Real-Time Water Quality Report

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

Deployment Period
October 17, 2017 to November 27, 2017

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

Prepared by:

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General

The Water Resources Management Division (WRMD), in partnership with Water Survey of Canada - Environment and Climate Change Canada (WSC-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.

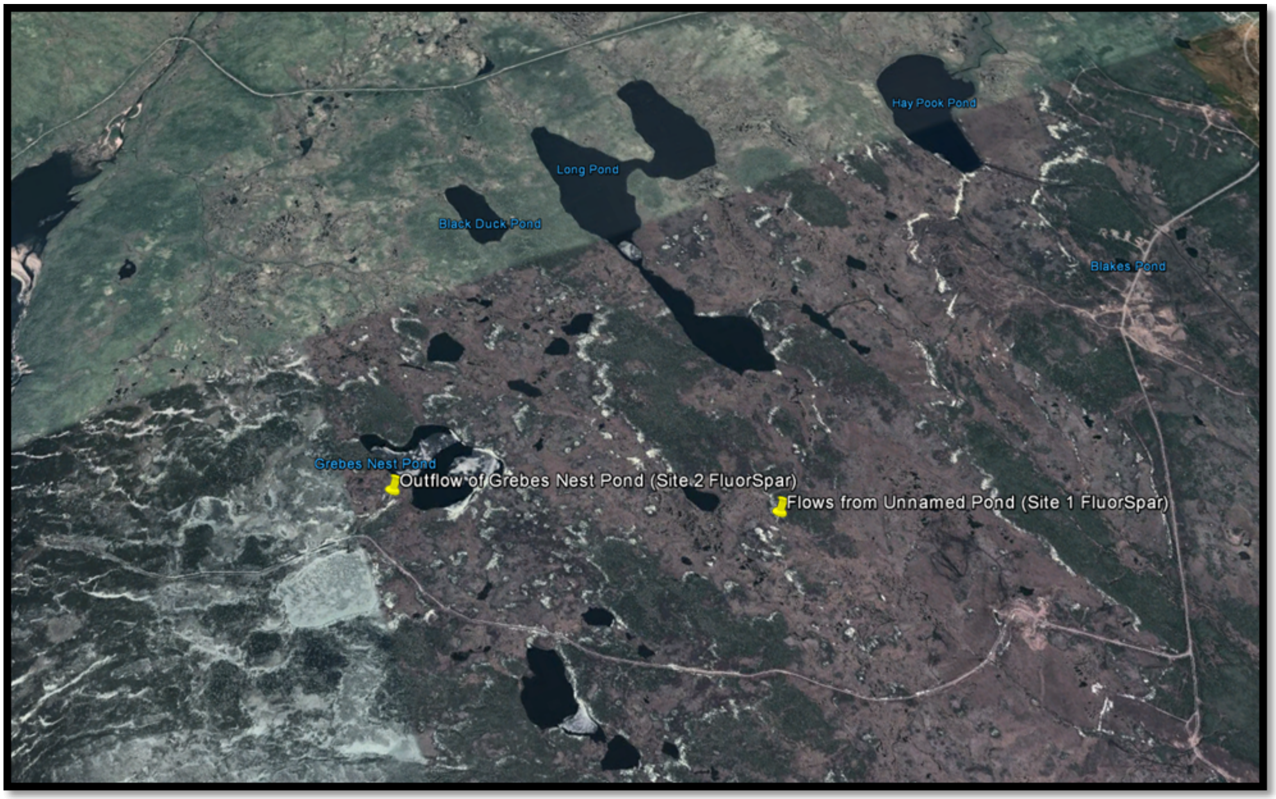

Figure 1: Real-Time Water Quality and Quantity Stations at Canada Fluorspar Inc

The real-time water quantity/quality station downstream from Grebes Nest Pond was labeled "Outflow of Grebes Nest Pond". The location of Outflow of Grebes Nest Pond station is established downstream of the pit dewatering effluent outfall upstream of John Fitzpatrick Pond. The stream is approximately 1.0 to 2.0 meters wide. The brook 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 left 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.

The real-time water quantity/quality station labeled "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 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 alongside 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)) is responsible for maintenance of the real-time water quality monitoring equipment, as well as recording and managing the water quality data. Tara Clinton, under the supervision of Renee Paterson, 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 (Environment and Climate Change Canada (ECCC)) under the management of Howie Wills, play an essential role in the data logging/communication aspect of the network and the maintenance of the water quantity monitoring equipment. WSC-ECCC 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 dependant, 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	Oct 17	Deployment	Excellent	Good	Good	Good	Excellent
	Nov 27	Removal	Excellent	Fair	Good	Poor	Good
Unnamed Pond	Oct 17	Deployment	Good	Good	Good	Excellent	Good
	Nov 27	Removal	Excellent	Good	Excellent	Good	Good

At deployment of the field instrument at Outflow of Grebes Nest Pond site, the water temperature, pH, specific conductivity, dissolved oxygen and turbidity data ranked within 'Good' and 'Excellent' against the QA values that were recorded.

During removal of the instrument the ranking for water temperature, specific conductivity and turbidity ranked 'Excellent' and 'Good' against the QA data. pH data ranked as 'Fair' at removal. Dissolved oxygen data ranked as 'Poor' at removal, however it is likely an issues with the QA sonde as the instrument recorded a value of 119.5 %sat and 15.44 mg/L which are unlikely values for dissolved oxygen in a brook.

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

At the end of the deployment the data was ranked again to compare. The ranking for water temperature, pH, dissolved oxygen, specific conductivity and turbidity where within 'Good' to 'Excellent' in the ranking categories.

Concerns or Issues during the Deployment Period

The water supply for Outflow of Grebes Nest Pond station has changed. Currently the water is originating from a sedimentation pond that is upstream of the Real-Time station. A new 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 a sedimentation pond that naturally overflows down a trough and into a culvert that flows into Outflow of Grebes Nest Pond.

Turbidity data had to be removed from Outflow of Grebes Nest Pond dataset for this deployment, from November 7th to November 9th, 2017. There was a high stage event which increased the turbidity, however the turbidity did not settle down after the increase indicating that the sensor was likely blocked. Environmental staff from Canada Fluorspar visited Grebes Station and confirmed that the turbidity data was not representing the brook at this time. The Environmental staff cleaned the debris from the instrument, which allowed for the turbidity values to return to an expected range.

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 3.12°C to 11.62°C during the deployment period (Figure 4). The water temperature at the station displays obvious diurnal variations of the temperature at the beginning of the deployment. As the air temperatures start to drop, the water temperature decreased as well. There is more variation in the water temperature from November 4th, 2017 onwards; it coincides with changes in the stage levels.

High stage events are likely a result of precipitation events. The water temperature responds during these events by decreasing for a short period of time, which is a normal occurrence. Water temperature can be expected to drop as the seasons change into winter and below 0 °C air temperatures.

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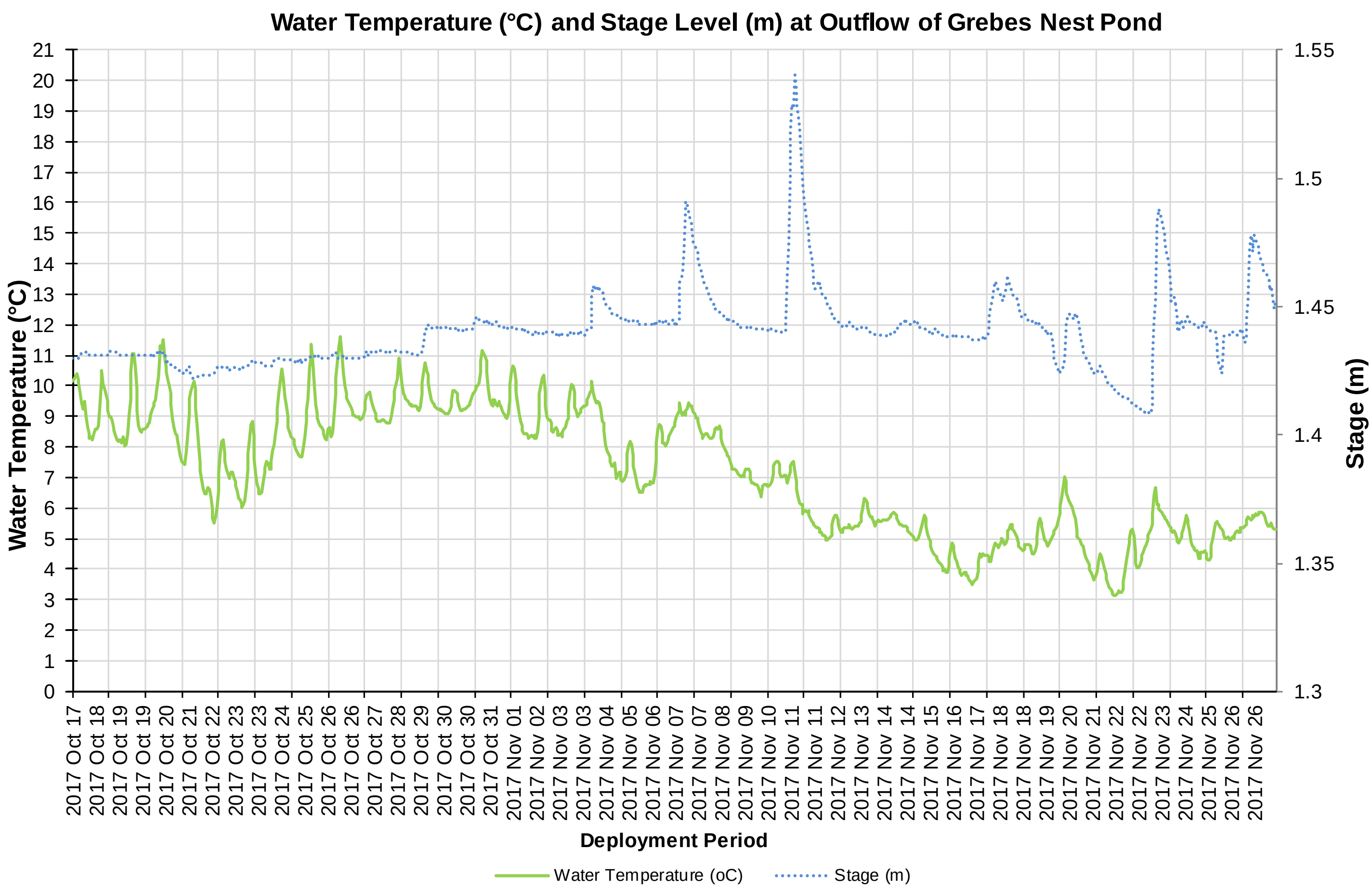

Figure 4: Water temperature (°C) values at Outflow of Grebes Nest Pond

pH

Throughout the deployment period, pH values ranged between 5.22 pH units and 6.12 pH units (Figure 5) and are reasonably consistent. The pH data remain below the minimum Guideline for Protection of Aquatic Life. The Canadian Council of Ministers of the Environment (CCME) guidelines is just a basis by which to compare the pH data within a dataset. Every brook is different with its own natural background range. It is not uncommon for Newfoundland and Labrador waters to be below the CCME pH guideline.

The pH level will decrease during high stage events. This is displayed on Figure 5, on several days in November. Natural processes such as rainfall and snow melt will alter the pH of a brook for a period of time and then the pH should return to pervious levels.

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.

