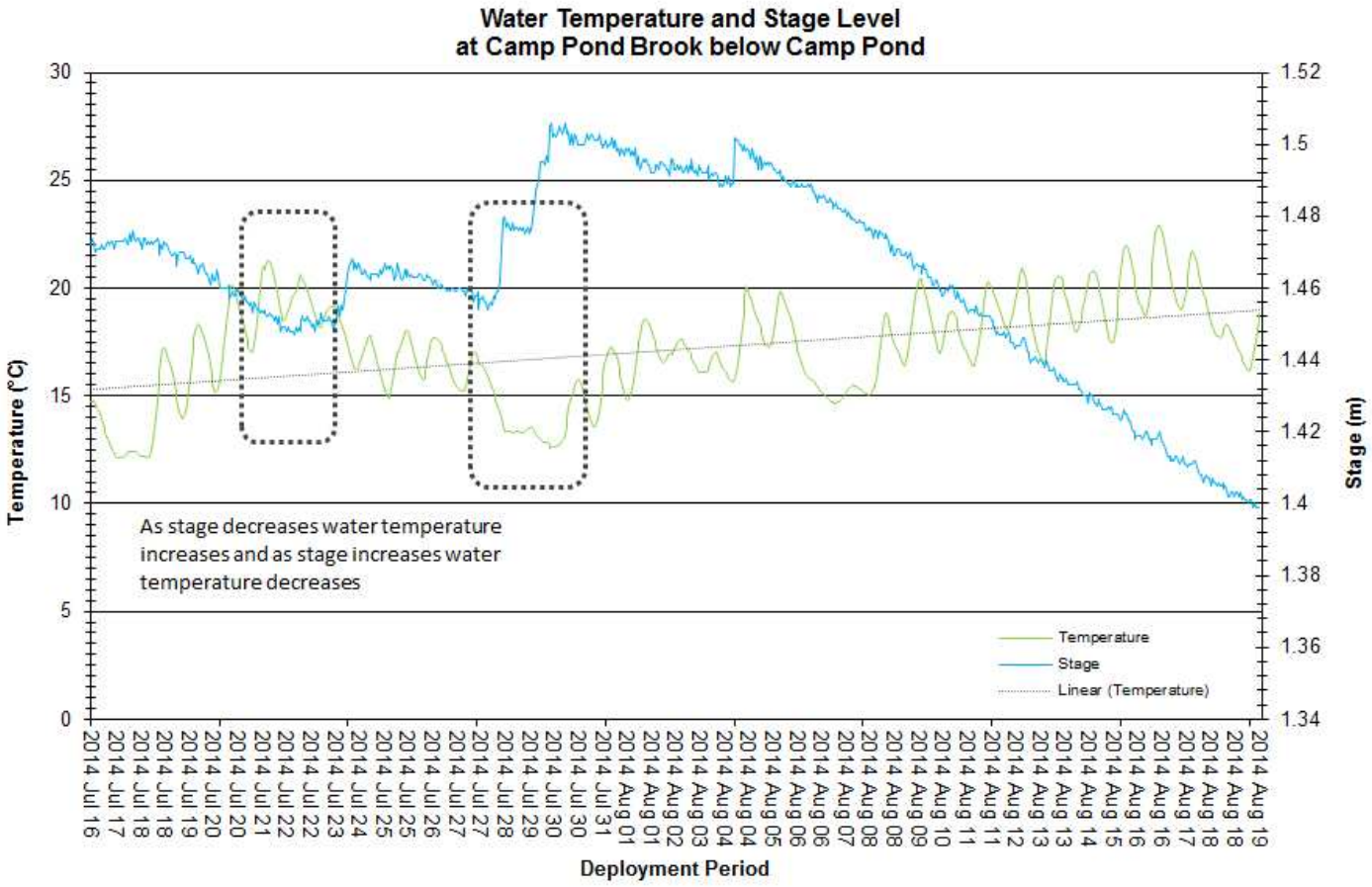

Figure 7: Water Temperature & Stage Level at Camp Pond Brook

pH

During this deployment period the pH ranges are between 6.70 and 7.01 pH units (Figure 8).

The pH values are very stable at this station, only fluctuating diurnally during the deployment period. On July 28th and 29th, there is a small flattening out of the pH level as the stage level increases. This is a natural occurrence between high stage level and pH. pH levels are more acidic as the water chemistry readjusts to an increase in water volume.

All pH values during this deployment are 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). Guidelines are indicated in red on Figure 8.

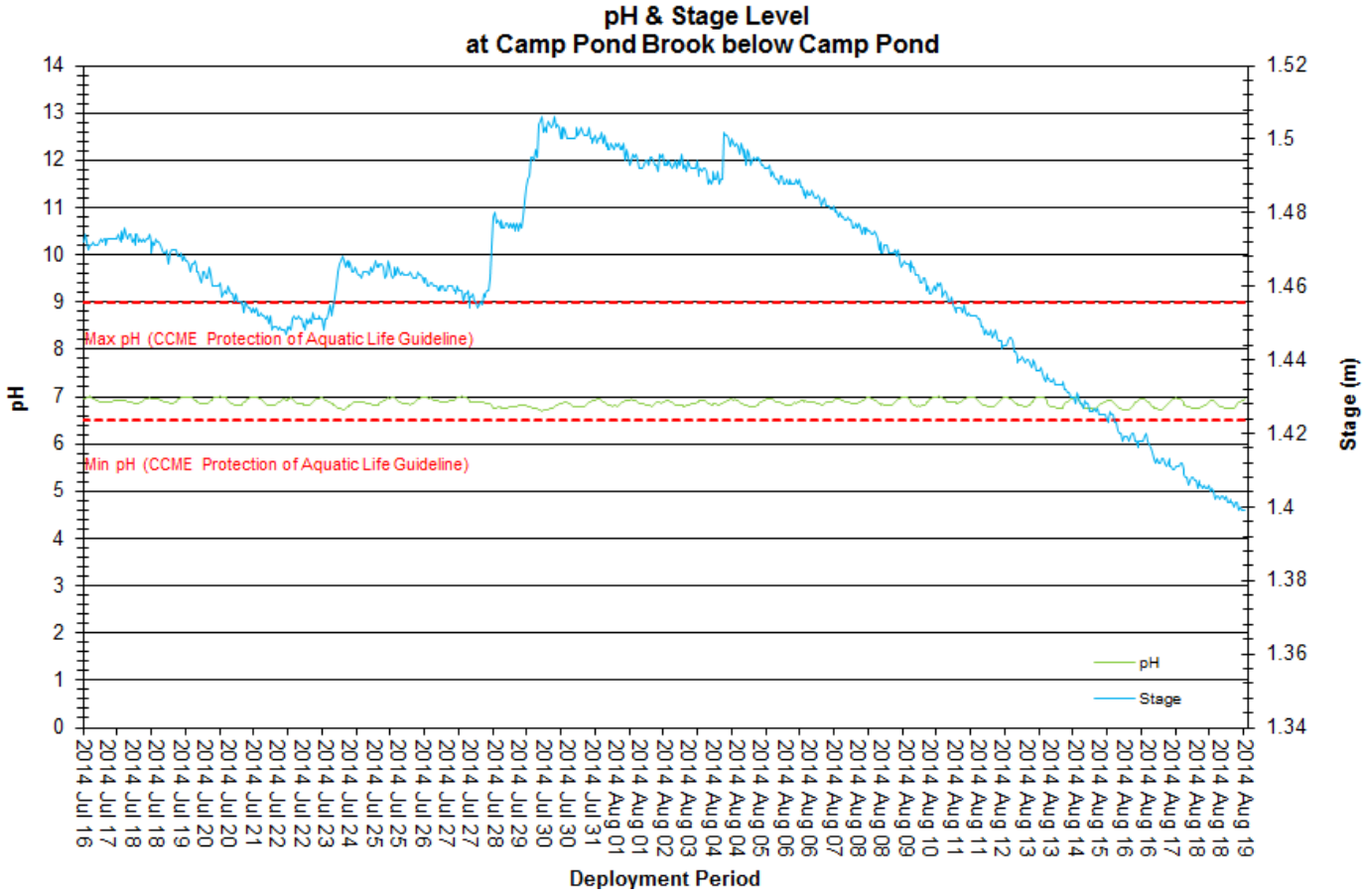

Figure 8: pH & Stage Level at Camp Pond Brook below Camp Pond

Specific Conductivity

During the deployment the specific conductivity data ranged between a minimum of 29.7µS/cm to a maximum of 41.7µS/cm, with a median of 31.9µS/cm (Figure 9).

There are a few peaks in conductivity on July 24th and July 28th, 2014. 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 due to increased suspended matter in the water column the conductivity increased.

The remainder of the conductivity data, although increasing slightly, was stable.

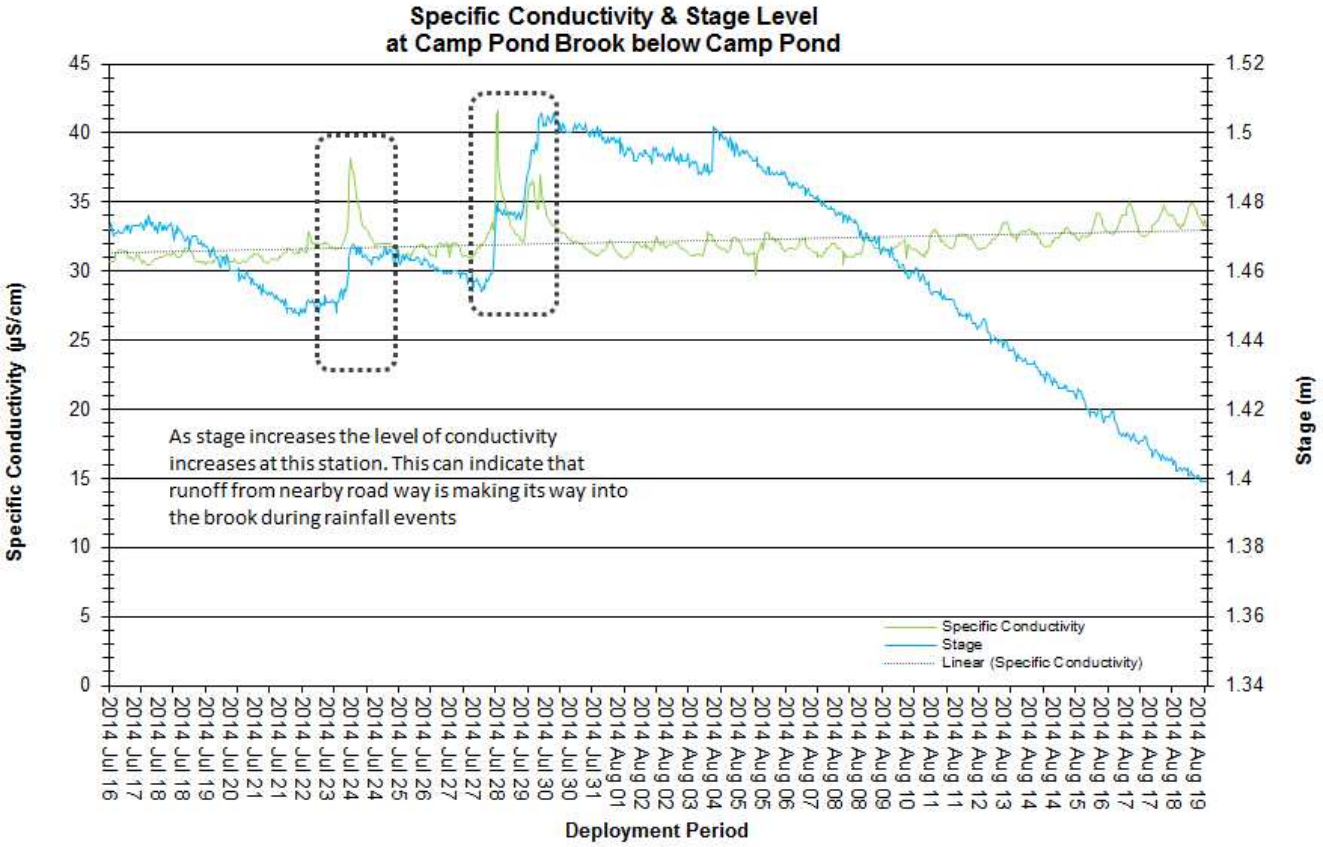

Figure 9: Specific Conductivity & Stage Level at Camp Pond Brook

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 8.36mg/l and 10.43mg/l. The saturation of dissolved oxygen ranges from 90.9% to 102.8% (Figure 10).

Dissolved Oxygen (%Sat) remains stable throughout this deployment period. There are several decreases and increases that correspond with water temperature during these same times (highlighted in black on Figure 10). This is to be expected as water temperature directly influences the level of dissolved oxygen present in a water column.

