Real-Time Water Quality Deployment Report

Voisey's Bay Network

July 7 to August 13, 2019

Newfoundland Labrador

Government of Newfoundland & Labrador

Department of Municipal Affairs and Environment

Water Resources Management Division

Contents

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Real Time Water Quality Monitoring

Staff with the Department of Municipal Affairs and Environment monitor the real-time web pages regularly.

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

On July 7, 2019, Vale Environment staff deployed real-time water quality monitoring instruments at the four real-time stations in the Voisey's Bay network. Instruments were removed by Vale Environment Staff on August 13, 2019. This was the second deployment for the 2019 season.

Quality Assurance and Quality Control

As part of the Quality Assurance and Quality Control protocol (QA/QC), an assessment of the reliability of data recorded by an instrument is made at the beginning and end of the deployment period. This procedure is based on the approach used by the United States Geological Survey.

At deployment and removal, a QA/QC instrument is temporarily deployed adjacent to 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 QA/QC instrument at deployment and at removal, a qualitative statement is made about 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 dependent; 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	July 7	Deployment	Excellent	Marginal	Excellent	Fair	Excellent
	August 13	Removal	Excellent	Poor	Excellent	Good	Excellent
Camp Pond Brook	July 7	Deployment	Excellent	Fair	Excellent	Fair	Excellent
	August 13	Removal	Excellent	Good	Excellent	Good	Good
Reid Brook below Tributary	July 7	Deployment	Excellent	Good	Excellent	Excellent	Excellent
	August 13	Removal	Good	Excellent	Good	Good	Excellent
Tributary to Reid Brook	July 7	Deployment	Excellent	Good	Excellent	Marginal	Excellent
	August 13	Removal	Excellent	Good	Excellent	Good	Excellent

Reid Brook at Outlet of Reid Pond

- At deployment, temperature, conductivity, and turbidity all ranked as 'excellent', while pH was 'marginal' and dissolved oxygen was 'fair'.
- At removal, temperature, conductivity, and turbidity all ranked as 'excellent', while dissolved oxygen was 'good' and pH was 'poor'. This discrepancy may be attributed to the field sonde not being given sufficient time to acclimatize to its surroundings before a reading was taken.

Camp Pond Brook below Camp Pond

- At deployment, temperature, conductivity, and turbidity all ranked as 'excellent', while pH and dissolved oxygen were 'fair'.
- At removal, temperature and conductivity were 'excellent', while all other parameters were 'good'.

Reid Brook below Tributary

- At deployment, all parameters ranked as either 'excellent' or 'good'.
- At removal, all parameters ranked as either 'excellent' or 'good'.

Tributary to Reid Brook

- At deployment, temperature, conductivity, and turbidity all ranked as 'excellent', while pH was 'good' and dissolved oxygen was 'marginal'.
- At removal, all parameters ranked as either 'excellent' or 'good'.

It is important to note that, in general, there are several conditions under which a less than ideal QA/QC ranking may be obtained. These include, but are not limited to: placement of the QA/QC sonde in relation to the field sonde; the amount of time each sonde is given to stabilize before readings are recorded; and deteriorating performance of one or more of the sensors.

Data Interpretation

The following graphs and discussion illustrate significant water quality-related events from July 7th to August 13^{h}, 2019 in the Voisey's Bay Real-Time Water Quality Monitoring Network.

With the exception of water quantity data (stage and flow), all data used in the preparation of the graphs and subsequent discussion below adhere to stringent QA/QC protocol. Water Survey of Canada is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

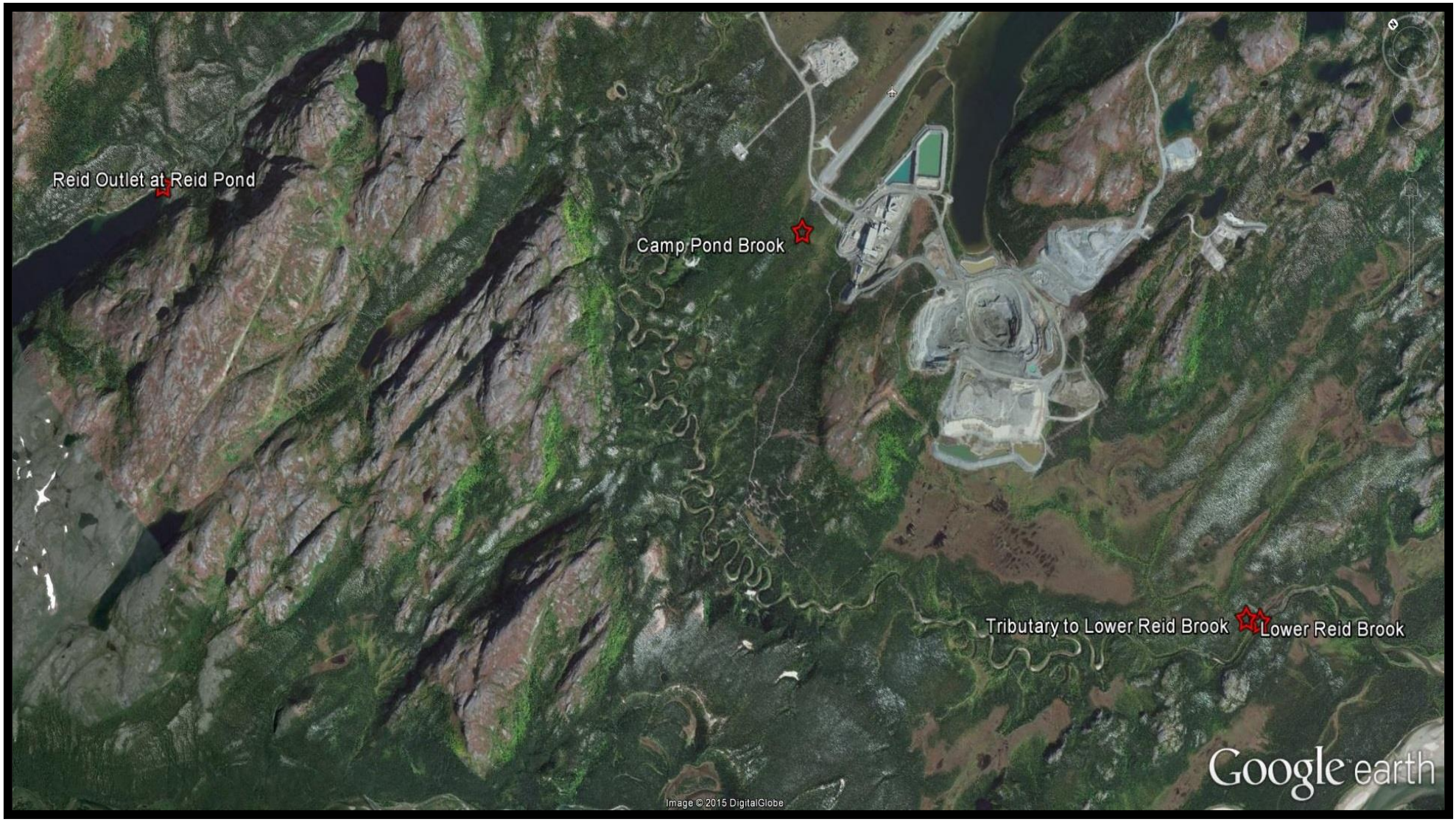

Figure 1: Voisey's Bay Network Station Locations

Reid Brook at Outlet of Reid Pond

Water Temperature

Over the deployment period, water temperature ranged from 5.17°C to 13.46°C, with a median value of 8.78°C (Figure 2). As evidenced in the graph below, air temperature fluctuates to a much greater extent each day compared to water temperature. Air temperature data was obtained from the Voisey's Bay airstrip weather station.

This water body takes longer to acclimatize to changes in temperature as it has a much larger surface area compared to the brooks at the other RTWQ stations in this network.

Please note the stage data used below is raw data. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request to WSC.

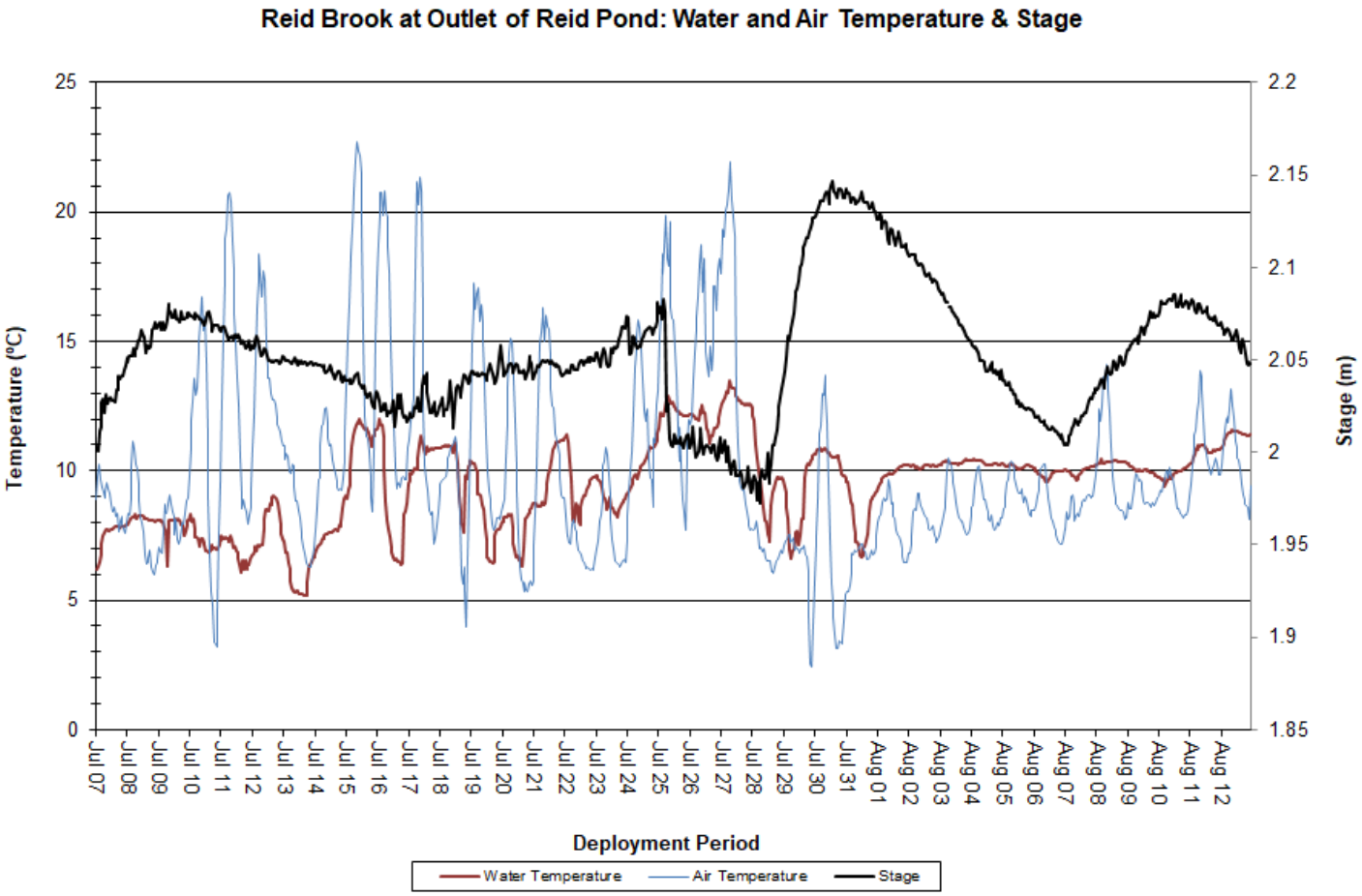

Figure 2: Water and Air Temperature & Stage at Reid Brook at Outlet of Reid Pond

pH

Over the deployment period, pH values ranged from 5.21 pH units to 7.17 pH units, with a median value of 6.95 pH units (Figure 3).

pH levels were below the CCME's Guidelines for the Protection of Aquatic Life for the very beginning of deployment, but quickly rose to and remained within the guidelines for the remainder of the deployment period.

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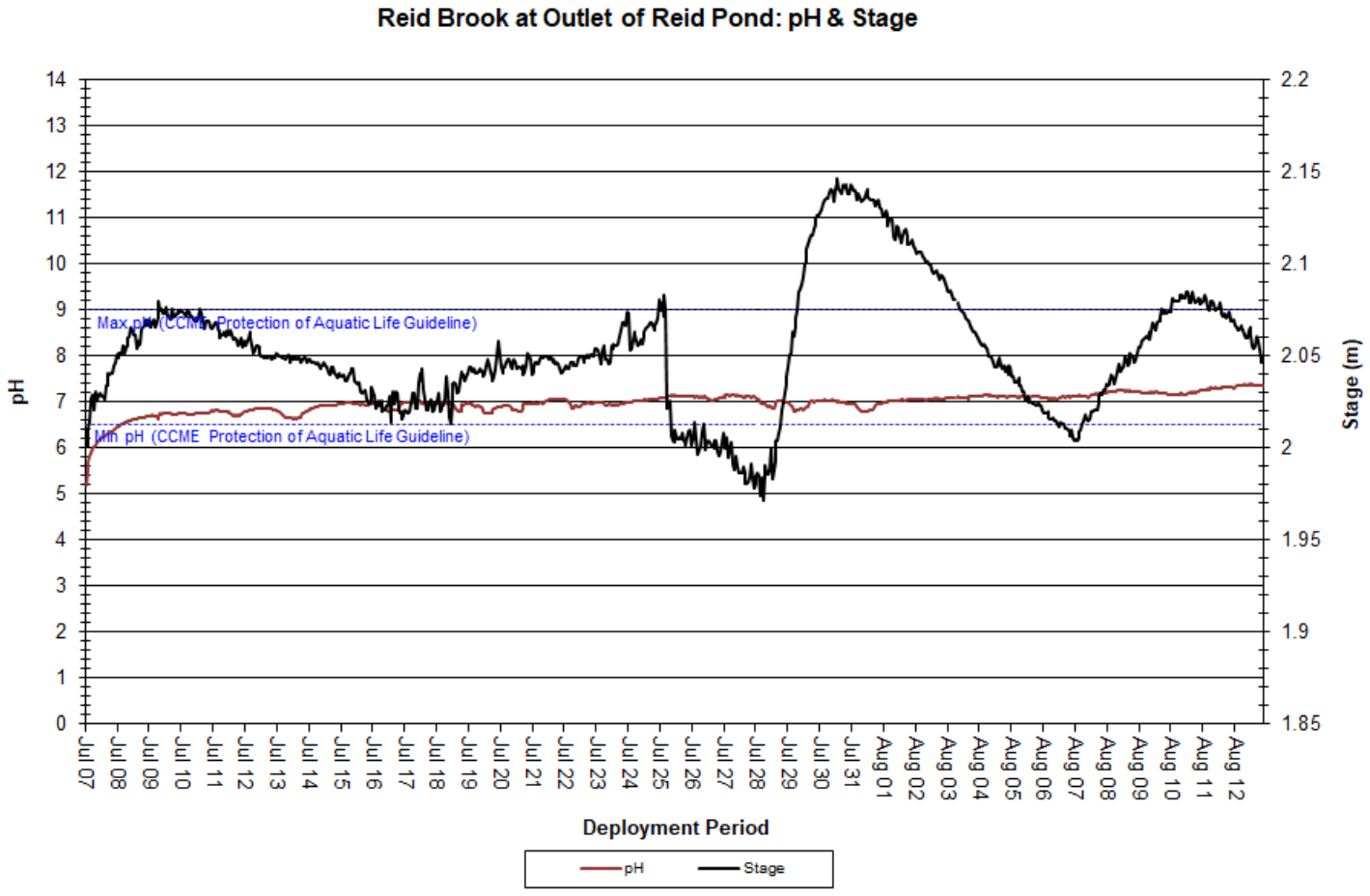

Figure 3: pH & Stage at Reid Brook at Outlet of Reid Pond

Specific Conductivity

Over the deployment period, specific conductivity levels ranged from 11.7µS/cm to 12.2µS/cm, with a median value of 11.9µS/cm (Figure 4). Conductivity at Reid Brook remained very stable; this is to be expected as this water body is pristine in nature and is far removed from any anthropogenic disturbances that could affect water quality.

The relationship between conductivity and stage level is generally inversed. When stage levels decrease, specific conductivity levels increase, as the decreased amount of water in the river system concentrates the solids that are present. Similarly, as stage levels rise, conductivity levels will dip in response. This relationship is not as evident at Reid Brook as it is at other stations in the Voisey's Bay network (Figure 4).

Please note the stage data used below is raw data. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request to WSC.

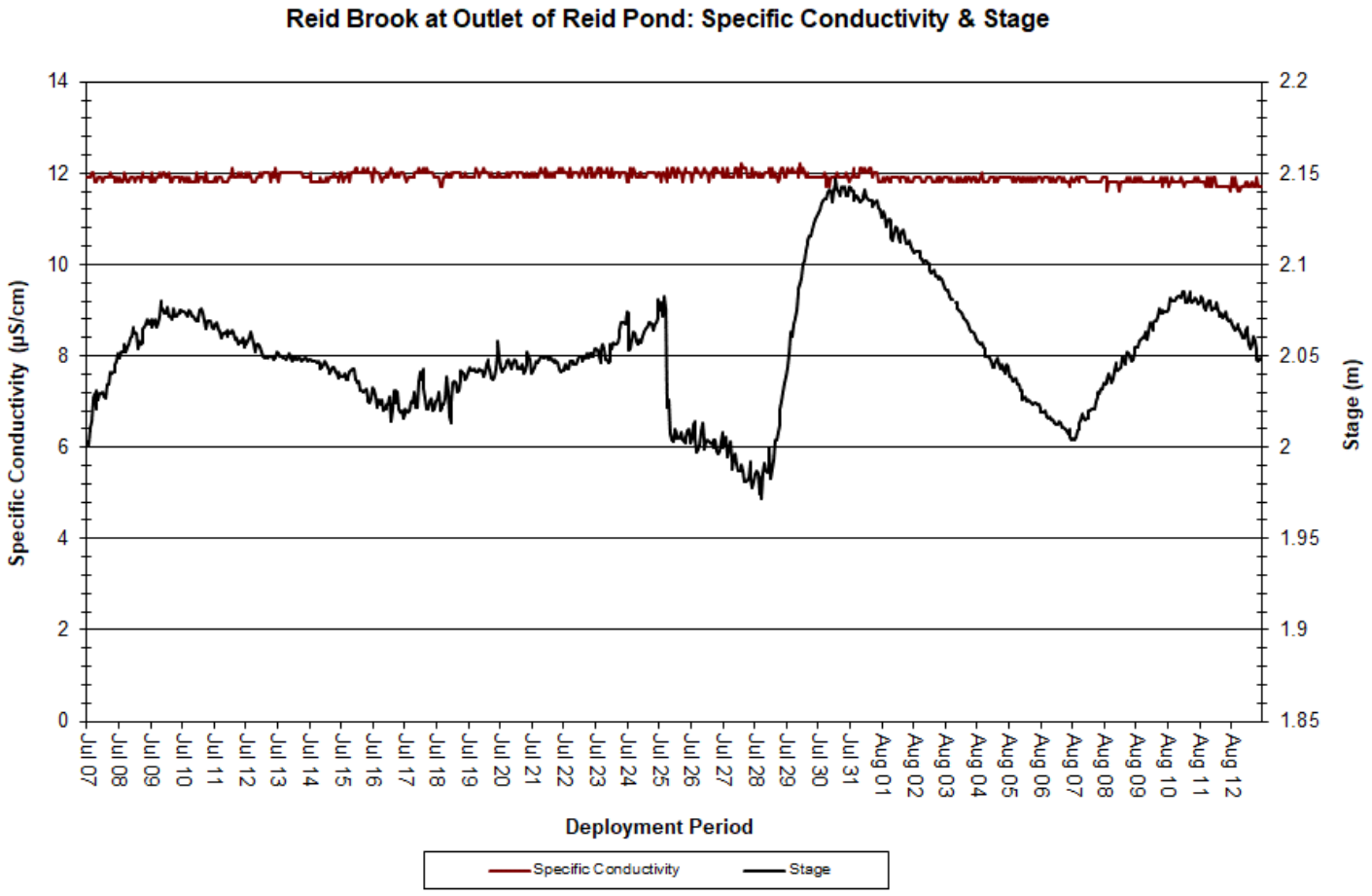

Figure 4: Specific Conductivity & Stage at Reid Brook at Outlet of Reid Pond

Dissolved Oxygen

Over the deployment period, dissolved oxygen concentration levels ranged from 10.68mg/L to 12.47mg/L, with a median value of 11.72mg/L. Percent saturation levels for dissolved oxygen ranged from 97.8% saturation to 106.7% saturation, with a median value of 101.6% saturation (Figure 5).

