Real Time Water Quality Report

Tata Steel Minerals Canada
Elross Lake Network

Annual Deployment Report 2018

2018-06-19 to 2018-10-02

Government of Newfoundland & Labrador
Department of Municipal Affairs & Environment
Water Resources Management Division
St. John's, NL, A1B 4J6 Canada

Prepared by:

Ian Bell
Environmental Scientist
Department of Municipal Affairs & Environment
Water Resources Management Division
Government of Newfoundland & Labrador
9th Floor, Sir Richard Squires Building
84 mount Bernard Ave., Corner Brook, NL, A2H 5G2

t. 709.637.2431
f. 709.637.2541
e. ianbell@gov.nl.ca

Acknowledgements

The Real-Time Water Quality/Quantity Monitoring Network in the vicinity of the Elross Lake Iron Ore Mine in western Labrador is fully funded by Tata Steel Minerals Canada Limited (TSMC) and its success is dependent on a joint partnership between TSMC, Environment and Climate Change Canada (ECCC), and the Newfoundland & Labrador Department of Municipal Affairs & Environment (MAE). Managers and program leads from each organization, namely Mariana Trindade (TSMC), Melisa McComiskey (ECC), and Perry Pretty (ECCC), are committed to the operation of this network and ensuring that it provides meaningful and accurate water quality/quantity data.

In addition to funding this program, TSMC also assisted MAE and ECCC staff with fieldwork operations. TSMC employees who were helpful in this regard included Loic Didillon, Mariana Trindade, Youness Elhariri, Tara Oak, Pallav Sinha, Larry Johnston, George Chemaganish, and Jean-Francois Dion.

ECCC plays an essential role in the data logging/communication aspect of the network. In particular, ECCC staff of the Water Survey of Canada, including Perry Pretty, Roger Ellsworth, Taylor Krupa, Dwayne Ackerman and Mike Ludwicki visited network stations regularly to ensure that the data logging and data transmitting equipment was working properly. ECCC also plays the lead role in dealing with stage and flow issues.

MAE is responsible for recording and managing water quality data. Ian Bell, under the supervision of Melissa McComiskey, is MAE’s main contact for Real-Time Water Quality Monitoring operations at the Elross Lake Mine, and was responsible for maintaining and calibrating water quality instruments, as well as grooming, analyzing and reporting on water quality data recorded at the stations. Paul Rideout with the Water Resources Management Division provided assistance with field work for one deployment during the 2018 field season. Instrument performance evaluation and repairs, during the winter of 2018, were conducted in-house by Tara Clinton.

Introduction

- An agreement was signed on April 18, 2011, between the Newfoundland & Labrador Department of Municipal Affairs & Environment (MAE) and Tata Steel Minerals Canada Limited (TSMC), to establish two real-time water quality/quantity stations in the vicinity of Elross Lake Iron Ore Mine in western Labrador, near Schefferville, QC.
- An amendment to the original agreement was signed on February 10, 2015, to establish an additional station at Joan Brook below the outlet of Joan Lake. The purpose of this station was to monitor the impacts of mining activity on surface water downstream of the five pits (Kivivic 1, 2, 3N, 4 and 5) which are included in the DSO4 Project 2B mining operation. The DSO4 Project 2B mining operation is located approximately 24 km northwest of the main mine complex.
- The official name of each station is ELROSS CREEK BELOW PINETTE LAKE INFLOW, GOODREAM CREEK 2KM NORTHWEST OF TIMMINS 6, and JOAN BROOK BELOW OUTLET OF JOAN LAKE, hereafter referred to as the *Elross Creek Station*, the *Goodream Creek Station*, and the *Joan Brook Station* respectively (Figure 1).

a. Elross Creek Station b. Goodream Creek Station c. Joan Brook Station

Figure 1: RTWQ stations are located alongside (a) Elross Creek, (b) Goodream Creek & (c) Joan Brook

- **Please note that the Goodream Creek Station has been temporarily shut down to allow for moving the station to a new location further downstream near Triangle Lake. It is hoped that this move will be completed early in the 2019 field season and that the station will be fully operational at the new location before the end of the 2019 field season.**

- Table 1 lists the geographic coordinates of each station, including the location of the water quality instrument, gauge house, and helicopter pad.

Table 1. Geographic coordinates of Elross Creek, Goodream Creek and Joan Brook Stations

	Elross Creek Station		Goodream Creek Station		Joan Brook Station	
	Latitude	Longitude	Latitude	Longitude	Latitude	Longitude
Instrument	54.877757	-67.099728	54.917549	-67.124027	*55.03334	*-67.17597
Gauge house	54.877698	-67.099848	54.917564	-67.123939	*55.03334	*-67.17597
Helicopter pad	54.877604	-67.100014	54.917699	-67.123763	*55.03334	*-67.17597

*General Site Location

- Station sites were selected to monitor all surface water outflows from the Elross Lake mining site and the DSO4 Project 2B mining sites (Figure 2).
- The Elross Creek Station monitors surface water downstream of the Timmins 1 pit, and downstream of Pinette Lake.
- The first Goodream Creek Station monitored potential impacts from groundwater flowing from Timmins 6 pit into the surface water of Goodream Creek. The new Goodream Creek Station will monitor impacts on Goodream Creek near Triangle Lake from the development of the Howse deposit.
- The Joan Brook station monitors surface water downstream of the five pits (Kivivic 1, 2, 3N, 4 and 5) which are included in the DSO4 Project 2B mining operation.
- The Elross Creek and Goodream Creek stations went into operation October 17-18, 2011, recording only stage values for the first 7 months until June 5, 2012, when water quality instruments were first deployed. The Joan Brook station went into operation for stage values and water quality in June of 2016.
- Six parameters are measured at each station during ice-free months, including five water quality parameters (i.e., temperature, pH, specific conductivity, dissolved oxygen and turbidity) and one water quantity parameter (i.e., stage).
- Water quality parameters are recorded on an hourly basis, typically from early-June to early-October, when streams are ice-free. MAE is responsible for collecting and managing this dataset.
- Stage is recorded year-round on an hourly basis. ECCC is responsible for collecting and managing this dataset.
- ECCC is responsible for logging and transmitting all water quality and water quantity data to a central repository via satellite communications.
- The purpose of the real-time network at these stations is to monitor, process, and distribute water quality and water quantity data to TSMC, MAE, and ECCC, for assessment and

management of water resources, as well as to provide an early warning of any potential or emerging water issues, such that mitigative measures can be implemented in a timely manner.

- MAE informs TSMC of any significant water quality events by email notification. Monthly and annual deployment reports serve to document water parameters measured at these stations.
- This annual deployment report presents water quality and water quantity data recorded at the Elross Creek, Goodream Creek and Joan Brook stations from June 19, 2018 to October 2, 2018.

