Real-Time Water Quality Deployment Report

Voisey's Bay Network

June 12 to
July 15, 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 June 12, 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 33 days. Instruments were removed by Vale Environment staff on July 15, 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 alongside 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)	June 12 2014	Deployment	Fair	Fair	Good	Excellent	Excellent
	July 15 2014	Removal	-	-	-	-	-
Camp Pond Brook (62885)	June 12 2014	Deployment	Excellent	Good	Fair	Good	Excellent
	July 15 2014	Removal	-	-	-	-	-
Tributary to L. Reid B. (62886)	June 12 2014	Deployment	Excellent	Excellent	Good	Fair	Fair
	July 15 2014	Removal	-	-	-	-	-
Lower Reid Brook (62887)	June 12 2014	Deployment	Good	Good	Good	Good	Excellent
	July 15 2014	Removal	-	-	-	-	-

- During deployment at Reid Brook at outlet to Reid Pond station, the field instrument ranked against the QAQC as 'fair' for temperature, and pH. It ranked 'good' for specific conductivity readings and 'excellent' for dissolved oxygen and turbidity. The 'fair' ranking for water temperature and pH may be a result of the two instruments (field & QA) not being left to stabilize in the brook long enough. The instrument takes some time to acclimatize before producing an accurate field reading. 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, water temperature and turbidity data ranked as 'excellent' with pH and dissolved oxygen data ranking as 'good'. Specific Conductivity data ranked as 'fair' at deployment, which may be a result of a bubble becoming trapped within the conductivity probe and influencing a less than accurate reading. Conductivity data for the rest of the deployment period appears to be accurate. 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 the Tributary to Lower Reid Brook, temperature and pH readings ranked as 'excellent' with specific conductivity comparisons ranking as 'good'. The comparisons between readings for dissolved oxygen and turbidity ranked as 'fair' at deployment. The 'fair' ranking for dissolved oxygen and turbidity may have been a result of the positioning of the instruments when the readings were taken. The slightest disturbance in the water can create a difference in the reading. The differences between the QA reading and the field reading were not great enough to cause concern that the instrument was not performing accurately. There was no QAQC Comparison done at the removal of the instrument for this deployment period, therefore there is no ranking for removal.

- At the station on Lower Reid Brook, temperature, pH, specific conductivity and dissolved oxygen readings rank as 'good' at deployment while turbidity reading comparisons ranked as 'excellent'. These readings are considered reasonable for initial deployment. There was no QAQC comparison done at removal of the instrument for this deployment period, therefore is no ranking for removal.

Data Interpretation

- The following graphs and discussion illustrate significant water quality-related events from June 12 to July 15, 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 from Reid Pond

Water Temperature

- Water temperature ranges from 2.21°C to 9.95°C during the deployment period (Figure 1).
- Water temperature is increasing throughout the deployment period. This is indicated by the linear trend line through the temperature data. This trend is expected given the warming ambient air temperatures as the summer month's approach which directly influences the water temperatures.
- Average water temperature is 5.23°C for the deployment period.

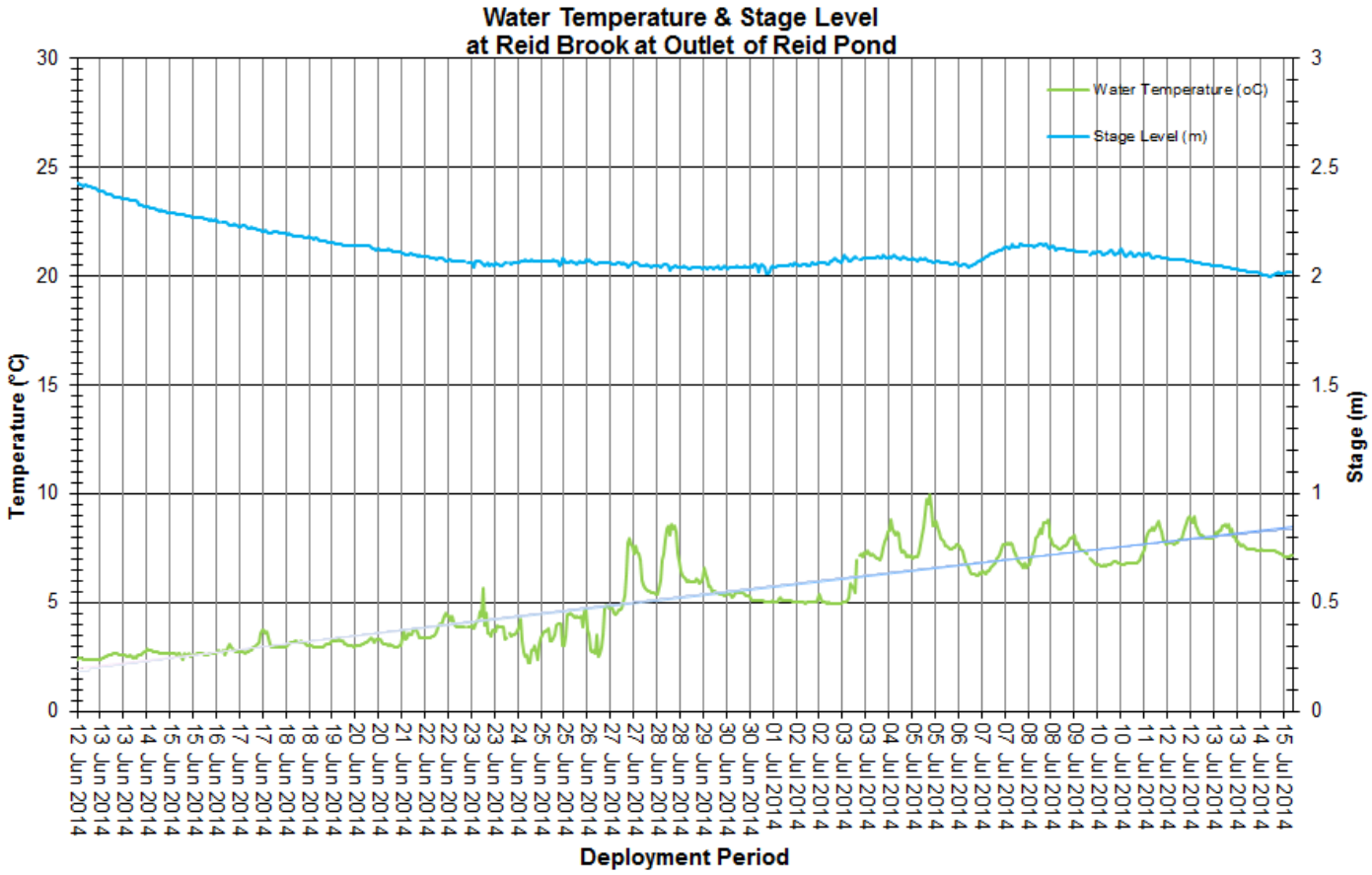

Figure 1: Water temperature & Stage Level at Reid Brook at Outlet of Reid Pond

pH Levels

- During the deployment period the pH ranged between 6.17 and 6.76 pH units (Figure 2).
- During this deployment, the majority of pH values were just below and along the minimum CCME guideline for the Protection of Aquatic Life. On July 3rd there is a slight increase in stage levels which reflected in a slight decrease in pH values for a short period of time.
- During lower stage periods pH values will increase. This is seen on Figure 2 from July 4th onwards the pH level increases slightly as the stage starts to level out.
- The CCME Guidelines for the Protection of Aquatic Life provide a basis by which to evaluate the overall health of the brook. Naturally all streams and brooks are different and can have 'normal' ranges outside of the guidelines identified. Guidelines are indicated in red on Figure 2.

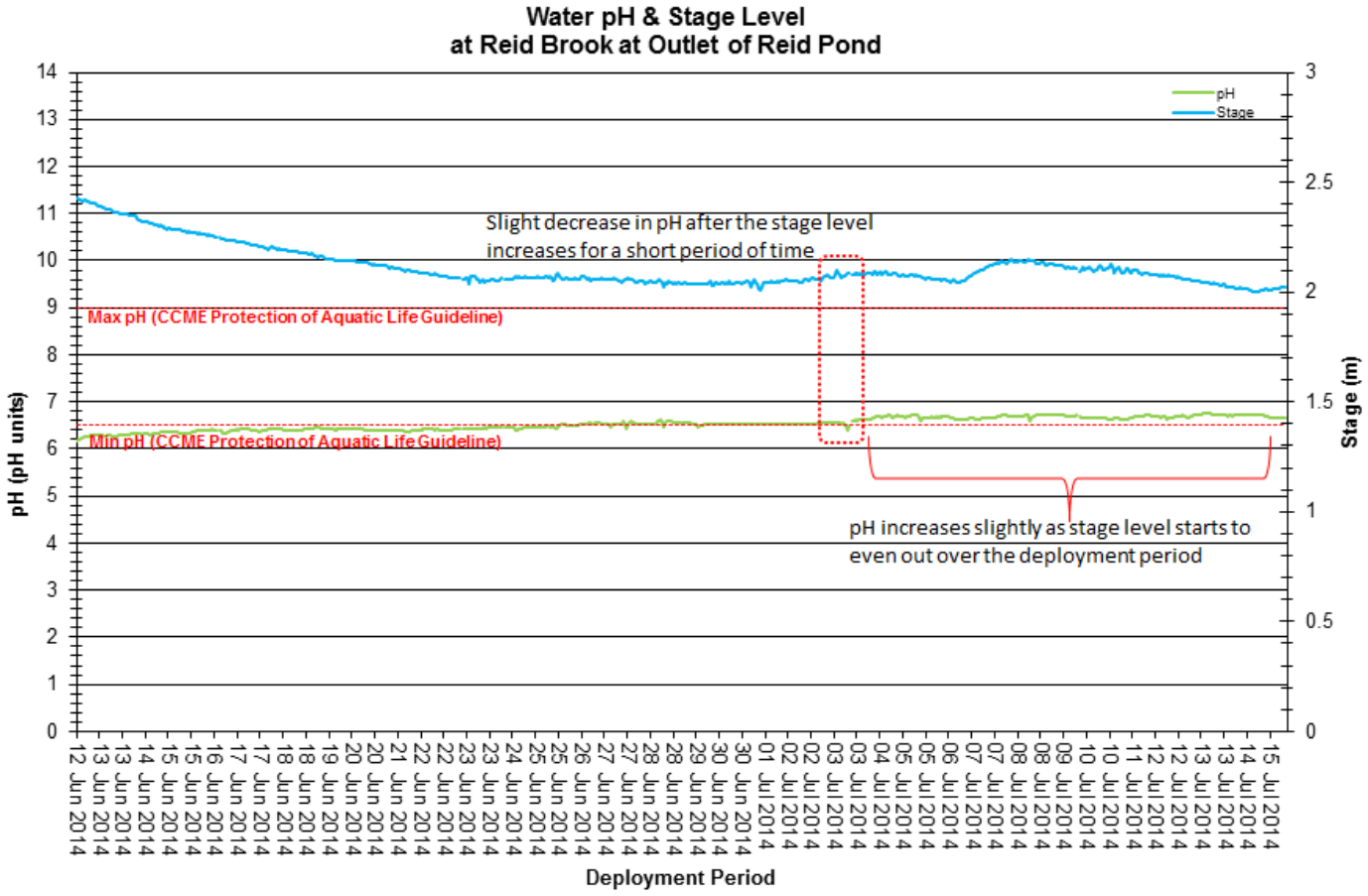

Figure 2: pH and stage level

Specific Conductivity

- Specific conductivity values range from 9.7µS/cm to 11.5µS/cm during the deployment period, with a median of 11.0µS/cm (Figure 3).
- Specific conductivity remains very low throughout the deployment period. This trend is expected as the flow from this station is directly from a stable lake environment.
- There are small dips in the specific conductivity levels during the deployment. Generally when stage level increases it is common to see the conductivity levels decrease as particles in the water column are flushed through the system during high stage times.

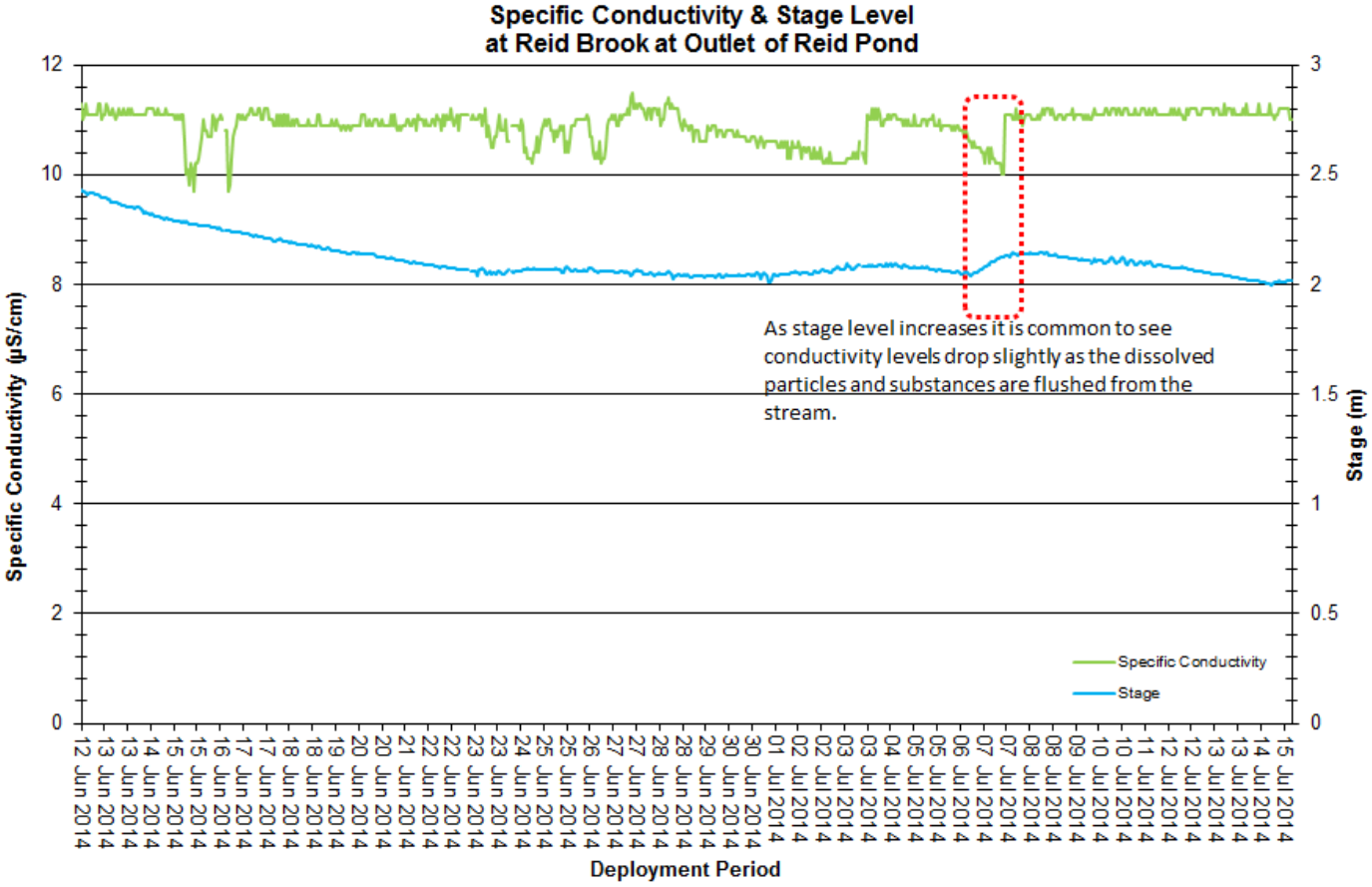

Figure 3: Specific conductivity and stage level

Dissolved Oxygen

- Dissolved oxygen content ranges between 11.28mg/l and 12.76mg/l. The saturation of dissolved oxygen ranges from 88.5% to 102.7% (Figure 4).
- Dissolved oxygen in mg/L is measured by the water quality instrument, the instrument then calculates percent saturation with water temperature. Dissolved Oxygen mg/L is directly influenced by the temperature of the water; therefore as water temperatures increase during this deployment (Figure 4) the Dissolved Oxygen concentration decreases slightly in the water column.
- The dissolved oxygen concentration levels (mg/L) 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. The median dissolved oxygen content for this deployment period is 12.31mg/l.

