Real-Time Water Quality Report

Canada Fluorspar (NL) Inc, Real-Time Water Quality Stations

Deployment Period
September 27 2018 to November 21 2018

Government of Newfoundland & Labrador
Department of Municipal Affairs & Environment
Water Resources Management Division

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General

The Water Resources Management Division (WRMD), in partnership with Water Survey of Canada (WSC) -Environment and Climate Change Canada (ECCC), maintain real-time water quality and water quantity monitoring stations on Outflow of Grebes Nest Pond and Outflow of Unnamed Pond south of Long Pond, brooks that are within the site of Canada Fluorspar (NL) Inc, St. Lawrence, Newfoundland & Labrador.

Figure 1: Real-Time Water Quality and Quantity Stations at Canada Fluorspar Inc

Outflow of Grebes Nest Pond

The Outflow of Grebes Nest Pond station is established downstream of the pit dewatering effluent outfall and upstream of John Fitzpatrick Pond. The stream is approximately 1.0 to 2.0 meters wide and sustains a sufficient pool for the instrumentation to be placed in (Figure 2). The pool depth is approximately 0.5 to 1.0 metres. The GPS coordinates for this site are as follows**: N46° 54' 35.9" W055° 27' 45.6"**.

The station hut was placed on the north bank looking downstream approximately 5 metres from the stream. This station will provide real-time water quality and quantity data to ensure emerging issues associated with the open pit (from both the construction and operational phases)are detected, to allow the appropriate mitigation measures to be implemented in a timely manner, thus reducing any adverse effect on the downstream systems.

Outflow of Unnamed Pond south of Long Pond

The Outflow of Unnamed Pond south of Long Pond is established downstream of the Tailings Management Facility (TMF). This station will provide near real-time water quality and quantity data to ensure emerging issues associated with the TMF are detected, to allow the appropriate mitigation measures to be implemented in a timely manner, thus reducing any adverse effect on the downstream systems. The location of Outflow of Unnamed Pond south of Long Pond was selected due to accessibility to the brook and the sufficient pool available to place the water quality and quantity instruments (See Figure 3). The stream initiates from a small unnamed pond and meanders through a marsh environment alongside the TMF. The stream is approximately 1.0 to 2.0 meters wide. Where the instrument is deployed, there is a depth of approximately 1.0 to 1.5 meters. The GPS coordinates for this site are as follows: **N46° 54' 14.1" W055° 26' 37.5"**. The station hut was placed on the right bank looking downstream approximately 8 meters from the stream (Figure 3).

Figure 2: Real-Time Water Quality and Quantity Station at Outflow of Grebes Nest Pond.

Figure 3: Real-Time Water Quality and Quantity Station at Outflow of Unnamed Pond south of Long Pond.

Quality Assurance and Quality Control

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

At deployment and removal, a QA/QC Sonde is temporarily deployed adjacent to the Field Sonde. Values for temperature, pH, conductivity, dissolved oxygen and turbidity are compared between the two instruments**.** Based on the degree of difference between the parameters on the Field Sonde and QA/QC Sonde at deployment and at removal, a qualitative statement is made on the data quality (Table 1).

WRMD staff (Municipal Affairs and Environment (MAE)) are responsible for maintenance of the real-time water quality monitoring equipment, as well as recording and managing the water quality data. Tara Clinton, is MAE's main contact for the real-time water quality monitoring operation at Canada Fluorspar (NL) Inc, and is responsible for maintaining and calibrating the water quality instrument, as well as grooming, analyzing and reporting on water quality data recorded at the station.

WSC staff have an essential role in the data logging/communication aspect of the network and the maintenance of the water quantity monitoring equipment. WSC staff visit the site regularly to ensure the data logging and data transmitting equipment are working properly. WSC is responsible for handling stage and streamflow issues. The quantity data is raw data that is transmitted via satellite and published online along with the water quality data on the Real-Time Stations website. Quantity data has not been corrected or groomed when published online or used in the monthly reports for the stations. WSC is responsible for QA/QC of water quantity data. Corrected stage and streamflow data can be obtained upon request to WSC.

Table 1: Instrument Performance Ranking classifications for deployment and removal

	Rank				
Parameter	**Excellent**	**Good**	**Fair**	**Marginal**	**Poor**
Temperature (°C)	<=+/-0.2	>+/-0.2 to 0.5	>+/-0.5 to 0.8	>+/-0.8 to 1	<+/-1
pH (unit)	<=+/-0.2	>+/-0.2 to 0.5	>+/-0.5 to 0.8	>+/-0.8 to 1	>+/-1
Sp. Conductance (µS/cm)	<=+/-3	>+/-3 to 10	>+/-10 to 15	>+/-15 to 20	>+/-20
Sp. Conductance > 35 µS/cm (%)	<=+/-3	>+/-3 to 10	>+/-10 to 15	>+/-15 to 20	>+/-20
Dissolved Oxygen (mg/L) (% Sat)	<=+/-0.3	>+/-0.3 to 0.5	>+/-0.5 to 0.8	>+/-0.8 to 1	>+/-1
Turbidity <40 NTU (NTU)	<=+/-2	>+/-2 to 5	>+/-5 to 8	>+/-8 to 10	>+/-10
Turbidity > 40 NTU (%)	<=+/-5	>+/-5 to 10	>+/-10 to 15	>+/-15 to 20	>+/-20

It should be noted that the temperature sensor on any sonde is the most important. All other parameters can be divided into subgroups of: temperature dependent temperature compensated and temperature independent. Due to the temperature sensor's location on the sonde, the entire sonde must be at a constant temperature before the temperature sensor will stabilize. The values may take some time to climb to the appropriate reading; if a reading is taken too soon it may not accurately portray the water body.

Table 2: Instrument performance rankings

Station	Date	Action	Comparison Ranking				
			Temperature	pH	Conductivity	Dissolved Oxygen	Turbidity
Grebes Nest Pond	September 27	Deployment	Good	Good	Good	Good	Marginal
	November 21	Removal	Good	Excellent	Good	Marginal	Poor
Unnamed Pond	September 27	Deployment	Good	Excellent	Good	Excellent	Excellent
	November 21	Removal	Excellent	Excellent	Good	Good	Excellent

At deployment of the field instrument at Outflow of Grebes Nest Pond site, the water temperature, pH, specific conductivity and dissolved oxygen data ranked 'Good' against the QA sonde data. The turbidity data ranked 'Marginal'. This site is heavily impacted by sediment from the sedimentation pond which may have influenced the readings for both sondes.

During removal of the instrument, the rankingd for water temperature, pH, and specific conductivity data were 'Excellent' or 'Good' against the QA data. Dissolved oxygen ranked as 'Marginal' and turbidity data ranked as 'Poor'. It was noted at removal of the instrument that there was a lot of debris and leaf litter in the brook. It was determined that debris was blocking the turbidity sensor upon removal. This debris may have contributed to the 'Marginal' and 'Poor' rankings.

At deployment of the field instrument at Outflow of Unnamed Pond south of Long Pond the data for water temperature, and conductivity ranked 'Good' while pH, dissolved oxygen and turbidity ranked as 'Excellent'. All rankings were acceptable for deployment of the instrument.

At the end of the deployment the water quality parameters all ranked as 'Good' and 'Excellent'.

Concerns or Issues during the Deployment Period

During the deployment at Outflow to Unnamed Pond south of Long Pond, hourly stage data was not available for comparison against the hourly water quality parameters. However, daily averaged stage levels were provided with each graph for a general overview of the deployment.

Outflow to Grebes Nest Pond station is fed via a sedimentation pond. The lack of consistent flow results in significant stage level fluctuations across a deployment.

Please note that the stage data in this document 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.

Outflow of Grebes Nest Pond

Water Temperature

Water temperature ranged from 0.66°C to 14.61°C during the deployment period (Figure 4). The average water temperature for the deployment is 7.7°C, which is lower than the previous deployment. As the air temperature and subsequently the water temperature started to decrease with the change of season into winter, there was a notable change in the brook's water quality.