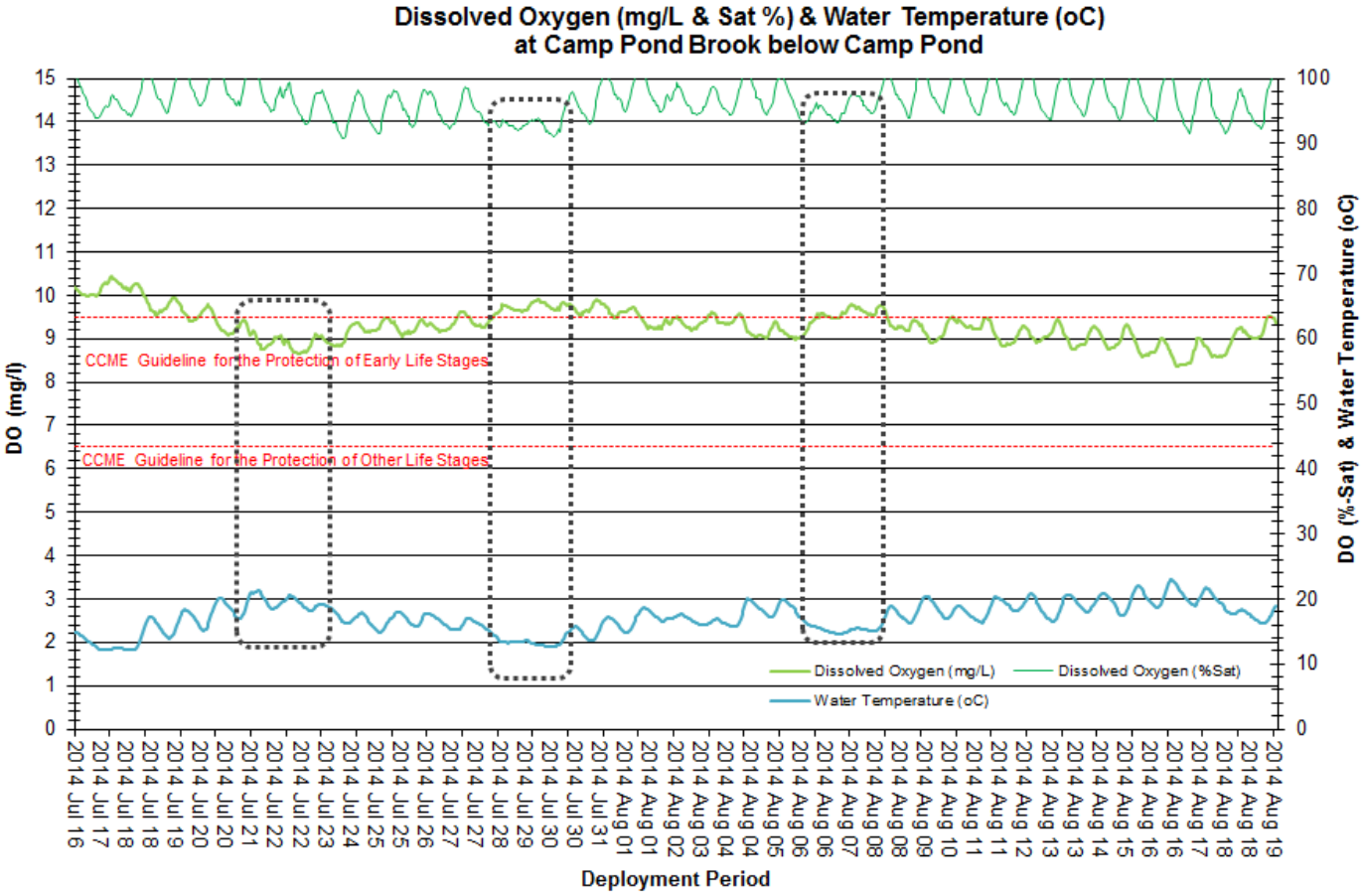

Figure 10: Dissolved Oxygen & Percent Saturation at Camp Pond Brook below Camp Pond

Turbidity

Turbidity values range between 0 NTU and 22.3 NTU (Figure 11). A median value of 1.1 NTU indicates there is very little natural background turbidity at this station during this deployment period.

There are a number of low turbidity events at this station throughout the duration of this deployment. This is a typical trend for this station. Some of the larger turbidity events correspond with rainfall events (rainfall indicated on figure 12). Higher stage levels can be a direct result of precipitation events.

The largest event of 22.3 NTU on July 29th, 2014 corresponds with a precipitation event (on Figure 11). It can be assumed that the turbidity value of 22.3 NTU was a result of runoff and rainfall stirring up particles and substances in the brook.

There is a slight increase in turbidity from the start of deployment to the end. This is represented by the trend line. The higher turbidity levels at the end of deployment may be a result of the decreasing stage level, with less water in the brook the suspended materials becomes more concentrated.

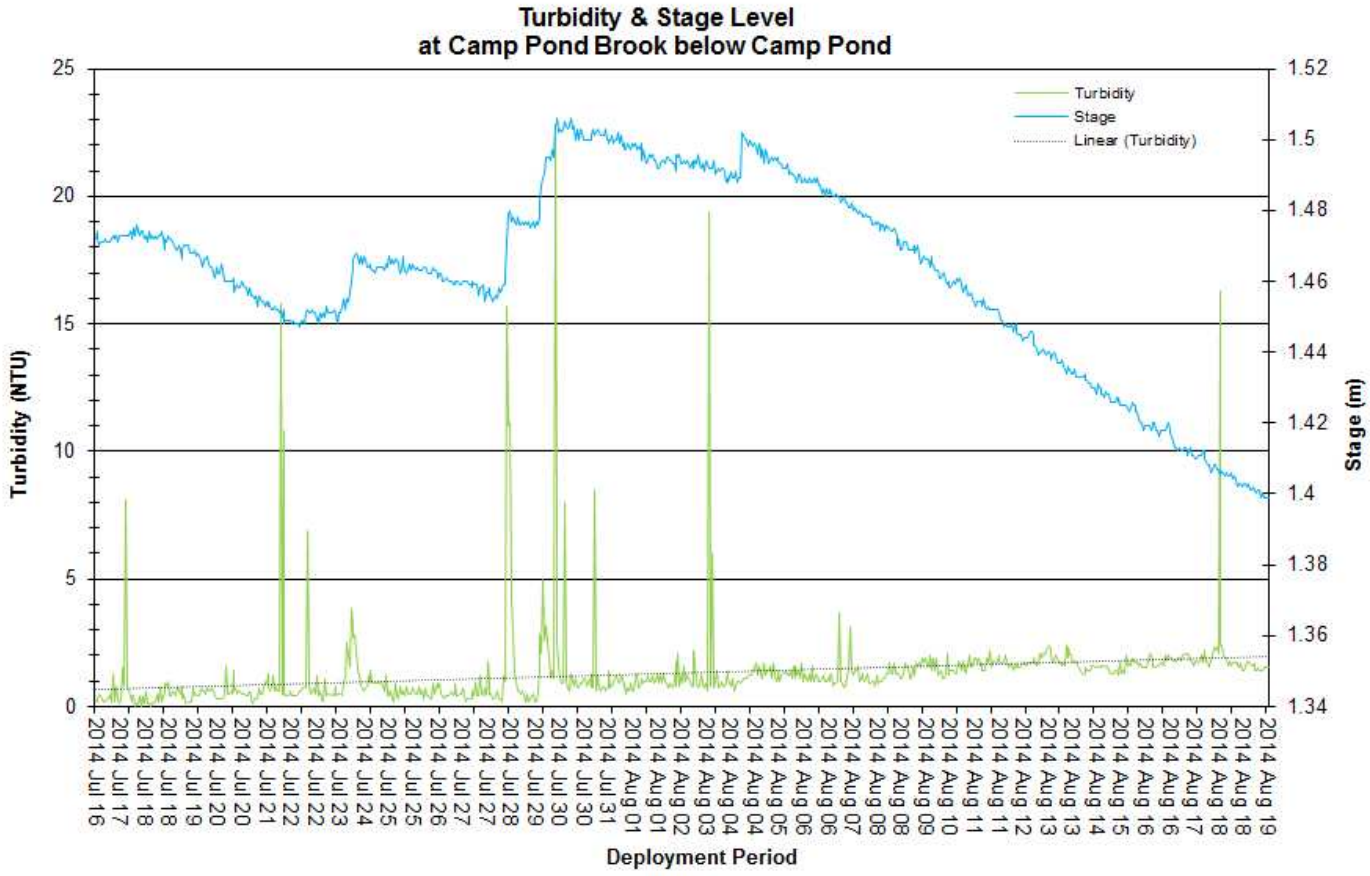

Figure 11: Turbidity & Stage Level at Camp Pond Brook

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 July 28th, with an average of 31.5 mm that day.

During the deployment period, the stage values ranged from 1.40 m to 1.51 m. The larger peaks in stage correspond with substantial rainfall events as noted on Figure 12. Streamflow had a minimum amount of 0.38 m^3/s and a maximum flow of 0.96 m^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.

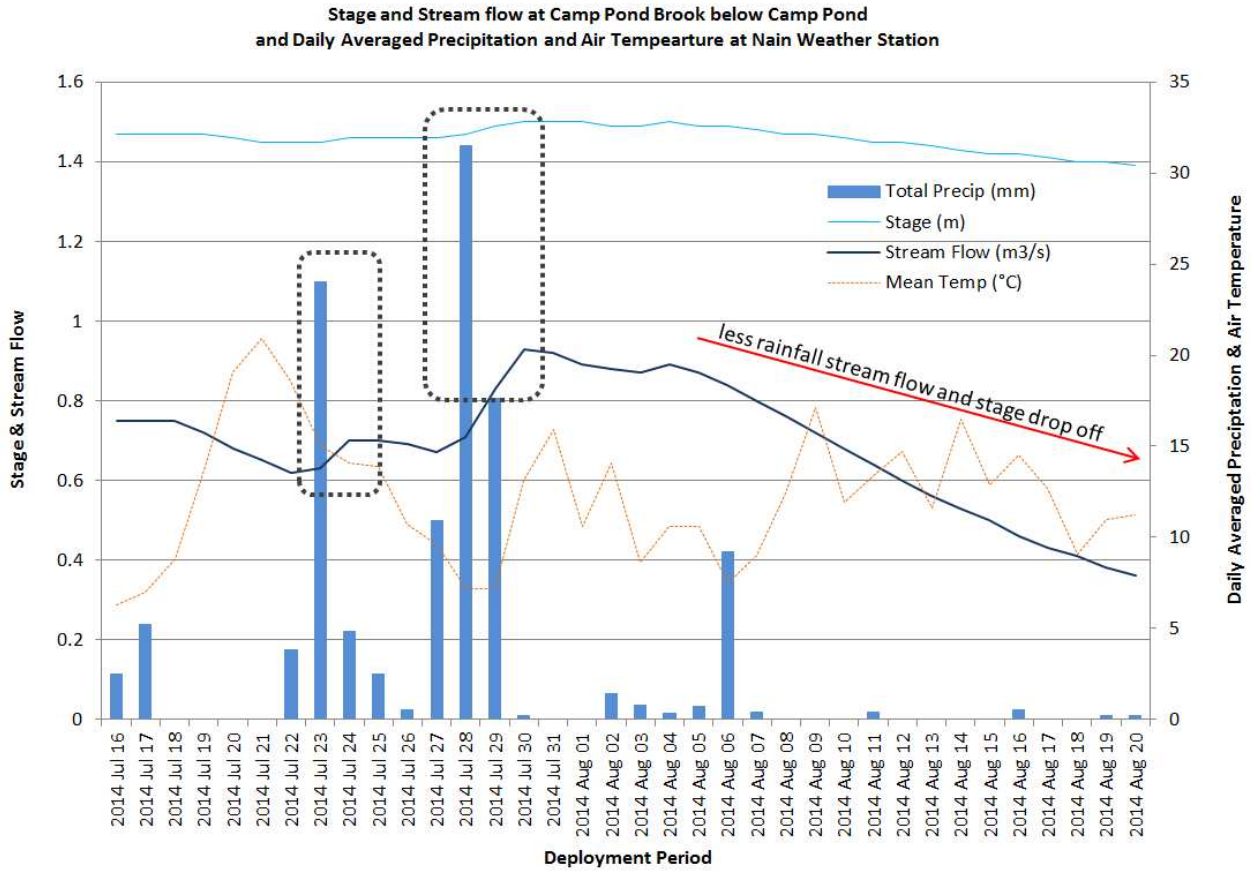

Figure 12: Daily Precipitation, Average Daily Stage & Flow level at Camp Pond Brook

(Weather data recorded at Nain)

Tributary to Lower Reid Brook

Water Temperature

At this station the water temperature ranged from 9.10°C to 18.30°C during the deployment period (Figure 13). The water temperature median the for deployment was 13.60 °C.

The linear trend line shows that water temperature is increasing throughout the deployment period. This trend is expected given the warming ambient air temperatures as the summer 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.