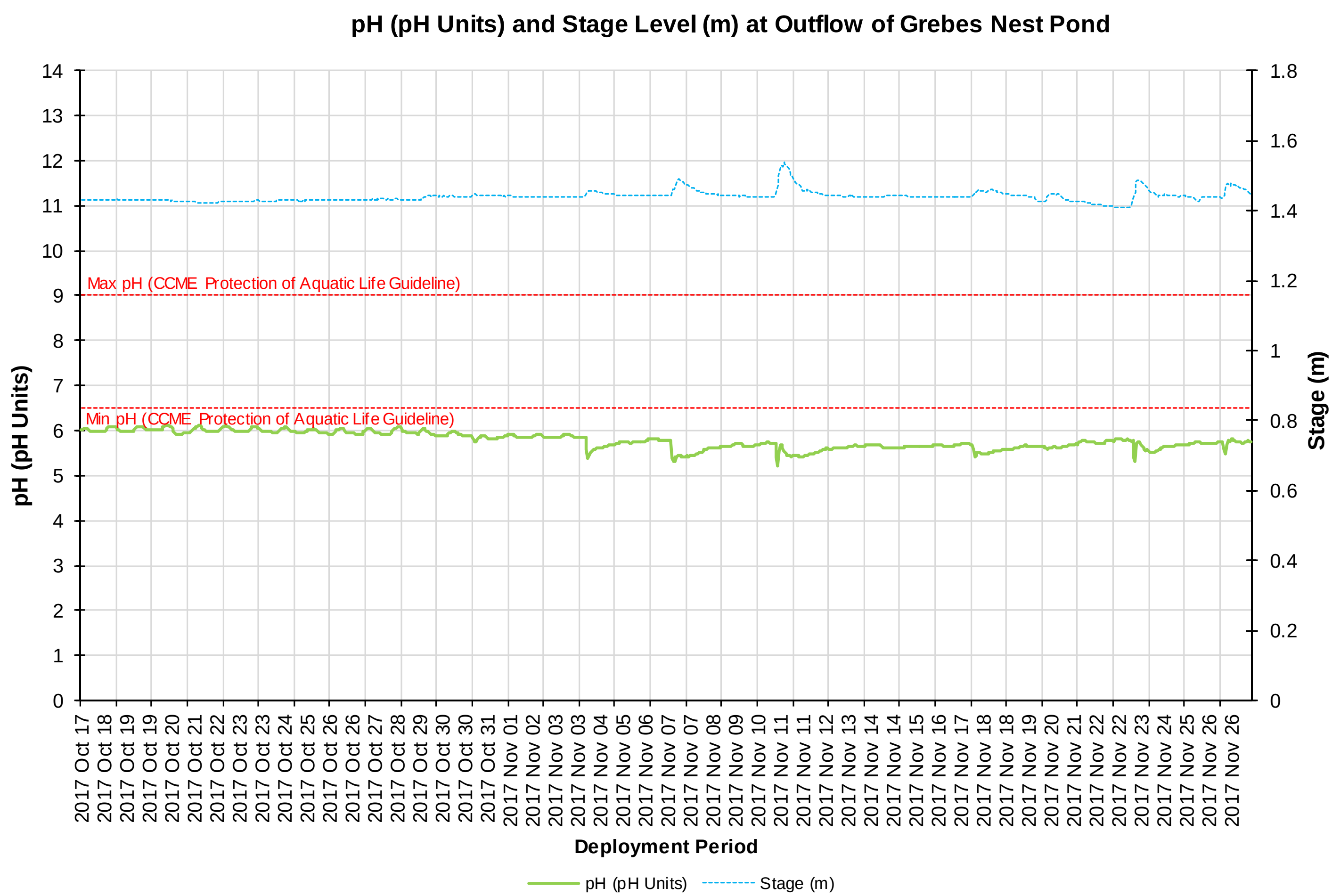

Figure 5: pH (pH units) and stage level (m) values

Specific Conductivity

The conductivity levels were within 47.1 µS/cm and 89.9 µS/cm during this deployment period (Figure 6).

The relationship between conductivity and stage level can react in several different ways. During this deployment the specific conductivity levels responded to high stage levels by decreasing initially at the onset of the precipitation amount, however shortly after the dip the conductivity levels increased. This is evident on Figure 6 in several places but most noticeably in early November 2017.

Rainfall initially dilutes the brook water before organic and inorganic matter is naturally flushed into the brook, which in turn increases the conductivity for a short period of time (Figure 9, Precipitation graph).

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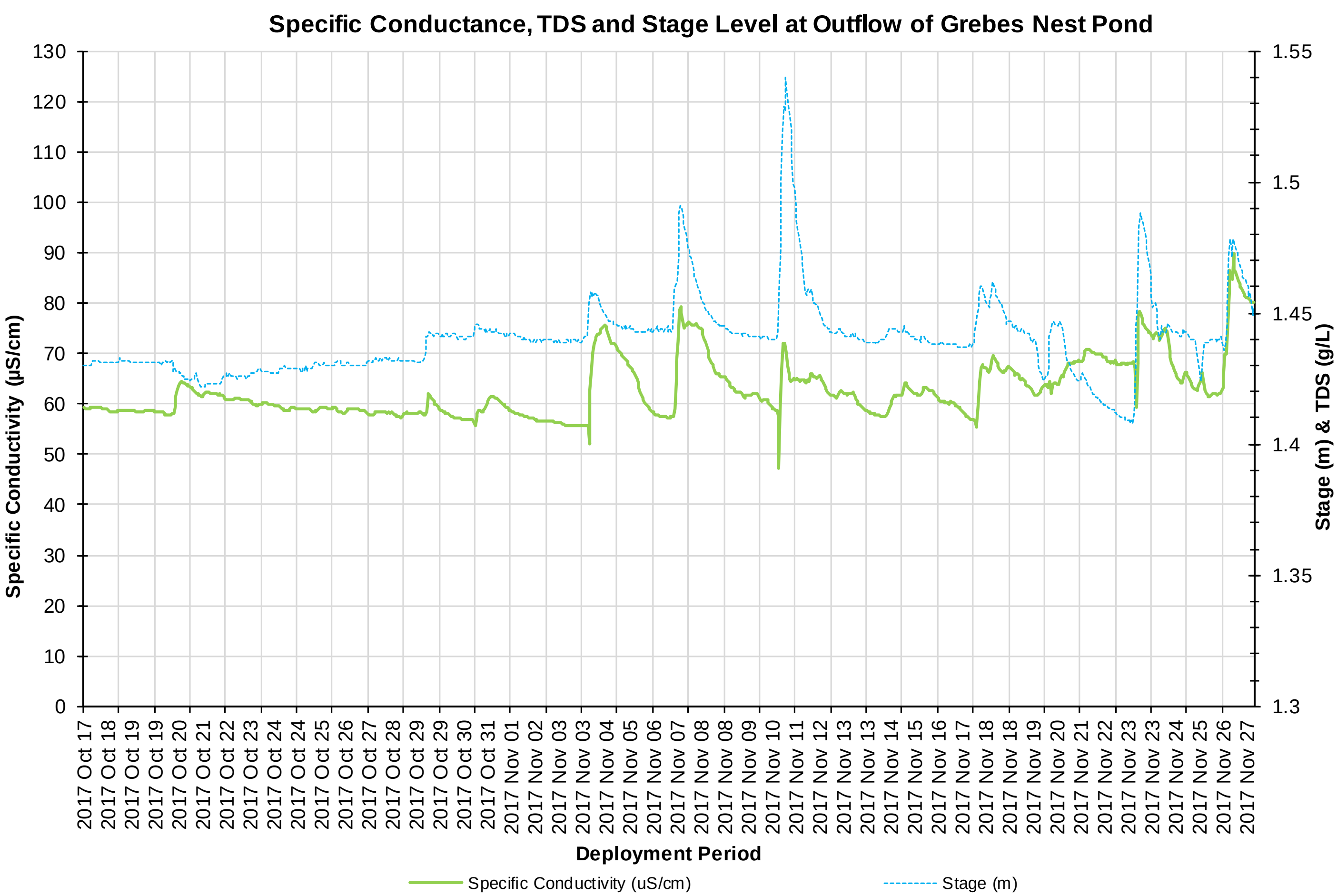

Figure 6: Specific conductivity (µS/cm) and stage (m) values

Dissolved Oxygen

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

During the deployment the dissolved oxygen concentration levels ranged within a minimum of 9.91 mg/L to a maximum of 12.35 mg/L. The percent saturation levels for dissolved oxygen ranged within 80.3% Saturation to 104.7% Saturation (Figure 7).

There was a change in the overall dissolved oxygen concentration on November 23rd to November 24th, 2017; this change corresponded with an increase in stage. The precipitation graph (Figure 9) indicates rainfall of 17.3mm on November 23rd, 2017. This is a normal reaction in water bodies as the temperature of the rainfall influences the brook water for a short period of time.

The CCME guidelines for the Protection of Aquatic Life provide national guidance. There are many occasions that natural brook environments move within these guidelines.

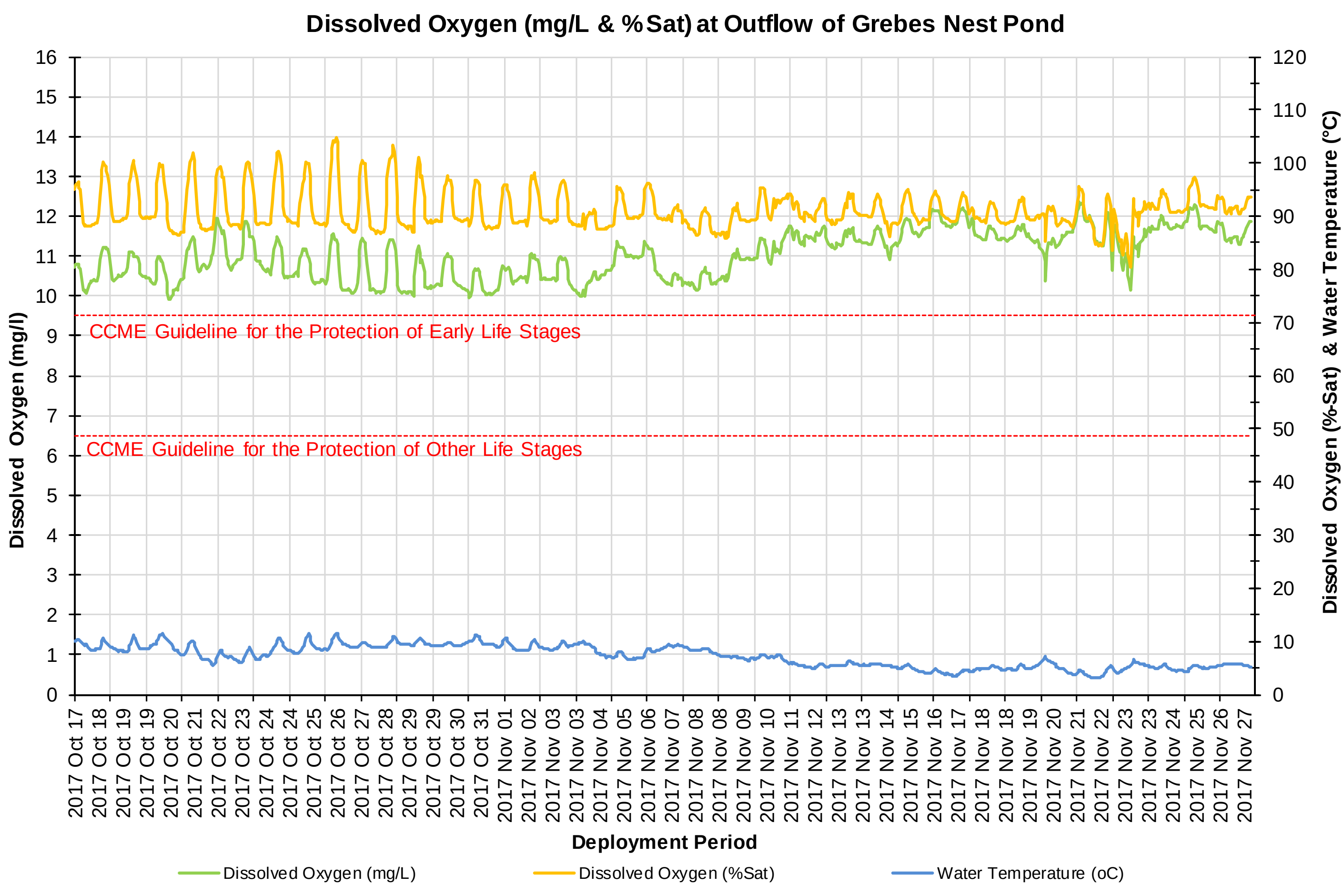

Figure 7: Dissolved Oxygen (mg/L & Percent Saturation) values and Water Temperature (°C)

Turbidity

Turbidity levels during the deployment ranged within 3.0 NTU and 234.6 NTU (Figure 8). The deployment data has a median of 5.9 NTU which is slightly lower than previous deployment median of 9.0 NTU.