The water quality instrument measures dissolved oxygen concentration (mg/L) with a dissolved oxygen probe. The instrument then calculates percent saturation (% Sat) taking into account water temperature.

Dissolved oxygen levels slowly decreased over the course of the deployment period. This is to be expected, as water temperatures slowly increased over the same period. Dissolved oxygen concentration values remained above the CCME's Guidelines for the Protection of Early Life Stages (9.5 mg/L) and Other Life Stages (6.5 mg/L) for the duration of deployment (Figure 5).

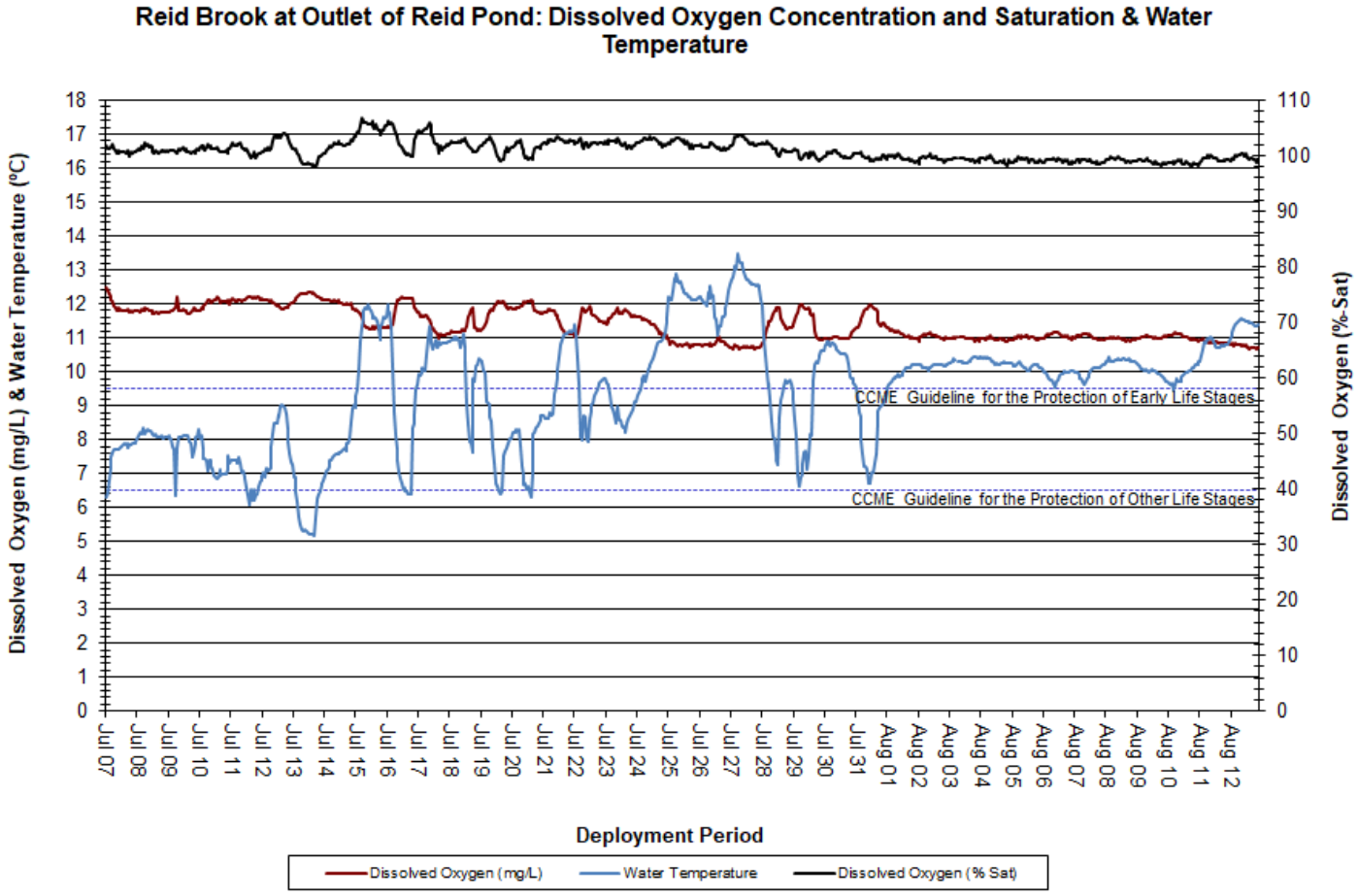

Figure 5: Dissolved Oxygen Concentration and Saturation & Water Temperature at Reid Brook at Outlet of Reid Pond

Turbidity

Over the deployment period, turbidity levels ranged from 0.0NTU to 12.4NTU, with a median value of 0.0NTU (Figure 6). This indicates that there was very little background turbidity at this station during deployment.

All water bodies have a natural level of turbidity. A significant increase in turbidity is of concern when monitoring water quality. Higher turbidity readings would normally be expected during heavy rainfall or runoff events. Generally, turbidity levels increase for a short period of time and then return to within a baseline range. Turbidity values can also increase when there is a decrease in water level, which causes natural material in the water body to become concentrated.

Despite several precipitation events, turbidity levels remained very stable for the duration of deployment (Figure 6). This is not unusual for this station as it is pristine in nature and far removed from anthropogenic influences that may affect water quality.

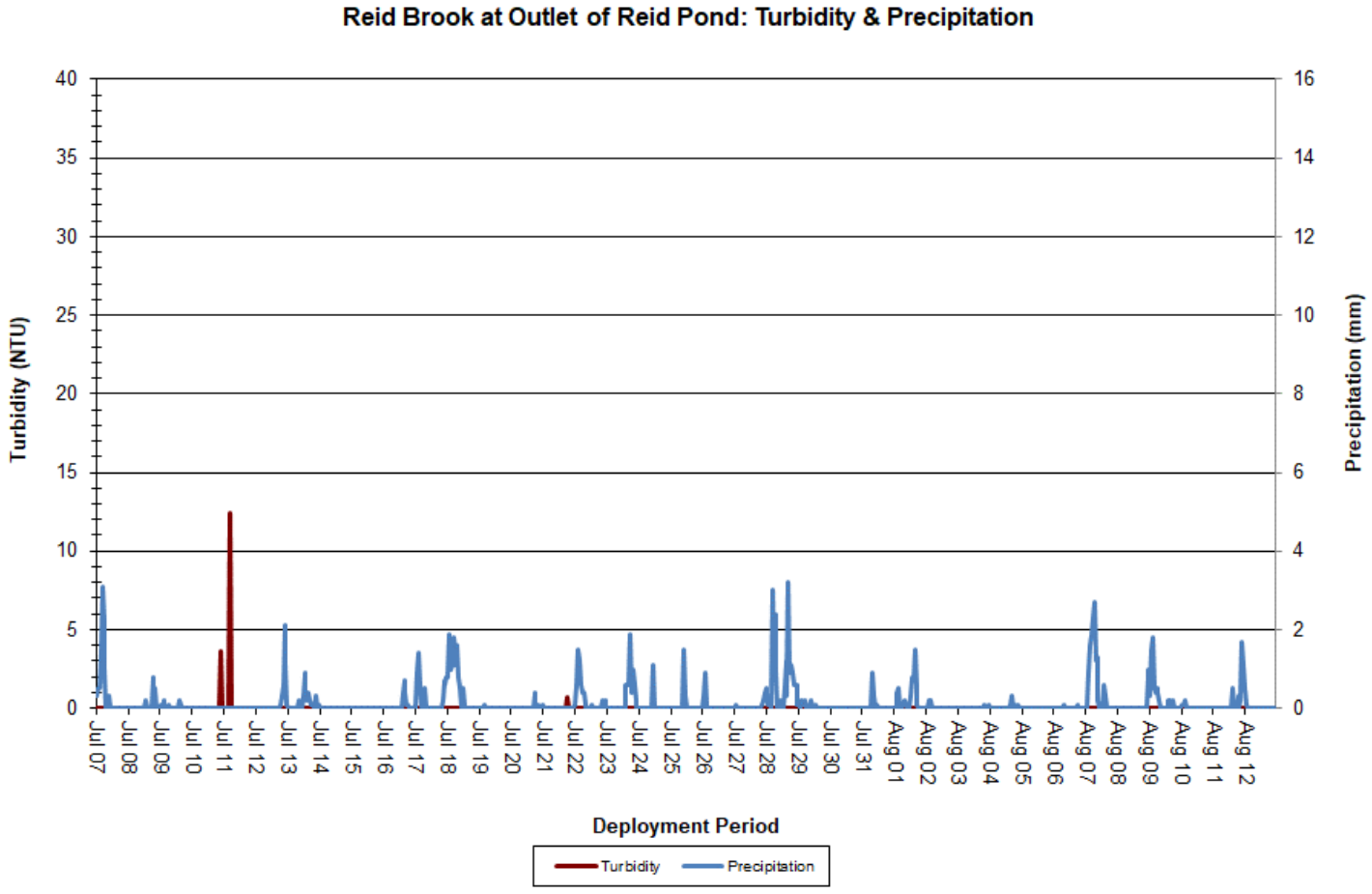

Figure 6: Turbidity & Precipitation at Reid Brook at Outlet of Reid Pond

Stage, Flow & Precipitation

Stage is an important parameter, as it provides an estimate of water level at a station and can explain some of the events that are occurring with other parameters (e.g. specific conductivity, DO, and turbidity). Stage will generally increase during rainfall events (Figure 7) and during any surrounding snow or ice melt; however, direct snowfall will not cause a significant increase in stage.

Over the deployment period, stage values ranged from 1.97m to 2.15m, with a median value of 2.05m. Flow values ranged from 3.01m^3/s to 5.47m^3/s, with a median value of 3.99m^3/s. Precipitation data was obtained from the Voisey's Bay airstrip weather station (Figure 7).

Please note the stage and flow data used below is raw data. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request to WSC.

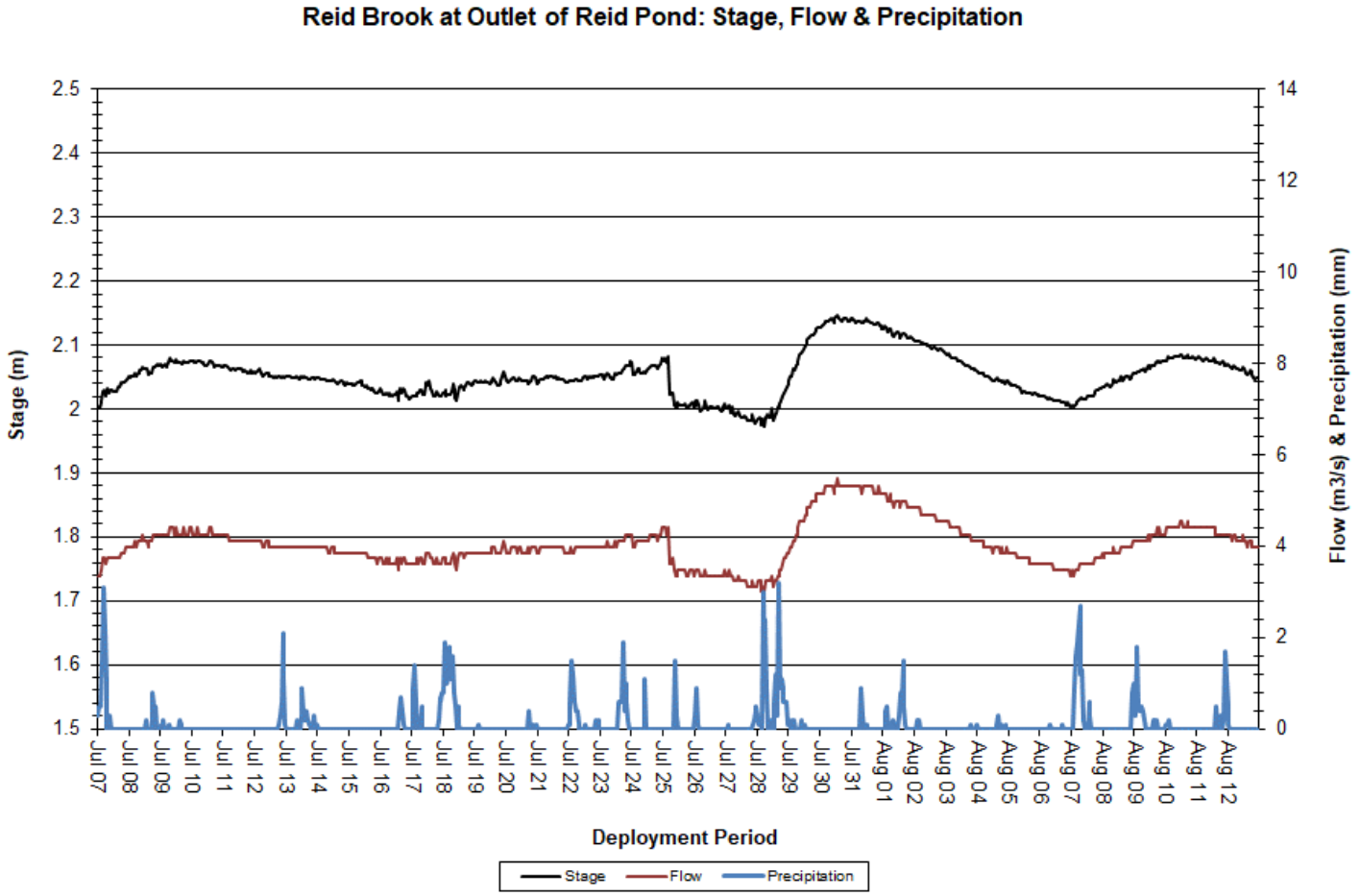

Figure 7: Stage, Flow & Precipitation at Reid Brook at Outlet of Reid Pond

Camp Pond Brook below Camp Pond

Water Temperature

Over the deployment period, water temperature ranged from 10.01°C to 18.76°C, with a median value of 12.76°C (Figure 8).

Water temperature at this station displays diurnal variations. There was a gradual increase in water temperature for the first half of deployment, after which it remained fairly stable. This is to be expected as air temperatures also increased for the first part of deployment and then stabilized (Figure 8). Air temperature data was obtained from the Voisey's Bay airstrip weather station.

Camp Pond Brook is sensitive to changes in ambient air temperature and fluctuates considerably depending on the weather and time of day. This station typically has the highest water temperatures and greatest fluctuations when compared to the other stations in the network.

Please note the stage data used below is raw data. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request to WSC.

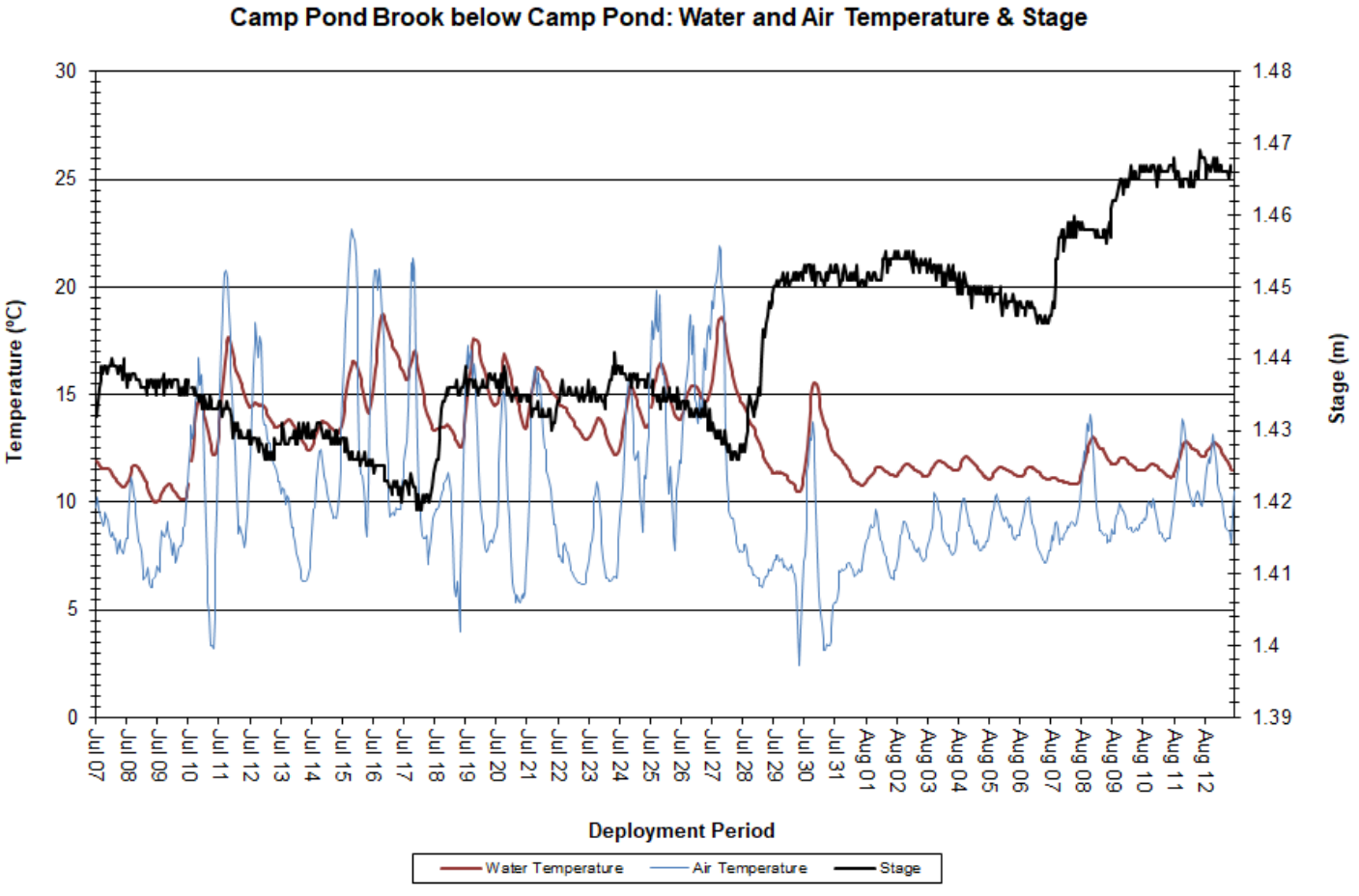

Figure 8: Water and Air Temperature & Stage at Camp Pond Brook below Camp Pond

pH

Over the deployment period, pH values ranged from 5.88 pH units to 6.14 pH units, with a median value of 6.00 pH units (Figure 9).

pH levels were quite stable across the deployment period, but remained below the CCME's Guidelines for the Protection of Aquatic Life.

