Real-Time Water Quality Report

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

Deployment Period
June 21, 2017 to July 24, 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.

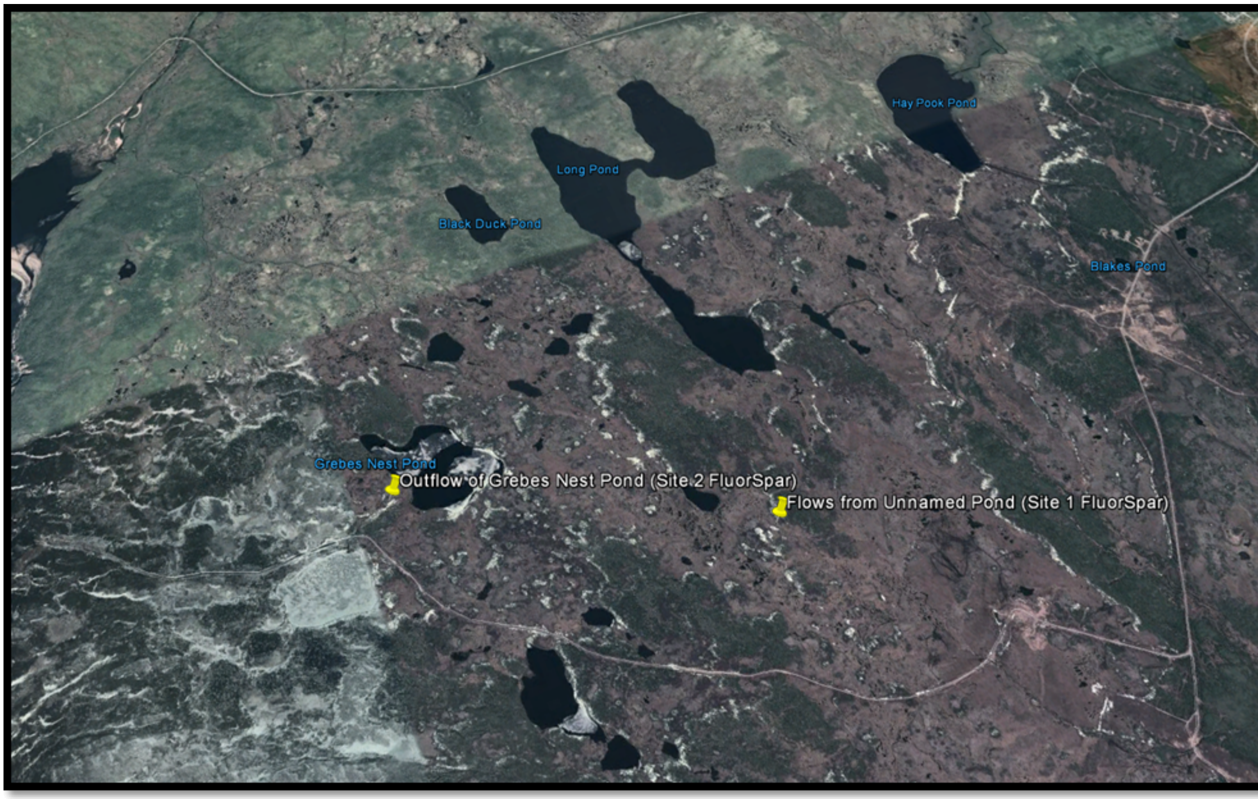

Figure 1: Real-Time Water Quality and Quantity Stations at Canada Fluorspar Inc

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	June 21	Deployment	Excellent	Excellent	Excellent	Good	Fair
	July 24	Removal	Poor	Excellent	Excellent	Good	Good
Unnamed Pond	June 21	Deployment	Excellent	Excellent	Excellent	Excellent	Excellent
	July 24	Removal	Fair	Excellent	Excellent	Excellent	Poor

At deployment of the field instrument, at Outflow of Grebes Nest Pond site, the ranking of the field data against the QAQC data were acceptable for the initial deployment of the field instrument at this station. During removal of the instrument the ranking water temperature was 'Poor'. This ranking may have occurred if the water temperature reading was taken before the data had stabilized. The rankings for the other water quality parameters were acceptable for removal (Table 2).

At deployment of the field instrument at Outflow of Unnamed Pond south of Long Pond the data ranked as 'Excellent' for all parameters. During the removal of the instrument, the water temperature data ranked as 'Fair', pH, specific conductivity and dissolved oxygen ranked as 'Excellent' with turbidity ranking as 'Poor'. The 'Poor' ranking for turbidity could have been a result of the heavy silt that was coating the bottom of the brook at the time. There is a possibility that the turbidity sensor had been compromised by the silt during the deployment.

Concerns or Issues during the Deployment Period

Canada Fluorspar is continuing to pump water from the small pond that is upstream from the original Grebes Nest Pond. Grebes Nest Pond has been dewatered for mining purposes and no longer exists.

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 8.50°C to 19.93°C during the deployment period (Figure 4). The water temperature at this station displayed diurnal variations that are common of water temperature.

During high stage events throughout deployment the water temperature responds by dipping slightly during that timeframe, this is a normal occurrence. Toward the end of the deployment the water temperatures are starting to increase, this mirrors the air temperatures at this time as well (Appendix A).

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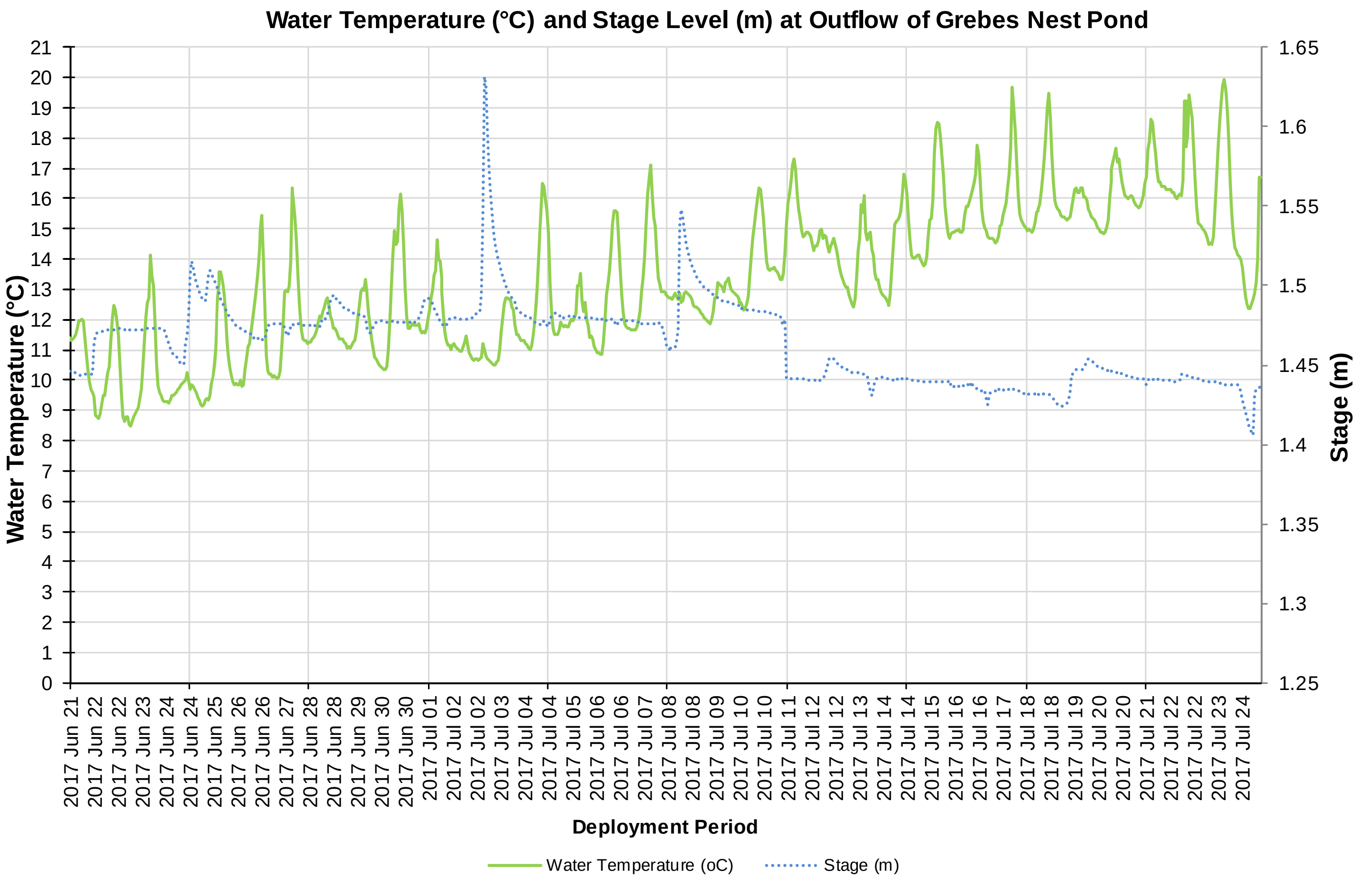

Figure 4: Water temperature (°C) values at Outflow of Grebes Nest Pond

pH

Throughout the deployment period, pH values ranged between 5.11 pH units and 6.23 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.

Generally pH data dips during high stage events, as displayed on June 24th 2017, July 2nd and July 8th, 2017. There was recorded rainfall on this day which may have contributed to material being flushed into the brook. 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.