During rainfall or runoff, higher turbidity readings are expected. Generally the turbidity levels increase for a short period of time and then return to within the range of the baseline. However if - after a turbidity event - the values do not decrease and there is greater frequency and higher values being recorded then these outcomes would be of concern.

Throughout this deployment the higher turbidity values correlate with precipitation events and subsequently increases in stage (Figure 9). Runoff from surrounding environments can increase the presence of suspended material in water. The turbidity spikes are high; however the turbidity levels do decrease after the peaks. Turbidity data had to be removed from Outflow of Grebes Nest Pond dataset for this deployment, from November 7th to November 9th, 2017. There was a high stage event which increased the turbidity, however the turbidity did not settle down after the increase indicating that the sensor was blocked.

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.

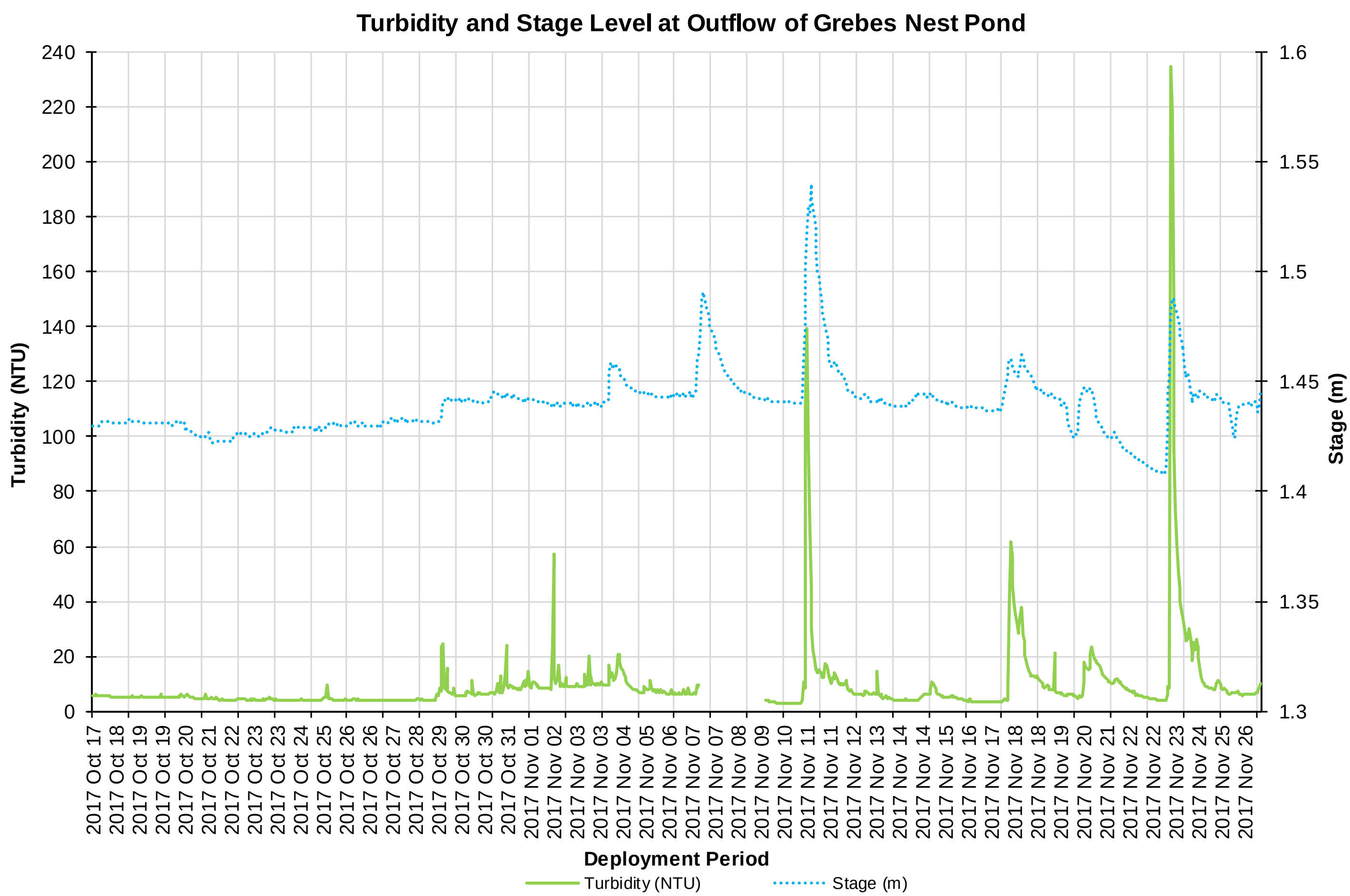

Figure 8: Turbidity (NTU) and stage level (m) values.

Stage and Precipitation

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.

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 9) 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 1.41m to 1.54m. The larger peaks in stage do correspond with substantial rainfall events as noted on Figure 9. Precipitation data was obtained from Environment Canada's St. Lawrence weather station. Precipitation ranges for the deployment period were a minimum of 0.0 mm and a maximum of 41 mm on November 10th, 2017.

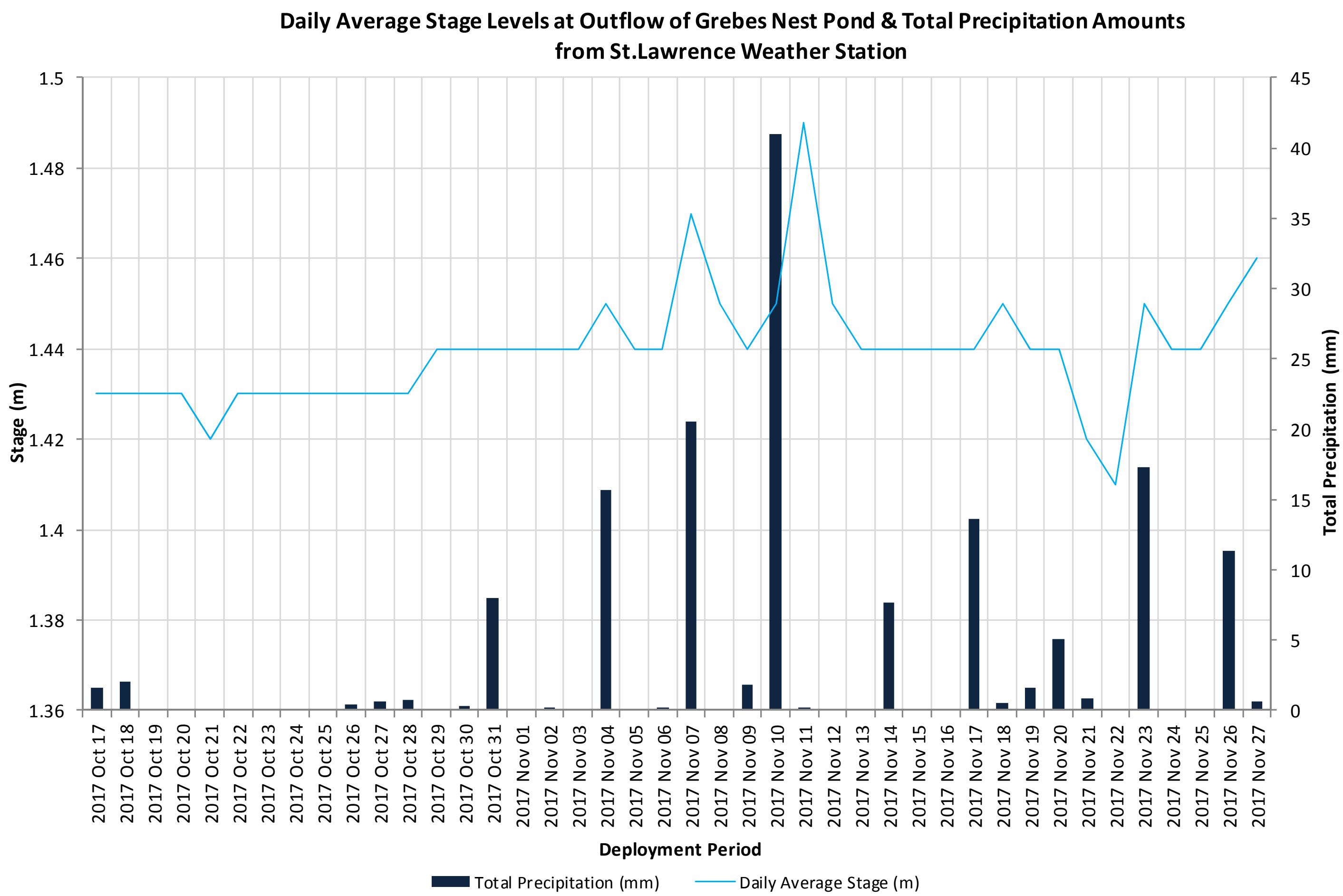

Figure 9: Daily average stage values and daily total precipitation.

Conclusion

Outflow of Grebes Nest Pond currently flows through a developing mine site. At this phase of the project, the natural environment is constantly being disturbed by construction activities. 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. Currently the water is originating from a sedimentation pond that is upstream of the Real-Time station. A new 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 a sedimentation pond that naturally overflows down a trough and into a culvert that flows into Outflow of Grebes Nest Pond.

The brook and pond's watershed are bordered by marshland, which can also influence the material present in the water column. These factors combined can impact the water quality parameters during climatic events such as precipitation and high air temperatures.