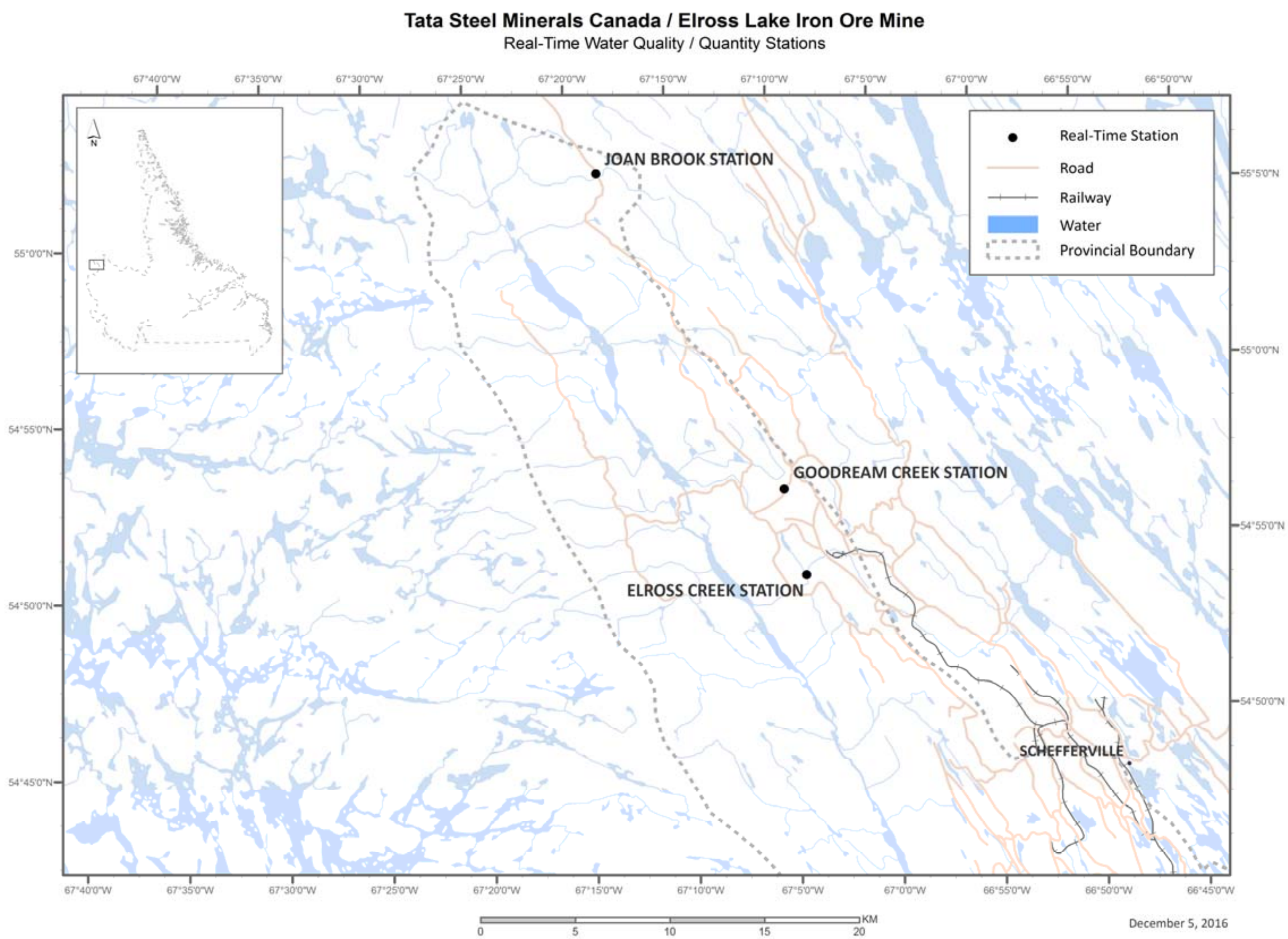

Figure 2. Map of real-time water quality/quantity stations in the vicinity of Elross Lake Iron Ore Mine in Western Labrador.

Quality Assurance & Quality Control

- Water quality parameters are measured at each station using a Hydrolab DataSonde instrument (Figure 3).

Model DS5 © 2005 Hach Company

Figure 3. Hydrolab DataSonde used for monitoring five water quality parameters.

- To ensure accurate data collection, water quality instruments are subjected to quality assurance procedures, in order to mitigate any errors caused by biofouling and/or sensor drift.
- Quality assurance procedures include: (i) a thorough cleaning of the instrument, (ii) replacement of any small sensor parts that are damaged or unsuitable for reuse, and (iii) the calibration of four instrument sensors (i.e., pH, specific conductivity, dissolved oxygen, and turbidity sensors).
- Quality assurance procedures are carried out every 27-36 days, before the start of a new deployment period. Deployment start and end dates are summarized in Table 2.

Table 2. Water quality instrument deployment start and end dates for 2018 at Elross Creek, Goodream Creek and Joan Brook.

Station	Start date	End date	Duration (days)	Instrument
Elross Creek	2018-06-19	2018-07-24	35	62068
	2018-07-24	2018-08-29	36	66462
	2018-08-29	2018-10-02	34	66462
Joan Brook	2018-06-20	2018-07-25	35	62065
	2018-07-25	2018-08-29	35	62068
	2018-08-29	2018-10-02	34	62068

- As part of the quality control procedures, instrument performance is tested at the start and end of its deployment period. The process is outlined in Appendix A.
- Instruments are assigned a performance rating (i.e., poor, marginal, fair, good or excellent) for each water quality parameter measured.
- Table 3 shows the performance ratings of the instrument sensors (i.e., temperature, pH, conductivity, dissolved oxygen and turbidity) deployed at Elross Creek and Joan Brook. Based on

quality control procedures, instrument sensor performance ranged from marginal to excellent with the majority of rankings being “good” and “excellent” in 2018. There was one “Marginal” turbidity rating at Joan Brook at the time when the instrument was installed at the beginning of the deployment period. This marginal rating was related to higher and variable turbidity readings at the time of deployment due to heavy rain. While the instruments generally performed well at the time of installation, it is not unusual for sensors to develop issues over the deployment period, particularly at sites where there is significant siltation related to mining activity.

Table 3. Instrument sensor performance at the start and end of each deployment period for the Elross Creek, Goodream Creek and Joan Brook RTWQ stations.

Station	Stage of deployment	Date (yyyy-mm-dd)	Instrument	Temperature (°C)	pH	Specific conductivity (µS/cm)	Dissolved oxygen (mg/L)	Turbidity (NTU)
Elross Creek	Start	2018-06-19	62068	Excellent	Good	Excellent	Fair	Excellent
	End	2018-07-24		Excellent	Excellent	Excellent	Good	Fair
	Start	2018-07-24	66462	Excellent	Good	Excellent	Good	Excellent
	End	2018-08-29		Excellent	Good	Excellent	Fair	Good
	Start	2018-08-29	66462	Excellent	Good	Excellent	Excellent	Excellent
	End	2018-10-02		Excellent	Good	Excellent	Excellent	Good
Joan Brook	Start	2018-06-07	62069	Excellent	Excellent	Excellent	NA	Excellent
	End	2018-07-12		Excellent	Good	Excellent	Excellent	Excellent
	Start	2018-07-12	66462	Excellent	Excellent	Excellent	Good	Marginal
	End	2018-08-08		Excellent	Good	Excellent	Good	Excellent
	Start	2018-08-09	66462	Excellent	Excellent	Excellent	Excellent	Excellent
	End	2018-09-06		Excellent	Excellent	Excellent	Excellent	Excellent

- Bath tests conducted in the winter of 2018 prior to the commencement of the field season showed that all sensors performed well for all instruments. The discrepancies between field instruments and QA/QC instruments for the 2018 field season were relatively minor and within the range normally experienced under rigorous field conditions.

Deployment Notes

- Mining Operations at TSMC’s DSO Project recommenced in May 2018 at Goodwood pit (Quebec) in Area 4. Run of Mine (ROM) was hauled to the processing plant (Plant 1) where the ore was crushed and sized before sending to Sept-Iles via rail. Mining operations ceased temporarily on July 31 due to a blockade established by the local community. Mining operations resumed on August 3 after peaceful issues resolution between TSMC and the local community. The Dryer was not operational until mid-August, which resulted in a large oversize stockpile. Due to poor Plant 1 and Dryer performance, mining operations from Goodwood pit ceased on September 17. Operations continued to process ore at Plant 1 and the Dryer until mid-November when the ROM and oversize stockpiles were depleted.
- Due to a very late spring thaw the 2018 field season at TSMC started quite late and ran from June 19th, 2018 until October 2nd, 2018, with three back-to-back deployment periods. There

were no significant operational issues with any of the equipment deployed during the 2018 field season.

- The Goodream Creek Station was not active for the 2018 season pending its move to a new location further downstream near Triangle Lake. It was hoped that this move would be completed in 2018, however this was not accomplished, and now it is planned for early in the 2019 field season.

Data Interpretation

- Performance issues and data records were interpreted for each station during the deployment period for the following six parameters:

  (i.) Stage (m)
  (ii.) Temperature (^{o}C)
  (iii.) pH
  (iv.) Specific conductivity (µs/cm)
  (v.) Dissolved oxygen (mg/l)
  (vi.) Turbidity (NTU)

- A description of each parameter is provided in Appendix B.

Stage

- Figures 4 and 5 display stage values recorded at the two stations from June 19th, 2018 to October 2nd, 2018. These values are provisional. A complete dataset of quality assured and quality controlled stage values should be available upon request through ECCC after March 2019 (http://www.ec.gc.ca/rhc-wsc/default.asp).
- Stage values ranged from 1.11 m to 1.34m at Elross Creek, and from 1.46 m to 1.61 at Joan Brook from June 19th, 2018 to October 2nd, 2018.
- Fluctuations in stage corresponded well with rainfall events (Climate data located in Appendix C). A good example of this can be seen at both stations around July 25th (see inside red ovals) when there was a significant spike in stage at both stations which was related to a major precipitation event of 46.1 mm on July 24th and July 25th.
- Stage values are based on a vertical reference that is unique to each station. As a result, absolute values of stage are not comparable between stations, but relative changes in stage are.