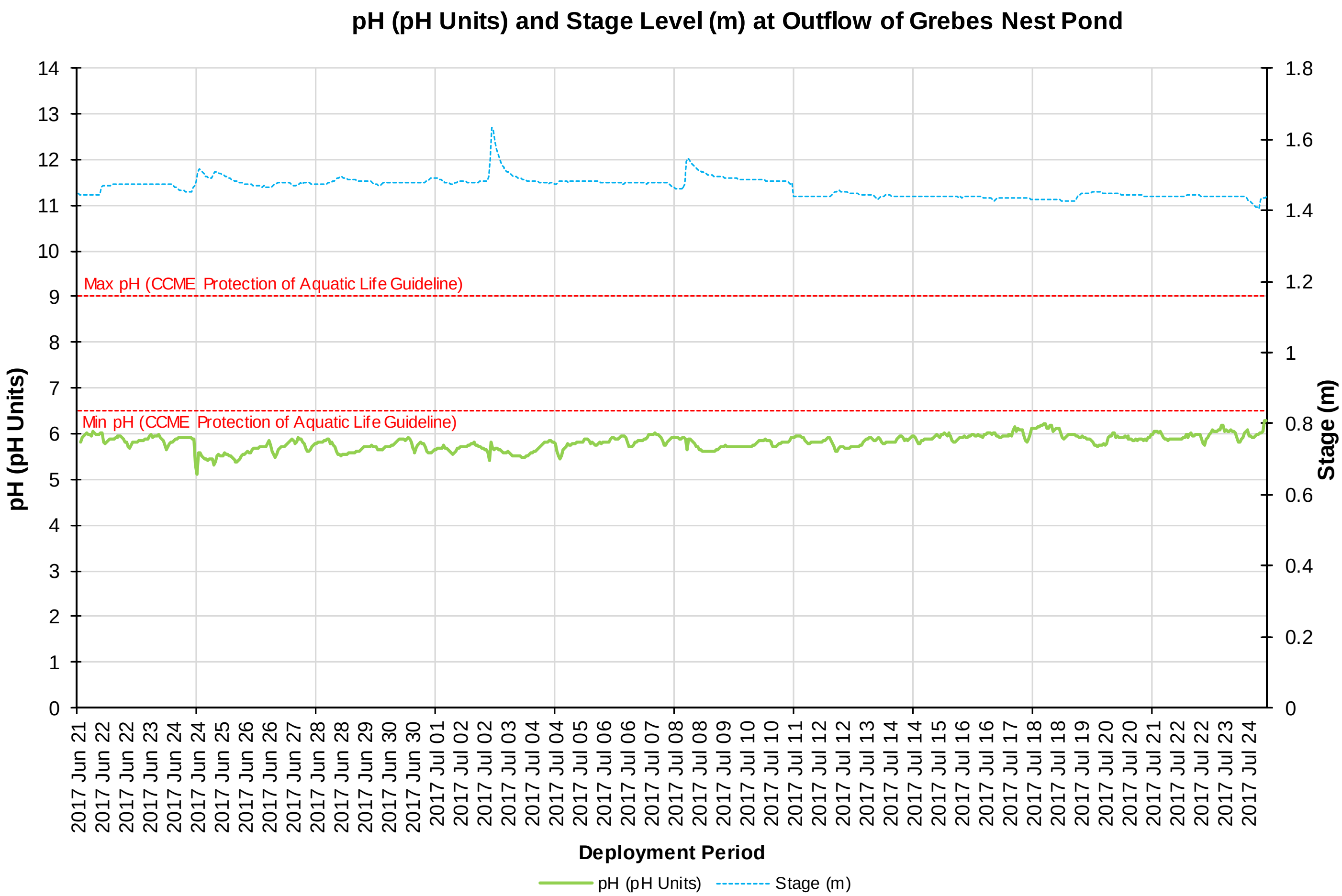

Figure 5: pH (pH units) and stage level (m) values

Specific Conductivity & Total Dissolved Solids

The conductivity levels were within 40.4 µS/cm and 69.2 µS/cm during this deployment period. TDS (a calculated value) ranged from 0.0300 g/L to 0.0400 g/L (Figure 6). TDS is a calculated measurement that the instrument provides once conductivity levels have been recorded.

The relationship between conductivity and stage level is inversed. When stage levels rise, the specific conductance levels drop in response, as the increased amount of water in the river system dilutes the solids that are present. This is evident on Figure 6 in several places but most noticeably on July 2ndand July 8th, 2017.

It is common to see an increase in conductivity with an increase in stage. This is evident on June 24th 2017 where there is a spike in conductivity and an increase in stage. On June 24th there is also an increase in air temperature and a recorded precipitation amount indicating that the spike in conductivity is likely a result of rainfall (Appendix A). 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.

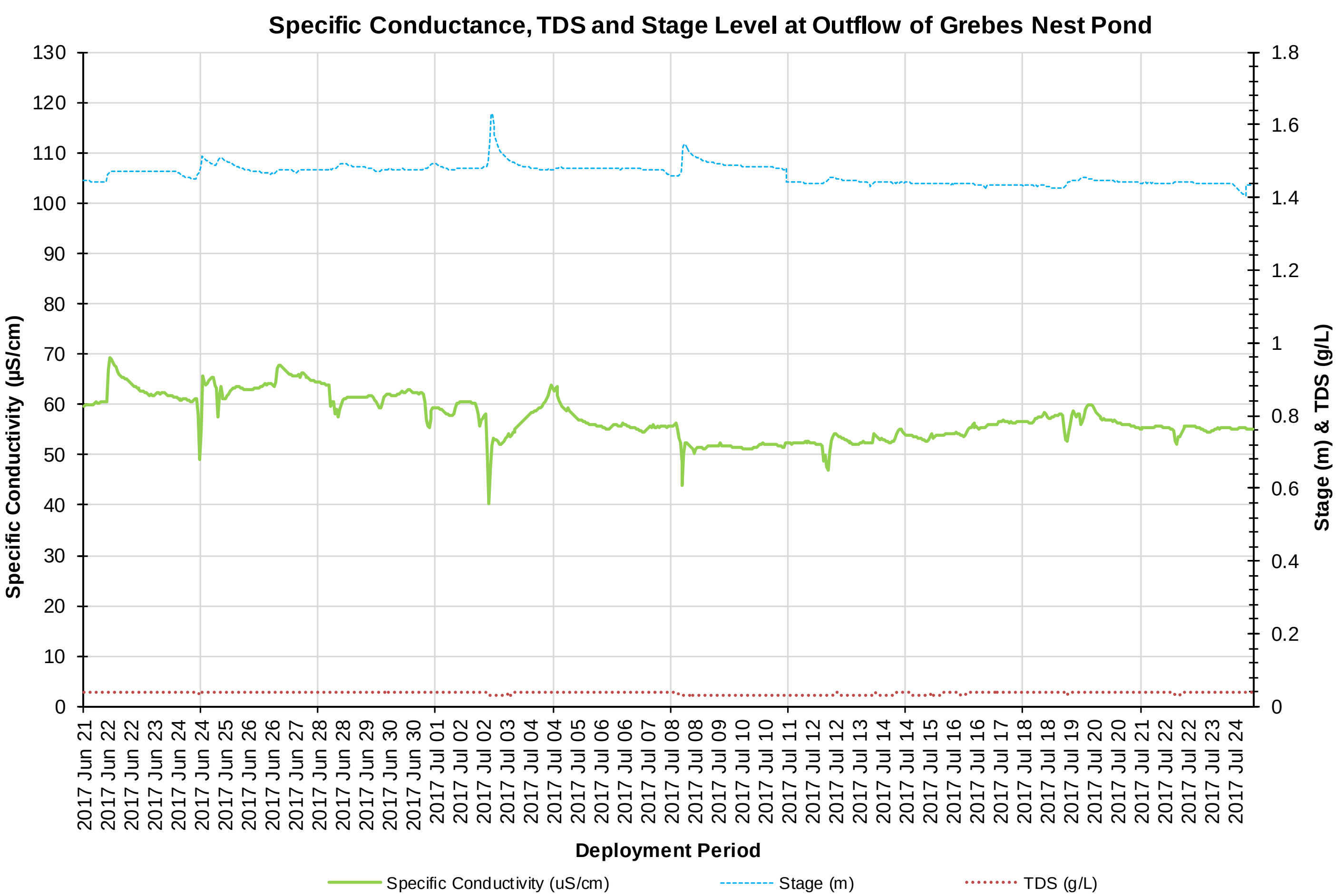

Figure 6: Specific conductivity (µS/cm), TDS (g/L) and stage (m) values

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 7.64 mg/L to a maximum of 10.54 mg/L. The percent saturation levels for dissolved oxygen ranged within 74.7% Saturation to 98.4% Saturation (Figure 7).

Temperatures increased as the summer season adjusted to the warmer temperatures. There was a natural increase in water temperature during this deployment; this reaction reduced the dissolved oxygen present in the brook. The dissolved oxygen concentration dipped below the CCME guideline for the Protection of Early Life Stages (9.5mg/L) from June 25th, onwards. This is a normal reaction in water bodies during the warmer seasons.

The CCME guidelines for the Protection of Aquatic Life provide natural guidance. There are many occasions that natural brook environments move within these guidelines. Every brook is different with its own natural background range for dissolved oxygen. It is not uncommon for Newfoundland and Labrador waters to be within or above the CCME guideline.

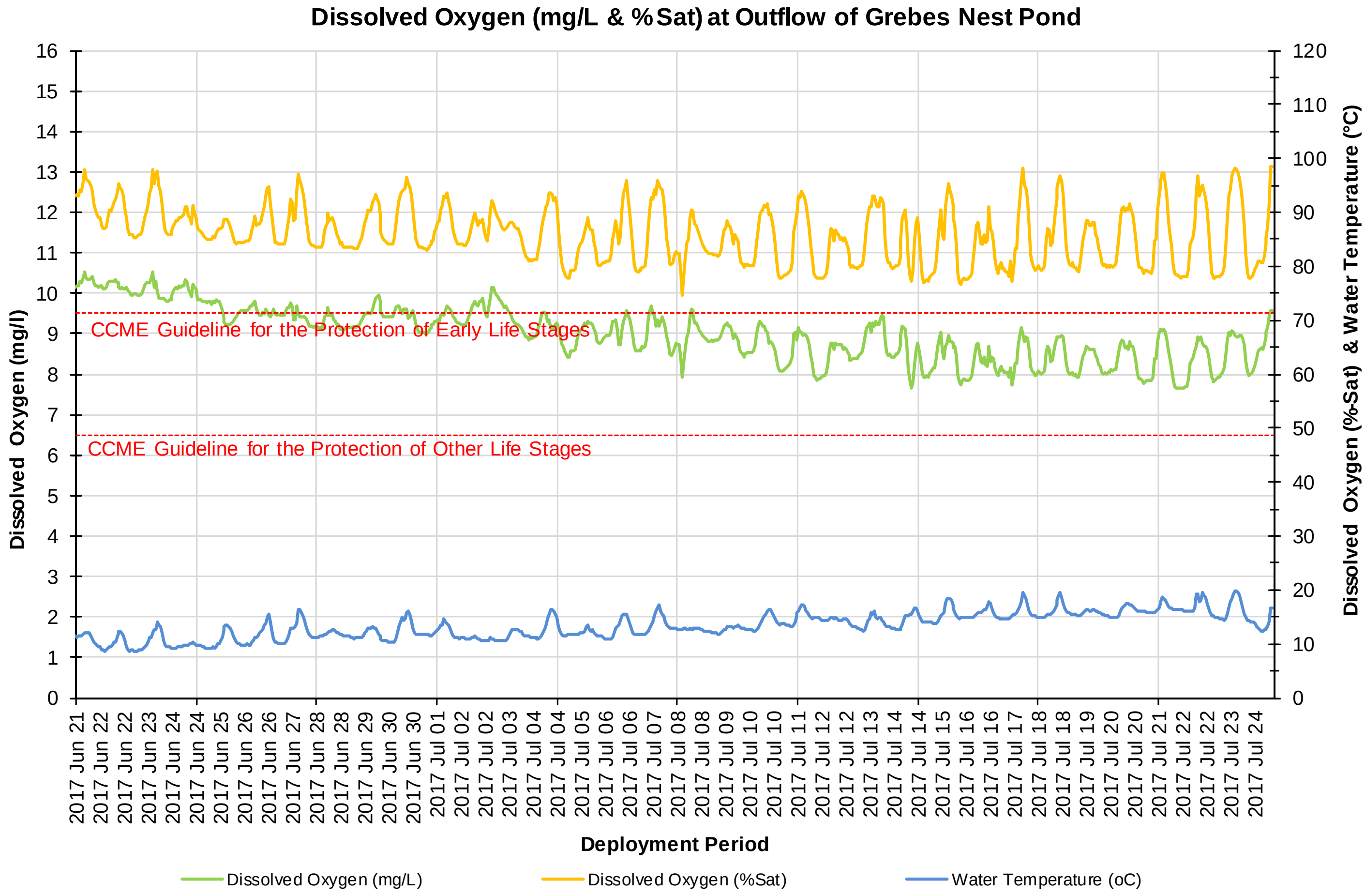

Figure 7: Dissolved Oxygen (mg/L & Percent Saturation) values.