Natural events such as rainfall and snow melt will alter the pH of a brook for a period of time - pH levels will decrease slightly during and after high stage levels. This is a natural process and may have contributed to temporary decreases in pH levels observed throughout the deployment period (i.e. July 18, July 29, and August 8).

Please note the stage data used below is raw data. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request to WSC.

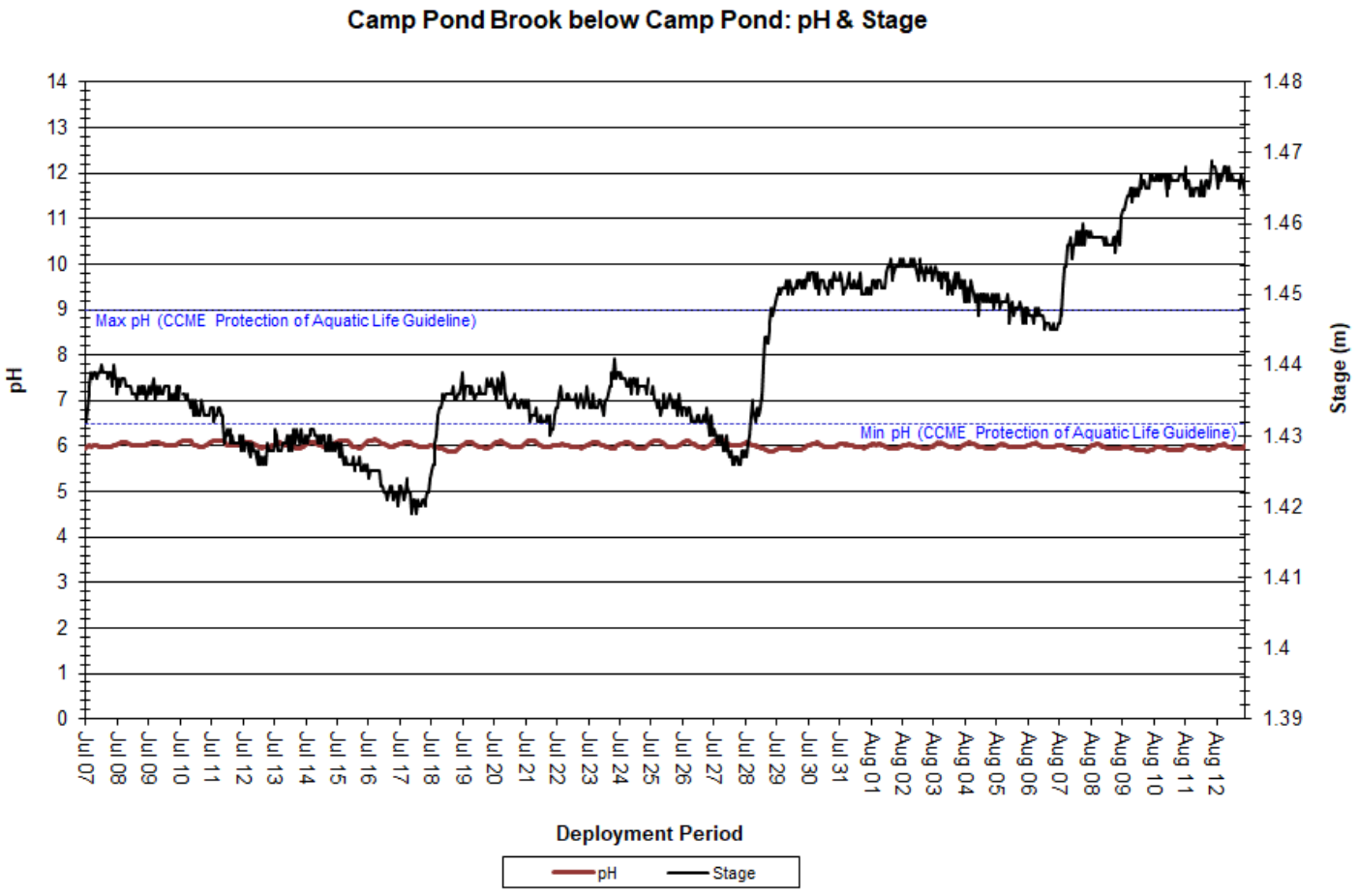

Figure 9: pH & Stage at Camp Pond Brook below Camp Pond

Specific Conductivity

Over the deployment period, specific conductivity ranged from 31.4µS/cm to 42.3µS/cm, with a median value of 34.9µS/cm (Figure 10).

Conductivity levels were variable but increasing across the deployment period, while stage was similarly variable but generally decreasing across deployment. An increase in water level generally serves to dilute suspended materials in the water column, in turn decreasing specific conductivity. This relationship is visible at times in the graph below; however, sudden increases in stage are often accompanied by similar sudden increases in conductivity, after which conductivity begins to decrease as expected (Figure 10). This is likely due to a third factor, such as a precipitation or runoff event, that serves to temporarily increase both stage and conductivity simultaneously.

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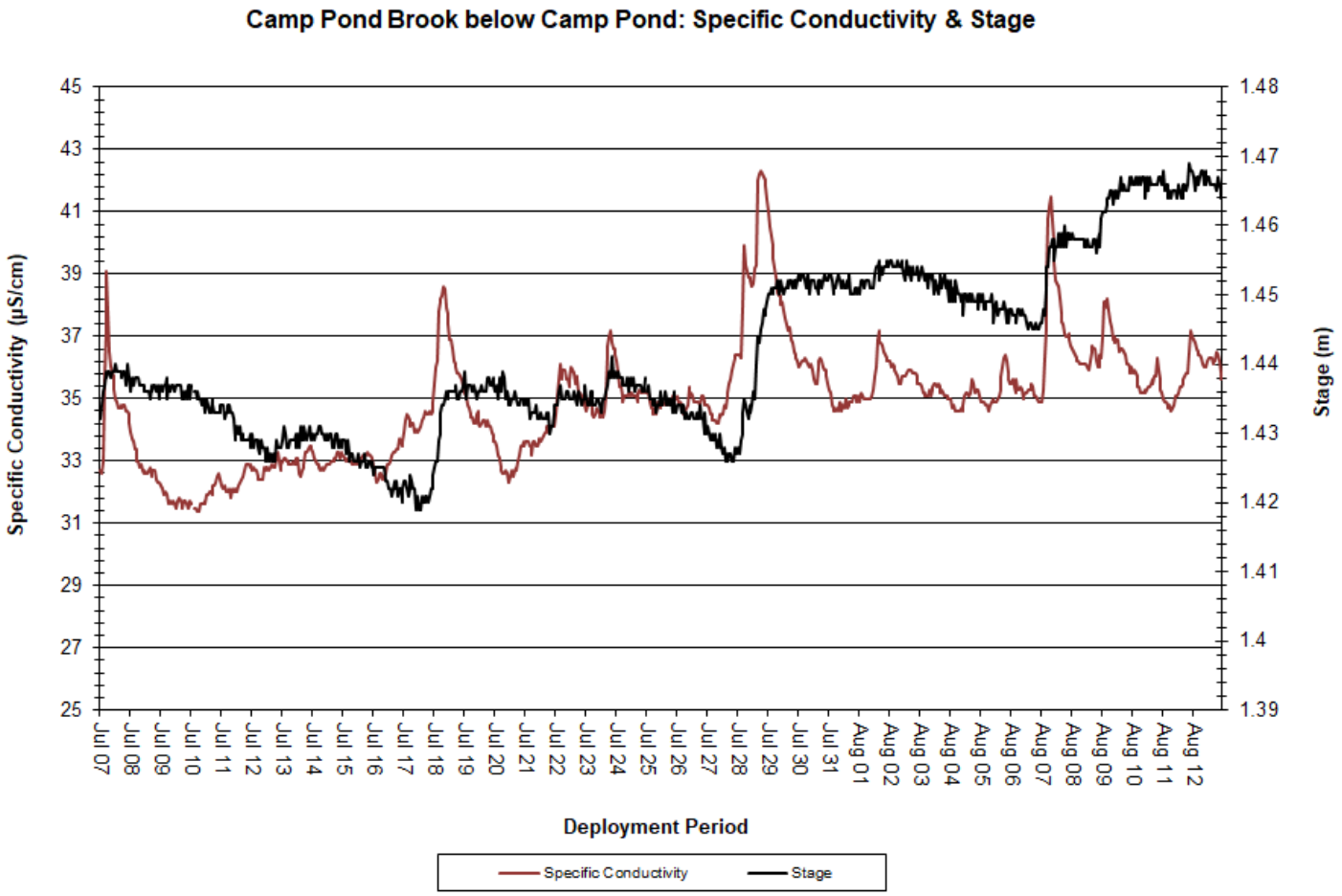

Figure 10: Specific Conductivity & Stage at Camp Pond Brook below Camp Pond

Dissolved Oxygen

Over the deployment period, dissolved oxygen concentration ranged from 9.00mg/L to 10.91mg/L, with a median value of 10.13mg/L. Saturation of dissolved oxygen ranged from 92.1% saturation to 104.3% saturation, with a median value of 96.6% (Figure 11).

Dissolved oxygen concentrations decreased for the first half of deployment, after which they increased slightly and stabilized. In contrast, water temperature increased for the first half of deployment and then decreased slightly and stabilized. This observation is to be expected as water temperature directly influences the level of dissolved oxygen present in the water column; as water temperatures increase, dissolved oxygen concentrations decrease, and vice versa.

Dissolved oxygen concentrations dipped below the CCME's Guidelines for the Protection of Early Life Stages on several occasions, but remained above the CCME's Guidelines for the Protection of Other Life Stages. The occasions when dissolved oxygen concentrations were below the CCME's Guideline for the Protection of Early Life Stages correlated closely with significant increases in water temperature (Figure 11).

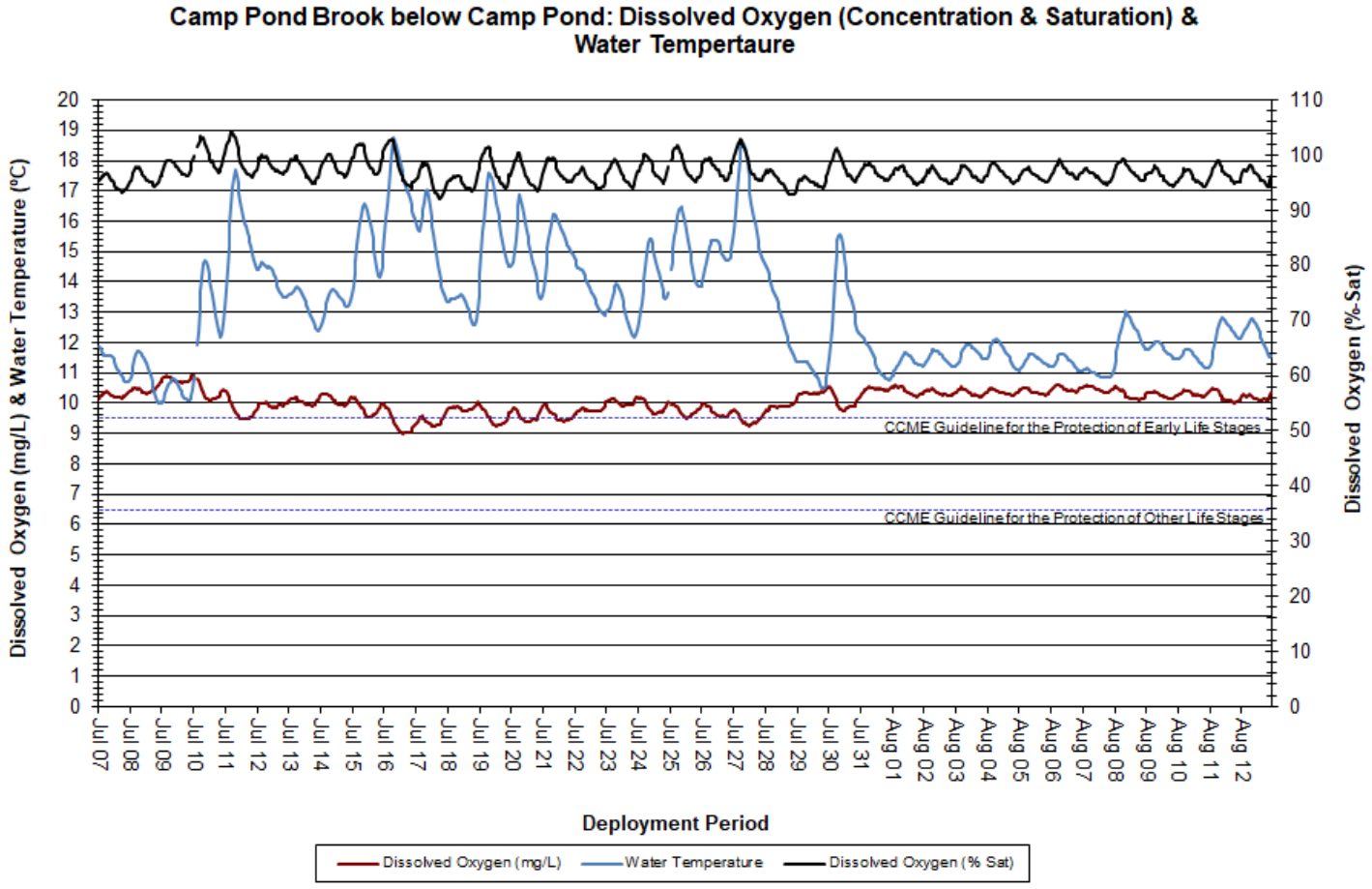

Figure 11: Dissolved Oxygen & Water Temperature at Camp Pond Brook below Camp Pond

Turbidity

Over the deployment period, turbidity ranged from 0.0NTU to 46.5NTU, with a median value of 0.0NTU (Figure 12). A median value of 0.0NTU indicates that there was very little natural background turbidity at this station.

The majority of turbidity peaks observed from throughout the deployment period correlate closely with rainfall events (Figure 12). Precipitation data was obtained from the Voisey's Bay airstrip weather station.

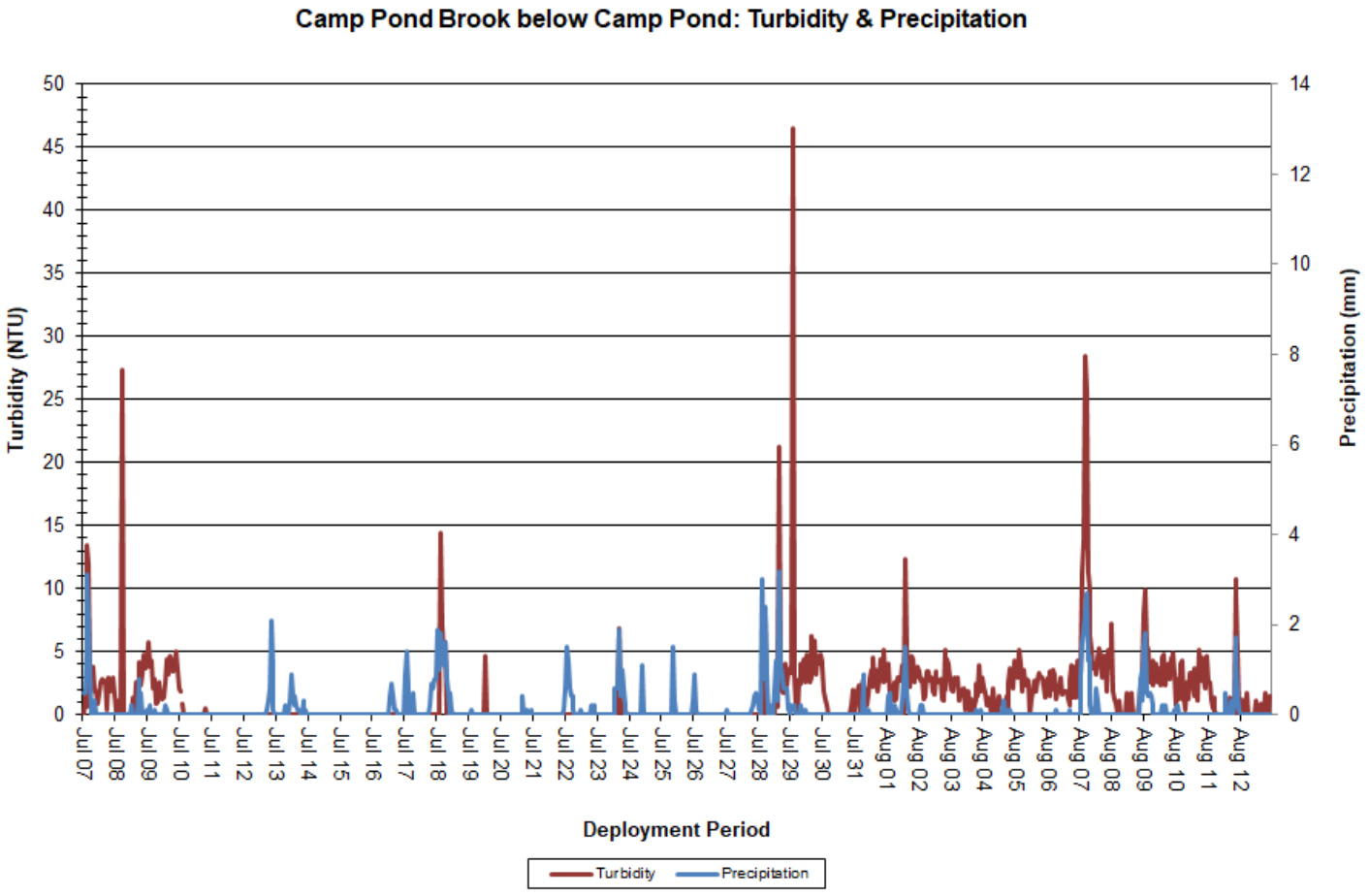

Figure 12: Turbidity & Precipitation at Camp Pond Brook below Camp Pond

Stage, Flow and Precipitation

Over the deployment period, stage values ranged from 1.42m to 1.47m, with a median value of 1.44m. Stream flow values ranged from 0.56m^3/s to 0.79m^3/s, with a median value of 0.66m^3/s (Figure 13). Precipitation data was obtained from the Voisey's Bay airstrip weather station.

Stage was variable across the deployment period, but generally showed a decreasing trend. The majority of observed increases in stage were temporary and correlated closely with significant precipitation events (Figure 13).

Please note the stage and flow data used below is raw data. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request to WSC.