When reviewing the graphs as a whole it is evident that the larger precipitation events did cause varying effects with the water quality parameters including pH, conductivity, dissolved oxygen and turbidity. The pH values were reasonably consistent, there was a small amount of movement during the higher stage spikes however the pH returned to background levels after each increase. All ambient waterbodies have a unique baseline range for pH levels. The CCME pH guidelines are just a basis by which to gage a water body. Specific conductivity levels responded to high stage levels by decreasing initially at the onset of the precipitation amount, however shortly after the dip the conductivity levels increased slightly. Overall the specific conductivity levels remained consistent throughout the deployment within a range of 47.1 – 89.9 µS/cm. As winter approaches the air and water temperatures decrease and the dissolved oxygen levels increase. This is a natural reaction that is expected during these changes. Turbidity values displayed higher levels during the high stage events, however returned to previous levels after a short period of time. These changes in water quality are likely a result of rainfall and subsequent runoff that occurred throughout this deployment period.

The water quality data for Outflow of Grebes Nest Pond was as expected of an impacted brook. After perturbations in the data, the parameters did return to the previous levels observed. 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 0.09°C to 13.75°C during this deployment period (Figure 10). The graph displays the diurnal pattern that is evident with water temperature and also a decrease of the water temperature as the season changes into winter. There is an evident decrease in the water temperature from November 3rd to the end of the deployment period (Figure 10).

The water temperatures do increase slightly with each stage increase. The stage level increases are likely a result of rainfall (Figure 15), the rainfall can increase the temperature of the water for a short period of time.

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.

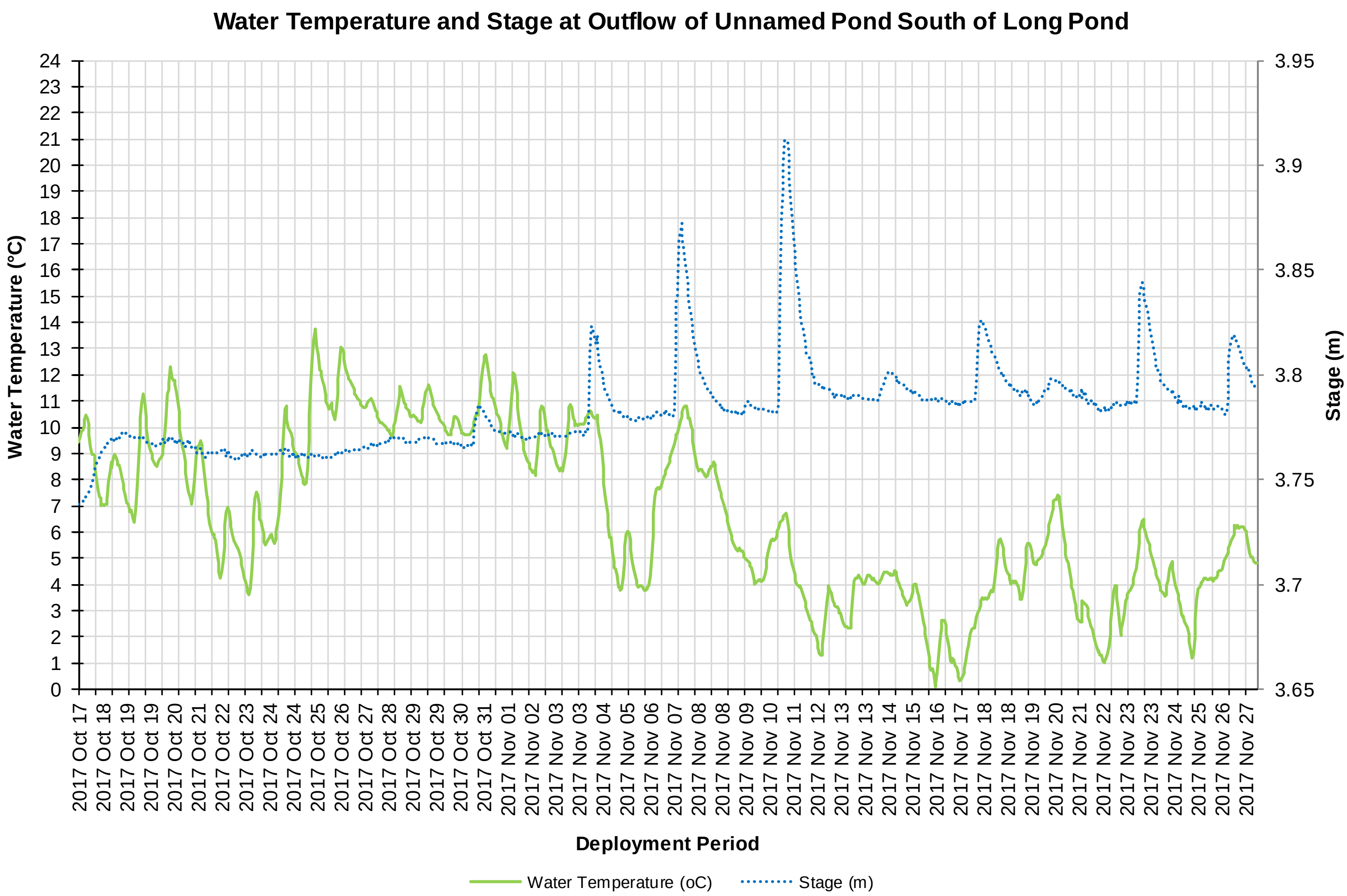

Figure 10: Water temperature (°C) values at Outflow of Unnamed Pond south of Long Pond

pH

Throughout this deployment period, pH values ranged between 7.11pH units and 7.71 pH units (Figure 11). The Canadian Council of Ministers of the Environment (CCME) guidelines is just a basis by which to compare any significant change in the pH data within a dataset. Every brook is different with its own natural background range. The pH data is consistent across the deployment.

Natural processes such as rainfall and snow melt will alter the pH of a brook for a period of time. This is evident on Figure 11, during and after high stage levels the pH data decreases slightly for a short period of time. This is a natural process and can be seen on the graph below on November 4th, November 7th and November 11th, 2017.

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.

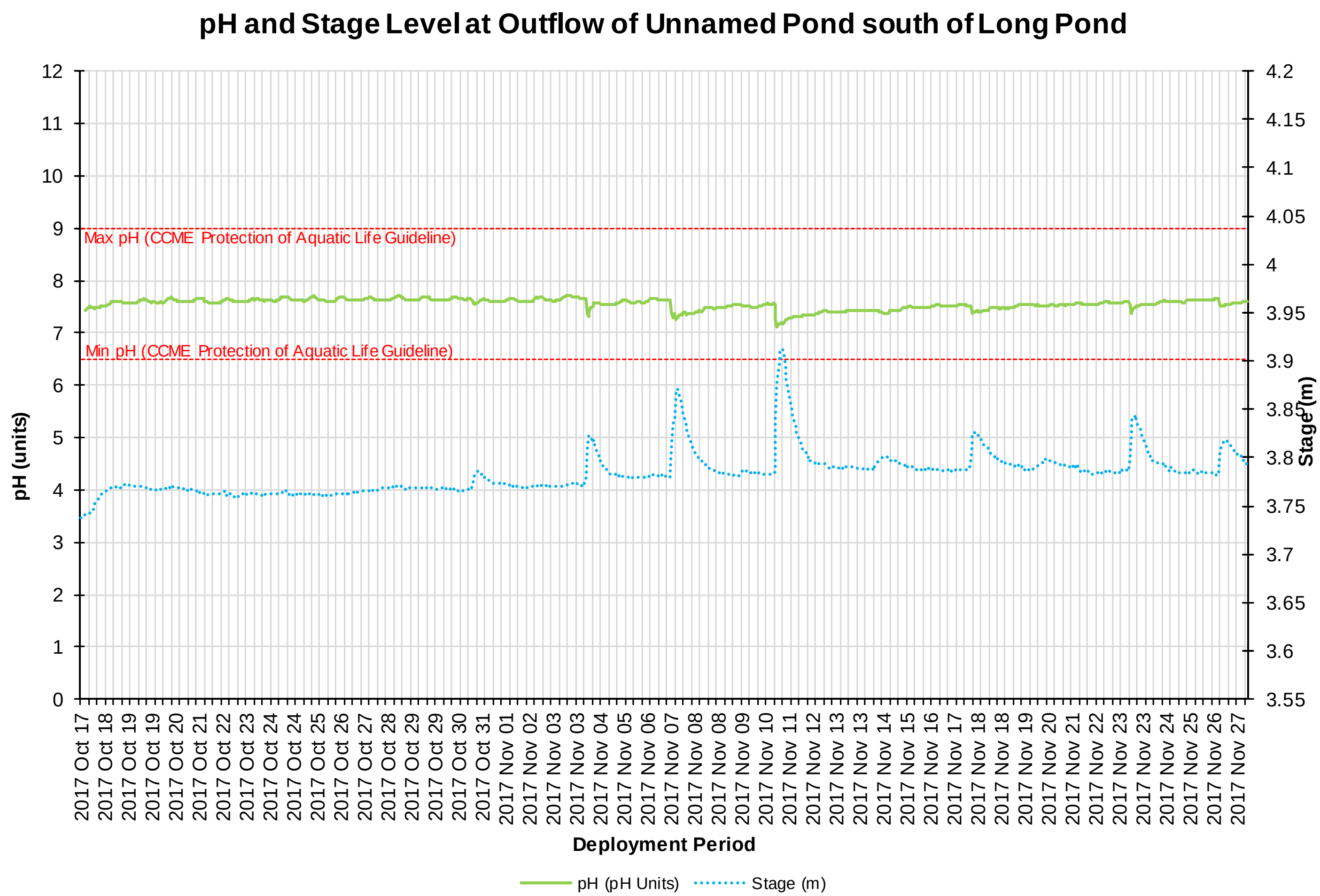

Figure 11: pH (pH units) and stage level (m) values

Specific Conductivity

The conductivity levels ranged between 119.4 µS/cm and 229.7 µS/cm during the deployment period (Figure 12). Specific conductivity measures the capability of a waterbody conducting an electrical current. Specific conductivity median of 186.4 µS/cm has remained consistent with the median from the previous deployment of 188.4 µS/cm.

There are several conductivity dips on November 4th, November 7th and November 11th, 2017 when stage level increased for a short period of time (Figure 12). Stage level was influenced by rainfall as displayed on Figure 15. There is a relationship between conductivity and stage, when stage levels rise, the specific conductance levels will decrease in response. With the stage level increasing, the increased amount of water in the river dilutes the suspended solids that are present (Figure 12).

There was one large spike in conductivity on November 14th, 2017 of 203.73 µS/cm. There was a small increase in stage during this timeframe likely a result of the recorded rainfall event that was on November 14th of 7.7mm (Figure 15).