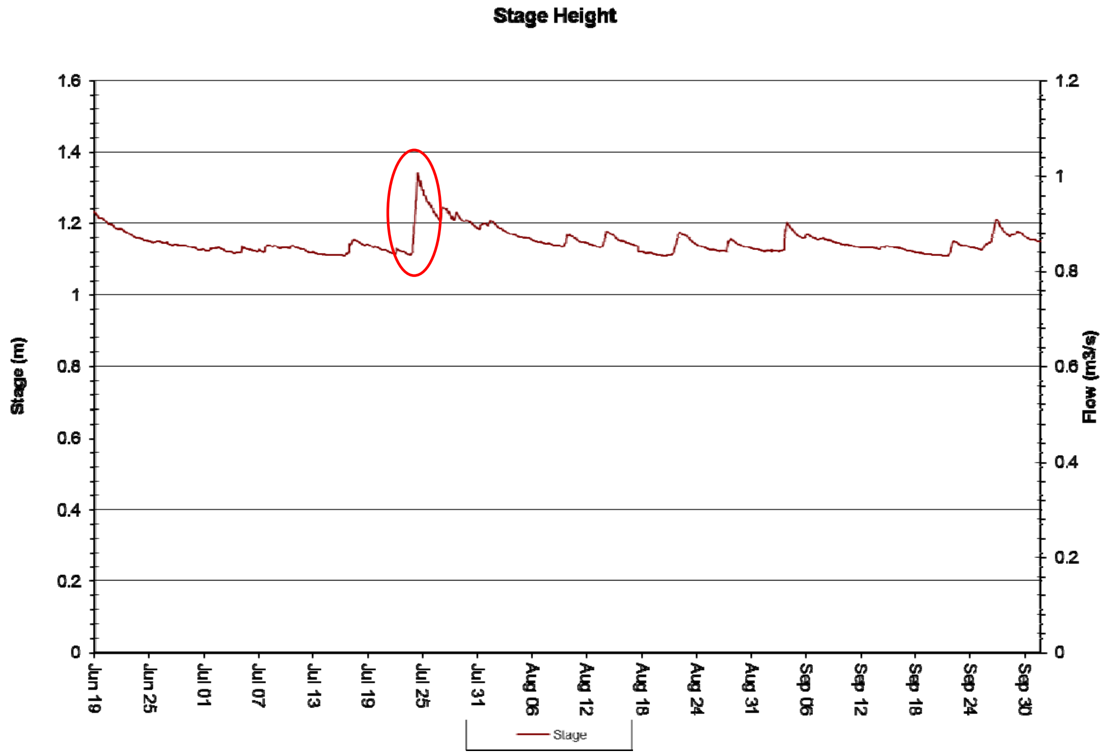

Figure 4. Elross Creek - Stage Height (m) - June 19, 2018 to October 2, 2018.

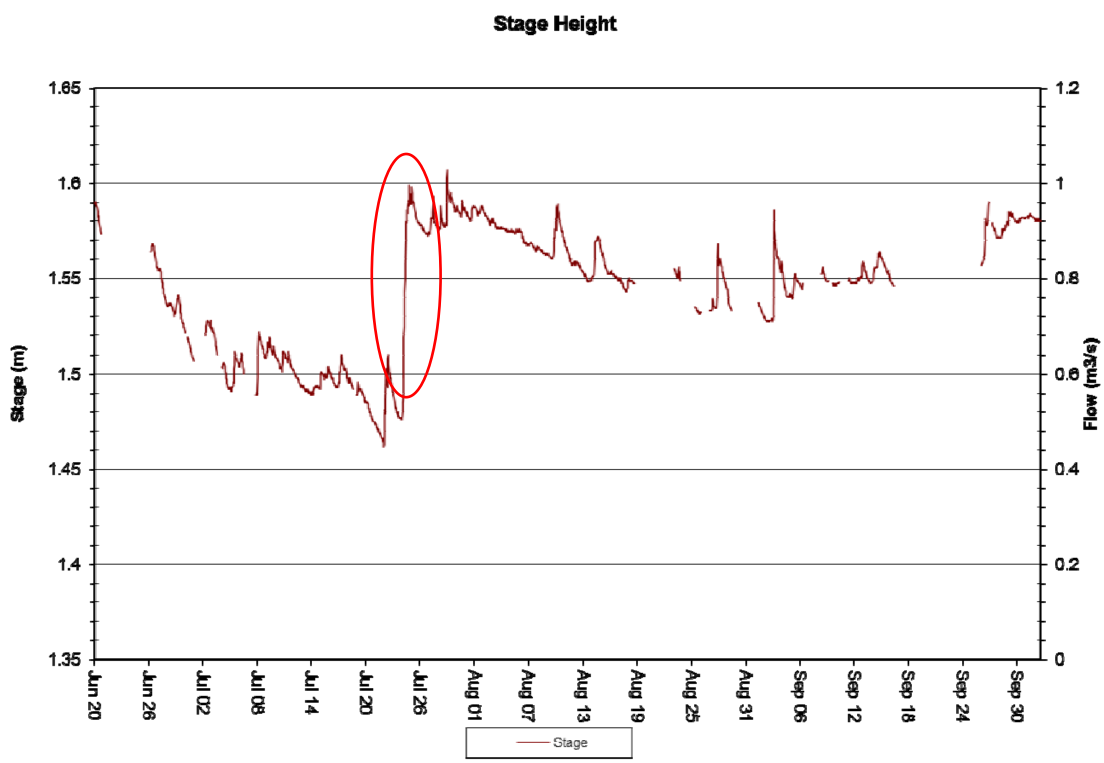

Figure 5. Joan Brook - Stage Height (m) - June 19, 2018 to October 2, 2018

Temperature

- Water temperature ranged from 0.70˚C to 16.60˚C at Elross Creek and from -0.01˚C to 16.10˚C at Joan Brook from June 19th, 2018 to October 2nd, 2018 (Figures 6 & 7).
- Water temperatures at both stations display large diurnal variations. This is typical of shallow water streams and ponds that are highly influenced by diurnal variations in ambient air temperatures.
- Trends in water temperature corresponded very well with trends in air temperatures, with increases from June through July and decreases after that as fall sets in.

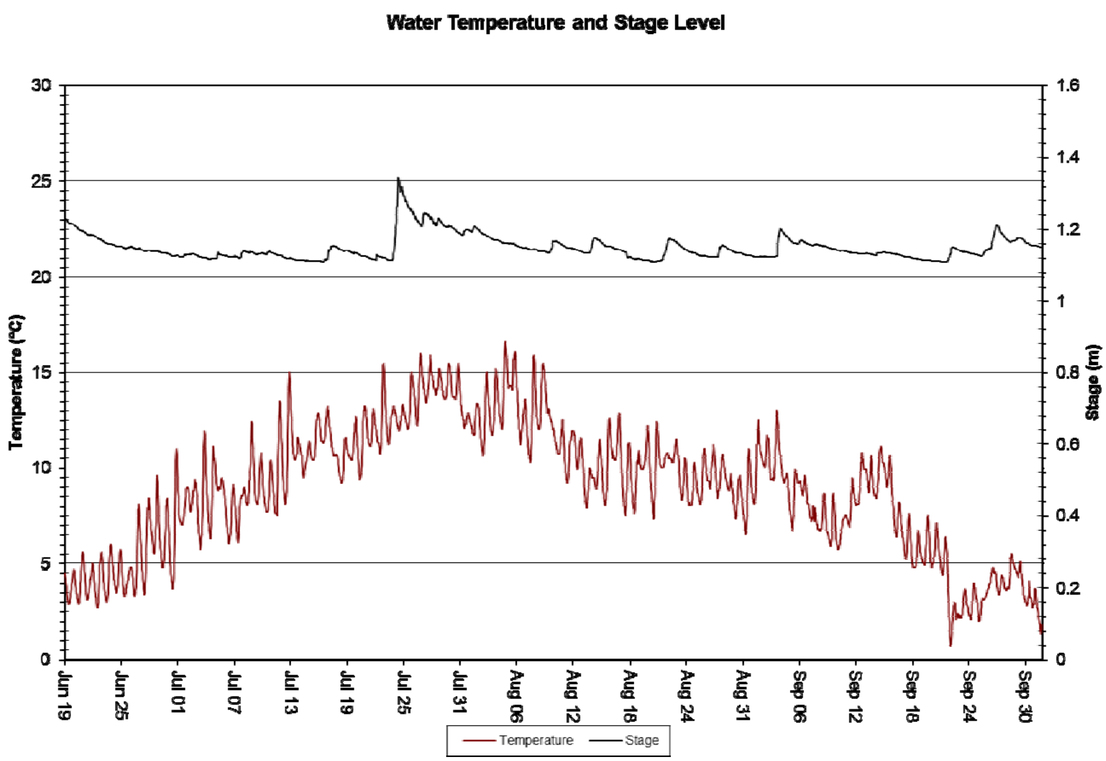

Figure 6. Elross Creek - Water Temperature (^oC) - June 19, 2018 to October 2, 2018

