Real Time Water Quality Report

Tata Steel Minerals Canada Elross Lake Network

Deployment Period
2012-08-23 to 2012-09-27

Government of Newfoundland & Labrador
Department of Environment and Conservation
Water Resources Management Division
St. John’s, NL, A1B 4J6 Canada

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General

- The Water Resources Management Division, in partnership with Tata Steel Minerals Canada Limited and Environment Canada, maintain two real-time water quality and water quantity stations in close proximity to the 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.
- Station sites were selected to monitor all surface water outflows from the Elross Lake mining site. The Elross Creek Station is situated downstream of the Timmins 1 pit, and downstream of Pinette Lake. The Goodream Creek Station will serve to monitor potential impacts from groundwater flowing from Timmins 6 pit into the surface water of Goodream Creek.
- The Water Resources Management Division will inform Tata Steel Minerals Canada Limited of any significant water quality events by email notification and by monthly deployment reports.
- This monthly deployment report, presents water quality and water quantity data recorded at the Elross Creek and Goodream Creek stations from August 23, 2012 to September 27, 2012.

Quality Assurance / Quality Control

- Water quality instrument performance is tested at the beginning 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 1 shows the performance ratings of five water quality parameters (i.e., temperature, pH, specific conductivity, dissolved oxygen and turbidity) measured by instruments deployed at the water monitoring stations.

Table 1. Water quality instrument performance at the beginning and end of deployment at the Elross Creek and Goodream Creek stations.

	Elross Creek (Sonde 62065)		Goodream Creek (Sonde 62068)	
Stage of deployment	Beginning	End	Beginning	End
Date	2012-08-23	2012-09-27	2012-08-23	2012-09-27
Temperature	Excellent	Excellent	Excellent	Excellent
pH	Excellent	Excellent	Good	Good
Specific Conductivity	Excellent	Excellent	Excellent	Excellent
Dissolved Oxygen	Excellent	Good	Excellent	Good
Turbidity	Excellent	Excellent	Excellent	Excellent

- The performances of all sensors were rated good to excellent at the beginning and end of the deployment period (Table 1).

Deployment Notes

- Transmission errors occurred sporadically throughout the deployment period at the Goodream Creek station, resulting in the loss of 206 hourly data records. It was suspected that the time allotted by the Automated Data Retrieval System (ADRS) for data upload from the station to the satellite was exceeded, causing 206 incomplete data transmissions. A more complete dataset was obtained from the Field Instrument's internal log file. The only exceptions were the *specific conductivity* and *TDS* datasets, which were extracted from the ADRS, due to the higher precision of the ADRS datasets. *Stage* values were also extracted from the ADRS, since stage values are not saved to the Field Instrument's internal log file. Data gaps are apparent in the specific conductivity, TDS, and stage graphs shown in this report.
- Mining operations were halted on June 29, 2012 and resumed around September 5, 2012.

Data Interpretation

- 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 (µS/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

- Stage values ranged from 1.111 m to 1.211 m at Elross Creek and from 1.828 m to 2.025 m at Goodream Creek from August 23, 2012 to September 27, 2012 (Figure 1).
- Fluctuations in stage, observed at both stations, coincided well with precipitation events (Figure 1 inset, Appendix C).
- 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.

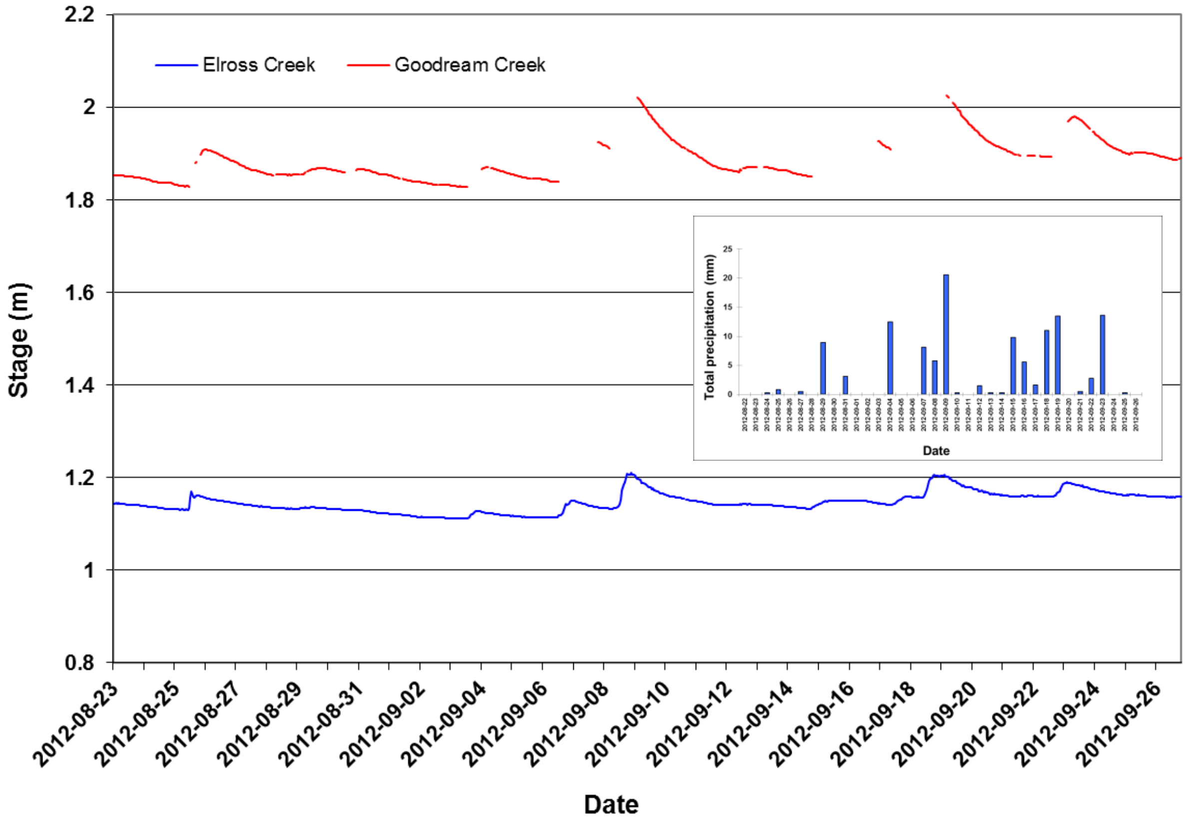

Figure 1. Hourly stage (m) values recorded at Elross Creek and Goodream Creek from August 23, 2012 to September 27, 2012.

