Real-Time Water Quality Report

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

Deployment Period
September 6, 2017 to October 16, 2017

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

Prepared by:

Tara Clinton
Environmental Scientist
Water Resources Management Division
Department of Municipal Affairs & Environment
4th Floor, Confederation Building, West Block
PO Box 8700, St. John's NL A1B 4J6
Ph. No.: (709) 729 - 5925
Fax No.: (709) 729 - 0320
taraclinton@gov.nl.ca

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.

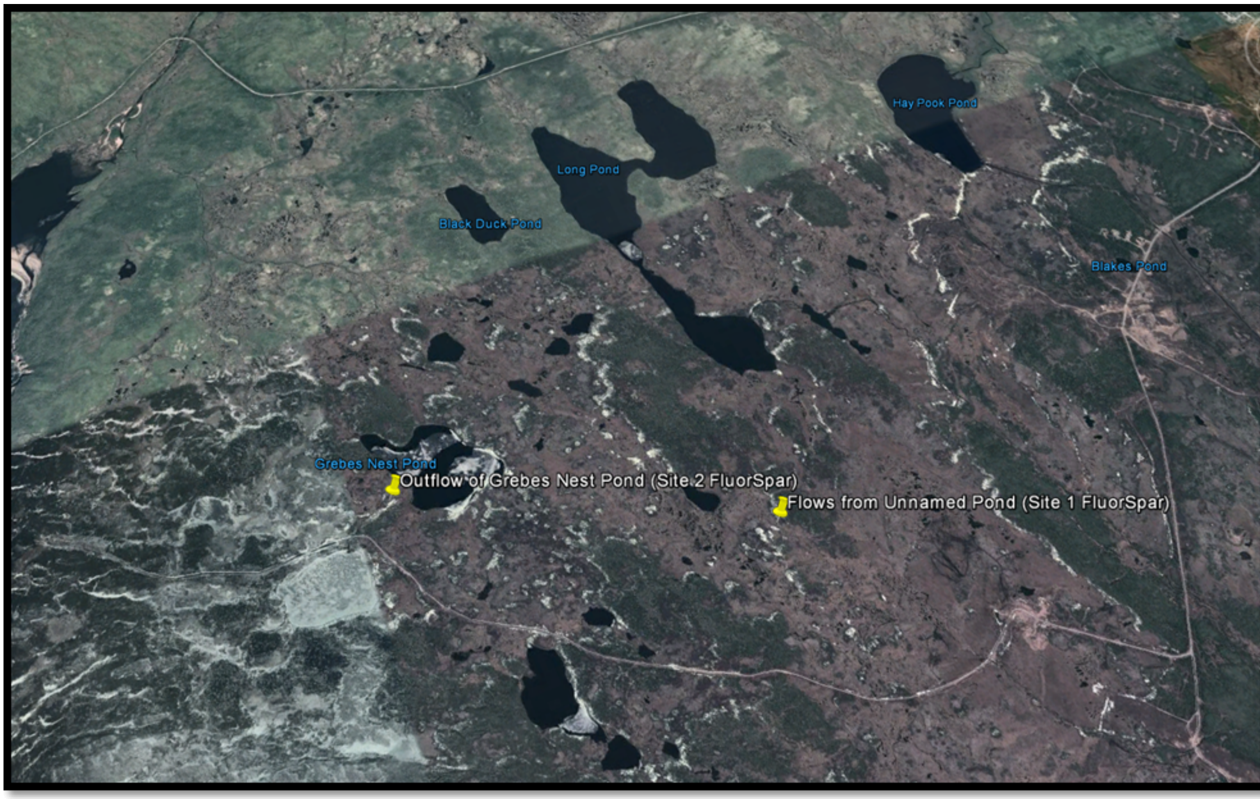


Figure 1: Real-Time Water Quality and Quantity Stations at Canada Fluorspar Inc

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	Sept 6	Deployment	Fair	Excellent	Good	Excellent	Good
	Oct 16	Removal	Fair	Excellent	Good	Excellent	Good
Unnamed Pond	Sept 6	Deployment	Excellent	Excellent	Fair	Excellent	Fair
	Oct 16	Removal	Excellent	Excellent	Good	Good	Good

At deployment of the field instrument at Outflow of Grebes Nest Pond site, the water temperature, data ranked as 'Fair'. pH, specific conductivity, dissolved oxygen and turbidity data ranked as 'Good' and 'Excellent' against the QA values that were recorded. Water Temperature ranking was likely a result of the instrument not being left in the brook long enough before the reading was taken. These instruments need time to acclimatize to the temperature of the water to ensure accurate data.

During removal of the instrument the ranking for water temperature 'Fair' against the QA data. It is likely now, that the 'Fair' ranking was a result of an issue with the QA sonde water temperature probe (Table 2). All other parameters ranked within acceptable range for the end of the deployment.

At deployment of the field instrument at Outflow of Unnamed Pond south of Long Pond the data ranked as the following; water temperature, pH and dissolved oxygen ranked as 'Excellent' during deployment. Specific conductivity and turbidity data ranked as 'Fair'. At deployment it was noted that the brook was turbid. The turbidity and conductivity readings for the field sonde are more representative of the brook for initial deployment. The QAQC sonde readings for conductivity and turbidity were lower than that of the field sonde, indicating that it may have needed more time to adjust, hence when ranked; the values were noted as 'Fair'.

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' for the ranking categories.

Concerns or Issues during the Deployment Period

Canada Fluorspar is pumping water from John Fitzpatrick pond back to an area upstream of the pond to maintain flow in the stream where the RTWQ station is located. Water is being pumped from John Fitzpatrick as the pond that initially supplied the brook is dewatered. This is recycled water and there may be events on the graph that is not representative of a natural brook environment.

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 5.14°C to 19.35°C during the deployment period (Figure 4). The water temperature at the station displayed diurnal variations representative of water temperature. The water temperatures were consistent, with slight decreases during high stage events, for example on September 26th and September 27th 2017. High stage events are generally a result of precipitation events and water temperature responds during these events by decreasing for a short period of time, this is a normal occurrence.

Over the course of the deployment the water temperatures were decreasing, this would be expected as the air temperatures are lower with winter approaching.

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.

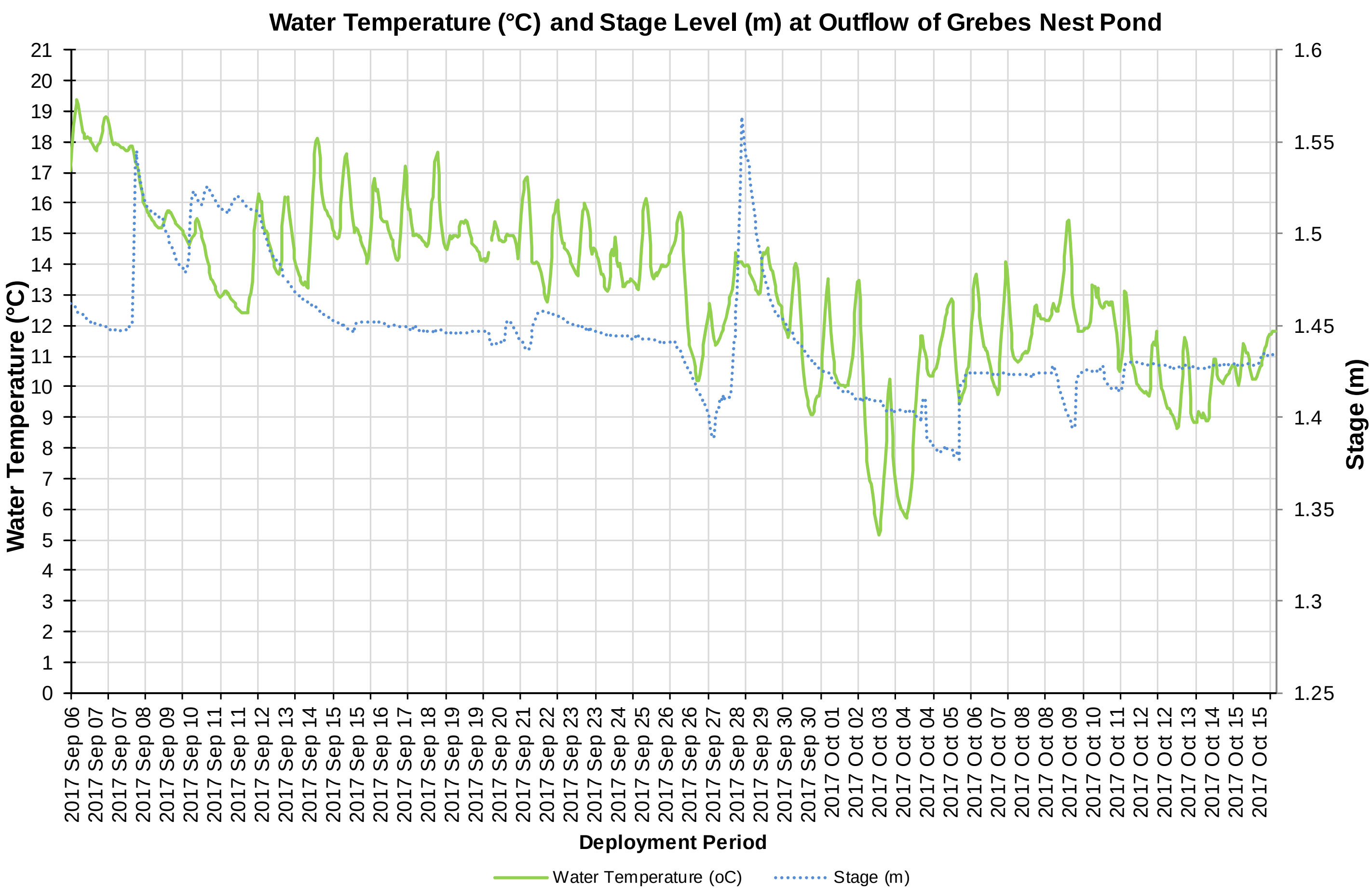


Figure 4: Water temperature (°C) values at Outflow of Grebes Nest Pond

pH

Throughout the deployment period, pH values ranged between 5.54 pH units and 6.34 pH units (Figure 5) and were reasonably consistent. The pH data remained 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.

Normally pH data dips during high stage events, as displayed on September 8th -9th and 27th - 28th 2017. There was missing data for precipitation on September 27th and 28th, 2017; however the stage data indicated that there may have been some rainfall during that time. Natural processes such as rainfall and snow melt will alter the pH of a brook for a period of time.

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.