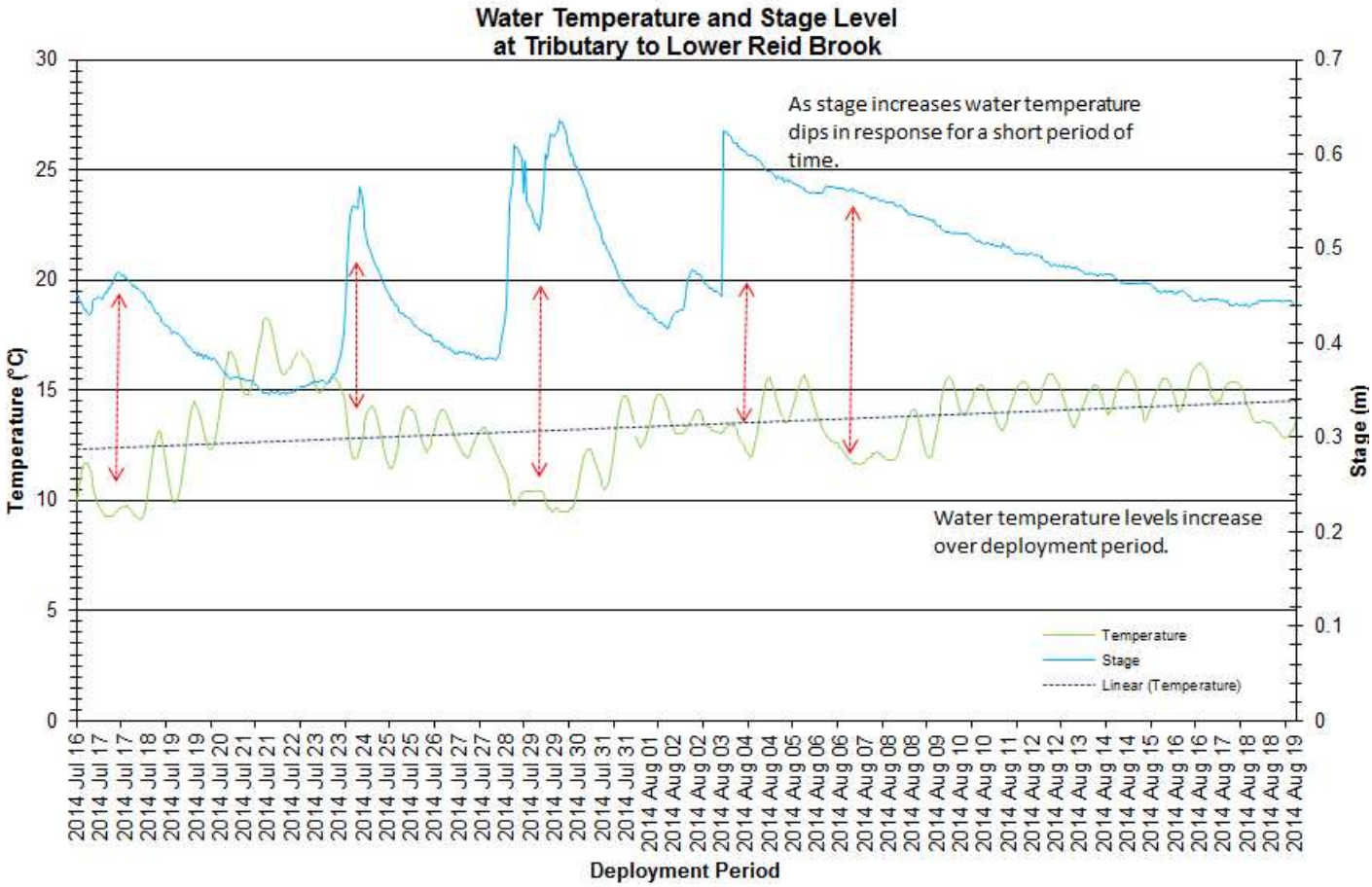

Figure 13: Water temperature at Tributary to Lower Reid Brook

pH

pH data at this station ranged within a minimum of 6.07 and a maximum of 6.75 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 July 17th, July 24th, July 28-30th and August 2nd. These events are circled in black on Figure 14.

Initially the pH data sits just on or below the CCME guidelines until half way through the deployment period. As the stage level starts to dip down from August 3rd onwards the pH values increase slightly, hence sitting just above the minimum CCME guideline. Guidelines are indicated in red on Figure 14.

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 6.52 pH units.

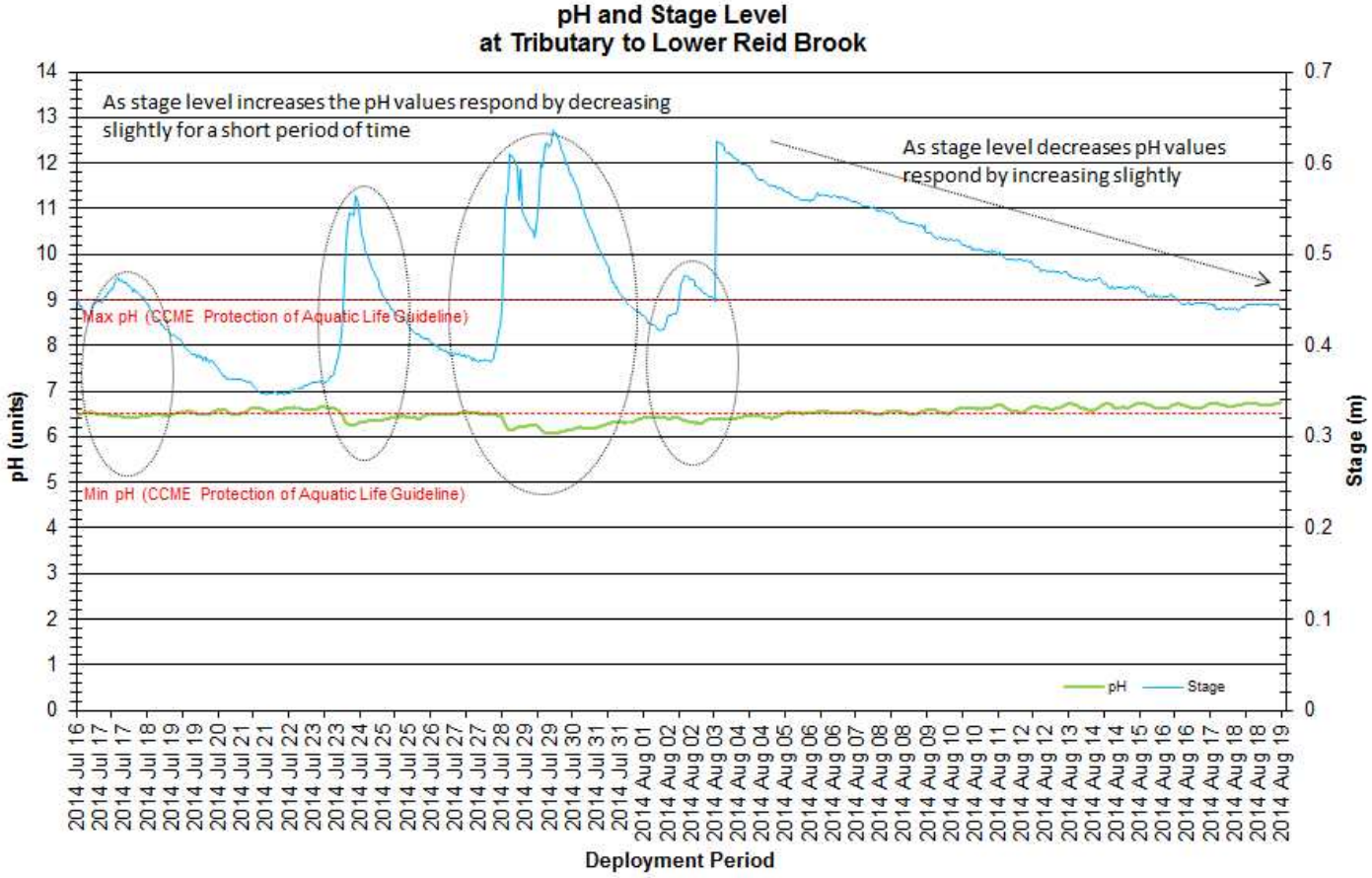

Figure 14: pH and stage level at Tributary to Lower Reid Brook

Specific Conductivity

Specific conductivity ranges between 20.5µS/cm and 38.9µS/cm during the deployment period, with a median for the deployment period of 27.0µS/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 the black circled events on the graph below.

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

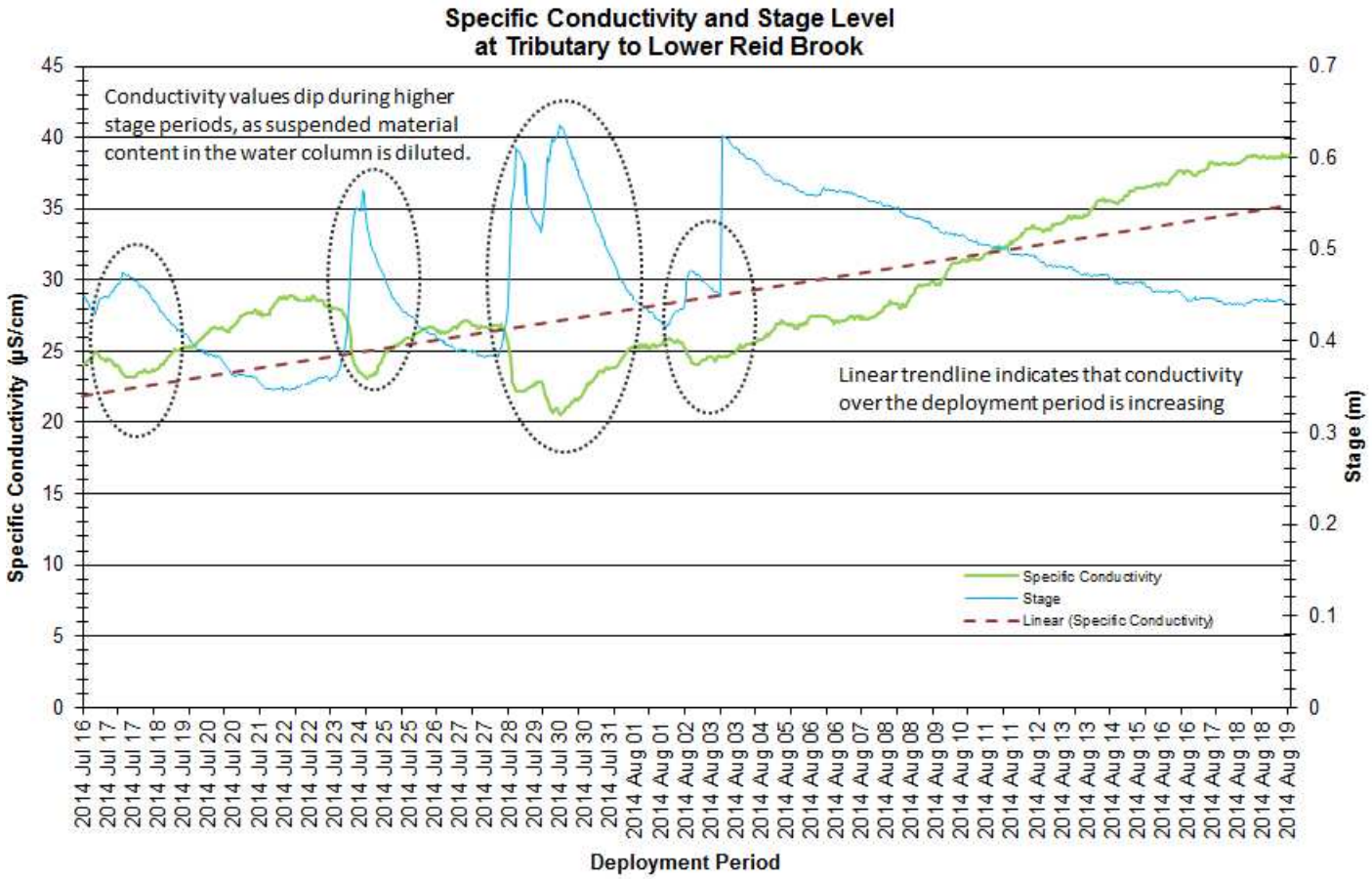

Figure 15: Specific conductivity and stage level at Tributary to Lower Reid Brook

Dissolved Oxygen

Dissolved oxygen content ranges between 8.99mg/l and 11.12mg/l. The saturation of dissolved oxygen ranges from 93.9% to 99.2% (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 is the opposite with warmer water temperatures which can be seen on July 21st- 23rd.