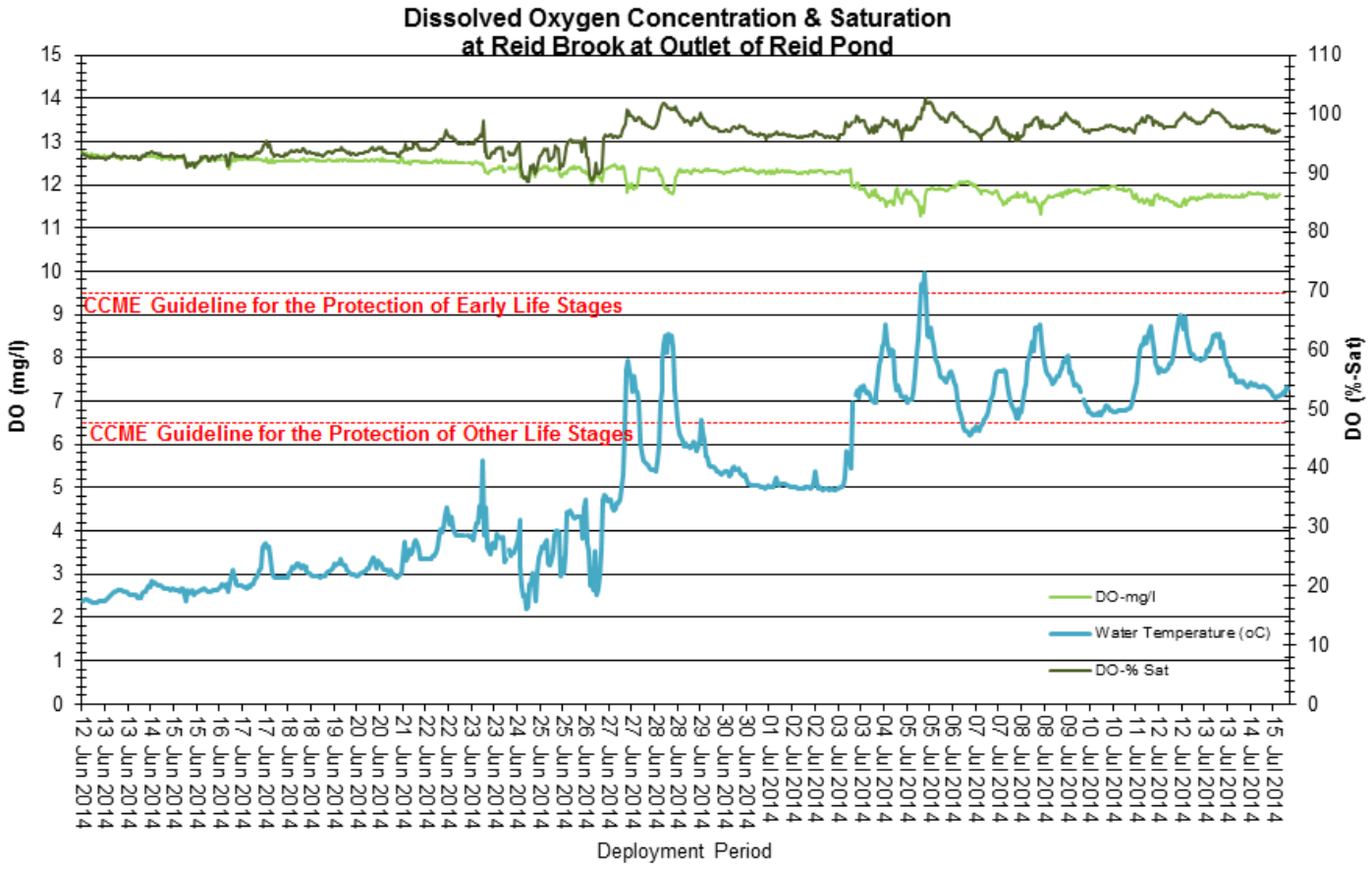

Figure 4: Dissolved Oxygen and Percent Saturation

Turbidity

- Turbidity levels during this deployment period ranged between a minimum of 0.0 NTU to a maximum of 49.3 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 remained at 0.0 NTU. This trend is not unusual for this station as the water flowing from the lake is typically very clean; clear and cold (Figure 5).
- The peaks in turbidity levels on June 18th - 19th, June 11th, June 30th and July 7th correspond with rainfall (figure 6) around those dates. The high turbidity peak on June 26th is likely a result of debris passing over the sensor at the exact time that the instrument was taking a reading as it cannot be linked to any natural influence.

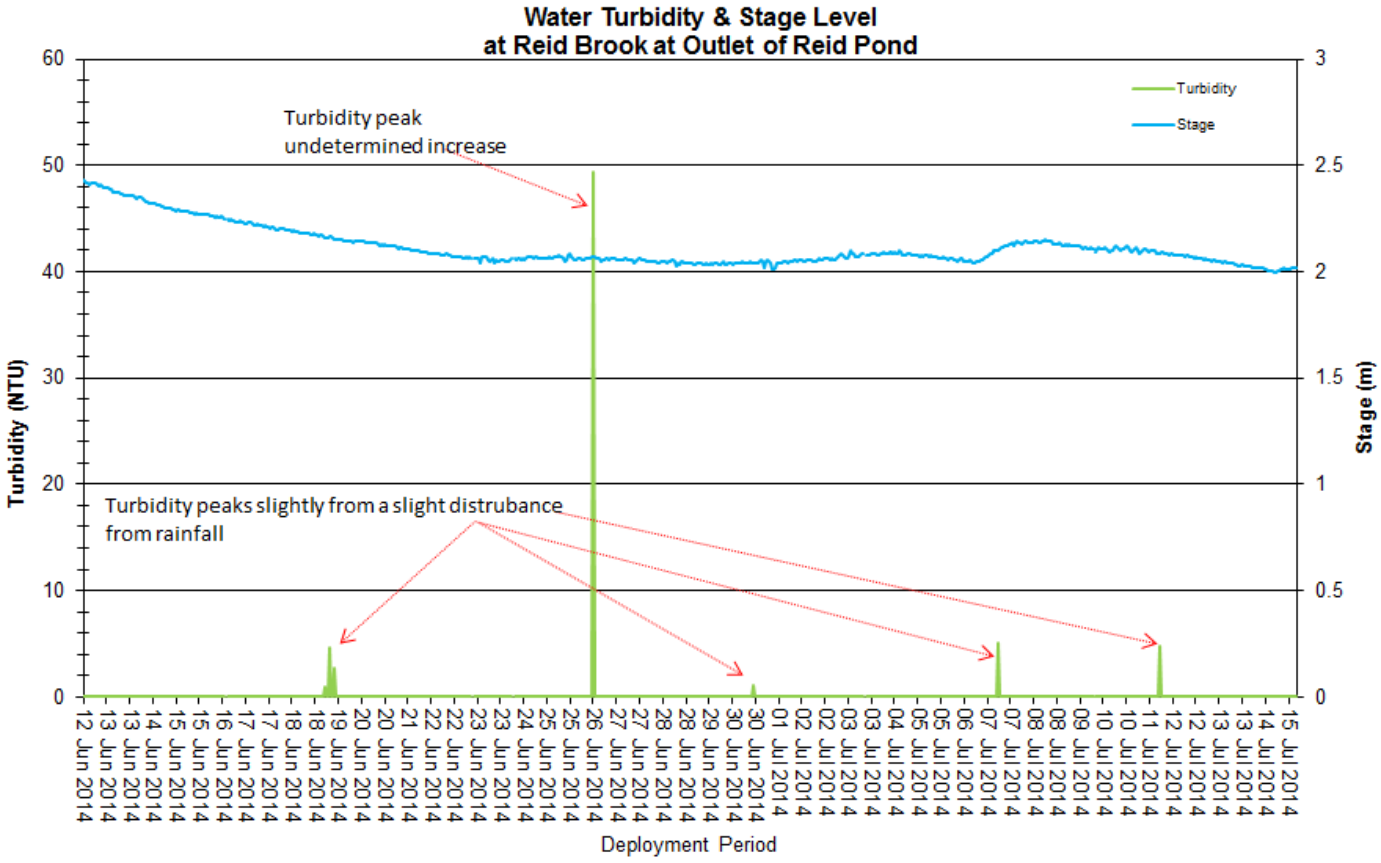

Figure 5: Turbidity and Stage level

Stage, Flow and Precipitation

- Stage, flow and precipitation are graphed below to show the relationship between rainfall and water level (Figure 6). The Precipitation data used in this report came from the weather station in Nain. This graph provides an overview of the rainfall that occurred during the deployment period.
- Stage is relatively stable throughout the deployment period. Stage ranges from 2.00m to 2.43m, a difference of 0.43m.
- During deployment, flow levels ranged within a minimum of 3.58 m^3/s to 11.10 m^3/s. At the beginning of the deployment the flow level dropped down to approximately 5 m^3/s and remained within that range for the rest of the deployment. This may be related to the draining off of the spring thaw water.

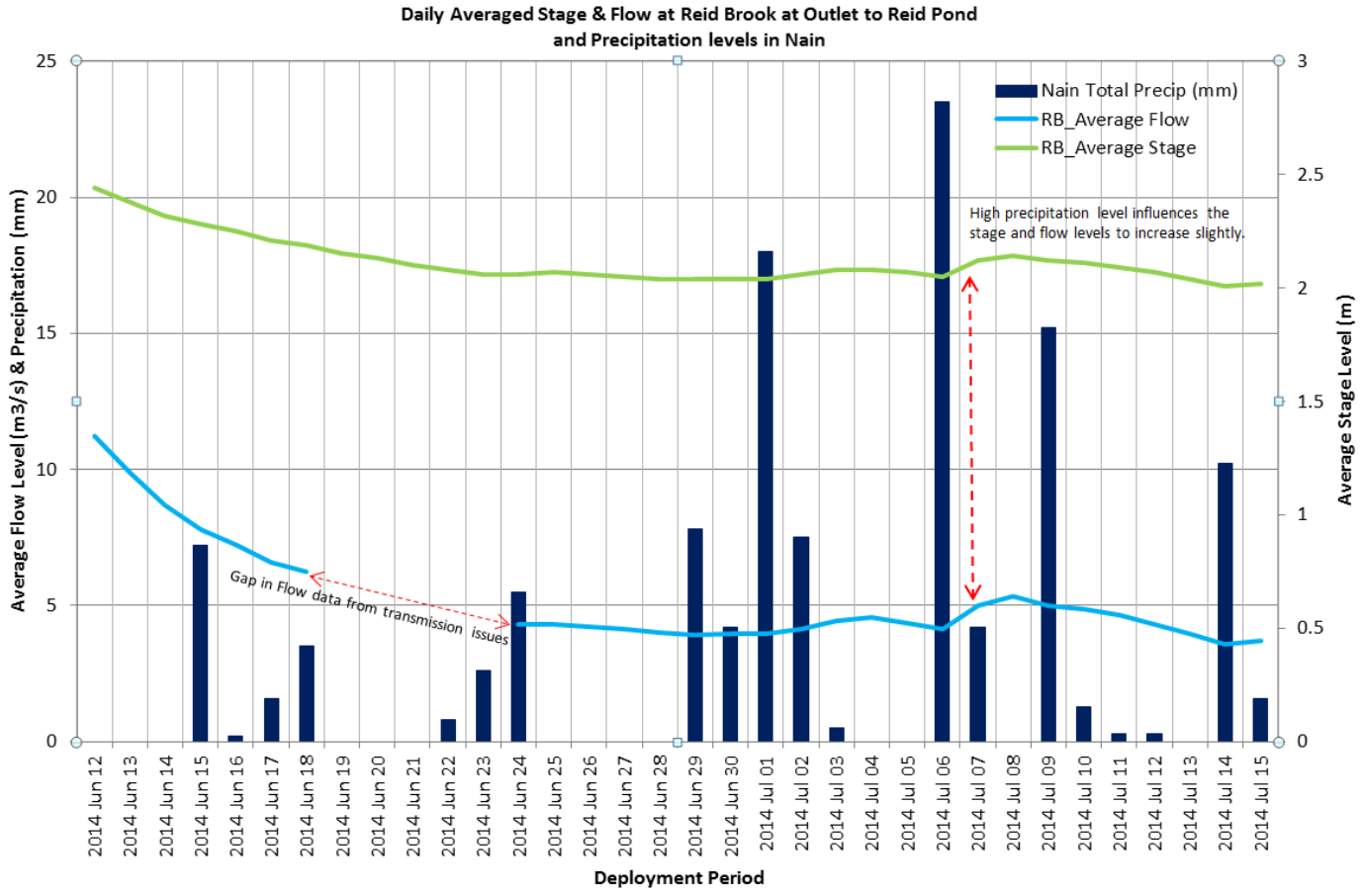

Figure 6: Daily precipitation in Nain and average daily stage & flow level at Reid Brook at Outlet of Reid Pond

Camp Pond Brook

Water Temperature

- Water temperature ranges from 8.35°C to 19.27°C during the deployment period (Figure 7).
- Water temperature is increasing during this deployment period. This trend is expected as the air temperatures increase with the onset of summer months. Average water temperature is 12.99°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 June the water temperatures are higher with the lower water level.
- This station typically has the highest water temperatures and greatest fluctuations when compared to the other stations in the network.

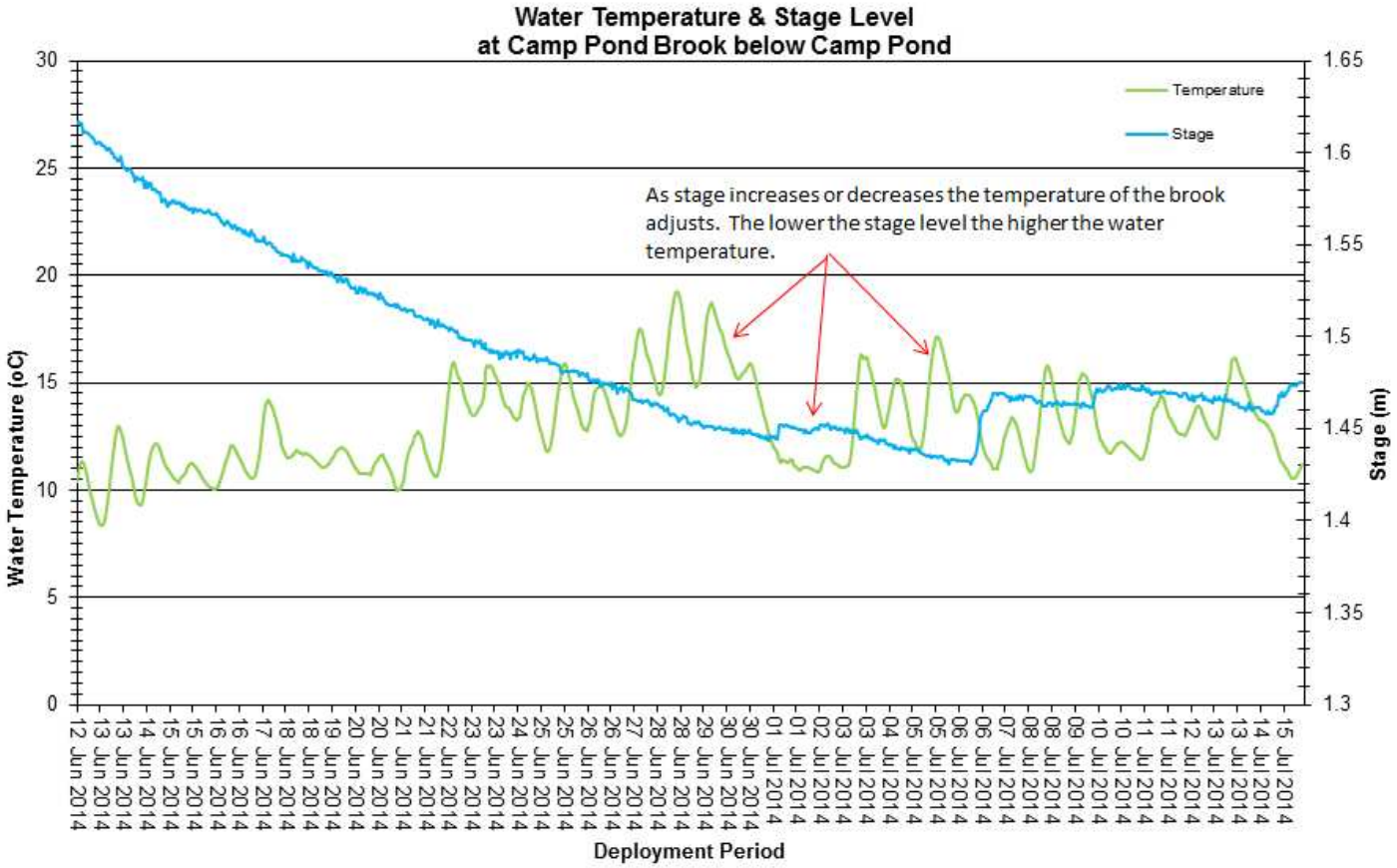

Figure 7: Water Temperature & Stage Level at Camp Pond Brook

pH

- During this deployment period the pH ranges are between 6.30 and 7.04 pH units (Figure 8).
- The pH values are very stable at this station, only fluctuating diurnally during the deployment period. On July 7th there is a small decrease in pH as the stage level increases. This is a natural occurrence between peaks in stage level and pH. pH levels become slightly acidic as the water chemistry readjusts to an increase in water volume.
- Majority of 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.
- CCME provides a guideline by which to evaluate the overall health of a waterway. Naturally all streams and brooks are different and have their own 'normal' range for pH.

