Real Time Water Quality Report

Tata Steel Minerals Canada
Elross Lake Network

Annual Deployment Report 2013

2013-06-04 to 2013-10-08

Government of Newfoundland & Labrador
Department of Environment and Conservation
Water Resources Management Division
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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 Canada (EC), and the Newfoundland & Labrador Department of Environment & Conservation (ENVC). Managers and program leads from each organization, namely Loic Didillon (TSMC), Renee Paterson (ENVC), and Howie Wills (EC), 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 ENVC and EC staff with fieldwork operations, transportation, food, accommodations, and equipment storage. TSMC employees who were helpful in this regard included Loic Didillon, Natasha Poole, and, Andrew McIntee.

EC plays an essential role in the data logging/communication aspect of the network. In particular, EC staff of the Water Survey of Canada, including Brent Ruth, 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. EC also plays the lead role in dealing with stage and flow issues.

ENVC is responsible for recording and managing water quality data. Ian Bell, under the supervision of Renee Paterson, is ENVC'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. Keith Abbott, who had operated the TSMC real-time network in previous years, offered assistance and advice during the 2013-14 season. Instrument performance evaluation and repairs, during the winter of 2012-2013, were conducted in-house by Ryan Pugh.

Introduction

- An agreement was signed on April 18, 2011, between the Newfoundland & Labrador Department of Environment & Conservation (ENVC) 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.
- The official name of each station is ELROSS CREEK BELOW PINETTE LAKE INFLOW and GOODREAM CREEK 2KM NORTHWEST OF TIMMINS 6, hereafter referred to as the *Elross Creek Station* and the *Goodream Creek Station*, respectively (Figure 1).

a. Elross Creek Station b. Goodream Creek Station

Figure 1. RTWQ stations are located alongside (a) Elross Creek and (b) Goodream Creek.

- 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 the Elross Creek Station and Goodream Creek Station components.

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

- Station sites were selected to monitor all surface water outflows from the Elross Lake mining site (Figure 2).
- The Elross Creek Station monitors surface water downstream of the Timmins 1 pit, and downstream of Pinette Lake.
- The Goodream Creek Station monitors potential impacts from groundwater flowing from Timmins 6 pit into the surface water of Goodream Creek.
- The 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.
- 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 late-May to mid-October, when streams are ice-free. ENVC is responsible for collecting and managing this dataset.
- Stage is recorded year-round on an hourly basis. EC is responsible for collecting and managing this dataset.
- EC 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, ENVC, and EC, 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.
- ENVC 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 and Goodream Creek stations from June 4, 2013 to October 8, 2013.

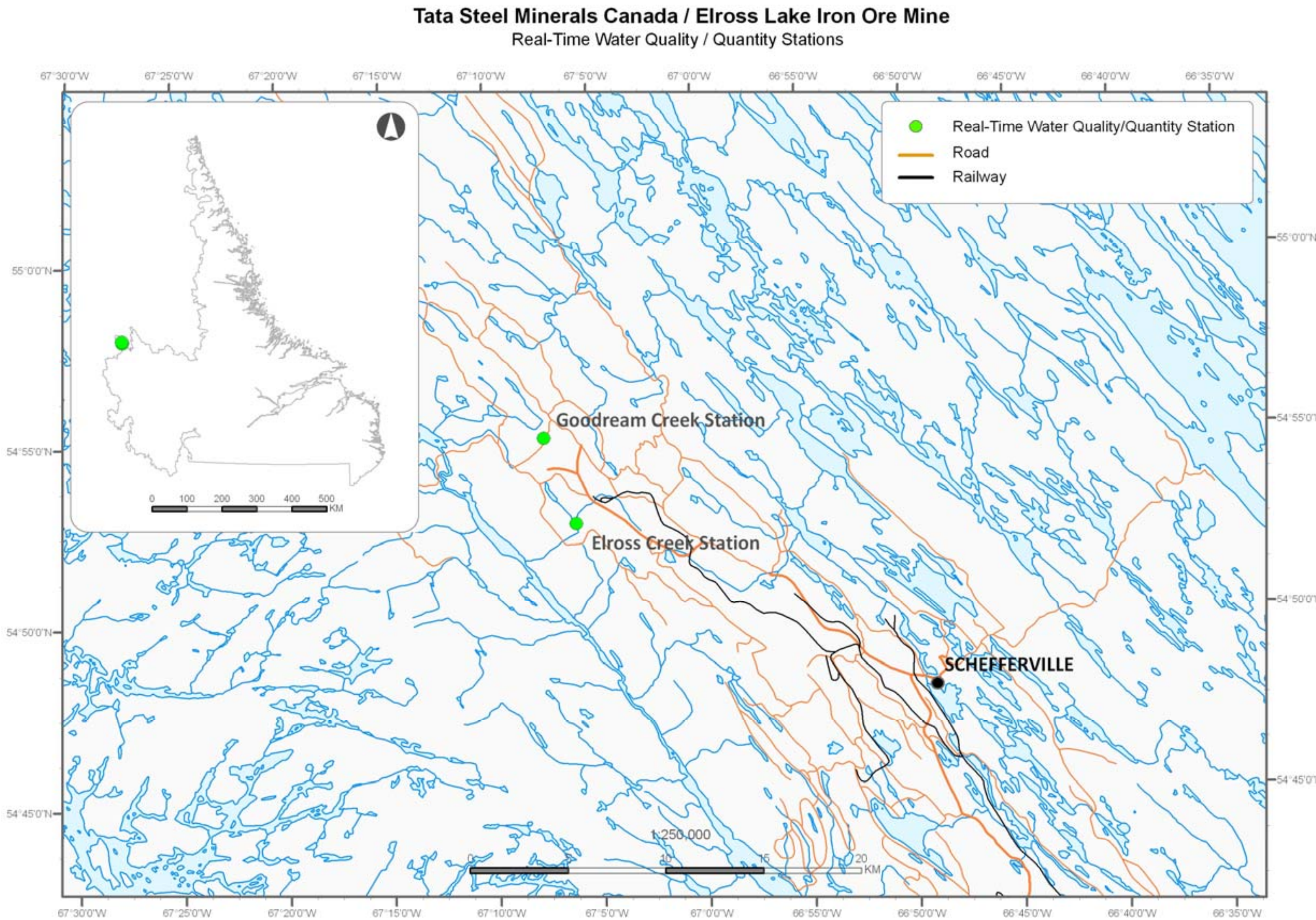

Figure 2. Map of real-time water quality/quantity stations in the vicinity of Elross Lake Iron Ore Mine in Western Labrador.

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)[1].
- Quality assurance procedures are carried out every 27-35 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 2013 at Elross Creek and Goodream Creek.

Station	Start date	End date	Duration (days)	Instrument
Elross Creek	2013-06-04	2013-07-03	29	62069
	2013-07-03	2013-08-07	35	62069
	2013-08-07	2013-09-11	35	62068
	2013-09-11	2013-10-08	27	62065
Goodream Creek	2013-06-04	2013-07-03	29	62065
	2013-07-03	2013-08-07	35	*
	2013-08-07	2013-09-11	35	62065
	2013-09-11	2013-10-08	27	62068

***The Goodream Creek hydrolab could not be deployed due to extreme low flow conditions**

[1] By design, the DataSonde temperature sensor cannot be calibrated using Hydras 3LT software; it is a factory calibration.