Temperature

- Water temperature ranged from 5.80˚C to 15.60˚C at Elross Creek and from 4.09˚C to 16.43˚C at Goodream Creek from August 23, 2012 to September 27, 2012 (Figure 2).
- 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.
- Weekly trends in water temperature also corresponded well with ambient air temperatures recorded by Environment Canada at the Schefferville weather station (Figure 2 inset, Appendix C).
- Water temperatures at both stations were very similar. On average, water temperature was 0.10 °C colder at Goodream Creek than at Elross Creek.

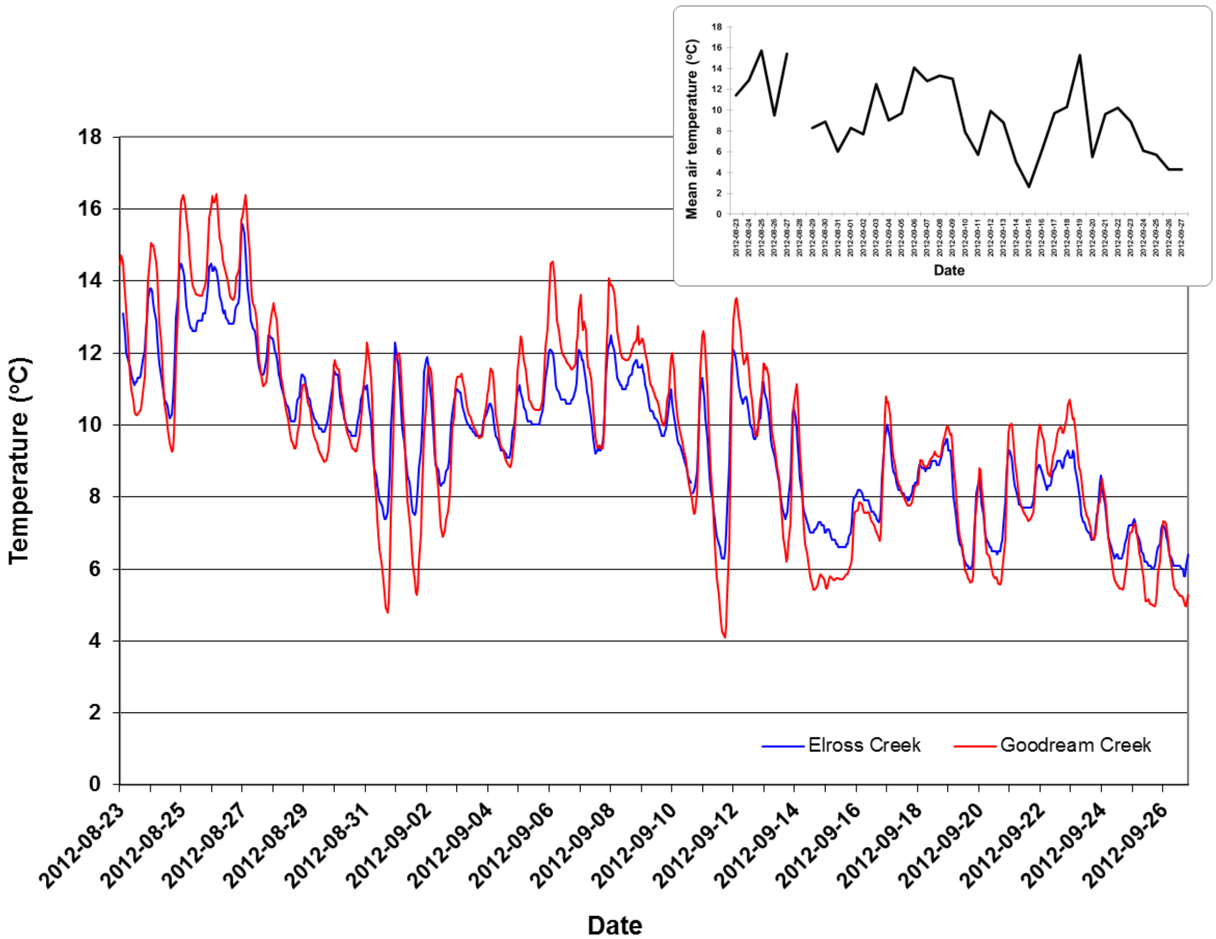

Figure 2. Hourly water temperature (°C) values recorded at Elross Creek and Goodream Creek from August 23, 2012 to September 27, 2012. The inset chart shows mean daily air temperature during the same period, as recorded by Environment Canada at the Schefferville weather station.

pH

- pH values ranged from 6.39 units to 6.86 units at Elross Creek and from 5.68 units to 6.53 units at Goodream Creek from August 23, 2012 to September 27, 2012 (Figure 3).
- pH values at both stations fluctuated daily with peaks typically occurring in the late afternoon/ early evening. These variations coincide with the photosynthetic cycling of CO_2 by aquatic organisms.
- Weekly trends in pH corresponded well with changes in stage (Figure 1), which is influenced by rainfall activity and surface runoff.
- On average, pH was 0.38 units higher at Elross Creek than at Goodream Creek.
- 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.