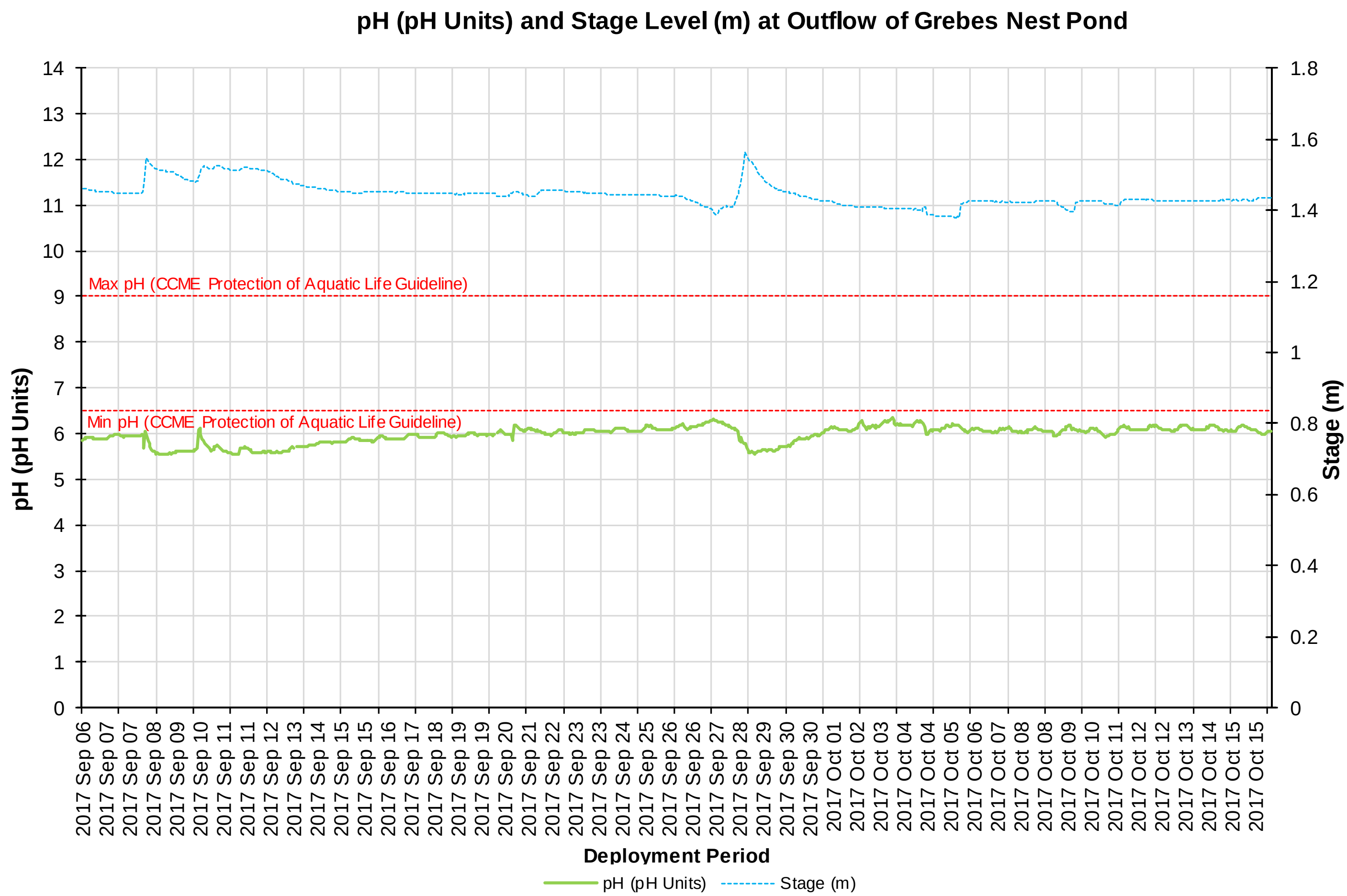


Figure 5: pH (pH units) and stage level (m) values

Specific Conductivity

The conductivity levels were within 42.9 µS/cm and 64.3 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 slightly. This is evident on Figure 6 in several places but most noticeably on September 27th and September 28th, 2017.

There was missing data for precipitation on September 27th and 28th, 2017; however the stage data indicates that there may have been some rainfall during that time. Rainfall can flush organic and inorganic matter into the brook, increasing the conductivity levels for a short period of time (Figure 9, Precipitation graph).

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.

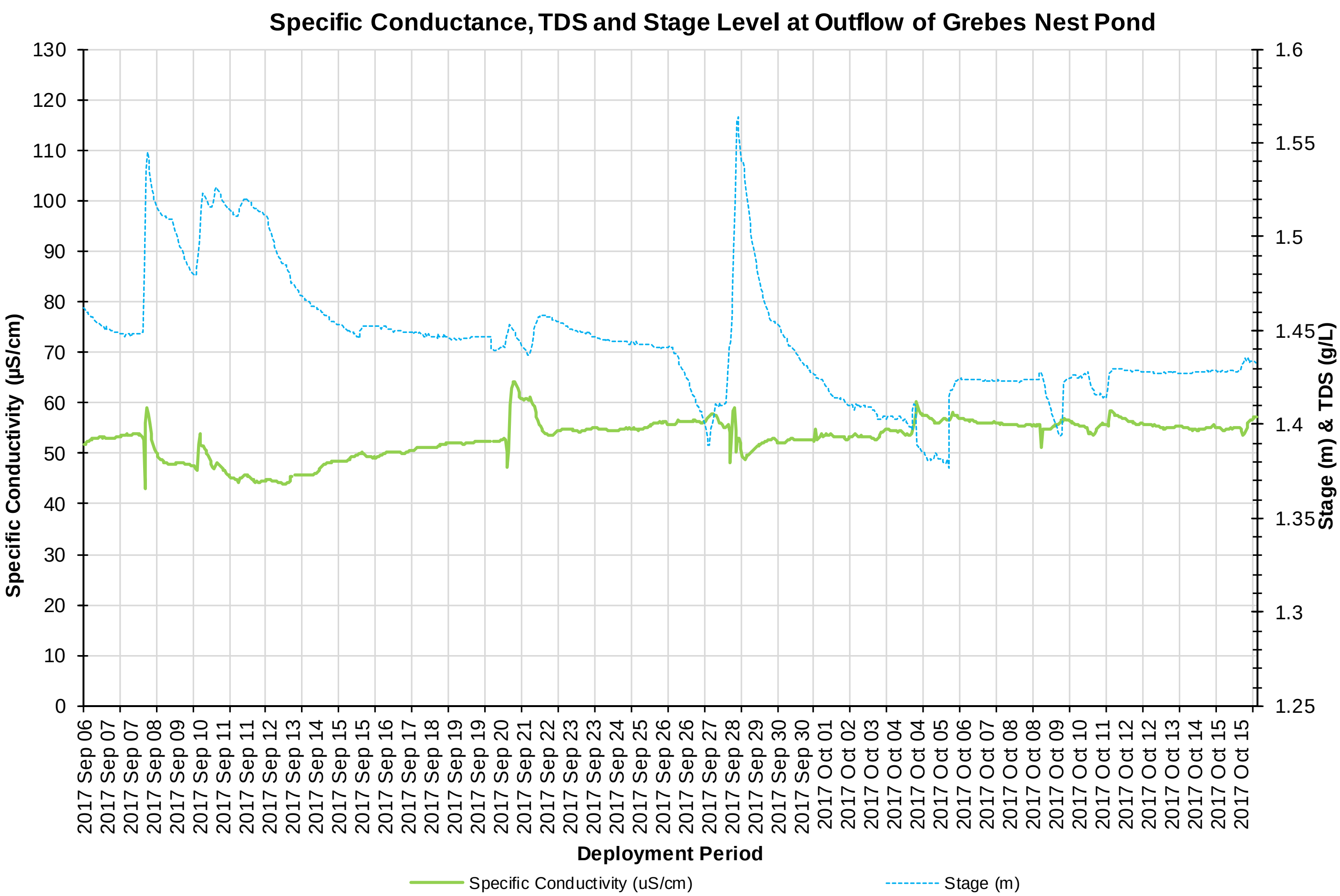


Figure 6: Specific conductivity (µS/cm) and stage (m) values

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 7.69 mg/L to a maximum of 12.30 mg/L. The percent saturation levels for dissolved oxygen ranged within 78.0% Saturation to 105.9% Saturation (Figure 7).

There was a change in the overall dissolved oxygen concentration on September 8th to September 12th, 2017; this change corresponded with an increase in stage. The precipitation graph (Figure 9) indicates rainfall during that time frame. This is a normal reaction in water bodies during the warmer season when there is a rainfall event.

The CCME guidelines noted on the graph provide national guidance. There are many occasions that waterbodies dissolved oxygen levels move within the guidelines noted below. Every brook is different with its own natural background range for dissolved oxygen.

