Real Time Water Quality Report

Tata Steel Minerals Canada
Elross Lake Network

Deployment Period
2012-09-27 to 2012-10-25

Government of Newfoundland & Labrador
Department of Environment and Conservation
Water Resources Management Division
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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 September 27, 2012 to October 25, 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	2012-09-27	2012-10-25	2012-09-27	2012-10-25
Temperature	Excellent	Excellent	Excellent	Excellent
pH	Good	Excellent	Good	Good
Specific Conductivity	Excellent	Excellent	Excellent	Good
Dissolved Oxygen	Excellent	Fair	Excellent	Fair
Turbidity	Excellent	Excellent	Excellent	Excellent

- Sensor performances were rated in the range of fair to excellent at the beginning and end of the deployment period at both stations (Table 1).

Deployment Notes

- Water quality monitoring stopped at Goodream Creek on October 12, 2012 at 3:30 am. Both the data logger inside the streamside hut, as well as the internal log file within the instrument, did not acquire any data from October 12-25, 2012. The portion of stream where the instrument was located was completely ice covered. The instrument regained its connection and started logging water quality data after it was removed from the stream and had its battery chamber dried of any water droplets. It was suspected that freezing temperatures and ice formation caused water to come in contact with the instrument's electrical components, resulting in an electrical short and the instrument to malfunction.

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 1.094 m to 1.164 m at Elross Creek and from 1.815 m to 2.202 m at Goodream Creek from September 27, 2012 to October 25, 2012 (Figure 1).
- Moderate fluctuations in stage, which were more evident at Goodream Creek, coincided well with precipitation events (Appendix C).
- Abrupt fluctuations in stage were attributed to freezing air temperatures and ice formation. Also, the Water Survey of Canada (WSC) vertical reference calibrations on September 28, 2012, resulted in a slight decrease in stage at both stations.
- Data loss on September 12, 2012, was attributed to an electrical short, after water was suspected of entering into the electrically system, affecting power distribution to the datalogger.
- 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.

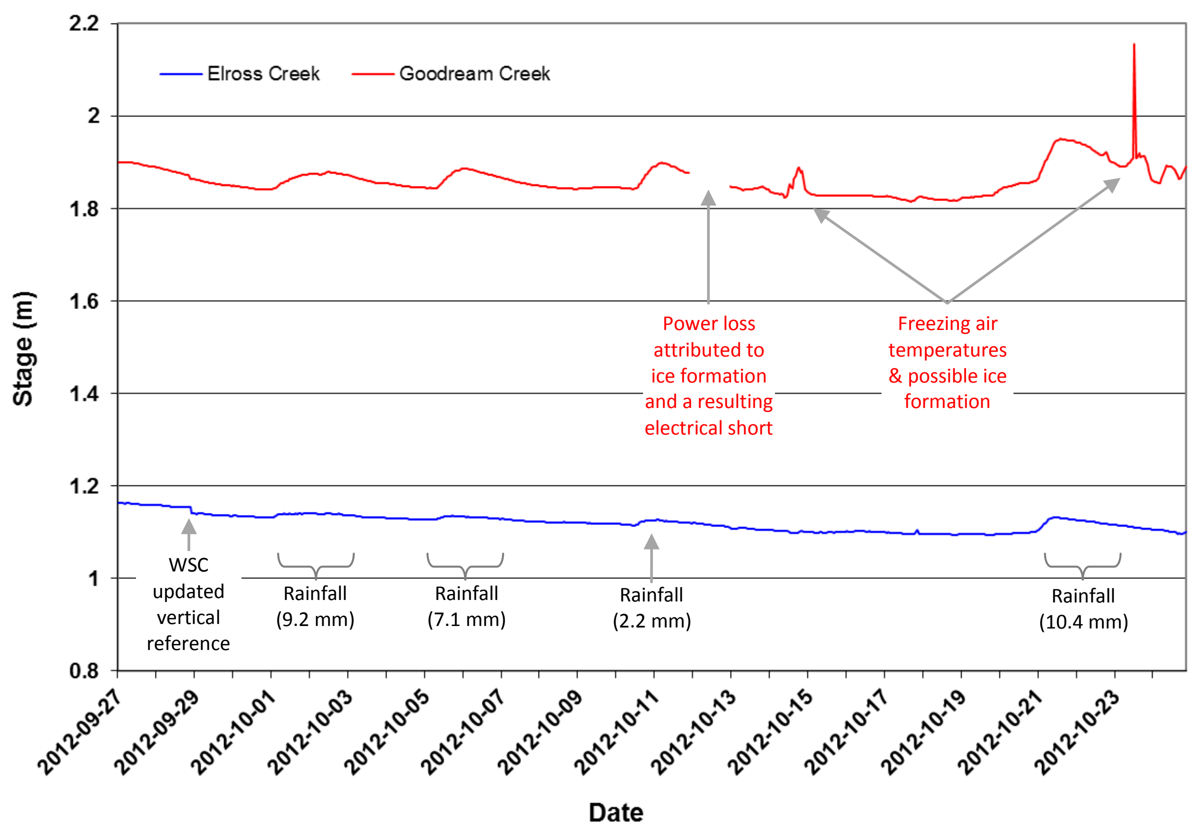

Figure 1. Hourly stage (m) values recorded at Elross Creek and Goodream Creek from September 27, 2012 to October 25, 2012.