Outflow to Grebes Nest Pond station is fed via a sedimentation pond. It does not have consistent flow, thus the stage data can fluctuate significantly across a deployment. Stage can influence water temperature as indicated on the graph on October 2nd, 6th and 9th. When the stage decreased, the water temperatures dipped for the same period.

Toward the end of the deployment, the lowest water temperatures were recorded as the climate adjusted to winter temperatures. Please note that the stage data in this document 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.

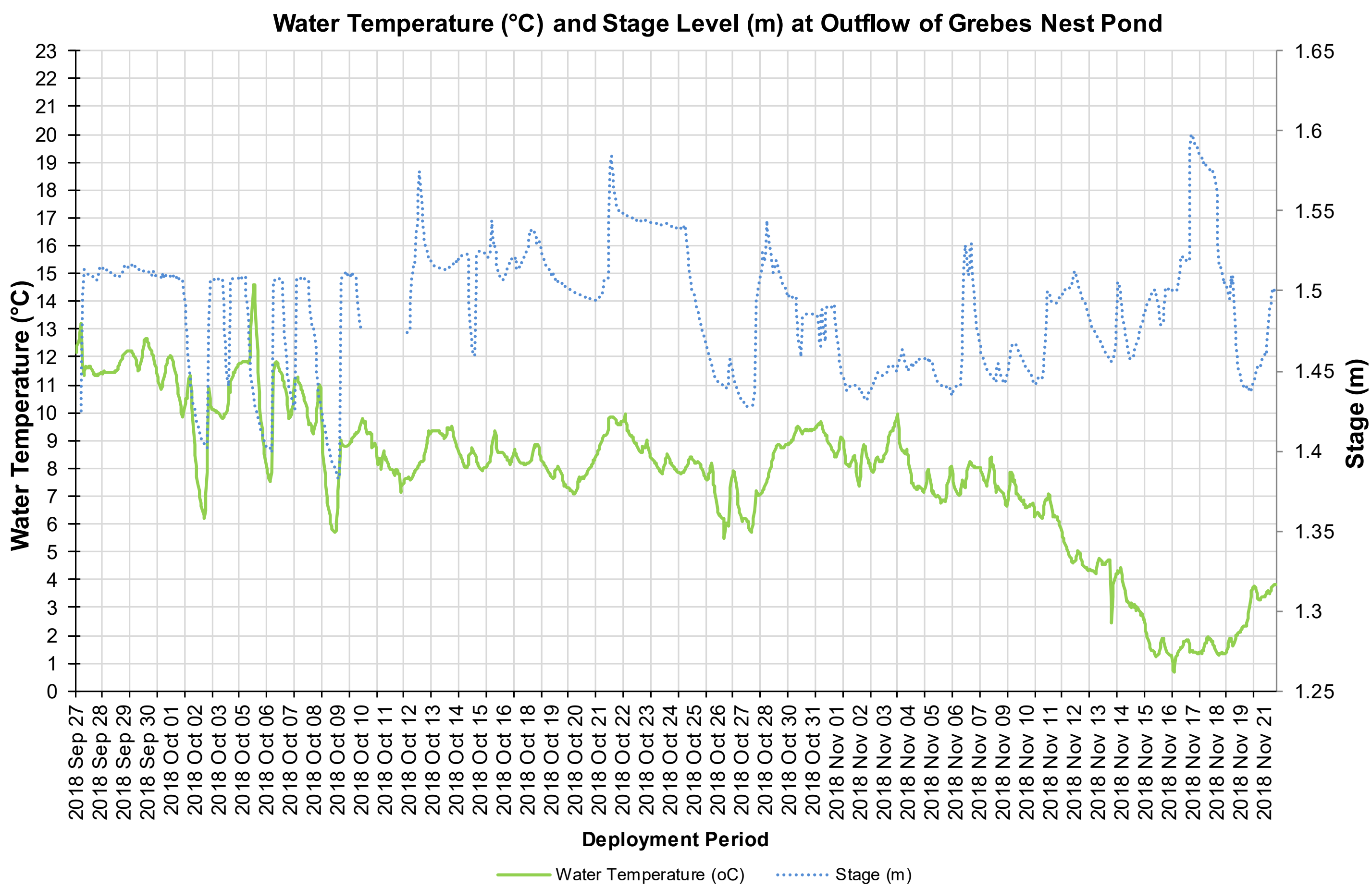

Figure 4: Water temperature (°C) values at Outflow of Grebes Nest Pond

pH

Throughout the deployment period, pH values ranged between 7.07 pH units and 7.81 pH units. There were significant fluctuations in stage during the deployment which influenced the pH levels in the brook for a short period of time. There were small decreases in pH when the stage increased, and small increases in pH when the stage level decreased (Figure 5).

The pH data was generally consistent and remained within the Canadian Council of Ministers of Environment (CCME) guidelines for Aquatic Life. Every brook is different with its own natural background range. It is not uncommon for Newfoundland and Labrador waters to be below or within the CCME pH guideline.

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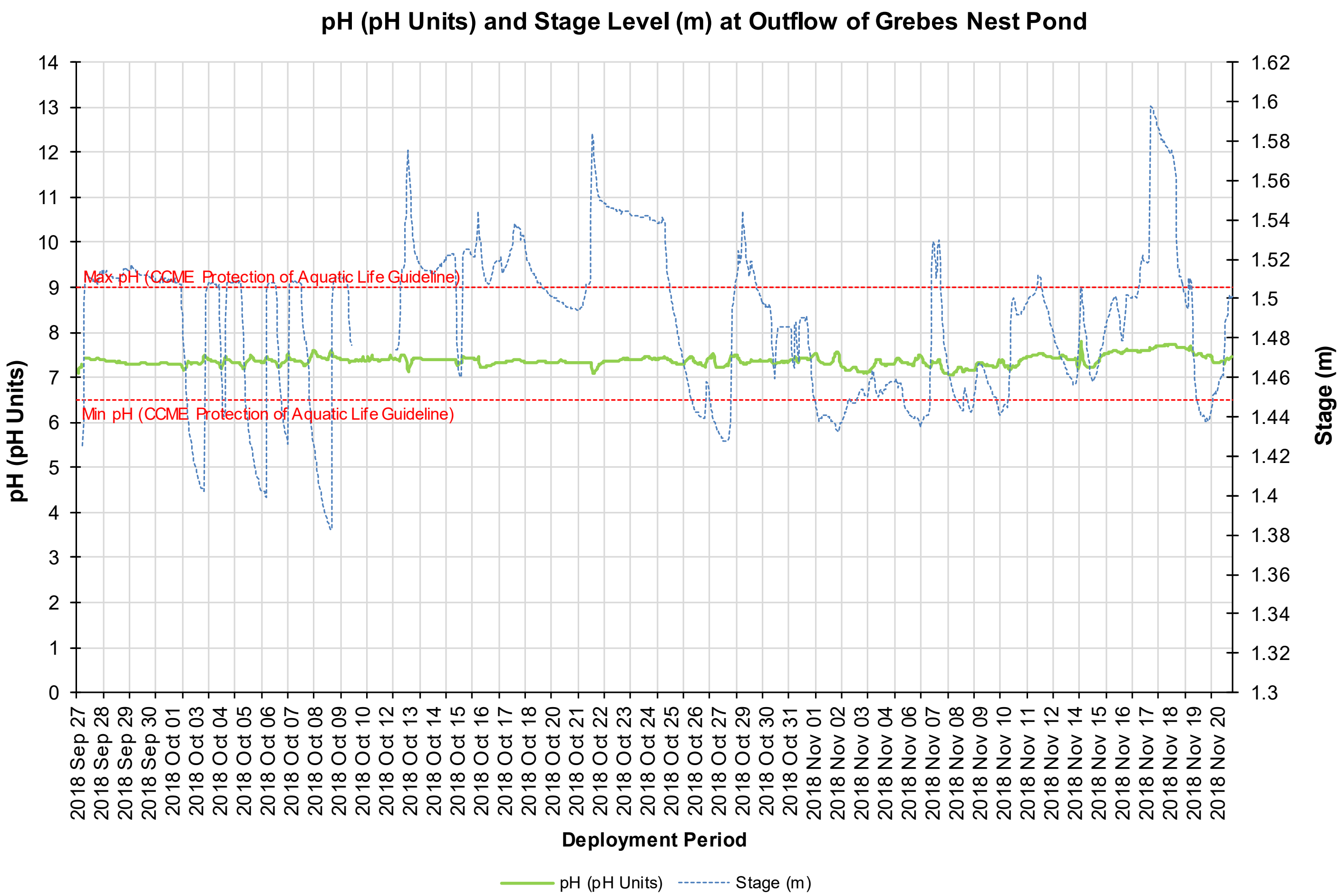

Figure 5: pH (pH units) values

Specific Conductivity

The conductivity levels were within 136.87 µS/cm and 392.43 µS/cm during this deployment period (Figure 6). The specific conductivity probe measures the diluted salts and inorganic materials present in the brook. The conductivity in a brook can be diluted by rainfall or increased by rainfall if there is runoff occurring.