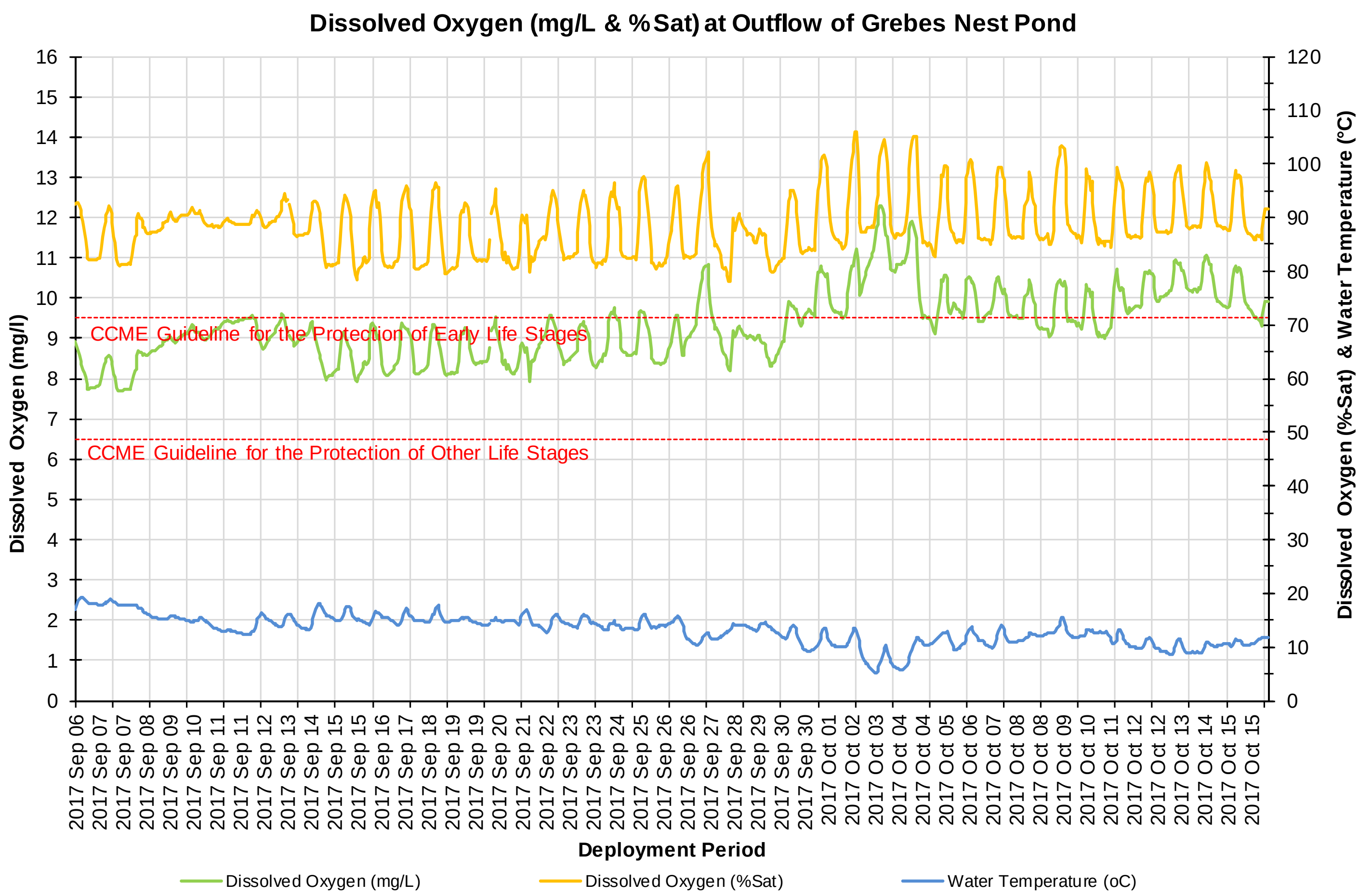


Figure 7: Dissolved Oxygen (mg/L & Percent Saturation) values and Water Temperature (°C)

Turbidity

Turbidity levels during the deployment ranged within 6.0 NTU and 922.6 NTU (Figure 8). The deployment data had a median of 9.0 NTU.

During rainfall or runoff, higher turbidity readings are expected. Generally the turbidity levels will increase for a short period of time and then return to the baseline of the brook. 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 the deployment the higher turbidity values correlate with precipitation events and subsequently increases in stage (Figure 9). There was one significant turbidity increase on September 20th – 21st, 2018, of 922.6 NTU; it is not common to record turbidity values of this level at this brook. Runoff from surrounding environments can increase the presence of suspended material in water. The high turbidity data did return to lower levels after a short period of time.

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.

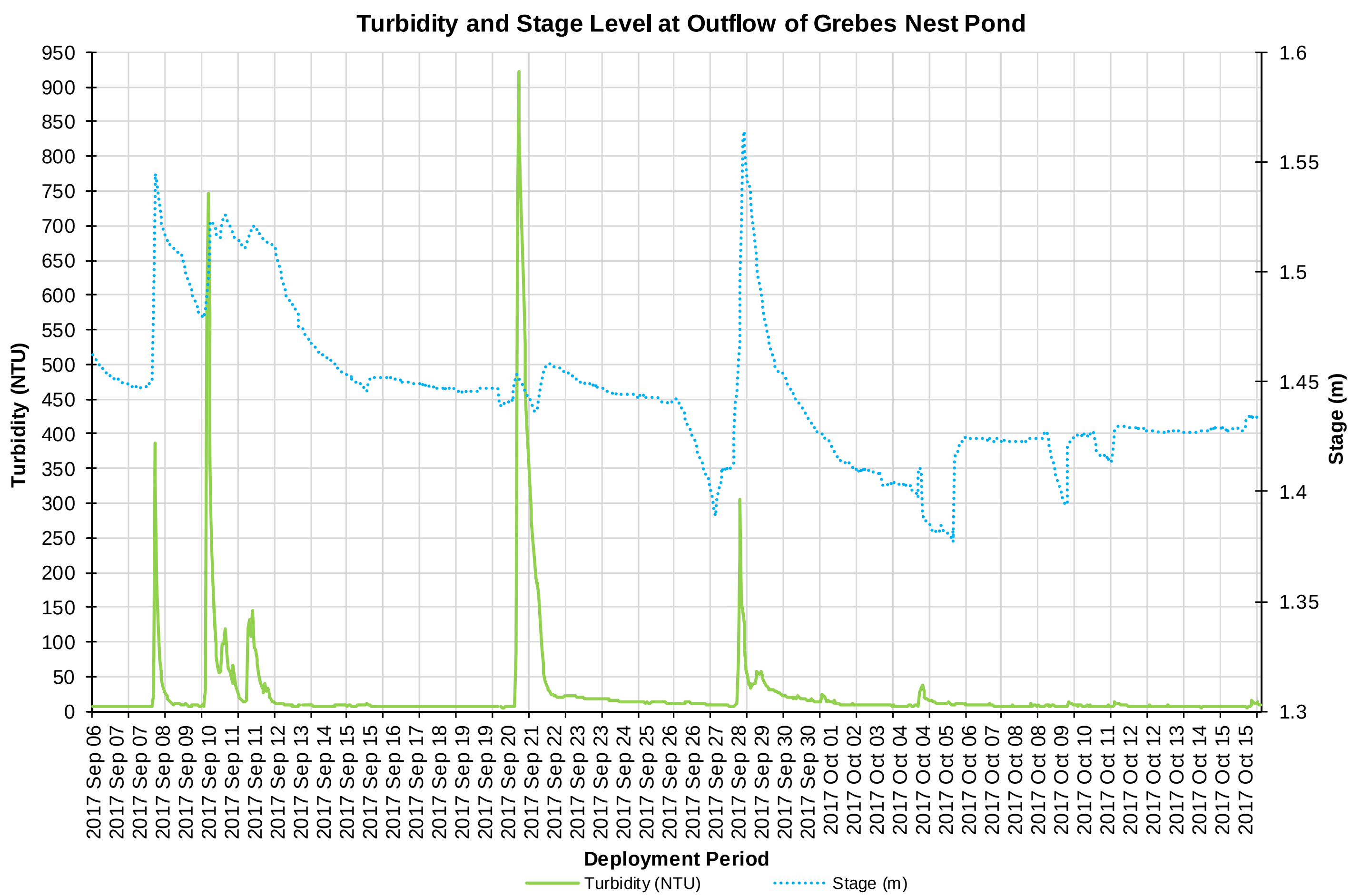


Figure 8: Turbidity (NTU) and stage level (m) values.

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 1.38m to 1.56m. 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 13.5 mm on September 8th, 2017. There is evidence of rainfall on September 27th and 28th; however the data is missing from the transmission.

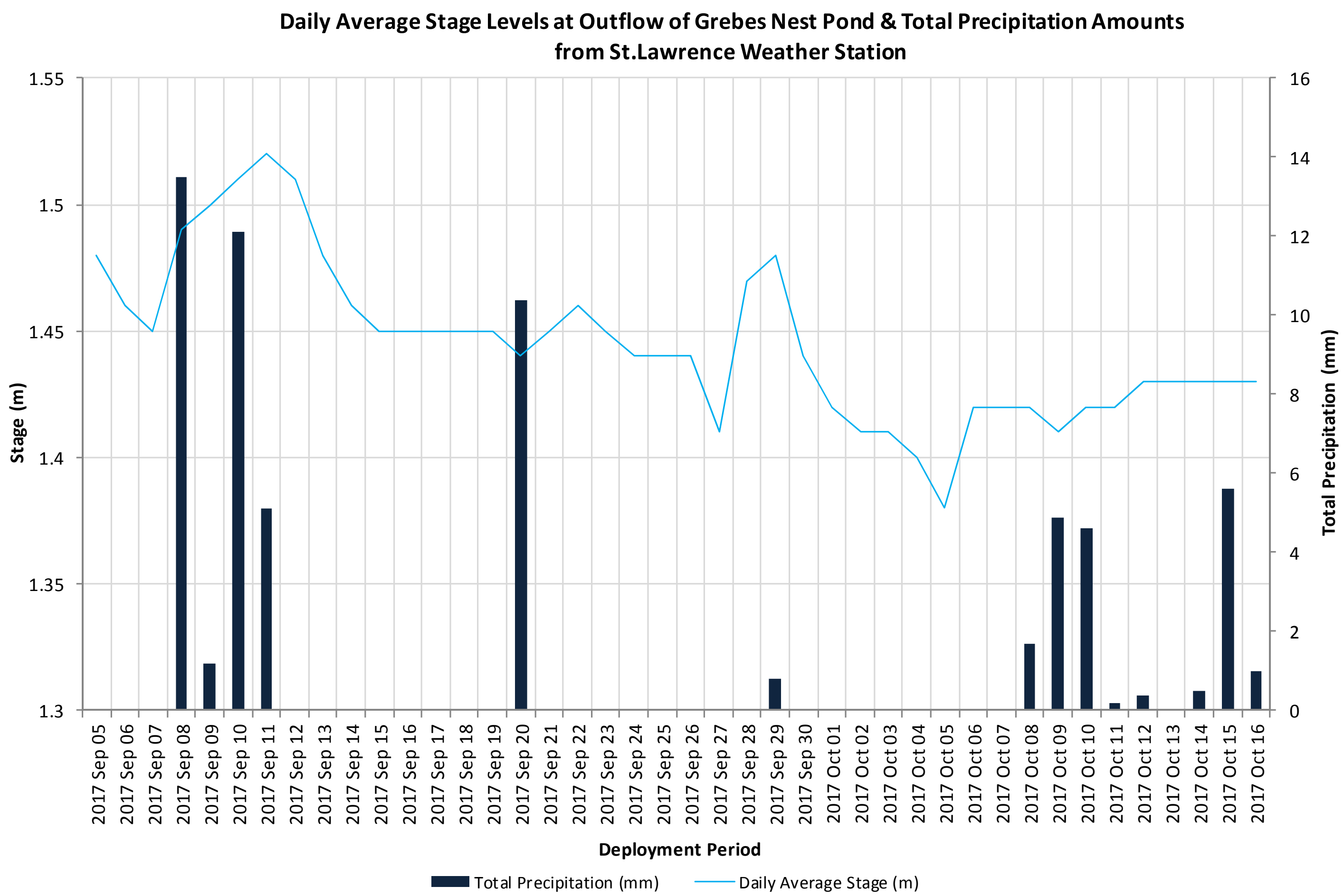


Figure 9: Daily average stage values and daily total precipitation.

Conclusion

Outflow of Grebes Nest Pond flows through an active mine site. At this phase of the project, the natural environment is constantly being disturbed by construction activities. Grebes Nest Pond had been dewatered for mining purposes and no longer exists. The brook is being flushed through with water from John Fitzpatrick pond that is located downstream from Outflow of Grebes Nest brook Station. The Grebes Nest brook flows into John Fitzpatrick 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 higher stage events on September 8th to September 14th and September 28th to September 29th, 2017 did influence changes in the water quality parameters.