- As part of 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 Goodream Creek. Based on quality control procedures, instrument sensor performance ranged from fair-to-excellent with the majority of rankings being "good" and "excellent" in 2013.

Table 3. Instrument sensor performance at the start and end of each deployment period for the Elross Creek and Goodream Creek 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	2013-06-04	62069	Excellent	Good	Excellent	Excellent	Good
	End	2013-07-03		Good	Excellent	Good	Excellent	Excellent
	Start	2013-07-03	62069	Fair	Excellent	Good	Excellent	Excellent
	End	2013-08-07		Excellent	Excellent	Excellent	Excellent	Excellent
	Start	2013-08-07	62068	Excellent	Excellent	Excellent	Excellent	Excellent
	End	2013-09-11		Excellent	Excellent	Excellent	Good	Good
	Start	2013-09-11	62068	Excellent	Excellent	Excellent	Good	Fair
	End	2013-10-08		Excellent	Good	Excellent	Fair	Excellent
Goodream Creek	Start	2013-06-04	62065	Excellent	Excellent	Excellent	Excellent	Excellent
	End	2013-07-03		Good	Excellent	Excellent	Fair	Excellent
	Start	2013-07-03	*					
	End	2013-08-07						
	Start	2013-08-07	62065	Excellent	Excellent	Excellent	Excellent	Excellent
	End	2013-09-11		Fair	Good	Excellent	Excellent	Excellent
	Start	2013-09-11	62065	Excellent	Good	Excellent	Excellent	Excellent
	End	2013-10-08		Excellent	Good	Excellent	Good	Excellent

*The Goodream Creek hydrolab could not be deployed due to extreme low flow conditions

- The temperature sensor at the Elross Creek station was given a fair performance rating at the beginning of the second deployment. It should be noted that the actual temperature difference between the two probes was only 0.61 ^{0}C.
- The turbidity sensor at Elross Creek was given a fair performance rating at the beginning of fourth deployment period. At the time of the deployment the field sonde was reading 32.7 NTU and the QA/QC sonde was reading 39.5 NTU. When a small stream has these relatively high levels of turbidity, readings are often highly variable from one minute to the next, as well as from one location in the stream to other nearby locations. With highly variable turbidity levels it is often difficult to get close comparison readings between a field and QA/QC sonde.

- The dissolved oxygen sensor at Elross Creek received a fair performance rating at the end of the fourth deployment period. It is possible that the moderate level of turbidity during the deployment led to sediment deposition on the oxygen sensor which contributed to it drifting off calibration over the deployment period.
- The dissolved oxygen sensor at Goodream Creek received a fair performance rating at the end of the first deployment period. At the end of the first deployment period the flow in Goodream Creek was critically low which could have affected the performance of oxygen sensor.
- The temperature sensor at the Goodream Creek station was given a fair performance rating at the end of the third deployment. It should be noted that the actual temperature difference between the two probes was only 0.53 ^{0}C.
- Bath tests conducted in February of 2013 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 2013 field season were relatively minor and within the range normally experienced under rigours field conditions.

Deployment Notes

- Mining operations were active during the entire 2013 field season starting May 12th , 2013, in Flemming 7 with overburden removal , then waste and ore removal up until around Aug 5th, 2013. Material was moved from Timmons 4 stockpiles between July 23 and July 30th. Operations moving waste out of Timmons 4 started on August 3rd then switched to ore movement on Aug 5th, which continued until mining/crushing operations finished for the season on October 23rd, 2013.
- During the second deployment period, from July 3rd, 2013 to August 7th, 2013, it was not possible to install a DataSonde at the Goodream Creek Station due to extremely low flow conditions which meant it was impossible to submerse the instrument in flowing water.
- During the second deployment period, from July 3rd, 2013 to August 7th, 2013, the oxygen sensor at the Elross Creek deployment experienced technical difficulties and was not reading accurately for much of the deployment period.
- There were no significant issues with transmission errors or lost transmission records during the four deployment periods making up the 2013 field season.

Data Interpretation

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

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

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

Stage

- Figure 4 displays stage values recorded at both stations from June 4, 2013 to October 8, 2013. These values are provisional. A complete dataset of quality assured and quality controlled stage values should be available upon request through EC after March 2014 (http://www.ec.gc.ca/rhc-wsc/default.asp).
- Stage values ranged from 1.093 m to 1.419 m at Elross Creek and from 1.742 m to 2.247 m at Goodream Creek from June 4, 2013 to October 8, 2013.
- Fluctuations in stage corresponded well with rainfall events (Figure 4 inset).
- At the end of the first deployment period on July 3, 2013 the stage height at the Goodream Creek station was critically low and it was not possible to redeploy a DataSonde and ensure that it would be fully submerged in flowing water for the following deployment period.
- 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.

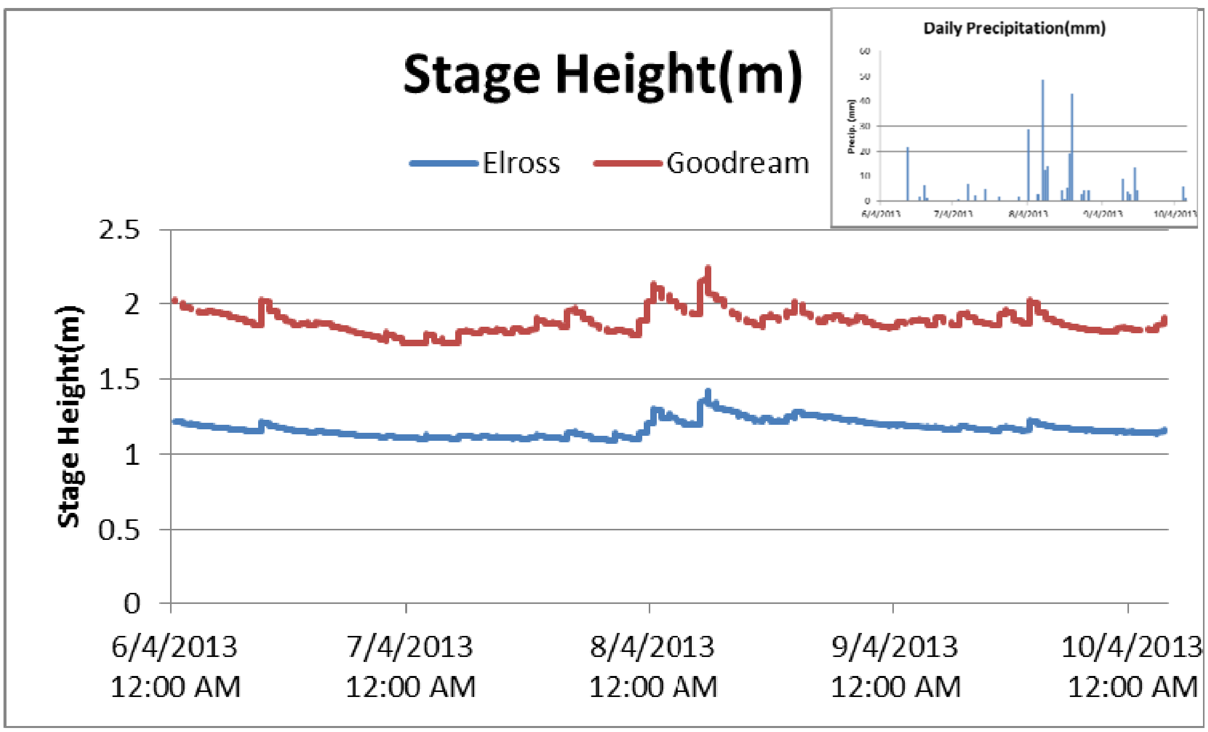

Figure 4. Hourly stage (m) values recorded at Elross Creek and Goodream Creek from June 4, 2013 to October 8, 2013. The inset chart shows total precipitation (mm) recorded at the Schefferville weather station during the same time period. All data was recorded by Environment Canada.