Across the deployment period, the conductivity in the brook fluctuated with the changes to stage level. During high and low stage events, the conductivity levels responded by decreasing. The exception was on October 29th, when the conductivity in the brook increased alongside an increase in stage before dropping again shortly after.

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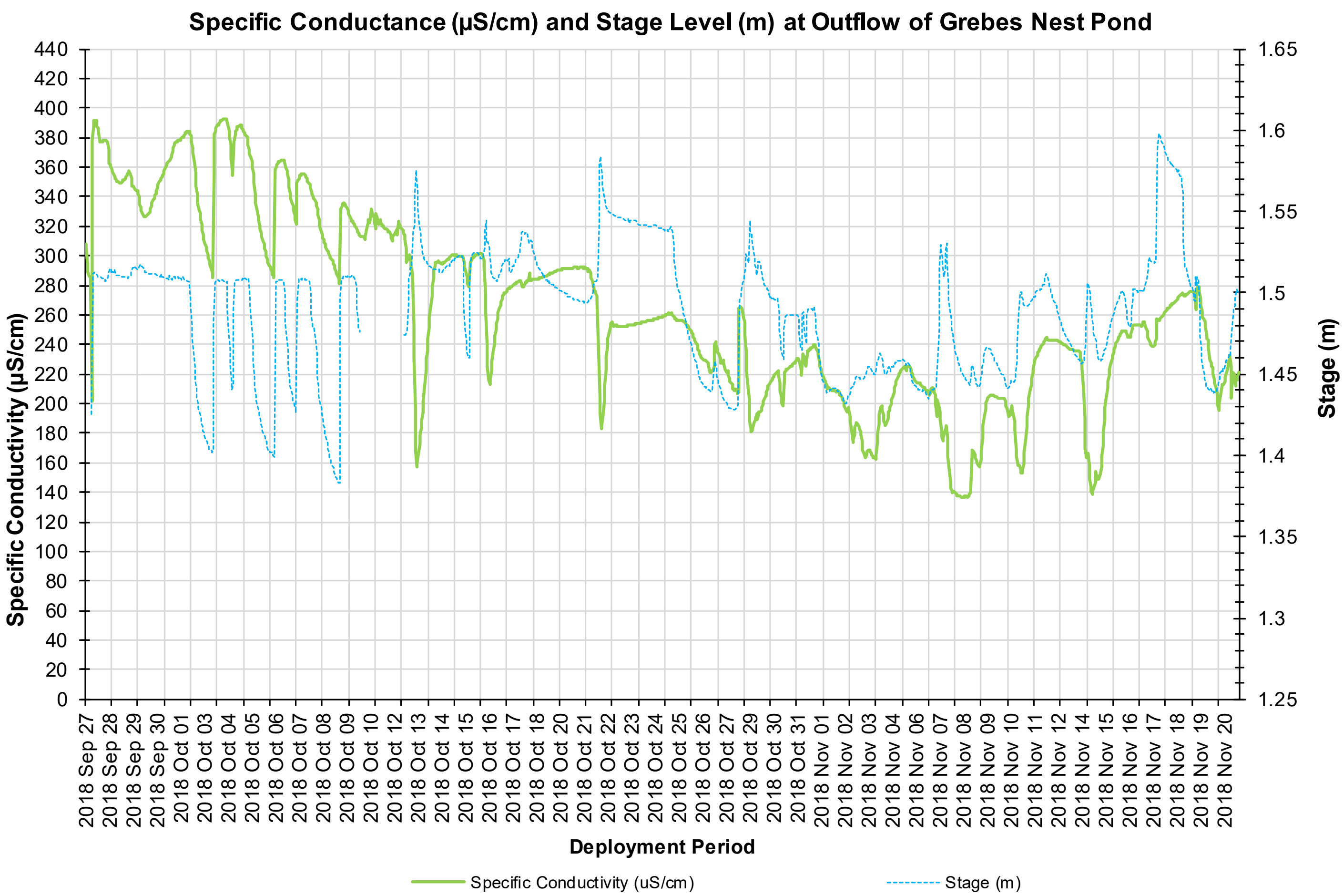

Figure 6: Specific conductivity (µS/cm) values

Dissolved Oxygen

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

During the deployment, the dissolved oxygen concentration levels ranged within a minimum of 7.37 mg/L to a maximum of 13.56 mg/L. The percent saturation levels for dissolved oxygen ranged within 68.1% Saturation to 105.4% Saturation (Figure 7). Dissolved oxygen concentration maximums were slightly higher than the previous deployment, likely a result of the cooler air and water temperatures at this time of year.

Large variations in dissolved oxygen concentration and saturation on October 2nd to October 7th and October 26th and 27th, may be the result of varying stage levels and /or streamflow through the brook at this time followed by a precipitation event or snowfall event.