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 42.9 – 64.3 µS/cm. The air and water temperatures decrease as fall approaches while the dissolved oxygen levels will increase. This is a natural response and is expected during these changing seasons. Turbidity values displayed higher levels during the high stage events with one significant event on September 20th – 21st, 2018 of 922.6 NTU, however the turbidity did return to previous levels after a period of time.

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 ranged from 5.60°C to 22.16°C during the deployment period (Figure 10). The deployment period displayed diurnal patterns, as well as a slight decrease of the water temperature toward the end of the deployment. During the higher stage events there were several large dips in the water temperature. The stage level spikes were likely a result of rainfall (Figure 15) and rainfall can lower the temperature of the water for a period of time.

Outflow of Unnamed Pond is a shallow brook and is more likely to be influenced by air temperature changes and climatic changes. The natural diurnal variation of the water temperature is evident as the peaks and valleys of the water temperature indicate warmer daytime temperatures and cooler nighttime temperatures. On October 3rd and 4th and October 11th to 14th, the water temperatures point toward cooler temperatures as the winter season approaches.

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.

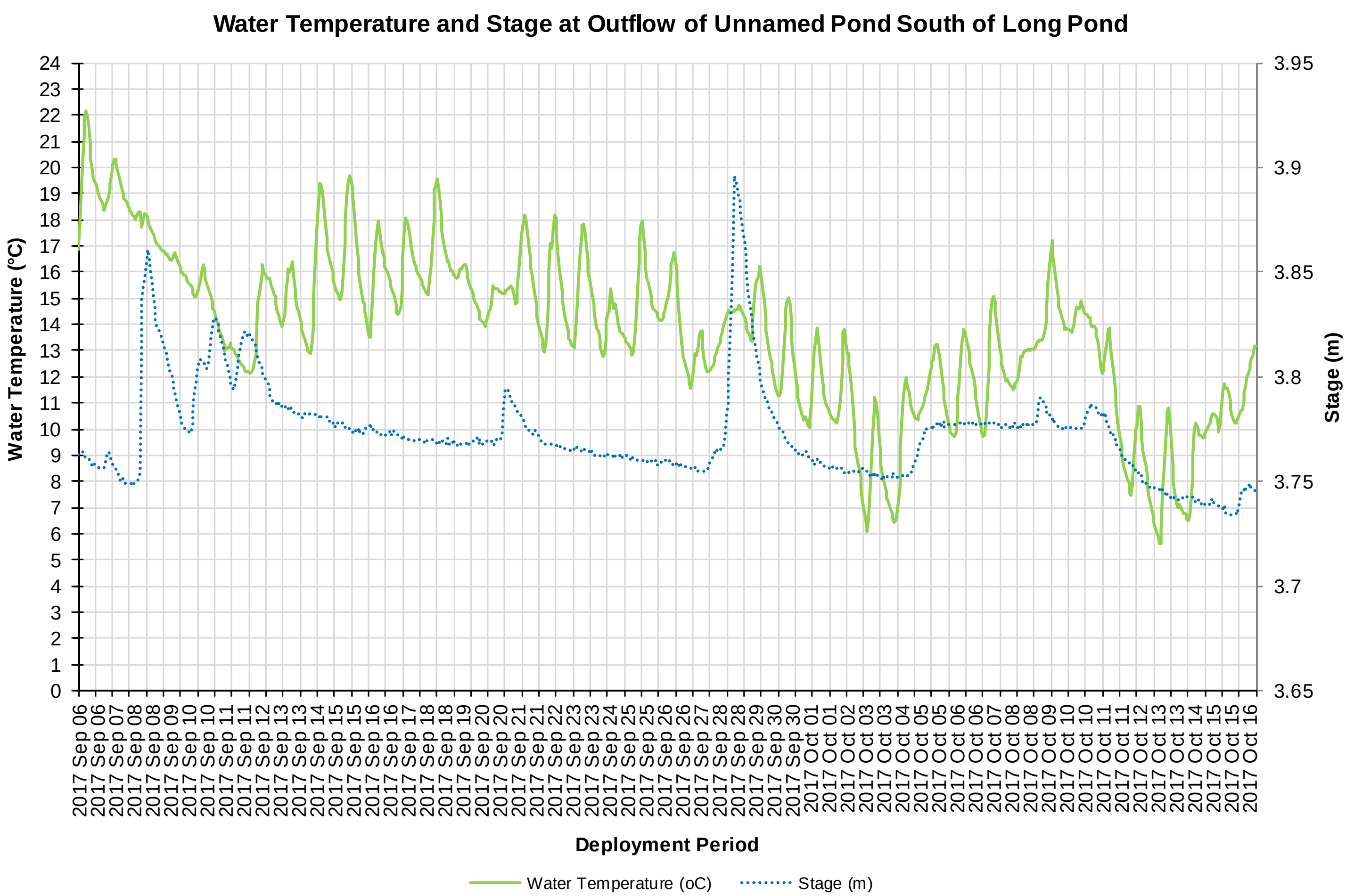


Figure 10: Water temperature (°C) values at Outflow of Unnamed Pond south of Long Pond

pH

Throughout the deployment period, pH values ranged between 6.96 pH units and 7.73 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.

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 before returning to background levels. This is a natural process and can be seen on the graph below on September 8th and September 28th, 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.

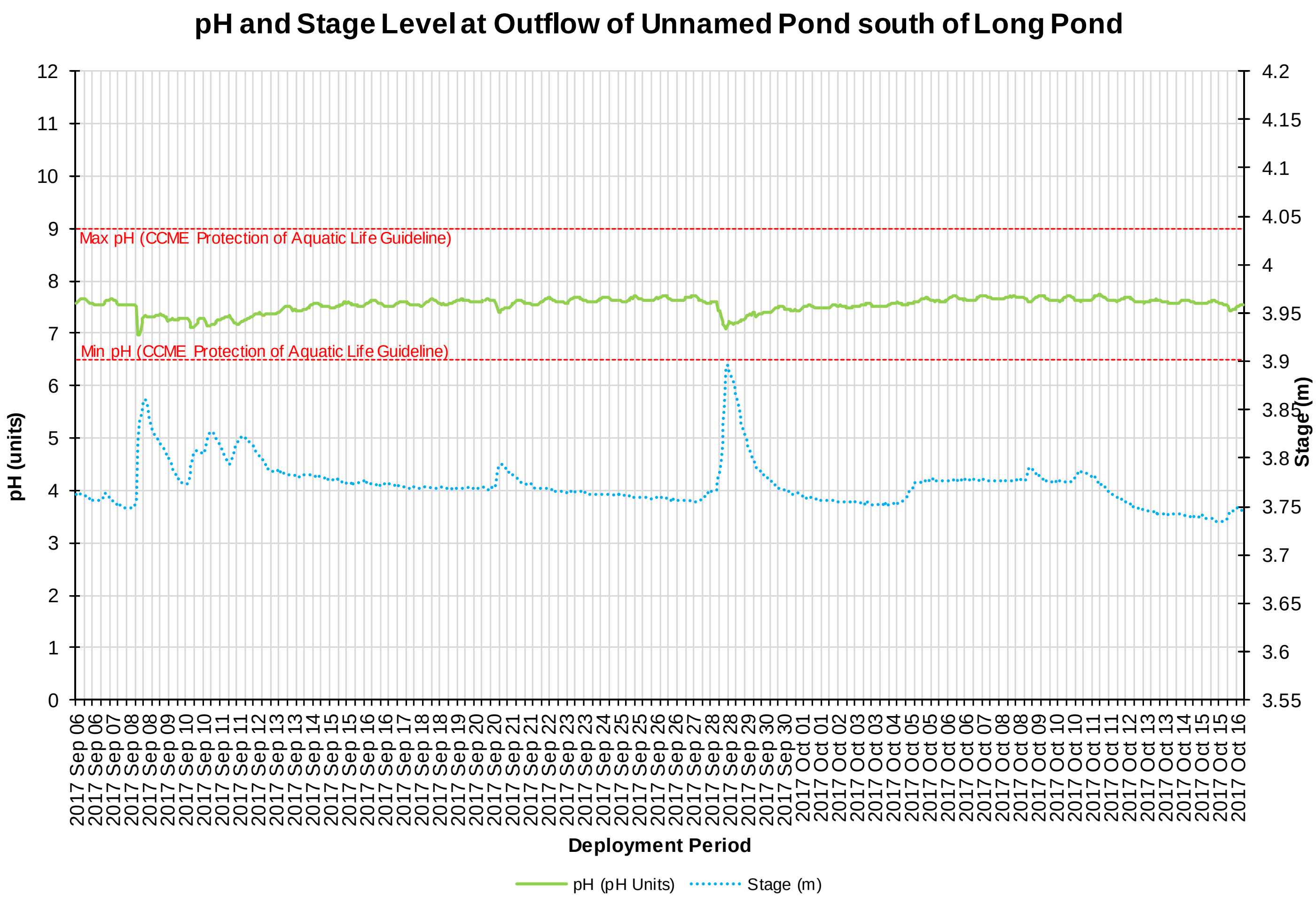


Figure 11: pH (pH units) and stage level (m) values

Specific Conductivity

The conductivity levels were between 104.8 µS/cm and 219.8 µS/cm during this deployment period (Figure 12). Specific conductivity measures how well water can conduct an electrical current. Specific conductivity has increased slightly since the previous deployment.

There are several conductivity dips on September 8th, September 20th and September 28th, 2017 when stage level increases for a short period of time (Figure 12). Stage level was likely influenced by rainfall (Figure 15). There is a general relationship between conductivity and stage, whereby the interaction between the two water quality parameters is inversed. For example, 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).

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.