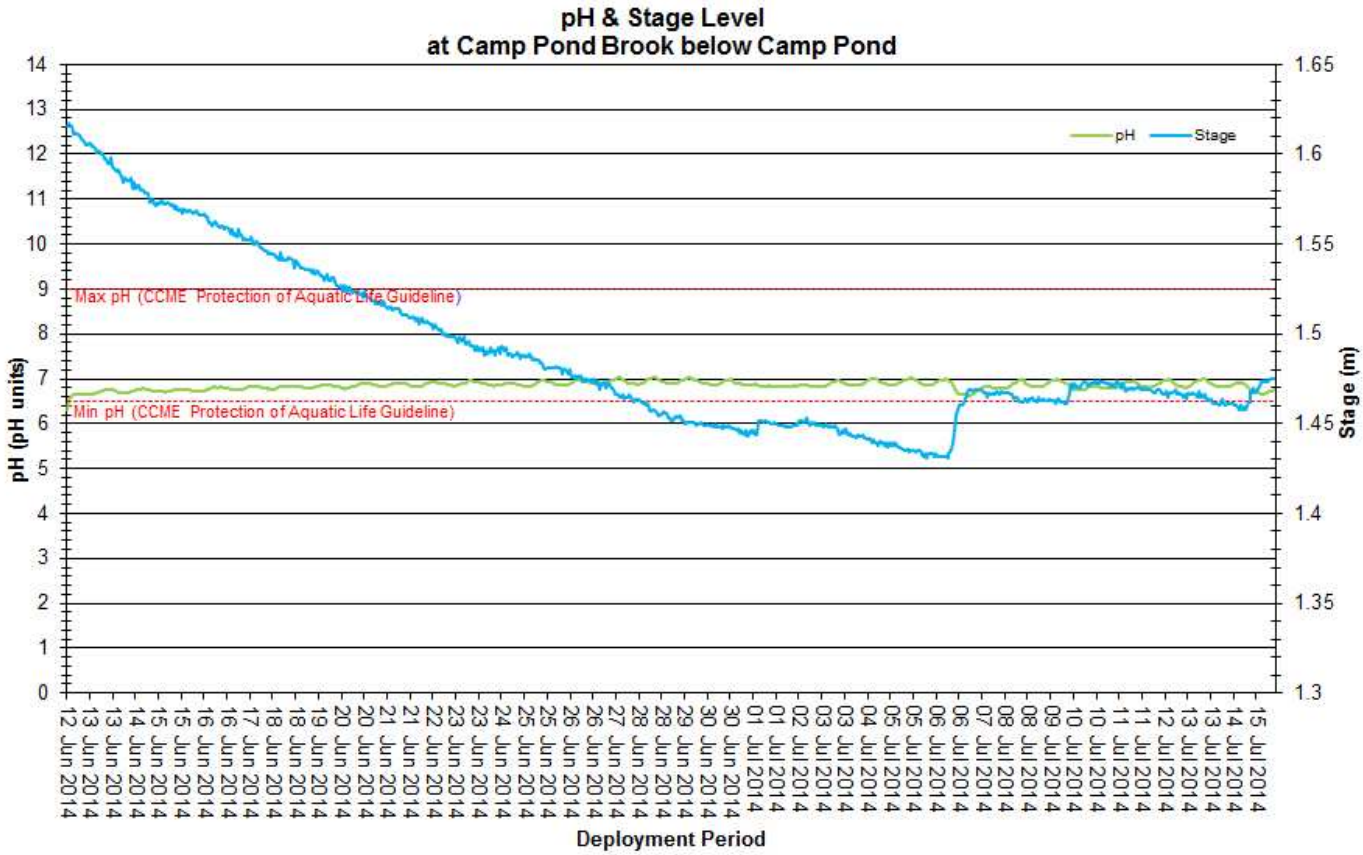

Figure 8: pH & Stage Level at Camp Pond Brook

Specific Conductivity

- Specific conductivity ranges from 27.8µS/cm to 43.9µS/cm during the deployment period, with a median of 31.7µS/cm (Figure 9).
- Stage data is included in Figure 9 to illustrate the influence that stage level has on conductivity at this station. Typically, as stage level decreases, the specific conductivity of the water increases because of the increase in concentration of dissolved solids present in the water column. This relationship is evident at the beginning of deployment until June 21st.
- On several different days of deployment the increase in stage influenced an increase in conductivity at this station. The highlighted spikes in conductivity correspond with precipitation events recorded on the same dates (see Figure 12). It is likely that runoff from nearby roadways and heavily used areas made its way into the brook increasing the suspended sediment content.

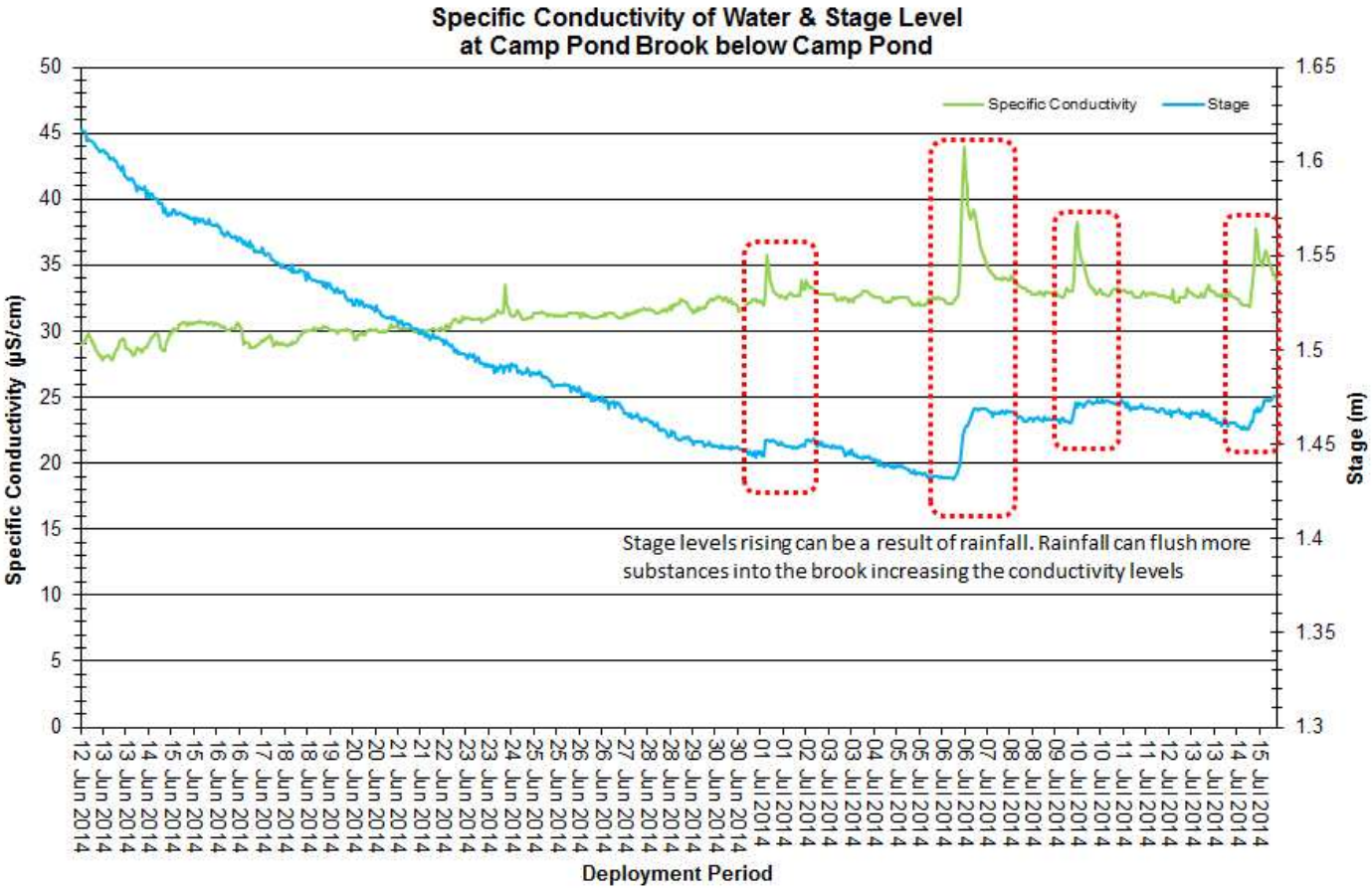

Figure 9: Specific Conductivity & Stage Level at Camp Pond Brook

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 8.66mg/l and 10.81mg/l. The saturation of dissolved oxygen ranges from 86.8% to 99.5% (Figure 10).
- Dissolved Oxygen (%Sat) remains stable throughout this deployment period. Dissolved Oxygen (mg/L) is relatively stable however there are several evident decreases and increases that correspond with the stage level during these times (noted in red circles on Figure 10).
- Guidelines are indicated in red on Figure 10. Early on in the deployment period the DO mg/L values are sitting just above the CCME Guideline for the Protection of Early Life Stages. Midway through the deployment there are several low DO (mg/L) values. This is to be expected as water temperatures increases in the summer months and stage level fluctuates.

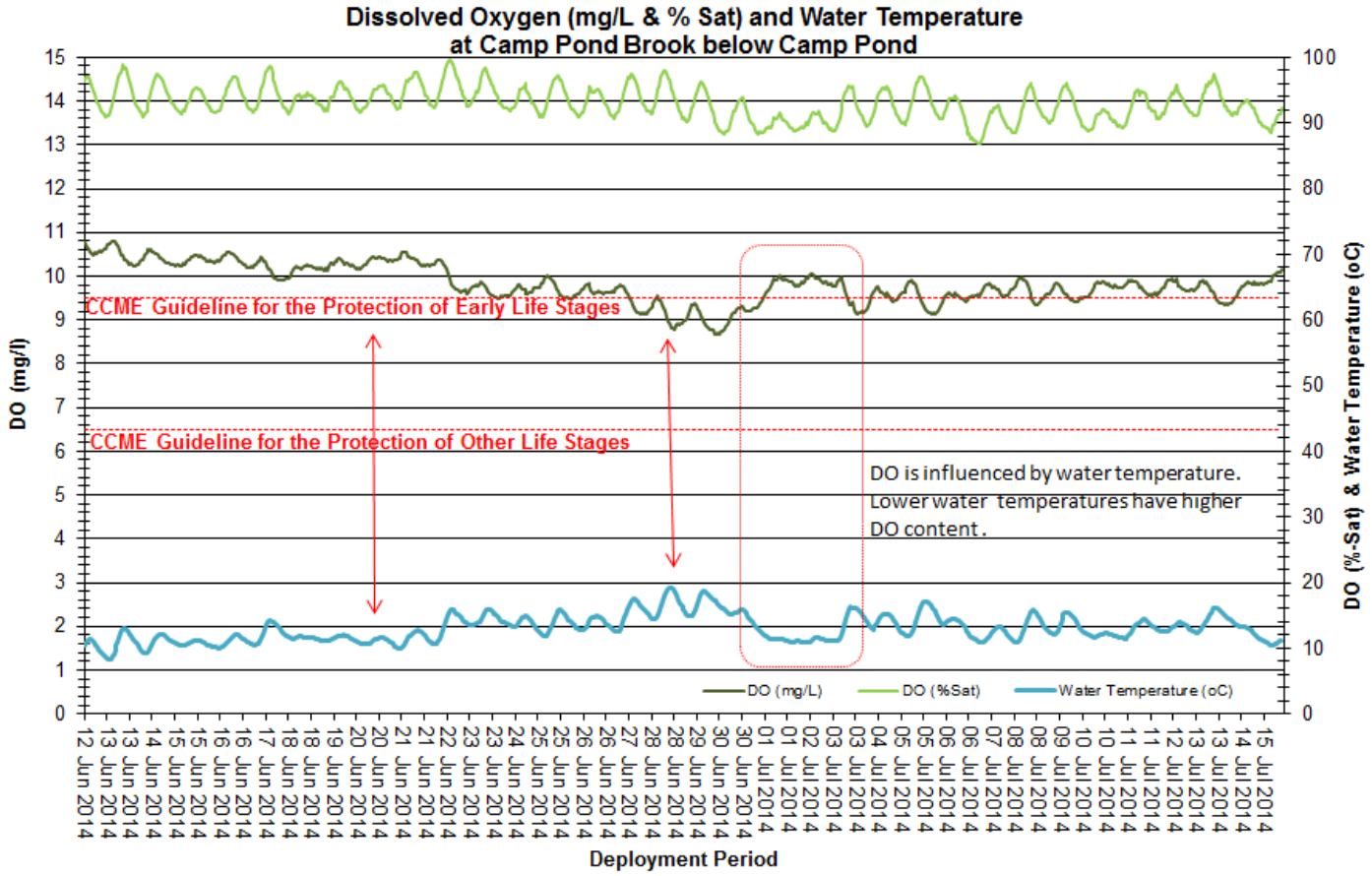

Figure 10: Dissolved Oxygen & Percent Saturation at Camp Pond Brook

Turbidity

- Turbidity values range between 0NTU and 61.3NTU (Figure 11). A median value of 0.5 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. Some of the higher stage levels also have corresponding turbidity peaks.
- The largest event of 61.3 NTU on July 1st, 2014 corresponds with a large precipitation event (on Figure 11). It can be assumed that the turbidity value of 61.3 NTU was a result of runoff and rainfall stirring up particles and substances in the brook.

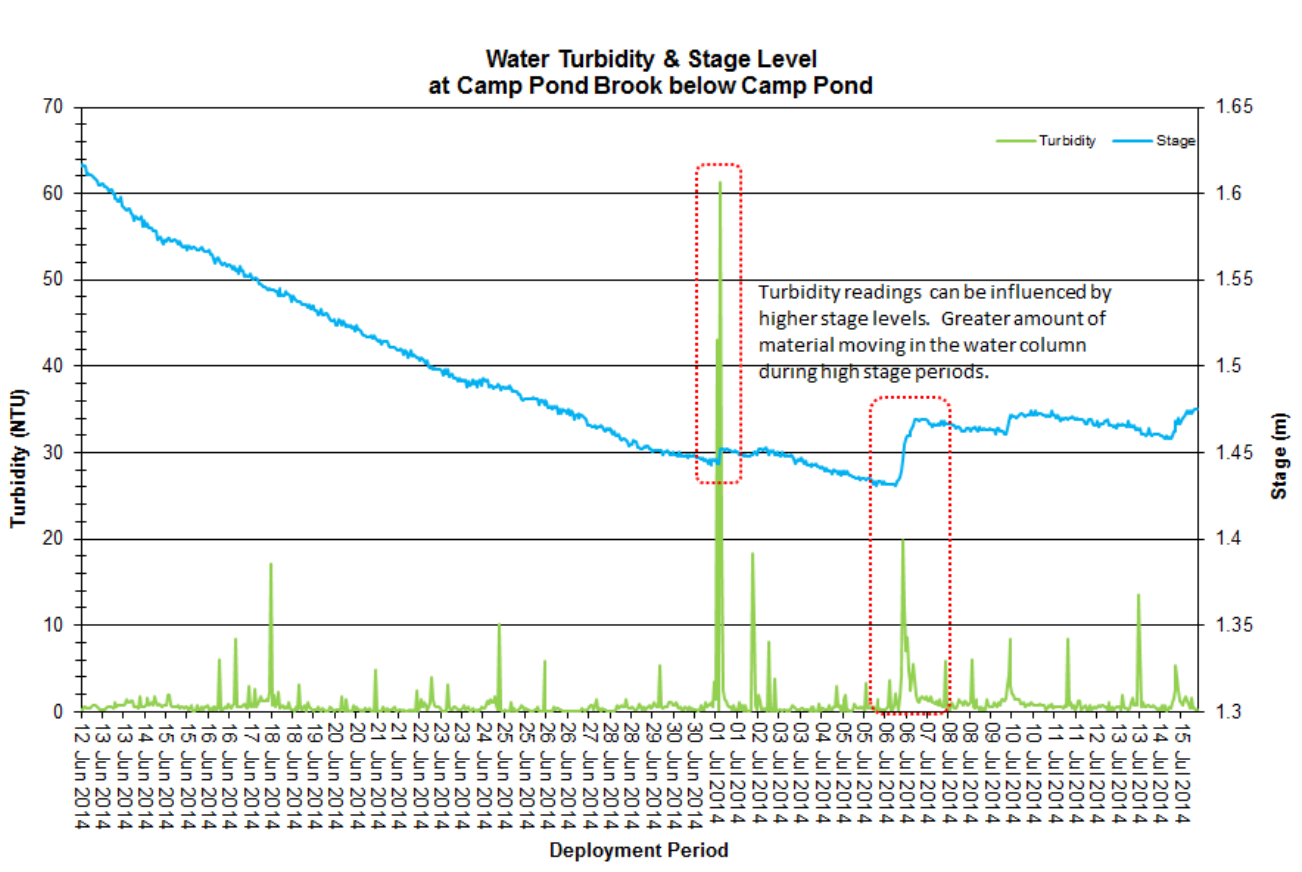

Figure 11: Turbidity & Stage Level at Camp Pond Brook

Stage 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 Environment Canada's Nain weather station.
- During the deployment period, the stage values ranged from 1.43 m to 1.62 m. The larger peaks in stage do correspond with substantial rainfall events as noted on Figure 12.
- Stage, Flow and precipitation are graphed below to show the relationship between rainfall and water level (Figure 12). It is evident with the stage (m) data that the peaks in stage are a result of precipitation.