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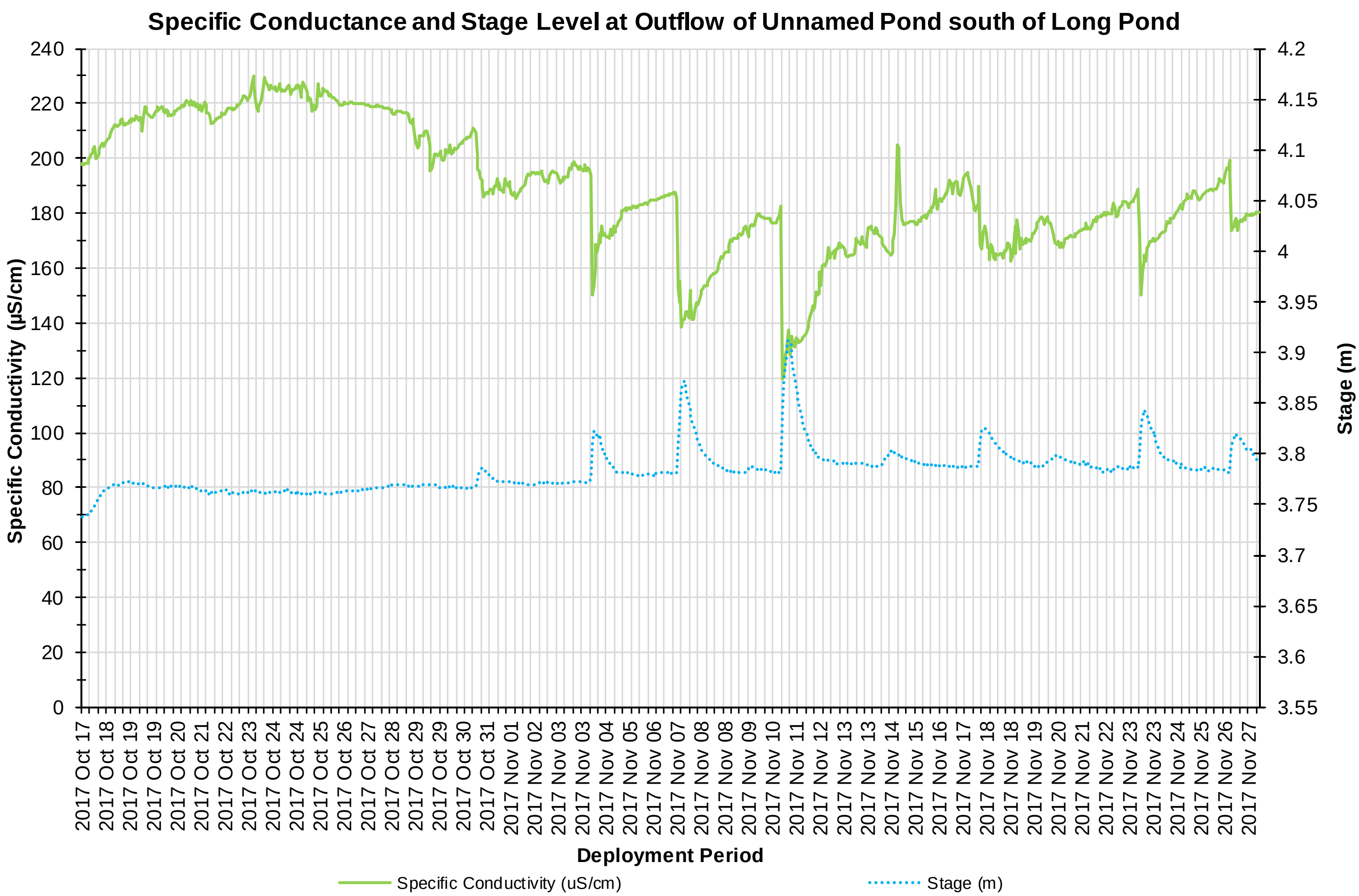

Figure 12: Specific conductivity (µS/cm), and stage (m) values

Dissolved Oxygen

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

During the deployment the dissolved oxygen concentration levels ranged within a minimum of 10.24 mg/L to a maximum of 14.14 mg/L. The percent saturation levels for dissolved oxygen ranged within 94.9% Saturation to 101.2% Saturation (Figure 13).

There is a natural diurnal pattern that occurs with dissolved oxygen, as the water temperatures decrease in the evening the dissolved oxygen will increase and as the water temperatures increase during daylight hours the dissolved oxygen will decrease. The increases in the dissolved oxygen concentration, which are outside of the natural diurnal pattern, are during the colder water temperatures, for example on November 4th to November 6th, 2017. This is a result of the normal reaction between water temperature and dissolved oxygen. It is to be expected as the air temperatures decrease for the concentrations of dissolved oxygen to increase in the brook.

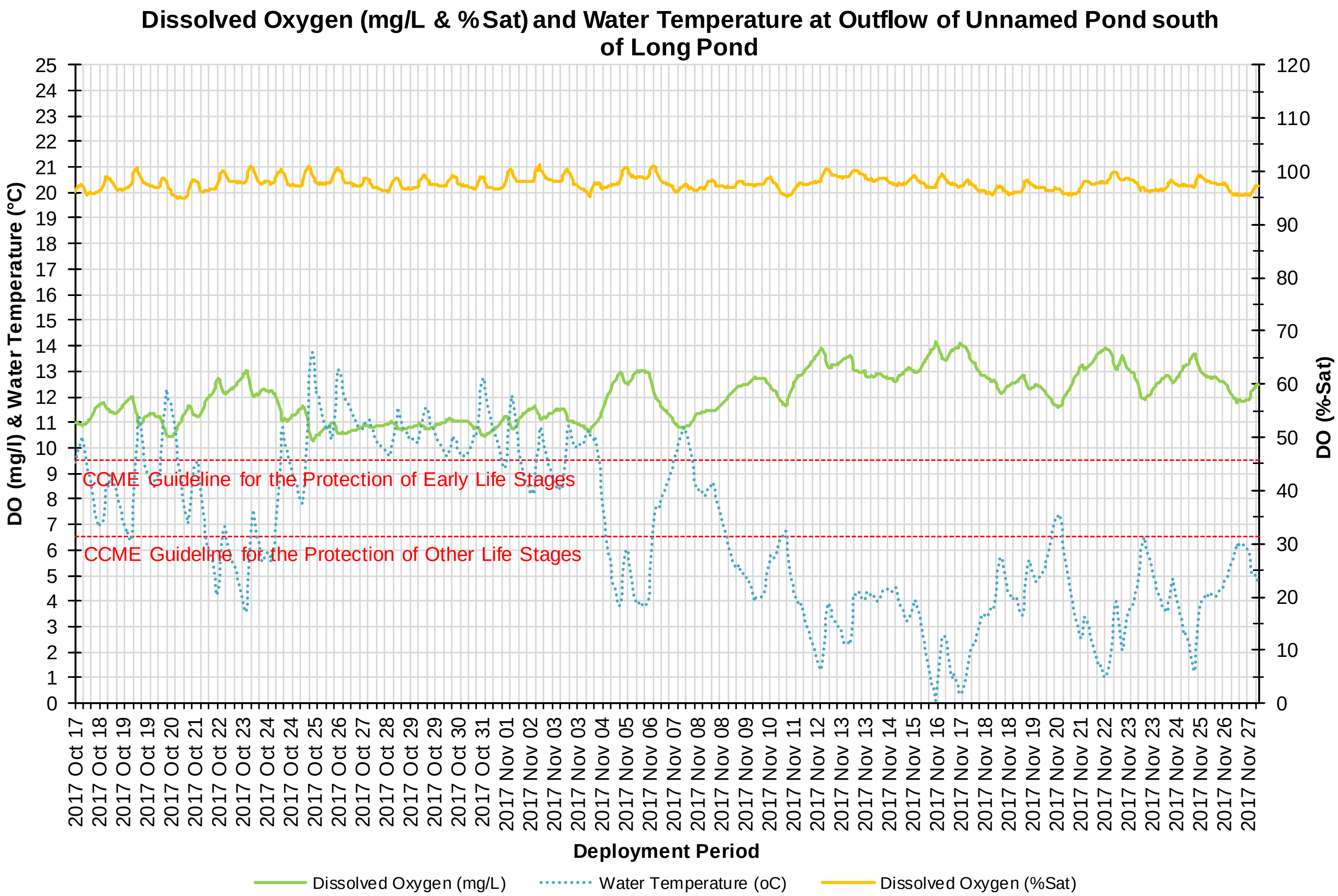

Figure 13: Dissolved Oxygen (mg/L & Percent Saturation) values.

Turbidity

Turbidity levels during the deployment ranged within 2.9 NTU and 39.8 NTU (Figure 14). The deployment data has a median of 12.1 NTU. The median is slightly higher than the previous deployment median of 9.1 NTU. It has been acknowledged that there is seepage occurring from the polishing pond and coupled with rainfall the overall increase in turbidity could be related to these two factors.

After November 3rd there is a steady increase in turbidity toward the end of the deployment. There are several rainfall events within this time (Figure 15) which likely contributed to the levels. Runoff from the surrounding environment will increase the presence of suspended material in water. There is no indication that this data is not accurate, at removal this instrument was compared again a QA sonde and provided a ranking of 'Good' for turbidity data. The turbidity data displayed a spike on November 14th despite no large change in stage data, this corresponded with the spike that was seen in the conductivity data as well.

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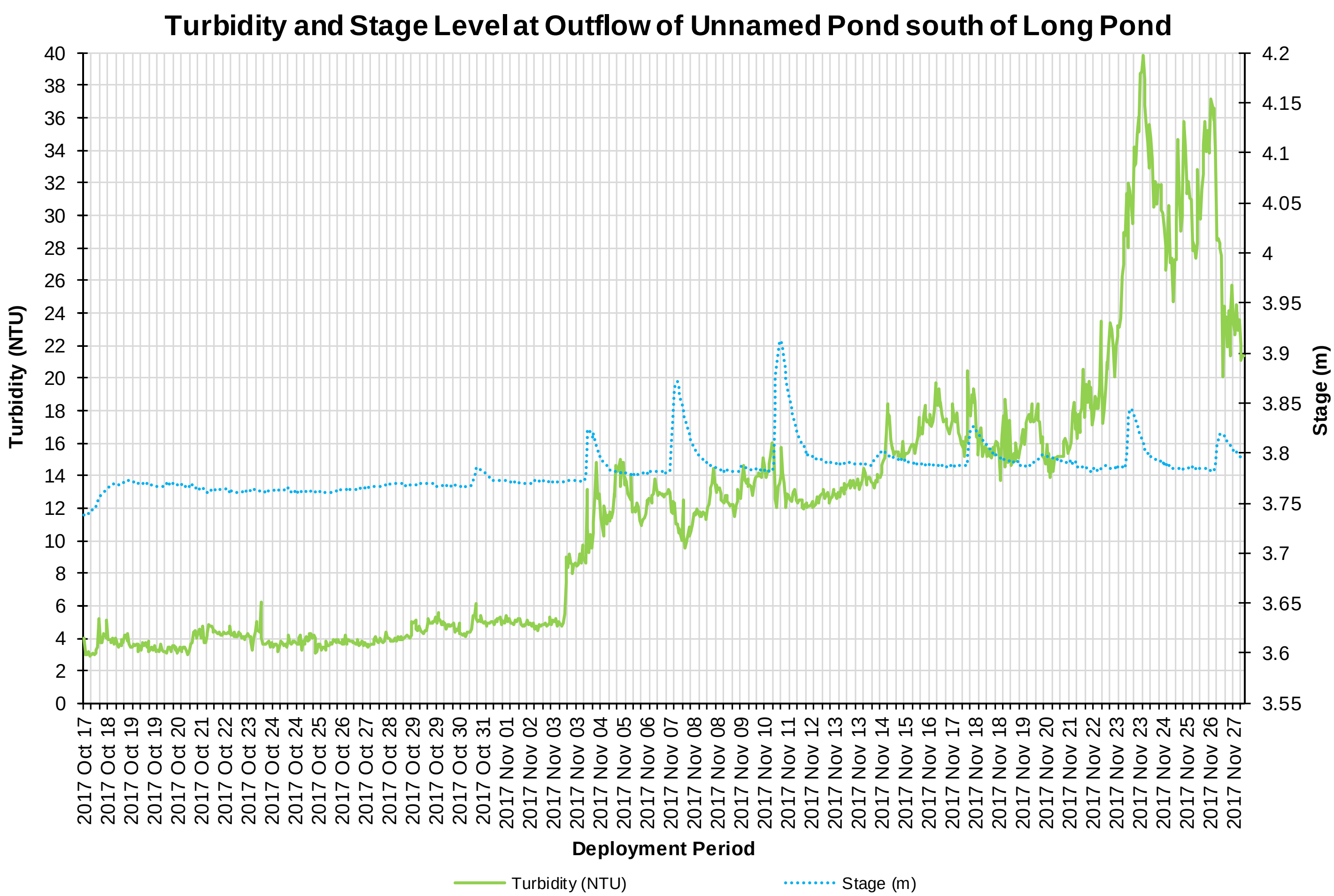

Figure 14: Turbidity (NTU) and stage level (m) values.