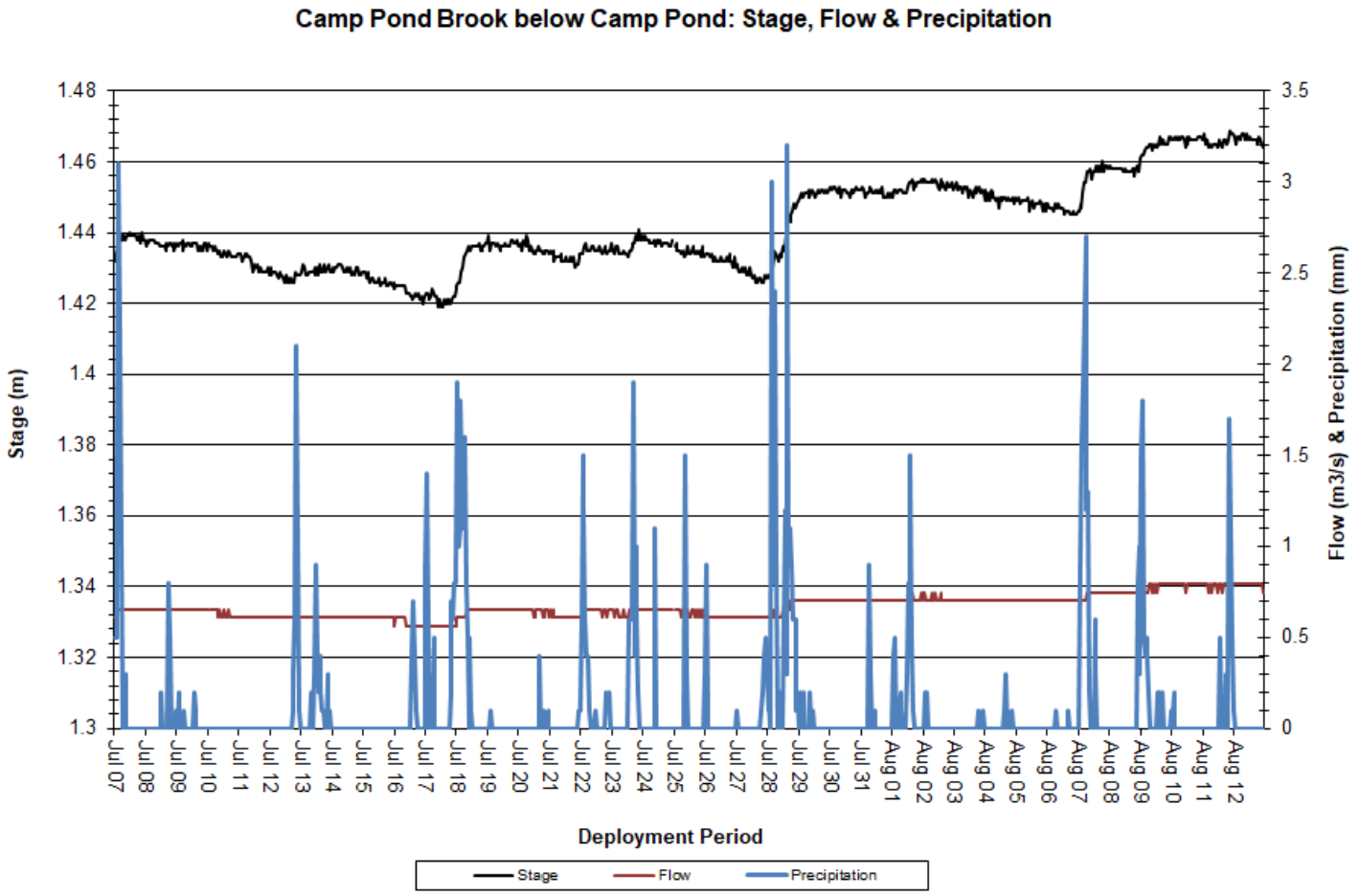

Figure 13: Stage, Flow & Precipitation at Camp Pond Brook below Camp Pond

Reid Brook below Tributary

Water Temperature

Over the deployment period, water temperature ranged from 8.08°C to 15.20°C, with a median value of 10.47°C (Figure 14).

Water temperature at this station displays diurnal variations. There was a gradual increase in the water temperature throughout the first half of deployment as spring changed to summer, after which water temperatures decreased slightly and then stabilized. This is to be expected as air temperatures followed a very similar trend (Figure 14). Air temperature data was obtained from the Voisey's Bay airstrip weather station.

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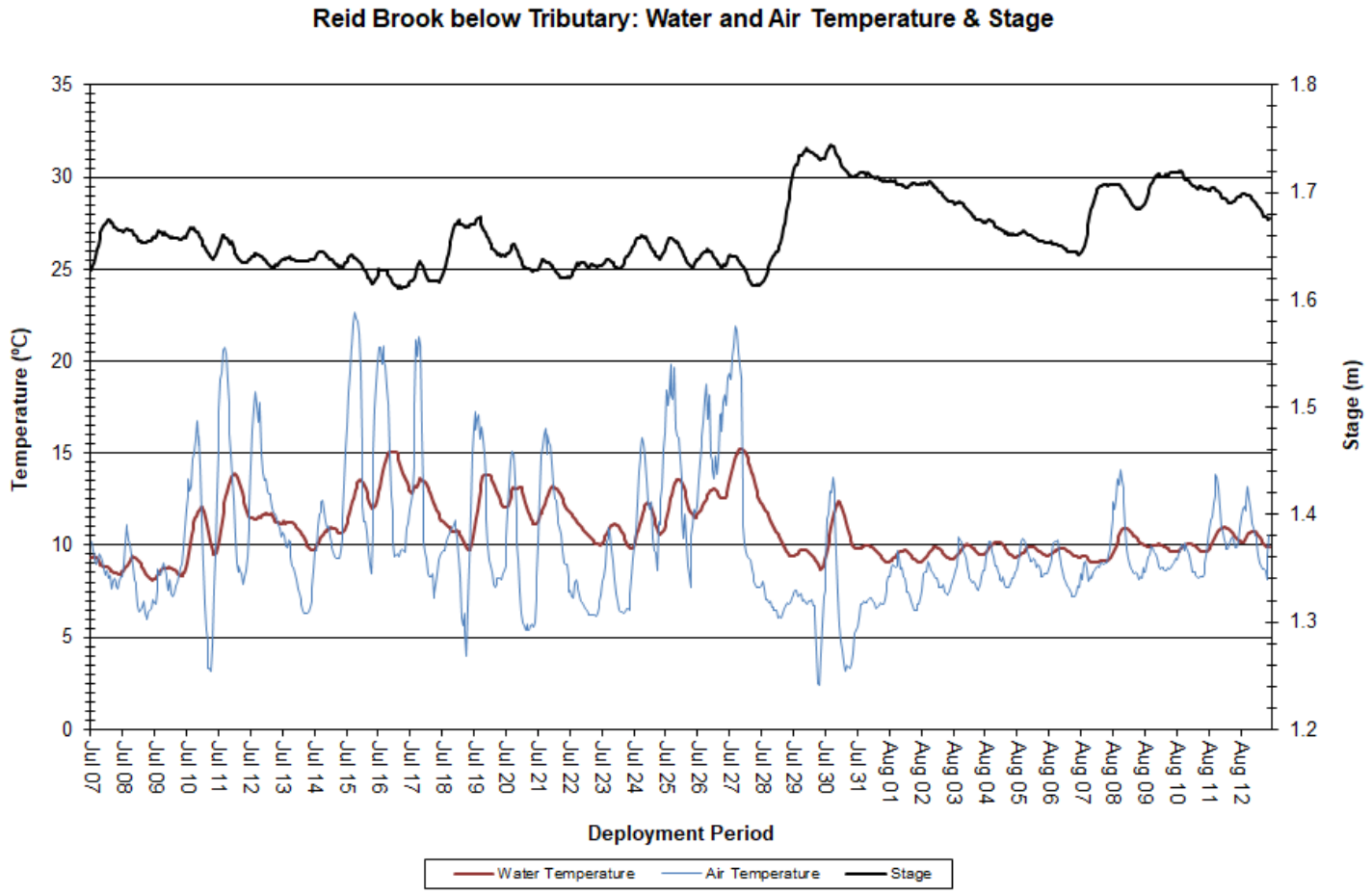

Figure 14: Water and Air Temperature & Stage at Reid Brook below Tributary

pH

Over the deployment period, pH ranged from 6.13 pH units to 6.62 pH units, with a median value of 6.39 (Figure 15).

pH was below the CCME's Minimum Guideline for the Protection of Aquatic Life for the majority of the deployment period. Sharp increases in stage correlated closely with temporary decreases in pH (Figure 15).

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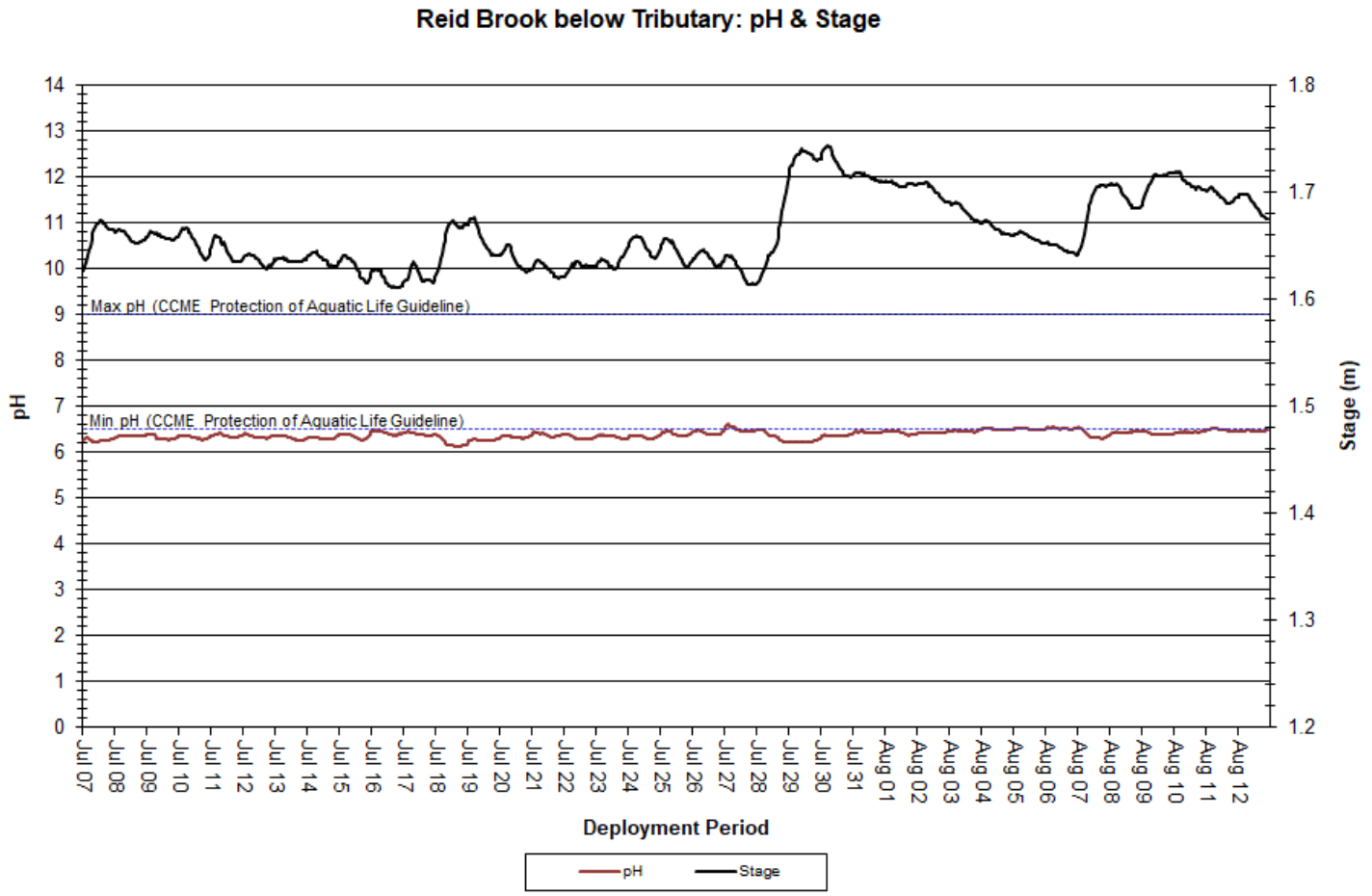

Figure 15: pH & Stage at Reid Brook below Tributary

Specific Conductivity

Over the deployment period, specific conductivity ranged from 23.6µS/cm to 33.1µS/cm, with a median value of 28.0µS/cm (Figure 16).

Specific conductivity steadily increased over the course of deployment (Figure 16).

Specific conductivity and stage generally exhibit an inverse relationship: as one parameter increases, the other decreases. This relationship is evident in the graph below.

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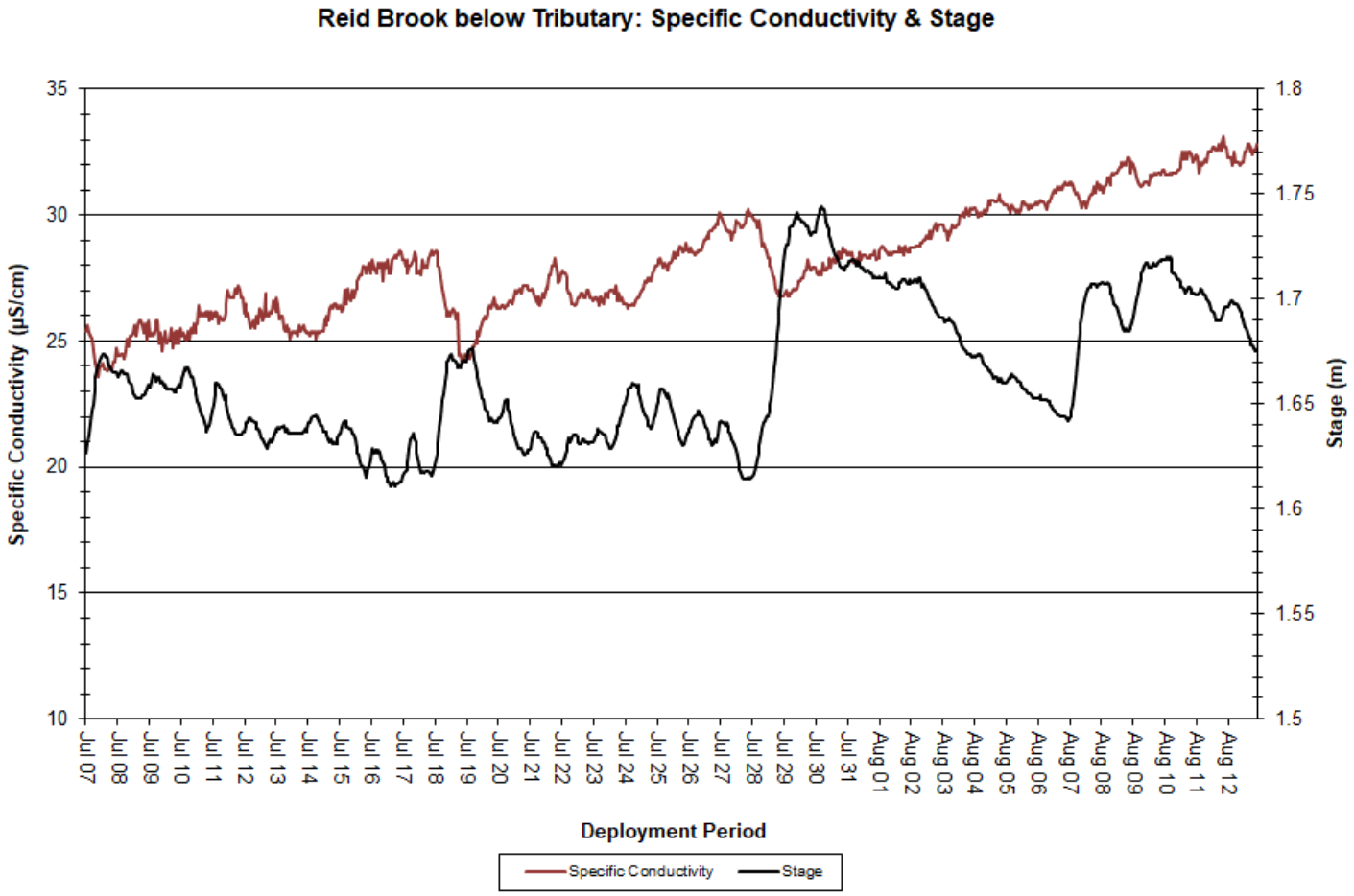

Figure 16: Specific Conductivity & Stage at Reid Brook below Tributary

Dissolved Oxygen

Over the deployment period, dissolved oxygen concentration ranged from 9.58mg/L to 11.60mg/L, with a median value of 10.80mg/L. The saturation of dissolved oxygen ranged from 95.5% saturation to 102.3% saturation, with a median value of 98.1% (Figure 17).

Dissolved oxygen concentrations remained above the CCME's Guidelines for the Protection of Early Life Stages (9.5mg/L) and Other Life Stages (6.5 mg/L) for the duration of deployment. Dissolved oxygen concentration was fairly consistent over the course of deployment, with fluctuations closely connected to changes in water temperature. This is to be expected as water temperature and dissolved oxygen concentration generally exhibit an inverse relationship.

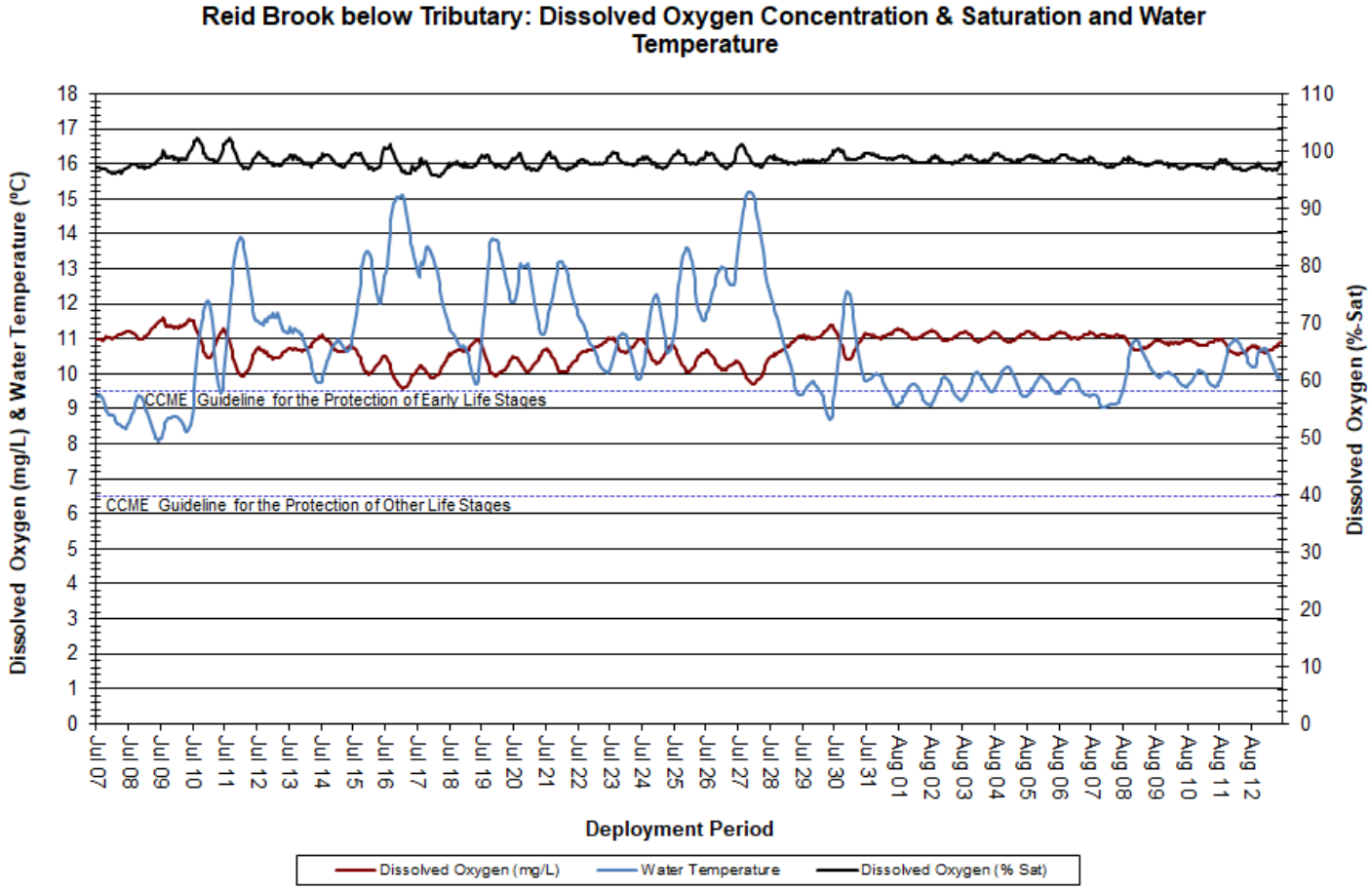

Figure 17: Dissolved Oxygen & Water Temperature at Reid Brook below Tributary

Turbidity

Over the deployment period, turbidity ranged from 0.0 NTU to 1053.0 NTU, with a median value of 0.2 NTU (Figure 18). A median turbidity value of 0.2 NTU indicates that there was very little background turbidity at this station.