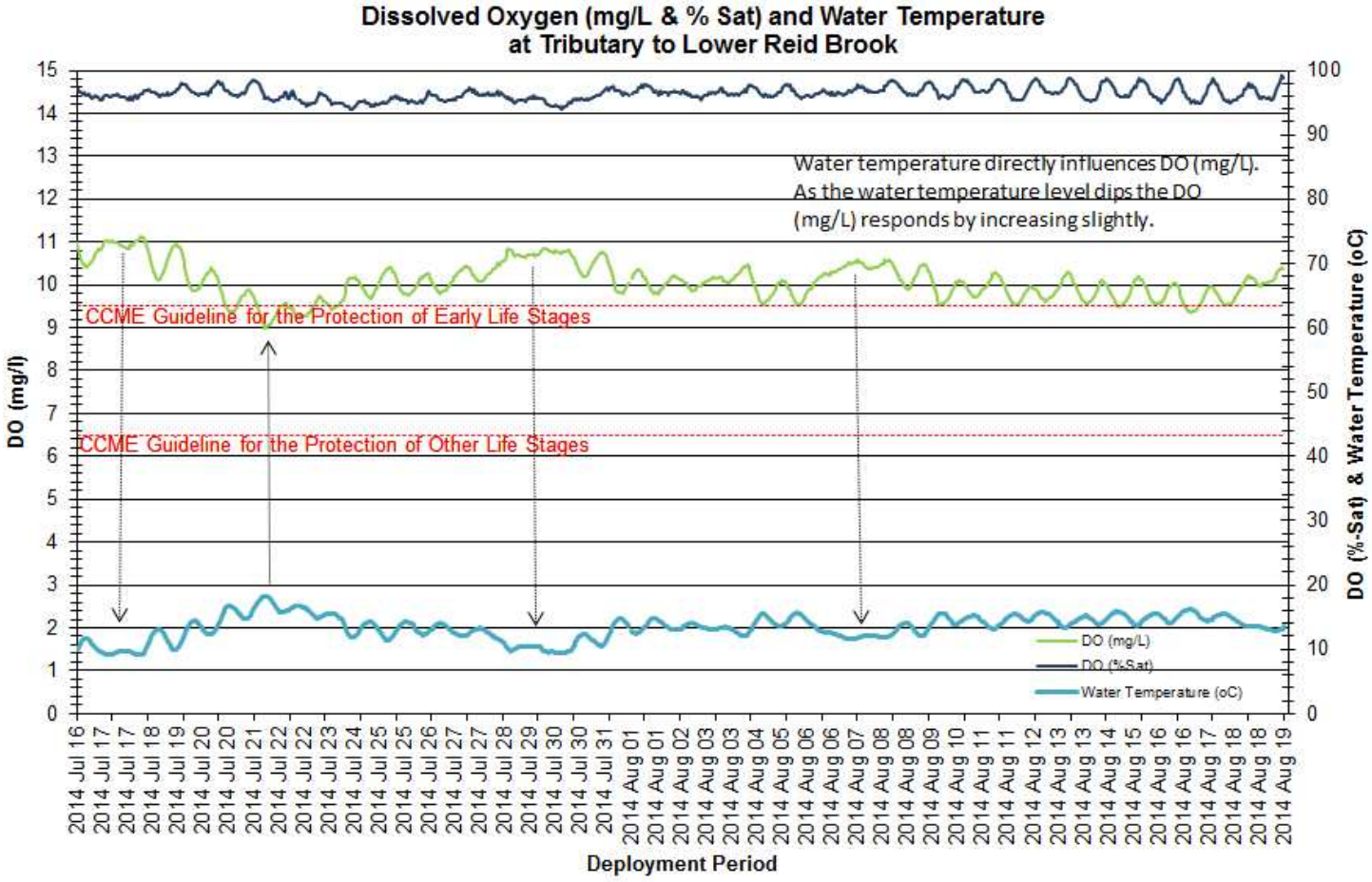

Figure 16: Dissolved oxygen and percent saturation at Tributary to Lower Reid Brook

Turbidity

During this deployment period the turbidity data for this deployment ranged within a minimum of 0.0NTU and a maximum of 62.1NTU (Figure 17). The median for this data set was 0.8 NTU; 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. As the stage levels increases so does the presence of suspended solids and particles in the water column which is captured by the turbidity sensor.

On July 20th there is a turbidity spike that is not linked to an increase in stage at that time. It is likely this peak was a result of debris passing over the sensor at the exact time a reading was being recorded hence the straight up and down result on the graph.

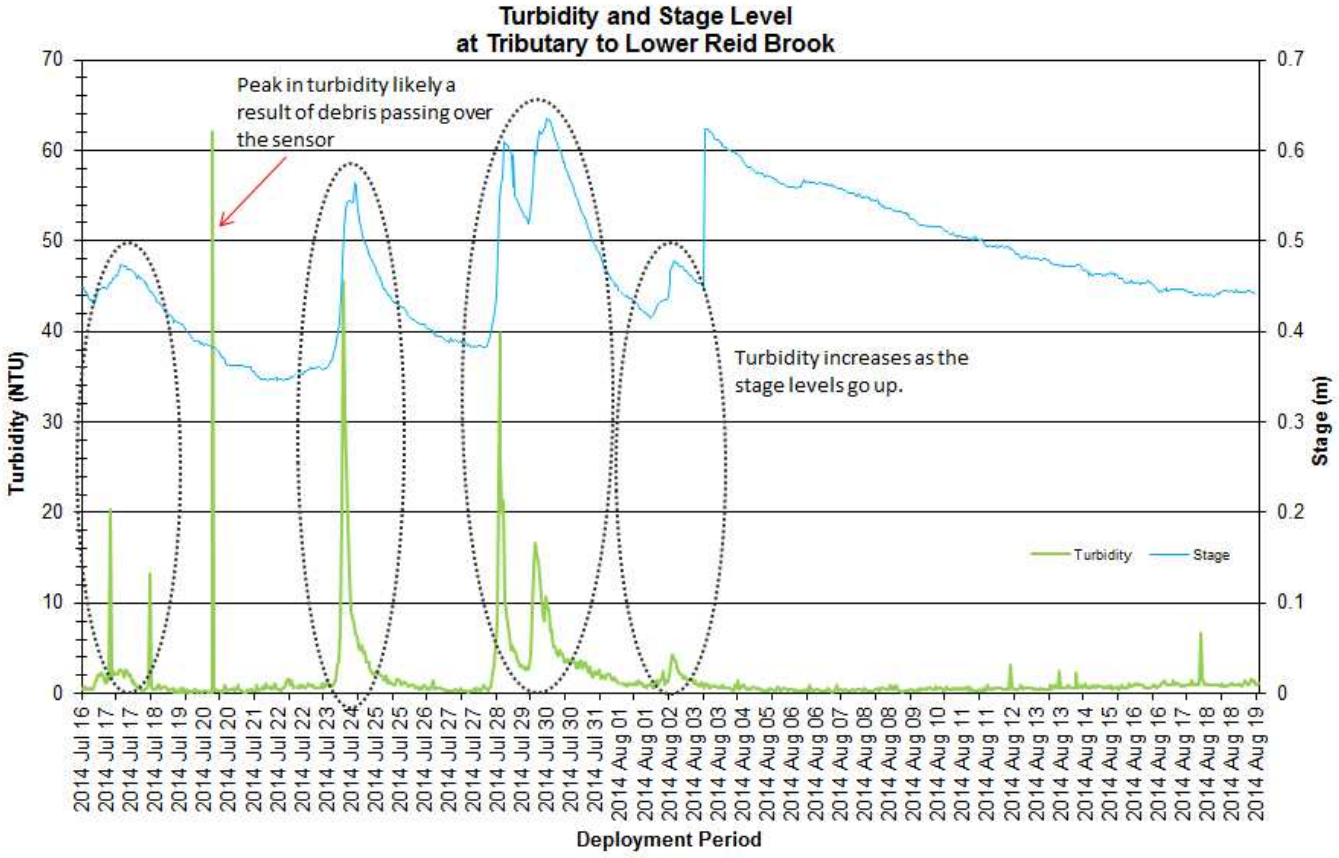

Figure 17: Turbidity and stage level at Tributary to Lower Reid Brook

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. The streamflow values ranged from 0.03m^3/s to 0.61m^3/s .The larger peaks in stage and streamflow do correspond with substantial rainfall events as noted on Figure 18.

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 31.5 mm on July 28th.

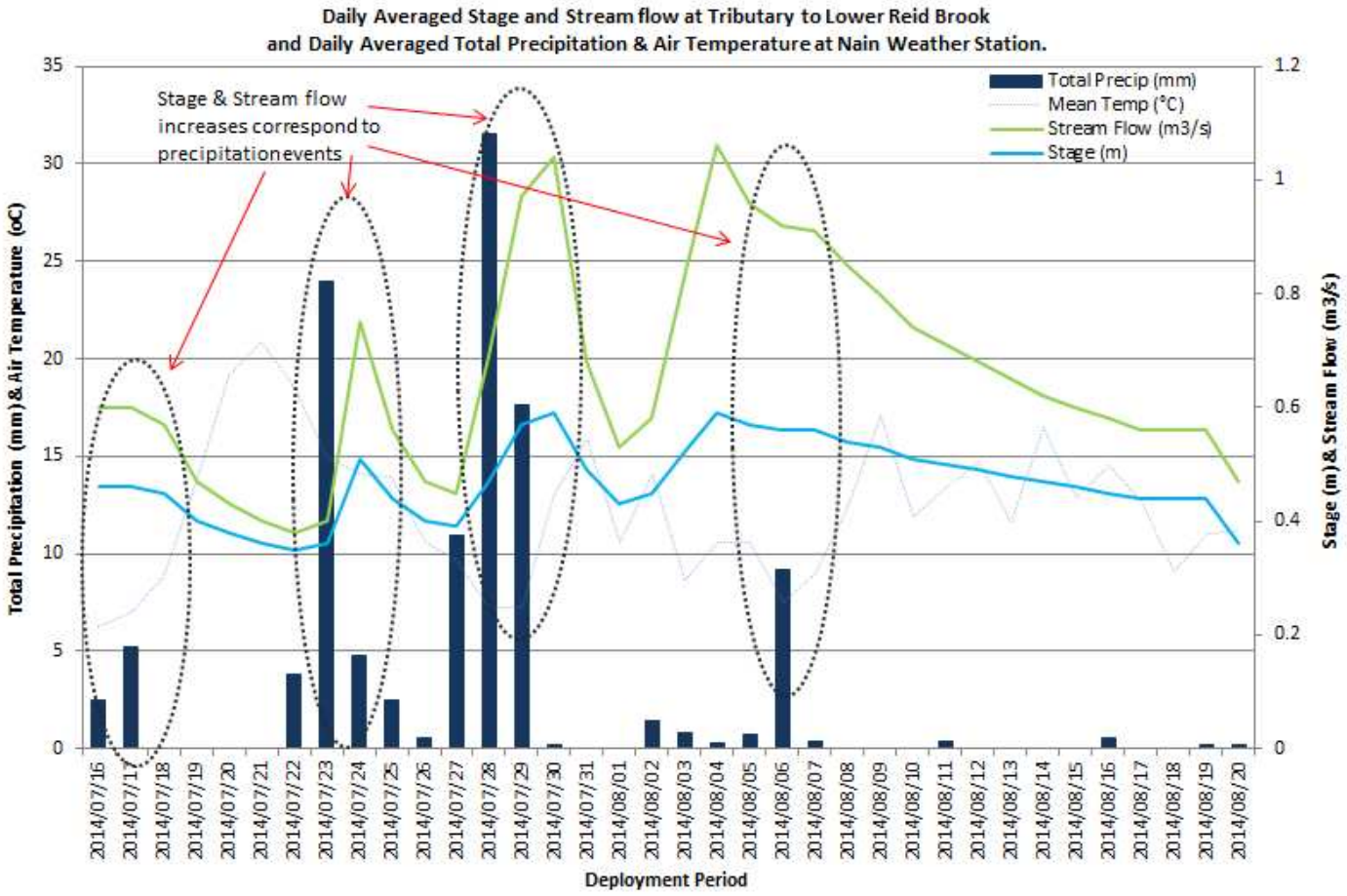

Figure 18: Daily precipitation, air temperature and average daily stage and stream flow at Tributary to Lower Reid Brook

(Weather data recorded at Nain)

Lower Reid Brook below Tributary

Water Temperature

Water temperature ranges from 9.27°C to 19.44°C during the deployment period (Figure 19). The data set for this deployment had a median of 14.14°C.

Water temperature is increasing during this deployment period. This trend is expected as the ambient air temperatures increase with the summer 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 July 23rd & 24th and again on July 29th to 31st.