Turbidity

Turbidity levels during the deployment ranged within 4.7 NTU and 856.9 NTU (Figure 8). The deployment data had a median of 21.6 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 there were substantial turbidity events. The turbidity spikes did 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 data does return to lower levels after the high peaks.

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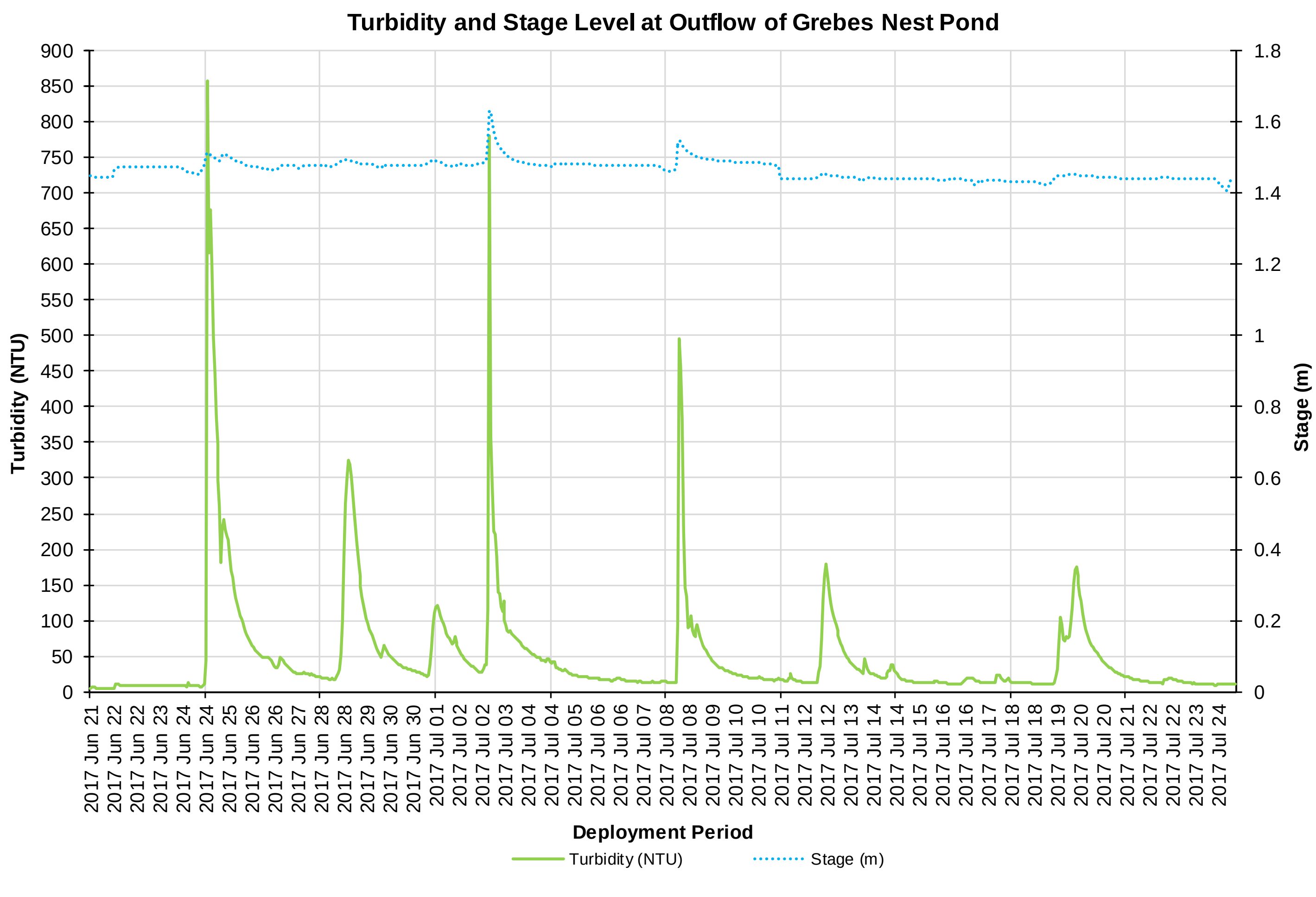

Figure 8: Turbidity (NTU) and stage level (m) values.

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 1.63m. The larger peaks in stage did 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 53.9 mm on July 2nd, 2017. High precipitation was also recorded on June 24th, July 8th and July 19th, 2017.

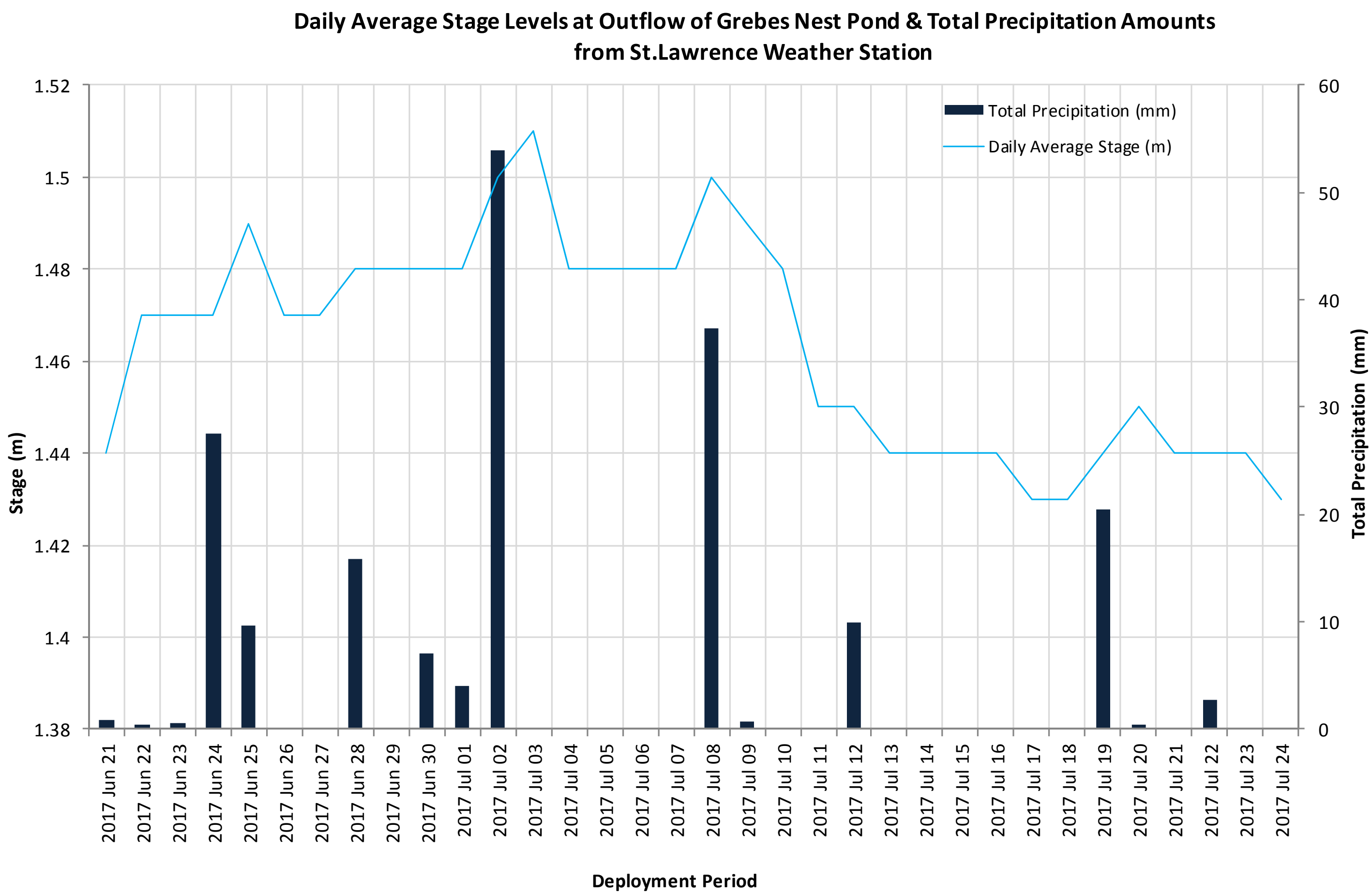

Figure 9: Daily average stage values and daily total precipitation.

Conclusion

Outflow of Grebes Nest Pond currently flows through an established mine site. At this phase of the mines progress, the natural environment is constantly being disturbed by construction activities. Grebes Nest Pond had been dewatered for mining purposes and no longer exists. At this time the brook is being flushed through with water from a pond that is located upstream from the old Grebes Nest Pond.

The brook's watershed is 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, snow and spring thaw melt.

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 movement in the water temperature data indicated that, air temperatures influenced the drop in the water temperature, which in turn, influenced the dissolved oxygen concentration in the brook. Shallower brooks are highly influenced by air temperatures.

For most of the deployment period the pH values were reasonably consistent, there was a small amount of movement during the higher stage spikes however the pH returned to more normal values after each increase. Specific conductivity did decrease during the higher stage level spikes, however overall remained consistent throughout the deployment. Naturally as the air and water temperatures increase during the summer period the dissolved oxygen levels will decrease. This is a natural reaction. Turbidity values also indicated increases during the higher stage events. These small changes in water quality are likely a result of rainfall 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 ranged from 10.55°C to 26.57°C during the deployment period (Figure 10). There were several dips in the water temperature during the higher stage events. The higher stage levels were likely a result of rainfall (Figure 15), the rainfall can lower the temperature of the water for a short period of time.

Outflow of Unnamed Pond is a shallow brook and it 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.

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.