Temperature

- Water temperature ranged from 1.6˚C to 16.9˚C at Elross Creek and from 1.1˚C to 16.6˚C at Goodream Creek from June 4, 2013 to October 8, 2013 (Figure 5).
- 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. Diurnal variations were larger at Goodream Creek compared to Elross Creek, since Goodream Creek is a shallower stream, and as a result, more responsive to diurnal changes in air temperatures.
- Weekly trends in water temperature corresponded well with hourly air temperatures recorded by Environment Canada at the Schefferville weather station (Figure 5 inset, Appendix C).

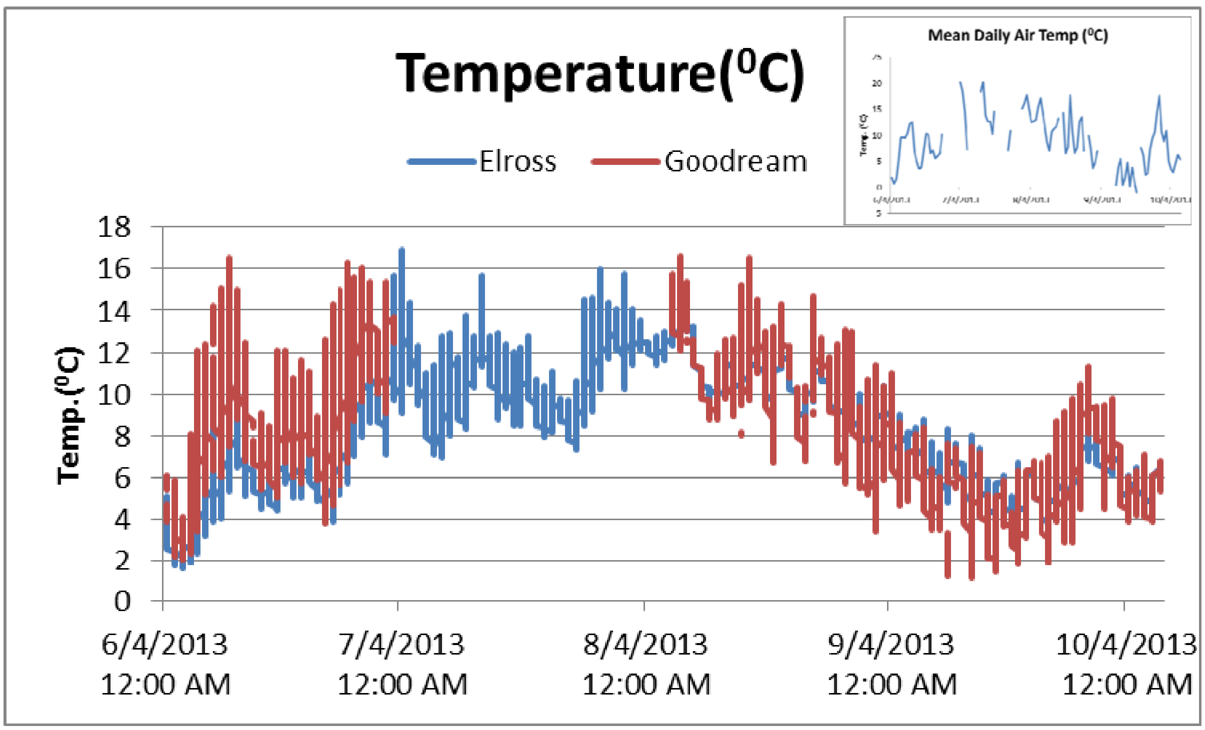

Figure 5. Hourly water temperature (^{o}C) values recorded at Elross Creek and Goodream Creek from June 4, 2013 to October 8, 2013. Inset chart shows air temperature during the same period, as recorded by Environment Canada at the Schefferville weather station.

pH

- pH values ranged from 6.17 units to 7.02 units at Elross Creek and from 5.07 units to 6.63 units at Goodream Creek from June 4, 2013 to October 8, 2013 (Figure 6).

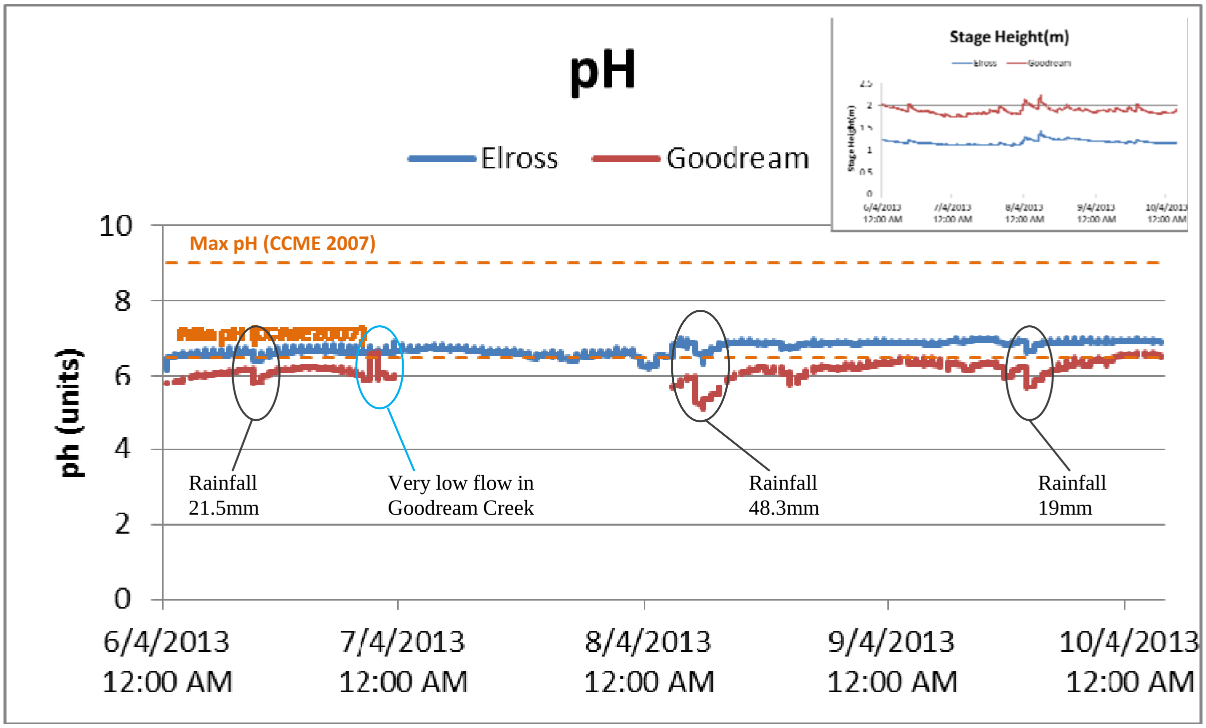

Figure 6. Hourly pH values recorded at Elross Creek and Goodream Creek from June 4, 2013 to October 8, 2013.