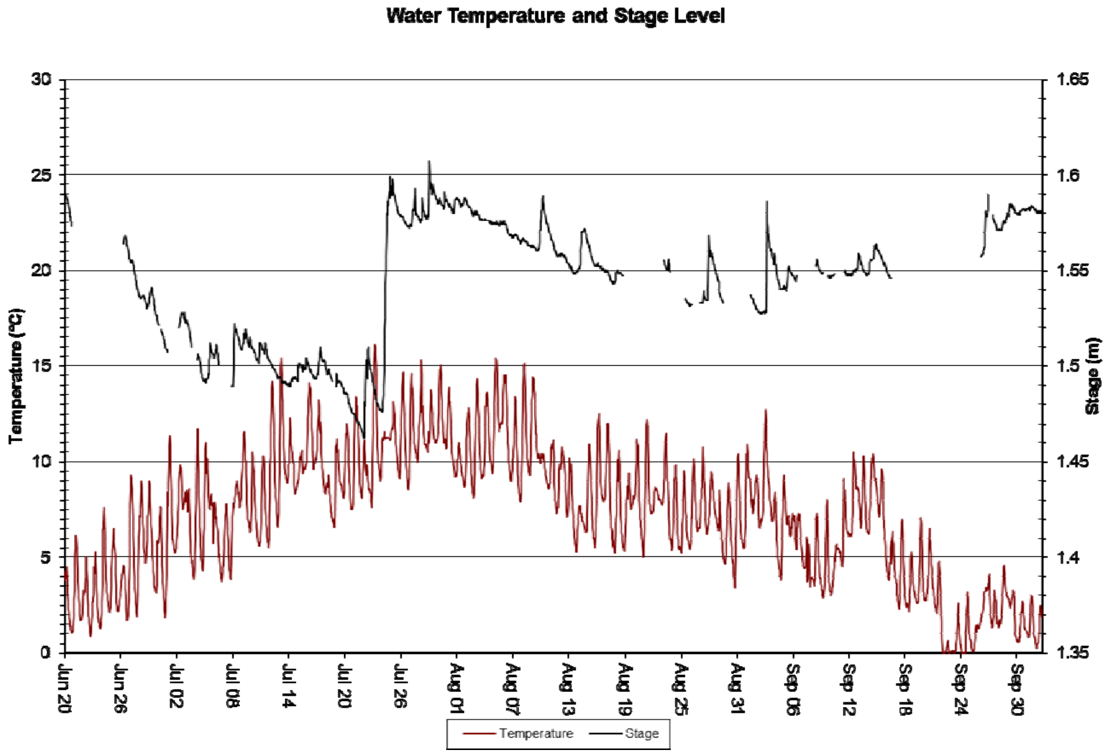

Figure 7. Joan Brook - Water Temperature (^{o}C) - June 19, 2018 to October 2, 2018

pH

- pH values ranged from 5.63 units to 7.11 units at Elross Creek and from 6.26 units to 6.78 units at Joan Brook, from June 19th, 2018 to October 2nd, 2018 (Figures 8 & 9).
- pH values show diurnal variations at both stations. These diurnal variations are related to diurnal fluctuations in temperature, oxygen and photosynthetic cycling of CO_2 by aquatic organisms.
- pH values at both Elross creek and Joan Brook (Figures 8 & 9) are relatively stable throughout the deployment season.
- With a median value of 6.46 most pH values recorded at Elross Creek were at, or very near, the minimum pH guideline set for the protection of aquatic life (i.e., 6.5 units), as defined by the Canadian Council of Ministers of the Environment (2007). At Joan Brook the median pH value was 6.57 and most of the pH values recorded were at or above the minimum pH guideline. In general low pH levels are considered normal for this area, based on baseline data collected around July 17-19, 2008 and September 10-12, 2008 (AMEC 2009, as cited in NML 2009). It should be noted that acidic waters are quite common in Canada, particularly in boreal and northern ecoregions, and pH is often naturally below the 6.5 unit guideline.

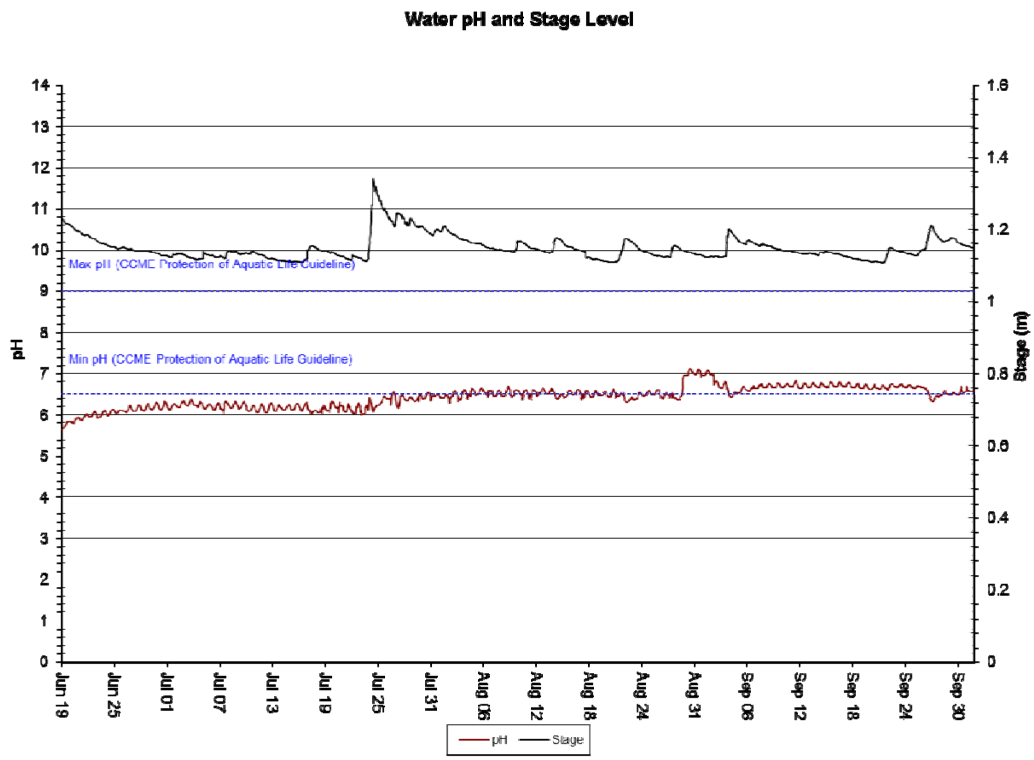

Figure 8. Elross Creek - pH Values - June 19, 2018 to October 2, 2018

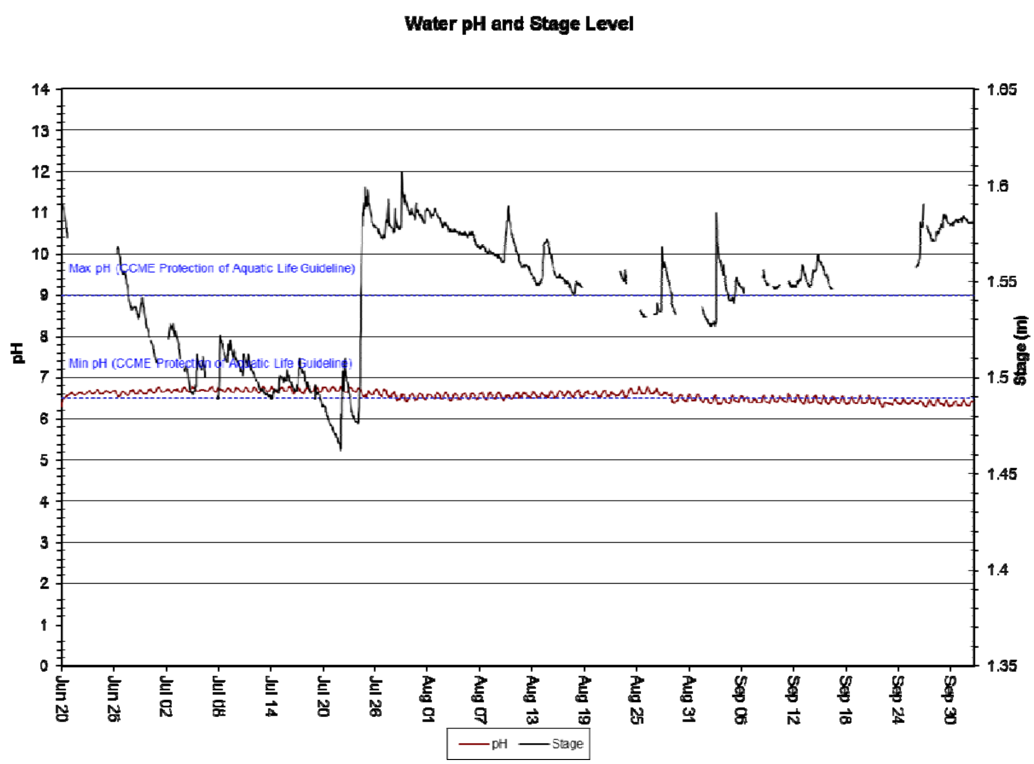

Figure 9. Joan Brook - pH Values – June 19, 2018 to October 2, 2018

Specific Conductivity

- Specific Conductivity ranged from 4.7 µs/cm to 19.9 µs/cm at Elross Creek and from 5.0 µs/cm to 10.2 µs/cm at Joan Brook, from June 19th, 2018 to October 2nd, 2018 (Figures 10 & 11).
- Specific conductivity is highly variable at both stations.
- Specific conductivity values at both stations showed regular diurnal fluctuations which are related to diurnal temperature fluctuations.
- At both Elross Creek and Joan Brook it is possible to see dips in specific conductivity which correspond with significant spikes in stage height and corresponding flow (see inside red ovals). During these high flow events the normal background specific conductivity is diluted by precipitation.