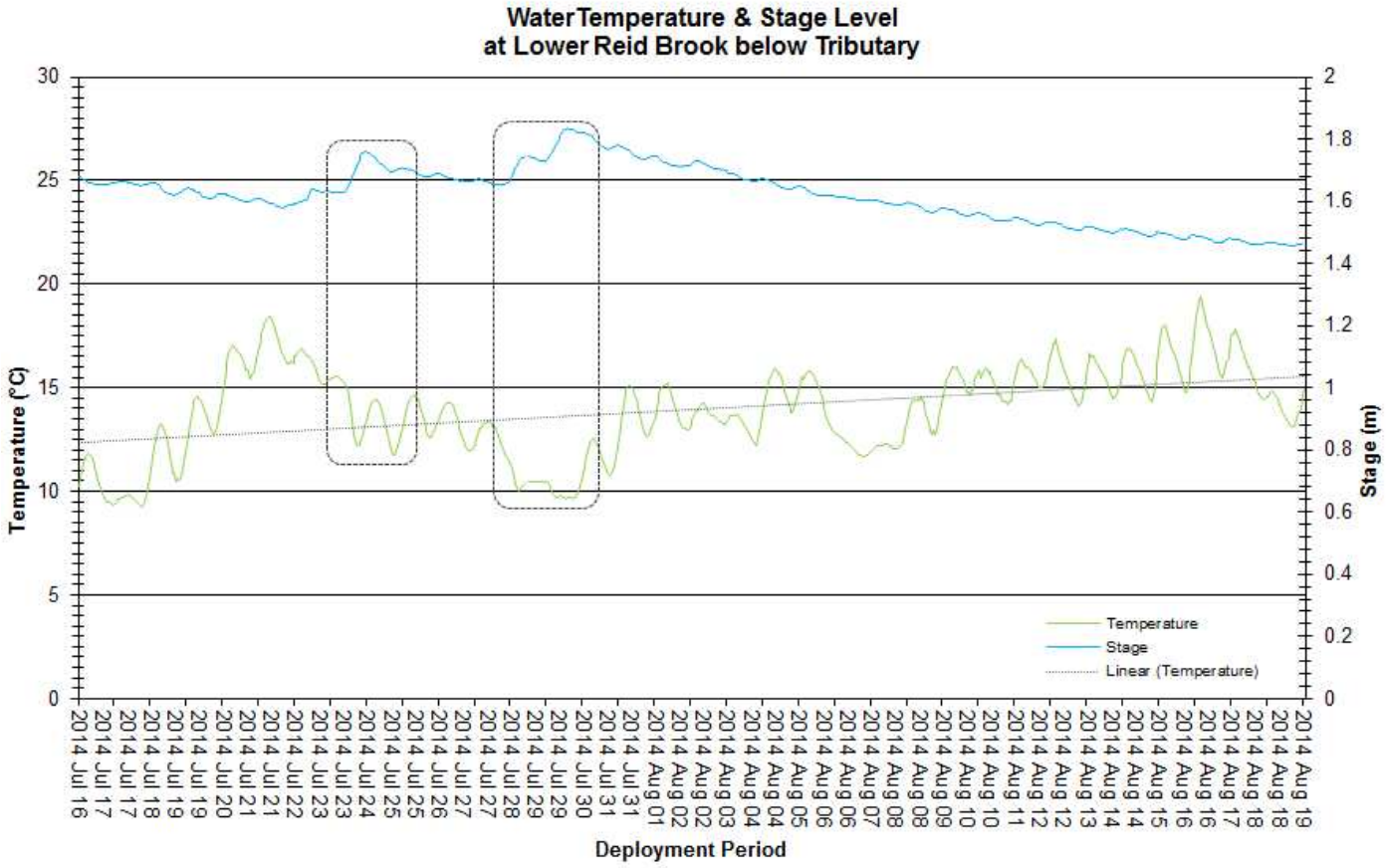

Figure 19: Water temperature and Stage levels at Lower Reid Brook below Tributary

pH

During this deployment period pH data ranged between a minimum of 6.27 and a maximum of 7.42 pH units (Figure 20). pH values had a median of 6.75 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 20 as stage levels increase on July 23rd and again on July 29th, the pH values drop slightly as a response.

As the deployment period continues pH levels start to increase. This increase coincides with a decrease in stage levels. 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.

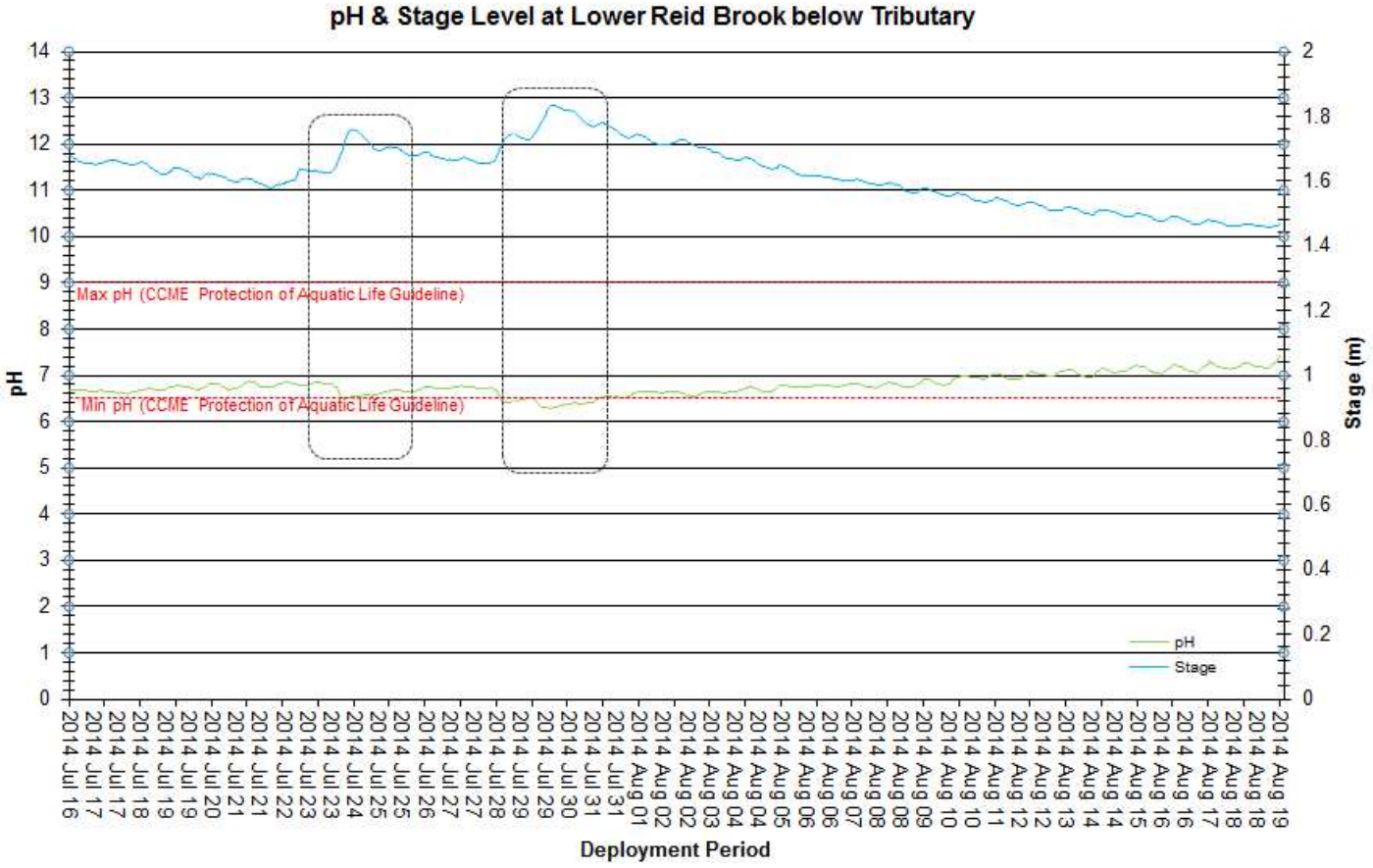

Figure 20: pH and stage level at Lower Reid Brook below Tributary

Specific Conductivity

During this deployment the specific conductivity data ranged between 20.2µS/cm and 35.7µS/cm, with a median of 25.3µS/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 July 24th and again on July 29th to 30th.

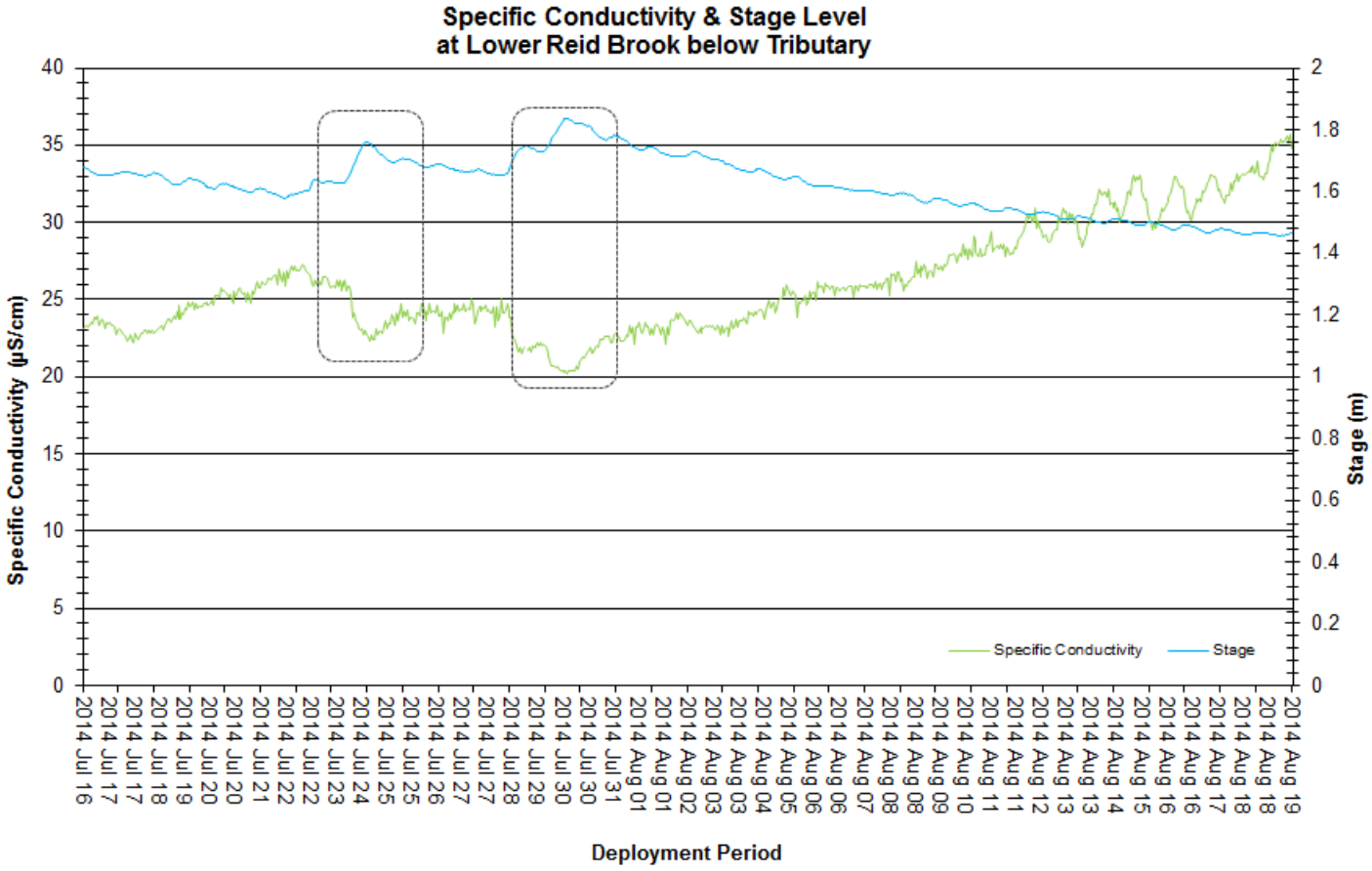

Figure 21: Specific conductivity and stage level at Lower Reid Brook below Tributary

Dissolved Oxygen

Dissolved oxygen content ranges between 8.91mg/l and 10.96mg/l. The saturation of dissolved oxygen ranges from 92.8% to 101.3% (Figure 22).

Dissolved oxygen percent saturation is relatively consistent throughout the deployment period. On July 21st there is a slight dip in DO (mg/L) as the water temperature increases at the same time. There are three other noticeable events in DO (mg/L) during low water temperature periods, on July 29th, August 7th and August 19th the DO levels increase slightly.