- pH values show diurnal variations at both stations which are related to diurnal fluctuations in temperature, oxygen and photosynthetic cycling of CO_2 by aquatic organisms.
- Weekly trends in pH corresponded well with changes in stage (Inset in top right of Figure 6), and were primarily attributed to rainfall activity and surface runoff.
- Significant rainfall events and increases in flow have an impact on pH, causing a noticeable dip in the pH value. This impact is most noticeable with the Goodream Creek data and in Figure 6 three occasions where there is a noticeable dip in pH related to rainfall events are noted inside grey ovals.
- Towards the end of the first deployment Goodream Creek experienced extremely low flow which prevented redeployment of the DataSonde during the second deployment period. It appears that between June 30 and July 1 this low flow may have impacted pH causing a small spike which is noted in a blue oval on Figure 6.
- Most pH values recorded at Elross Creek fluctuated above 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), while most pH values recorded at Goodream Creek fell below this minimum guideline. Low pH levels were 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). Indeed, baseline data was highly variable and acidic at times at the DSO3-15 sampling site (5.8-7.78 units) that is in close proximity to the Elross Creek station, as well as at sampling sites DSO3-11 and DSO3-14 (5.6-7.2 units) that are upstream from the Goodream Creek station.

- During the 2013 field season the median pH at Elross Creek was 6.76 while at Goodream Creek it was 6.19. This difference could be attributed to a number of variables including such thing as; differences in geology between the two watersheds, different levels of influence from groundwater at the two stations, and different historical and ongoing land use activity in the two watershed areas.

Specific Conductivity

- Specific Conductivity ranged from 11.6 µs/cm to 23.9 µs/cm at Elross Creek and from 2.3 µs/cm to 8.6 µs/cm at Goodream Creek from June 4, 2013 to October 8, 2013 (Figure 7).
- Specific conductivity values at both stations showed regular diurnal fluctuations which are related to diurnal temperature fluctuations.

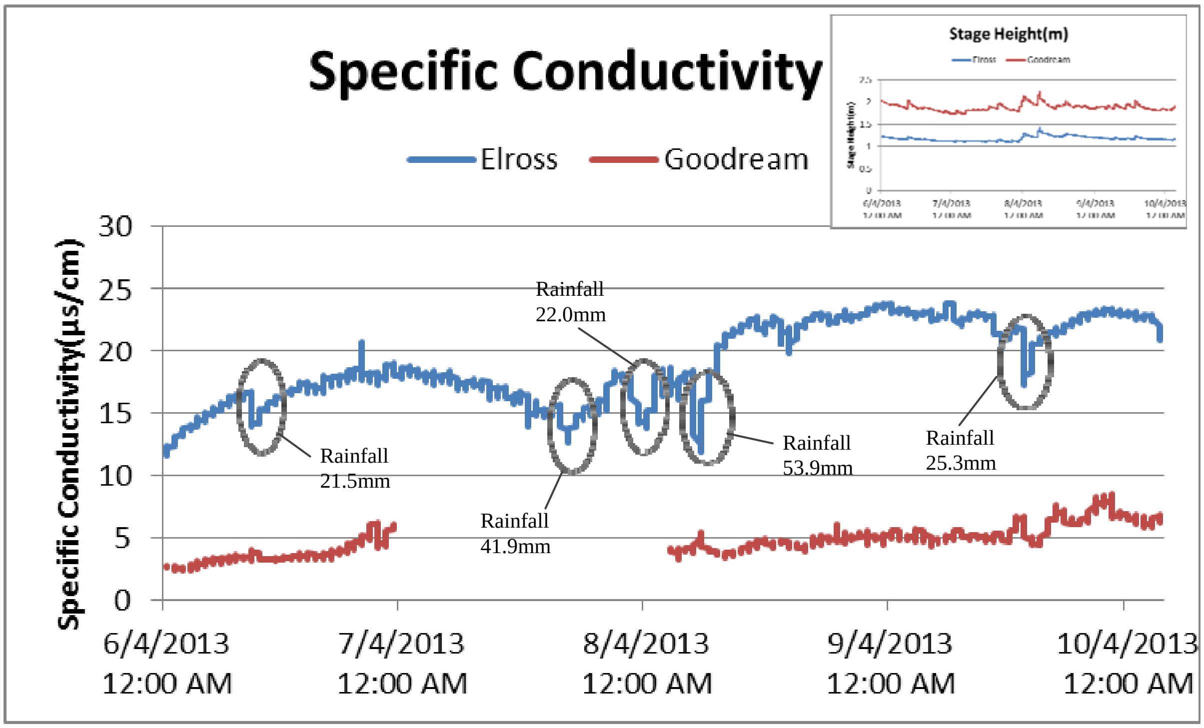

Figure 7. Hourly specific conductivity (µS/cm) values recorded at Elross Creek and Goodream Creek from June 4, 2013 to October 8, 2013.

- Weekly trends in specific conductivity were primarily influenced by rainfall events and surface runoff (see sage height inset in Figure 7). The trends were more pronounced at the Elross Creek station, where the concentration of dissolved solids was expected to be more varied due to flow contribution from the Timmins 1 mine site.

- Significant rainfall events and increases in flow tend to cause a noticeable drop in specific conductivity. These impacts are most noticeable in the Elross Creek data and several examples are highlighted in gray ovals in Figure 7.
- During the 2013 field season the median specific conductivity was 18.0 µs/cm at Elross Creek while at Goodream Creek it was 4.7 µs/cm. This difference could be attributed to a number of variables including such thing as; differences in geology between the two watersheds, different levels of influence from groundwater at the two stations, and different historical and ongoing land use activity in the two watershed areas.

Dissolved Oxygen

- Dissolved Oxygen (DO) values ranged from 6.77 mg/l to 13.29 mg/l at Elross Creek and from 5.14 mg/l to 13.3 mg/l at Goodream Creek from June 4, 2013 to October 8, 2013 (Figure 8).
- DO levels show diurnal variations at both stations which are related to diurnal fluctuations in temperature and photosynthetic cycling of CO_2 by aquatic organisms.