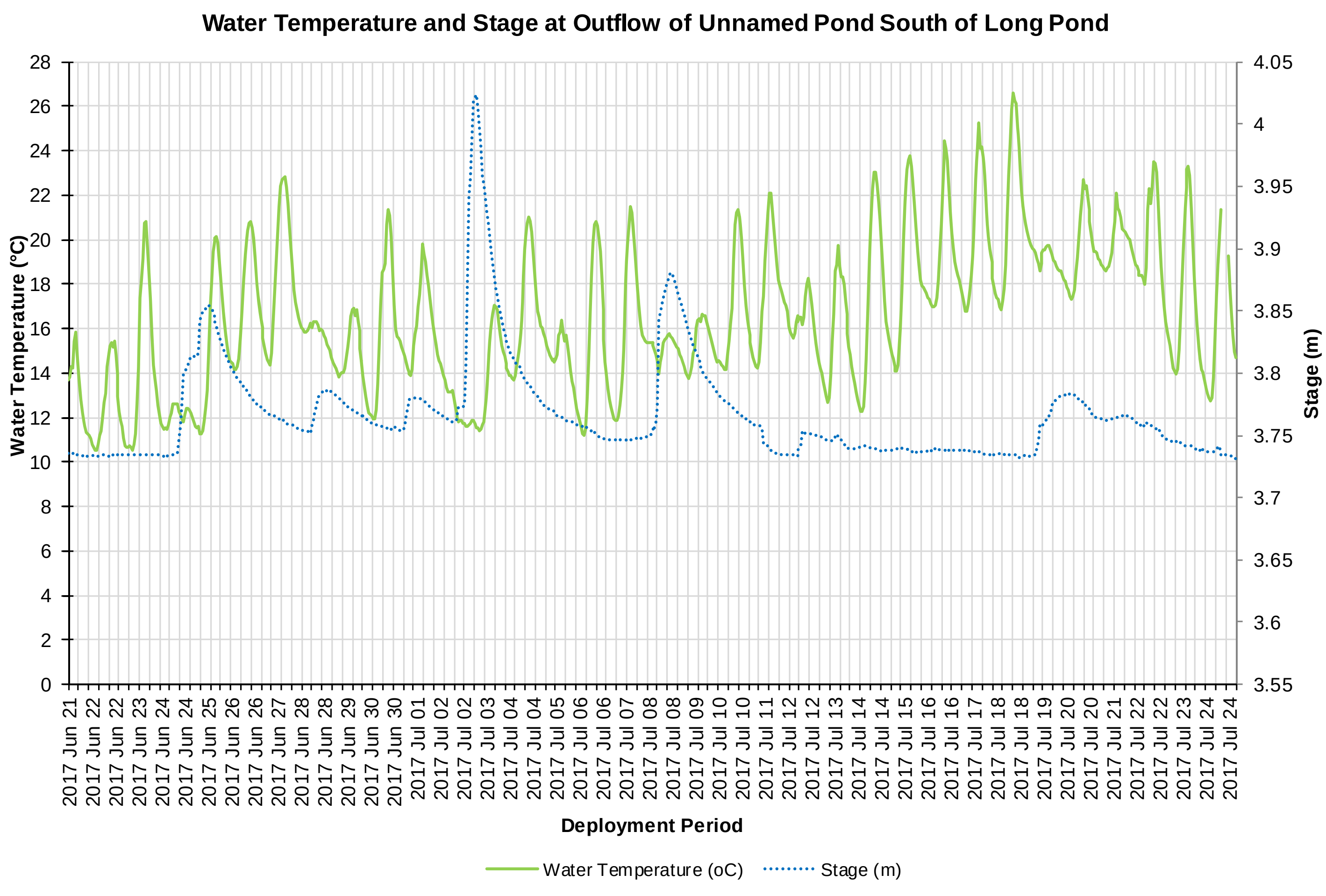

Figure 10: Water temperature (°C) values at Outflow of Unnamed Pond south of Long Pond

pH

Throughout the deployment period, pH values ranged between 5.82 pH units and 7.32 pH units (Figure 11). The Canadian Council of Ministers of the Environment (CCME) guidelines is just a basis by which to compare any dramatic change in 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.

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 short period of time. This is a natural process and can be seen on the graph below on June 24th, July 2nd and July 8th, 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.

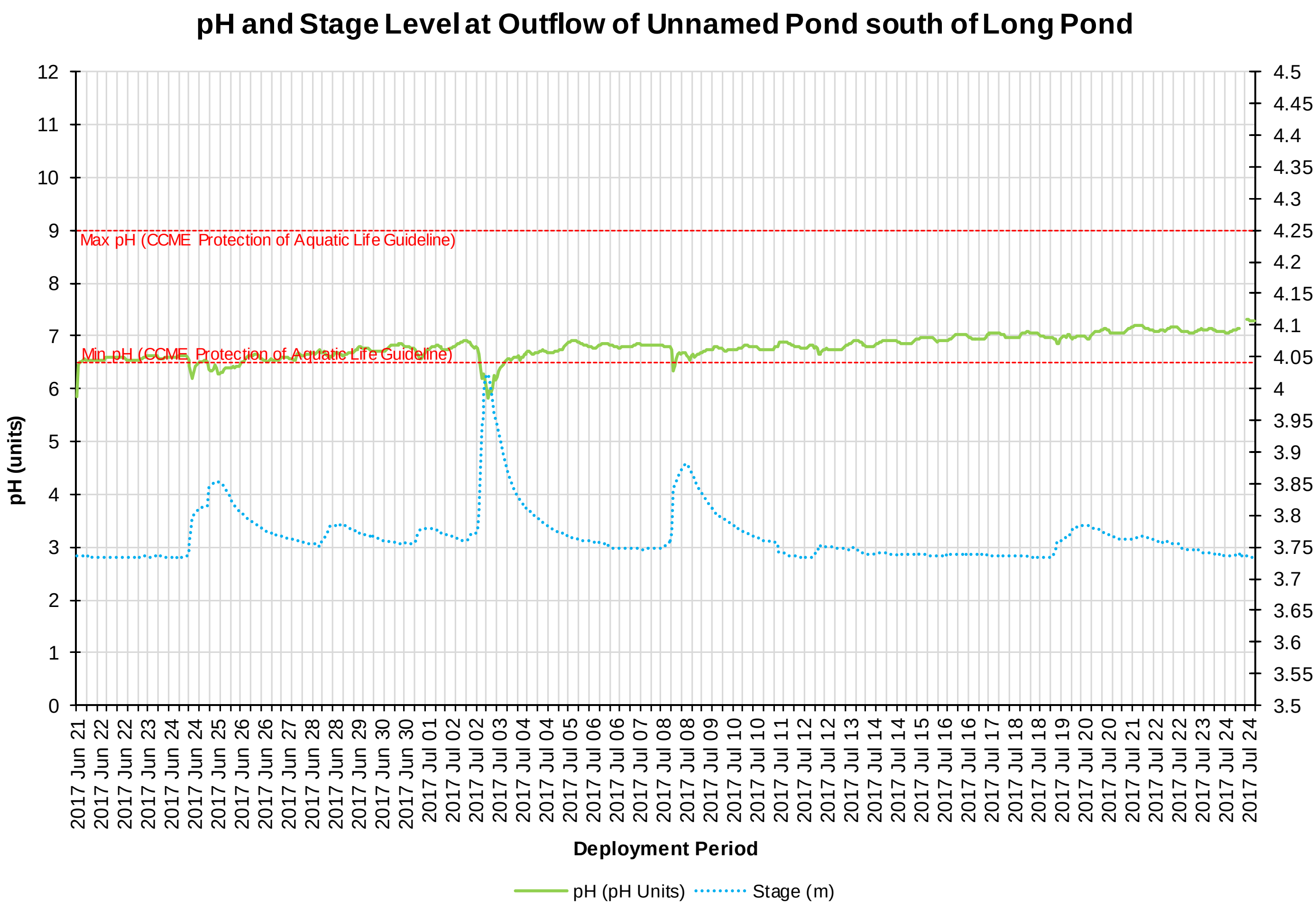

Figure 11: pH (pH units) and stage level (m) values

Specific Conductivity

The conductivity levels were between 61.6 µS/cm and 179.7 µS/cm during this deployment period (Figure 12). 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. As the stage level increases, the increased amount of water in the river dilutes the suspended solids that are present (Figure 12).

The data for conductivity from July 4th to July 8th, 2017, indicated that there was fouling occurring on the sensor. This data was removed; therefore there is a gap in the graph. Specific conductivity levels are increasing during this deployment, the median of 117.2 µS/cm has increased from the previous deployment median of 56.2 µS/cm. During construction or earth moving work organic matter/sediment can be flushed into nearby waterways (Figure 15).

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.