The majority of the turbidity events observed at this station closely correlated with rainfall events (Figure 18), which can cause mixing of solids in the water column. A modified y-axis is used in the graph below to show how precipitation events correlate with smaller turbidity events (Figure 18). Precipitation data was obtained from the Voisey's Bay airstrip weather station.

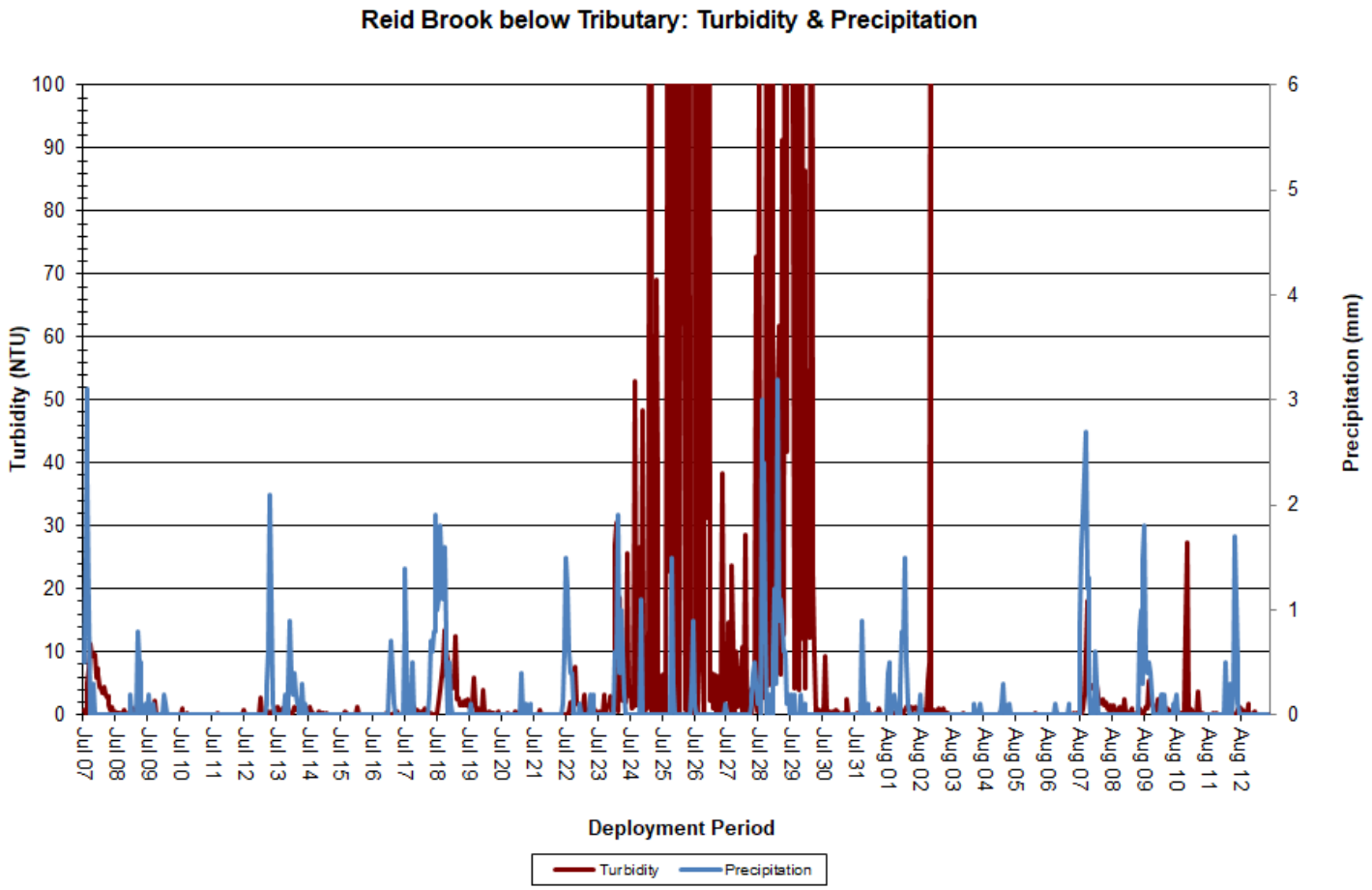

Figure 18: Turbidity & Precipitation at Reid Brook below Tributary

Stage and Flow

Over the deployment period, stage values ranged from 1.61m to 1.74m, with a median value of 1.66m. Stream flow values ranged from 4.80m^3/s to 9.39m^3/s, with a median value of 6.46m^3/s (Figure 19). Precipitation data was obtained from the Voisey's Bay airstrip weather station.

Stage and flow were variable across the deployment period, but generally showed an increasing trend. The majority of observed increases in stage and flow correlated closely with precipitation events (Figure 19).

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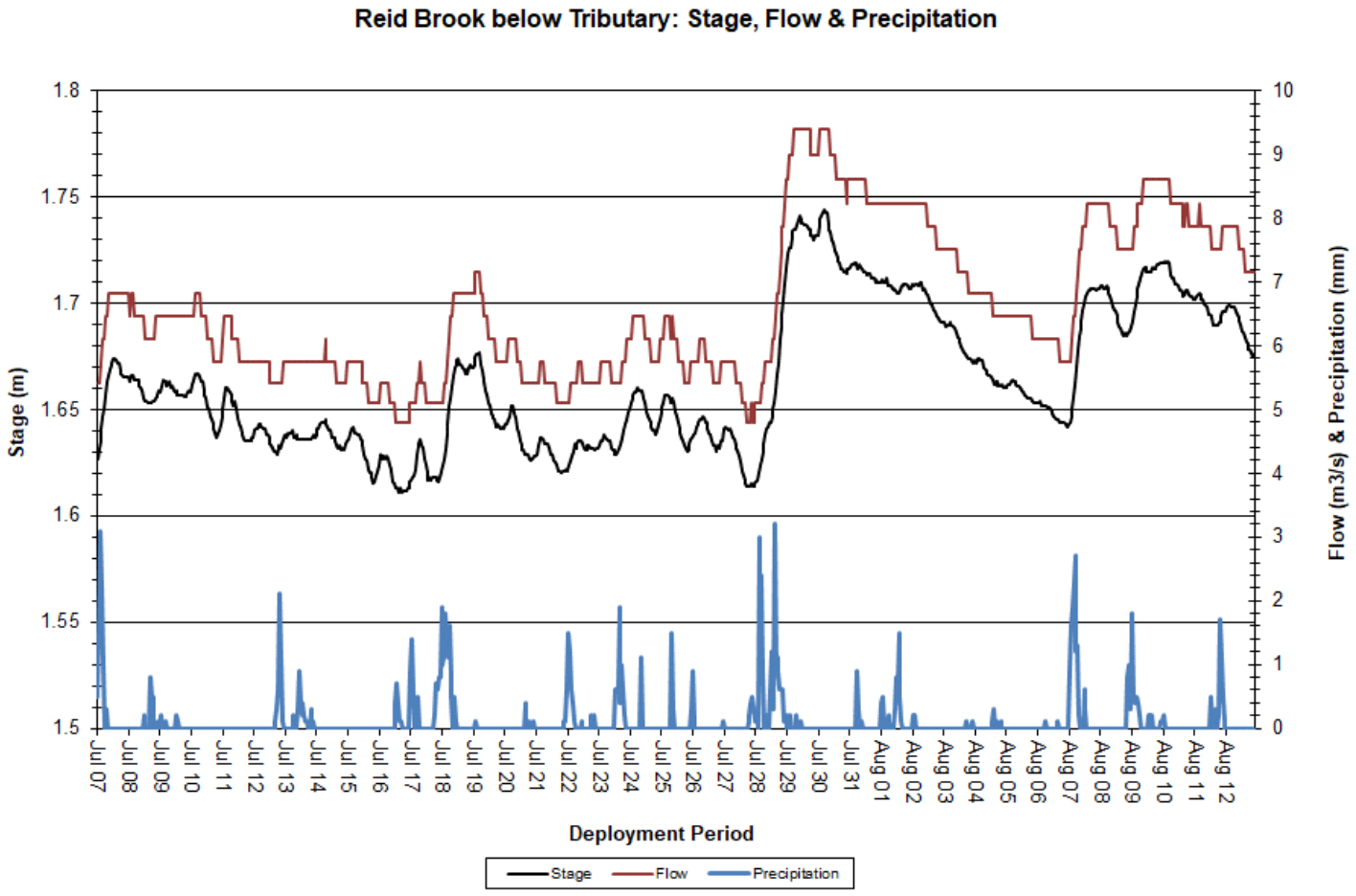

Figure 19: Stage, Flow & Precipitation at Reid Brook below Tributary

Tributary to Reid Brook

Water Temperature

Over the deployment period, water temperature ranged from 8.10°C to 15.10°C, with a median value of 10.30°C (Figure 20). Streams and brooks are sensitive to changes in the ambient air temperature, thus water temperature will fluctuate considerably depending on the weather and the time of day. Air temperature fluctuates to a greater extent compared to water temperature. Air temperature data was obtained from the Voisey's Bay airstrip weather station.

Water temperature data displays a natural diurnal pattern. As expected, water temperatures increased gradually over the course of deployment with the change from spring to summer, and correlated closely with ambient air temperatures.

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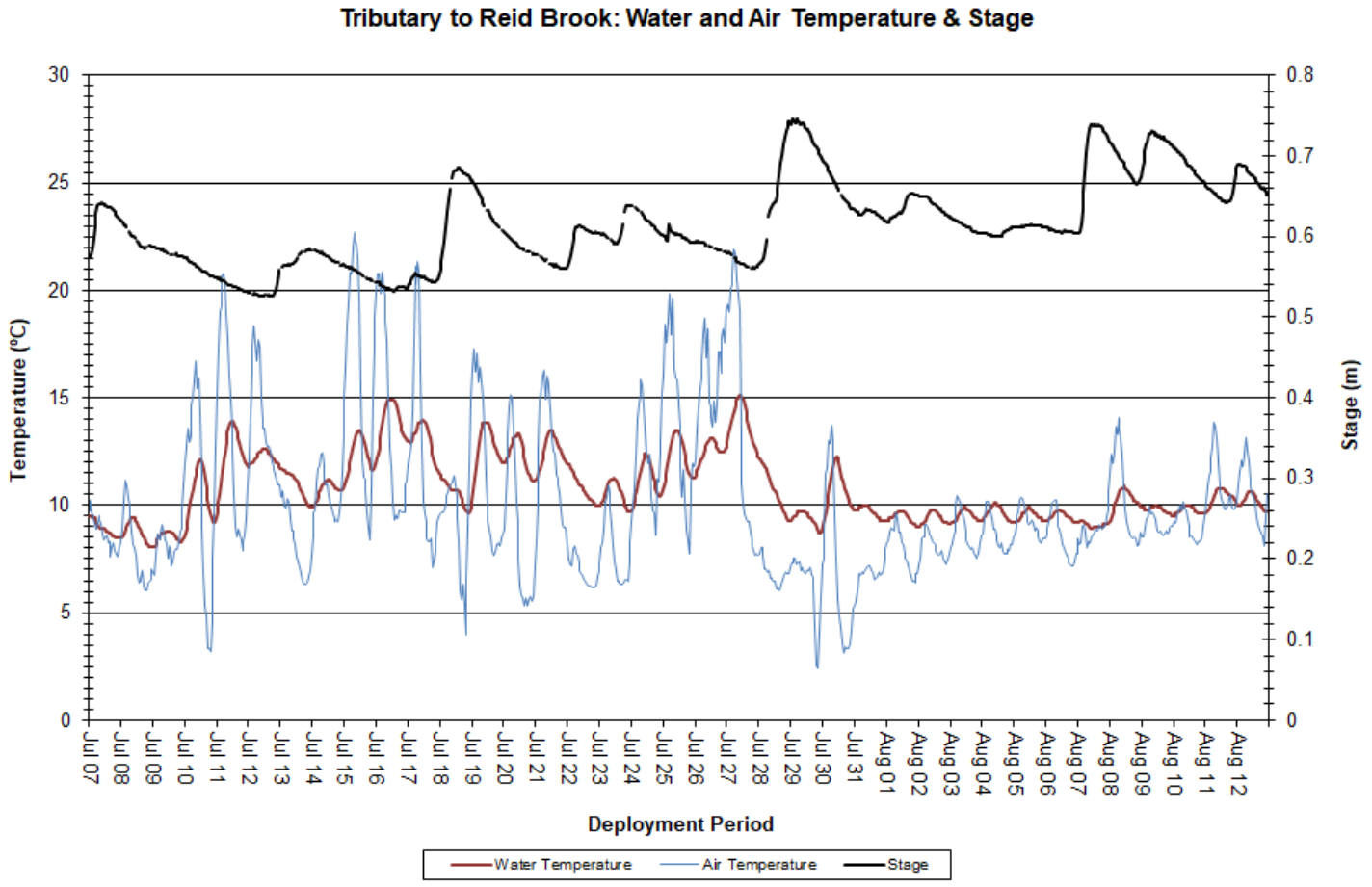

Figure 20: Water and Air Temperature & Stage at Tributary to Reid Brook

pH

Over the deployment period, pH ranged from 6.21 pH units to 6.88 pH units, with a median value of 6.73 (Figure 21).

pH values reached the CCME's Minimum Guideline for the Protection of Aquatic Life quickly after the start of deployment, and remained within the acceptable range for the remainder of the deployment period.

Please note the stage and flow data used below is raw data. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request to WSC.

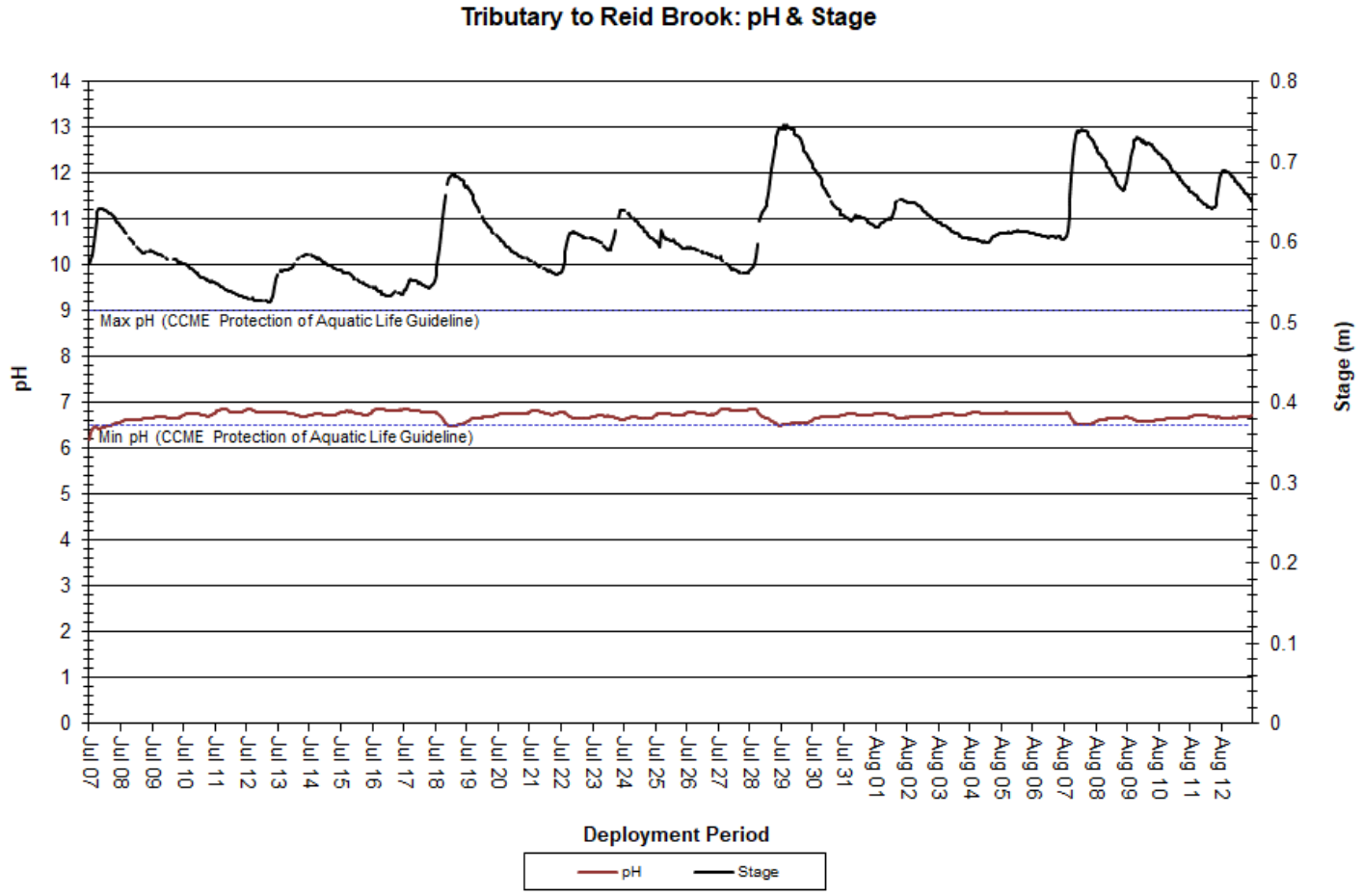

Figure 21: pH & Stage at Tributary to Reid Brook

Specific Conductivity

Over the deployment period, specific conductivity ranged from 24.8µS/cm to 31.3µS/cm, with a median value of 27.6µS/cm (Figure 22).

Specific conductivity and stage generally exhibit an inverse relationship: as one parameter increases, the other decreases. When stage levels decrease, specific conductivity levels increase, as the decreased amount of water in the river system concentrates the solids that are present. This inverse relationship is readily visible in the graph below (Figure 22).

Please note the stage and flow data used below is raw data. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request to WSC.