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

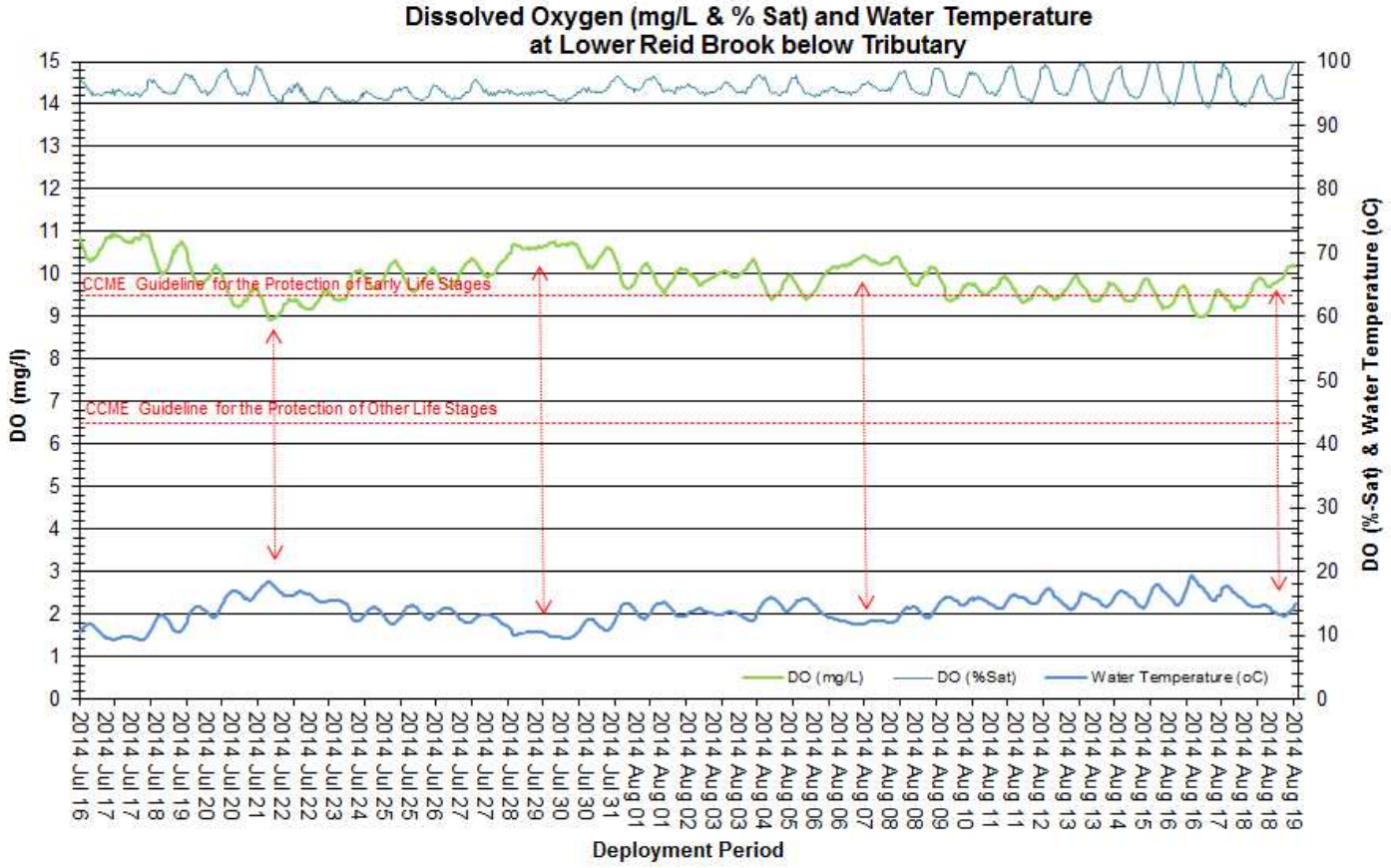

Figure 22: Dissolved oxygen (mg/L & %Sat) at Lower Reid Brook below Tributary

Turbidity

During the deployment period the turbidity values ranged between a minimum of 0 NTU and a maximum of 48.1 NTU (Figure 23). A median value of 0.0 NTU indicates there is no natural background turbidity data for this deployment period.

There are very few turbidity increases captured during the deployment period, all of which only last 1-2 hours. When graphed the data displayed two clusters of turbidity peaks on July 22nd and July 24th, as well as July 28th, 30th and 31st, all increases correspond with an increase in stage level for the same time frame.

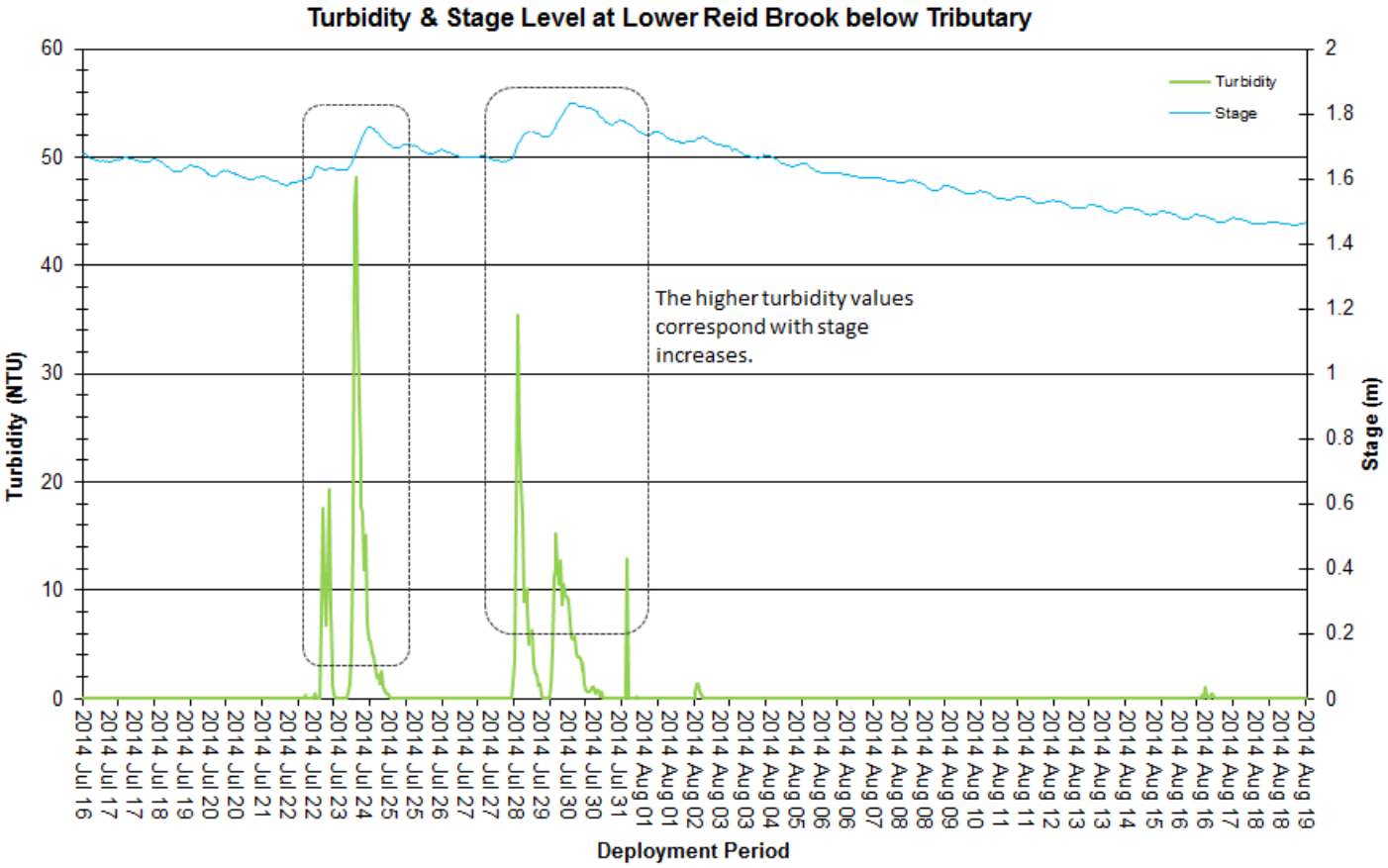

Figure 23: Turbidity and stage level at Lower Reid Brook below Tributary

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.

During the deployment period, the stage values ranged from 1.46m to 1.83m. The streamflow values ranged from 1.78 m^3/s to 13.90 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.

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 31.5 mm on July 28th.

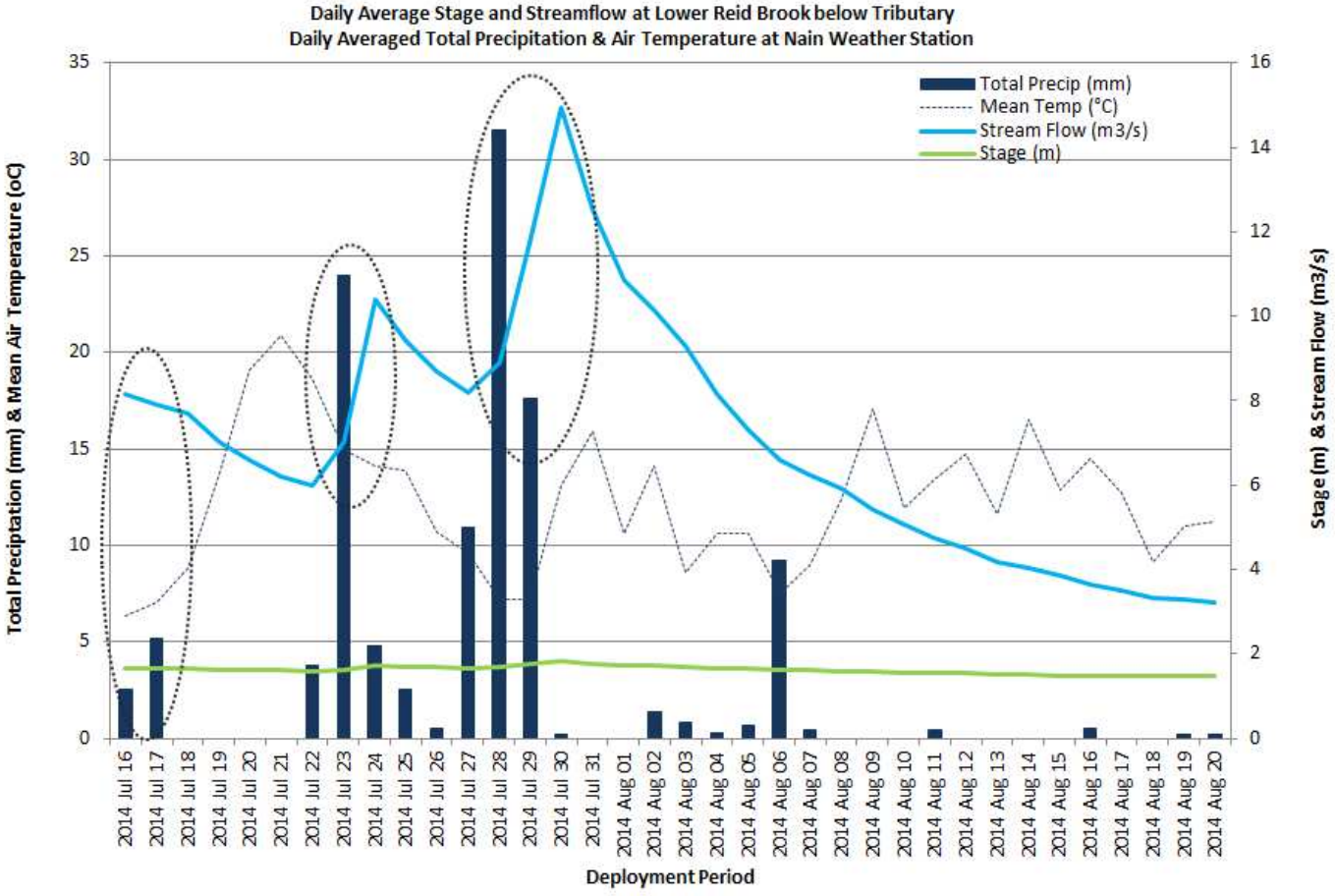

Figure 24: Daily precipitation and average daily stage and stream flow level at Lower Reid Brook below Tributary (Weather data recorded at Nain)

Conclusions

- The overall water temperatures across all stations were within a minimum of 7.77°C found at Reid Brook at Outlet of Reid Pond and a maximum of 22.90°C recorded at Camp Pond Brook below Camp Pond. Despite a dip in water temperatures at all stations on July 26th through to July 29th the water temperature was increasing slightly across the network. 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 higher 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 lowest minimum water temperature over the last two deployment periods.
- pH values ranged between a minimum of 6.07 pH units at Tributary to Lower Reid Brook and maximum of 7.42 recorded at Lower Reid Brook below Tributary. Reid Brook at Outlet of Reid Pond pH data was not included in the station comparisons due to the pH probe malfunctioning. Precipitation events during the deployment period caused dips in pH at the three stations on July 23-24th, July 28-29th and July 30th. PH values dipped slightly following stage level increases.
- The overall conductivity ranges within the four stations was a minimum of 10.6 µS/cm at Reid Brook at Outlet of Reid Pond and a maximum value of 41.7 µS/cm at Camp Pond Brook below Camp Pond. Conductivity values at Reid Brook at Outlet of Reid Pond and Lower Reid Brook below Tributary are the lowest of the four stations. With Camp Pond Brook below Camp Pond having the highest median at 31.9 µS/cm for the data range. This is to be expected with Camp Pond Brook being slightly closer to the mine site and the potential for roadway runoff and other influences. This is actually evident on July 23rd and July 28th, when all of the other stations indicate a lowering in conductivity from rainfall, Camp Pond Brook data actually peaks.
- Dissolved oxygen levels for the deployment period ranged between 8.36 mg/l at Camp Pond Brook below Camp Pond and 12.30 mg/l found at Reid Brook at Outlet of Reid Pond. Dissolved oxygen content was decreasing slightly at all stations. During the warmer seasons there is a greater use of dissolved oxygen in the water bodies. This is a natural process and is expected given the change in season during this deployment period.
- Turbidity levels for the four real-time stations ranged within a minimum of 0.0 NTU from all stations and a maximum of 62.1 NTU at Tributary to Lower Reid Brook. The cause of the high turbidity reading at Tributary to Lower Reid Brook was not determined. Lower Reid below Tributary has the second highest maximum reading of 48.1 NTU. Rainfall events will cause disturbances to the water column and affect the turbidity values in the brooks for a short time frame.