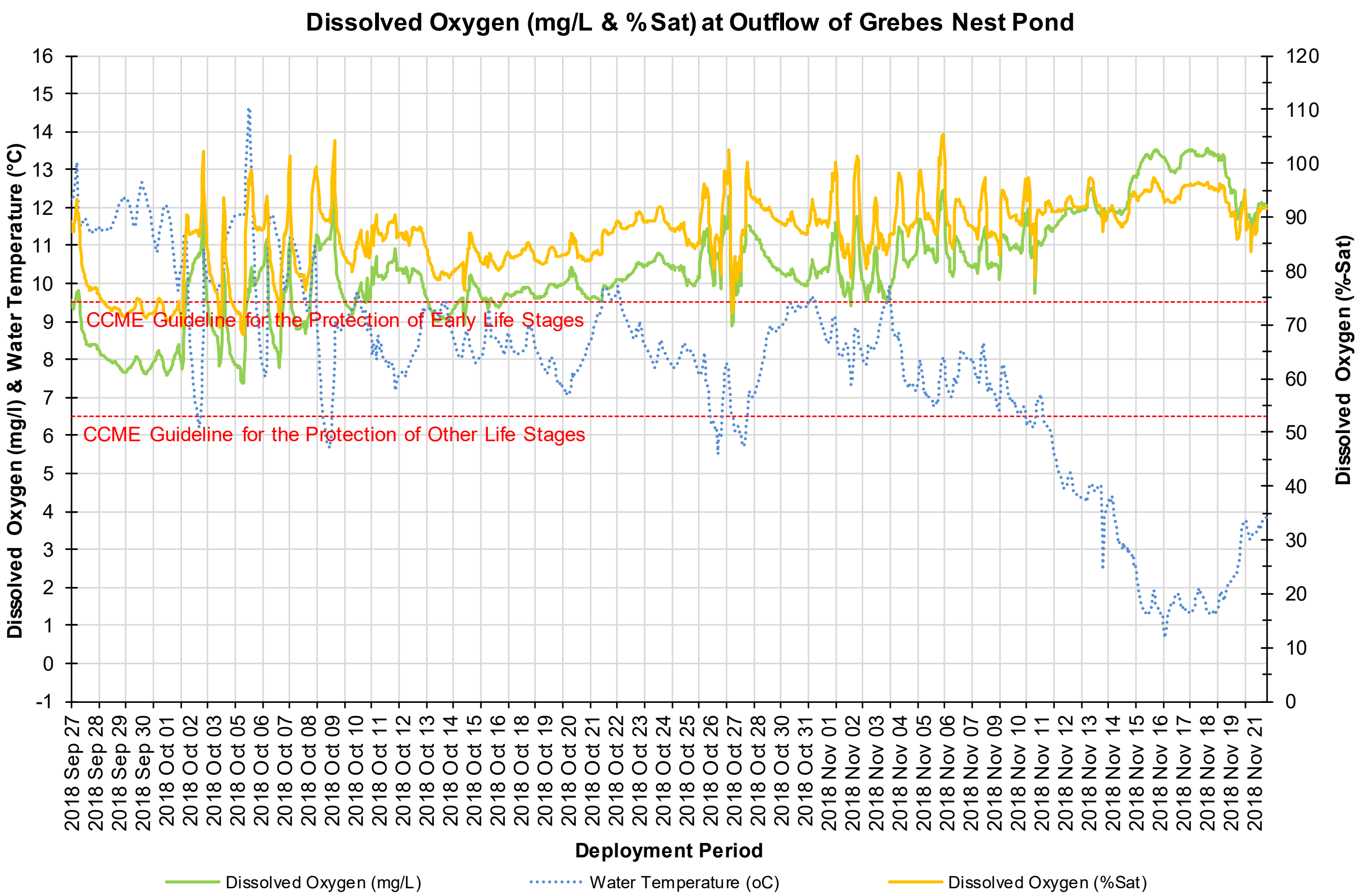

Figure 7: Dissolved Oxygen (mg/L & Percent Saturation) values and Water Temperature (°C)

Turbidity

Turbidity levels during the deployment ranged within 7.8 NTU and 699.1 NTU (Figure 8). The deployment data had a median of 73.3 NTU which is higher than the previous deployment median of 15.78 NTU.

Outflow to Grebes Nest Brook is fed upstream by a sedimentation pond and is heavily impacted by the material that is in the sedimentation pond. The real-time station has significant fluctuations in turbidity and the turbidity levels will increase in either high or low stage events.

Please note the stage data on the graph 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.

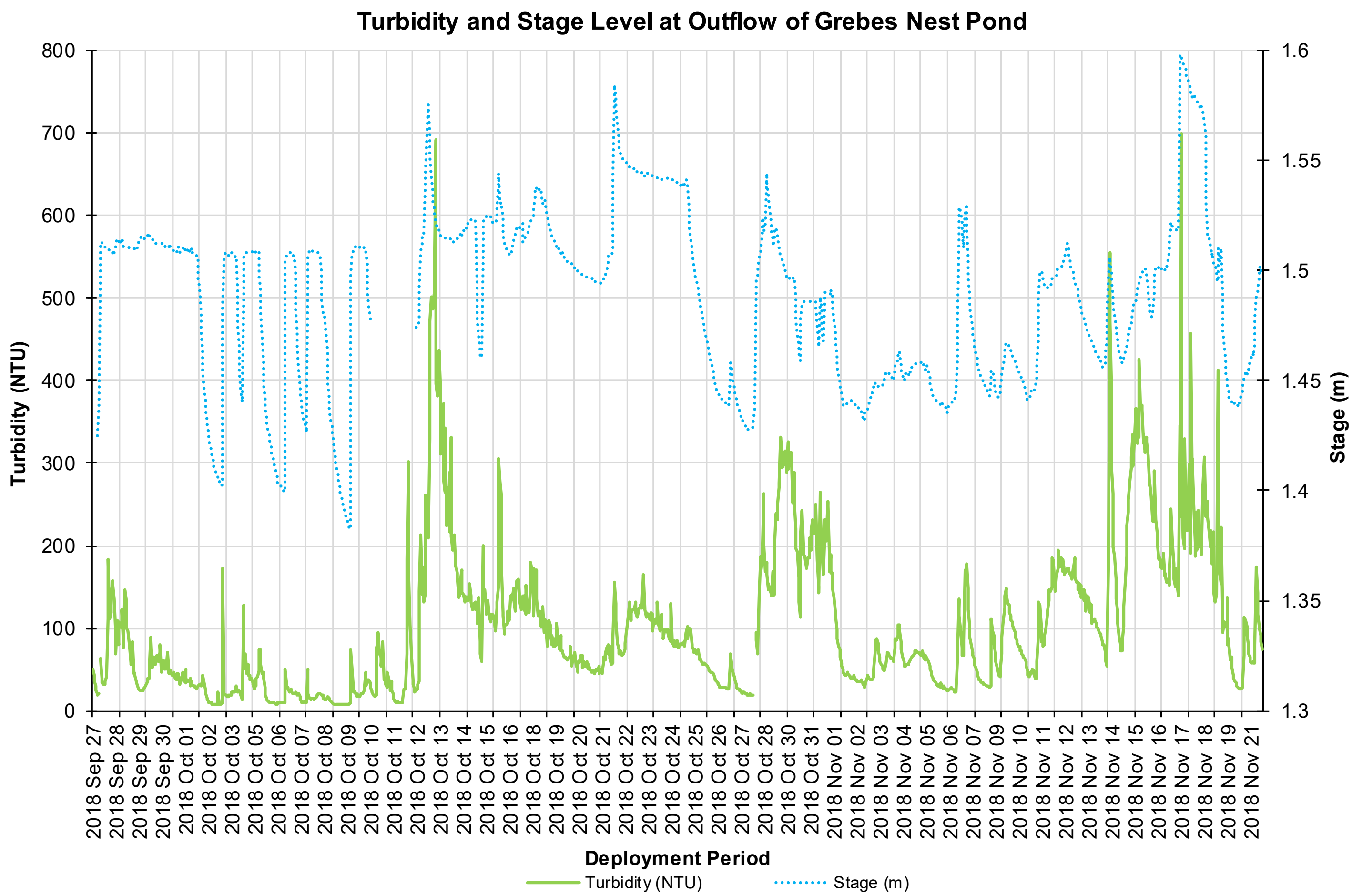

Figure 8: Turbidity (NTU) values.

Total Precipitation & Stage Level

Stage is the level of the water surface above a given datum at the station. Stage provides an estimation of the water level at the station, and can explain some of the water quality events that occur. Stage will increase during rainfall events (Figure 9) and during snow or ice melt, as the runoff will collect in the brook, influencing the water level.

Although this brook is fed via a sedimentation pond, rainfall is very influential as it assists in supplementing the water supply. Total Precipitation data was obtained from Environment Canada's St. Lawrence weather station. Total precipitation ranges for the deployment period were a minimum of 0.0 mm and maximum of 49.2 mm on October 12th, 2018.