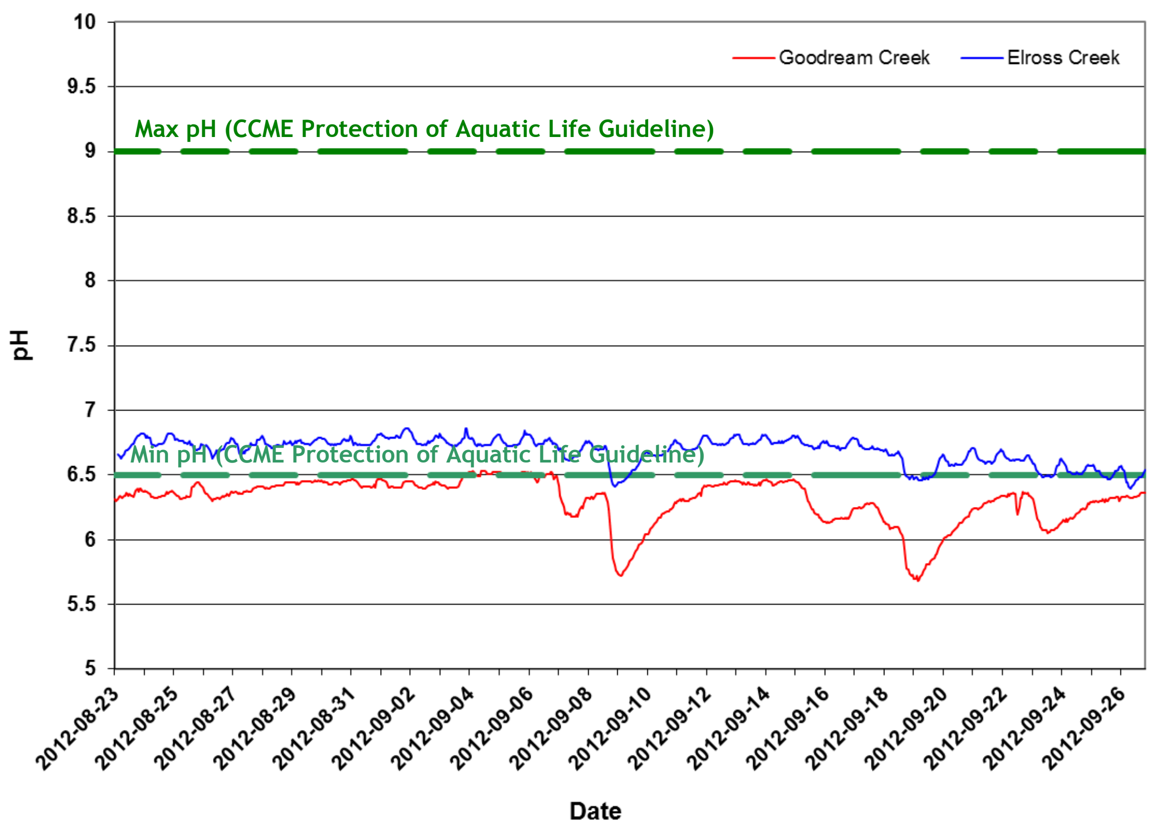

Figure 3. Hourly pH values recorded at Elross Creek and Goodream Creek from August 23, 2012 to September 27, 2012.

Specific Conductivity

- Specific Conductivity ranged from 14.0 μs/cm to 19.9 μs/cm at Elross Creek and from 4.0 μs/cm to 6.9 μs/cm at Goodream Creek from August 23, 2012 to September 27, 2012 (Figure 4).
- Specific conductivity values at both stations fluctuated daily with peaks typically occurring late evening/early morning. Diurnal fluctuations could be attributed to the photosynthetic cycling of CO_2 by aquatic organisms, with peaks coinciding with a presumed increase in major ions (e.g., HCO_3^-) during the night.
- Weekly trends in specific conductivity were more apparent at Elross Creek compared to Goodream Creek. Weekly fluctuations coincided with changes in stage (Figure 1), which is influenced by rainfall activity and surface runoff.
- On average, specific conductivity was 12.4 μS/cm higher at Elross Creek than at Goodream Creek.