APPENDIX I

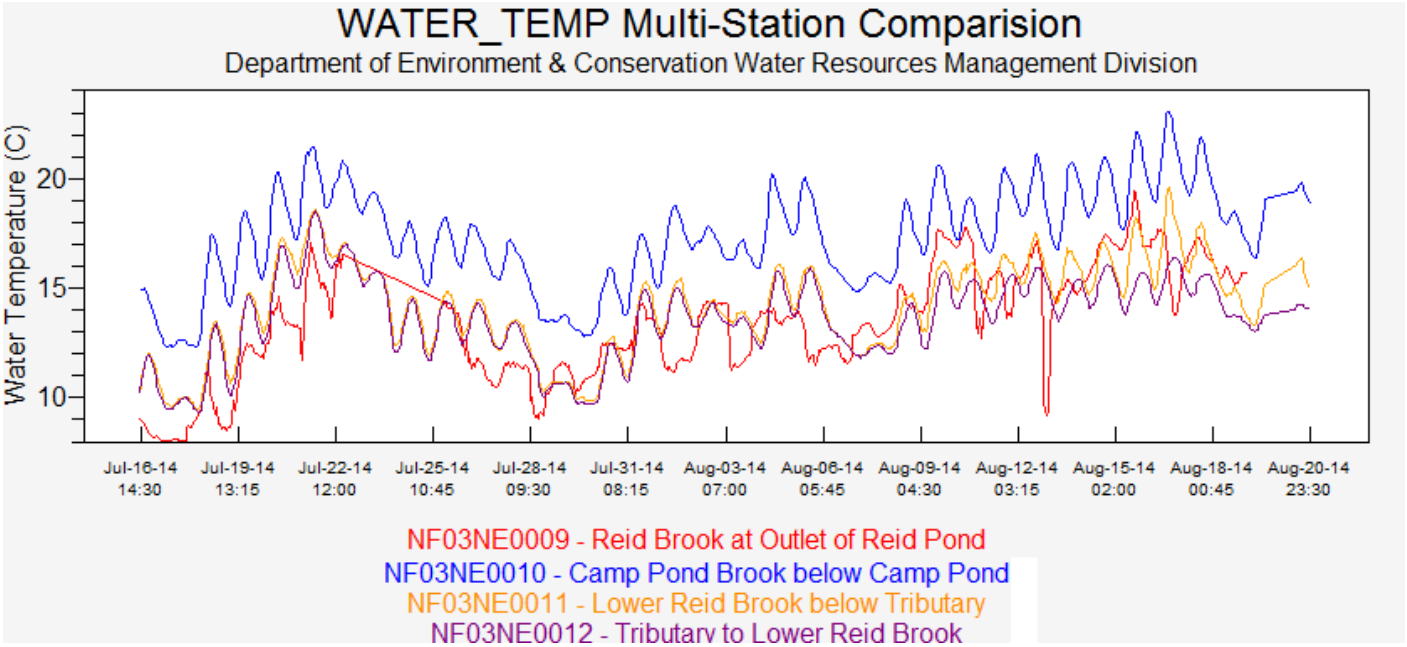

Figure A1: Comparison of Water Temperature at the Real-Time Stations in Voisey's Bay

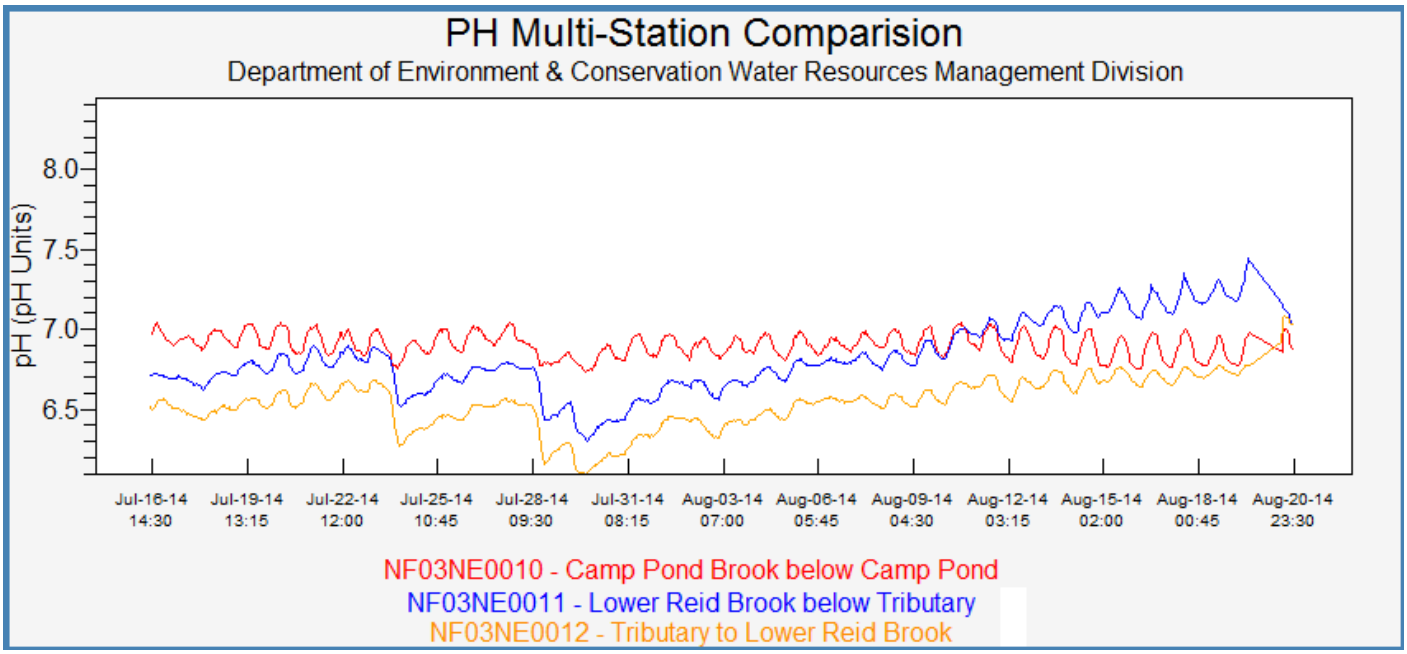

Figure A2: Comparison of pH at the Real-Time Stations in Voisey's Bay

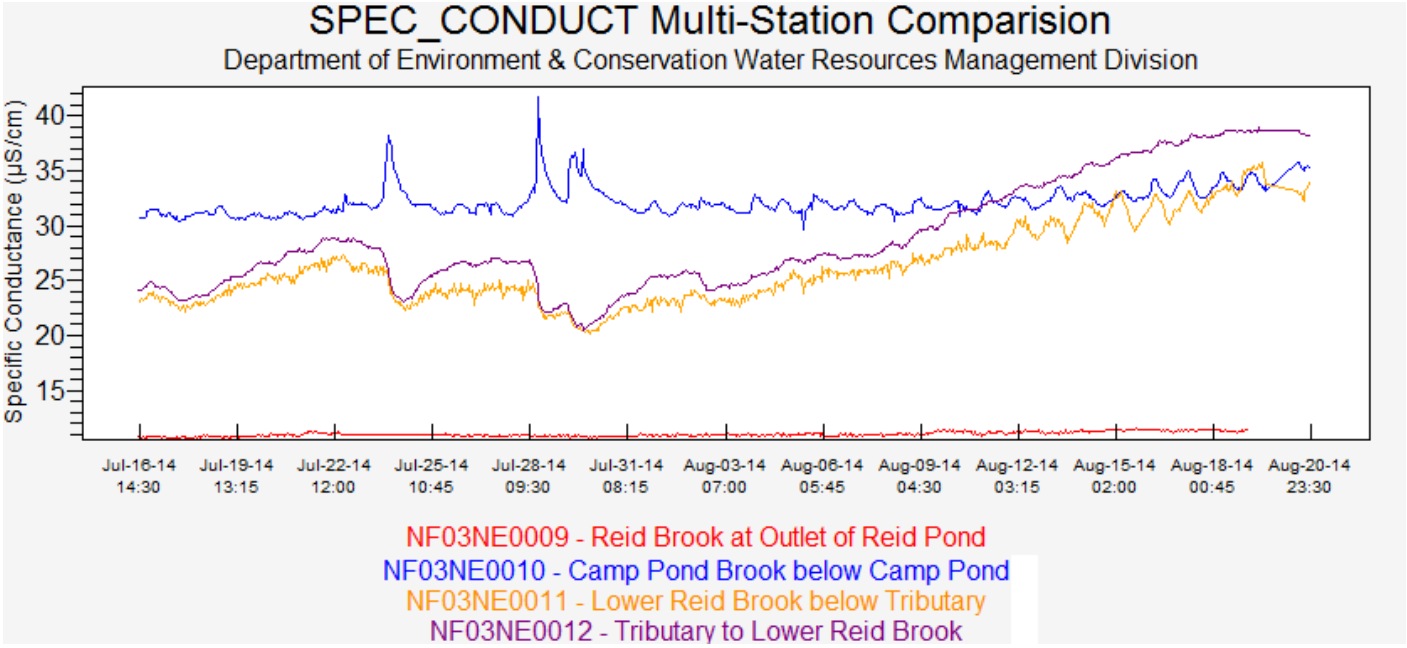

Figure A3: Comparison of Conductivity at the Real-Time Stations in Voisey's Bay

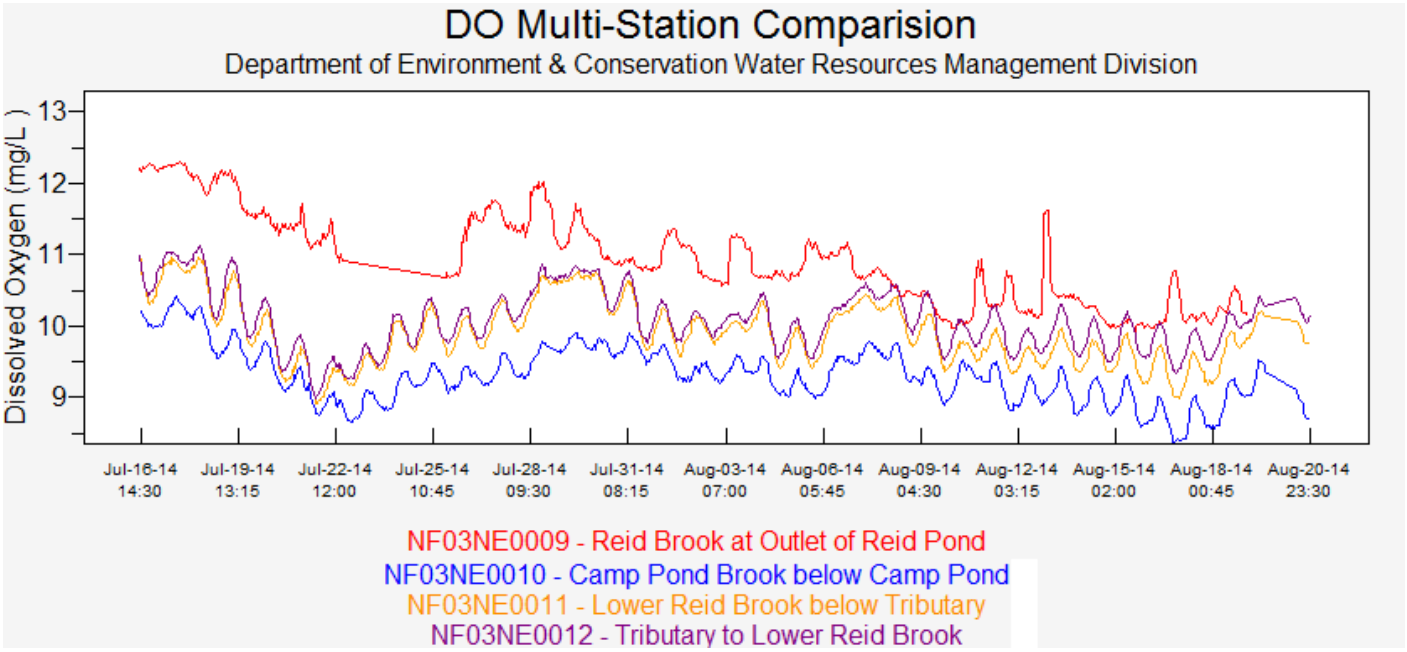

Figure A4: Comparison of Dissolved Oxygen (mg/L) at the Real-Time Stations in Voisey's Bay