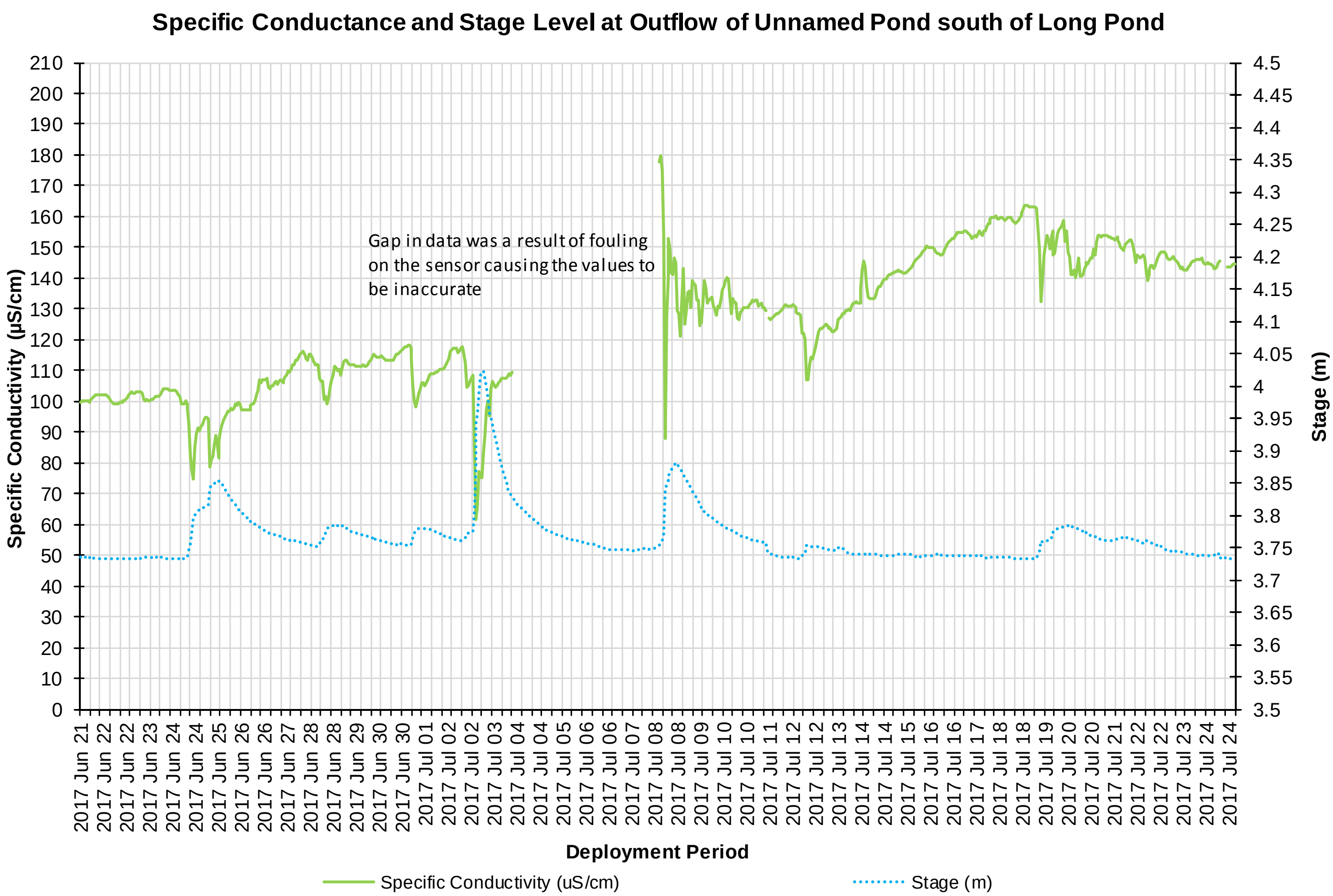

Figure 12: Specific conductivity (µS/cm) and stage (m) values

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 8.20 mg/L to a maximum of 11.08 mg/L. The percent saturation levels for dissolved oxygen ranged within 93.0% Saturation to 104.8% 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. This is evident on Figure 13.

The lower dips in dissolved oxygen are likely linked to slightly warmer temperatures for that time frame.

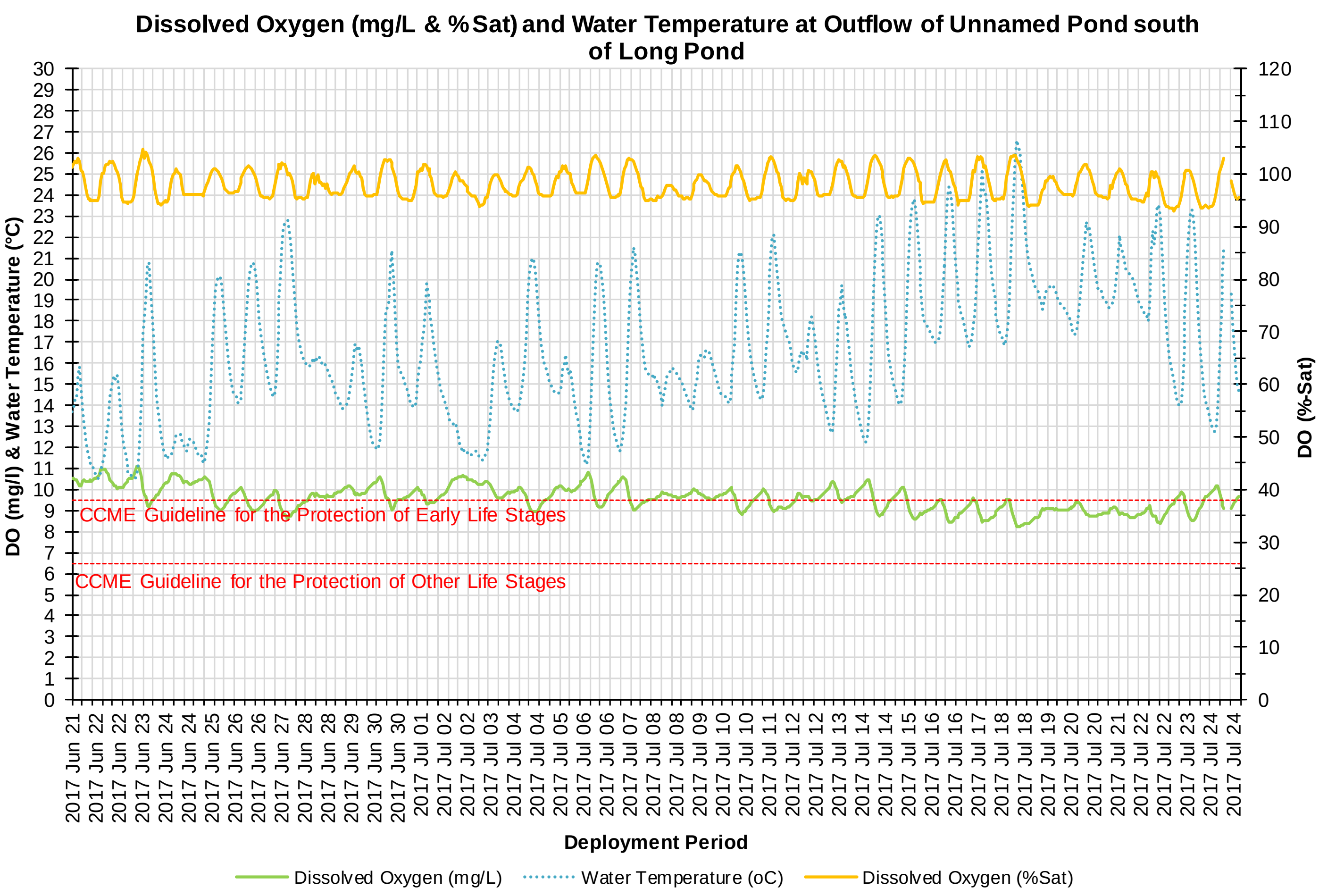

Figure 13: Dissolved Oxygen (mg/L & Percent Saturation) values.

Turbidity

Turbidity levels during the deployment ranged within 0.0 NTU and 133.9 NTU (Figure 14). The deployment data had a median of 22.1 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.

After the precipitation event on July 2nd, 2017 the turbidity sensor indicated that it was blocked by debris. Therefore, the data has been removed from July 4th to July 12th, 2017 as it did not represent the brook at this time.

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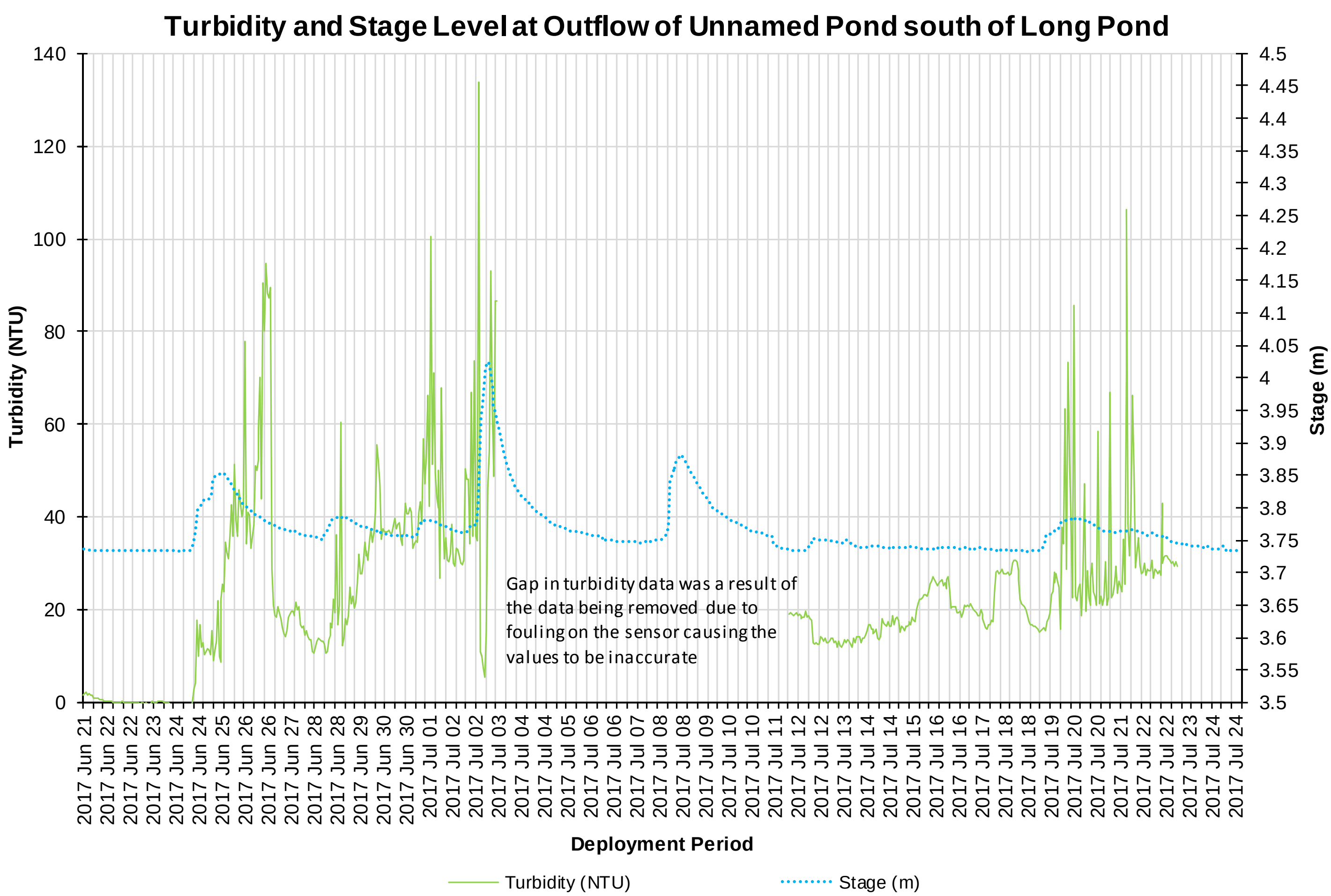

Figure 14: Turbidity (NTU) and stage level (m) values.

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 3.73m to 4.02m. 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 53.9 mm on July 2nd, 2017.