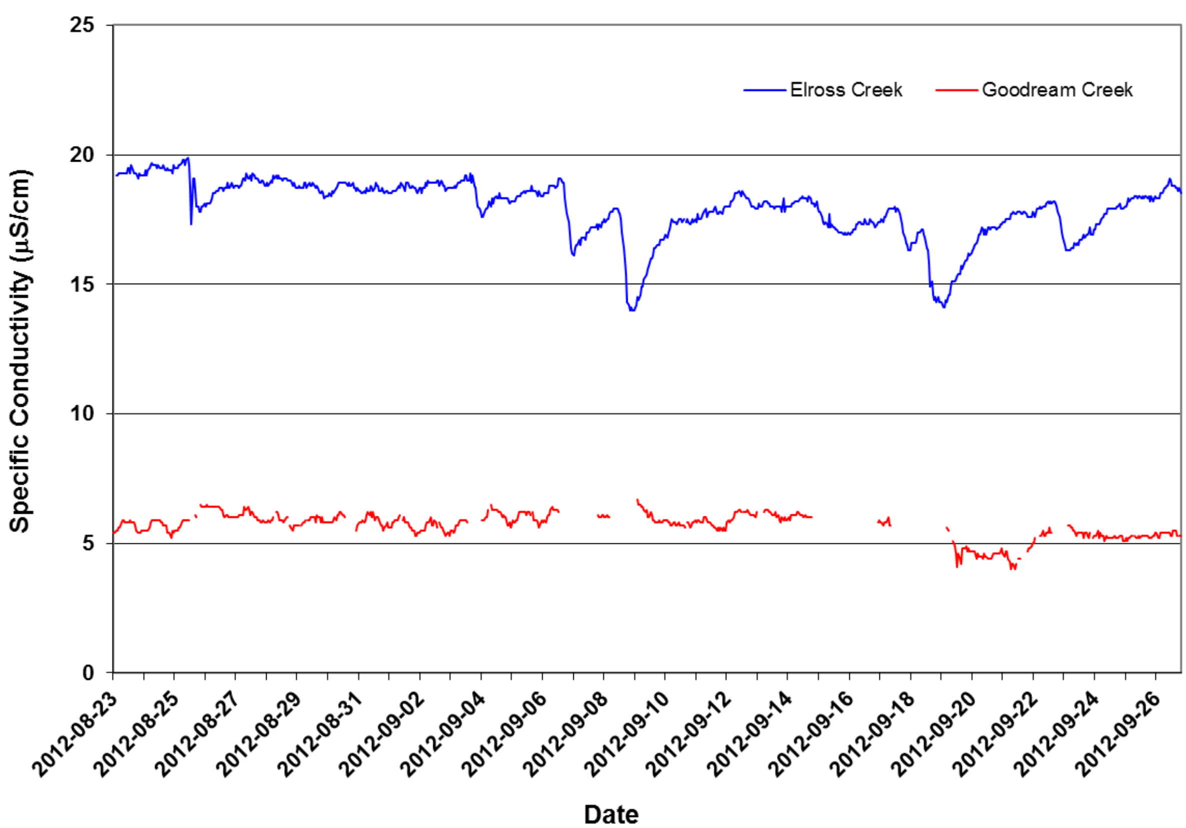

Figure 4. Hourly specific conductivity (μs/cm) values recorded at Elross Creek and Goodream Creek from August 23, 2012 to September 27, 2012.

Total Dissolved Solids

- Total Dissolved Solids (TDS) values ranged from 0.0089 g/l to 0.0127 g/l at Elross Creek and from 0.0026 g/l to 0.0044 g/l at Goodream Creek from August 23, 2012 to September 27, 2012 (Figure 5).
- TDS is calculated directly from conductivity and temperature measurements, and as a result TDS values show a similar trend to specific conductance (Figure 4).
- TDS values were on average 0.0080 g/l higher at Elross Creek compared to Goodream Creek.

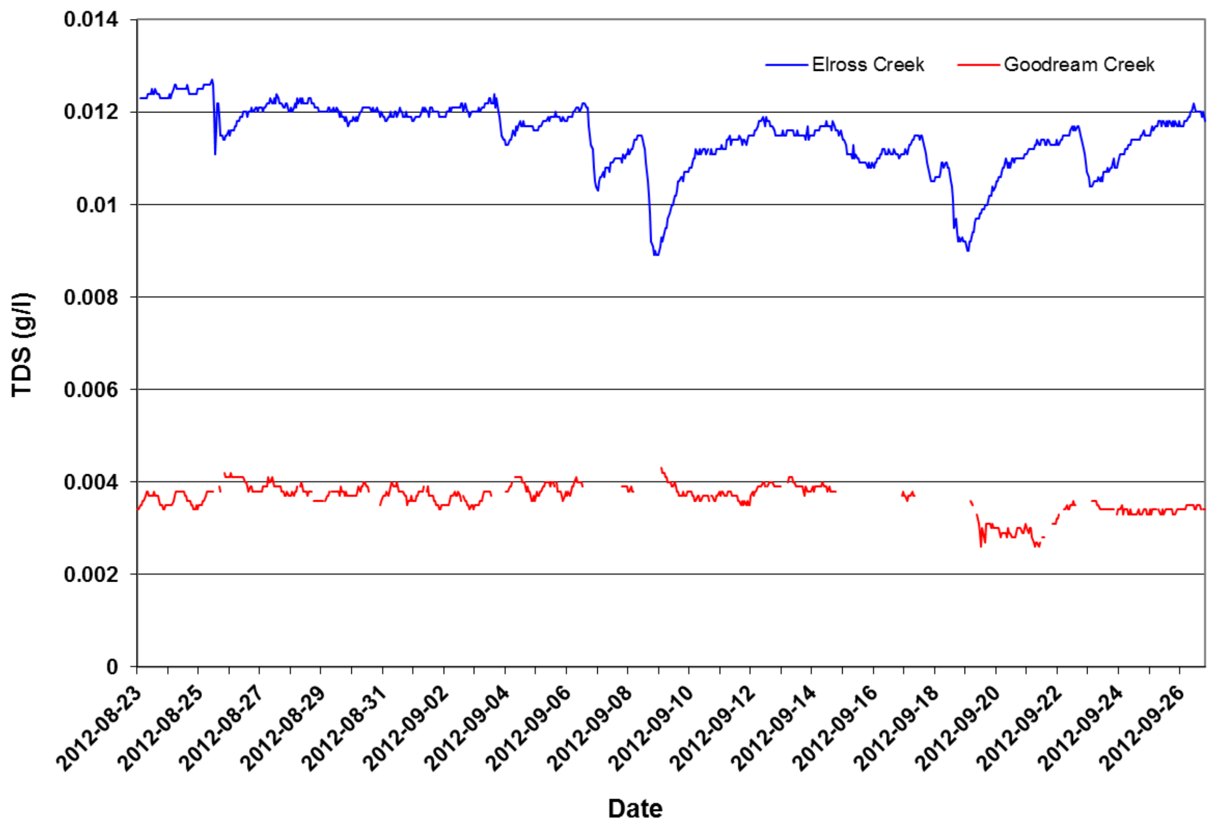

Figure 5. Hourly TDS (g/l) values recorded at Elross Creek and Goodream Creek August 23, 2012 to September 27, 2012.