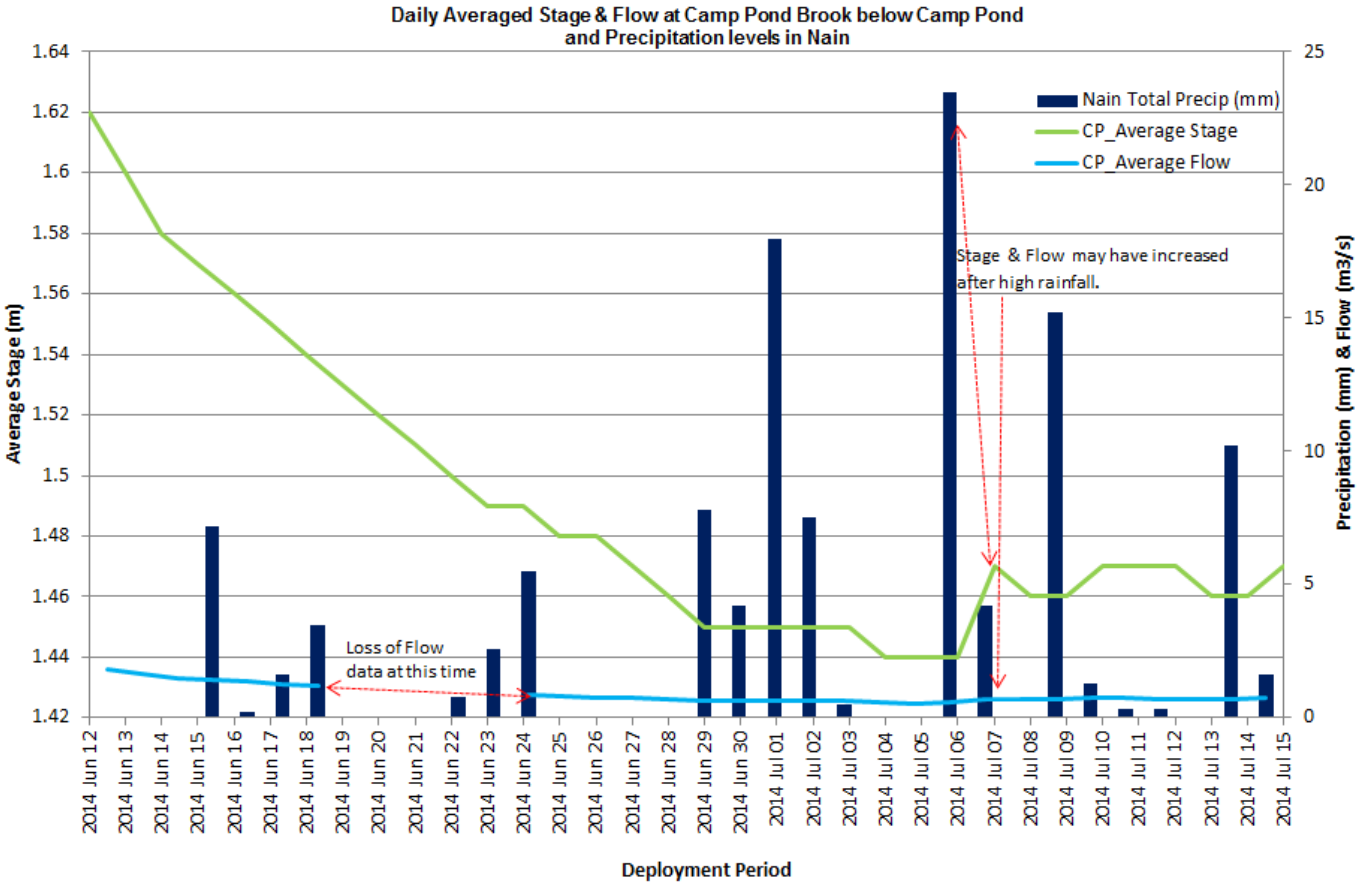

Figure 12: Daily Precipitation, Average Daily Stage & Flow level at Camp Pond Brook

(Weather data recorded at Nain)

Tributary to Lower Reid Brook

Water Temperature

- Water temperature ranges from 5.8°C to 15.80°C during the deployment period (Figure 13).
- Water temperature is increasing throughout the deployment period. This trend is expected given the warming ambient air temperatures as the summer approaches (Figure 13). This stream is sensitive to changes in the ambient air temperature and fluctuates considerably depending on the weather and time of day.
- It is evident on the graph that as the stage levels increase the water temperature decreases for a short span of time.
- The median water temperature is 9.70°C for this deployment period.

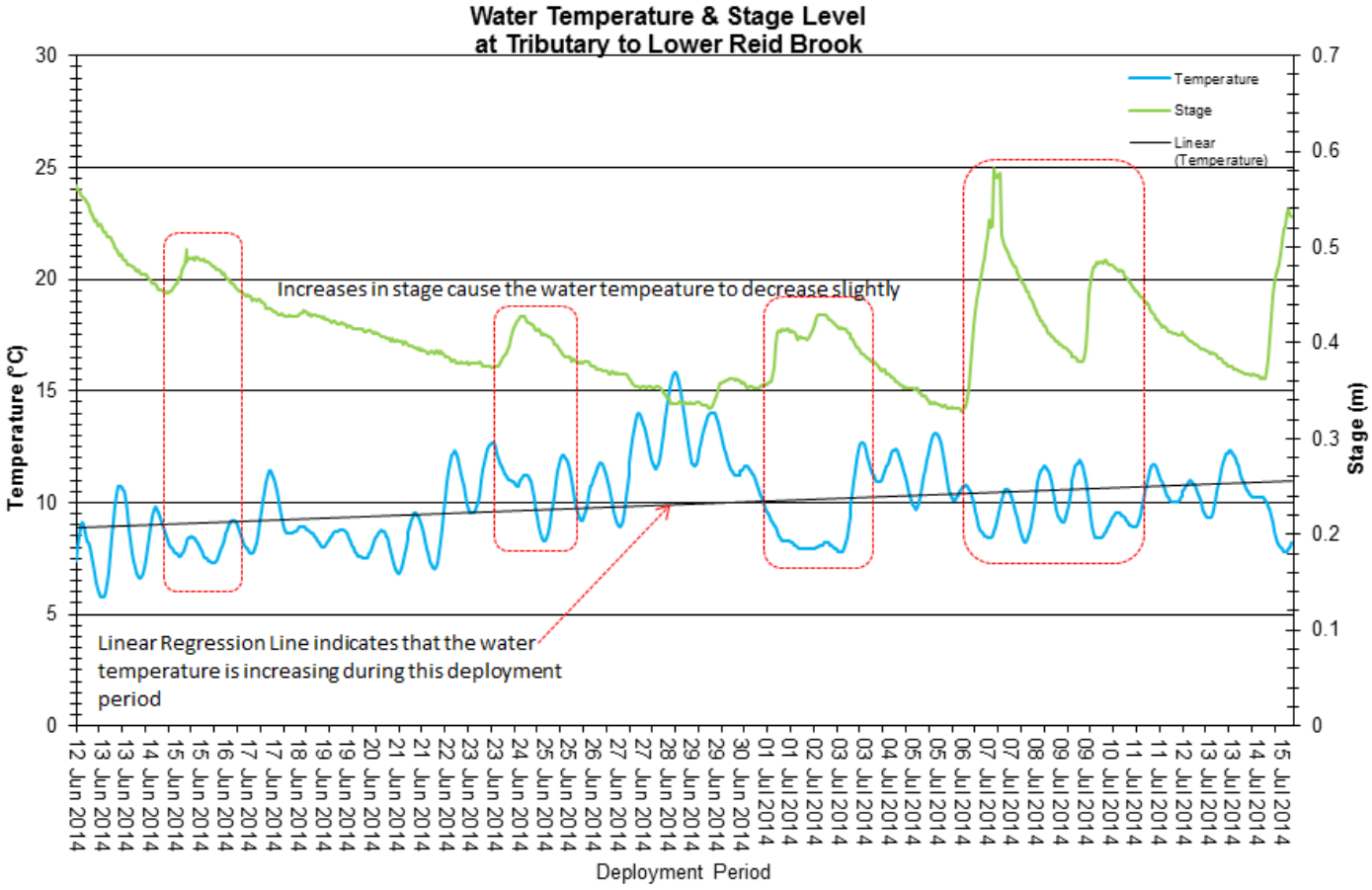

Figure 13: Water temperature at Tributary to Lower Reid Brook

pH

- pH ranges between a minimum of 6.18 and a maximum of 6.82 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 June 15th, July 7th and July 9th. These events are highlight in red on Figure 14.
- Majority of the pH readings fall within the recommended range 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 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 6.6 pH units.

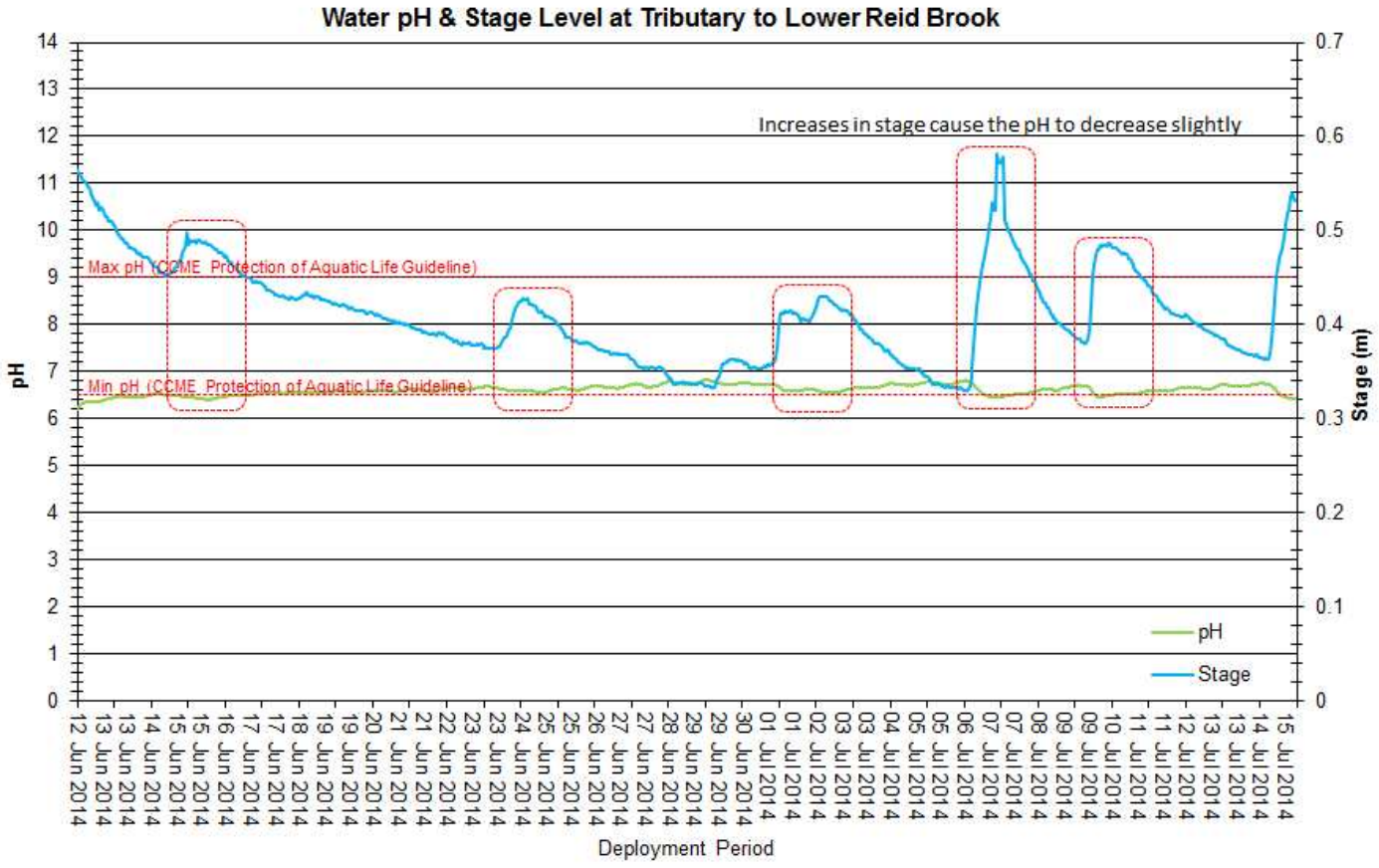

Figure 14: pH and stage level at Tributary to Lower Reid Brook

Specific Conductivity

- Specific conductivity ranges between 18.4µS/cm and 29.0µS/cm during the deployment period, with a median of 23.9 µS/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.

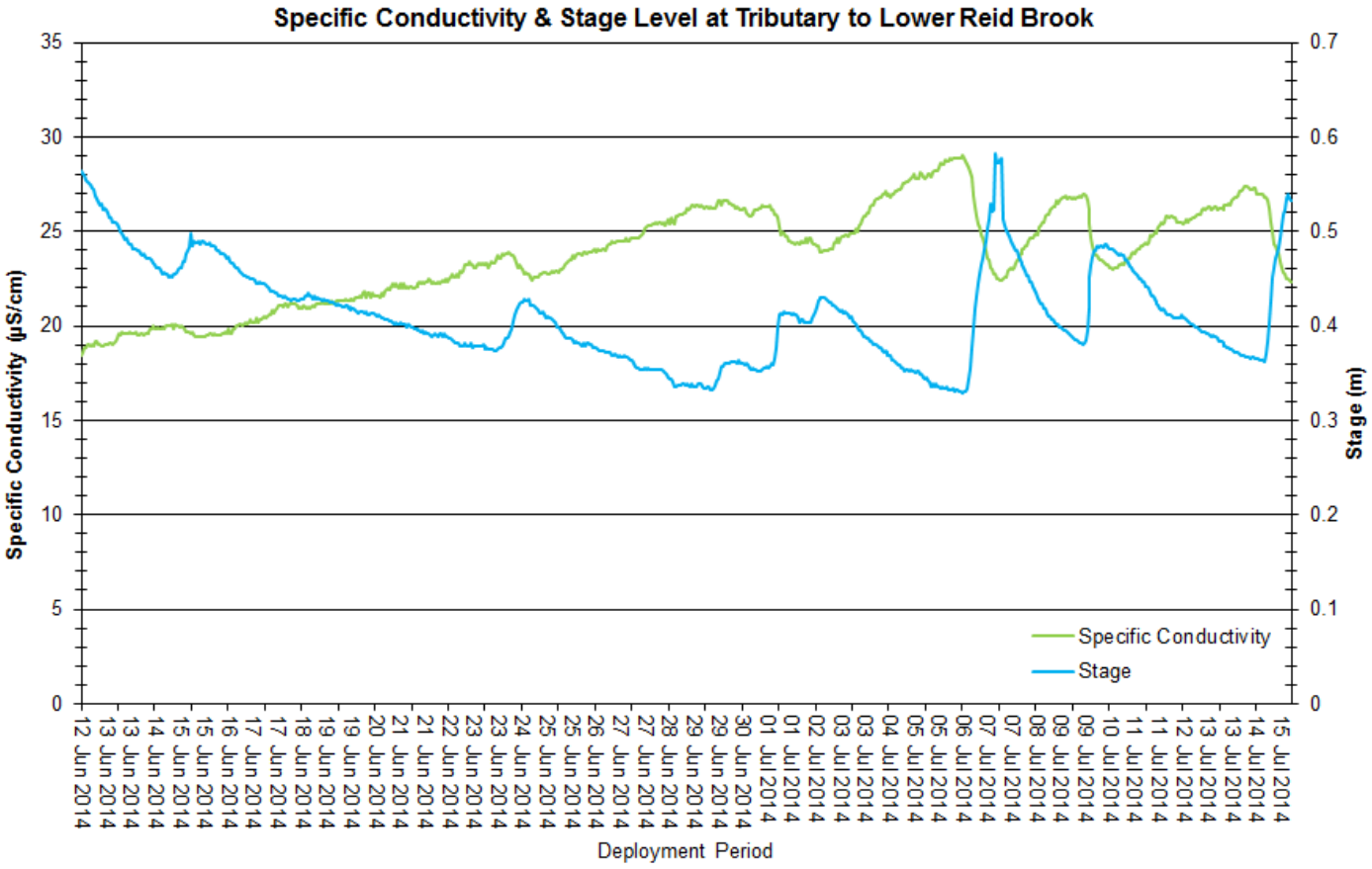

Figure 15: Specific conductivity and stage level at Tributary to Lower Reid Brook

Dissolved Oxygen

- Dissolved oxygen content ranges between 9.28mg/l and 11.88mg/l. The saturation of dissolved oxygen ranges from 91.5% to 95.8% (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.
- During this deployment the dissolved oxygen levels were reasonably consistent. The circled data on Figure 16 indicates the relationship between water temperature and dissolved oxygen. As water temperature increases the level of dissolved oxygen consumed increases, which means there is less dissolved oxygen in the brook during these temperatures. This is the opposite with cooler water temperatures.
- The dip in dissolved oxygen on June 17th also corresponds with spikes in turbidity at those times. It is unclear what external factor could have affected this parameter and turbidity at the same time.
- There are several small events noted on Figure 16, on June 21st and July 1st – 2nd. These events also correspond with some of the warmer air temperatures during the deployment period (depicted on Figure 15).