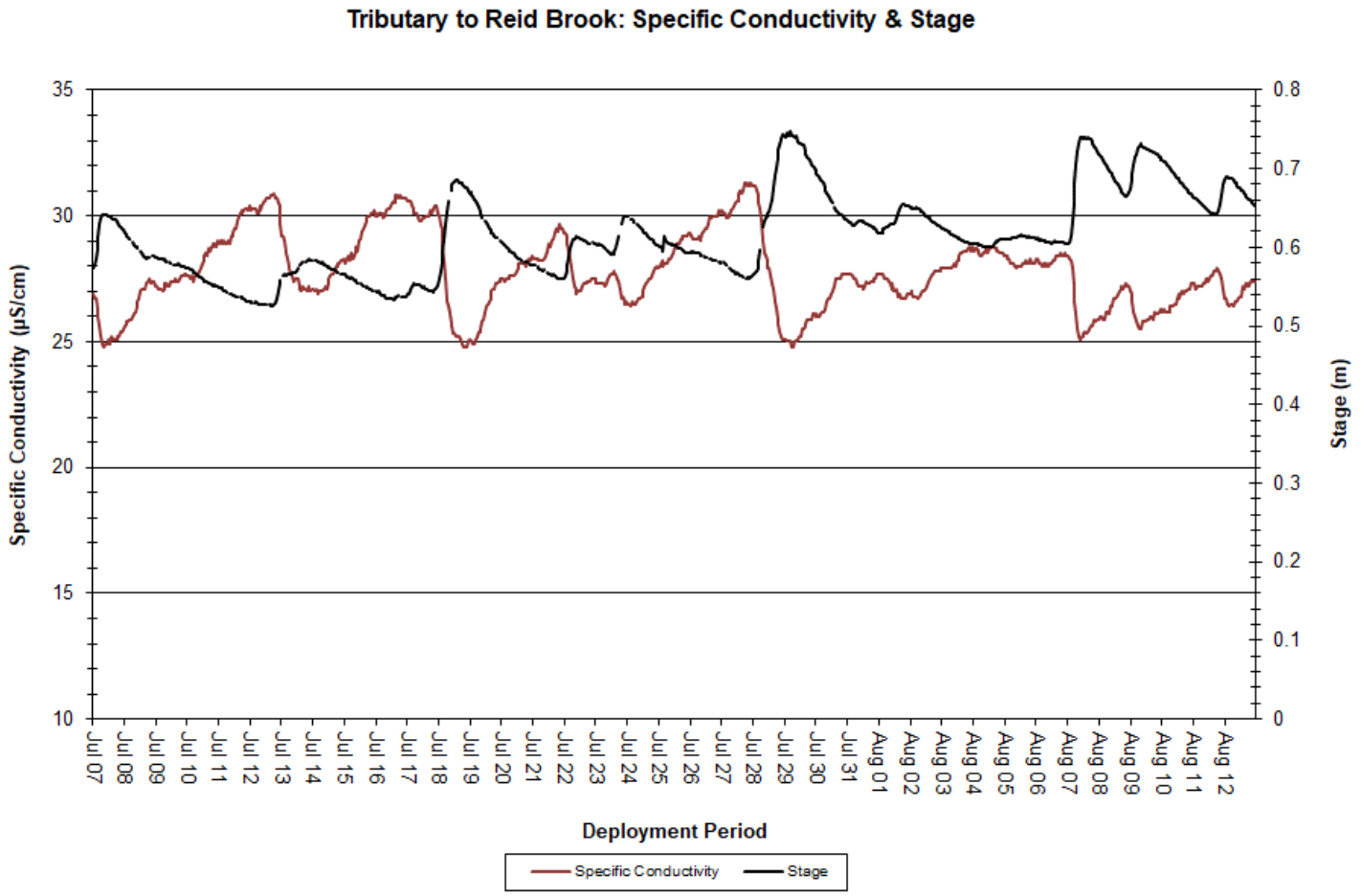

Figure 22: Specific Conductivity & Stage at Tributary to Reid Brook

Dissolved Oxygen

Over the deployment period, dissolved oxygen concentration ranged from 9.50mg/L to 11.46mg/L, with a median value of 10.69mg/L. The saturation of dissolved oxygen ranged from 94.2% saturation to 100.0% saturation, with a median value of 96.8% (Figure 23).

Dissolved oxygen levels remained above the CCME's Guidelines for the Protection of Early and Other Life Stages for the duration of deployment.

Dissolved oxygen concentration displays a diurnal pattern. During nightfall, dissolved oxygen levels are higher as cooler temperatures allow for more DO to be stored in the water column. During the day, dissolved oxygen levels are lower. This is a result of warmer water temperatures and photosynthesis by aquatic plants, which decrease dissolved oxygen levels in the water column.

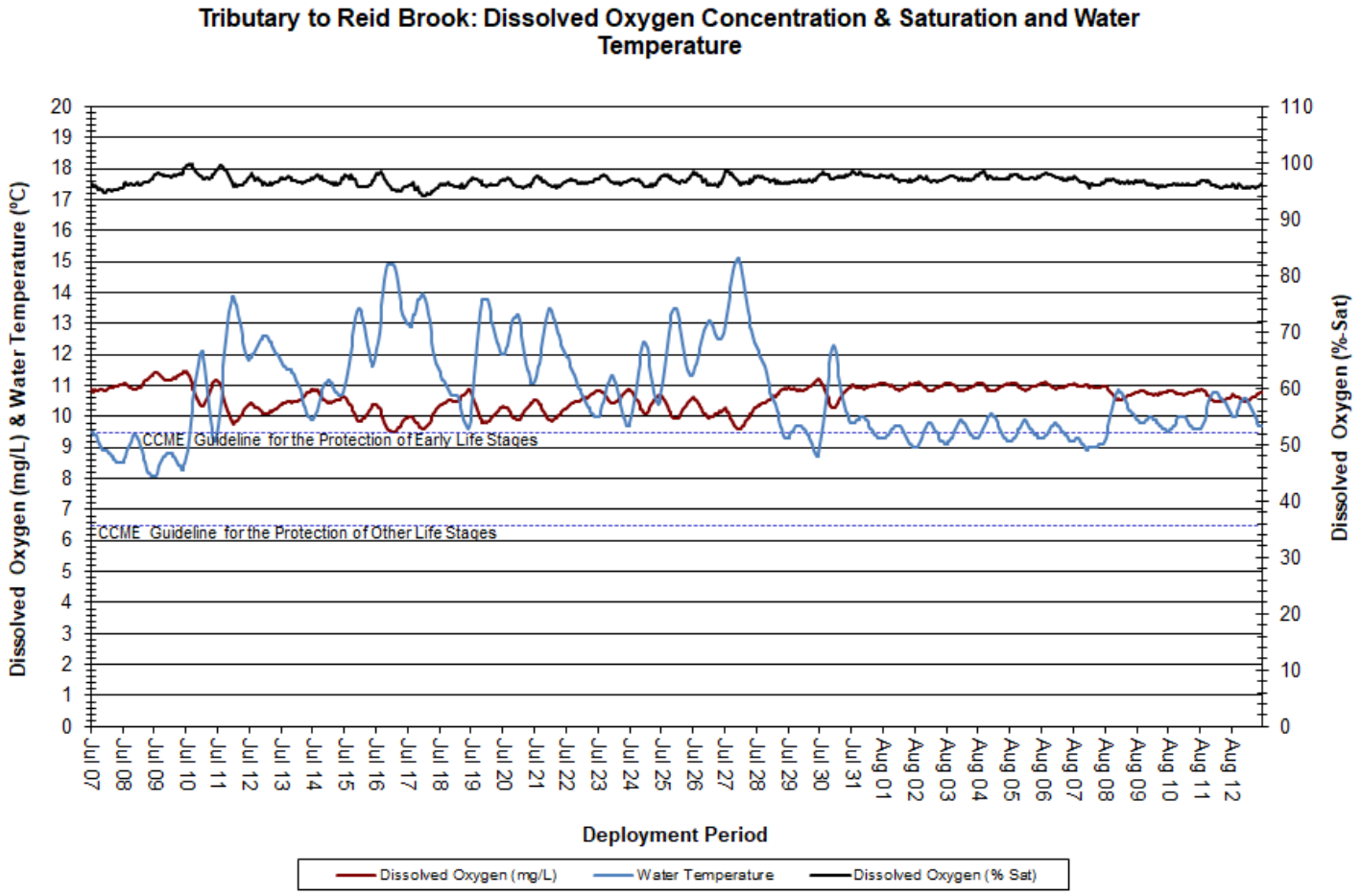

Figure 23: Dissolved Oxygen & Water Temperature at Tributary to Reid Brook

Turbidity

Over the deployment period, turbidity ranged from 0.0 NTU to 23.4 NTU, with a median value of 0.6 NTU (Figure 24). A median value of 0.6 NTU indicates that there was a small amount of natural background turbidity at this station.

There were a number of turbidity events at this station, with many of the larger turbidity events correlating closely with rainfall events (Figure 24). Rainfall generally causes an increase in water volume, which serves to stir up solid materials in the water column, in turn increasing turbidity. This site is particularly prone to variable turbidity, as it has a sandy-clay bottom that is easily disturbed by precipitation events.

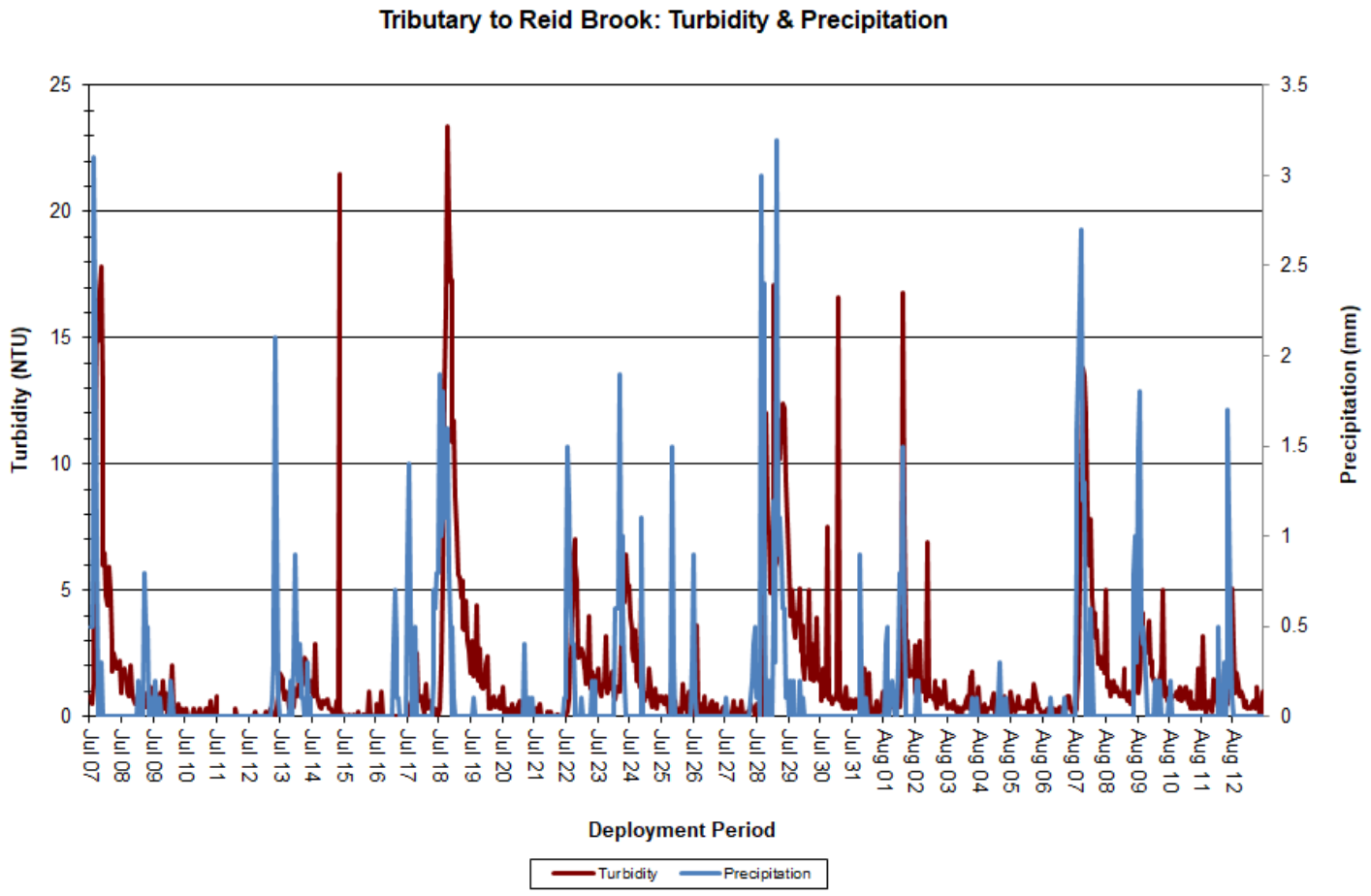

Figure 24: Turbidity & Precipitation at Tributary to Reid Brook

Stage and Flow

Over the deployment period, stage values ranged from 0.53m to 0.75m, with a median value of 0.61m. Stream flow values ranged from 0.23m^3/s to 1.10m^3/s, with a median value of 0.41m^3/s (Figure 25). Precipitation data was obtained from the Voisey's Bay airstrip weather station.

Stage and flow were variable across the deployment period, but generally showed an increasing trend. The majority of observed increases in stage and flow correlated closely with precipitation events (Figure 25).

Please note the stage and flow data used below is raw data. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request to WSC.

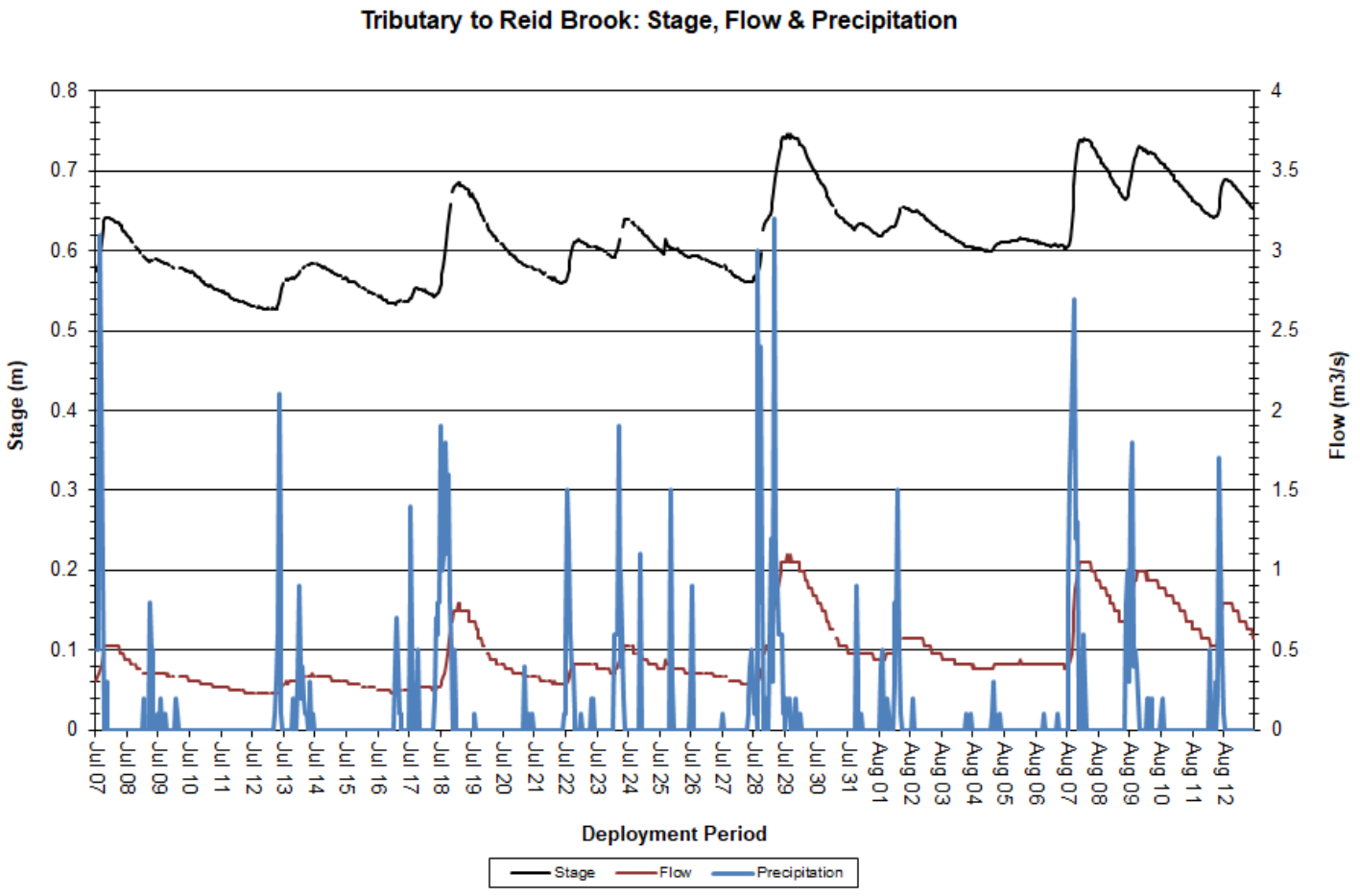

Figure 25: Stage, Flow & Precipitation at Reid Brook below Tributary

Conclusions

Water temperatures across all stations ranged from a minimum of 5.17°C at Reid Brook at Outlet of Reid Pond to a maximum of 18.76°C at Camp Pond Brook below Camp Pond. Overall, water temperature was increasing across the network. Stations at Camp Pond Brook, Tributary to Reid Brook, and Reid Brook below Tributary are more sensitive to changes in ambient air temperatures as these sites are brooks with continuously moving water. In contrast, Reid Brook at Outlet of Reid Pond is a large pond with a high surface area and deeper, slower-moving water. This large body of water regulates the rate of warming and cooling.

pH values across all stations ranged from a minimum of 5.21pH units to a maximum of 7.17pH units, both at Reid Brook at Outlet of Reid Pond. pH values at all stations were relatively consistent across the deployment period.

Specific conductivity across all stations ranged from a minimum of 11.7µS/cm at Reid Brook at Outlet of Reid Pond to a maximum of 42.3µS/cm at Camp Pond Brook below Camp Pond. Conductivity values at Reid Brook at Outlet of Reid Pond were the lowest across the network. Camp Pond Brook below Camp Pond had the highest median value at 34.9µS/cm, which is to be expected given the station's proximity to the Voisey's Bay mine site and increased potential for roadway runoff and other anthropogenic influences.

Dissolved oxygen levels across all stations ranged from a minimum of 9.00mg/L at Camp Pond Brook below Camp Pond to a maximum of 12.47mg/L at Reid Brook at Outlet of Reid Pond. Dissolved oxygen is generally lower at this time of year and varies diurnally as water temperature is greatly affected by ambient air temperature. Dissolved oxygen levels remained above the CCME's Guideline for the Protection of Early Life Stages at all stations for the duration of deployment, except for at Camp Pond Brook below Camp Pond.

Turbidity levels across all stations ranged from a minimum of 0.0 NTU at all stations to a maximum of 1053.0NTU at Reid Brook below Tributary. Turbidity levels showed natural increases and decreases generally corresponding to precipitation events.

Air temperature and precipitation data were obtained from the Voisey's Bay weather station, which is located at the airstrip. This data appears to be quite accurate and no modifications were made.

Overall, the changes in water quality parameters over the course of this deployment can be explained by natural events. Camp Pond Brook below Camp Pond does have the potential for anthropogenic influences as the site is the closest to the inhabited area. It is important to note that during a change (a decrease or increase) in water quality, change only occurs for a short period of time and then water quality parameters return to baseline.