Dissolved Oxygen

- Dissolved Oxygen [DO] values ranged from 9.21 mg/l to 11.37 mg/l at Elross Creek and from 8.84 mg/l to 12.93 mg/l at Goodream Creek from August 23, 2012 to September 27, 2012 (Figure 6).
- DO (mg/l) fluctuated daily, with increases in DO observed in the afternoon and decreases observed at night. These diurnal variations can be attributed to the photosynthetic activity of aquatic organisms.
- Weekly trends in DO (mg/l) corresponded well with the inverse of water temperature (Figure 2), since colder water has a greater potential to dissolve oxygen compared to warmer water.
- On average, DO values were 0.24 mg/l lower at Elross Creek compared to Goodream Creek. This difference can be attributed to the slightly warmer water temperatures at Elross Creek than at Goodream Creek (Figure 2).
- DO values at both stations fell below cold water minimum guidelines set for aquatic life during early life stages (9.5 mg/l) period, 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).

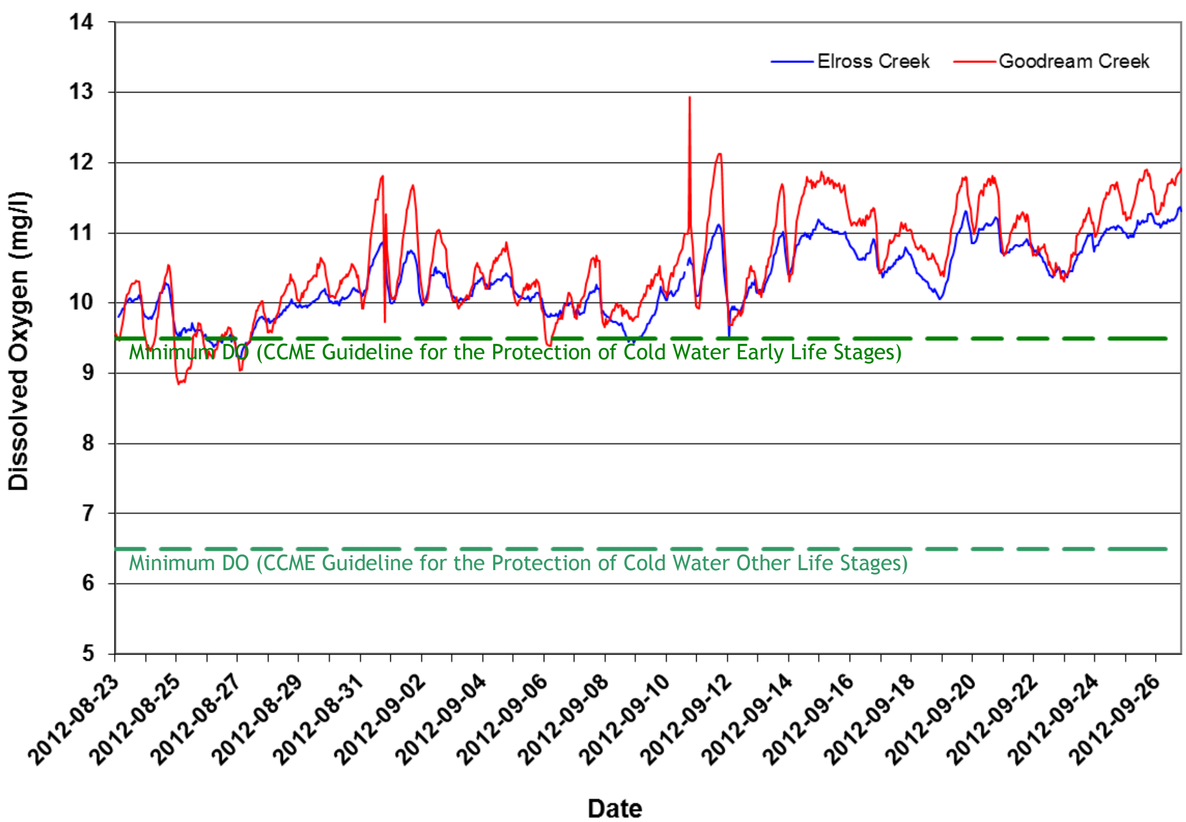

Figure 6. Hourly dissolved oxygen (mg/l) values recorded at Elross Creek and Goodream Creek from August 23, 2012 to September 27, 2012.

Turbidity

- Turbidity values ranged from 0.0 NTU to 3000.0 NTU[1] at Elross Creek and from 0.0 NTU to 3000.0 NTU[1] at Goodream Creek from August 23, 2012 to September 27, 2012 (Figure 7).
- Biofouling was thought to be responsible for causing large spikes in turbidity. Figure 8 shows a mix of leaves and sediment that was found interspersed in and around the instrument sensors at both stations on September 27, 2012. To prevent leaves and other debris from interfering with the sensors, station instruments were wrapped in a nylon mesh before their redeployment on September 27, 2012.
- Rainfall events are also known to cause spikes in turbidity at these stations, and may have contributed to increased turbidity levels.