Stage and Precipitation

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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 15) and during any surrounding snow or ice melt. However, direct snowfall will not cause stage to rise significantly.

During the deployment period, the stage values ranged from 3.74m to 3.91m. The larger peaks in stage correspond with substantial rainfall events as noted on Figure 15. Precipitation data was obtained from Environment Canada's St. Lawrence weather station. Precipitation ranges for the deployment period were a minimum of 0.0 mm and a maximum of 41mm on November 10th, 2017.

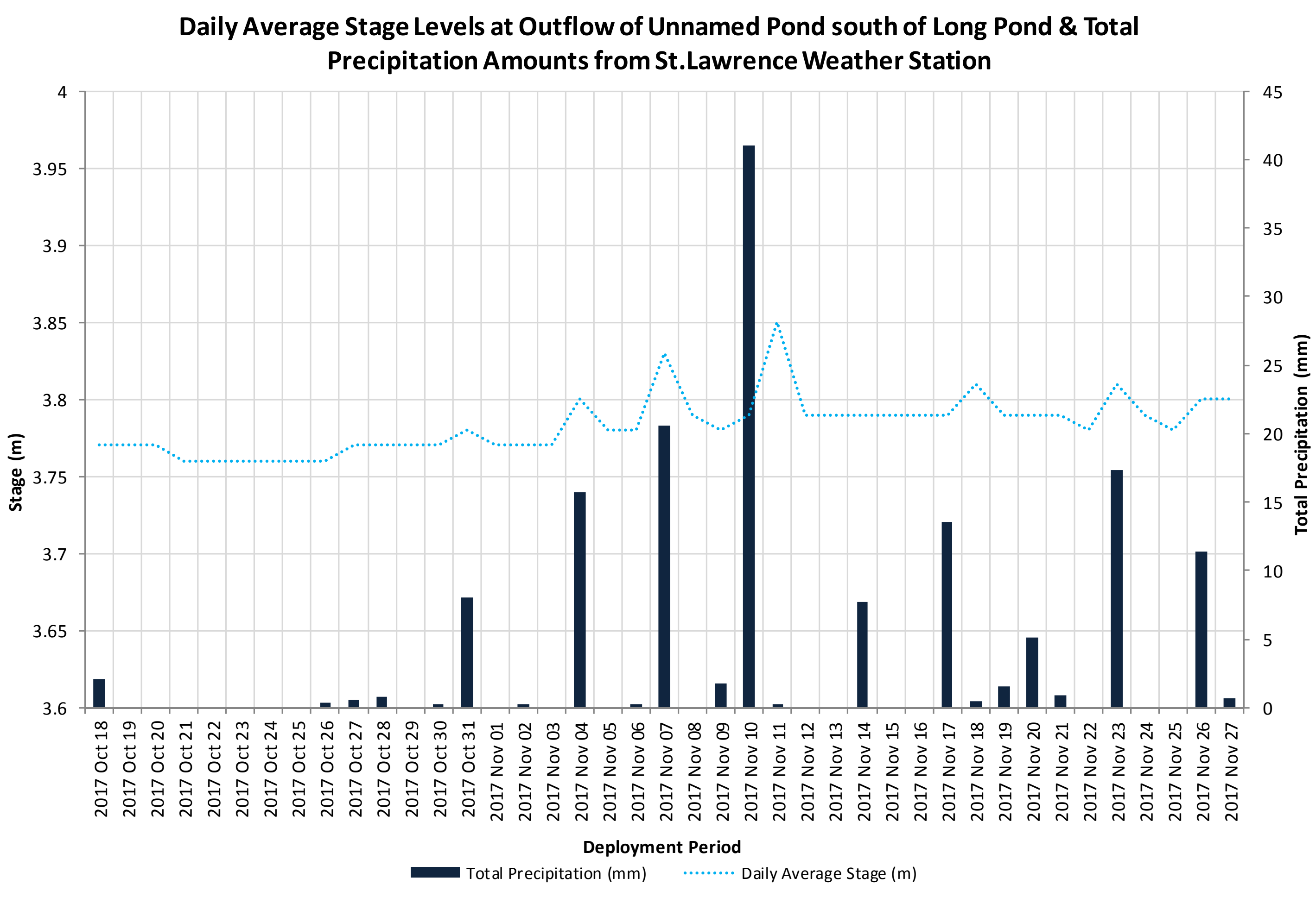


Figure 15: Daily average stage values and daily total precipitation.

Conclusion

As with many shallower brooks and streams, precipitation and runoff events play a significant role in influencing the water quality within the water body. The Outflow of Unnamed Pond south of Long Pond runs through some undeveloped area that includes natural wetlands and marshlands however the brook skirts along the construction activity that is ongoing. There will be influences from these activities on the water quality parameters. This station is the furthest away from the anthropogenic activities that are occurring on the mine site.

Water temperatures during this deployment were representative of the climate for this time of year. Water temperatures are directly influenced by air temperatures. Seasonal changes in water temperature are evident in the data displayed. These changes will also influence the dissolved oxygen concentration present in the brook. The levels of dissolved oxygen concentration are within natural and expected limits for this brook.

The pH values were consistent for this brook. Any significant change in pH data corresponded with a rise in the stage level. There was no significant change in the specific conductivity from the previous deployment. There was one specific conductivity spike on November 14th, while there was precipitation on that day, there wasn't a large increase in stage. An event like this indicates that an increase in material/minerals was flushed into the brook to display a spike on the graph.

Turbidity levels increased over the deployment. From November 3rd onwards the turbidity steadily increased. This change was also during the rainfall events for this deployment. The deployment had a higher median of 12.1 NTU than the previous deployment. There was also a recorded turbidity spike on November 14th, during the same time as the increase in conductivity.

Precipitation brings changes to water quality conditions, most of these changes are natural quick adjustments in levels before the data returns to background levels. Precipitation can influence the transfer of runoff from surrounding construction areas by flushing excess material into waterways. The watershed for this brook will undergo anthropogenic changes as the mining activities increase. The health of a brook can be determined by how quickly it returns to a consistent parameter level after a water quality event.

APPENDIX A

WATER TEMPERATURE AND AIR TEMPERATURE COMPARISON

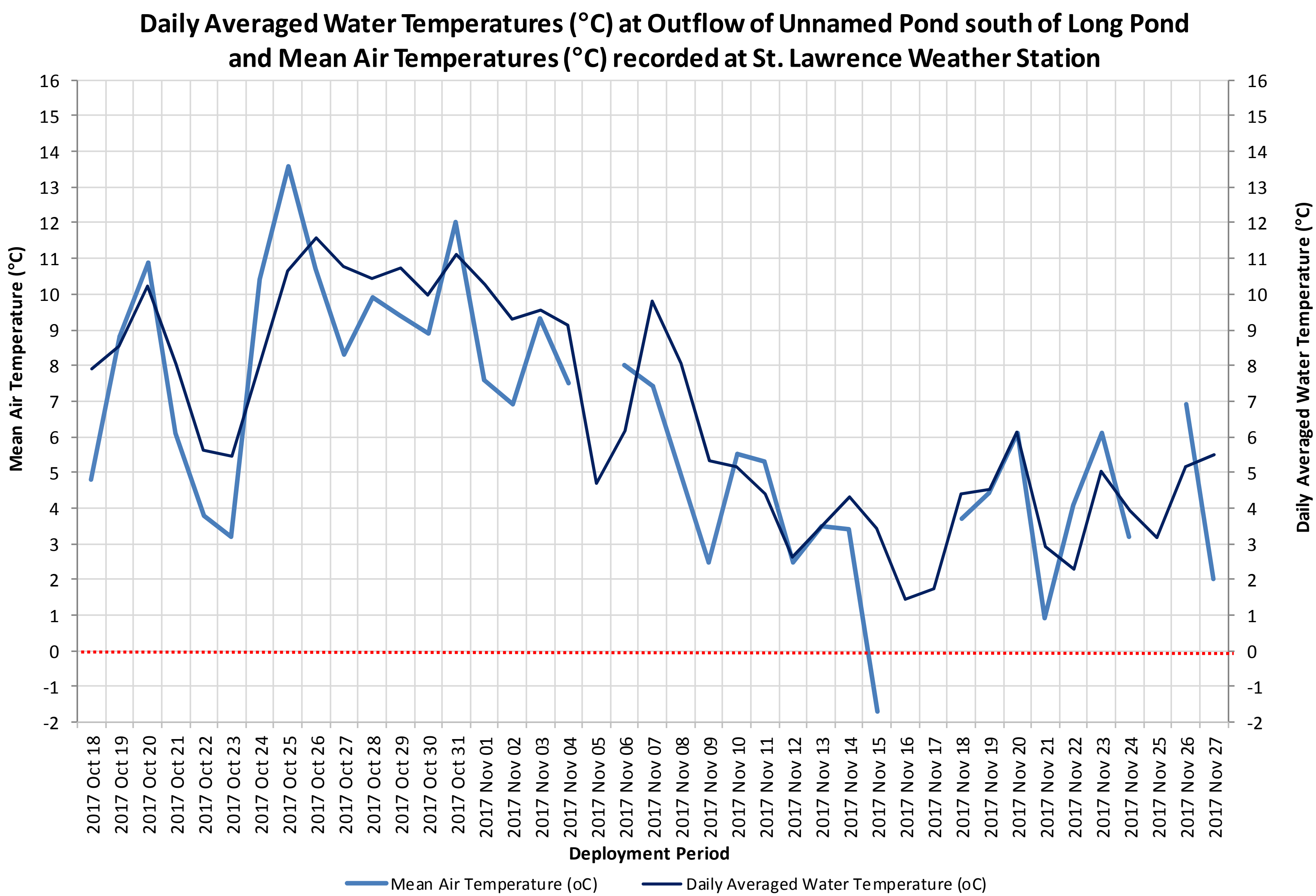


Figure A1: Water Temperatures at Outflow of Unnamed Pond south of Long Pond and Mean Air Temperatures recorded at St. Lawrence Weather Station