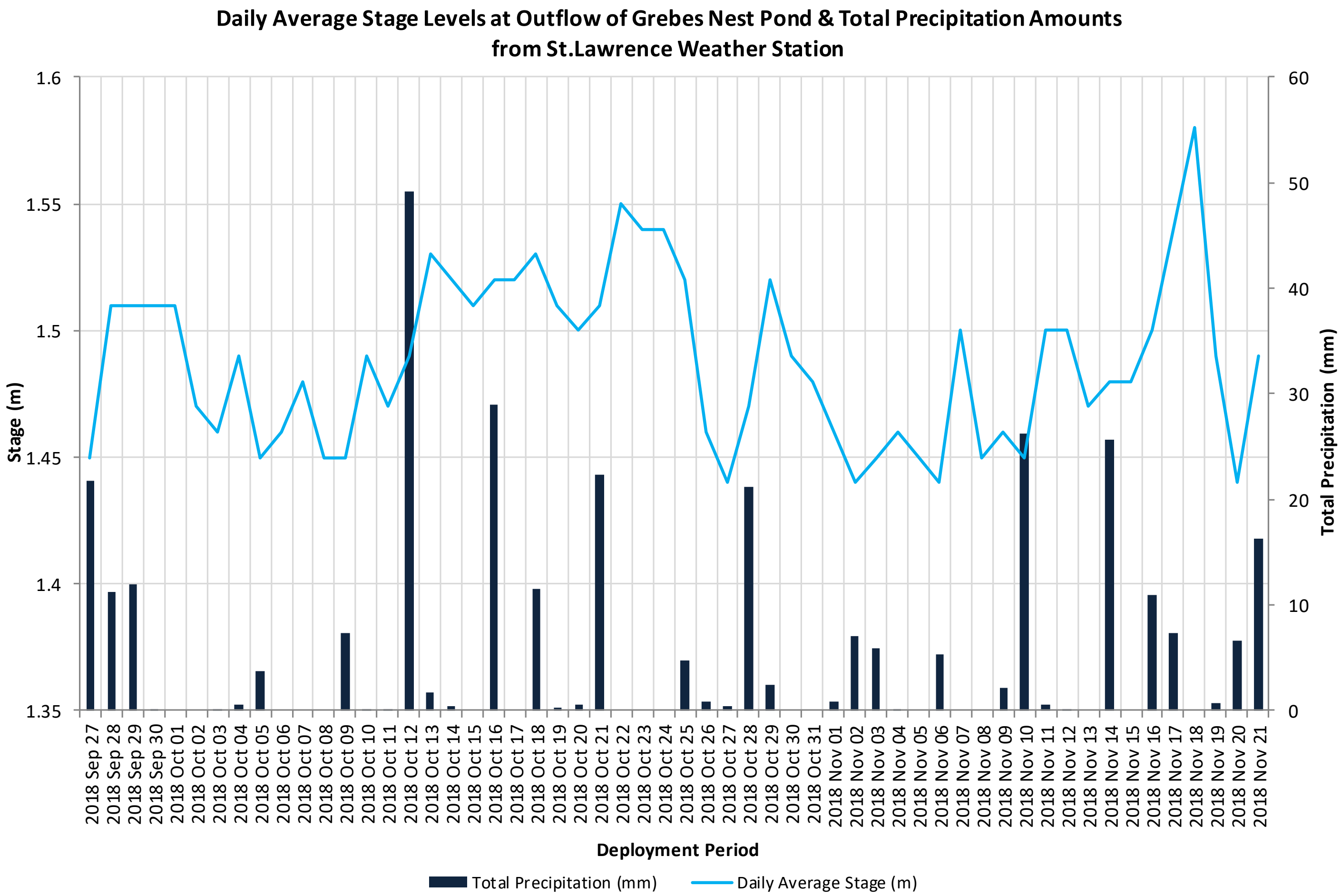

Figure 9: Daily average stage values and daily total precipitation.

Conclusion

Outflow of Grebes Nest Pond currently flows through a evolving mine site. Grebes Nest Pond has been dewatered for mining purposes and no longer exists. The water supply for Outflow of Grebes Nest Pond station has changed. The water supply is a sedimentation pond that is upstream of the Real-Time station. The sedimentation pond was developed to assist in settling out the sediment-laden water that is pumped from the open mine pit. Canada Fluorspar has created the sedimentation pond to naturally overflow down into a trough and through a culvert that flows into Outflow of Grebes Nest Pond.

When reviewing the parameter graphs it is evident that the larger precipitation events affected the water quality. Water temperature fluctuated with stage changes and generally decreased with the seasonal change to winter temperatures. pH levels at Grebes Nest station were consistent during the deployment, displaying only small dips in pH during higher stage events.

Conductivity at the brook ranged from 136µS/cm to 392µS/cm. The lower conductivity values were during the high stage events when the brook is diluted and flushed of suspended material for a short period of time.

Outflow to Grebes Nest Pond station is fed via a sedimentation pond and does not always have consistent flow. The dissolved oxygen concentration can thus change quickly over a few hours or days. Toward the end of the deployment, the dissolved oxygen concentration was steadily increasing as the season changes to Winter and temperatures decline.

The brook has significant fluctuations in turbidity and the turbidity levels will increase in either high or low stage events due to the influence of upstream sedimentation pond.

Overall, the water quality parameters recorded at Outflow of Grebes Nest Pond displayed events expected of a brook in an environment influenced by anthropogenic activities.

Outflow of Unnamed Pond south of Long Pond

Water Temperature

Water temperature ranges from -0.17ºC to 16.91ºC during this deployment period (Figure 10). The water temperature decreases steadily across the deployment, dropping down to zero and below as the winter temperatures for air and water cool.

During the larger increases in stage at the station, the water temperatures increased for a short period of time. The majority of the stage increases were likely a result of rainfall (Figure 15). The stage increases on November 13 and November 19 were likely a result of snowfall runoff into the brook.

Please note the stage data graphed 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.

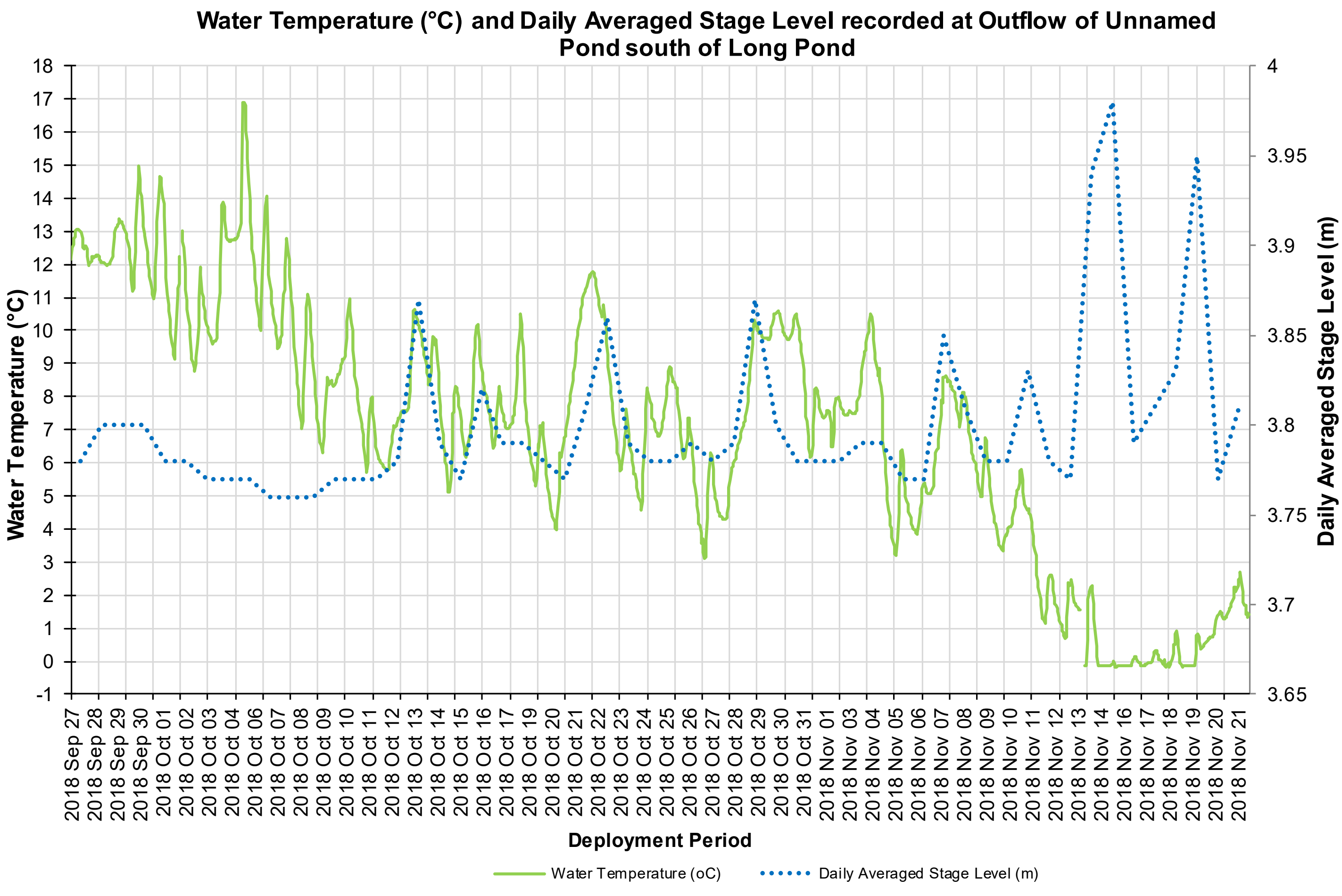

Figure 10: Water temperature (°C) values at Outflow of Unnamed Pond south of Long Pond

pH

Throughout this deployment period, pH values ranged between 7.34 pH units and 8.37 pH units (Figure 11). Values were consistent and within the Canadian Council of Ministers of the Environment (CCME) guidelines for aquatic life.