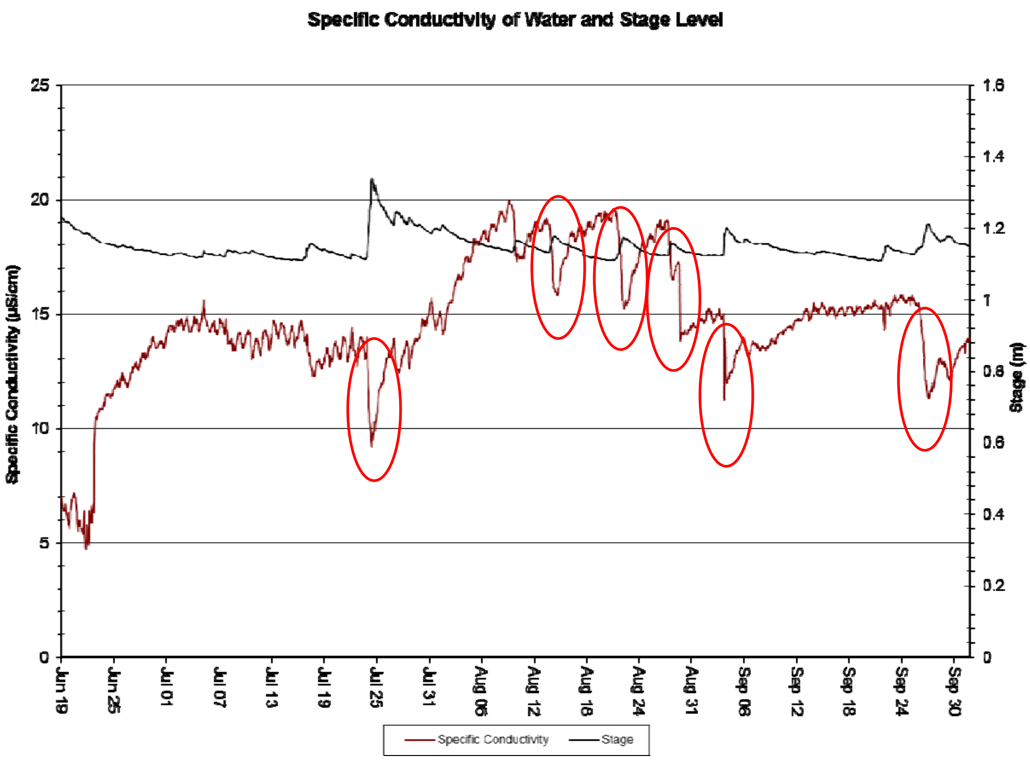

Figure 10. Elross Creek - Specific Conductivity (µS/cm) - June 19, 2018 to October 2, 2018

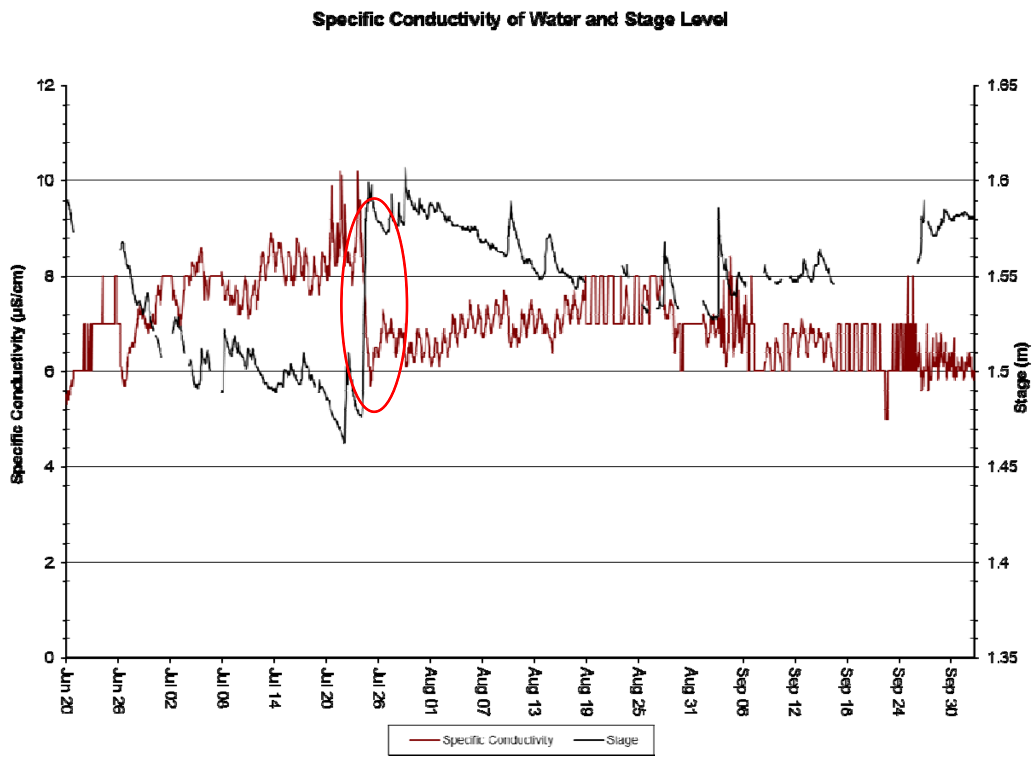

Figure 11. Joan Brook - Specific Conductivity (µS/cm) - June 19, 2018 to October 2, 2018

Dissolved Oxygen

- Dissolved Oxygen (DO) values ranged from 8.20 mg/l (82.2%) to 12.57 mg/l (100.4%) at Elross Creek and from 9.03 mg/l (90.3%) to 13.19 mg/l (101.8%) at Joan Brook, from June 19th, 2018 to October 2nd, 2018 (Figures 12 & 13).
- DO levels show diurnal variations at both stations. These diurnal variations are related to diurnal fluctuations in temperature and photosynthetic cycling of CO_2 by aquatic organisms.
- Trends in DO corresponded well with the inverse of water temperature, since colder water has a greater potential to dissolve oxygen compared to warmer water. As a result, DO is generally higher in the spring and fall when water temperatures are cooler.
- DO values at Elross Creek fell below cold water minimum guidelines set for aquatic life during early life stages (9.5 mg/l), but were above minimum guidelines set for other life stages (6.5 mg/l), as determined by the Canadian Council of Ministers of the Environment (2007). DO values at Joan Brook were at or above both guidelines.

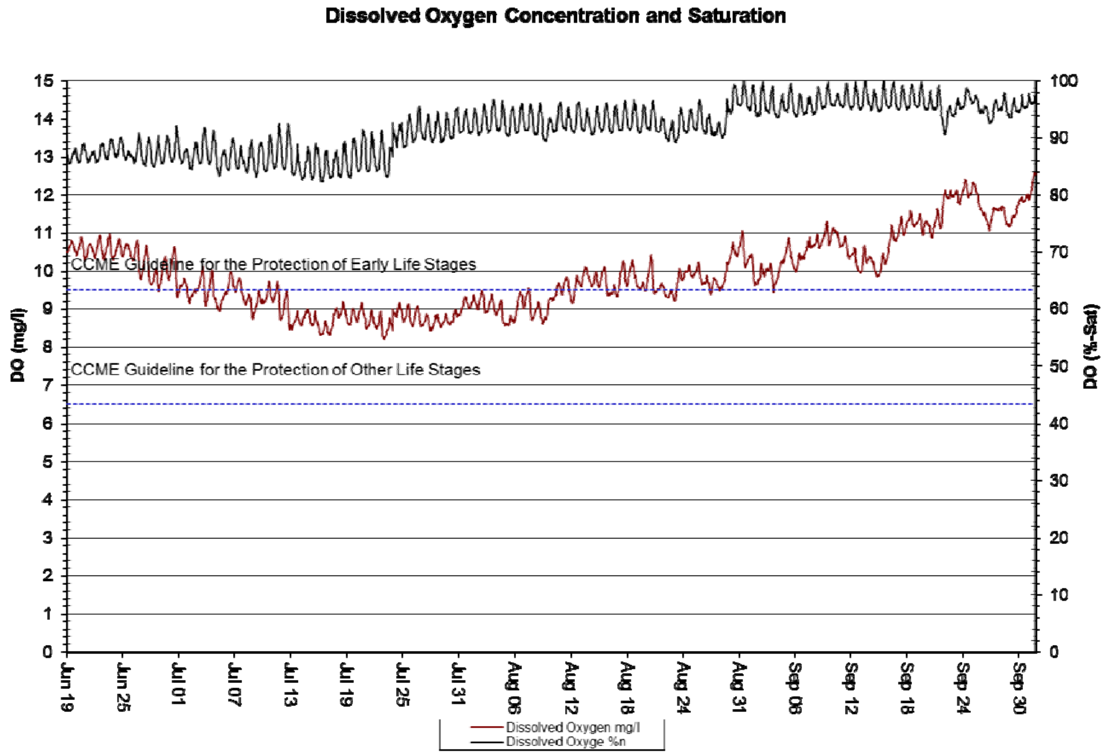

Figure 12. Elross Creek - Dissolved Oxygen (mg/l & %Saturation) – June 19, 2018 to October 2, 2018