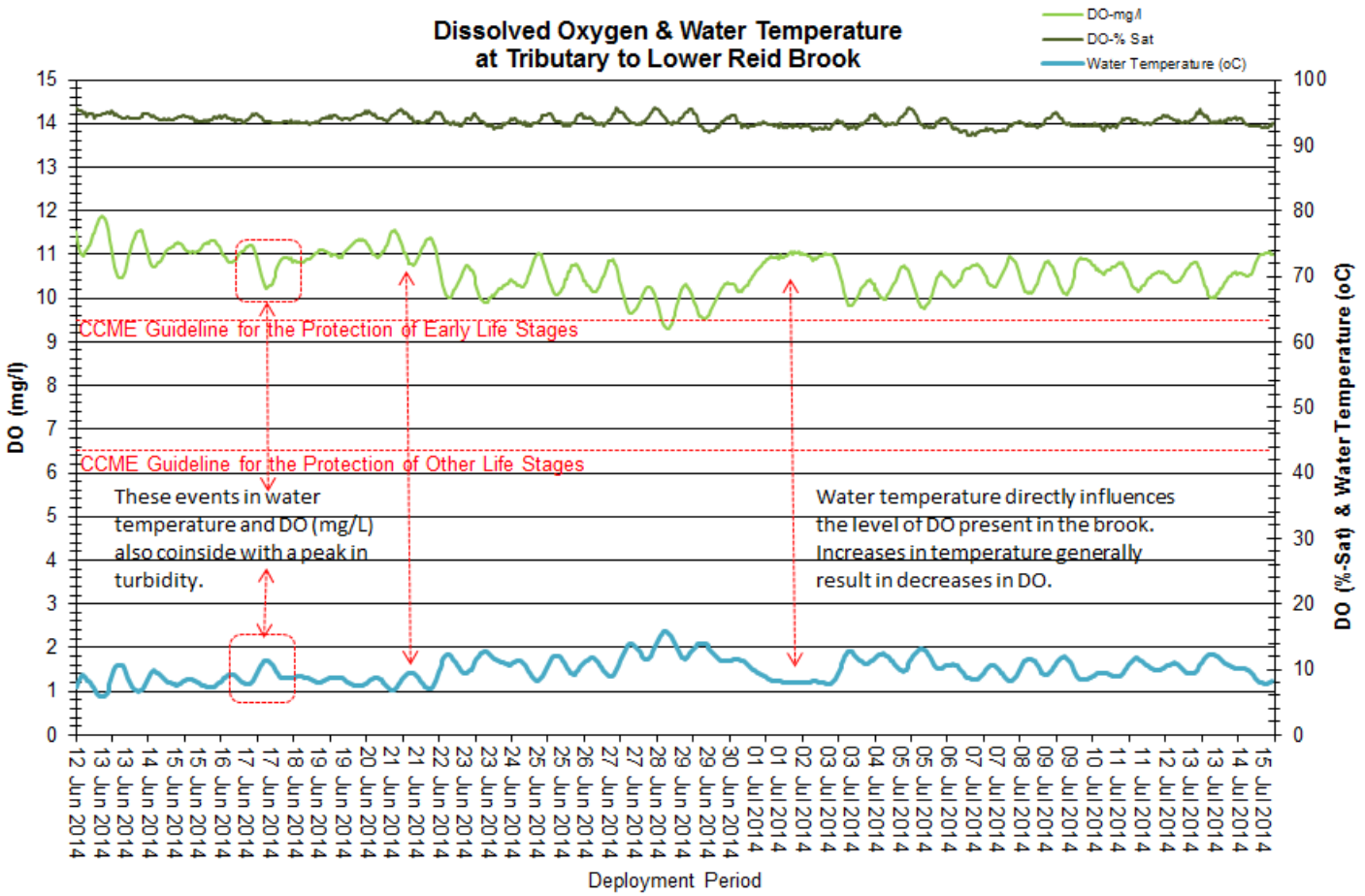

Figure 16: Dissolved oxygen and percent saturation at Tributary to Lower Reid Brook

Turbidity

- Turbidity data for this deployment ranged between a minimum of 0 NTU and a maximum of 125.3 NTU (Figure 17).
- The majority of the turbidity peaks correspond with higher stage values during the same time frame. These are highlighted on Figure 17 with red arrows.
- On June 17th on two separate occasions the turbidity data spiked and it was not related to a stage increase at that time. It is undetermined what caused these high turbidity increases. This spikes also corresponded with a decrease in dissolved oxygen on the same day.

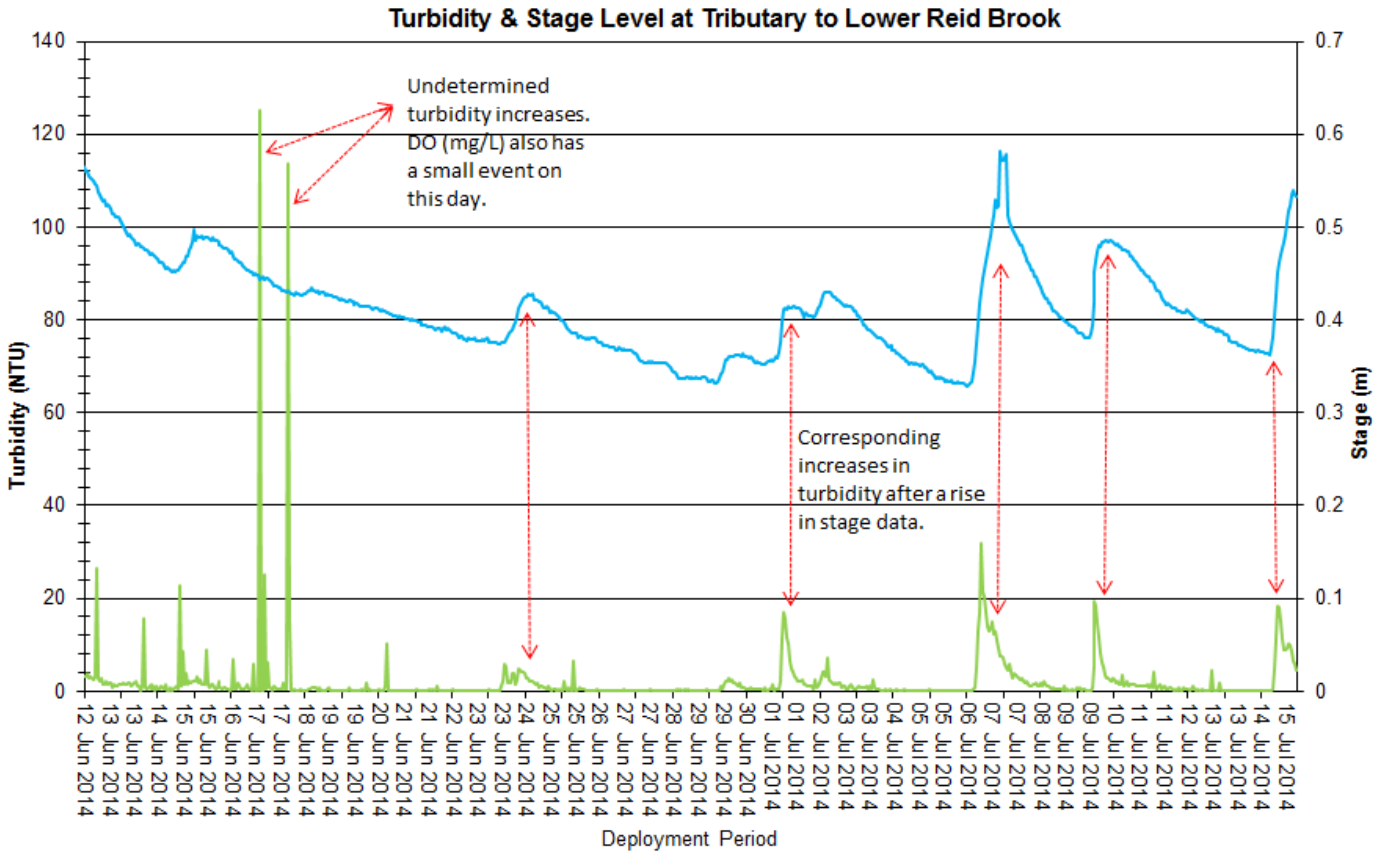

Figure 17: Turbidity and stage level at Tributary to Lower Reid Brook

Stage, Stream Flow 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). Stream flow 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 Stream flow 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 0.34m to 0.58m. The stream flow values ranges from 0.03m^3/s to 0.41m^3/s .The larger peaks in stage and stream flow do correspond with substantial rainfall events as noted on Figure 18.
- Precipitation data was obtained from Environment Canada's Weather station in Nain. Precipitation ranges for the deployment period were a minimum of 0.0 mm and a maximum of 23.5 mm on July 6th.

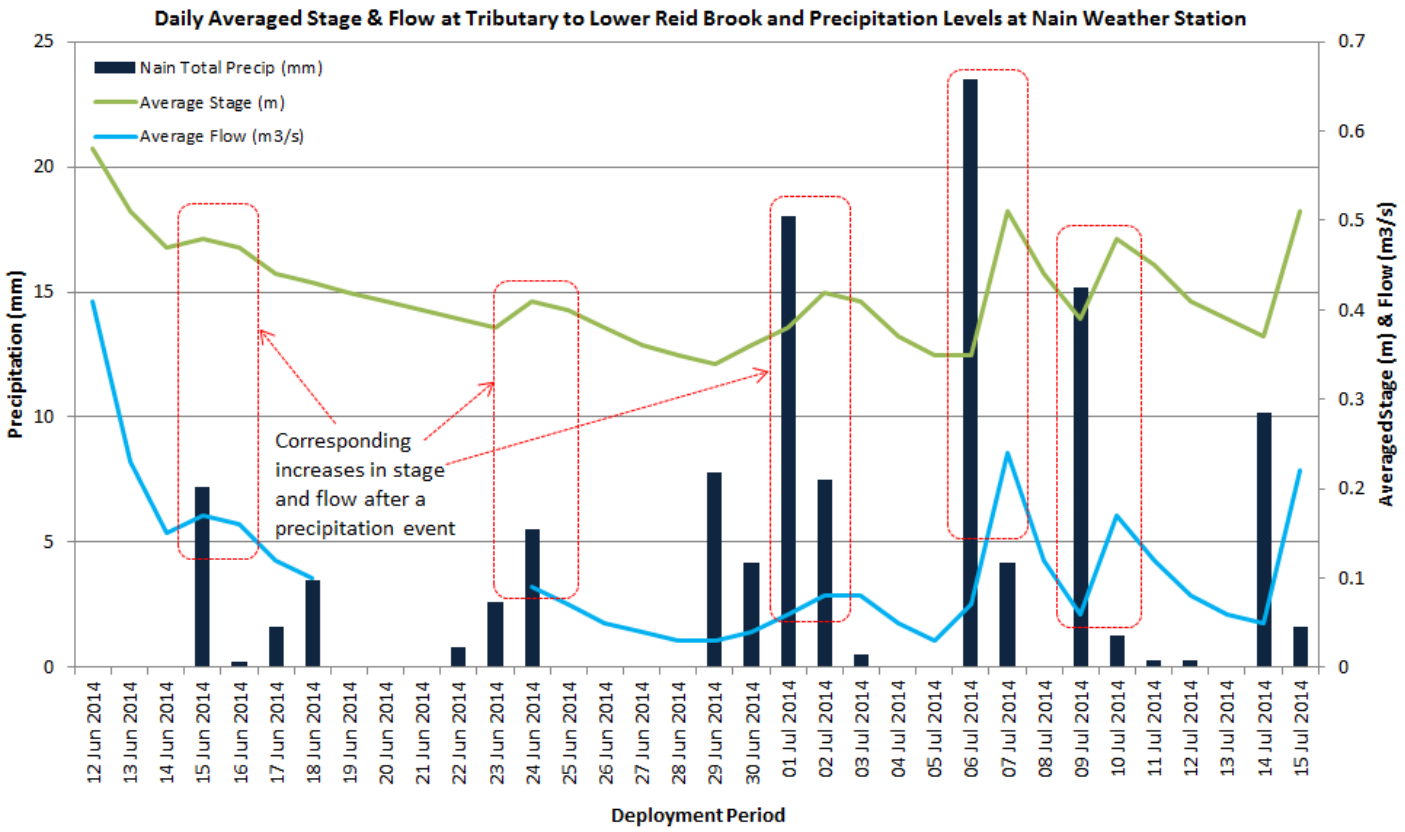

Figure 18: Daily precipitation and average daily stage and stream flow at Tributary to Lower Reid Brook (Weather data recorded at Nain)

Lower Reid Brook

Water Temperature

- Water temperature ranges from 5.29°C to 15.70°C during the deployment period (Figure 19).
- 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 1st – July 3rd.