There were slight decreases in pH during the higher stage increases, with pH returning to background levels shortly after. Natural processes such as rainfall and snowmelt will alter the pH of a brook for a period of time.

Please note the daily averaged stage data on the graph 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.

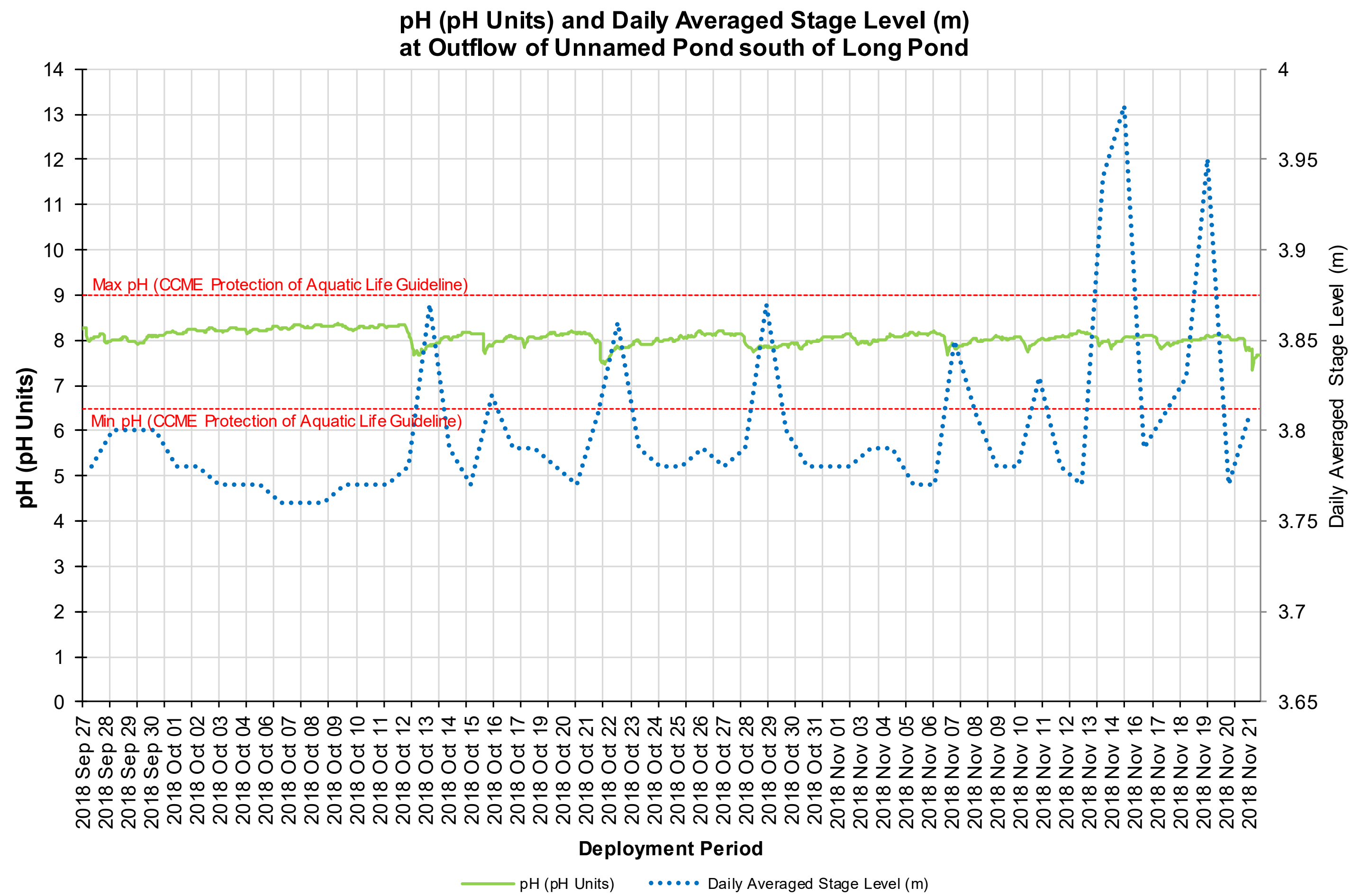

Figure 11: pH (pH units) at Outflow of Unnamed Pond south of Long Pond

Specific Conductivity

The conductivity levels ranged between 181.1 µS/cm and 408.7 µS/cm during deployment (Figure 12) with a median of 287.7 µS/cm which was lower than the median of the previous deployment of 337.6 µS/cm.

The conductivity in the brook was influenced by the stage fluctuations (Figure 12). The stage increases can dilute the particle matter and suspended solids that are present in a water body. This relationship can be seen in Figure 12, most notably on October 13th and November 13th. When stage decreases, conductivity levels will increase as the suspended solids become concentrated in the water column. This relationship can be seen in Figure 12 when stage levels drop, causing conductivity to increase.

Please note the daily averaged stage data on the graph 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.

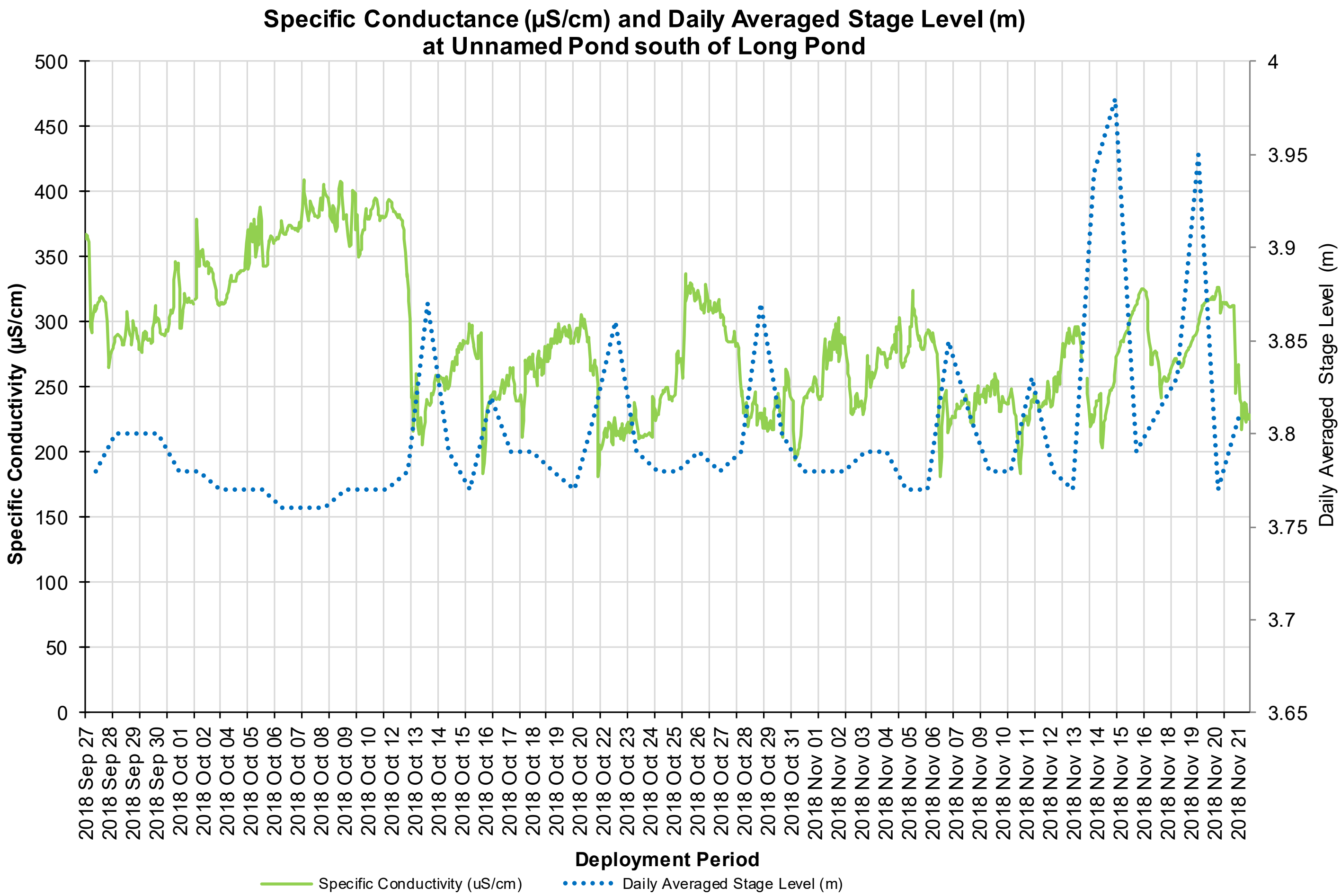

Figure 12: Specific conductivity (µS/cm) at Outflow of Unnamed Pond south of Long Pond