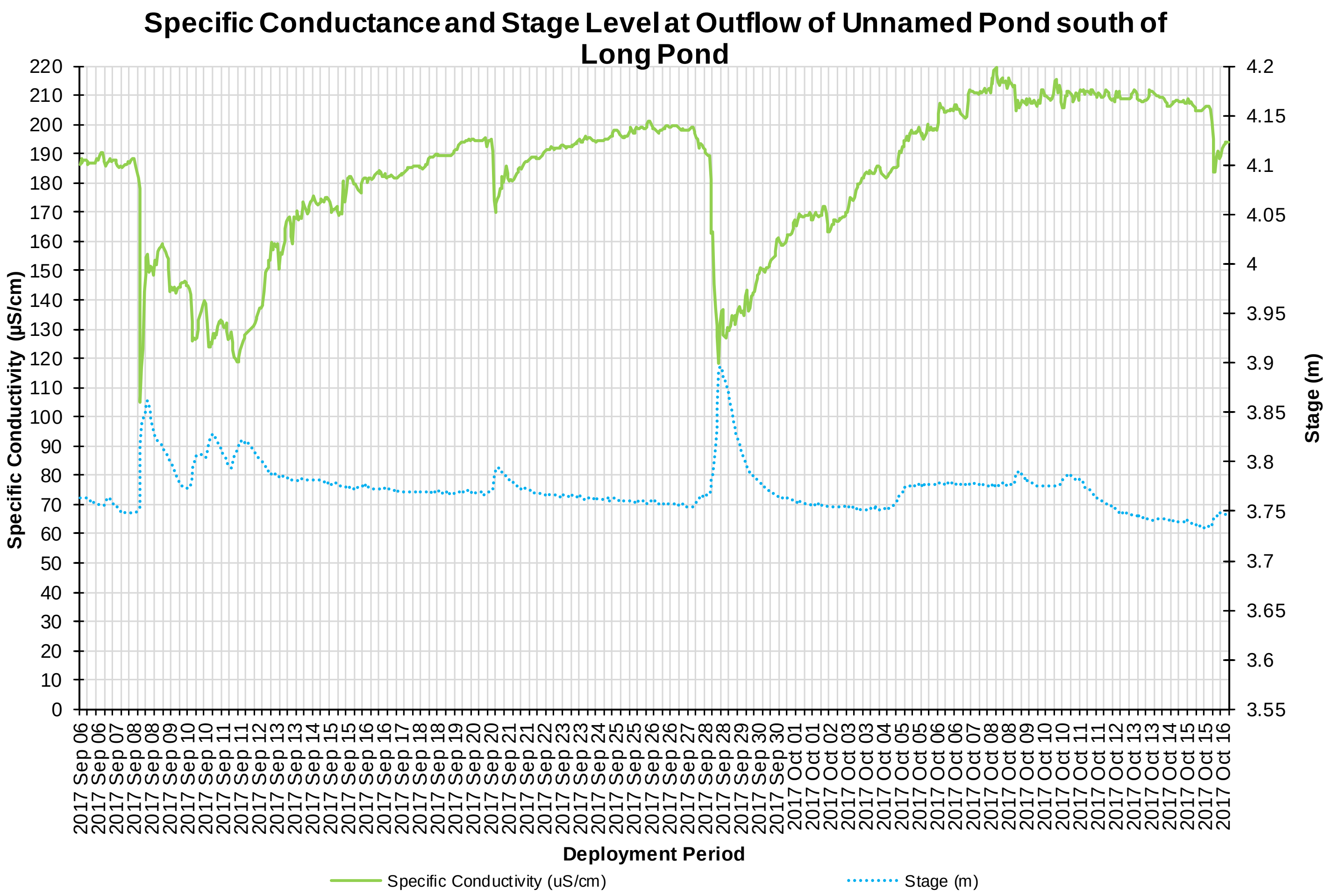


Figure 12: Specific conductivity (µS/cm), and stage (m) values

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 8.91 mg/L to a maximum of 12.57 mg/L. The percent saturation levels for dissolved oxygen ranged within 95.4% Saturation to 103.5% 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. 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.

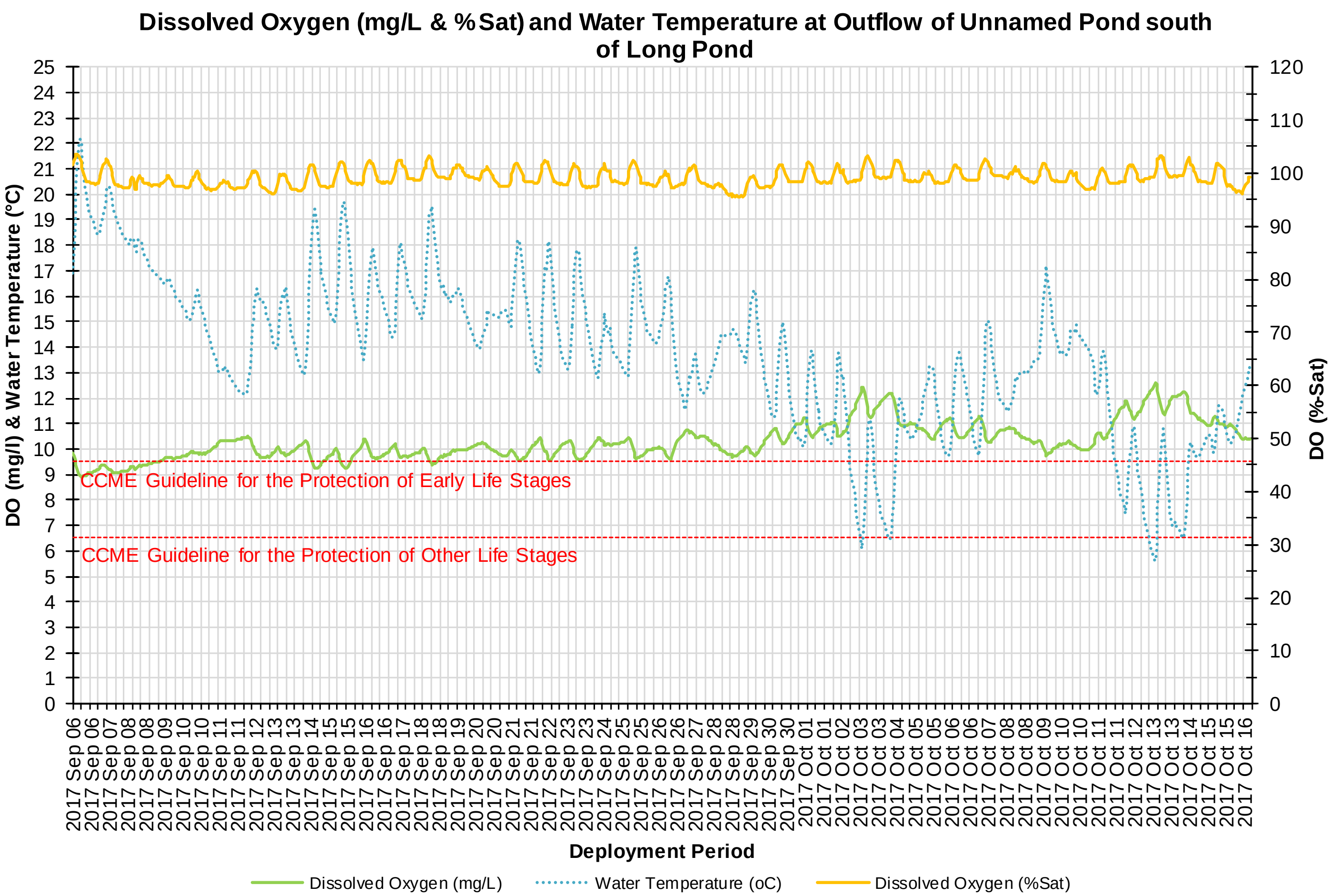


Figure 13: Dissolved Oxygen (mg/L & Percent Saturation) values.

Turbidity

Turbidity levels during the deployment ranged within 4.2 NTU and 29.1 NTU (Figure 14). The deployment data had a median of 9.1 NTU. The median is slightly higher than the previous deployment median of 5.8 NTU.

At this station the large turbidity events correlate with increases in stage level. The stage levels occurred during the precipitation events that were recorded in St. Lawrence. Rainfall and subsequent runoff can increase the presence of suspended material in water. The highest turbidity event during this deployment was on September 9th, the turbidity increase coincides with changes in other parameters for the same timeframe.

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.

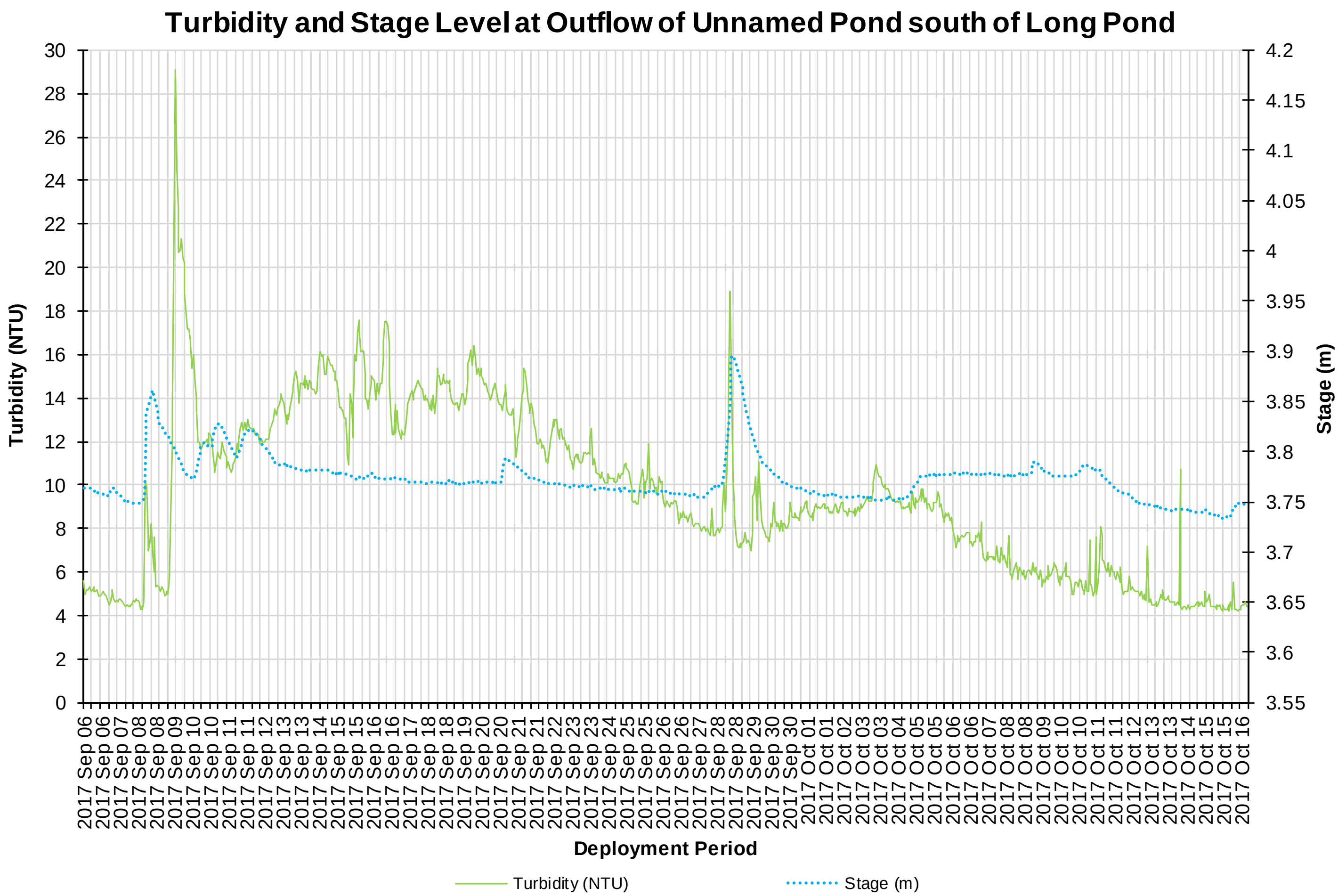


Figure 14: Turbidity (NTU) and stage level (m) values.