References

Canadian Council of Ministers of the Environment. (2014) "Canadian water quality guidelines for the protection of aquatic life" Canadian Council of Ministers of the Environment. Retrieved from: http://www.ccme.ca/en/resources/canadian_environmental_quality_guidelines/index.html

Canadian Council of Ministers of the Environment. (2014) "Water Quality Guidelines for the Protection of Aquatic Life" Canadian Council of Ministers of the Environment. Retrieved from: http://st-ts.ccme.ca/en/index.html?chems=162&chapters=1

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Swanson, H.A., and Baldwin, H.L., (1965) "A Primer on Water Quality" U.S. Geological Survey. Retrieved from: http://ga.water.usgs.gov/edu/characteristics.html

APPENDIX A: Comparison Graphs

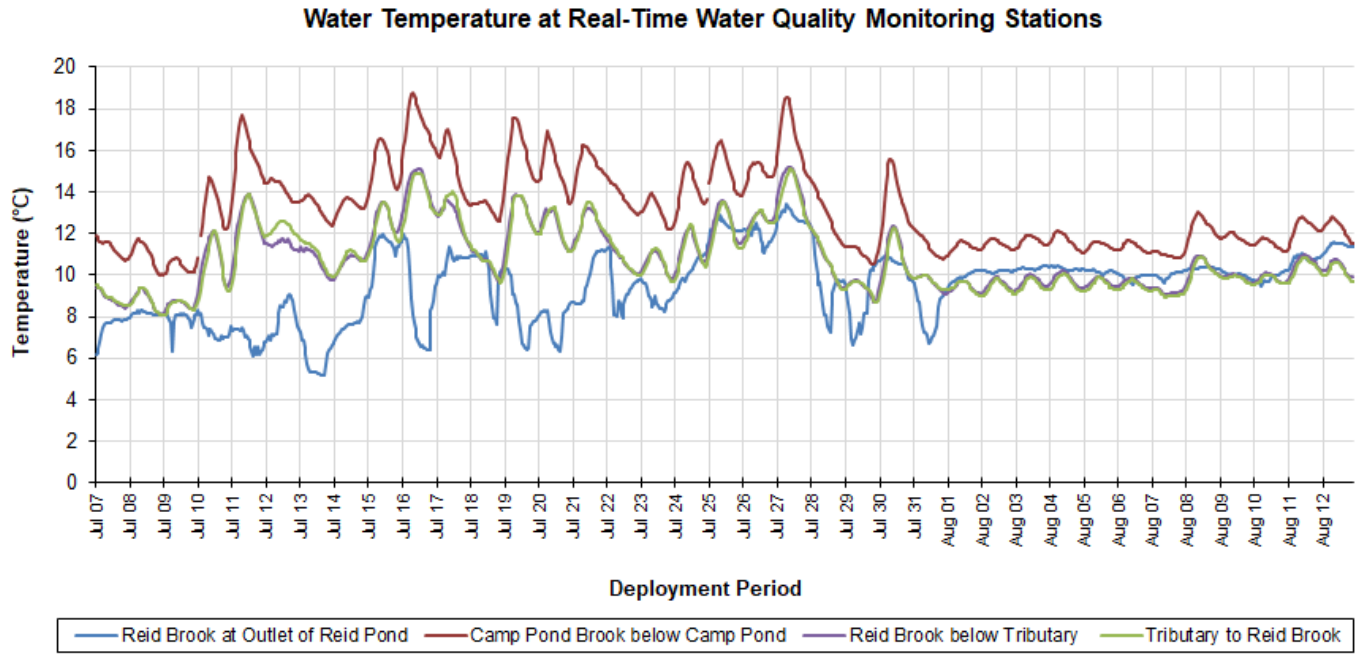

Figure A1: Comparison of Water Temperature (^{0}C) between all Real-Time Stations in Voisey's Bay.

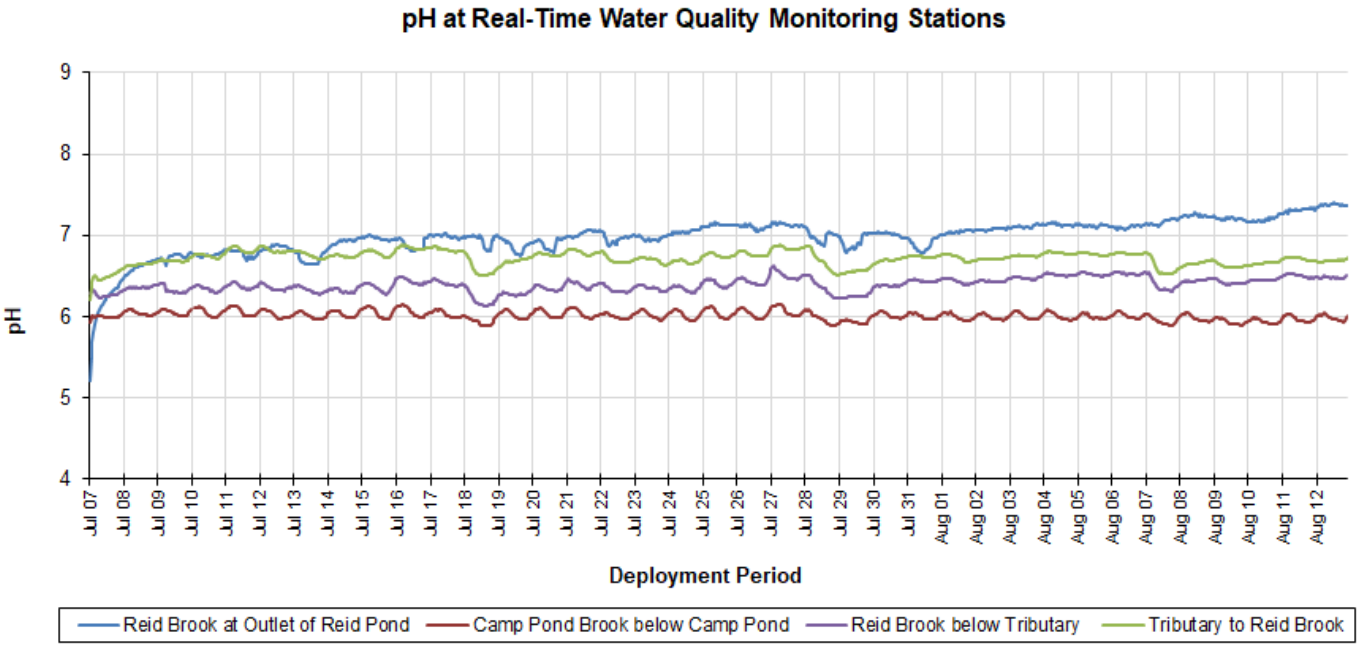

Figure A2: Comparison of pH between all Real-Time Stations in Voisey's Bay.

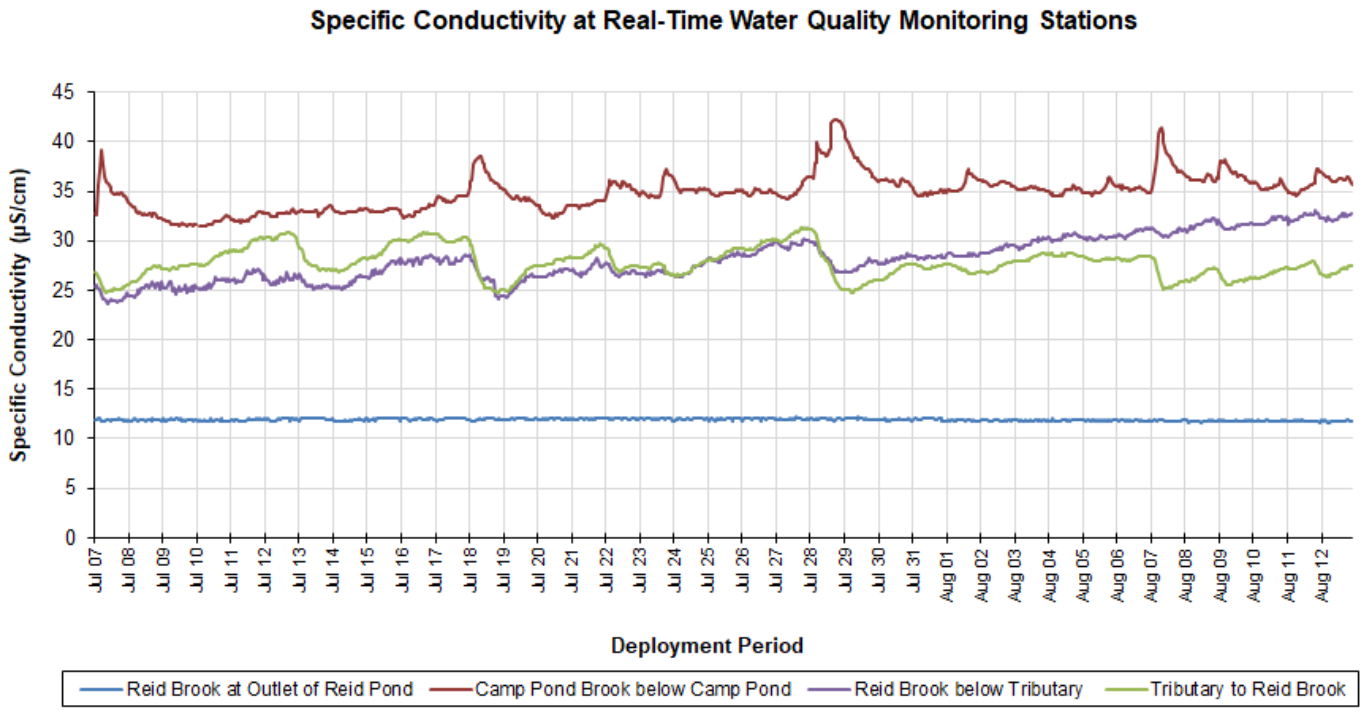

Figure A3: Comparison of Specific Conductivity (µS/cm) between all Real-Time Stations in Voisey's Bay.

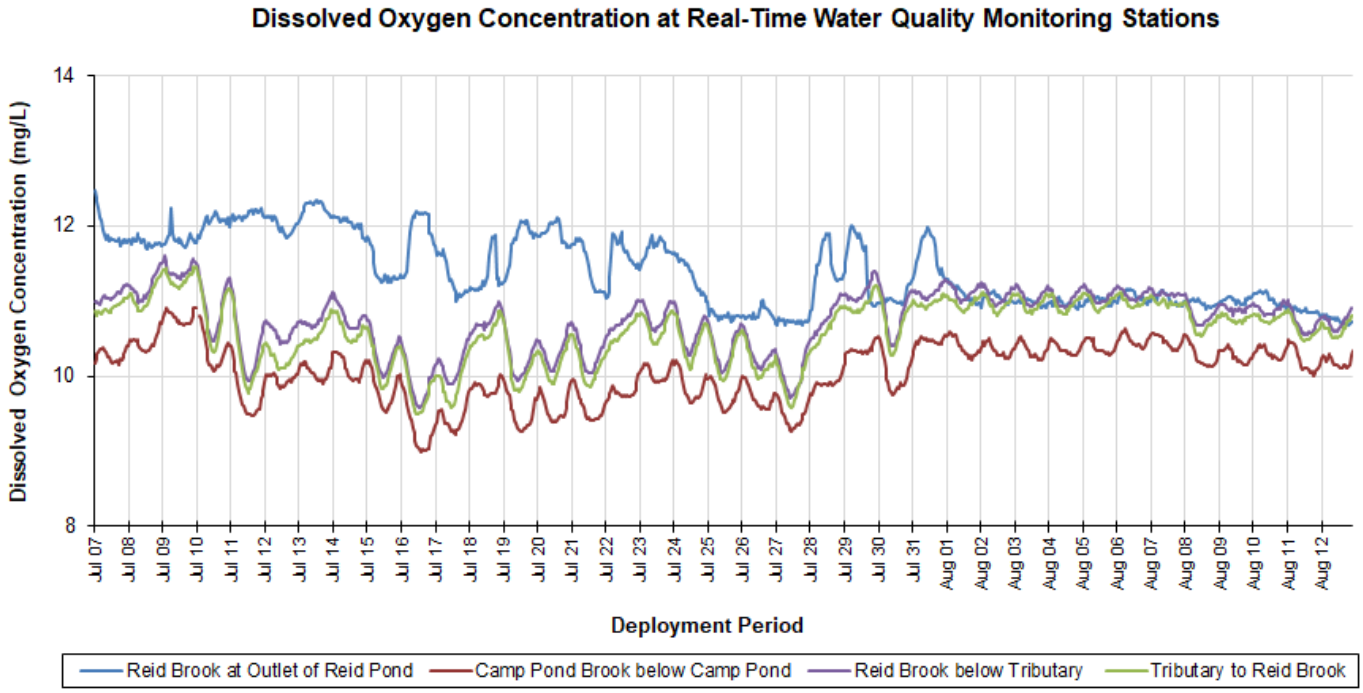

Figure A4: Comparison of Dissolved Oxygen (mg/L) between all Real-Time Stations in Voisey's Bay.

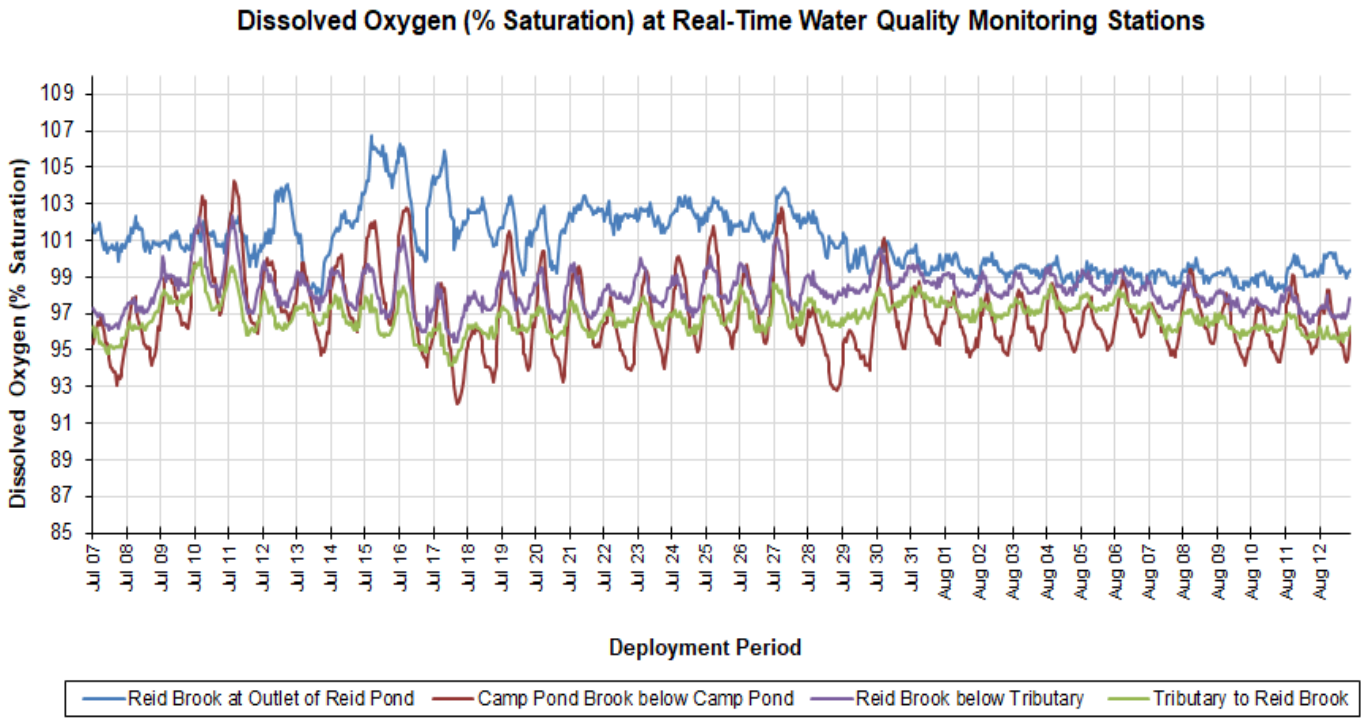

Figure A5: Comparison of Dissolved Oxygen (% Sat) between all Real-Time Stations in Voisey's Bay.

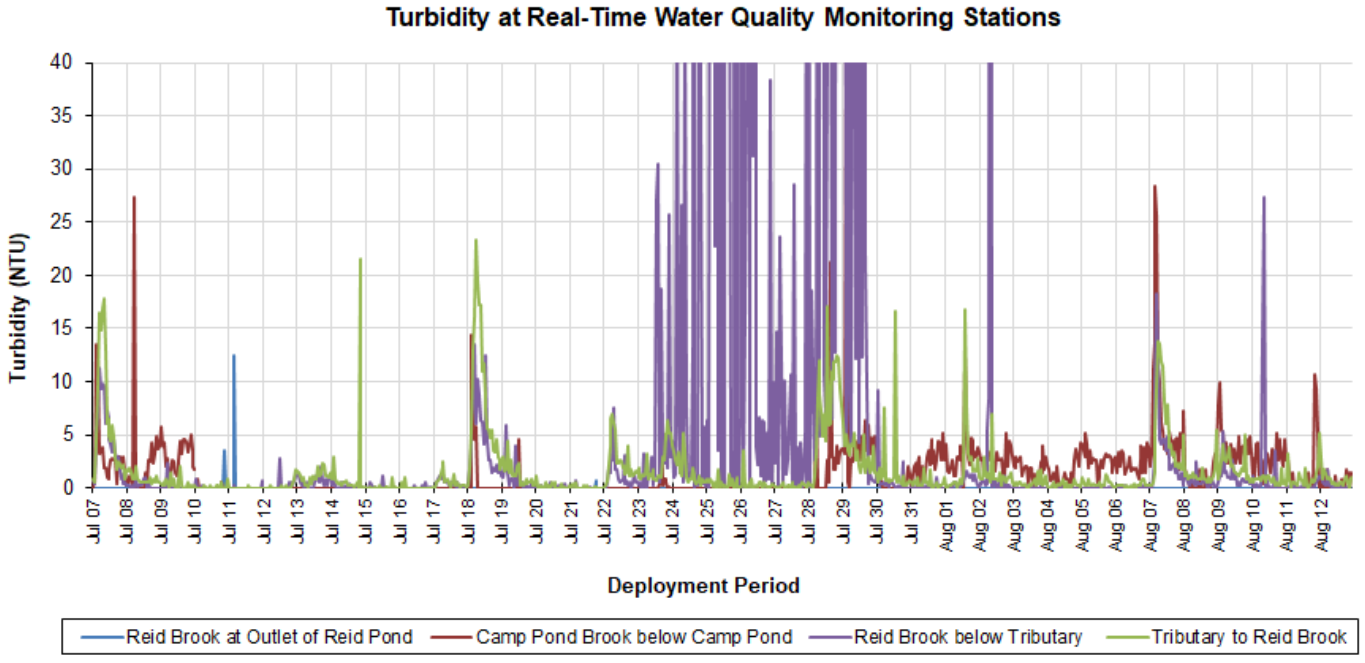

Figure A6: Comparison of Turbidity (NTU) between all Real-Time Stations in Voisey's Bay.