Dissolved Oxygen

The water quality instrument directly measures dissolved oxygen (mg/L) with the dissolved oxygen probe. The instrument then calculates percent saturation (% Sat) taking into account the water temperature. During this deployment the dissolved oxygen levels where within 9.6 mg/L and 14.8 mg/L for concentration and 93.9 % Sat and 102.6 % Sat for percent saturation.

There is a natural diurnal pattern with dissolved oxygen. Oxygen concentration levels will fluctuate throughout night and day. The significant dips/peaks outside of the diurnal pattern, are a result of fluxes in water temperature or influences from rainfall/runoff. The relationship with water temperature is evident in Figure 13 from November 14th onwards as the water temperature decreases into winter and the dissolved oxygen concentration correspondingly increases.

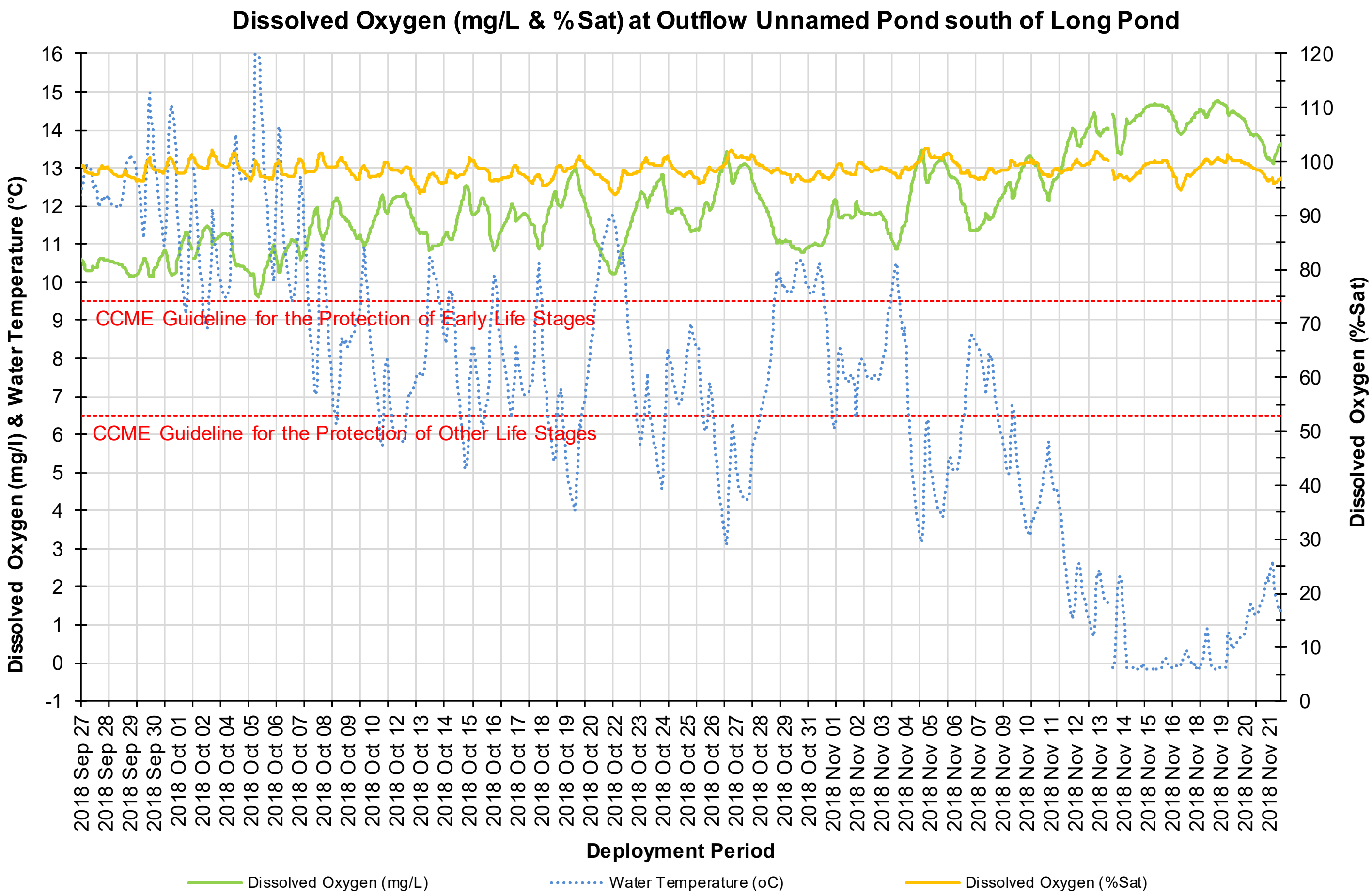

Figure 13: Dissolved Oxygen (%Sat & mg/L) at Outflow of Unnamed Pond south of Long Pond

Turbidity

Turbidity levels during the deployment ranged within 6.6 NTU and 53.5 NTU (Figure 14). The deployment data had a median of 21.0 NTU. This median is higher than the previous deployment median of 2.5 NTU.

Turbidity fluctuated throughout the duration of this deployment. The turbidity level did not settle to below 10 NTU indicating a higher amount of sediment or suspended material present in the water column throughout the deployment. Periodical stage events flushed the brook and reduced the turbidity for a short period of time, however, the turbidity levels increased again shortly after.

Please note the daily averaged stage data on the graph 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.