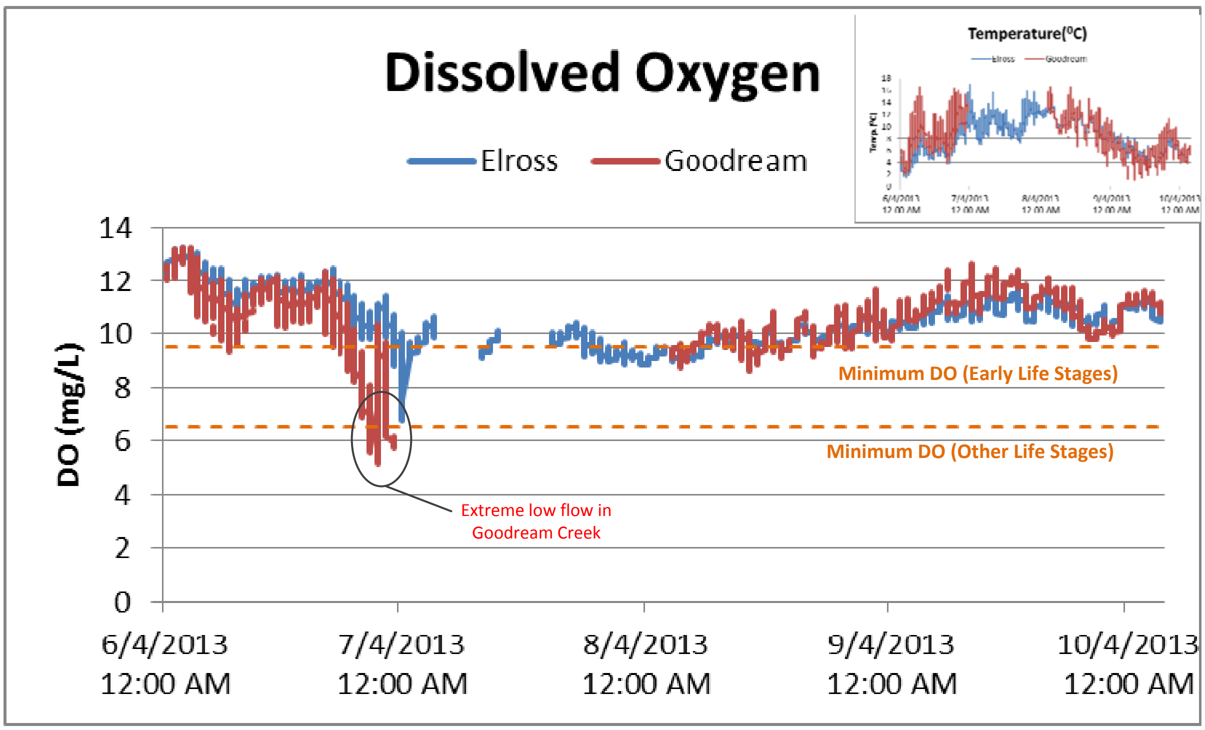

Figure 8. Hourly dissolved oxygen (mg/l) values recorded at Elross Creek and Goodream Creek from June 4, 2013 to October 8, 2013.

- Weekly trends in DO corresponded well with the inverse of water temperature (see temperature inset in Figure 9), since colder water has a greater potential to dissolve oxygen compared to warmer water.

- DO values at both stations fell below cold water minimum guidelines set for aquatic life during early life stages (9.5 mg/l), but were generally above minimum guidelines set for other life stages (6.5 mg/l), as determined by the Canadian Council of Ministers of the Environment (2007). The one exception where DO values fell below the 6.5 mg/l guideline was for Goodream Creek for a few days in early July, 2013, during extreme low flow conditions which led to the DataSonde being removed for the second deployment period.

Turbidity

- Turbidity values ranged from 0.0 NTU to 2760.0 NTU at Elross Creek and 0.0 NTU to 131.2 NTU at Goodream Creek from June 4, 2013 to October 8, 2013 (Figure 9).
- In order to better display the turbidity readings in the lower range a second graph was prepared with all values greater than 500 groomed out. This second graph is presented in Figure 10.

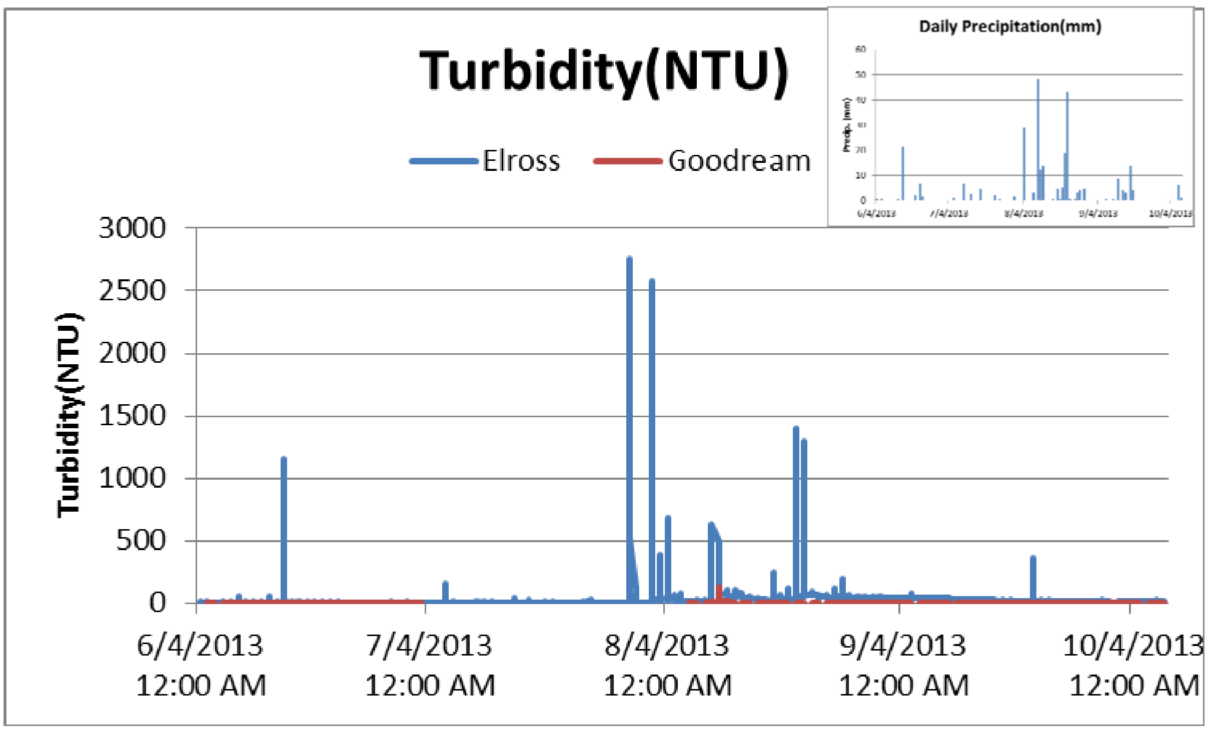

Figure 9. Hourly turbidity (NTU) values recorded at Elross Creek and Goodream Creek from June 4, 2013 to October 8, 2013.