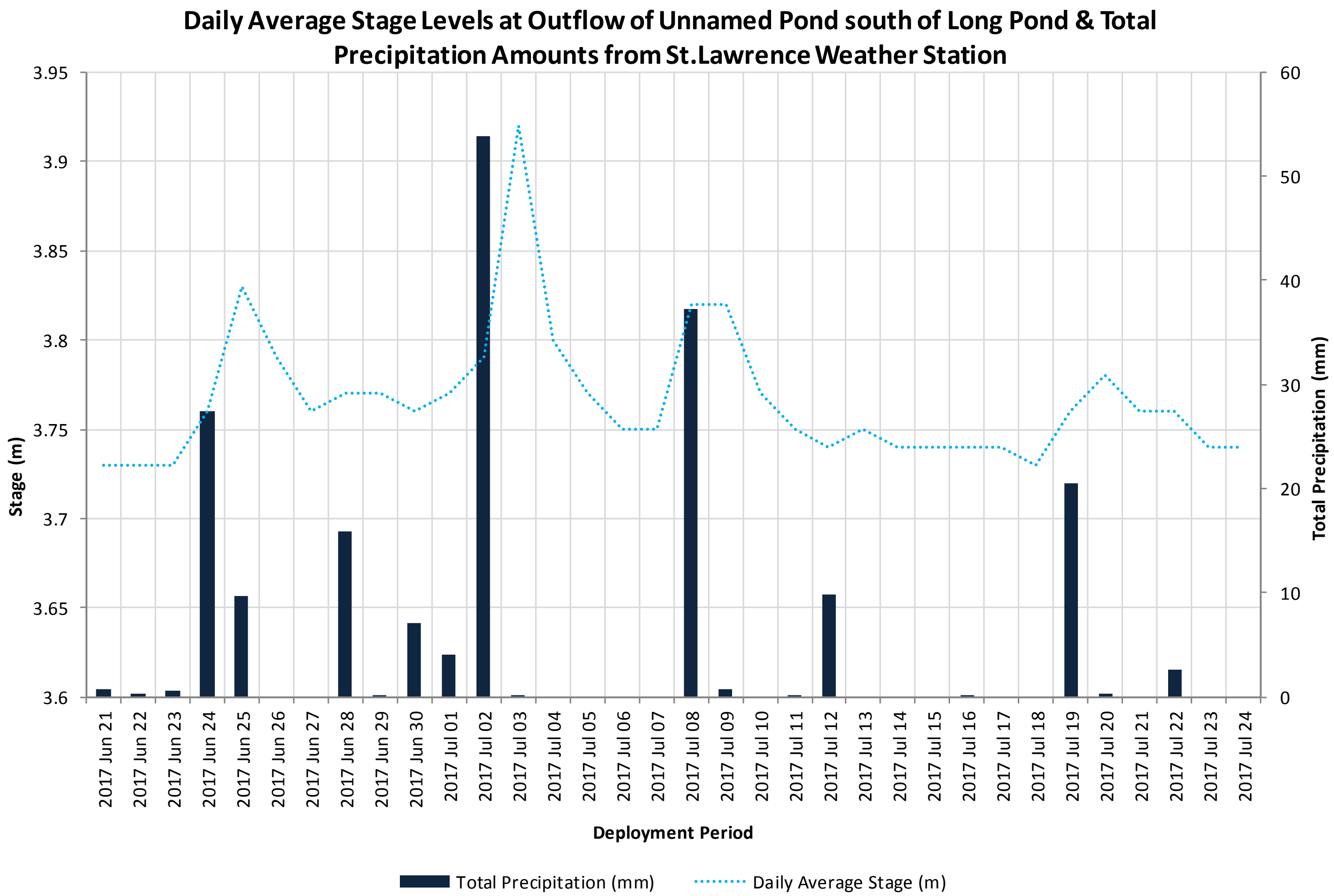

Figure 15: Daily average stage values and daily total precipitation.

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 undeveloped areas that include natural wetlands and marshlands however the brook skirts along the construction activity that is ongoing. This type of watershed environment will influence the water quality parameters. This station is the furthest away from the anthropogenic activities that would be occurring on the mine site.

It is evident that the larger precipitation events did cause varying effects with the water quality parameters including pH, conductivity, dissolved oxygen and turbidity. Water temperatures are directly influenced by air temperatures and then water temperatures, in turn, will influence the dissolved oxygen concentration in the brook. Water temperatures during this deployment were representative of the climate for this time of year.

For most of the deployment period the pH values were reasonably consistent. Any change in pH data corresponded with a rise or dip in the stage level during the same timeframe. The specific conductivity data had a slight increase over the deployment and had a higher median (117.2 µS/cm) that what was recorded at the previous deployment period (56.2 µS/cm). There was significant movement in the turbidity data during this deployment; the median for this deployment was 22.1 NTU. It is likely that some of the changes in turbidity and the specific conductivity data may have been a result of runoff from earth moving activities upstream from the real-time station.

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

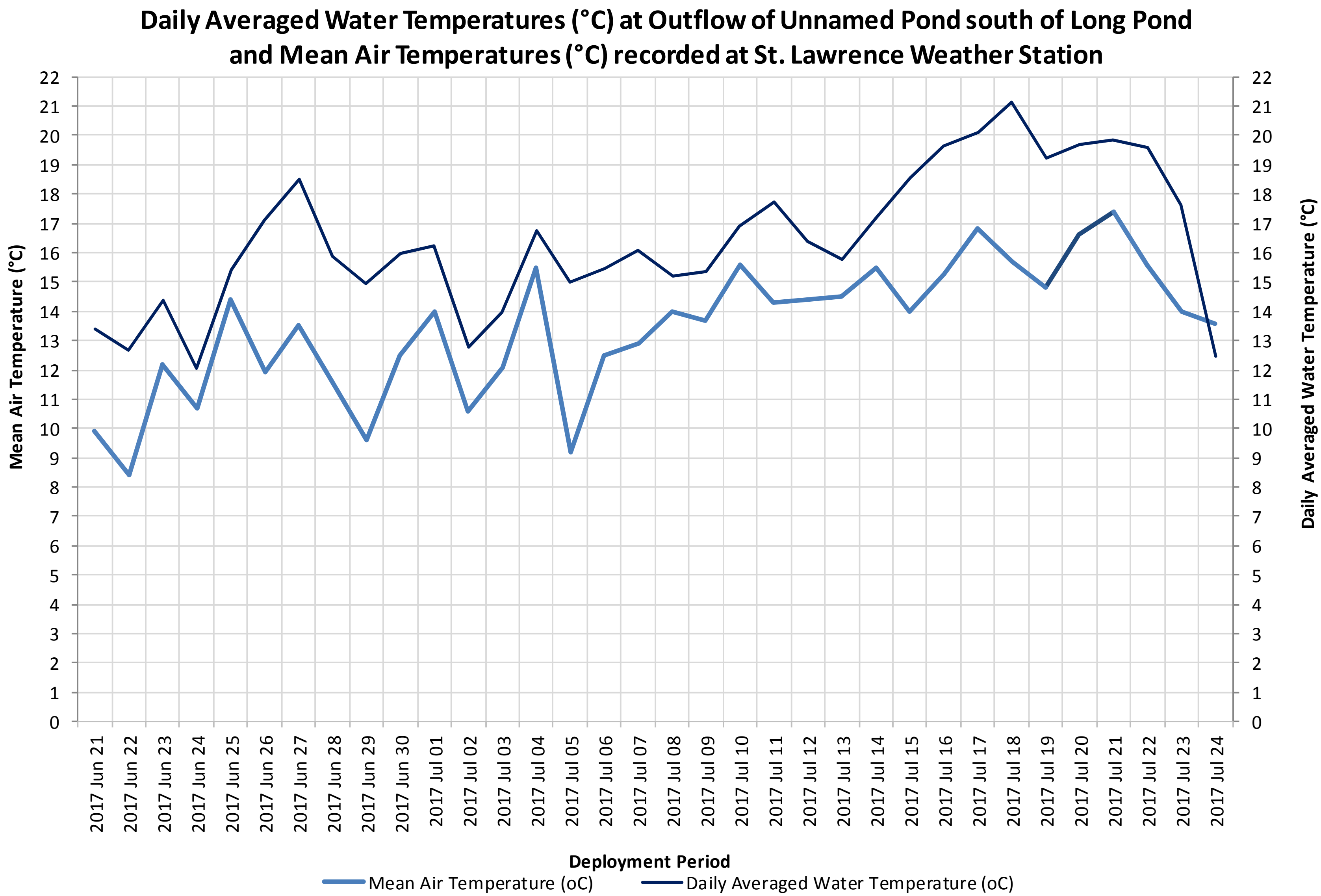

Figure A1: Water Temperatures at Outflow of Unnamed Pond south of Long Pond and Mean Air Temperatures recorded at St. Lawrence Weather Station

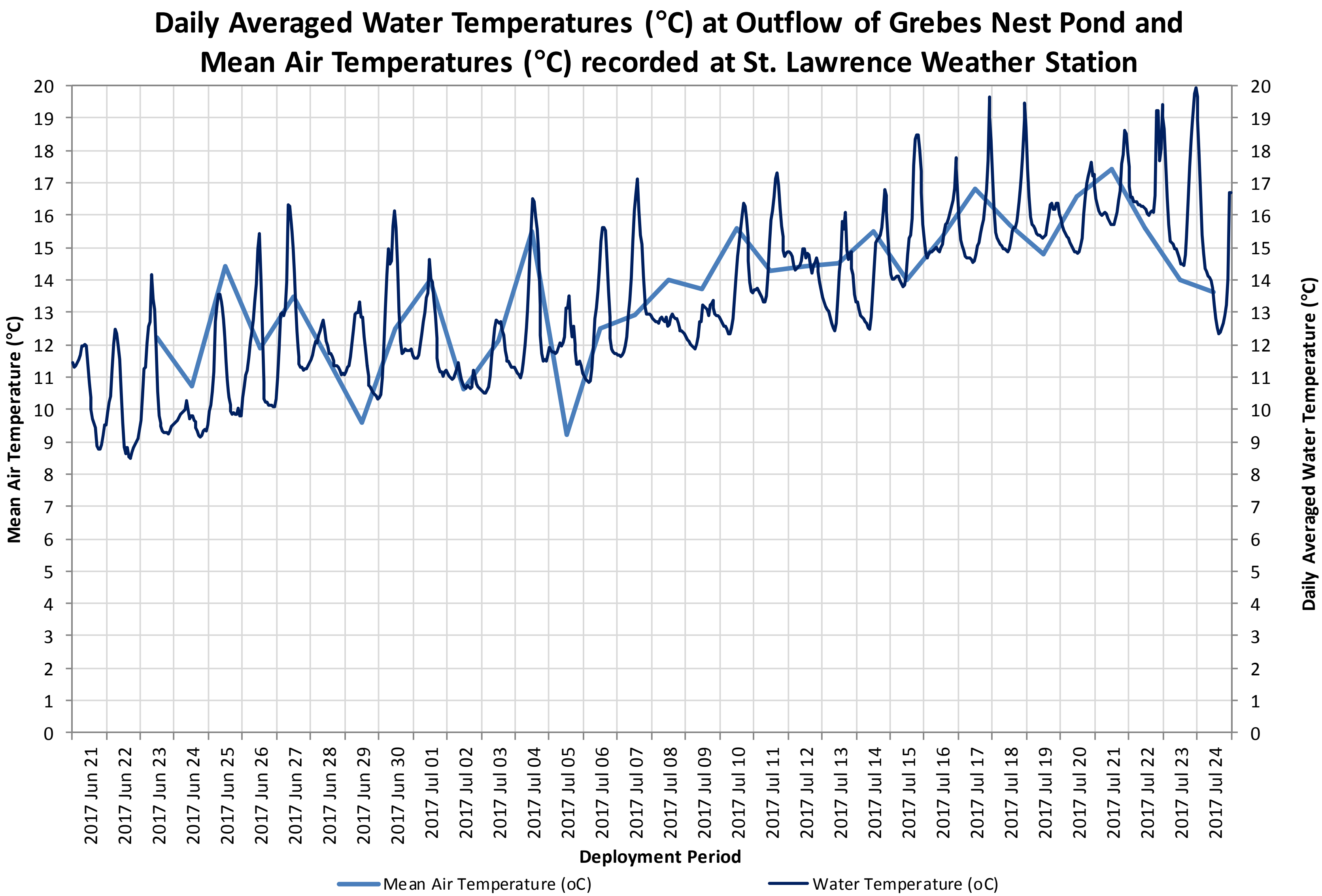

Figure A2: Water Temperatures at Outflow of Grebes Nest Pond and Mean Air Temperatures recorded at St. Lawrence Weather Station