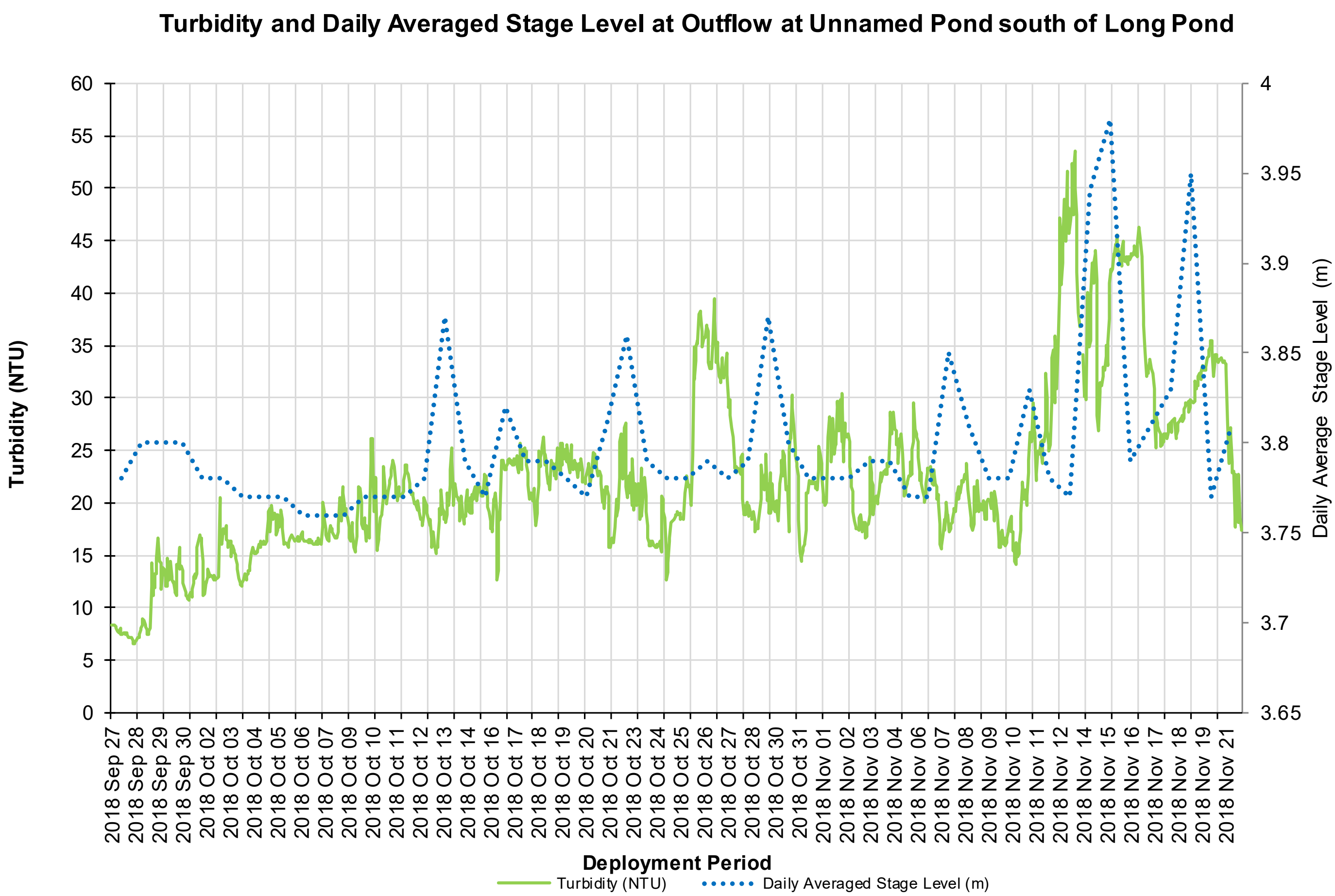

Figure 14: Turbidity (NTU) at Outflow of Unnamed Pond south of Long Pond

Daily Averaged Stage Level and Total Precipitation

Please note the stage data on the graph 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.

Stage provides an estimation of water level at the station and can explain fluctuations occurring with other parameters (i.e. Specific Conductivity, DO, turbidity). Stage will increase during rainfall events (Figure 15) and during any surrounding snow or ice melt. However, direct snowfall will not cause stage to rise significantly.

The larger peaks in stage correspond with the total precipitation events as noted on Figure 15. Total Precipitation data was obtained from Environment Canada's St. Lawrence weather station. Total Precipitation ranges for the deployment period were a minimum of 0.0 mm and a maximum of 49.2mm on October 12th, 2018.

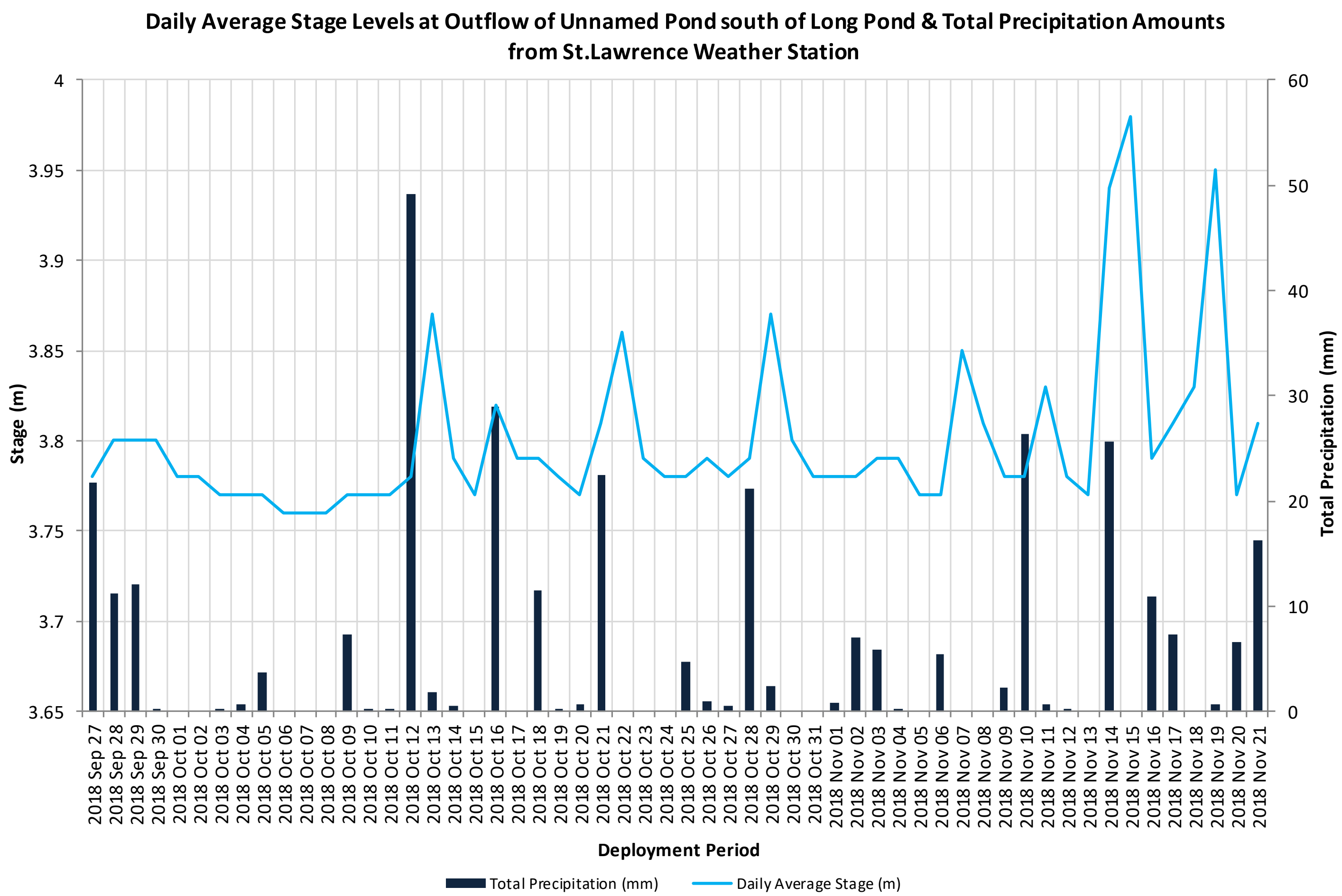

Figure 15: Daily averaged stage values and total precipitation.

Conclusion

The Outflow of Unnamed Pond south of Long Pond is established downstream of the Tailings Management Facility (TMF), to assist in capturing any emerging water quality issues with the management of the tailings facility. The Outflow of Unnamed Pond South of Long Pond also flows through an undeveloped area that includes natural wetlands and marshlands. This station is the furthest away from the anthropogenic activities that are occurring on the Canada Fluorspar mine site.

As with many shallow brooks and streams, precipitation and runoff play a significant role in influencing water quality. Decreasing water temperatures during the deployment were representative of the climate for the time of year. The pH values were consistent for this brook and any significant change in pH data corresponded with a rise in stage.

Conductivity levels responded to stage fluctuations by reducing conductivity during stage increases and increasing conductivity during periods of low stage. Dissolved oxygen levels were influenced by the cooler air/water temperatures, generally increasing as the deployment progressed into winter.

Turbidity levels were higher than previously recorded as the deployment had a turbidity median of 21.0 NTU which was higher than the previous deployment median of 2.5 NTU. This deployment had recorded total precipitation on 38 of the 56 day deployment, which likely influenced the higher turbidity median.

Precipitation brings changes to water quality conditions. Most of these changes are natural, quick adjustments in levels before the data returns to background conditions. Precipitation can influence the transfer of runoff from surrounding construction areas by flushing excess material into waterways. The health of a brook can be determined by how quickly it returns to its background data range after a water quality event.