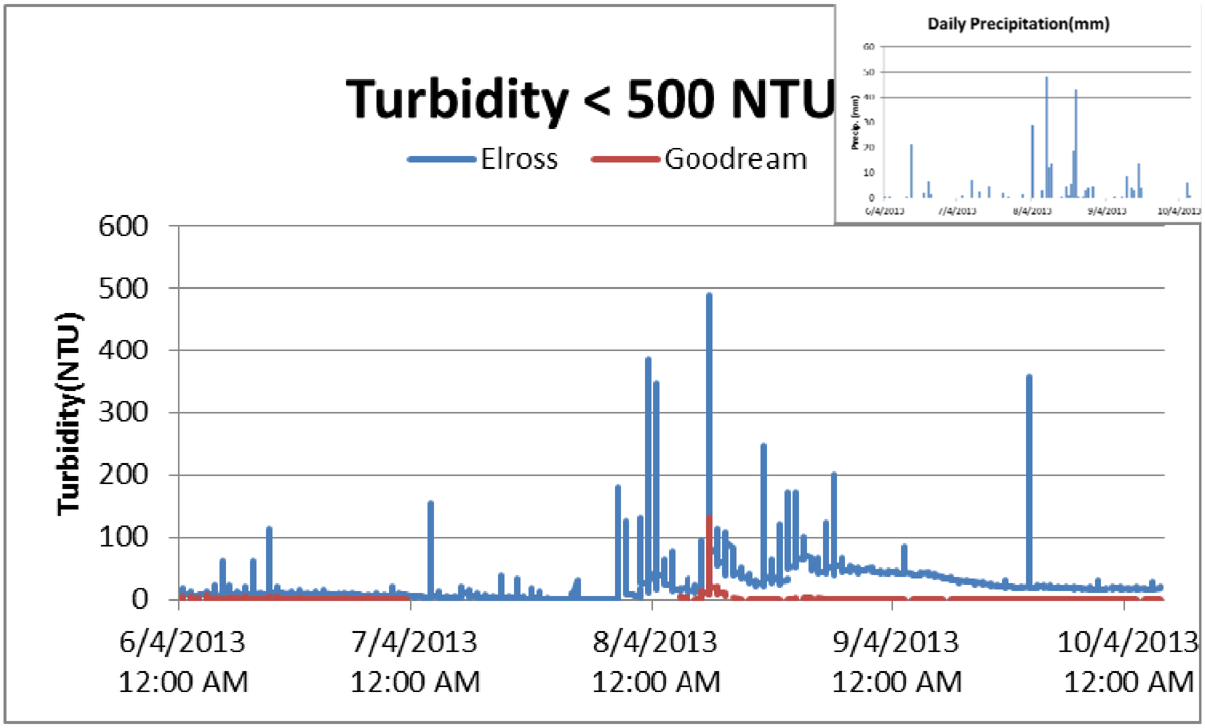

Figure 10. Hourly turbidity (NTU) values recorded at Elross Creek and Goodream Creek from June 4, 2013 to October 8, 2013 with values > 500NTU groomed out.

- Median turbidity at Elross Creek was 16.7 NTU, while at Goodream Creek it was 0.6 NTU. This difference is understandable given the fact that the Elross Creek watershed has significant disturbance from historical and ongoing mining activity while the Goodream Creek watershed is relatively undisturbed.
- From the inset precipitation graph it can be seen that turbidity trends correspond fairly well with precipitation events.

Conclusions

- Water quality monitoring instruments were deployed at two stations near the Elross Lake, Iron Ore Mine between June 4, 2013 and October 8, 2013. The stations are located on Elross Creek and Goodream Creek.
- The water quality monitoring instruments were deployed for four consecutive deployment periods however for the second deployment period it was impossible to redeploy the DataSonde at Goodream Creek due to extreme low flow conditions.
- The performance ratings of all instrument sensors ranged between fair and excellent at the beginning and end of each of the four deployment periods. It should be noted that during the second deployment the Oxygen sensor at Elross Creek experienced intermittent technical difficulties and there are several large gaps in the data during that deployment period.

- Variations in water quality/quantity values recorded at each station are summarized below:
  - STAGE: Stage values ranged from 1.093 m to 1.419 m at Elross Creek and from 1.742 m to 2.247 m at Goodream Creek from June 4, 2013 to October 8, 2013. Fluctuations in stage corresponded well with rainfall events.
  - WATER TEMPERATURE: Water temperature ranged from 1.6˚C to 16.9˚C at Elross Creek and from 1.1˚C to 16.6˚C at Goodream Creek from June 4, 2013 to October 8, 2013 Water temperatures at both stations display large diurnal variations which are related to diurnal trends in air temperatures. Weekly trends in water temperature corresponded well with trends in air temperatures.
  - pH: pH values ranged from 6.17 units to 7.02 units at Elross Creek and from 5.07 units to 6.63 units at Goodream Creek from June 4, 2013 to October 8, 2013. pH values show diurnal variations at both stations which are related to diurnal fluctuations in temperature, oxygen and photosynthetic cycling of CO_2 by aquatic organisms. Weekly trends in pH corresponded well with changes in stage and were primarily attributed to rainfall activity and surface runoff. Significant rainfall events and increases in flow have an impact on pH, causing a noticeable dip in the pH value. Most pH values recorded at Elross Creek fluctuated above 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), while most pH values recorded at Goodream Creek fell below this minimum guideline. Low pH levels were considered normal for this area.
  - SPECIFIC CONDUCTIVITY: Specific Conductivity ranged from 11.6 µs/cm to 23.9 µs/cm at Elross Creek and from 2.3 µs/cm to 8.6 µs/cm at Goodream Creek from June 4, 2013 to October 8, 2013. Specific conductivity values at both stations showed regular diurnal fluctuations which are related to diurnal temperature fluctuations. Weekly trends in specific conductivity were primarily influenced by rainfall events and surface runoff. These trends were more pronounced at the Elross Creek station. Significant rainfall events and increases in flow tend to cause a noticeable drop in specific conductivity. During the 2013 field season the median specific conductivity was 18.0 µs/cm at Elross Creek while at Goodream Creek it was 4.7 µs/cm. This difference could be attributed to a number of variables including such thing as; differences in geology between the two watersheds, different levels of influence from groundwater at the two stations, and different historical and ongoing land use activity in the two watershed areas.
  - DISSOLVED OXYGEN: Dissolved Oxygen (DO) values ranged from 6.77 mg/l to 13.29 mg/l at Elross Creek and from 5.14 mg/l to 13.3 mg/l at Goodream Creek from June 4, 2013 to October 8, 2013. DO levels show diurnal variations at both stations which are related to diurnal fluctuations in temperature and photosynthetic cycling of CO_2 by aquatic organisms. Weekly 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. DO values at both stations fell below cold water minimum guidelines set for aquatic life during early life stages (9.5 mg/l), but were generally above minimum guidelines set for other life stages (6.5 mg/l), as determined by the Canadian Council of Ministers of the Environment (2007). The one exception where DO values fell below the 6.5 mg/l guideline was for Goodream Creek for a few days in early July, 2013, during

extreme low flow conditions which led to the DataSonde being removed for the second deployment period.

- TURBIDITY: Turbidity values ranged from 0.0 NTU to 2760.0 NTU at Elross Creek and 0.0 NTU to 131.2 NTU at Goodream Creek from June 4, 2013 to October 8, 2013. Median turbidity at Elross Creek was 16.7 NTU, while at Goodream Creek it was 0.6 NTU. This difference is understandable given the fact that the Elross Creek watershed has significant disturbance from historical and ongoing mining activity while the Goodream Creek watershed is relatively undisturbed. Turbidity trends correspond fairly well with precipitation events.

Path Forward

- ENVC staff will redeploy RTWQ instruments at Elross Creek and Goodream Creek in spring 2014, when ice conditions allow, and perform regular site visits throughout the 2014 deployment season, for calibration and maintenance of the instruments.
- ENVC staff will continue to rely on input and assistance from TSMC staff in the operation and maintenance of the Elross Creek and Goodream Creek stations. Every effort will be made to coordinate in advance with TSMC staff for site visits during the 2014 field season. ENVC staff are very appreciative of the field assistance provided by TSMC staff during the 2013 field season and are hoping to carry on with this arrangement for the 2014 field season.
- If necessary, deployment techniques will be evaluated and adapted to each site, ensuring secure and suitable conditions for RTWQ monitoring.
- ENVC staff will update TSMC staff on any changes to processes and procedures with handling, maintaining and calibrating the real-time instruments.
- EC 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 2014 deployment season to notify ENVC 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.
- ENVC 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.
- ENVC will continue to work on its Automatic Data Retrieval System, to incorporate new capabilities in data management and data display.
- ENVC 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 ENVC, EC and TSMC employees involved with the agreement, in order to respond to emerging issues on a proactive basis.