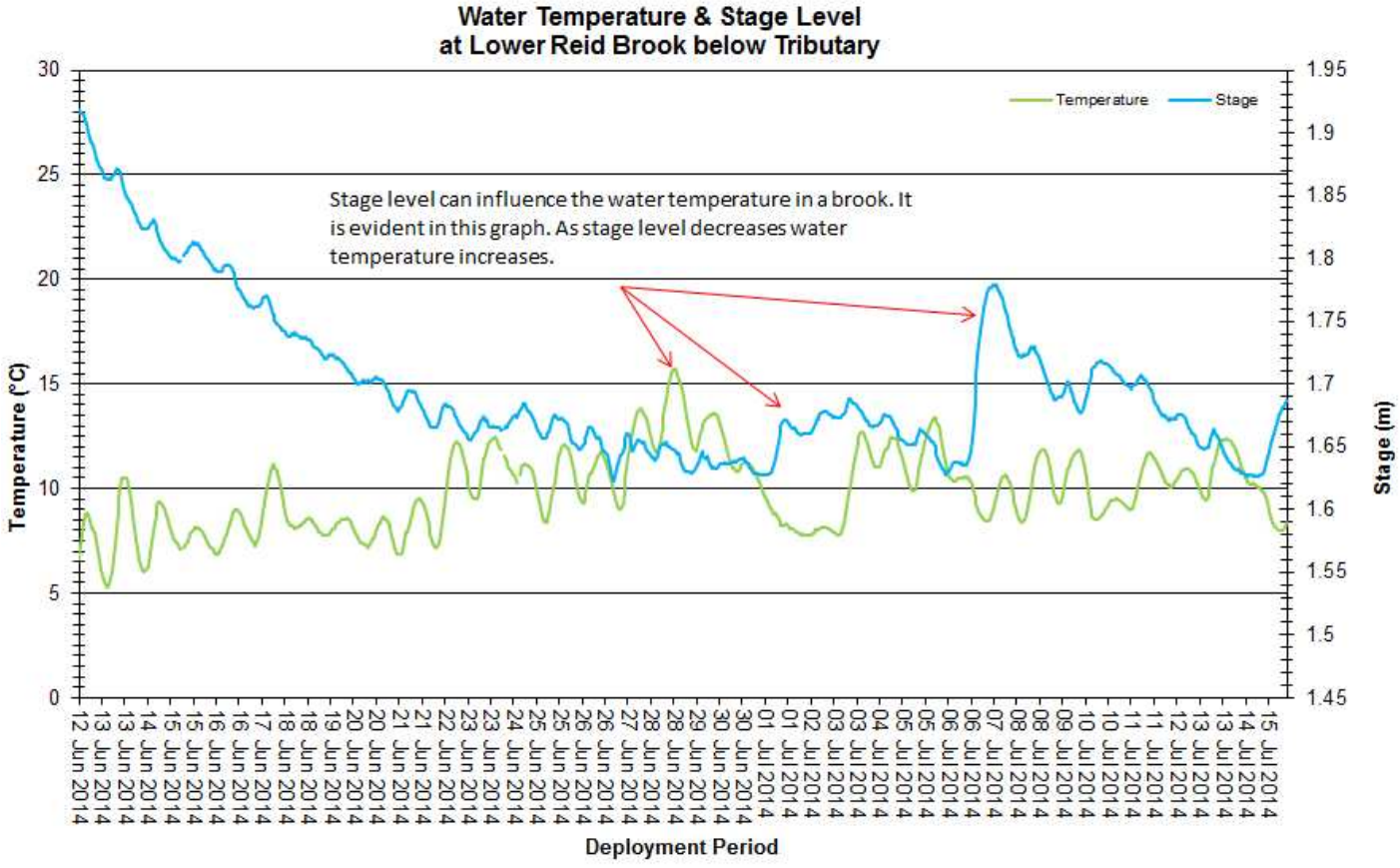

Figure 19: Water temperature at Lower Reid Brook

pH

- During this deployment period pH data ranged between a minimum of 6.20 and a maximum of 7.30 pH units (Figure 20).
- For 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 drop from June 21st through to July 6th, the pH values increase slightly as a response.
- There is a slight pH decrease July 7th and 8th following increases in stage indicating again that these two parameters do respond to each other.
- 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 7.01 pH units.

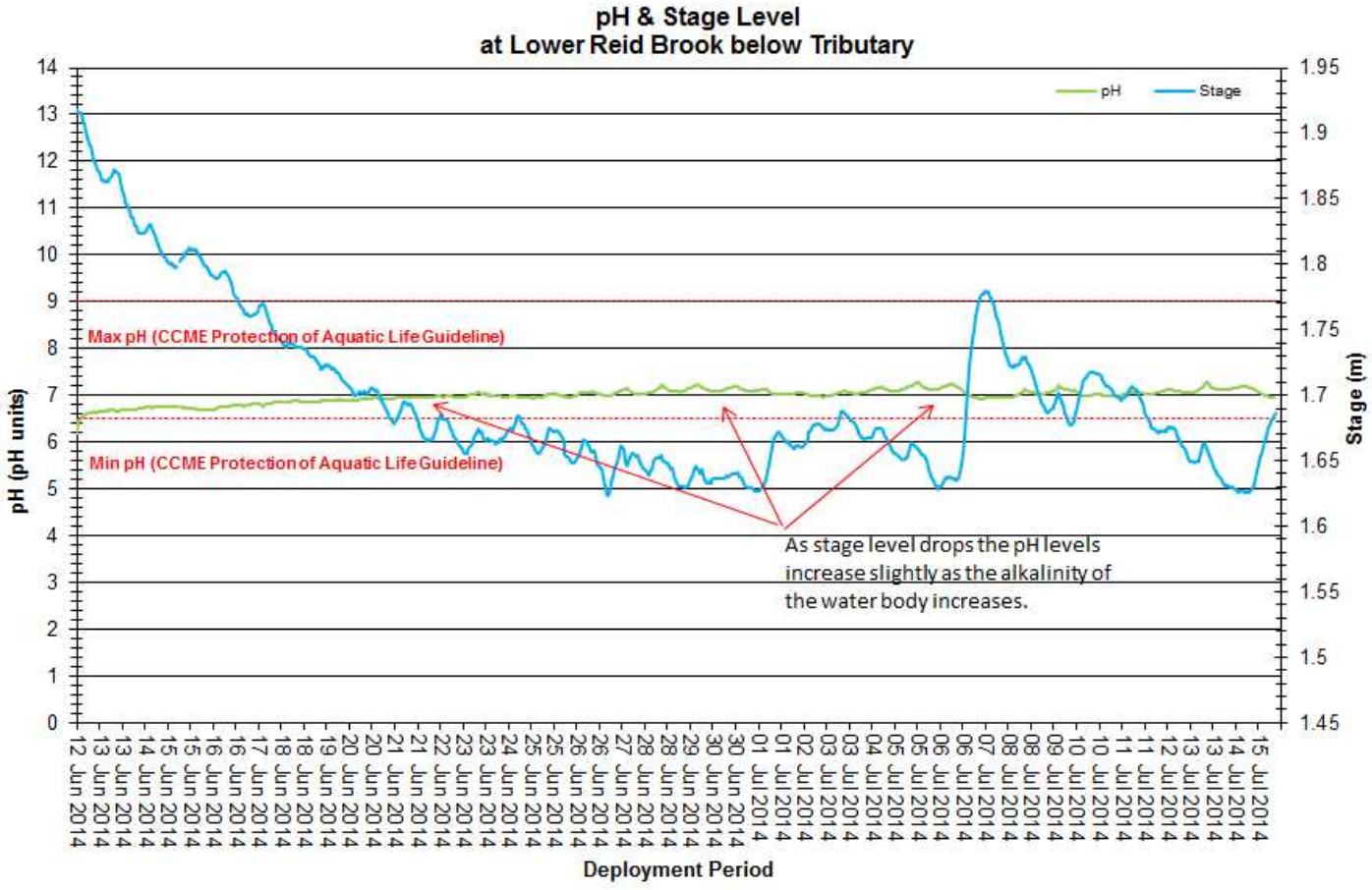

Figure 20: pH and stage level at Lower Reid Brook

Specific Conductivity

- Specific conductivity ranges between 15.1µS/cm and 23.4µS/cm, with a median of 20.3µS/cm (Figure 21).
- 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.

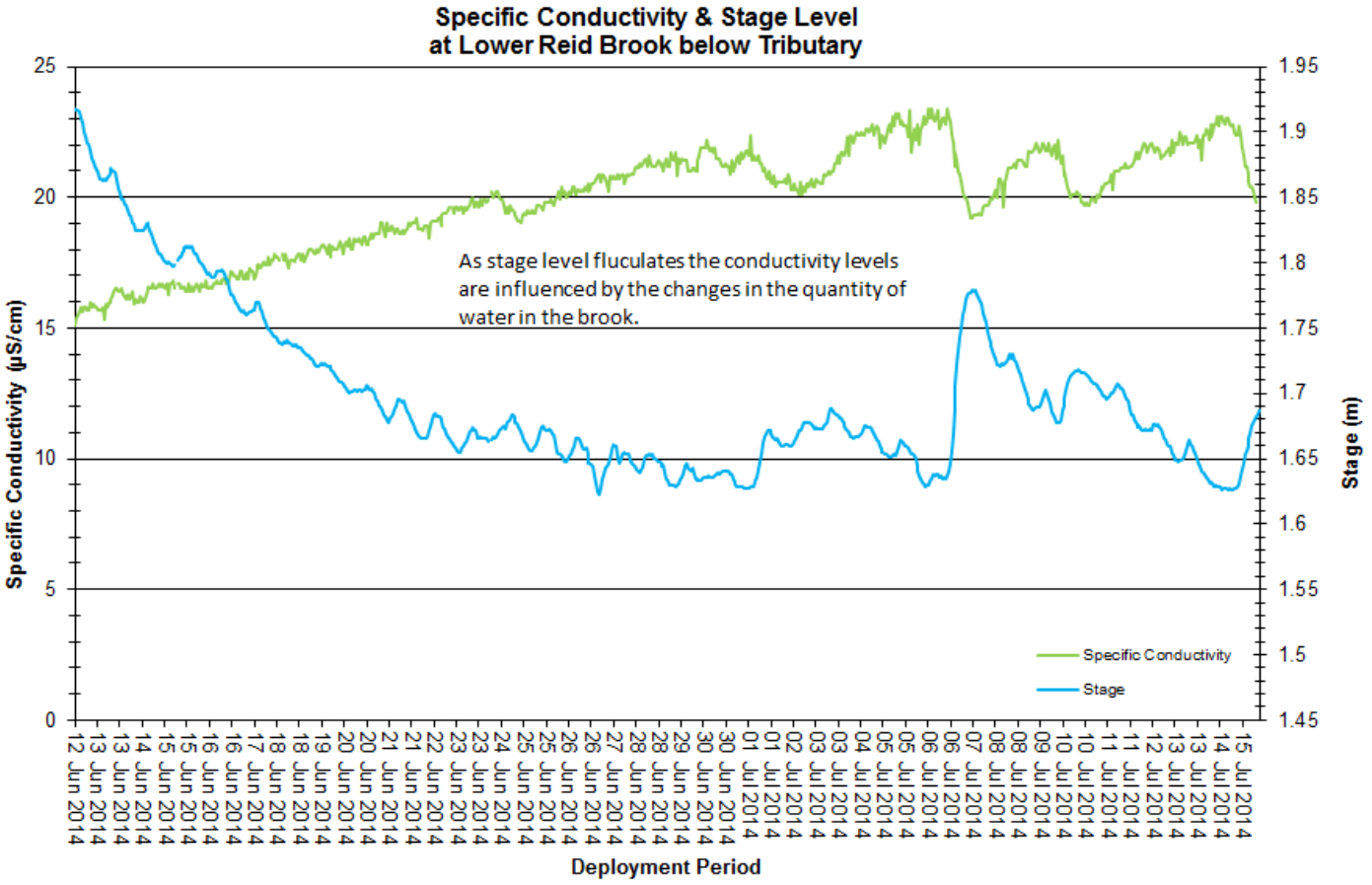

Figure 21: Specific conductivity and stage level at Lower Reid Brook

Dissolved Oxygen

- Dissolved oxygen content ranges between 9.14mg/l and 11.73mg/l. The saturation of dissolved oxygen ranges from 89.7% to 94.6% (Figure 22).
- Dissolved oxygen percent saturation is relatively consistent throughout the deployment period. There are several increases in dissolved oxygen that correspond with dips in water temperature, on June 19th – 20th and July 1st – 2nd. The majority of the DO values are above the CCME Guideline.
- A linear regression line indicates the slight decrease in dissolved oxygen content over the deployment period. This is to be expected as the water temperature values are increasing with the seasonal change into warmer months.

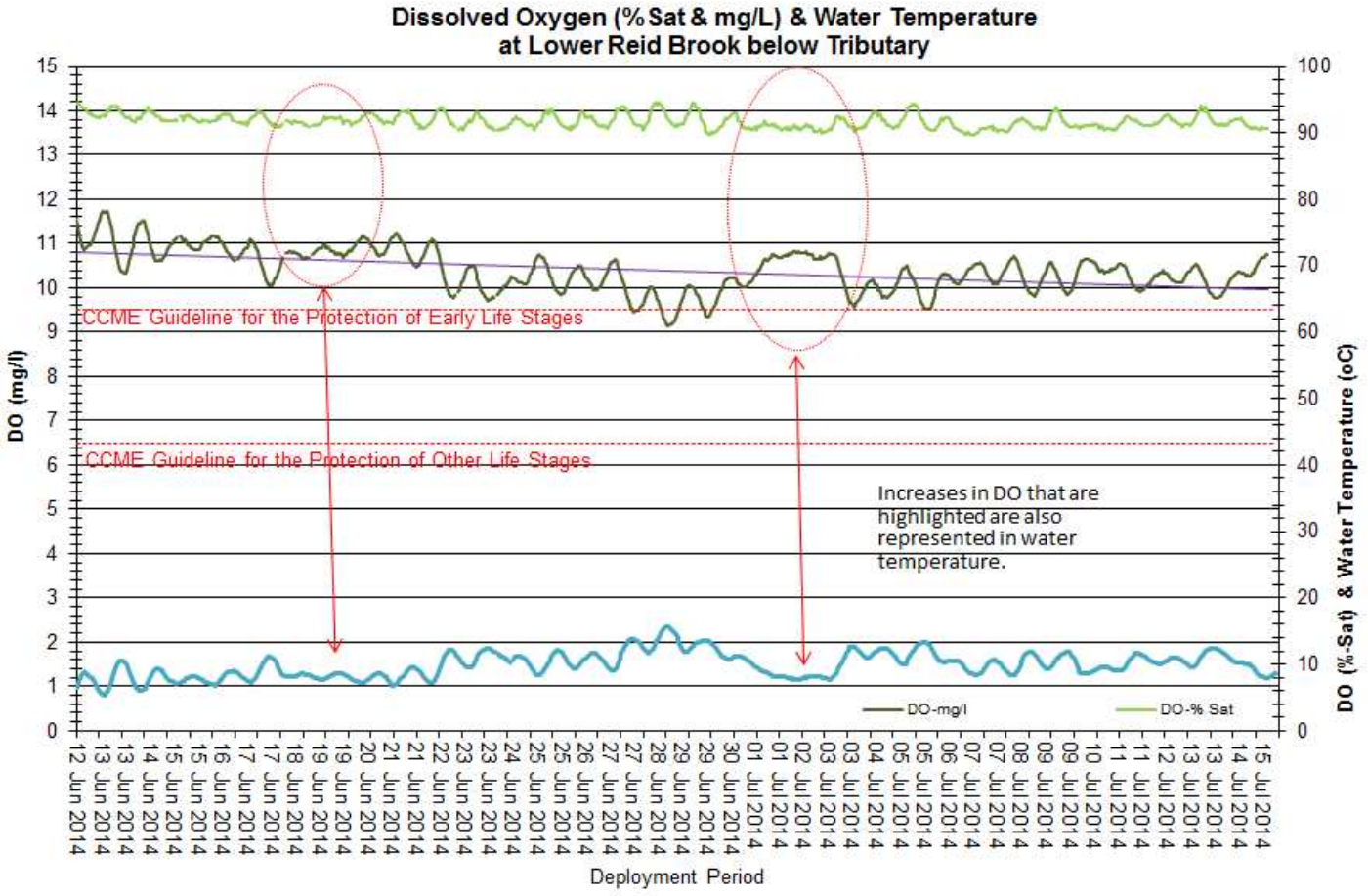

Figure 22: Dissolved oxygen and percent saturation at Lower Reid Brook below Tributary

Turbidity

- Turbidity values ranged between 0 NTU and 29 NTU throughout the deployment period (Figure 23). A median value of 0.0 NTU indicates there is no natural background turbidity data for this deployment period.
- Turbidity events at low magnitudes are normal for this station. There are very few turbidity increases captured during the deployment period, all of which only last 1-2 hours. There is one increase up to 29 NTU however this increase is also short-lived and should not be considered significant. The turbidity increases noted on Figure 23 correspond with peaks in stage level during the same time frame.