Stage and 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 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 3.73m to 3.90m. The larger peaks in stage do 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 13.5 mm on September 8th, 2017. There is evidence of rainfall on September 27th and 28th; however the data is missing from the transmission.

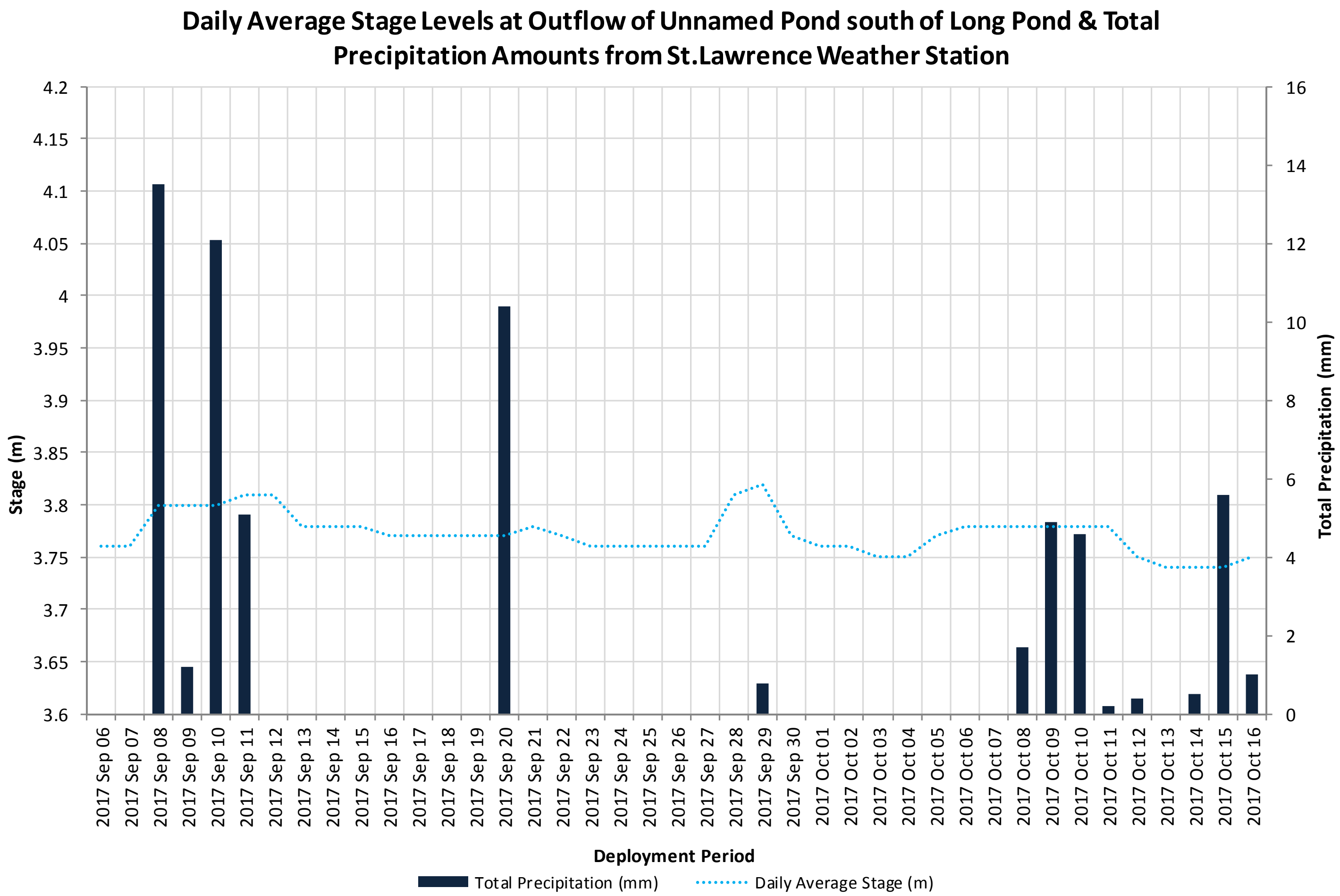


Figure 15: Daily average stage values and daily total precipitation.

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. This type of activity will influence 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. Overall there was a slight increase in the specific conductivity data over the deployment. The significant decreases in specific conductivity were during high stage events.

There is an indication from the turbidity data that was collected, that there was a slightly higher median of 9.1 NTU for this deployment than the previous deployment. This can be contributed to by increased rainfall events and subsequent runoff from the surrounding environment.

Precipitation brings changes to water quality conditions although most of the changes are natural occurrences, precipitation can also influence runoff from surrounding construction areas to flush 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

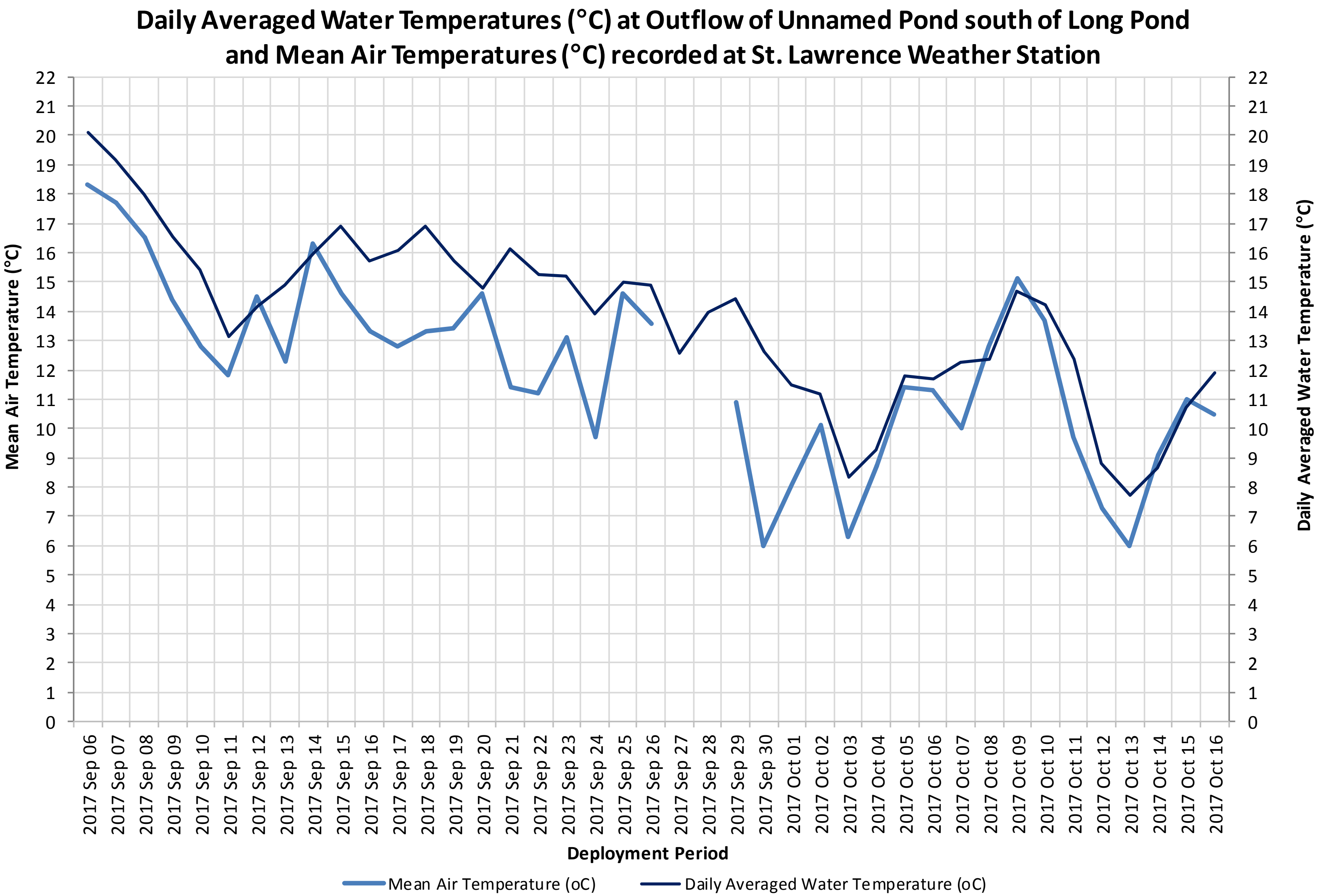


Figure A1: Water Temperatures at Outflow of Unnamed Pond south of Long Pond and Mean Air Temperatures recorded at St. Lawrence Weather Station