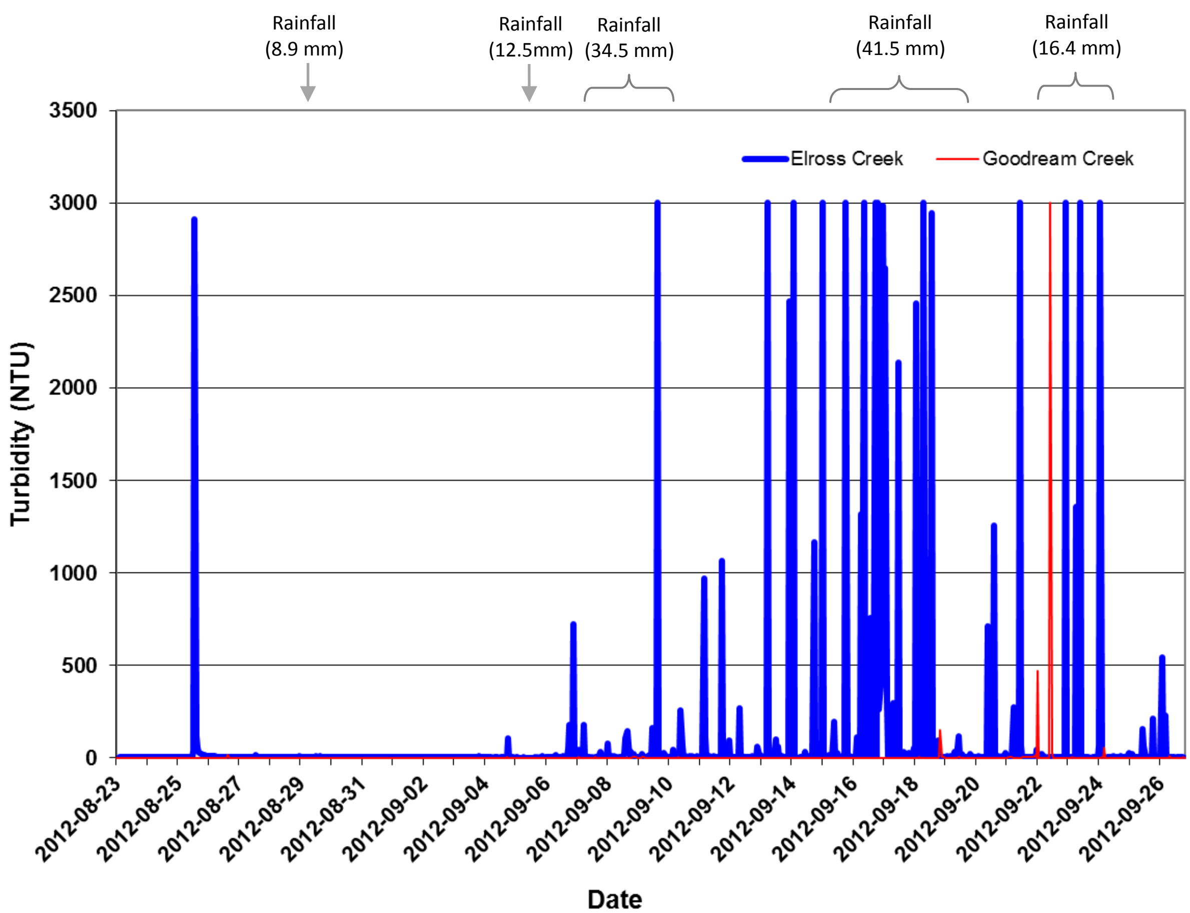

Figure 7. Hourly turbidity (NTU) values recorded at Elross Creek from August 23, 2012 to September 27, 2012.

[1] Please note that a turbidity reading of 3000.0 NTU can indicate an error result or that turbidity is greater or equal to 3000.0 NTU.

Figure 8. A mix of leaves and sediment were found tangled in and around the instrument sensors at (A) Elross Creek and (B) Goodream Creek on September 27, 2012.

Conclusion

- This monthly deployment report, presents water quality and water quantity data recorded at the Elross Creek and Goodream Creek stations from August 23, 2012 to September 27, 2012.
- Mining operations were halted on June 29, 2012, and resumed around September 5, 2012.
- Transmission errors occurred sporadically throughout the deployment period at the Goodream Creek station, resulting in the loss of 206 hourly data records. It was suspected that the time allotted by the ADRS for data upload from the station to the satellite was exceeded, causing 206 incomplete data transmissions. A more complete dataset was obtained from the Field Instrument's internal log file.
- The performances of all sensors were rated good to excellent at the beginning and end of the deployment period.
- Variations in water quality/quantity values recorded at each station are summarized below:
  - Weekly fluctuations in stage recorded at both stations coincided well with precipitation events.
  - Fluctuations in water temperature corresponded with fluctuations in air temperature.
  - Daily variations in pH coincided with the photosynthetic cycling of CO_2 by aquatic organisms and weekly trends in pH coincided well with changes in stage, which is influenced by rainfall activity and surface runoff.
  - Daily variations in specific conductivity and TDS values could be attributed to the photosynthetic cycling of CO_2 by aquatic organisms and weekly variations were in part attributed to changes in stage.
  - DO (mg/l) variations were related to changes in water temperature and the photosynthetic activity and aerobic respiration of aquatic organisms.
  - Turbidity events were mainly attributed to biofouling, and to a lesser extent, to rainfall events that cause increased flow rates and sedimentation.
- Field instruments for both stations were calibrated and redeployed on September 27, 2012.

References

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

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).

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 beginning 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 beginning 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 (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

[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 (μS/cm) is a measure of water's ability to conduct electricity, with values normalized to a water temperature of 25^{o}C. 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 (August 23, 2012 to September 27, 2012)