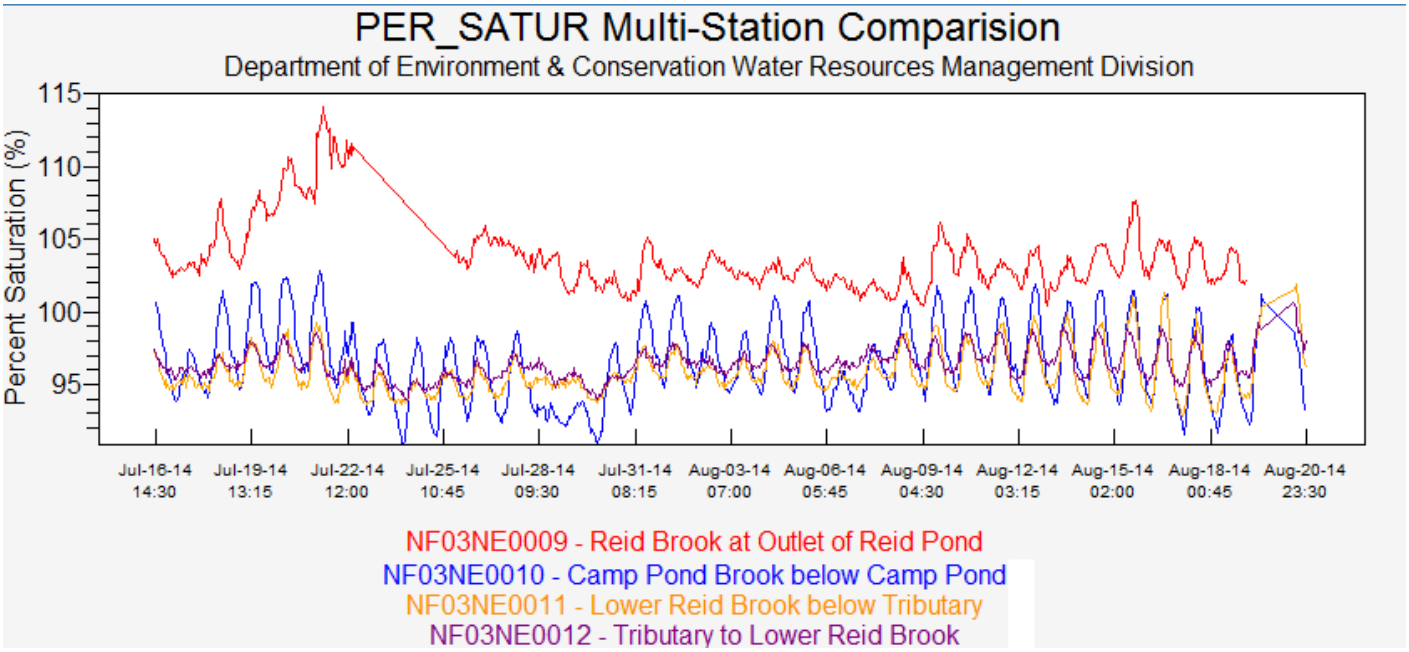

Figure A5: Comparison of Dissolved Oxygen (%Sat) at the Real-Time Stations in Voisey's Bay

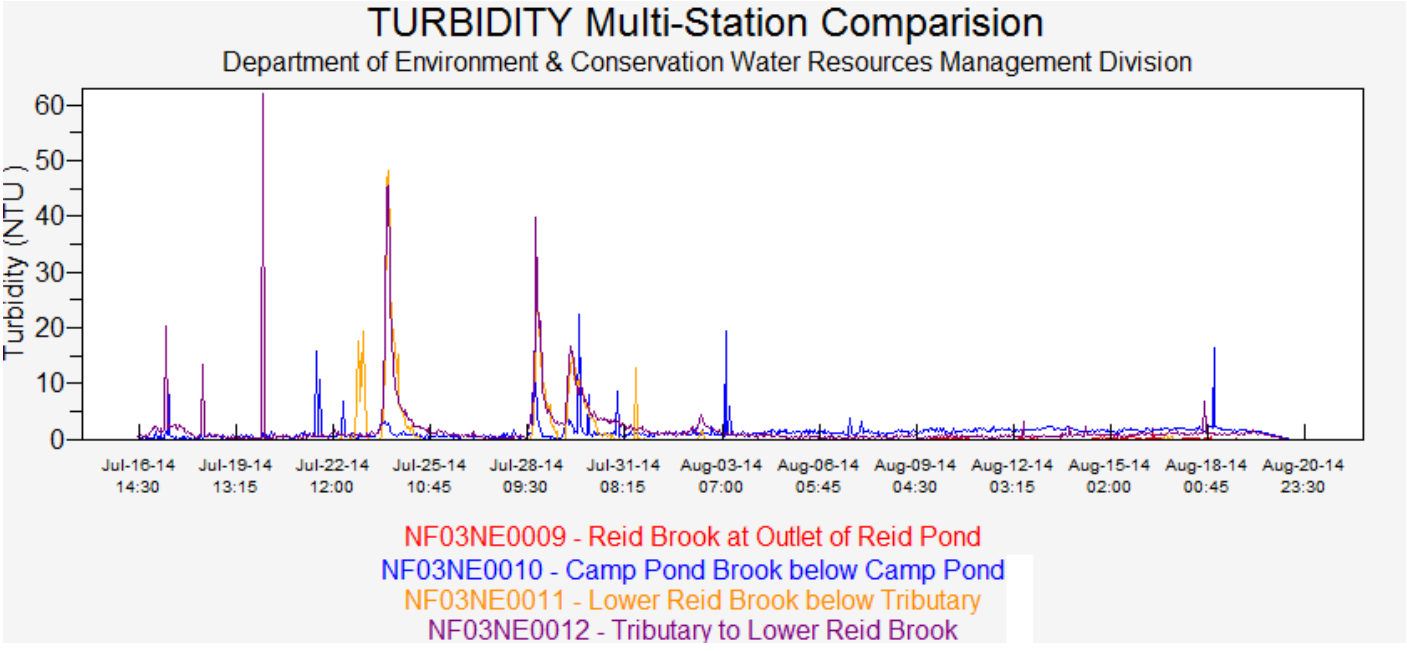

Figure A6: Comparison of Turbidity at the Real-Time Stations in Voisey's Bay

APPENDIX II

REPORT OF ANALYSIS

Lab Report Number: **1414975**

Cient:	Department of Environment	**COC Number:**	2816
Attention:	Ms. Melissa McComiskey	**Date Reported:**	2014-07-24
Client Project:	St Johns	**Date Submitted:**	2014-07-21
Purchase Order:	214004545	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date
1120531	WS-S-0000 Lower Reid Brook Below Tributary	2014-6406-00-SI-SP	2014-07-16

Sample comment:

Holding time for Turbidity analysis was exceeded for the entire report.

Report comment:

ANALYTE	UNIT	MRL	RESULT
Alkalinity as CaCO3	mg/L	5	6
Bromide	mg/L	0.25	<0.25
Chloride	mg/L	1	2
Colour	TCU	2	46
Conductivity	uS/cm	5	25
Dissolved Organic Carbon	mg/L	0.5	5.8
Fluoride	mg/L	0.10	<0.10
Hardness as CaCO3	mg/L	1	5
N-NH3 (Ammonia)	mg/L	0.02	0.07
N-NO2 (Nitrite)	mg/L	0.10	<0.10
N-NO3 (Nitrate)	mg/L	0.10	<0.10
pH		1.00	7.01
Sulphate	mg/L	1	2
Total Dissolved Solids (COND - CALC)	mg/L	1	16
Total Kjeldahl Nitrogen	mg/L	0.10	0.24
Total Organic Carbon	mg/L	0.5	5.5
Total Phosphorus	mg/L	0.01	<0.01
Turbidity	NTU	0.1	0.9
Aluminum	mg/L	0.01	0.13
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	2
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: **1414975**

Cient:	Department of Environment	**COC Number:**	2816
Attention:	Ms. Melissa McComiskey	**Date Reported:**	2014-07-24
Client Project:	St Johns	**Date Submitted:**	2014-07-21
Purchase Order:	214004545	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1120531	WS-S-0000 Lower Reid Brook Below Tributary	2014-6406-00-SI-SP	2014-07-16	Copper	mg/L	0.001	0.001
				Iron	mg/L	0.03	0.23
				Lead	mg/L	0.001	<0.001
				Magnesium	mg/L	1	<1
				Manganese	mg/L	0.01	<0.01
				Mercury	mg/L	0.0001	<0.0001
				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	0.012
				Uranium	mg/L	0.001	<0.001
				Zinc	mg/L	0.01	<0.01
				Total Suspended Solids	mg/L	2	<2

Sample comment:

Holding time for Turbidity analysis was exceeded for the entire report.

Report comment:

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: **1414975**

Cient:	Department of Environment	**COC Number:**	2816
Attention:	Ms. Melissa McComiskey	**Date Reported:**	2014-07-24
Client Project:	St Johns	**Date Submitted:**	2014-07-21
Purchase Order:	214004545	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1120532	WS-S-0000 Tributary to Reid Brook	2014-6407-00-SI-SP	2014-07-16	Alkalinity as CaCO3	mg/L	5	5
				Bromide	mg/L	0.25	<0.25
				Chloride	mg/L	1	2
				Colour	TCU	2	48
				Conductivity	uS/cm	5	26
				Dissolved Organic Carbon	mg/L	0.5	6.2
				Fluoride	mg/L	0.10	<0.10
				Hardness as CaCO3	mg/L	1	5
				N-NH3 (Ammonia)	mg/L	0.02	0.09
				N-NO2 (Nitrite)	mg/L	0.10	<0.10
				N-NO3 (Nitrate)	mg/L	0.10	<0.10
				pH		1.00	6.86
				Sulphate	mg/L	1	2
				Total Dissolved Solids (COND - CALC)	mg/L	1	17
				Total Kjeldahl Nitrogen	mg/L	0.10	0.22
				Total Organic Carbon	mg/L	0.5	6.1
				Total Phosphorus	mg/L	0.01	0.01
				Turbidity	NTU	0.1	0.9
				Aluminum	mg/L	0.01	0.13
				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	2
				Cadmium	mg/L	0.0001	<0.0001
				Chromium	mg/L	0.001	<0.001

Sample comment:

Report comment:

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

APPROVAL:

Lorna Wilson
Laboratory Supervisor, Inorganics

REPORT OF ANALYSIS

Lab Report Number: **1414975**

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Attention:	Ms. Melissa McComiskey	**Date Reported:**	2014-07-24
Client Project:	St Johns	**Date Submitted:**	2014-07-21
Purchase Order:	214004545	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1120532	WS-S-0000	2014-6407-00-SI-SP	2014-07-16	Copper	mg/L	0.001	0.001
	Tributary to Reid Brook			Iron	mg/L	0.03	0.26
				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	0.012
				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.

APPROVAL:

Lorna Wilson
Laboratory Supervisor, Inorganics

REPORT OF ANALYSIS

Lab Report Number: **1414975**

Cient:	Department of Environment	**COC Number:**	2816
Attention:	Ms. Melissa McComiskey	**Date Reported:**	2014-07-24
Client Project:	St Johns	**Date Submitted:**	2014-07-21
Purchase Order:	214004545	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date
1120533	WS-S-0000 Reid Brook at Outlet of Reid Pond	2014-6404-00-SI-SP	2014-07-16

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	9
Conductivity	uS/cm	5	14
Dissolved Organic Carbon	mg/L	0.5	2.1
Fluoride	mg/L	0.10	<0.10
Hardness as CaCO3	mg/L	1	2
N-NH3 (Ammonia)	mg/L	0.02	0.07
N-NO2 (Nitrite)	mg/L	0.10	<0.10
N-NO3 (Nitrate)	mg/L	0.10	<0.10
pH		1.00	6.73
Sulphate	mg/L	1	1
Total Dissolved Solids (COND - CALC)	mg/L	1	9
Total Kjeldahl Nitrogen	mg/L	0.10	0.20
Total Organic Carbon	mg/L	0.5	2.0
Total Phosphorus	mg/L	0.01	<0.01
Turbidity	NTU	0.1	0.3
Aluminum	mg/L	0.01	0.05
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:

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REPORT OF ANALYSIS

Lab Report Number: **1414975**

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Attention:	Ms. Melissa McComiskey	**Date Reported:**	2014-07-24
Client Project:	St Johns	**Date Submitted:**	2014-07-21
Purchase Order:	214004545	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1120533	WS-S-0000	2014-6404-00-SI-SP	2014-07-16	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	0.005
				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.

APPROVAL:

Lorna Wilson
Laboratory Supervisor, Inorganics

REPORT OF ANALYSIS

Lab Report Number: **1414975**

Cient:	Department of Environment	**COC Number:**	2816
Attention:	Ms. Melissa McComiskey	**Date Reported:**	2014-07-24
Client Project:	St Johns	**Date Submitted:**	2014-07-21
Purchase Order:	214004545	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date
1120534	WS-S-0000 Camp Pond Brook Below Camp Pond	2014-6405-00-SI-SP	2014-07-16

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	22
Conductivity	uS/cm	5	37
Dissolved Organic Carbon	mg/L	0.5	3.9
Fluoride	mg/L	0.10	<0.10
Hardness as CaCO3	mg/L	1	7
N-NH3 (Ammonia)	mg/L	0.02	0.07
N-NO2 (Nitrite)	mg/L	0.10	<0.10
N-NO3 (Nitrate)	mg/L	0.10	<0.10
pH		1.00	7.01
Sulphate	mg/L	1	4
Total Dissolved Solids (COND - CALC)	mg/L	1	24
Total Kjeldahl Nitrogen	mg/L	0.10	0.22
Total Organic Carbon	mg/L	0.5	4.0
Total Phosphorus	mg/L	0.01	0.03
Turbidity	NTU	0.1	0.5
Aluminum	mg/L	0.01	0.09
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.

APPROVAL:

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Laboratory Supervisor, Inorganics

REPORT OF ANALYSIS

Lab Report Number: **1414975**

Cient:	Department of Environment	**COC Number:**	2816
Attention:	Ms. Melissa McComiskey	**Date Reported:**	2014-07-24
Client Project:	St Johns	**Date Submitted:**	2014-07-21
Purchase Order:	214004545	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1120534	WS-S-0000	2014-6405-00-SI-SP	2014-07-16	Copper	mg/L	0.001	0.003
	Camp Pond Brook Below Camp Pond			Iron	mg/L	0.03	0.21
				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	0.023
				Potassium	mg/L	1	<1
				Selenium	mg/L	0.001	<0.001
				Sodium	mg/L	2	<2
				Strontium	mg/L	0.001	0.014
				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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