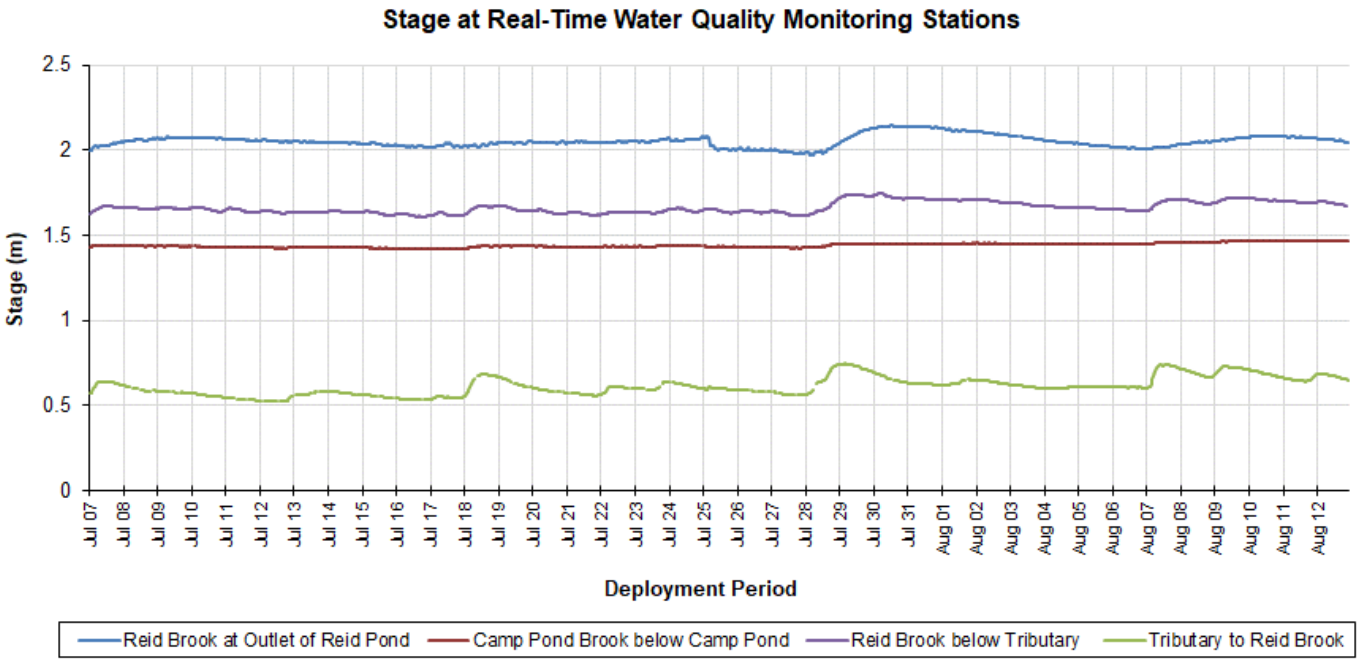

Figure A7: Comparison of Stage (m) between all Real-Time Stations in Voisey's Bay. Please note that stage data is raw data. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data.

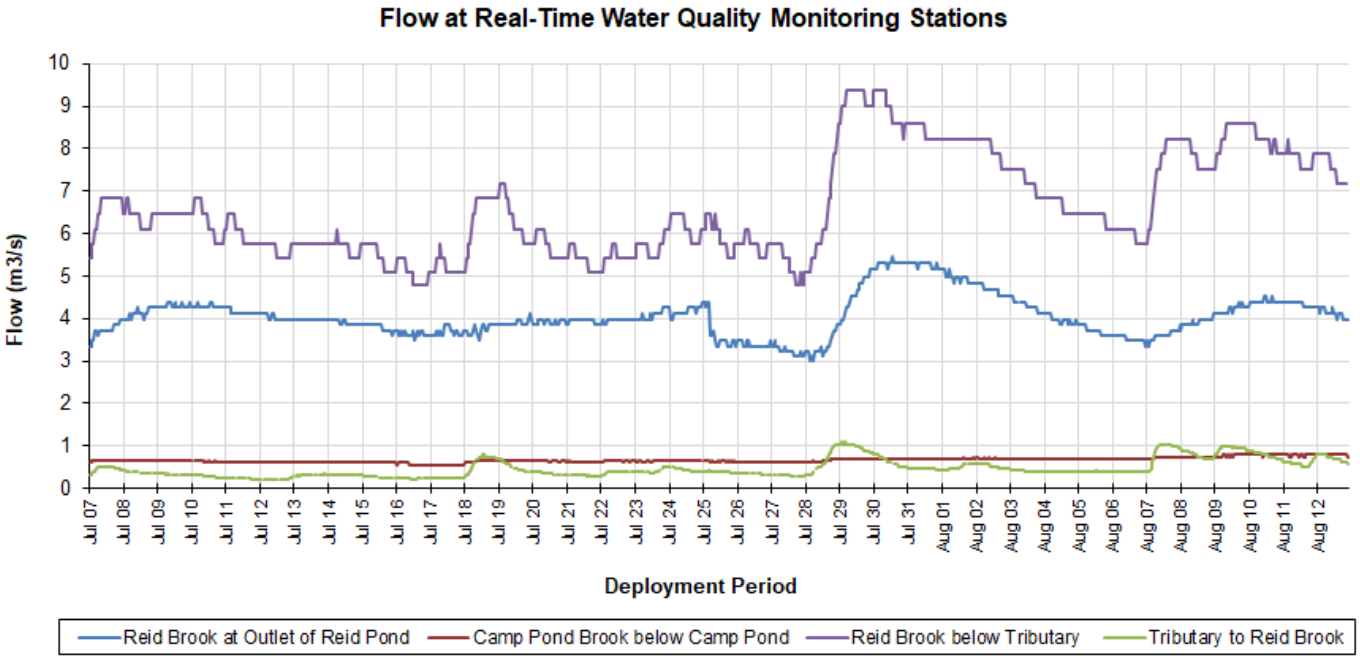

Figure A8: Comparison of Flow (m^3/s) between all Real-Time Stations in Voisey's Bay. Please note that flow data is raw data. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data.

APPENDIX B: Water Parameter Description

Dissolved Oxygen: The amount of Dissolved Oxygen (DO) (mg/L or % saturation) in the water is vital to the survival of aquatic organisms. The concentration of DO is affected by such things as water temperature, water depth and flow (e.g., aeration by rapids, riffles etc.), consumption by aerobic organisms, consumption by inorganic chemical reactions, consumption by plants during darkness, and production by plants during the daylight (CCME 2014).

Flow: Flow (m3/s) is a measure of how quickly a volume of water is displaced in streams, rivers, and other channels.

pH: pH is the measure of hydrogen ion activity and affects: (i) the availability of nutrients to aquatic life; (ii) the concentration of biochemical substances dissolved in water; (iii) the efficiency of hemoglobin in the blood of vertebrates; and (iv) the toxicity of pollutants. Changes in pH can be attributed to industrial effluence, saline inflows or aquatic organisms involved in the photosynthetic cycling of CO_2 (CCME 2014).

Specific conductivity: Specific conductivity (µS/cm) is a measure of water's ability to conduct electricity, with values normalized to a water temperature of 25°C. Specific conductance indicates the concentration of dissolved solids (such as salts) in the water, which can affect the growth and reproduction of aquatic life. Specific conductivity is affected by rainfall events, the composition of inflowing tributaries and their associated geology, saline inflow (e.g., road salt), agricultural run-off and industrial inputs (Swanson and Baldwin 1965).

Stage: Stage (m) is the elevation of the water surface and is often used as a surrogate for the more difficult to measure flow.

Temperature: Essential to the measurement of most water quality parameters, temperature (°C) controls most processes and dynamics of limnology. Water temperature is influenced by such things as ambient air temperature, solar radiation, meteorological events, industrial effluence, wastewater, inflowing tributaries, as well as water body size and depth (OTT Hydromet 2017).

Total Dissolved Solids: Total Dissolved Solids (TDS) (g/l) is a measure of alkaline salts dissolved in water or in fine suspension and can affect the growth and reproduction of aquatic life. It is affected by rainfall events, the composition of inflowing tributaries and their associated geology, saline inflow (e.g., road salt), agricultural run-off and industrial inputs (CCME 2014; Swanson and Baldwin 1965).

Turbidity: Turbidity (NTU) is a measure of the translucence of water and indicates the amount of suspended material in the water. Turbidity is caused by any substance that makes water cloudy (e.g., soil erosion, micro-organisms, vegetation, chemicals, etc.) and can correspond to precipitation events, high stage, and floating debris near the sensor (Sadar, 2017).

APPENDIX C: Grab Sample Results

REPORT OF ANALYSIS

Lab Report Number: 1912273

Cient:	Department of Environment	**COC Number:**	
Attention:	Ms. Leona Hyde	**Date Reported:**	2019-07-26
Client Project:		**Date Submitted:**	2019-07-12
Purchase Order:	2180014303	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1440901	WS-S-0000 Reid Brook @ Outlet	2019-6404-00-SI-SP	2019-07-07	Alkalinity as CaCO3	mg/L	5	<5
				Bromide	mg/L	0.25	<0.25
				Chloride	mg/L	1	<1
				Colour	TCU	2	8
				Conductivity	uS/cm	5	14
				Dissolved Organic Carbon	mg/L	0.5	1.8
				Fluoride	mg/L	0.10	<0.10
				Hardness as CaCO3	mg/L	1	2
				N-NH3 (Ammonia)	mg/L	0.01	<0.010
				N-NO2 (Nitrite)	mg/L	0.10	<0.10
				N-NO3 (Nitrate)	mg/L	0.10	<0.10
				pH		1.00	6.74
				Sulphate	mg/L	1	<1
				Total Dissolved Solids (COND - CALC)	mg/L	1	9
				Total Kjeldahl Nitrogen	mg/L	0.15	<0.15
				Total Organic Carbon	mg/L	0.5	2.2
				Turbidity	NTU	0.1	1.5
				Aluminum	mg/L	0.01	0.06

Sample comment:

Report comment:

Eurofins (Ottawa) is accredited for specific parameters by CALA. The scope can be viewed at http://www.cala.ca/scopes/2602.pdf.
Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

APPROVAL: Addrine Thomas

REPORT OF ANALYSIS

Lab Report Number: 1912273

Cient:	Department of Environment	**COC Number:**	
Attention:	Ms. Leona Hyde	**Date Reported:**	2019-07-26
Client Project:		**Date Submitted:**	2019-07-12
Purchase Order:	2180014303	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1440901	WS-S-0000	2019-6404-00-SI-SP	2019-07-07	Antimony	mg/L	0.0005	<0.0005
	Reid Brook @ Outlet			Arsenic	mg/L	0.001	<0.001
				Barium	mg/L	0.01	<0.01
Sample comment:				Boron	mg/L	0.01	<0.01
				Calcium	mg/L	1	1
				Cadmium	mg/L	0.0001	<0.0001
Report comment:				Chromium	mg/L	0.001	<0.001
				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	0.006

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APPROVAL: A. Thomas

Addrine Thomas

REPORT OF ANALYSIS

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Attention:	Ms. Leona Hyde	**Date Reported:**	2019-07-26
Client Project:		**Date Submitted:**	2019-07-12
Purchase Order:	2180014303	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1440901	WS-S-0000	2019-6404-00-SI-SP	2019-07-07	Uranium	mg/L	0.001	<0.001
	Reid Brook @ Outlet			Zinc	mg/L	0.01	<0.01
				Phosphorus	mg/L	0.002	<0.002
Sample comment:				Total Suspended Solids	mg/L	2	<2

Report comment:

Eurofins (Ottawa) is accredited for specific parameters by CALA. The scope can be viewed at http://www.cala.ca/scopes/2602.pdf.
Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

APPROVAL: A. Thomas

Addrine Thomas

REPORT OF ANALYSIS

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Cient:	Department of Environment	**COC Number:**	
Attention:	Ms. Leona Hyde	**Date Reported:**	2019-07-26
Client Project:		**Date Submitted:**	2019-07-12
Purchase Order:	2180014303	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1440902	WS-S-0000 Camp Pond Brook	2019-6405-00-SI-SP	2019-07-07	Alkalinity as CaCO3	mg/L	5	8
				Bromide	mg/L	0.25	<0.25
				Chloride	mg/L	1	2
				Colour	TCU	2	23
				Conductivity	uS/cm	5	35
				Dissolved Organic Carbon	mg/L	0.5	3.4
				Fluoride	mg/L	0.10	<0.10
				Hardness as CaCO3	mg/L	1	7
				N-NH3 (Ammonia)	mg/L	0.01	<0.010
				N-NO2 (Nitrite)	mg/L	0.10	<0.10
				N-NO3 (Nitrate)	mg/L	0.10	<0.10
				pH		1.00	7.09
				Sulphate	mg/L	1	4
				Total Dissolved Solids (COND - CALC)	mg/L	1	23
				Total Kjeldahl Nitrogen	mg/L	0.15	0.18
				Total Organic Carbon	mg/L	0.5	3.6
				Turbidity	NTU	0.1	0.9
				Aluminum	mg/L	0.01	0.09

Sample comment:

Report comment:

Eurofins (Ottawa) is accredited for specific parameters by CALA. The scope can be viewed at http://www.cala.ca/scopes/2602.pdf.
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Methods references and/or additional QA/QC information available on request.

APPROVAL: Addrine Thomas

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Client Project:		**Date Submitted:**	2019-07-12
Purchase Order:	2180014303	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1440902	WS-S-0000	2019-6405-00-SI-SP	2019-07-07	Antimony	mg/L	0.0005	<0.0005
	Camp Pond Brook			Arsenic	mg/L	0.001	<0.001
				Barium	mg/L	0.01	<0.01
Sample comment:				Boron	mg/L	0.01	<0.01
				Calcium	mg/L	1	3
				Cadmium	mg/L	0.0001	<0.0001
Report comment:				Chromium	mg/L	0.001	<0.001
				Copper	mg/L	0.001	0.003
				Iron	mg/L	0.03	0.20
				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	0.028
				Potassium	mg/L	1	<1
				Selenium	mg/L	0.001	<0.001
				Sodium	mg/L	2	<2
				Strontium	mg/L	0.001	0.022

Eurofins (Ottawa) is accredited for specific parameters by CALA. The scope can be viewed at http://www.cala.ca/scopes/2602.pdf.
Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

APPROVAL: A. Thomas

Addrine Thomas

REPORT OF ANALYSIS

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Client Project:		**Date Submitted:**	2019-07-12
Purchase Order:	2180014303	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1440902	WS-S-0000	2019-6405-00-SI-SP	2019-07-07	Uranium	mg/L	0.001	<0.001
	Camp Pond Brook			Zinc	mg/L	0.01	<0.01
				Phosphorus	mg/L	0.002	0.064
Sample comment:				Total Suspended Solids	mg/L	2	<2

Report comment:

Eurofins (Ottawa) is accredited for specific parameters by CALA. The scope can be viewed at http://www.cala.ca/scopes/2602.pdf.
Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

APPROVAL: A. Thomas

Addrine Thomas

REPORT OF ANALYSIS

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Attention:	Ms. Leona Hyde	**Date Reported:**	2019-07-26
Client Project:		**Date Submitted:**	2019-07-12
Purchase Order:	2180014303	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1440904	WS-S-0000	2019-6407-00-SI-SP	2019-07-07	Alkalinity as CaCO3	mg/L	5	7
	Reid Brook below Tributary			Bromide	mg/L	0.25	<0.25
				Chloride	mg/L	1	2
Sample comment:				Colour	TCU	2	39
				Conductivity	uS/cm	5	27
				Dissolved Organic Carbon	mg/L	0.5	5.0
Report comment:				Fluoride	mg/L	0.10	<0.10
				Hardness as CaCO3	mg/L	1	5
				N-NH3 (Ammonia)	mg/L	0.01	<0.010
				N-NO2 (Nitrite)	mg/L	0.10	<0.10
				N-NO3 (Nitrate)	mg/L	0.10	<0.10
				pH		1.00	7.09
				Sulphate	mg/L	1	2
				Total Dissolved Solids (COND - CALC)	mg/L	1	18
				Total Kjeldahl Nitrogen	mg/L	0.15	0.16
				Total Organic Carbon	mg/L	0.5	5.0
				Turbidity	NTU	0.1	1.0
				Aluminum	mg/L	0.01	0.15

Eurofins (Ottawa) is accredited for specific parameters by CALA. The scope can be viewed at http://www.cala.ca/scopes/2602.pdf.
Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

APPROVAL: A. Thomas

Addrine Thomas

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Purchase Order:	2180014303	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1440904	WS-S-0000	2019-6407-00-SI-SP	2019-07-07	Antimony	mg/L	0.0005	<0.0005
	Reid Brook below Tributary			Arsenic	mg/L	0.001	<0.001
				Barium	mg/L	0.01	<0.01
Sample comment:				Boron	mg/L	0.01	<0.01
				Calcium	mg/L	1	2
				Cadmium	mg/L	0.0001	<0.0001
Report comment:				Chromium	mg/L	0.001	<0.001
				Copper	mg/L	0.001	0.001
				Iron	mg/L	0.03	0.37
				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	0.017

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

APPROVAL: Addrine Thomas

REPORT OF ANALYSIS

Lab Report Number: 1912273

Cient:	Department of Environment	**COC Number:**	
Attention:	Ms. Leona Hyde	**Date Reported:**	2019-07-26
Client Project:		**Date Submitted:**	2019-07-12
Purchase Order:	2180014303	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1440904	WS-S-0000	2019-6407-00-SI-SP	2019-07-07	Uranium	mg/L	0.001	<0.001
	Reid Brook below Tributary			Zinc	mg/L	0.01	<0.01
				Phosphorus	mg/L	0.002	0.006
Sample comment:				Total Suspended Solids	mg/L	2	<2

Report comment:

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APPROVAL: A. Thomas

Addrine Thomas

REPORT OF ANALYSIS

Lab Report Number: 1912273

Cient:	Department of Environment	**COC Number:**	
Attention:	Ms. Leona Hyde	**Date Reported:**	2019-07-26
Client Project:		**Date Submitted:**	2019-07-12
Purchase Order:	2180014303	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1440903	WS-S-0000	2019-6406-00-SI-SP	2019-07-07	Alkalinity as CaCO3	mg/L	5	7
	Tributary to Reid Brook			Bromide	mg/L	0.25	<0.25
				Chloride	mg/L	1	2
Sample comment:				Colour	TCU	2	43
				Conductivity	uS/cm	5	28
				Dissolved Organic Carbon	mg/L	0.5	5.1
Report comment:				Fluoride	mg/L	0.10	<0.10
				Hardness as CaCO3	mg/L	1	5
				N-NH3 (Ammonia)	mg/L	0.01	<0.010
				N-NO2 (Nitrite)	mg/L	0.10	<0.10
				N-NO3 (Nitrate)	mg/L	0.10	<0.10
				pH		1.00	7.00
				Sulphate	mg/L	1	3
				Total Dissolved Solids (COND - CALC)	mg/L	1	18
				Total Kjeldahl Nitrogen	mg/L	0.15	0.18
				Total Organic Carbon	mg/L	0.5	5.2
				Turbidity	NTU	0.1	0.9
				Aluminum	mg/L	0.01	0.14

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APPROVAL: Addrine Thomas

REPORT OF ANALYSIS

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Attention:	Ms. Leona Hyde	**Date Reported:**	2019-07-26
Client Project:		**Date Submitted:**	2019-07-12
Purchase Order:	2180014303	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1440903	WS-S-0000	2019-6406-00-SI-SP	2019-07-07	Antimony	mg/L	0.0005	<0.0005
	Tributary to Reid Brook			Arsenic	mg/L	0.001	<0.001
				Barium	mg/L	0.01	<0.01
Sample comment:				Boron	mg/L	0.01	<0.01
				Calcium	mg/L	1	2
				Cadmium	mg/L	0.0001	<0.0001
Report comment:				Chromium	mg/L	0.001	<0.001
				Copper	mg/L	0.001	0.001
				Iron	mg/L	0.03	0.34
				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	0.015

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APPROVAL: A. Thomas

Addrine Thomas

REPORT OF ANALYSIS

Lab Report Number: 1912273

Cient:	Department of Environment	**COC Number:**	
Attention:	Ms. Leona Hyde	**Date Reported:**	2019-07-26
Client Project:		**Date Submitted:**	2019-07-12
Purchase Order:	2180014303	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1440903	WS-S-0000	2019-6406-00-SI-SP	2019-07-07	Uranium	mg/L	0.001	<0.001
	Tributary to Reid Brook			Zinc	mg/L	0.01	<0.01
				Phosphorus	mg/L	0.002	0.004
Sample comment:				Total Suspended Solids	mg/L	2	<2

Report comment:

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APPROVAL: A. Thomas

Addrine Thomas