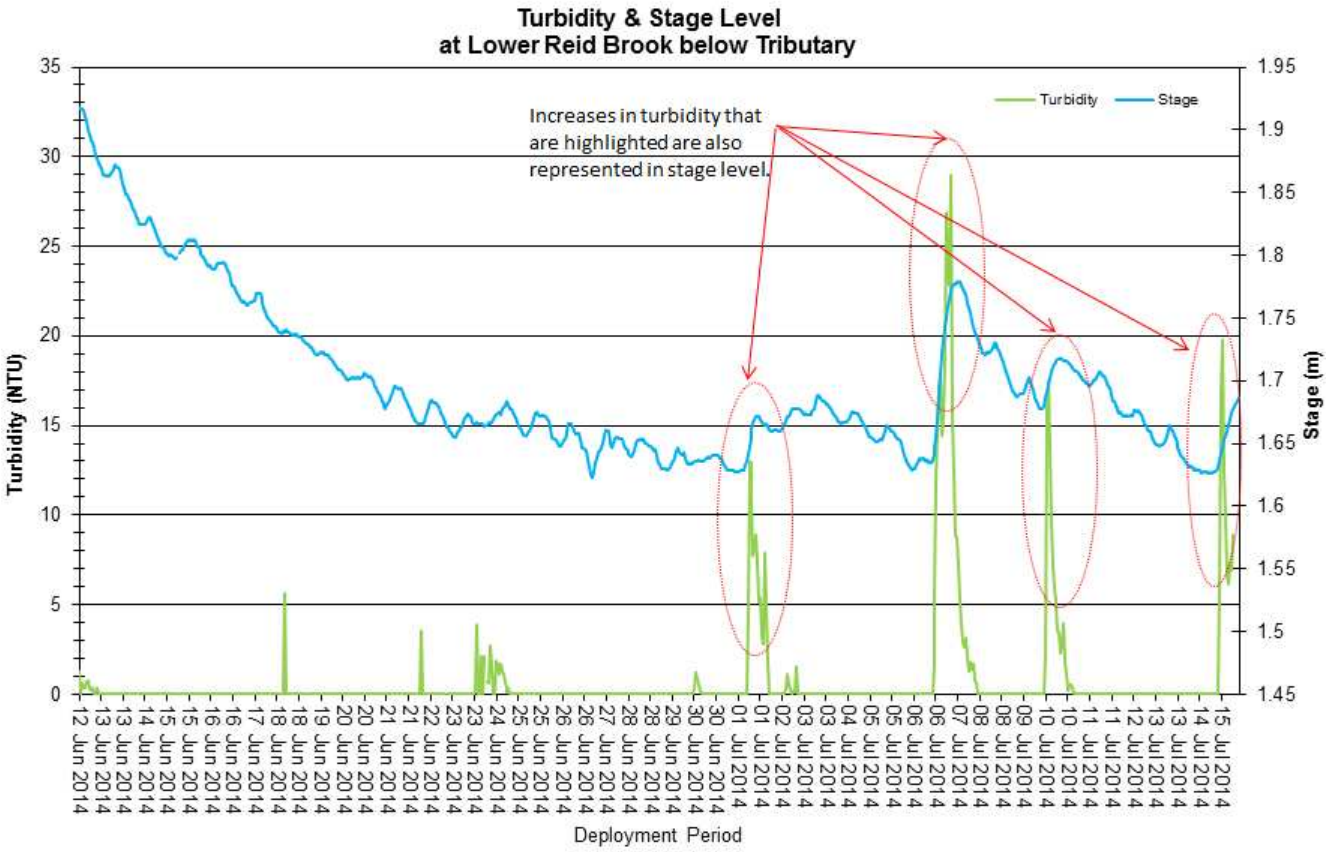

Figure 23: Turbidity and stage level at Lower Reid Brook below Tributary

Stage and Stream flow

- 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).
- Stream flow 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 1.62m to 1.92m. The stream flow values ranges from 5.18 m^3/s to 18.0 m^3/s. The larger peaks in stage and stream flow do correspond with substantial rainfall events as noted on Figure 24.
- Precipitation data was obtained from Environment Canada's Nain weather station. Precipitation ranges for the deployment period were a minimum of 0.0 mm and a maximum of 23.5 mm on July 6th.

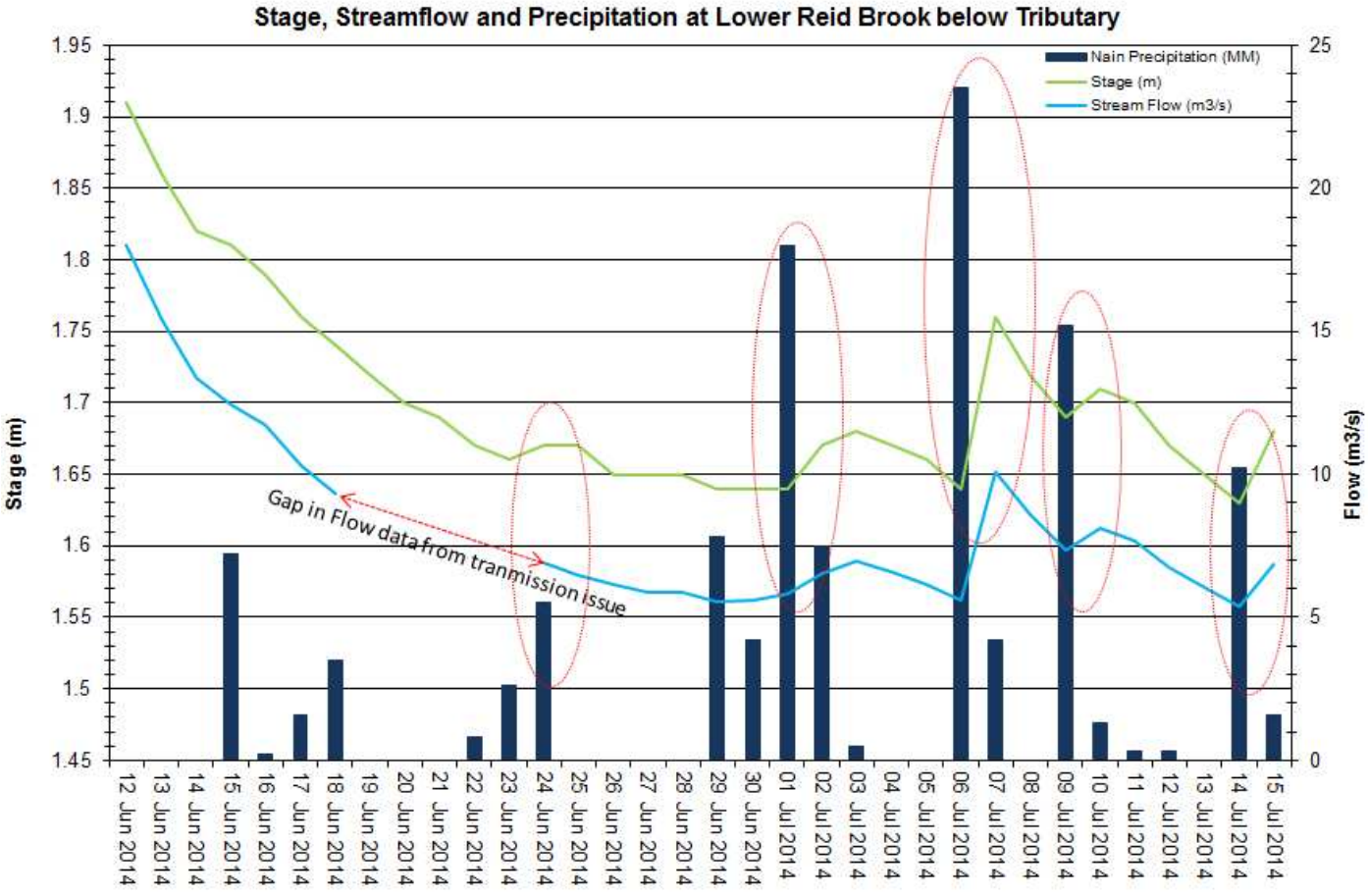

Figure 24: Daily precipitation and average daily stage and stream flow level at Lower Reid Brook

(Weather data recorded at Nain)

Conclusions

- The overall water temperatures across all stations were within a minimum of 2.21°C found at Reid Brook at Outlet of Reid Pond and a maximum of 19.27°C recorded at Camp Pond Brook below Camp Pond. Water temperature was increasing slightly at all stations and fluctuated throughout the deployment period depending on the weather conditions. 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.
- pH values ranged between a minimum of 6.17 pH units at Reid Brook at Outlet of Reid Pond and maximum of 7.30 recorded at Lower Reid Brook below Tributary. There is evident influence by precipitation events at the four stations on July 7th, July 10-11th and on July 15th. pH values dipped slightly following stage level increases.
- The overall conductivity ranges within the four stations was a minimum of 9.7 µS/cm at Reid Brook at Outlet of Reid Pond and a maximum value of 43.9 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 conductivity 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 7th, when all of the other stations indicate a lowering in conductivity from rainfall, Camp Pond Brook station actually peaks to 43.9 µS/cm.
- Dissolved oxygen levels for the deployment period ranged between 8.66 mg/l at Camp Pond Brook below Camp Pond and 12.76 mg/l found at Reid Brook at Outlet of Reid Pond. All values recorded at all stations were above the minimum CCME Guideline for the Protection of Aquatic Life at Other Life Stages (6.5mg/l). 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. Of the four stations the dissolved oxygen content at Reid Brook at Outlet of Reid Pond is the most stable. Reid Brook is a large pond with a deeper water level therefore the dissolved oxygen would stabilize a lot slower than a fast flowing stream.
- Turbidity levels for the four real-time stations ranged within a minimum of 0.0 NTU from all stations and a maximum of 125 NTU at Tributary to Lower Reid Brook. The cause of the high turbidity reading at Tributary to Lower Reid Brook was not determined. There was a small event on the dissolved oxygen graph and an increase in water temperature during that time frame for that station. Camp Pond Brook below Camp Pond has the second highest maximum reading of 61.3 NTU, this brook is closer to disturbance and potential for interference from roadways, runoff and debris.

APPENDIX I

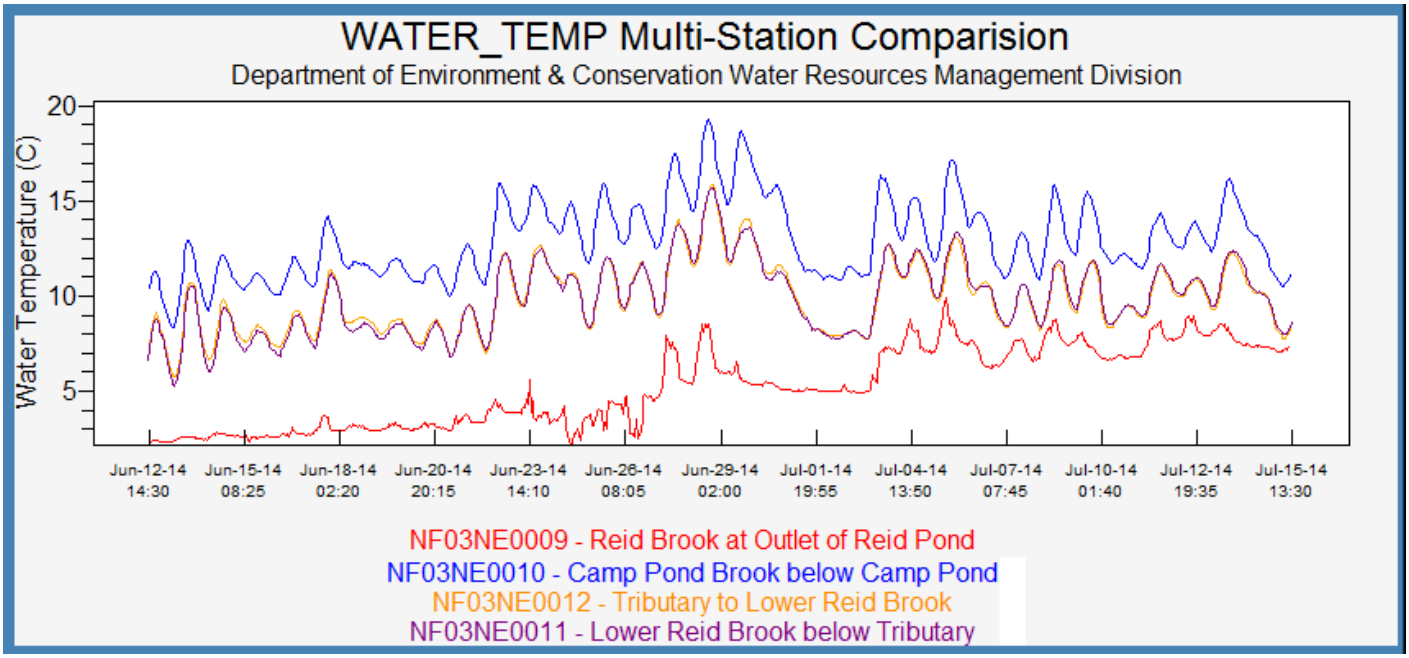

Figure A1: Comparison of Water Temperature at the Real-Time Stations in Voisey's Bay