APPENDIX B

COMPARISON GRAPHS OF CANADA FLUORSPAR (NL) INC REAL TIME STATIONS

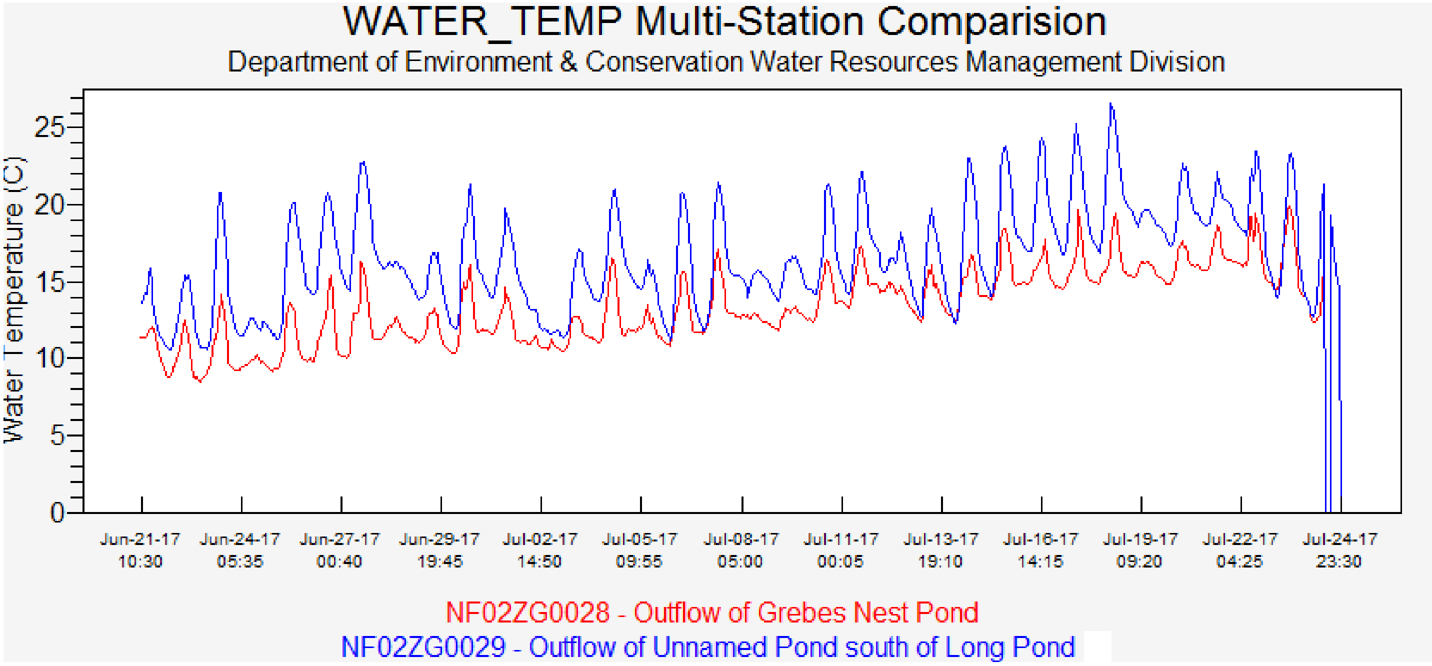

Figure B1: Comparison of Water Temperature at the Real-Time Stations at Canada Fluorspar (NL) Inc. Please note the data on this graph, is raw data. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data.

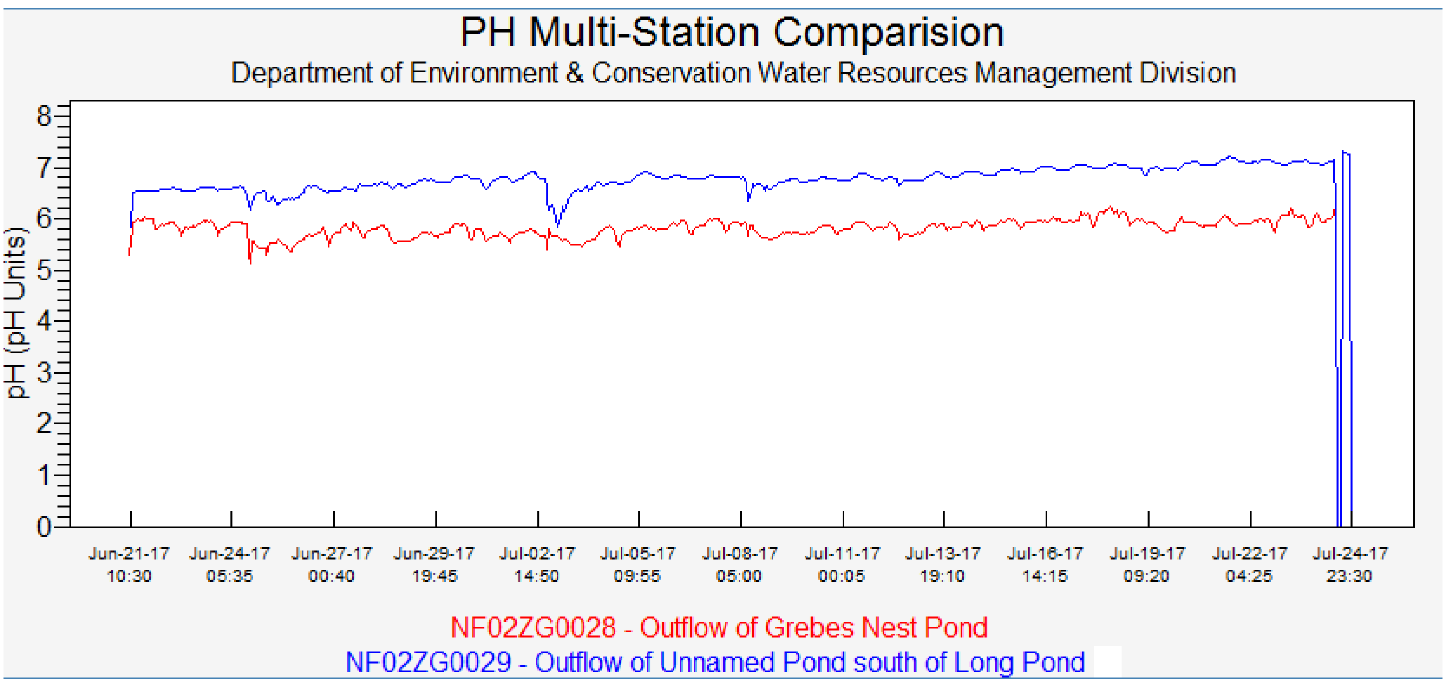

Figure B2: Comparison of pH at the Real-Time Stations at Canada Fluorspar (NL) Inc. Please note the data on this graph, is raw data. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data.

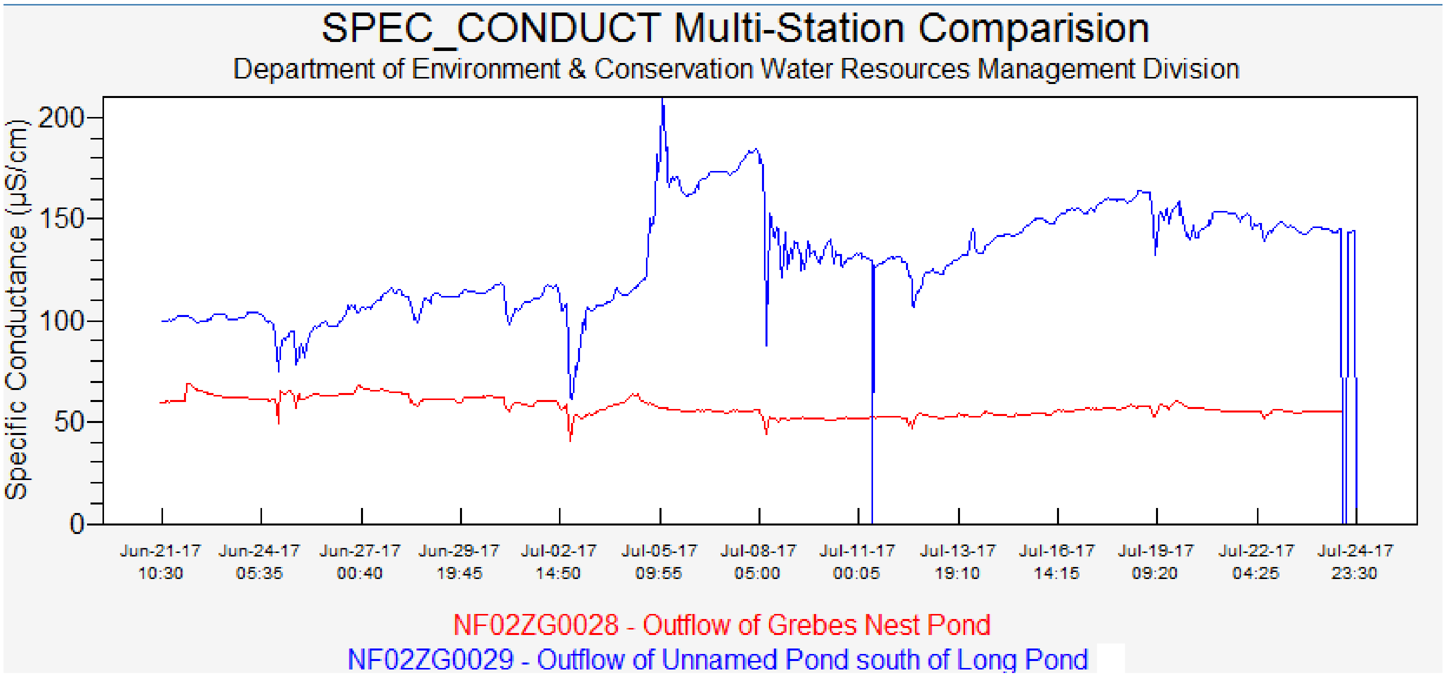

Figure B3: Comparison of Specific Conductivity at the Real-Time Stations at Canada Fluorspar (NL) Inc. Please note the data on this graph, is raw data. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data.