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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 (^{o}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 4, 2013 to Oct.8, 2013)

Date/Time	Max Temp (°C)	Min Temp (°C)	Mean Temp (°C)	Heat Deg Days (°C)	Cool Deg Days (°C)	Total Precip (mm)
6/4/2013	6.2	-2.3	2	16	0	1.1
6/5/2013	3.9	-2.7	0.6	17.4	0	0
6/6/2013	4.7	-1.7	1.5	16.5	0	0.8
6/7/2013	11.5	-0.5	5.5	12.5	0	0
6/8/2013	17.7	-0.4	8.7	9.3	0	0
6/9/2013	18.8	-0.2	9.3	8.7	0	0
6/10/2013	16.5	2.5	9.5	8.5	0	0
6/11/2013	19.4	1.2	10.3	7.7	0	0
6/12/2013	20.7	3.5	12.1	5.9	0	0
6/13/2013	21.4	3.9	12.7	5.3	0	0
6/14/2013	12.6	0.5	6.6	11.4	0	0
6/15/2013	7.2	2.7	5	13	0	23.9
6/16/2013	7.1	0	3.6	14.4	0	0.5
6/17/2013	7.7	-0.3	3.7	14.3	0	0
6/18/2013	14.4	-0.6	6.9	11.1	0	
6/19/2013	16.7	3.9	10.3	7.7	0	0
6/20/2013	17.4	3.1	10.3	7.7	0	3.6
6/21/2013	13	0.5	6.8	11.2	0	0
6/22/2013	10.1	4	7.1	10.9	0	7.1
6/23/2013	11.1	0.2	5.7	12.3	0	2
6/24/2013	12.3	-1.1	5.6	12.4	0	0
6/25/2013	14.1	-0.8	6.7	11.3	0	0
6/26/2013	18.8	0.8	9.8	8.2	0	0
6/27/2013	23.3	3.1	13.2	4.8	0	0
6/28/2013	24.9	5.6	15.3	2.7	0	0
6/29/2013	23.9	6.1	15	3	0	0
6/30/2013	23.4	8.5	16	2	0	0.5
7/1/2013	11.3	5.2	8.3	9.7	0	4.6
7/2/2013	23.6	6.1	14.9	3.1	0	0
7/3/2013	23.6	10.3	17	1	0	0
7/4/2013	28.8	10.5	19.7	0	1.7	0
7/5/2013	24.8	12.2	18.5	0	0.5	0
7/6/2013	22.5	6.1	14.3	3.7	0	2.1
7/7/2013	10.6	3.6	7.1	10.9	0	0.3
7/8/2013	11.6	3.5	7.6	10.4	0	1.6

7/9/2013	19.3	5.4	12.4	5.6	0	0
Date/Time	**Max Temp (°C)**	**Min Temp (°C)**	**Mean Temp (°C)**	**Heat Deg Days (°C)**	**Cool Deg Days (°C)**	**Total Precip (mm)**
7/11/2013		14.6				1.3
7/12/2013	18.3	8.6	13.5	4.5	0	3.3
7/13/2013	21.7	15.1	18.4	0	0.4	3.8
7/14/2013	24.6	16.3	20.5	0	2.5	0
7/15/2013	18.4	8	13.2	4.8	0	5.5
7/16/2013	17.9	6.3	12.1	5.9	0	0
7/17/2013	18.8	6	12.4	5.6	0	5.8
7/18/2013	14.7	5.5	10.1	7.9	0	0
7/19/2013	21.2	8.2	14.7	3.3	0	12.6
7/20/2013	14.5	5.1	9.8	8.2	0	4.8
7/21/2013	12.1	4.5	8.3	9.7	0	1.8
7/22/2013	9.2	4.6	6.9	11.1	0	1.6
7/23/2013	14.5	7.2	10.9	7.1	0	4.8
7/24/2013	9.8	6.4	8.1	9.9	0	41.9
7/25/2013	11.6	3.8	7.7	10.3	0	0.8
7/26/2013	18.6	3.7	11.2	6.8	0	1.4
7/27/2013	21.3	6.7	14	4	0	0.3
7/28/2013	22.3	6.2	14.3	3.7	0	0
7/29/2013	22.6	11.6	17.1	0.9	0	0
7/30/2013	21.6	13.4	17.5	0.5	0	0.3
7/31/2013	19.3	11.3	15.3	2.7	0	2
8/1/2013	23.6	8.7	16.2	1.8	0	0
8/2/2013	23.1	12.6	17.9	0.1	0	9.8
8/3/2013	17.2	12.9	15.1	2.9	0	22
8/4/2013	14.6	10.5	12.6	5.4	0	27.9
8/5/2013	15.3	9.9	12.6	5.4	0	4.8
8/6/2013	15.7	10.5	13.1	4.9	0	1.8
8/7/2013	19.8	11.6	15.7	2.3	0	0
8/8/2013	24	11	17.5	0.5	0	3.8
8/9/2013	17.3	11.7	14.5	3.5	0	5.3
8/10/2013	14	9.7	11.9	6.1	0	53.9
8/11/2013	10.2	7.2	8.7	9.3	0	13.3
8/12/2013	9	4.7	6.9	11.1	0	16.4
8/13/2013	15.1	6.1	10.6	7.4	0	0
8/14/2013	16.6	4.4	10.5	7.5	0	0
8/15/2013	16.5	6.4	11.5	6.5	0	0
8/16/2013	19.6	6.5	13.1	4.9	0	0

8/17/2013	20.9	10.6	15.8	2.2	0	0
Date/Time	**Max Temp (°C)**	**Min Temp (°C)**	**Mean Temp (°C)**	**Heat Deg Days (°C)**	**Cool Deg Days (°C)**	**Total Precip (mm)**
8/19/2013	10.9	1.7	6.3	11.7	0	1.3
8/20/2013	15.2	1.2	8.2	9.8	0	8.8
8/21/2013	21.2	14.2	17.7	0.3	0	21.2
8/22/2013	14.6	6.9	10.8	7.2	0	35.9
8/23/2013	11.6	2.2	6.9	11.1	0	0.8
8/24/2013	13.4	3.1	8.3	9.7	0	0.3
8/25/2013	20	5.3	12.7	5.3	0	0
8/26/2013	16.1	11	13.6	4.4	0	5.5
8/27/2013		10.2				
8/29/2013	18.3	2.8	10.6	7.4	0	5.3
8/30/2013	13.2	0.8	7	11	0	2
8/31/2013	7.8	0	3.9	14.1	0	0.5
9/1/2013	9.5	-0.6	4.5	13.5	0	0
9/2/2013	14.2	-0.4	6.9	11.1	0	0
9/3/2013	12.2	4	8.1	9.9	0	3.6
9/4/2013	14.4	1.7	8.1	9.9	0	4.8
9/5/2013	6.9	0.7	3.8	14.2	0	2.5
9/6/2013	10.7	0.4	5.6	12.4	0	3.3
9/7/2013	7.5	1	4.3	13.7	0	0.3
9/8/2013	6	-1.7	2.2	15.8	0	0
9/9/2013	8	0.2	4.1	13.9	0	5.3
9/10/2013	3.8	-2.1	0.9	17.1	0	0
9/11/2013	11.8	-3.5	4.2	13.8	0	0
9/12/2013	8.1	3.1	5.6	12.4	0	10.1
9/13/2013	3.1	-2	0.6	17.4	0	0
9/14/2013	8.7	-4.2	2.3	15.7	0	4
9/15/2013	8.8	0.5	4.7	13.3	0	2.9
9/16/2013	2.5	-1.9	0.3	17.7	0	0.3
9/17/2013	9.4	-2.1	3.7	14.3	0	15.8
9/18/2013	4.4	-2	1.2	16.8	0	4.3
9/19/2013	0.3	-2	-0.9	18.9	0	0
9/20/2013	4.6	-2.5	1.1	16.9	0	6.3
9/21/2013	13.2	2.4	7.8	10.2	0	19
9/22/2013	8.7	1.1	4.9	13.1	0	0.3
9/23/2013	5.9	-1.4	2.3	15.7	0	0
9/24/2013	8.7	-3.4	2.7	15.3	0	0
9/25/2013	12.4	2.1	7.3	10.7	0	0