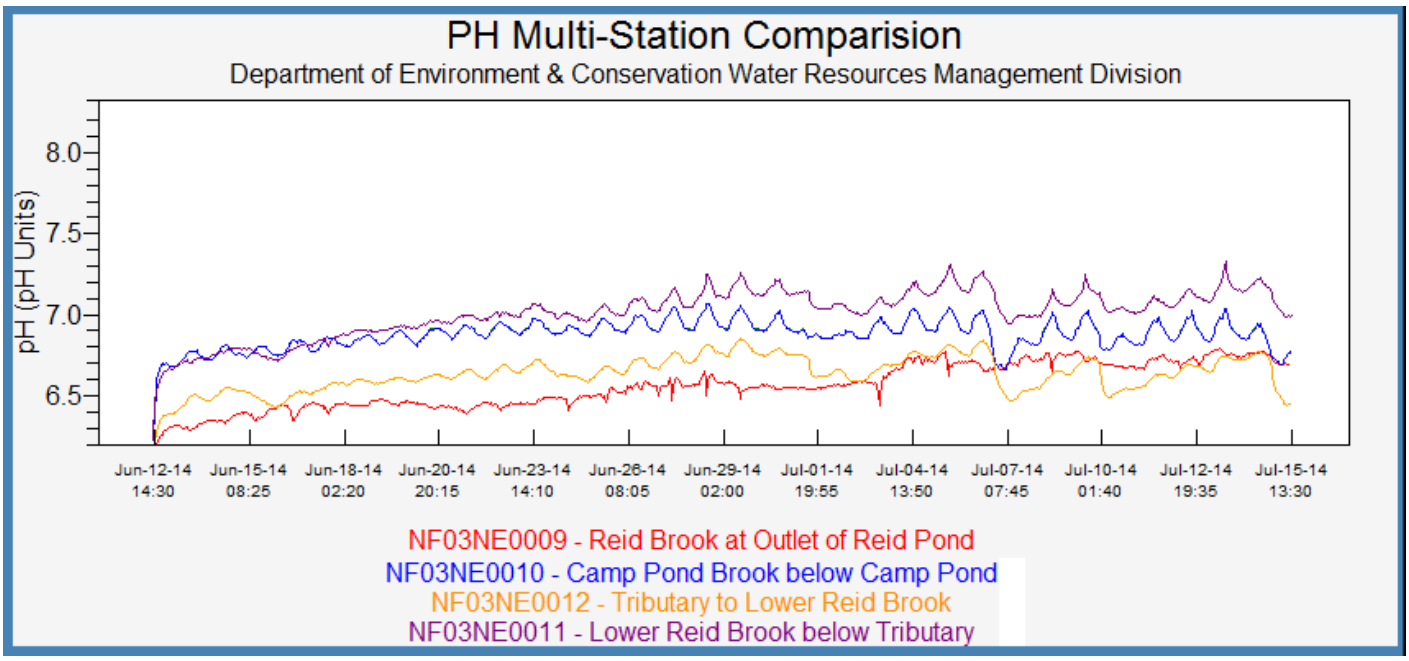

Figure A2: Comparison of pH at the Real-Time Stations in Voisey's Bay

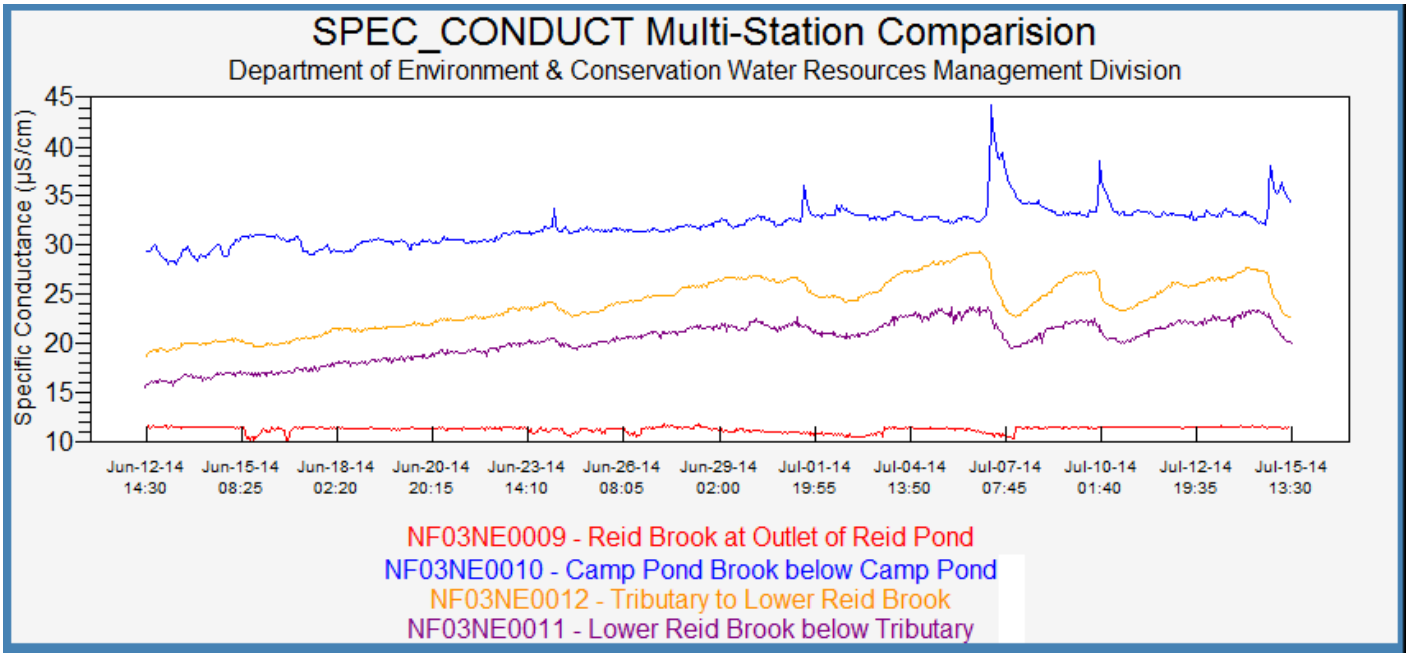

Figure A3: Comparison of Conductivity at the Real-Time Stations in Voisey's Bay

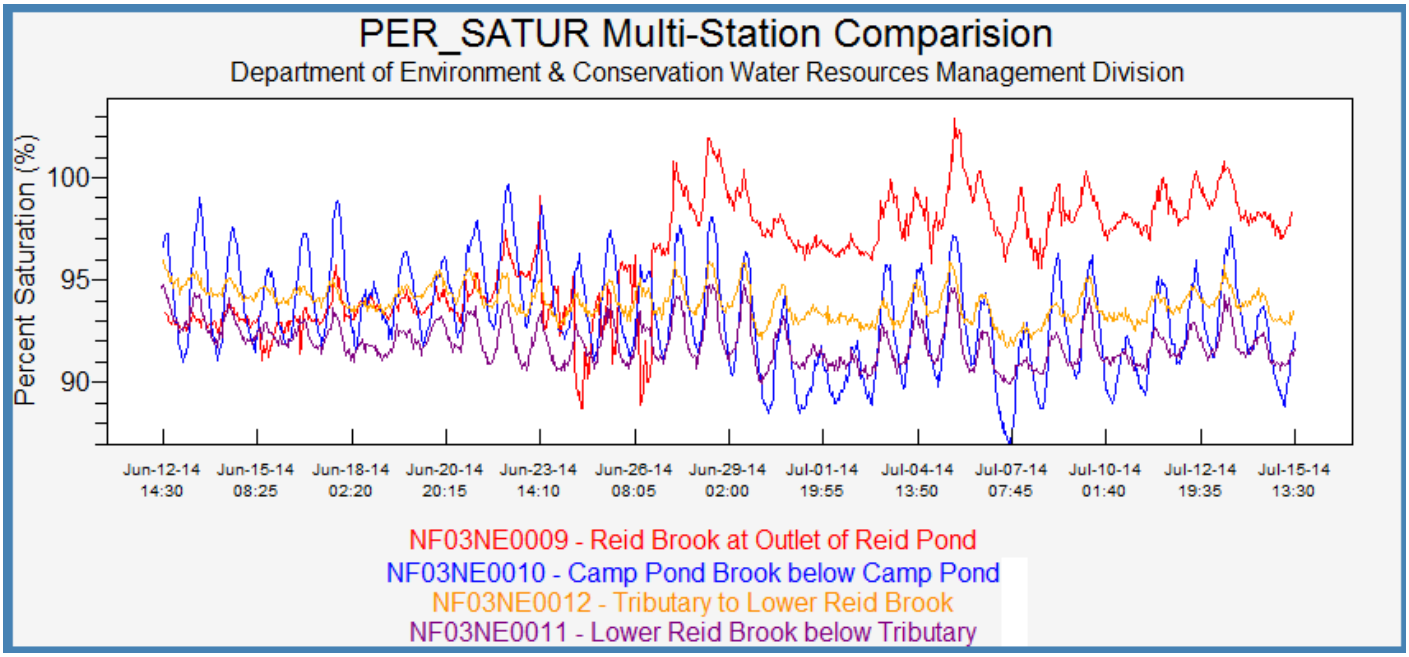

Figure A4: Comparison of pH at the Real-Time Stations in Voisey's Bay

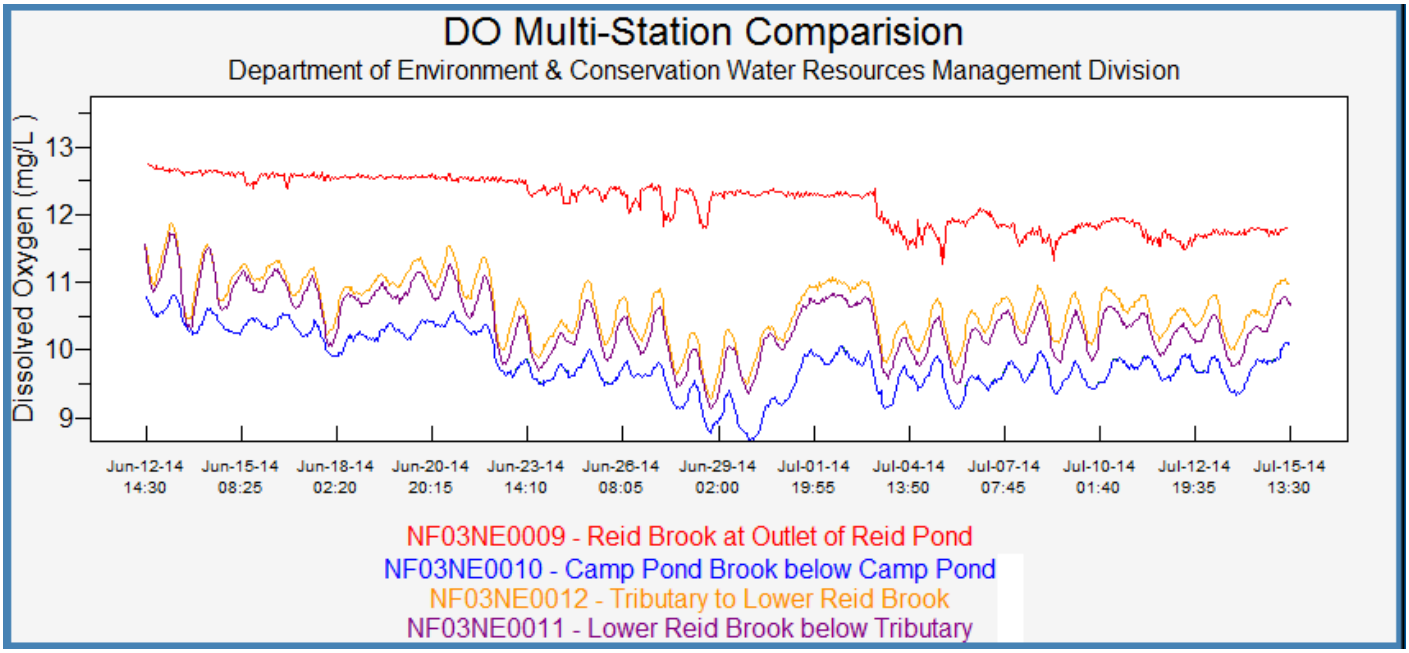

Figure A5: Comparison of Dissolved Oxygen at the Real-Time Stations in Voisey's Bay

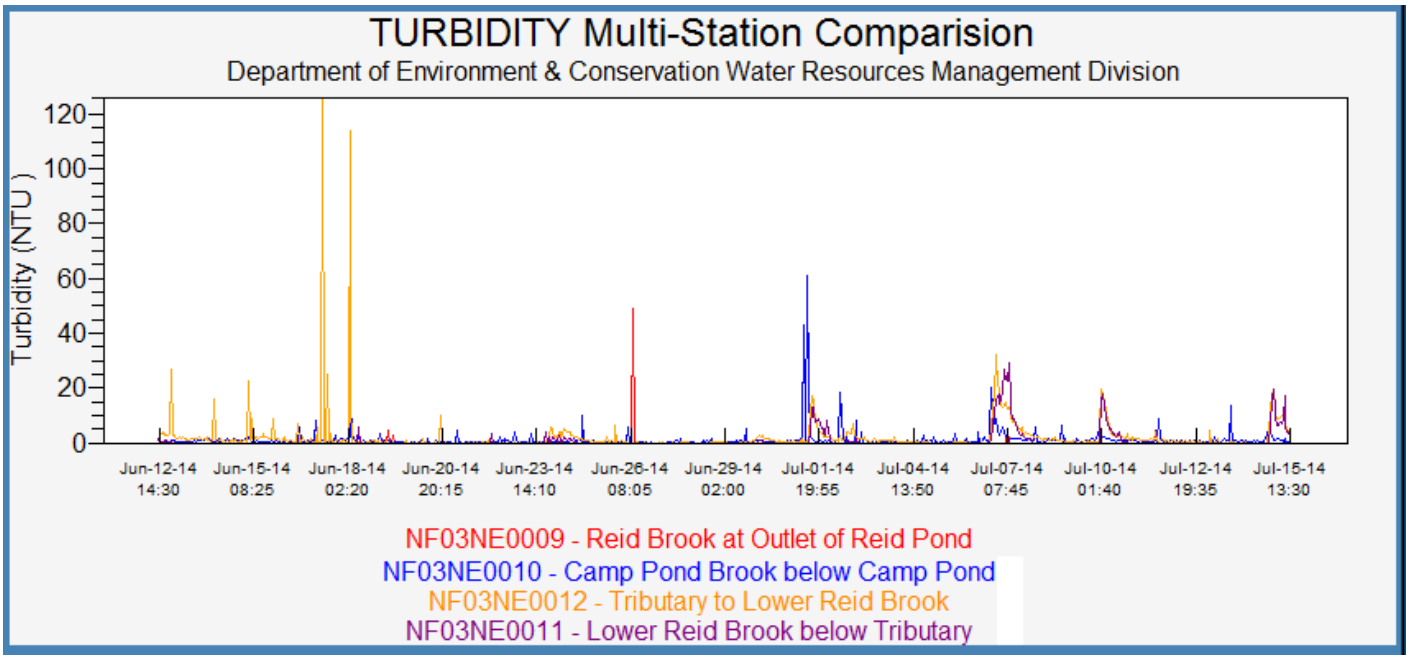

Figure A6: Comparison of Turbidity at the Real-Time Stations in Voisey's Bay

APPENDIX II

REPORT OF ANALYSIS

Lab Report Number: **1411924**

Cient:	Department of Environment	**COC Number:**	2823
Attention:	Ms. Melissa McComiskey	**Date Reported:**	2014-06-26
Client Project:	Happy Valley-Goose Bay	**Date Submitted:**	2014-06-19
Purchase Order:	214004545	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date
1112521	WS-S-0000 Reid Brook at Outlet of Pond	2014-6400-00-SI-RE	2014-06-12

Sample comment:

Holding time for turbidity and DOC 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	<1
Colour	TCU	2	12
Conductivity	uS/cm	5	14
Dissolved Organic Carbon	mg/L	0.5	2.2
Fluoride	mg/L	0.10	<0.10
Hardness as CaCO3	mg/L	1	2
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	6.59
Sulphate	mg/L	1	1
Total Dissolved Solids (COND - CALC)	mg/L	1	9
Total Kjeldahl Nitrogen	mg/L	0.10	0.16
Total Organic Carbon	mg/L	0.5	2.4
Total Phosphorus	mg/L	0.01	<0.01
Turbidity	NTU	0.1	0.2
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: **1411924**

Cient:	Department of Environment	**COC Number:**	2823
Attention:	Ms. Melissa McComiskey	**Date Reported:**	2014-06-26
Client Project:	Happy Valley-Goose Bay	**Date Submitted:**	2014-06-19
Purchase Order:	214004545	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1112521	WS-S-0000 Reid Brook at Outlet of Pond	2014-6400-00-SI-RE	2014-06-12	Copper	mg/L	0.001	<0.001
				Iron	mg/L	0.03	<0.03
				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	<0.005
				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	0.02
				Total Suspended Solids	mg/L	2	<2

Sample comment:

Holding time for turbidity and DOC 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: **1411924**

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Attention:	Ms. Melissa McComiskey	**Date Reported:**	2014-06-26
Client Project:	Happy Valley-Goose Bay	**Date Submitted:**	2014-06-19
Purchase Order:	214004545	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date
1112522	WS-S-0000 Camp Pond Brook Below Camp Pond	2014-6401-00-SI-RE	2014-06-12

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	11
Bromide	mg/L	0.25	<0.25
Chloride	mg/L	1	2
Colour	TCU	2	24
Conductivity	uS/cm	5	31
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	0.08
N-NO2 (Nitrite)	mg/L	0.10	<0.10
N-NO3 (Nitrate)	mg/L	0.10	<0.10
pH		1.00	7.02
Sulphate	mg/L	1	3
Total Dissolved Solids (COND - CALC)	mg/L	1	20
Total Kjeldahl Nitrogen	mg/L	0.10	0.14
Total Organic Carbon	mg/L	0.5	4.1
Total Phosphorus	mg/L	0.01	<0.01
Turbidity	NTU	0.1	0.8
Aluminum	mg/L	0.01	0.11
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:

Lorna Wilson
Laboratory Supervisor, Inorganics

REPORT OF ANALYSIS

Lab Report Number: **1411924**

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Client Project:	Happy Valley-Goose Bay	**Date Submitted:**	2014-06-19
Purchase Order:	214004545	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1112522	WS-S-0000	2014-6401-00-SI-RE	2014-06-12	Copper	mg/L	0.001	0.003
	Camp Pond Brook Below Camp Pond			Iron	mg/L	0.03	0.28
				Lead	mg/L	0.001	<0.001
				Magnesium	mg/L	1	<1
				Manganese	mg/L	0.01	0.02
				Mercury	mg/L	0.0001	<0.0001
				Nickel	mg/L	0.005	0.021
				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	4

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: **1411924**

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Attention:	Ms. Melissa McComiskey	**Date Reported:**	2014-06-26
Client Project:	Happy Valley-Goose Bay	**Date Submitted:**	2014-06-19
Purchase Order:	214004545	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date
1112523	WS-S-0000 Lower Reid Brook Below Tributary	2014-6402-00-SI-RE	2014-06-12

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	9
Bromide	mg/L	0.25	<0.25
Chloride	mg/L	1	1
Colour	TCU	2	49
Conductivity	uS/cm	5	20
Dissolved Organic Carbon	mg/L	0.5	6.5
Fluoride	mg/L	0.10	<0.10
Hardness as CaCO3	mg/L	1	5
N-NH3 (Ammonia)	mg/L	0.02	0.08
N-NO2 (Nitrite)	mg/L	0.10	<0.10
N-NO3 (Nitrate)	mg/L	0.10	<0.10
pH		1.00	6.76
Sulphate	mg/L	1	2
Total Dissolved Solids (COND - CALC)	mg/L	1	13
Total Kjeldahl Nitrogen	mg/L	0.10	0.26
Total Organic Carbon	mg/L	0.5	6.4
Total Phosphorus	mg/L	0.01	0.12
Turbidity	NTU	0.1	1.4
Aluminum	mg/L	0.01	0.26
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

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Client Project:	Happy Valley-Goose Bay	**Date Submitted:**	2014-06-19
Purchase Order:	214004545	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1112523	WS-S-0000 Lower Reid Brook Below Tributary	2014-6402-00-SI-RE	2014-06-12	Copper	mg/L	0.001	0.002
				Iron	mg/L	0.03	0.59
				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	0.010
				Uranium	mg/L	0.001	<0.001
				Zinc	mg/L	0.01	0.02
				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:

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Purchase Order:	214004545	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date
1112524	WS-S-0000 Tributary to Reid Brook	2014-6403-00-SI-RE	2014-06-12

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	1
Colour	TCU	2	56
Conductivity	uS/cm	5	20
Dissolved Organic Carbon	mg/L	0.5	7.0
Fluoride	mg/L	0.10	<0.10
Hardness as CaCO3	mg/L	1	5
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	6.52
Sulphate	mg/L	1	2
Total Dissolved Solids (COND - CALC)	mg/L	1	13
Total Kjeldahl Nitrogen	mg/L	0.10	0.18
Total Organic Carbon	mg/L	0.5	7.0
Total Phosphorus	mg/L	0.01	<0.01
Turbidity	NTU	0.1	0.9
Aluminum	mg/L	0.01	0.17
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:

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REPORT OF ANALYSIS

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Client Project:	Happy Valley-Goose Bay	**Date Submitted:**	2014-06-19
Purchase Order:	214004545	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1112524	WS-S-0000 Tributary to Reid Brook	2014-6403-00-SI-RE	2014-06-12	Copper	mg/L	0.001	0.002
				Iron	mg/L	0.03	0.35
				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	0.010
				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