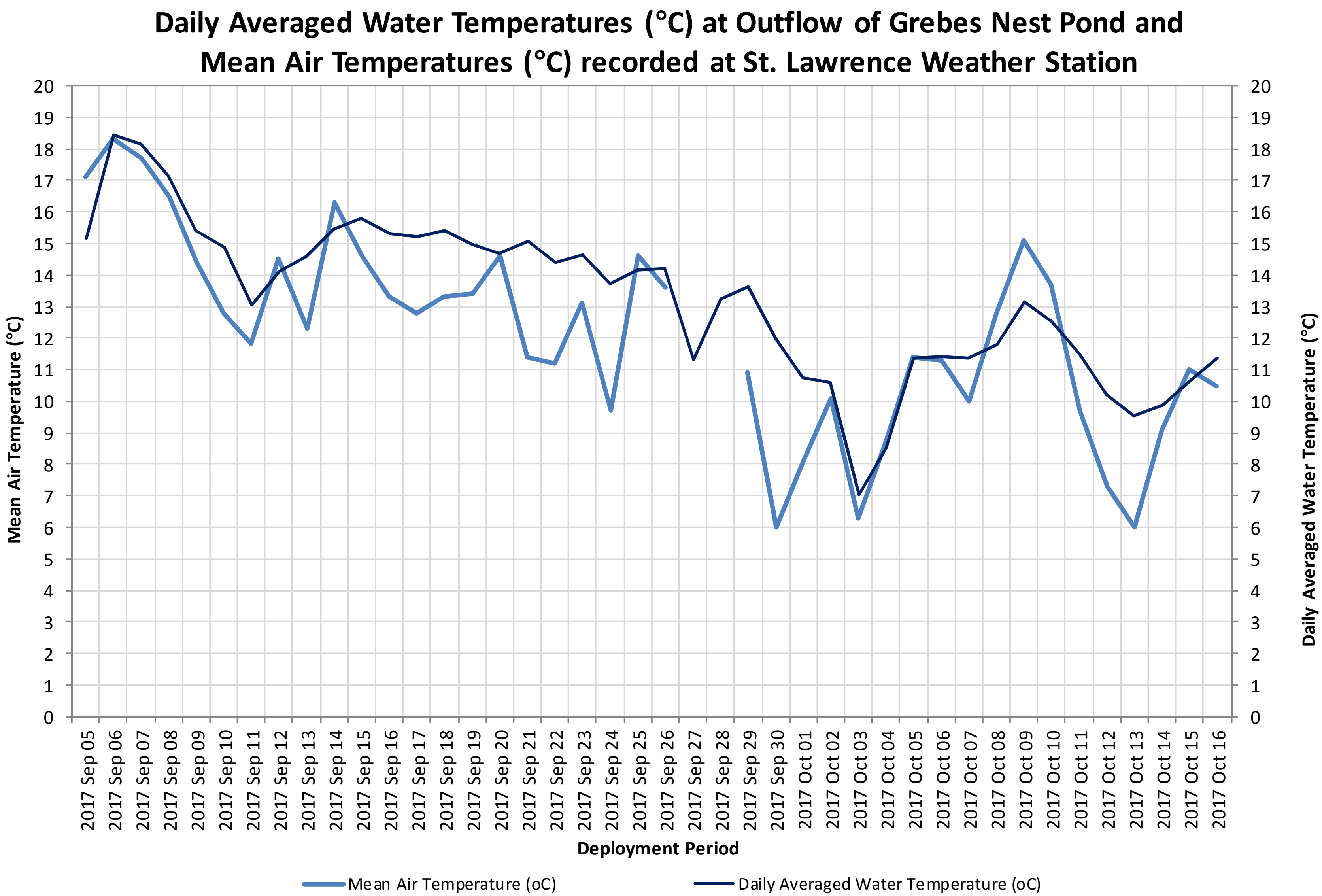
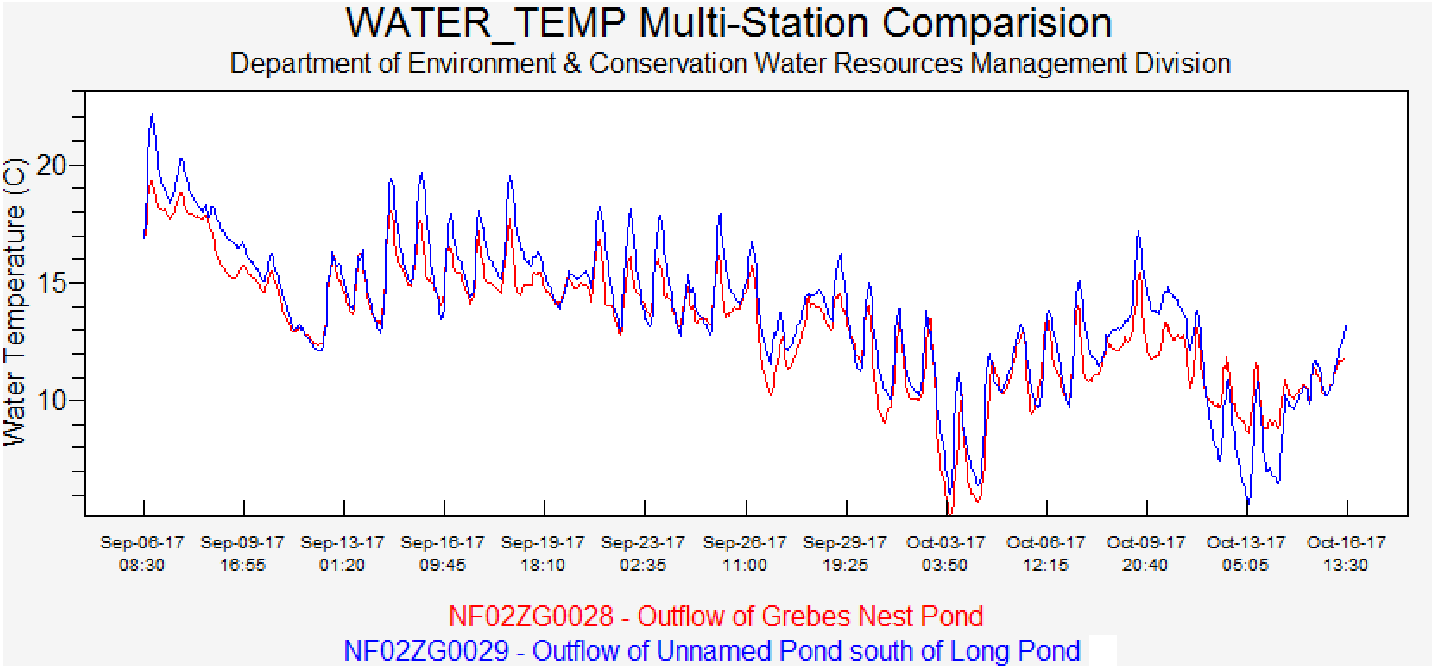


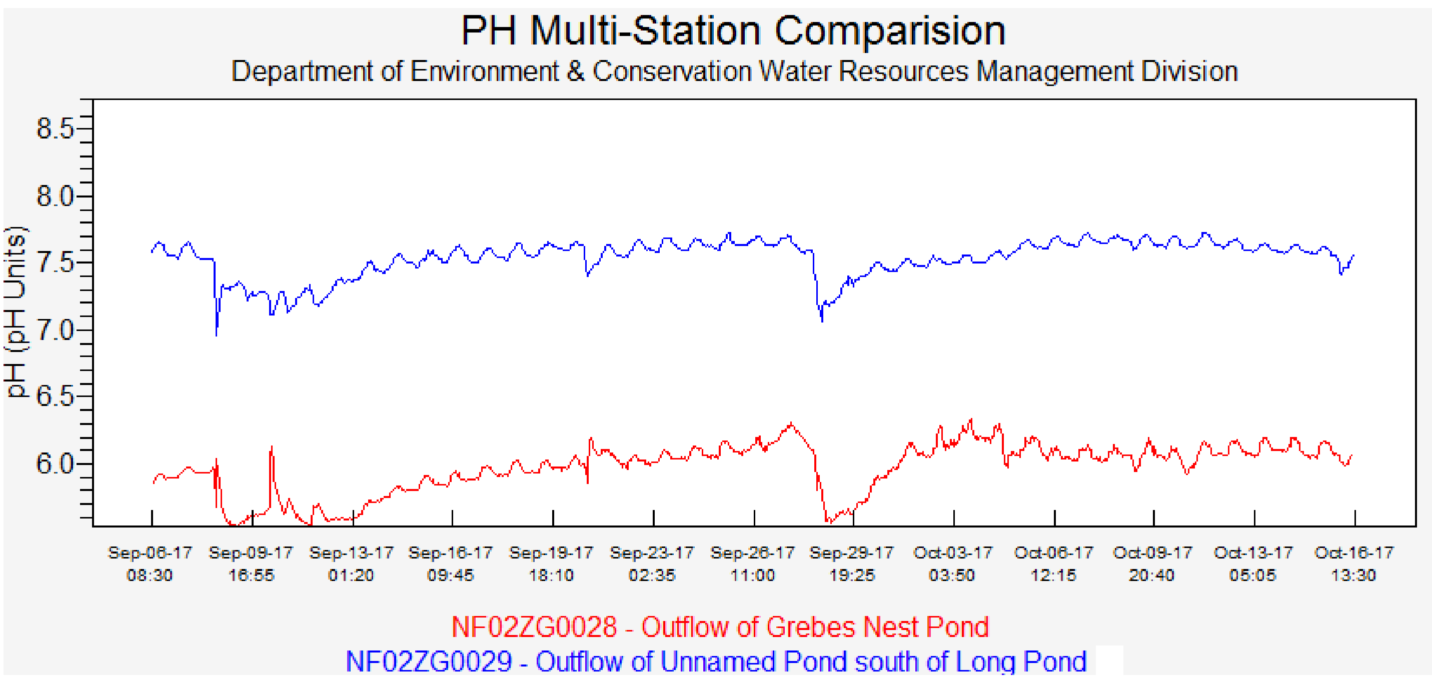
Figure A2: Water Temperatures at Outflow of Grebes Nest Pond and Mean Air Temperatures recorded at St. Lawrence Weather Station

APPENDIX B

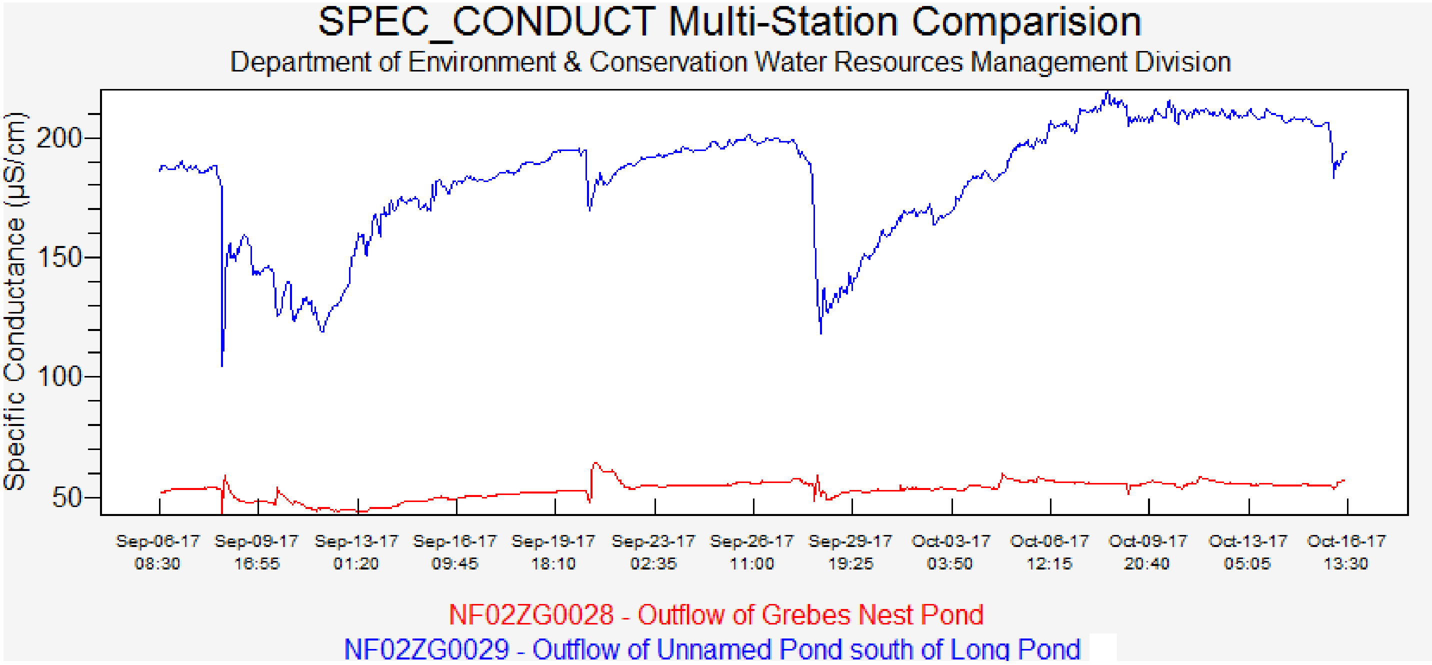
COMPARISON GRAPHS OF REALTIME STATIONS AT CANADA FLUORSPAR