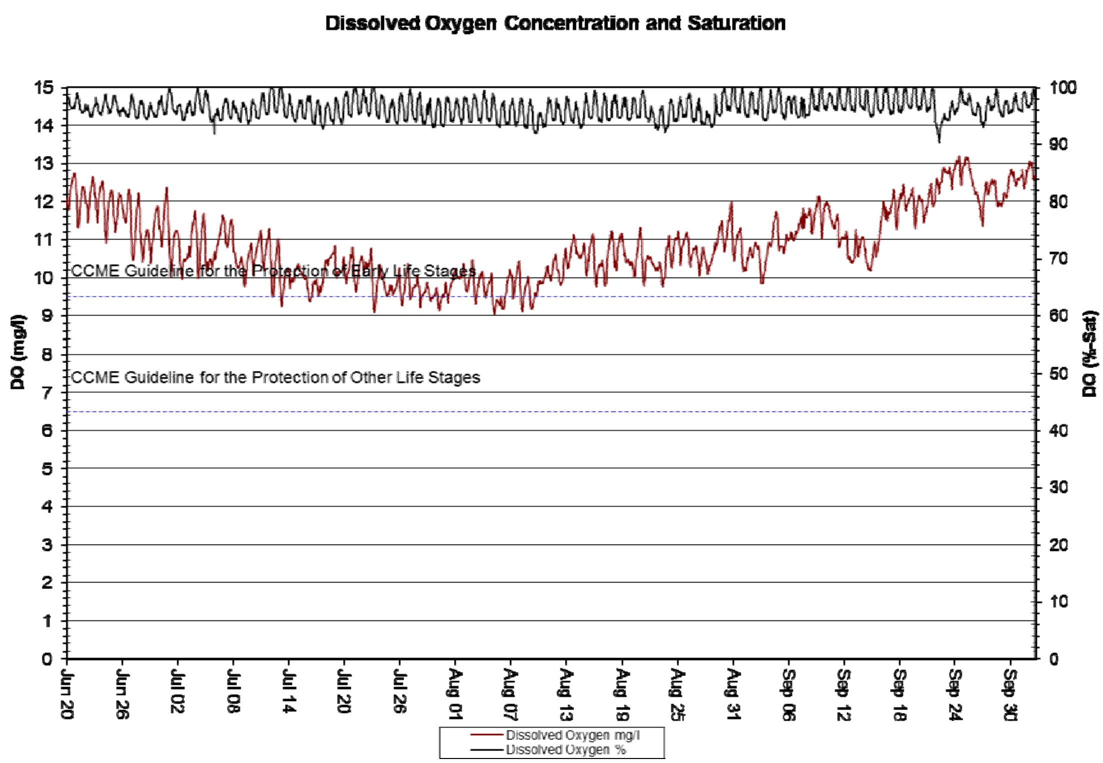

Figure 13. Joan Brook - Dissolved Oxygen (mg/l & % Saturation) - June 19, 2018 to October 2, 2018

Turbidity

- Turbidity values ranged from 3.0 NTU to 3000 NTU at Elross Creek and from 0.0 NTU to 2959.0 NTU at Joan Brook, from June 19th, 2018 to October 2nd, 2018 (Figures 14 & 15).
- For both stations significant spikes in turbidity correspond closely with significant increases in flow as indicated by stage height (see inside red ovals).

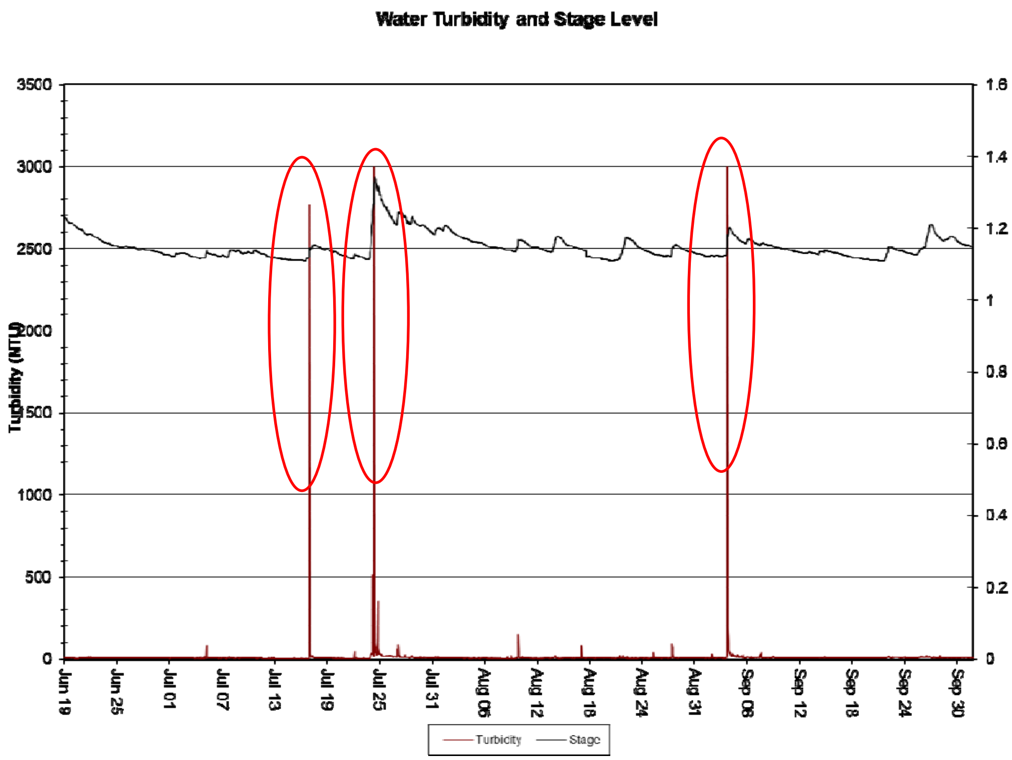

Figure 14. Elross Creek - Turbidity (NTU) - June 19, 2018 to October 2, 2018

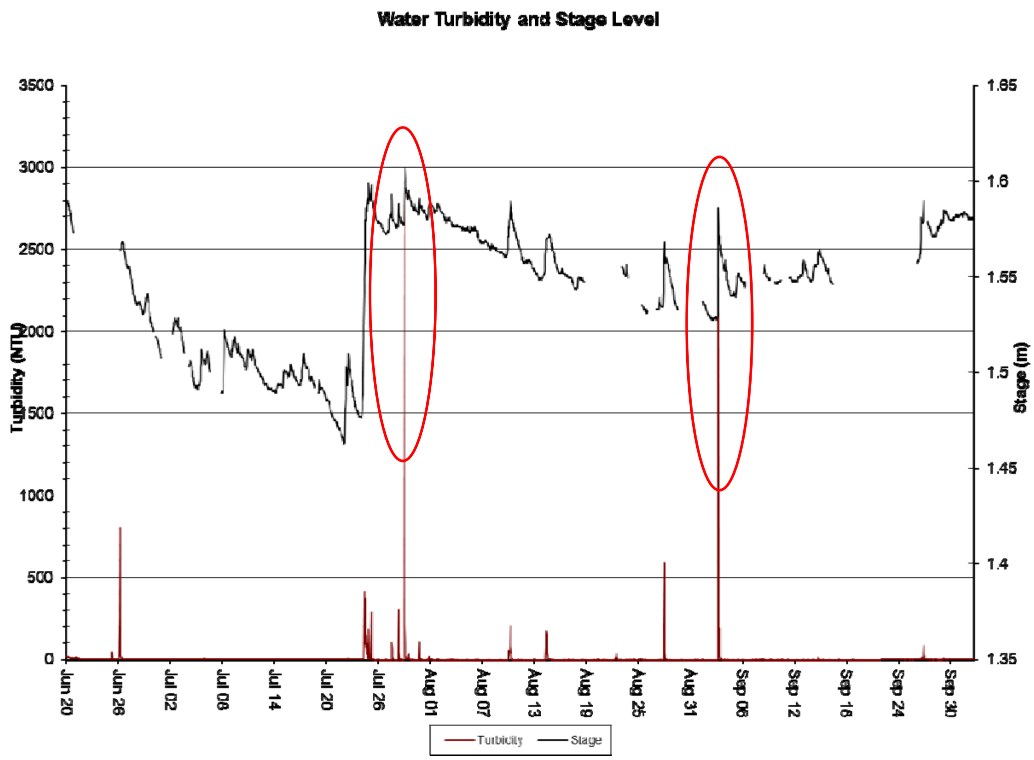

Figure 15. Joan Brook - Turbidity (NTU) - June 19, 2018 to October 2, 2018

Conclusions

- Water quality monitoring instruments were deployed at two stations near the Elross Lake and DSO4 Project 2B, Iron Ore Mine, between June 19th, 2018 and October 2nd, 2018. The stations are located on Elross Creek and Joan Brook.
- The water quality monitoring instruments were deployed for three consecutive deployment periods ranging from 34 to 36 days.
- The performance ratings of all instrument sensors ranged from marginal-to-excellent with the majority of rankings being "good" and "excellent" in 2018. There was one "Marginal" rating at the time when an instrument was installed at Joan Brook which was attributed to elevated and highly variable turbidity at the time of installation.
- Variations in water quality/quantity values recorded at each station are summarized below:

  - STAGE: Stage values ranged from 1.11 m to 1.34m at Elross Creek, and from 1.46 m to 1.61 at Joan Brook from June 19th, 2018 to October 2nd, 2018. Fluctuations in stage corresponded well with rainfall events.
  - WATER TEMPERATURE: Water temperature ranged from 0.70˚C to 16.60˚C at Elross Creek and from -0.01˚C to 16.10˚C at Joan Brook from June 19th, 2018 to October 2nd, 2018. Water temperatures at both stations display large diurnal variations. Trends in water temperature corresponded very well with trends in air temperatures, with increases from June through July and decreases after that as fall sets in.