Date yyyy-mm-dd	Max Temp °C	Min Temp °C	Mean Temp °C	Heat Deg Days °C	Cool Deg Days °C	Total Rain mm	Total Snow cm	Total Precip mm	Snow on Grnd cm	Avg Wind Spd km/hr	Avg Wind Dir deg
2012-08-23	14.6	8.2	11.4	6.6	0	-	-	6.6	-	-	-
2012-08-24	16.4	9.4	12.9	5.1	0	-	-	0.3	-	-	-
2012-08-25	21.7	9.7	15.7	2.3	0	-	-	0.8	-	-	-
2012-08-26	21.8	14.5	18.2	0	0.2	-	-	5.3	-	-	-
2012-08-27	21.1	9.7	15.4	2.6	0	-	-	0.5	-	24.1	259.0
2012-08-28	-	8.6 (E)	-	-	-	-	-	-	-	17.4	271.9
2012-08-29	10.5	6	8.3	9.7	0	-	-	8.9	-	18.9	304.6
2012-08-30	11.2	6.6	8.9	9.1	0	-	-	0	-	13.8	271.7
2012-08-31	10.5	1.5	6	12	0	-	-	3.1	-	10.5	104.1
2012-09-01	15.4	1.2	8.3	9.7	0	-	-	0	-	12.2	296.1
2012-09-02	13.9	1.4	7.7	10.3	0	-	-	0	-	10.8	261.3
2012-09-03	16.8	8.1	12.5	5.5	0	-	-	0	-	18.3	257.8
2012-09-04	9.9	8.1	9	9	0	-	-	12.5	-	9.4	112.6
2012-09-05	12.1	7.3	9.7	8.3	0	-	-	0	-	14.2	145.8
2012-09-06	17.8	10.4	14.1	3.9	0	-	-	0	-	11.9	165.4
2012-09-07	16.2	9.4	12.8	5.2	0	-	-	8.1	-	12.5	177.5
2012-09-08	18	8.6	13.3	4.7	0	-	-	5.8	-	11.5	165.7
2012-09-09	16.5	9.5	13	5	0	-	-	20.6	-	27.3	210.8
2012-09-10	10.5	5.3	7.9	10.1	0	-	-	0.3	-	22.5	276.3
2012-09-11	12	-0.7	5.7	12.3	0	-	-	0	-	15.8	289.6
2012-09-12	20.8	-1	9.9	8.1	0	-	-	1.5	-	21.4	176.3
2012-09-13	14.3	3.2	8.8	9.2	0	-	-	0.3	-	30.3	263.8
2012-09-14	8.5	1.5	5	13	0	-	-	0.3	-	10.5	213.8
2012-09-15	3.8	1.3	2.6	15.4	0	-	-	9.8	-	10.9	91.3
2012-09-16	8.5	3.4	6	12	0	-	-	5.6	-	9.9	131.7
2012-09-17	14.4	5	9.7	8.3	0	-	-	1.6	-	13.2	301.7
2012-09-18	14.2	6.3	10.3	7.7	0	-	-	11	-	9.4	183.3
2012-09-19	14.1	1.7	7.9	10.1	0	-	-	13.5	-	31.3	196.7
2012-09-20	9.8	1.2	5.5	12.5	0	-	-	0	-	22.7	233.8
2012-09-21	15.5	3.6	9.6	8.4	0	-	-	0.5	-	18.7	174.2
2012-09-22	13.2	7.1	10.2	7.8	0	-	-	2.8	-	9.7	160.0
2012-09-23	13.5	4.2	8.9	9.1	0	-	-	13.6	-	19.7	176.7
2012-09-24	8.4	3.7	6.1	11.9	0	-	-	0	-	21.6	204.3
2012-09-25	8.2	3.1	5.7	12.3	0	-	-	0.3	-	-	-
2012-09-26	6.4	2.2	4.3	13.7	0	-	-	0	-	-	-
2012-09-27	6.8	1.8	4.3	13.7	0	-	-	5.1	-	-	-
2012-08-23	14.6	8.2	11.4	6.6	0	-	-	6.6	-	-	-
2012-08-24	16.4	9.4	12.9	5.1	0	-	-	0.3	-	-	-
2012-08-25	21.7	9.7	15.7	2.3	0	-	-	0.8	-	-	-
2012-08-26	21.8	14.5	18.2	0	0.2	-	-	5.3	-	-	-

- = No data available
M = Missing
E = Estimated
A = Accumulated
C = Precipitation occurred, amount uncertain
L = Precipitation may or may not have occurred
F = Accumulated and estimated
N = Temperature missing but known to be > 0
Y = Temperature missing but known to be < 0
S = More than one occurrence
T = Trace
* = The value displayed is based on incomplete data
† = Data for this day has undergone only preliminary quality checking

APPENDIX C (continued...)

Environment Canada Weather Data – Schefferville (August 23, 2012 to September 27, 2012)