9/26/2013	17.4	1.6	9.5	8.5	0	0
Date/Time	**Max Temp (°C)**	**Min Temp (°C)**	**Mean Temp (°C)**	**Heat Deg Days (°C)**	**Cool Deg Days (°C)**	**Total Precip (mm)**
9/28/2013	22.2	7.1	14.7	3.3	0	0
9/29/2013	22.1	13.6	17.9	0.1	0	0
9/30/2013	13.7	7.6	10.7	7.3	0	0
10/1/2013	15.7	2.9	9.3	8.7	0	0
10/2/2013	14.4	7.3	10.9	7.1	0	8.5
10/3/2013	7.7	2.4	5.1	12.9	0	0.3
10/4/2013	5.4	1.6	3.5	14.5	0	0.9
10/5/2013	4.6	1	2.8	15.2	0	3.8
10/6/2013	7.3	2.1	4.7	13.3	0	0
10/7/2013	9.2	3.7	6.5	11.5	0	6.8
10/8/2013	10.7	0.3	5.5	12.5	0	2.1

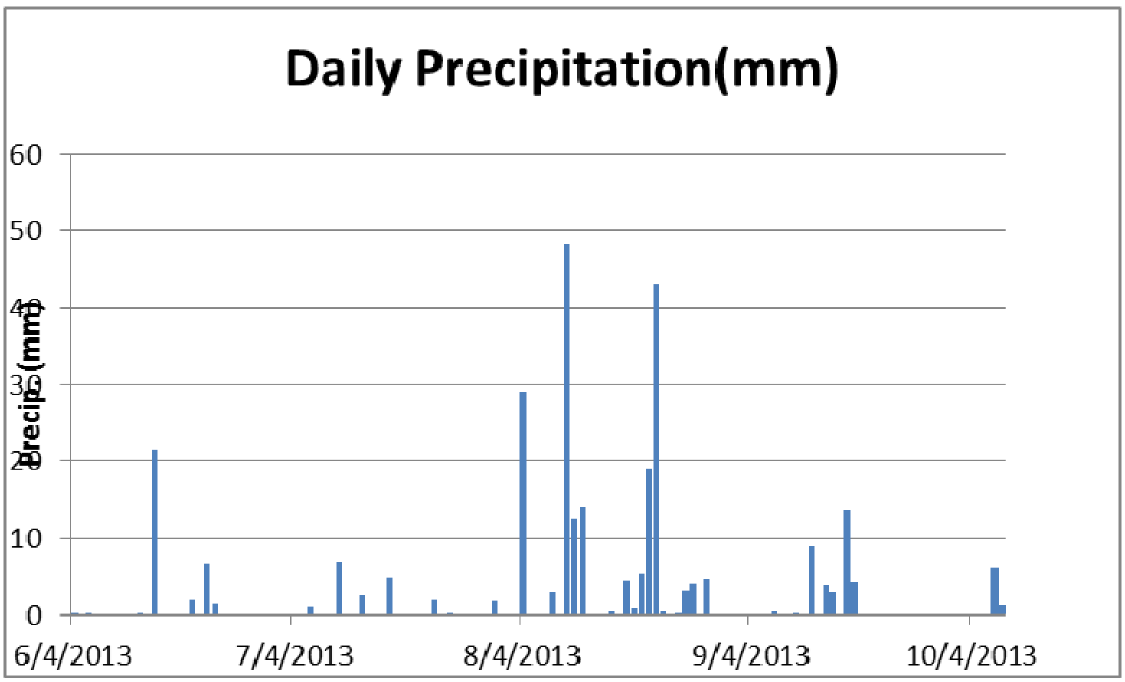

Figure 1. Daily precipitation recorded at the Schefferville Weather Station by Environment Canada from June 4, 2013 to October 8, 2013.

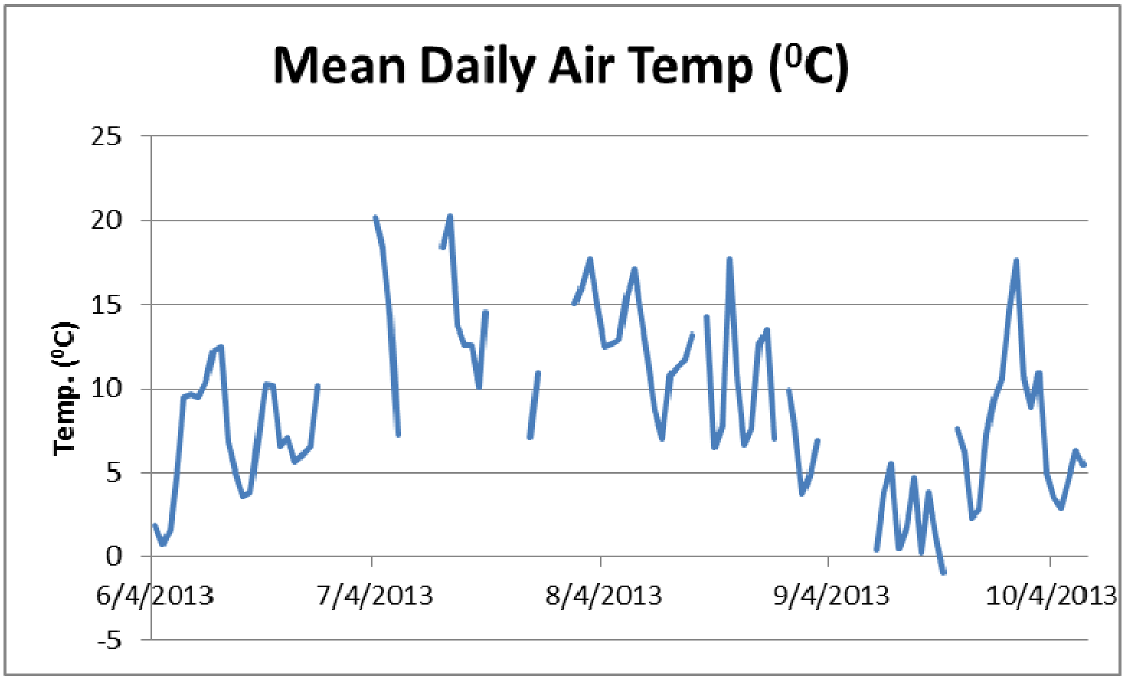

Figure 2. Daily mean temperature recorded at the Schefferville Weather Station by Environment Canada from June 4, 2013 to October 8, 2013.