- pH: pH values ranged from 5.63 units to 7.11 units at Elross Creek and from 6.26 units to 6.78 units at Joan Brook, from June 19th, 2018 to October 2nd, 2018. pH values show diurnal variations at both stations. pH values at both Elross creek and Joan Brook are relatively stable throughout the deployment season.
- SPECIFIC CONDUCTIVITY: Specific Conductivity ranged from 4.7 µs/cm to 19.9 µs/cm at Elross Creek and from 5.0 µs/cm to 10.2 µs/cm at Joan Brook, from June 19th, 2018 to October 2nd, 2018. Specific conductivity is highly variable at both stations. Specific conductivity values at both stations showed regular diurnal fluctuations which are related to diurnal temperature fluctuations.
- DISSOLVED OXYGEN: Dissolved Oxygen (DO) values ranged from 8.20 mg/l (82.2%) to 12.57 mg/l (100.4%) at Elross Creek and from 9.03 mg/l (90.3%) to 13.19 mg/l (101.8%) at Joan Brook, from June 19th, 2018 to October 2nd, 2018. DO levels show diurnal variations at both stations. Trends in DO corresponded well with the inverse of water temperature, since colder water has a greater potential to dissolve oxygen compared to warmer water. As a result DO is generally higher in the spring and fall when water temperatures are cooler.
- TURBIDITY: Turbidity values ranged from 3.0 NTU to 3000 NTU at Elross Creek and from 0.0 NTU to 2959.0 NTU at Joan Brook, from June 19th, 2018 to October 2nd, 2018. For both stations significant spikes in turbidity correspond closely with significant increases in flow as indicated by stage height

Path Forward

- MAE staff will redeploy RTWQ instruments at Elross Creek and Joan Brook in the spring of 2018, when ice conditions allow. The field season will be broken down into four, month long deployment periods, and MAE staff will perform regular site visits for calibration and maintenance of the instruments.
- MAE staff will continue to work co-operatively with TSMC staff to co-ordinate the relocation of the Goodream Creek Station to a new monitoring location further downstream on Goodream Creek above Triangle Lake. An instrument will be redeployed at the new Goodream Creek location as soon as possible in the 2019 field season once the new station hut is installed.
- MAE staff will continue to rely on input and assistance from TSMC staff in the operation and maintenance of all three TSMC Real Time Water Quality stations at Elross Creek, Goodream Creek and Joan Brook. Every effort will be made to coordinate in advance with TSMC staff for site visits during the 2019 field season. MAE staff are very appreciative of the field assistance provided by TSMC staff during the 2018 field season and are hoping to carry on with this arrangement again next year.
- If necessary, deployment techniques will be evaluated and adapted to each site, ensuring secure and suitable conditions for RTWQ monitoring.
- MAE staff will update TSMC staff on any changes to processes and procedures with handling, maintaining and calibrating the real-time instruments.

- ECCC staff will perform regular site visits to ensure water quantity instrumentation is correctly calibrated and providing accurate measurements.
- Parameter alerts will be set prior to the 2019 deployment season to notify MAE staff by email of any emerging water quality issues.
- TSMC will continue to be informed of data trends and any significant water quality events in the form of email and/or monthly deployment reports, when the deployment season begins. TSMC will also receive an annual report, summarizing the events of the deployment season.
- MAE has begun development of models using water quality monitoring data and grab sample data to estimate a variety of additional water quality parameters (e.g., TSS and major ions). This work will continue with a goal in implementing these models for RTWQ data collected.
- MAE will continue to work on its Automatic Data Retrieval System, to incorporate new capabilities in data management and data display.
- MAE will be active in creating new value added products using the RTWQ data and water quality indices.
- Open communication will continue to be maintained between MAE, ECCC and TSMC employees involved with the agreement, in order to respond to emerging issues on a proactive basis.

References

Allan, D. (2010). Advanced Water Quality Instrumentation Training Manual. Edmonton, AB: Allan Environmental Services Inc. (pp. 160).

AMEC, 2009, Fish and Fish Habitat Investigation for the Direct-Shipping Ore Project. Report No. TF 8165902. Submitted to Groupe Hémisphères for New Millennium Capital Corp.

Canadian Council of Ministers of the Environment. 2007. Canadian water quality guidelines for the protection of aquatic life: Summary table. Updated December, 2007. In: Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg. (Website: http://ceqg-rcqe.ccme.ca/download/en/222/)

Hach (2006) Important water quality factors - H2O University. Hach Company. Online: http://www.h2ou.com/index.htm (accessed August 24, 2010).

NML, 2009, Elross Lake Area Iron Ore Mine, Environmental Impact Statement, submitted to Government of Newfoundland and Labrador, December 2009. Online: http://www.env.gov.nl.ca/env/env_assessment/projects/Y2010/1380/nml_pfwa_eis_for_gnl_december_2009.pdf (accessed October 12, 2012).

Swanson, H.A., and Baldwin, H.L., 1965. A Primer on Water Quality, U.S. Geological Survey. Online: http://ga.water.usgs.gov/edu/characteristics.html (accessed August 24, 2010)

APPENDIX A
Quality Assurance / Quality Control Procedures

- As part of the Quality Assurance / Quality Control (QA/QC) protocol, the performance of a station's water quality instrument (i.e., Field Sonde) is rated at the start and end of its deployment period. The procedure is based on the approach used by the United States Geological Survey (Wagner *et al.* 2006)[1].
- At the start of the deployment period, a fully cleaned and calibrated QA/QC water quality instrument (i.e., QA/QC Sonde) is placed *in-situ* with the fully cleaned and calibrated Field Sonde. After Sonde readings have stabilized, which may take up to five minutes in some cases, water quality parameters, as measured by both Sondes, are recorded to a field sheet. Field Sonde performance for all parameters is rated based on differences recorded by the Field Sonde and QA/QC Sonde. If the readings from both Sondes are in close agreement, the QA/QC Sonde can be removed from the water. If the readings are not in close agreement, there will be attempts to reconcile the problem on site (e.g., removing air bubbles from sensors, etc.). If no fix is made, the Field Sonde may be removed for recalibration.
- At the end of the deployment period, a fully cleaned and calibrated QA/QC Sonde is once again deployed *in-situ* with the Field Sonde, which has already been deployment for 30-40 days. After Sonde readings have stabilized, water quality parameters, as measured by both Sondes, are recorded to a field sheet. Field Sonde performance for all parameters is rated based on differences recorded by the Field Sonde and QA/QC Sonde.
- Performance ratings are based on differences listed in the table below.

	Rating				
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 ≤ 35 (µS/cm)	≤ ±3	> ±3 to 10	> ±10 to 15	> ±15 to 20	> ±20
Sp. Conductance > 35 (�S/cm)	≤ ±3	> ±3 to 10	> ±10 to 15	> ±15 to 20	> ±20
Dissolved Oxygen (mg/l)	≤ ±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 (NTU)	≤ ±5	> ±5 to 10	> ±10 to 15	> ±15 to 20	> ±20

[1] Wagner, R.J., Boulger, R.W., Jr., Oblinger, C.J., and Smith, B.A., 2006, Guidelines and standard procedures for continuous water-quality monitors—Station operation, record computation, and data reporting: U.S. Geological Survey Techniques and Methods 1–D3, 51 p. + 8 attachments; accessed April 10, 2006, at *http://pubs.water.usgs.gov/tm1d3*

APPENDIX B
Water Parameter Description

Dissolved Oxygen - The amount of Dissolved Oxygen (DO) (mg/l) in the water is vital to aquatic organisms for their survival. The concentration of DO is affected by such things as water temperature, water depth and flow (e.g., aeration by rapids, riffles etc.), consumption by aerobic organisms, consumption by inorganic chemical reactions, consumption by plants during darkness, and production by plants during the daylight (Allan 2010).

pH - pH is the measure of hydrogen ion activity and affects: (i) the availability of nutrients to aquatic life; (ii) the concentration of biochemical substances dissolved in water; (iii) the efficiency of hemoglobin in the blood of vertebrates; and (iv) the toxicity of pollutants. Changes in pH can be attributed to industrial effluence, saline inflows or aquatic organisms involved in the photosynthetic cycling of CO_2 (Allan 2010).

Specific conductivity - Specific conductivity (S/cm) is a measure of water's ability to conduct electricity, with values normalized to a water temperature of 25ºC. Specific conductance indicates the concentration of dissolved solids (such as salts) in the water, which can affect the growth and reproduction of aquatic life. Specific conductivity is affected by rainfall events, the composition of inflowing tributaries and their associated geology, saline inflow (e.g., road salt), agricultural run-off and industrial inputs (Allan 2010; Swanson and Baldwin 1965).