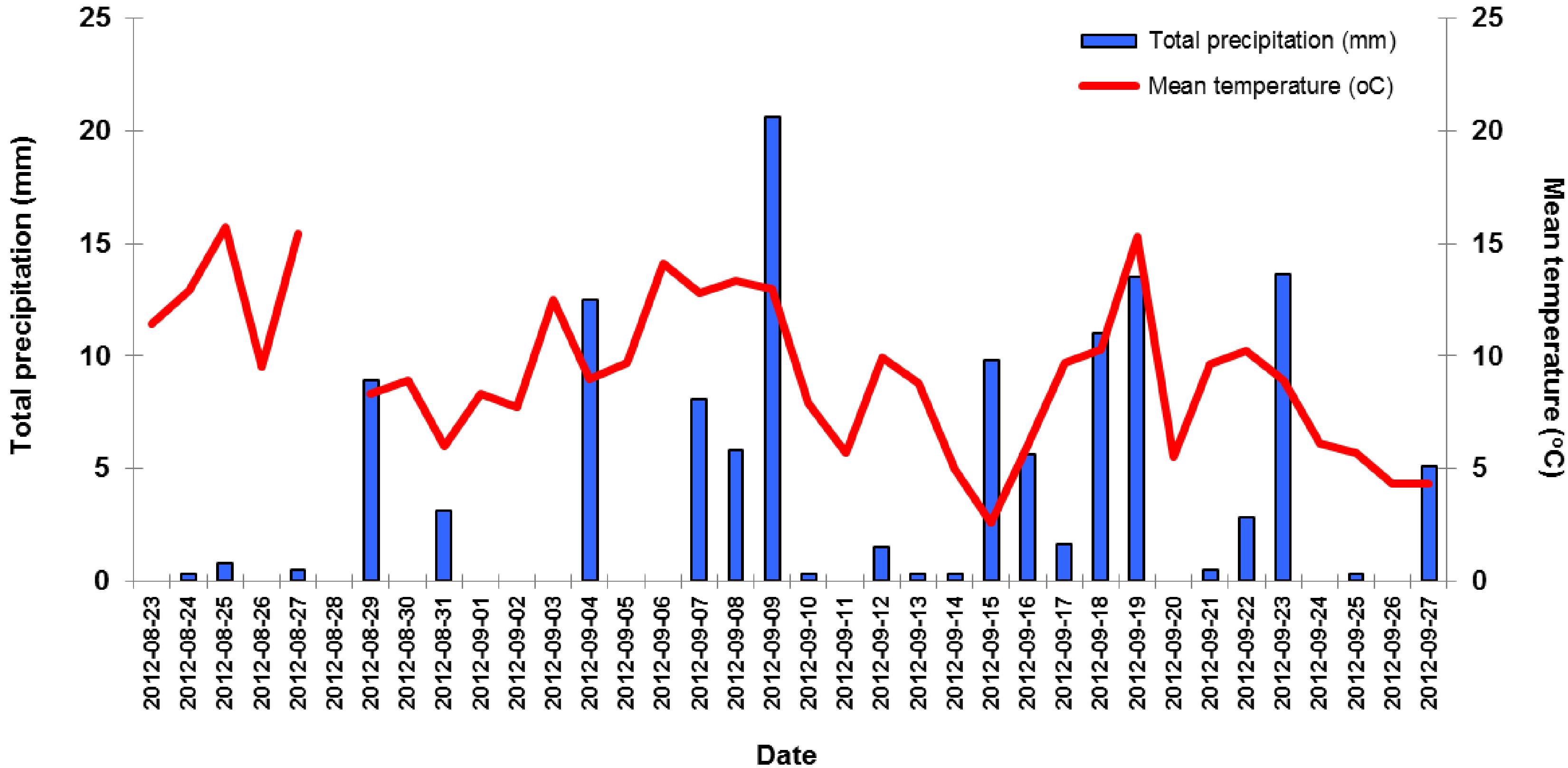

Figure 1. Daily precipitation and mean temperature recorded at the Schefferville Weather Station by Environment Canada from August 23, 2012 to September 27, 2012.

APPENDIX C (continued...)

Environment Canada Weather Data - Schefferville (August 23, 2012 to September 27, 2012)

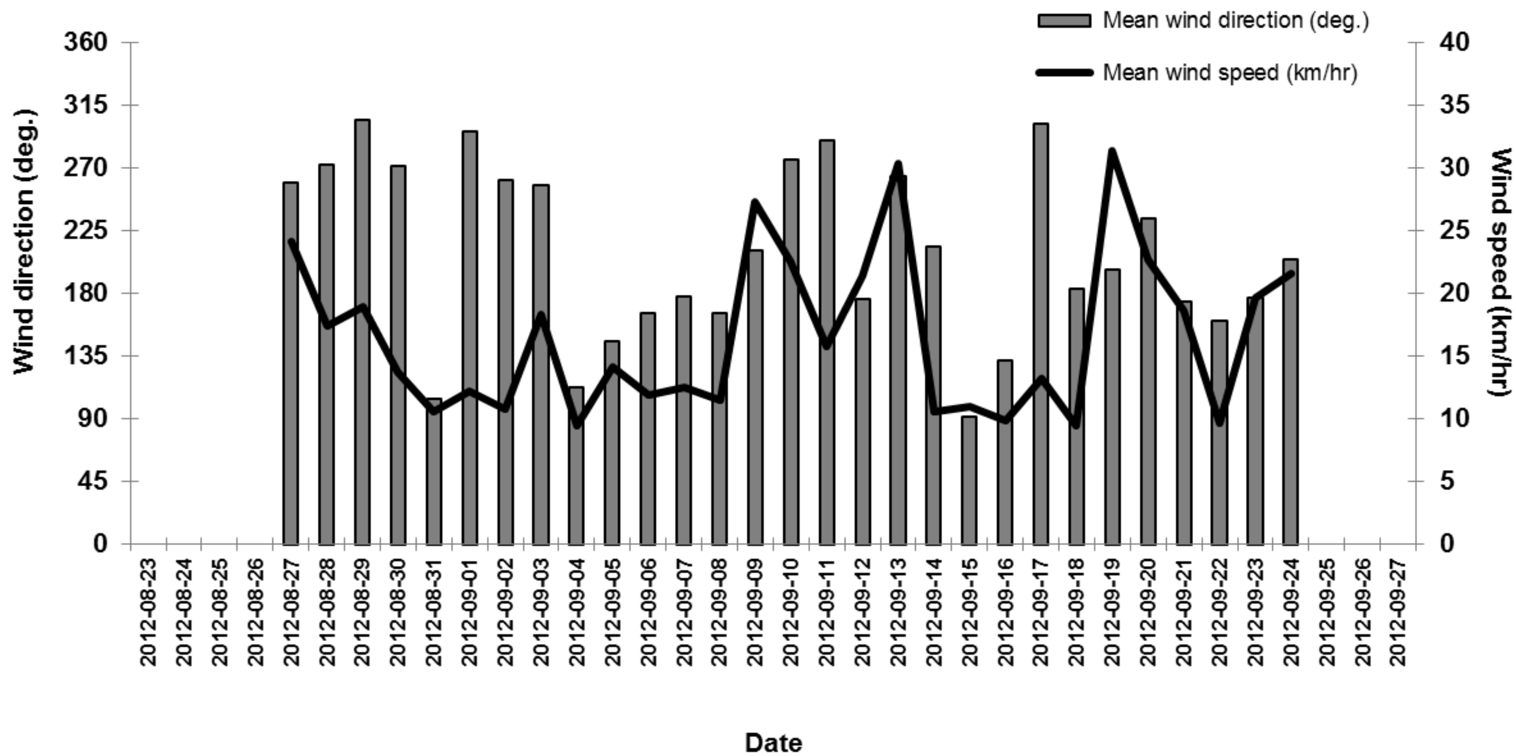

Figure 2. Mean daily wind direction and wind speed recorded at the Schefferville Weather Station by Environment Canada from August 23, 2012 to September 27, 2012.