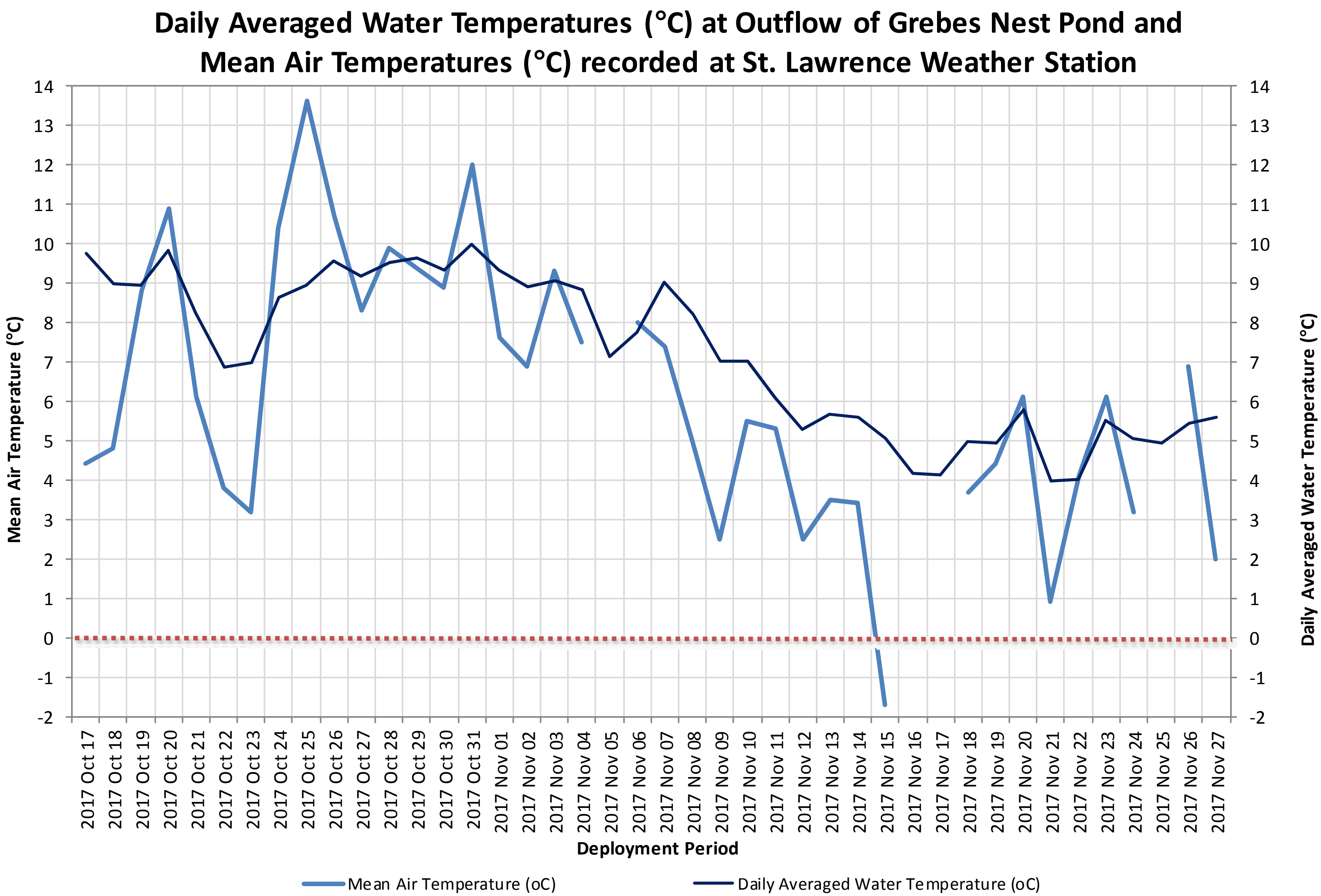
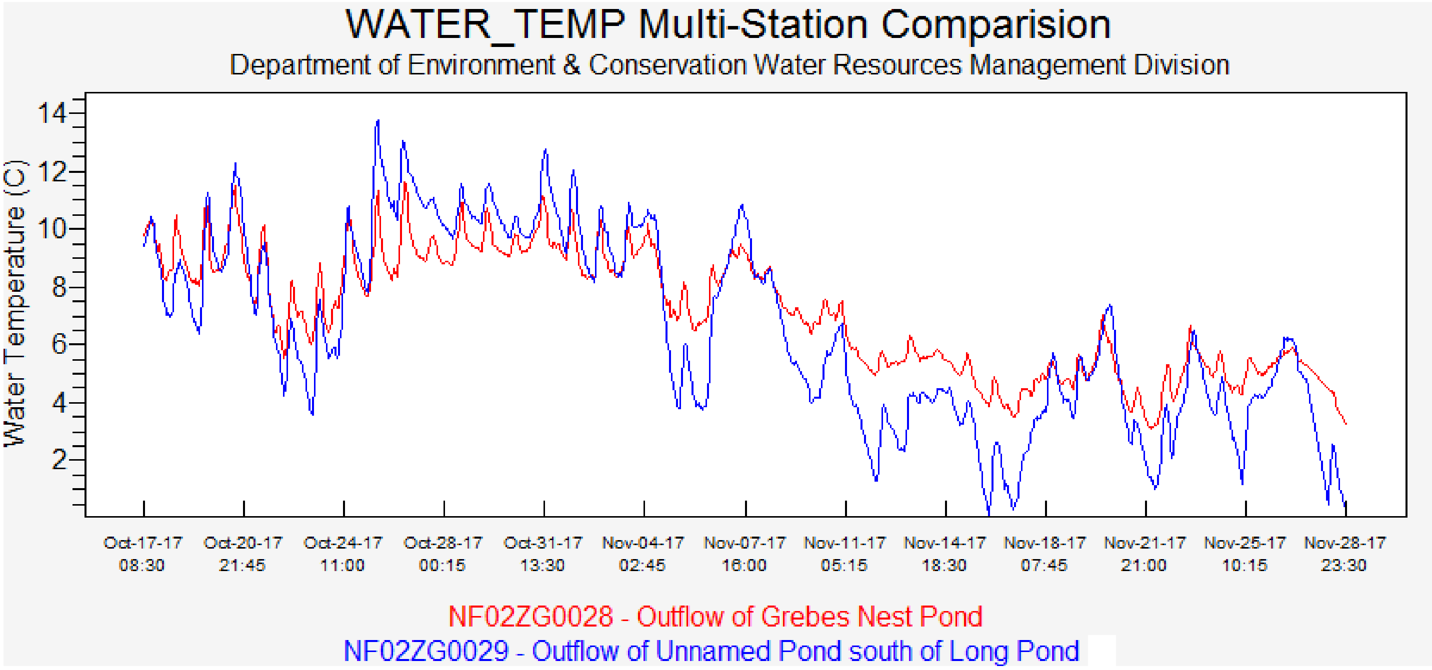


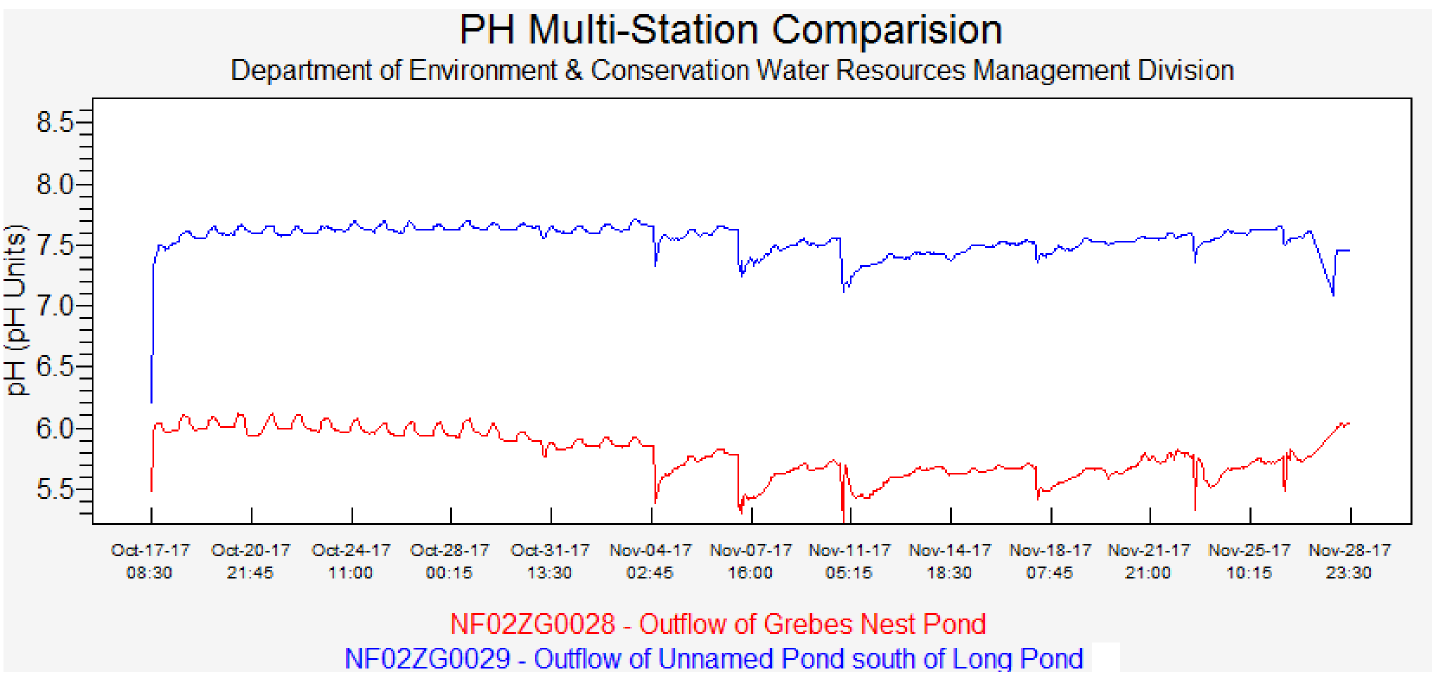
Figure A2: Water Temperatures at Outflow of Grebes Nest Pond and Mean Air Temperatures recorded at St. Lawrence Weather Station