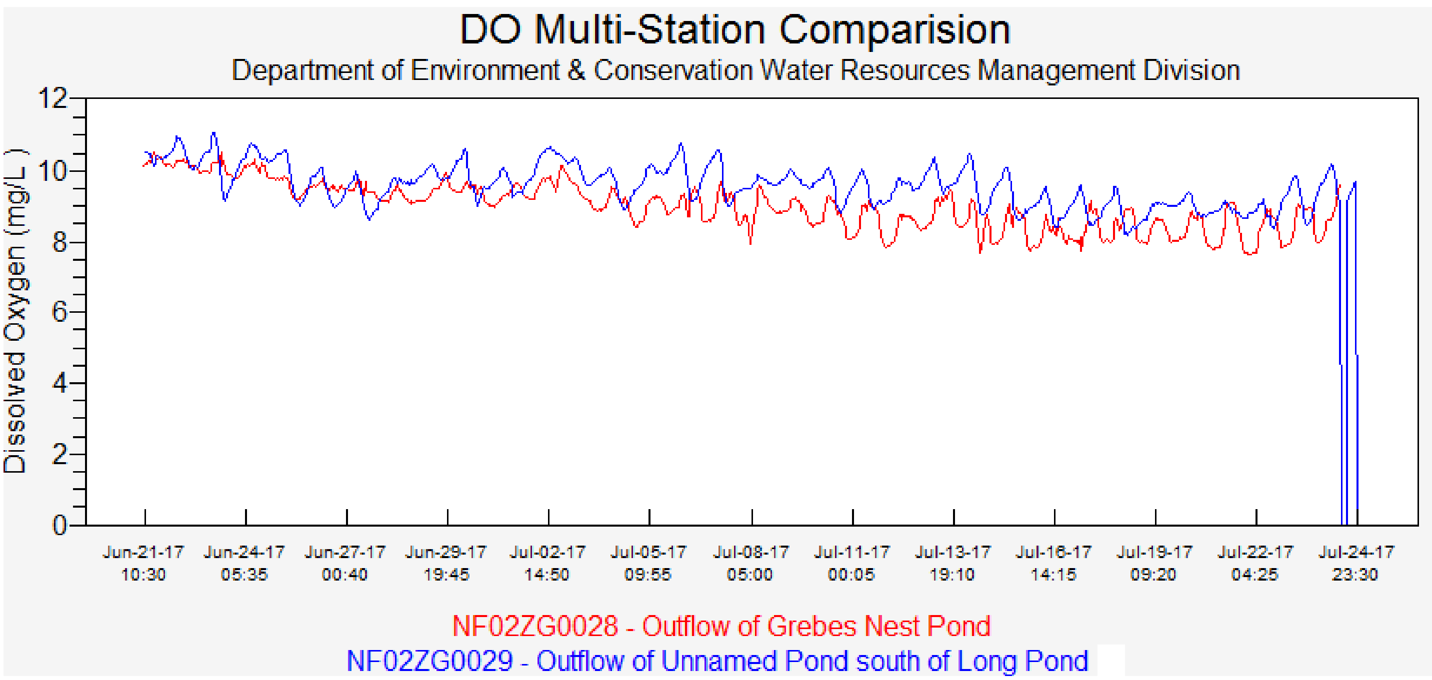

Figure B4: Comparison of Dissolved Oxygen (mg/L) at the Real-Time Stations at Canada Fluorspar (NL) Inc. Please note the data on this graph, is raw data. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data.

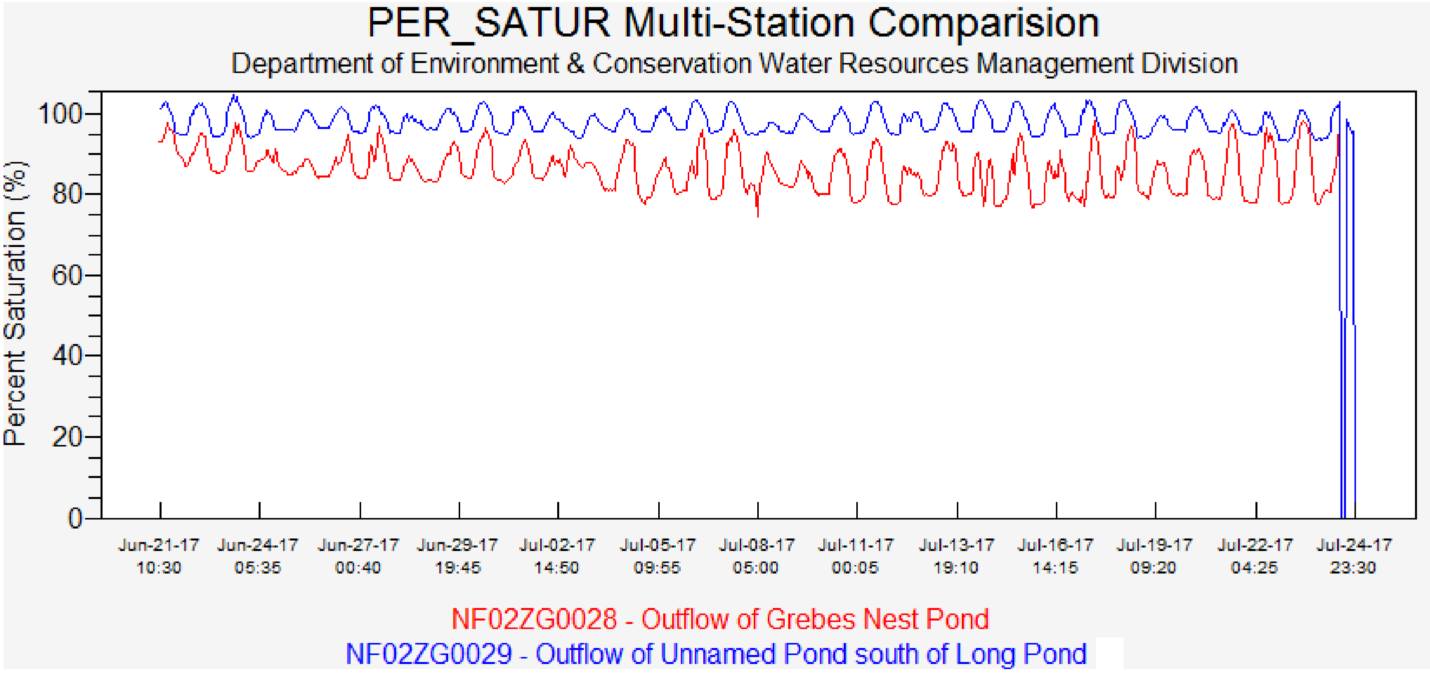

Figure B5: Comparison of Percent Saturation at the Real-Time Stations at Canada Fluorspar (NL) Inc. Please note the data on this graph, is raw data. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data.

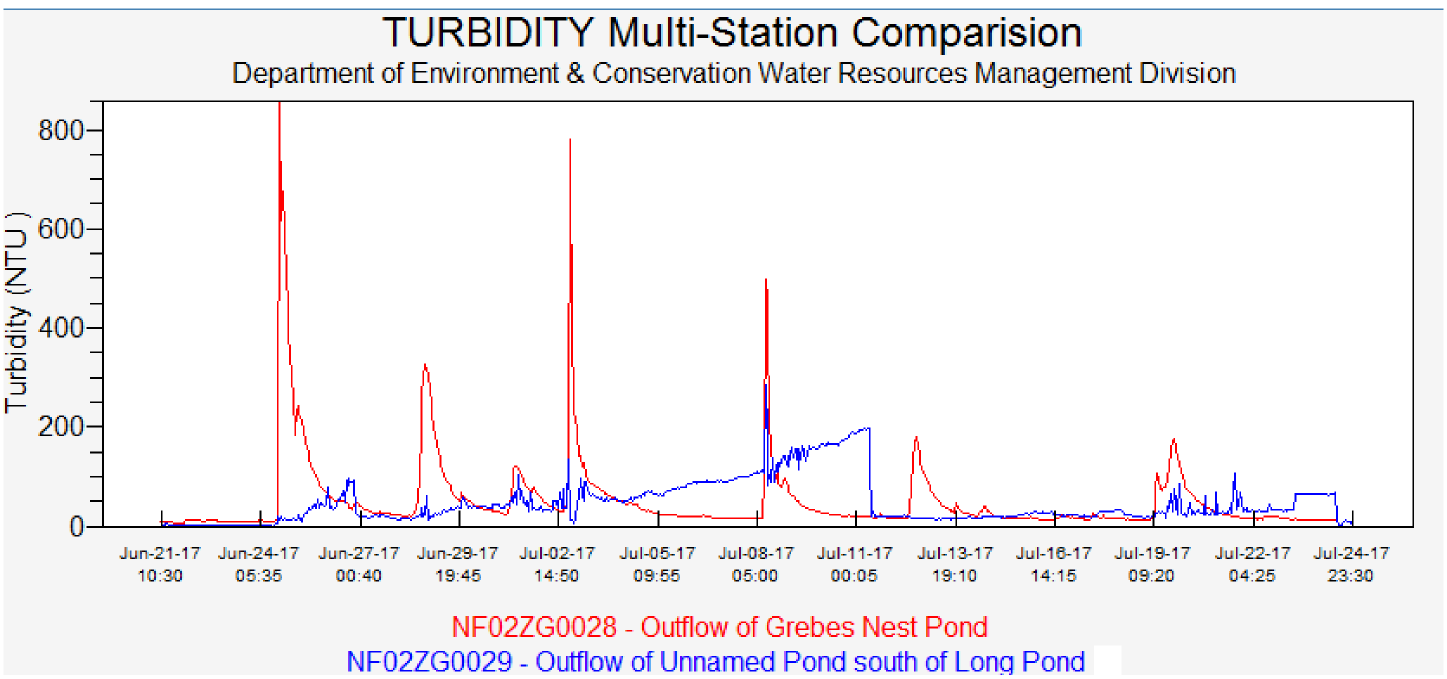

Figure B6: Comparison of Turbidity at the Real-Time Stations at Canada Fluorspar (NL) Inc. Please note the data on this graph, is raw data. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data.