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

Temperature - Essential to the measurement of most water quality parameters, temperature (^{o}C) controls most processes and dynamics of limnology. Water temperature is influenced by such things as ambient air temperature, solar radiation, meteorological events, industrial effluence, wastewater, inflowing tributaries, as well as water body size and depth (Allan 2010; Hach 2006).

Total Dissolved Solids - Total Dissolved Solids (TDS) (g/l) is a measure of alkaline salts dissolved in water or in fine suspension and can affect the growth and reproduction of aquatic life. It is affected by rainfall events, the composition of inflowing tributaries and their associated geology, saline inflow (e.g., road salt), agricultural run-off and industrial inputs (Allan 2010; Swanson and Baldwin 1965).

Turbidity - Turbidity (NTU) is a measure of the translucence of water and indicates the amount of suspended material in the water. Turbidity is caused by any substance that makes water cloudy (e.g., soil erosion, micro-organisms, vegetation, chemicals, etc.) and can correspond to precipitation events, high stage, and floating debris near the sensor (Allan 2010; Hach 2006; Swanson and Baldwin 1965).

APPENDIX C

Environment Canada Weather Data - Schefferville (June 18, 2018 to Oct.2, 2018)

Date/Time	Max Temp (°C)	Min Temp (°C)	Mean Temp (°C)	Heat Deg Days (°C)	Cool Deg Days (°C)	Total Precip (mm)
6/18/2018	13.3	7.7	10.5	7.5	0	4.5
6/19/2018	8.9	0.4	4.7	13.3	0	1.4
6/20/2018	6.9	-0.1	3.4	14.6	0	3.7
6/21/2018	10	0.4	5.2	12.8	0	0.6
6/22/2018	11.4	1.4	6.4	11.6	0	2.3
6/23/2018	8.9	0.2	4.6	13.4	0	0
6/24/2018	8	1	4.5	13.5	0	1
6/25/2018	10.5	2.5	6.5	11.5	0	0
6/26/2018	11.6	2.7	7.2	10.8	0	2.8
6/27/2018	12.7	0.5	6.6	11.4	0	0.5
6/28/2018	16.8	-0.7	8.1	9.9	0	1.5
6/29/2018	18.5	1.7	10.1	7.9	0	0.2
6/30/2018	12.1	-0.6	5.8	12.2	0	0.8
7/1/2018	18.5	-2.2	8.2	9.8	0	0
7/2/2018	19.9	8.7	14.3	3.7	0	2.8
7/3/2018	16.8	7.8	12.3	5.7	0	0
7/4/2018	17.5	4.1	10.8	7.2	0	0
7/5/2018	17.7	2.1	9.9	8.1	0	10.6
7/6/2018	15.1	9	12.1	5.9	0	
7/7/2018	12.6	3.7	8.2	9.8	0	4.6
7/8/2018	17.7	4.8	11.3	6.7	0	8.7
7/9/2018	22.6	7	14.8	3.2	0	3.8
7/10/2018	12.4	6.2	9.3	8.7	0	5.4
7/11/2018	13.2	5.1	9.2	8.8	0	6.3
7/12/2018	20.7	4.6	12.7	5.3	0	0
7/13/2018	25.6	6.3	16	2	0	0
7/14/2018	18.9	13.7	16.3	1.7	0	0.4
7/15/2018	19.2	13.1	16.2	1.8	0	0.6
7/16/2018	22.8	16.5	19.7	0	1.7	1.9
7/17/2018	22	11	16.5	1.5	0	14.6
7/18/2018	11.6	7.6	9.6	8.4	0	5.4
7/19/2018	18.3	7.3	12.8	5.2	0	4.4
7/20/2018	17.1	6.7	11.9	6.1	0	2.3
7/21/2018	21.1	5.3	13.2	4.8	0	0

Date/Time	Max Temp (°C)	Min Temp (°C)	Mean Temp (°C)	Heat Deg Days (°C)	Cool Deg Days (°C)	Total Precip (mm)
7/23/2018	22.9	10.1	16.5	1.5	0	0
7/24/2018	20.8	12.9	16.9	1.1	0	29
7/25/2018	16.6	11.5	14.1	3.9	0	17.1
7/26/2018	19.7	9.7	14.7	3.3	0	1
7/27/2018	22.7	9.4	16.1	1.9	0	7.3
7/28/2018	20.8	11.2	16	2	0	2
7/29/2018	21	13.8	17.4	0.6	0	3.5
7/30/2018	20.8	14	17.4	0.6	0	7.4
7/31/2018	17.9	9.8	13.9	4.1	0	0.6
8/1/2018	11.8	7.7	9.8	8.2	0	12.9
8/2/2018	15.2	7.4	11.3	6.7	0	9.6
8/3/2018	21.2	7.3	14.3	3.7	0	0
8/4/2018	21.4	10.3	15.9	2.1	0	0
8/5/2018	27.4	11.7	19.6	0	1.6	2.5
8/6/2018	23	8.4	15.7	2.3	0	0
8/7/2018	14.7	4.4	9.6	8.4	0	0
8/8/2018	22	3.5	12.8	5.2	0	0
8/9/2018	23.5	12.3	17.9	0.1	0	0
8/10/2018	14	8.3	11.2	6.8	0	33.3
8/11/2018	13.9	5.1	9.5	8.5	0	1.4
8/12/2018	19.3	6.4	12.9	5.1	0	0.2
8/13/2018	11.7	2.9	7.3	10.7	0	0
8/14/2018	10.2	1.3	5.8	12.2	0	22.8
8/15/2018	13.4	2.5	8	10	0	0.2
8/16/2018	17.4	1.6	9.5	8.5	0	0
8/17/2018	16.4	5	10.7	7.3	0	0
8/18/2018	15	3.7	9.4	8.6	0	0
8/19/2018	18.7	4.5	11.6	6.4	0	0
8/20/2018	18.5	5.7	12.1	5.9	0	0
8/21/2018	16.3	1.4	8.9	9.1	0	3.9
8/22/2018	13.2	8.9	11.1	6.9	0	47.5
8/23/2018	17.4	3.2	10.3	7.7	0	4
8/24/2018	11.6	2.2	6.9	11.1	0	0
8/25/2018	13.2	4	8.6	9.4	0	0
8/26/2018	14	5.3	9.7	8.3	0	0
8/27/2018	18.7	6.1	12.4	5.6	0	2.1
8/28/2018	18.7	6.7	12.7	5.3	0	14.4

Date/Time	Max Temp (°C)	Min Temp (°C)	Mean Temp (°C)	Heat Deg Days (°C)	Cool Deg Days (°C)	Total Precip (mm)
8/30/2018	9.9	1.8	5.9	12.1	0	0.3
8/31/2018	14.8	-0.1	7.4	10.6	0	0
9/1/2018	21.3	10.4	15.9	2.1	0	1.6
9/2/2018	15.7	7	11.4	6.6	0	0.7
9/3/2018	23.2	9.2	16.2	1.8	0	16.7
9/4/2018	10.4	3	6.7	11.3	0	0.6
9/5/2018	11.2	0.1	5.7	12.3	0	7.4
9/6/2018	11.5	3.4	7.5	10.5	0	1.8
9/7/2018	7.6	0	3.8	14.2	0	4.1
9/8/2018	9	0.2	4.6	13.4	0	0.4
9/9/2018	8.5	-0.1	4.2	13.8	0	0.2
9/10/2018	13	3.2	8.1	9.9	0	0.4
9/11/2018	17	8	12.5	5.5	0	0
9/12/2018		11				
9/13/2018	14.6	6.3	10.5	7.5	0	1.2
9/14/2018	21.8	8.6	15.2	2.8	0	4.3
9/15/2018	13.1	0.3	6.7	11.3	0	1.1
9/16/2018	6.1	-0.5	2.8	15.2	0	
9/17/2018	4.4	-1.9	1.3	16.7	0	0
9/18/2018	2.5	-0.8	0.9	17.1	0	0
9/19/2018	7.4	-0.9	3.3	14.7	0	0
9/20/2018	10.3	-0.1	5.1	12.9	0	2.3
9/21/2018	3.4	-1	1.2	16.8	0	4.2
9/22/2018	0.6	-3.6	-1.5	19.5	0	14.7
9/23/2018	0.9	-3.1	-1.1	19.1	0	0.9
9/24/2018	1.8	-3.5	-0.9	18.9	0	1
9/25/2018	4.7	-3.7	0.5	17.5	0	9.7
9/26/2018	11.8	1.9	6.9	11.1	0	
9/27/2018	4.7	0.3	2.5	15.5	0	
9/28/2018	9.4	1.9	5.7	12.3	0	
9/29/2018	5.2	-1.4	1.9	16.1	0	4.9
9/30/2018	3.8	-1.2	1.3	16.7	0	0.5
10/1/2018	3	-3.7	-0.4	18.4	0	1.2
10/2/2018	0.9	-5.7	-2.4	20.4	0	0