APPENDIX B

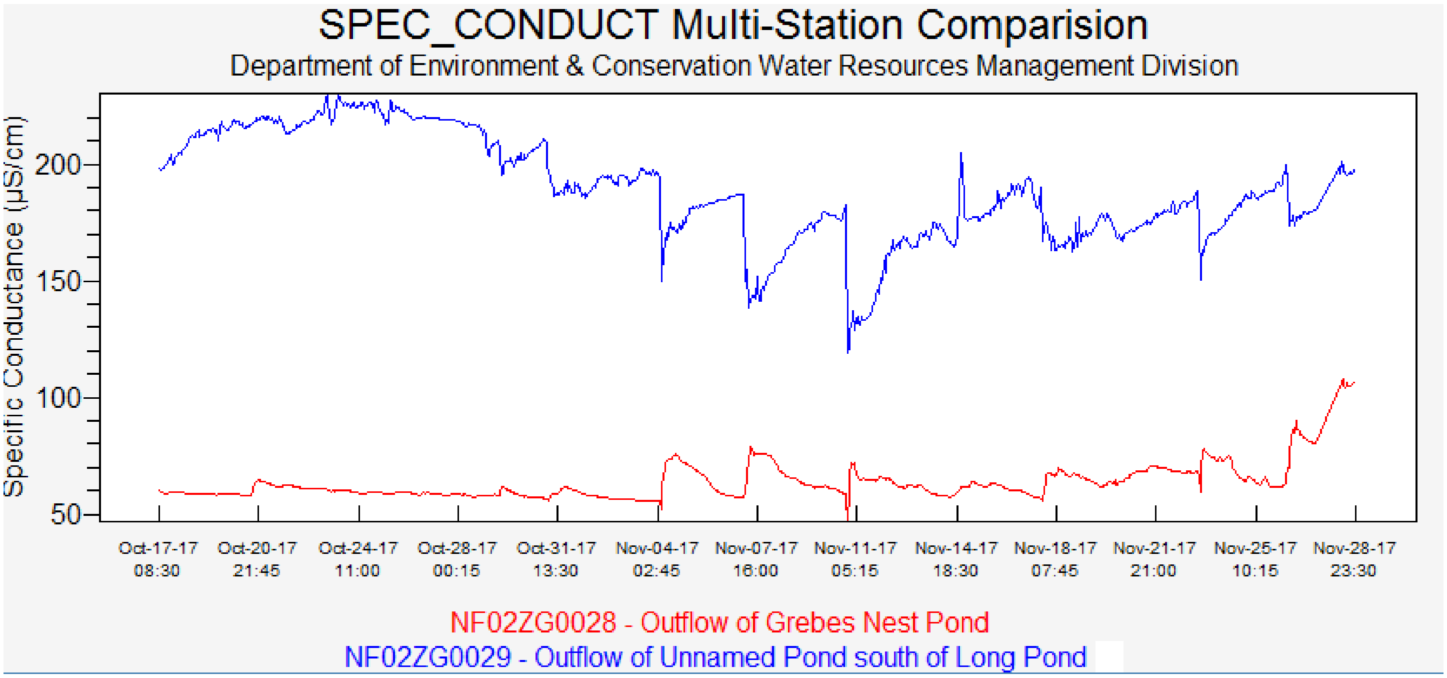
COMPARISON GRAPHS OF STATIONS



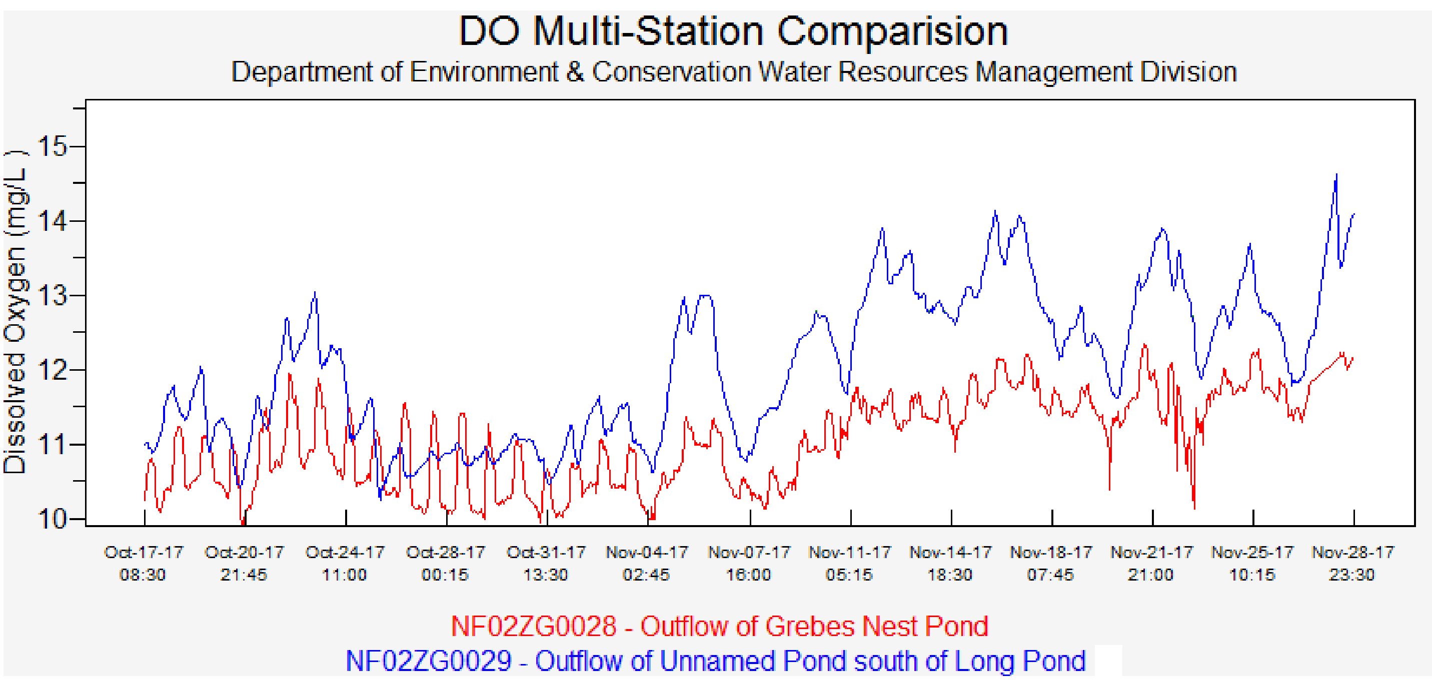
Comparison of Water Temperature at Canada Fluorspar Stations



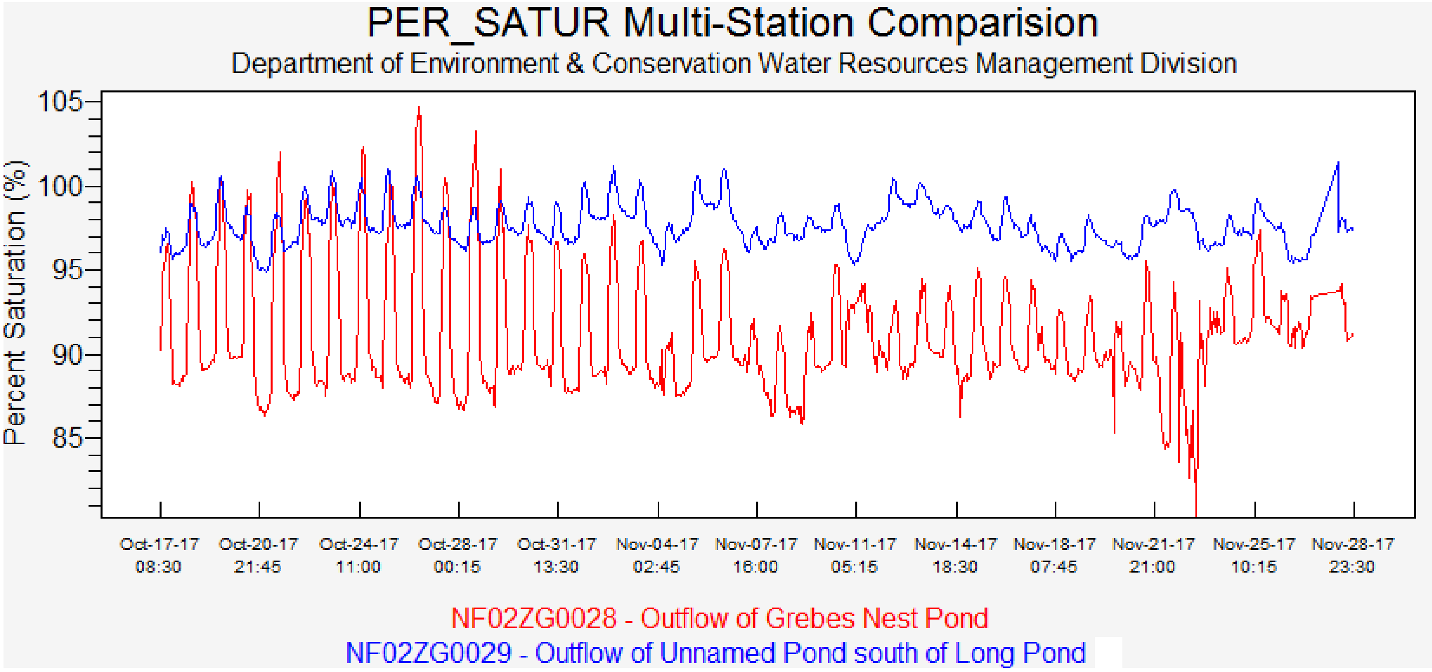
Comparison of pH at Canada Fluorspar Stations



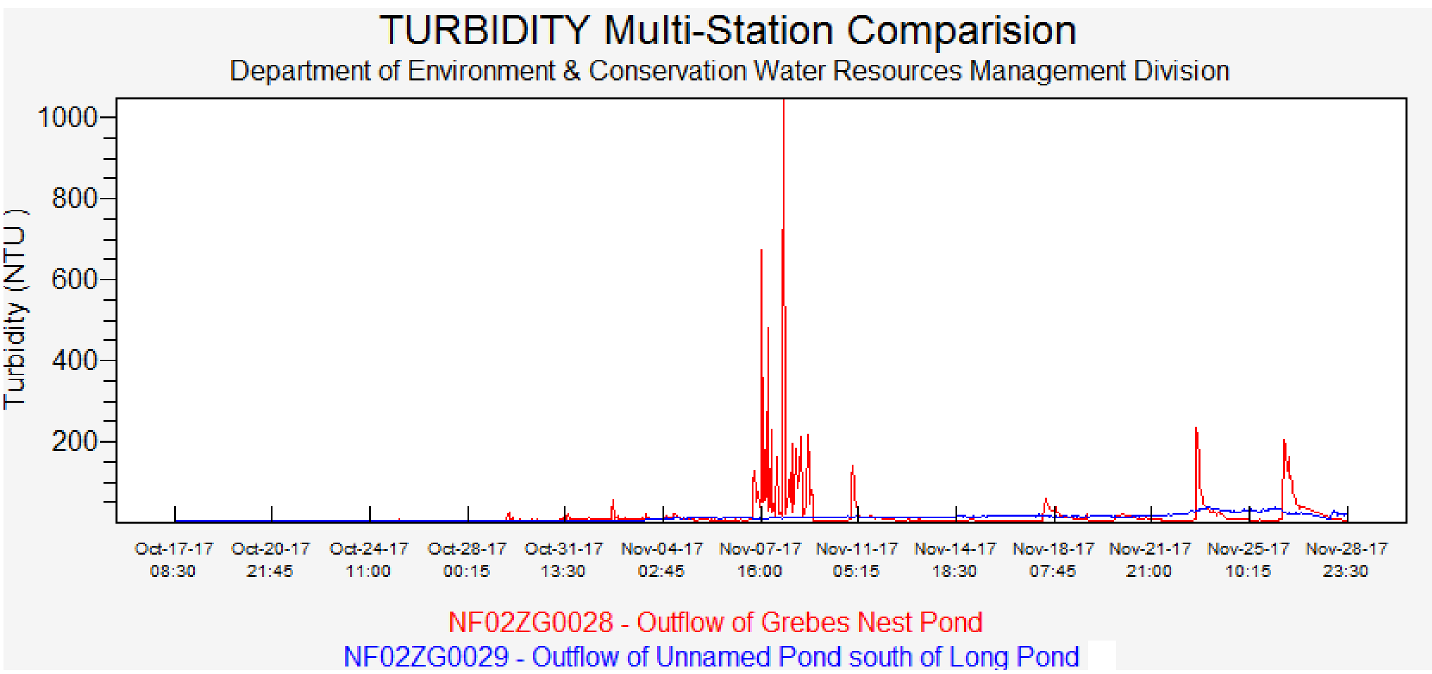
Comparison of Specific Conductivity at Canada Fluorspar Stations



Comparison of Dissolved Oxygen (mg/L) at Canada Fluorspar Stations



Comparison of Dissolved Oxygen (%Sat) at Canada Fluorspar Stations



Comparison of Turbidity at Canada Fluorspar Stations

*please note that these graphs contain data that was removed for the report due to inaccuracies.