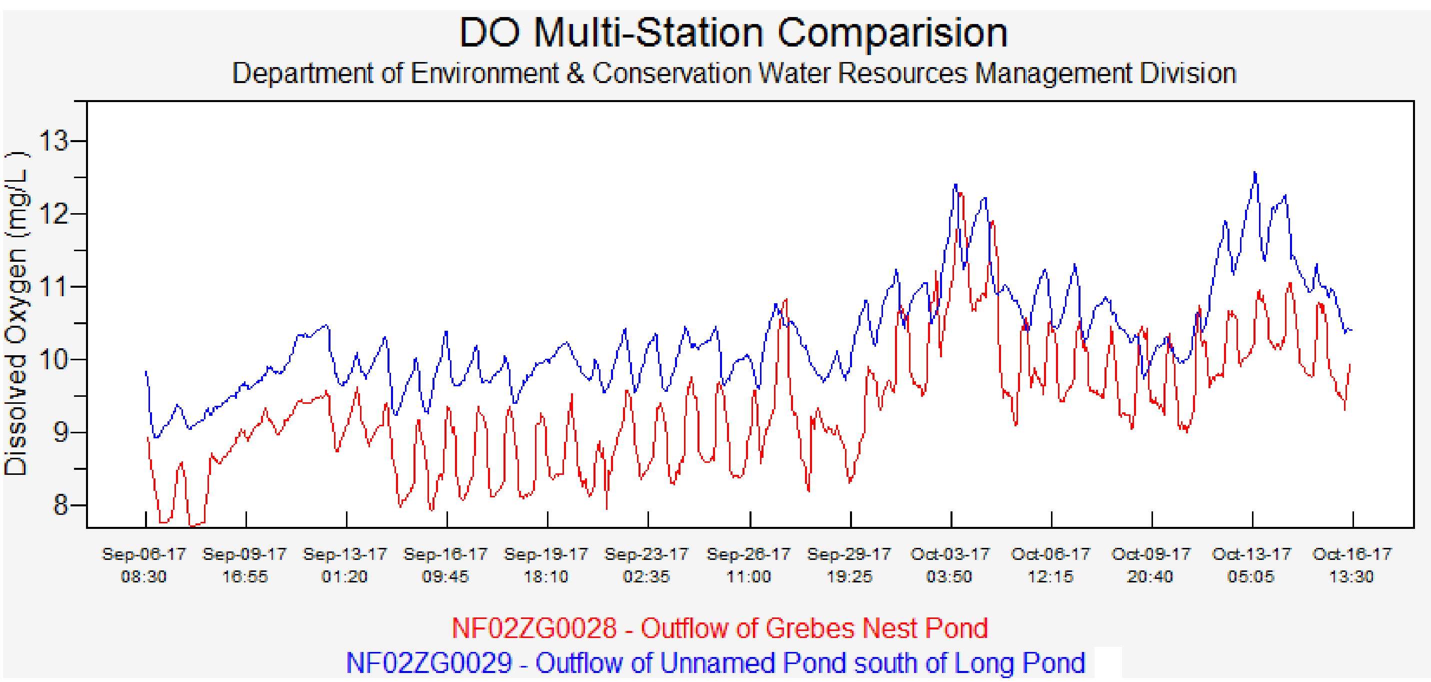
Comparison Graph of Water Temperature for Canada Fluorspar real-time stations



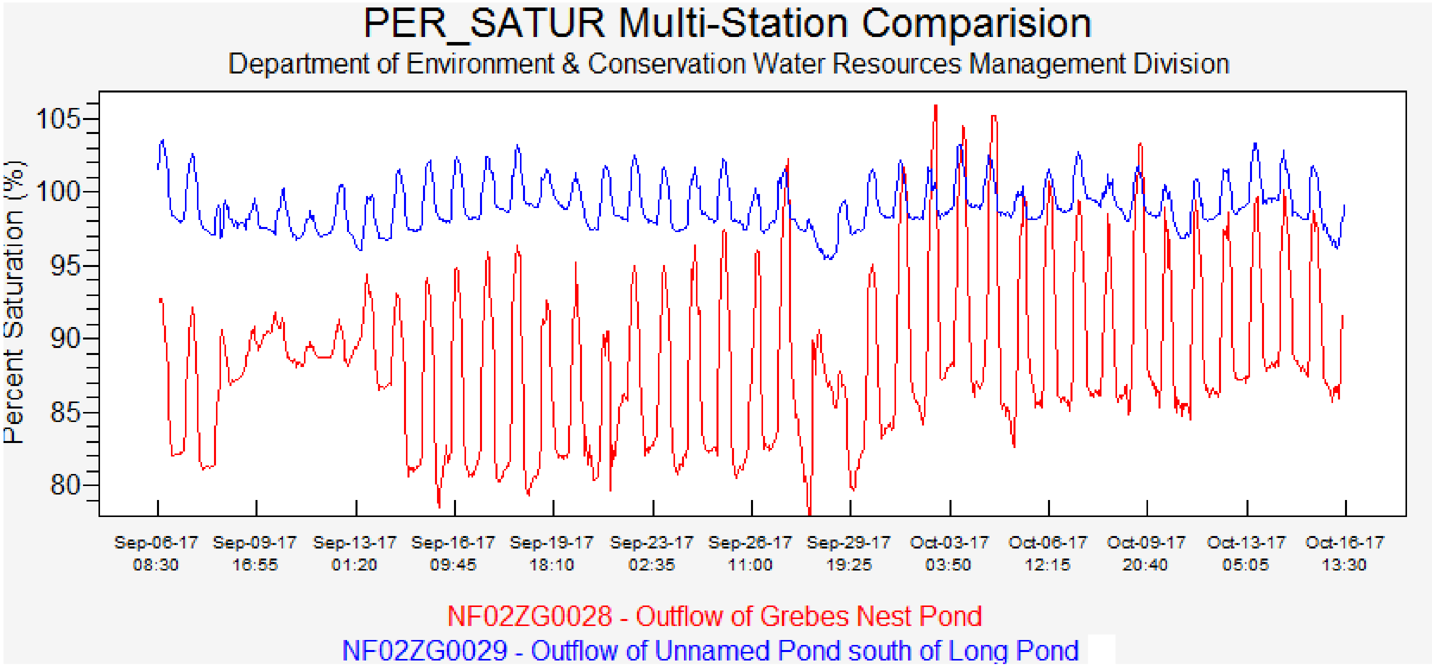
Comparison Graph of pH for Canada Fluorspar real-time stations



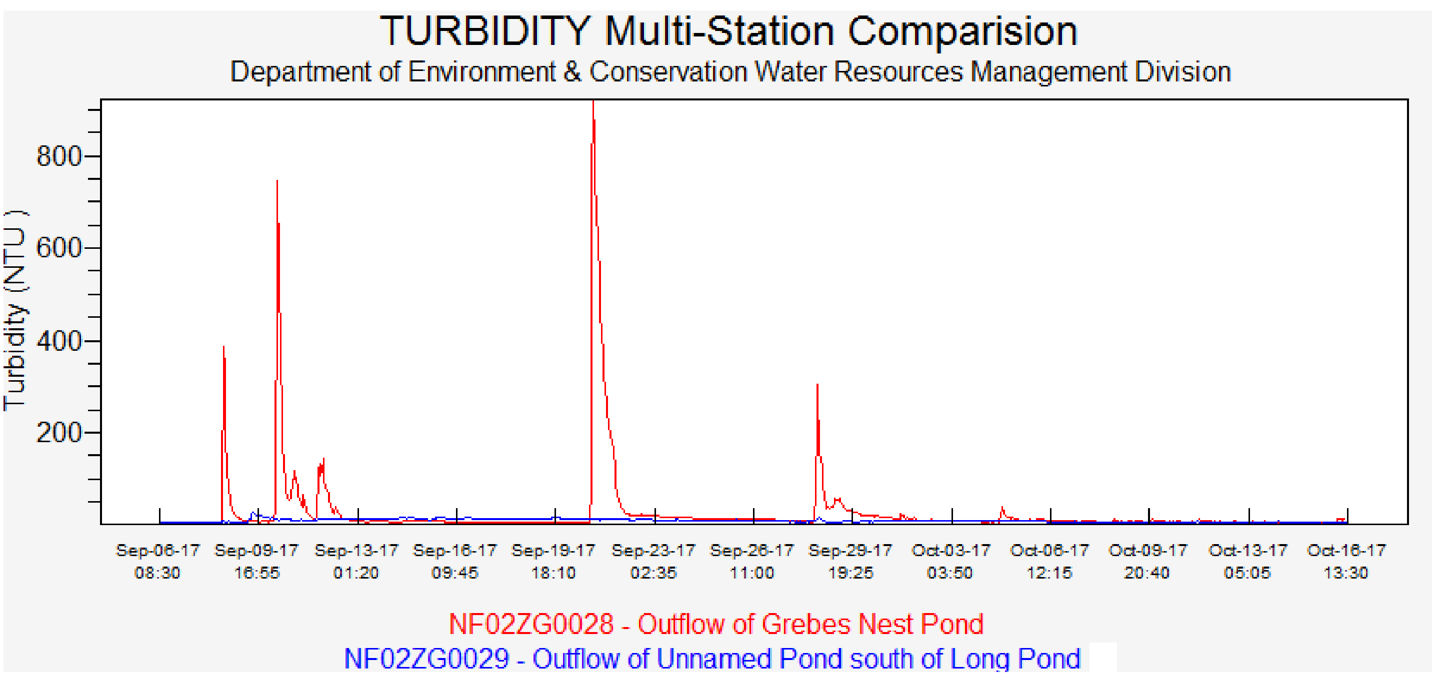
Comparison Graph of Specific Conductivity for Canada Fluorspar real-time stations



Comparison Graph of Dissolved Oxygen (mg/L) for Canada Fluorspar real-time stations



Comparison Graph of Dissolved Oxygen (%Sat) for Canada Fluorspar real-time stations



Comparison Graph of Turbidity for Canada Fluorspar real-time stations