Temperature

- Water temperature ranged from 0.20˚C to 9.10˚C at Elross Creek and from 1.50˚C to 10.40˚C at Goodream Creek from September 27, 2012 to October 25, 2012 (Figure 2).
- Water temperatures at both stations display large diurnal variations, 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).
- On average, water temperature was 0.71°C colder at Goodream Creek than at Elross Creek.

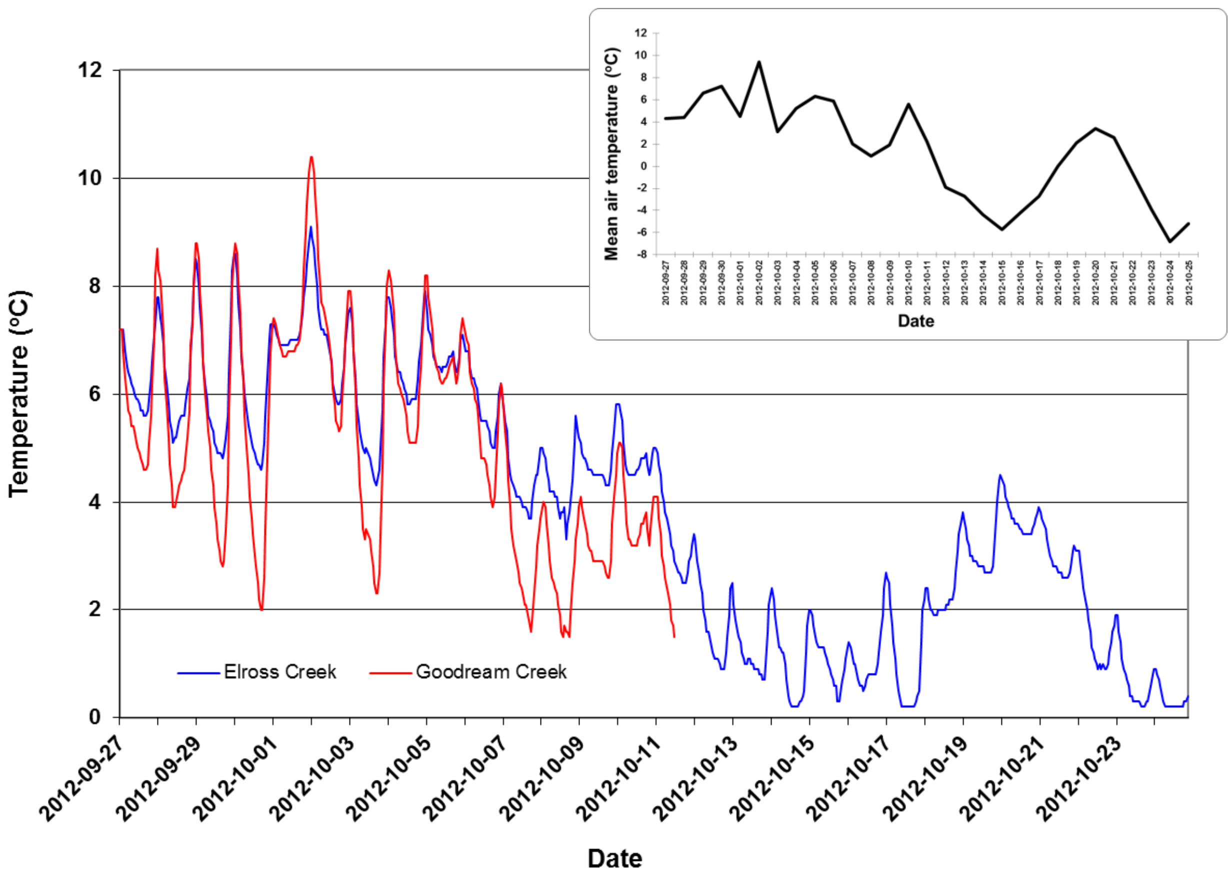

Figure 2. Hourly water temperature (°C) values recorded at Elross Creek and Goodream Creek from September 27, 2012 to October 25, 2012. The inset chart shows mean daily air temperature during the same period, as recorded by Environment Canada at the Schefferville weather station.

pH

- pH values ranged from 6.61 units to 6.87 units at Elross Creek and from 6.24 units to 6.53 units at Goodream Creek from September 27, 2012 to October 25, 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.
- On average, pH was 0.40 units higher at Elross Creek than at Goodream Creek.
- pH values recorded at Elross Creek were 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 pH values recorded at Goodream Creek fell below this minimum guideline.

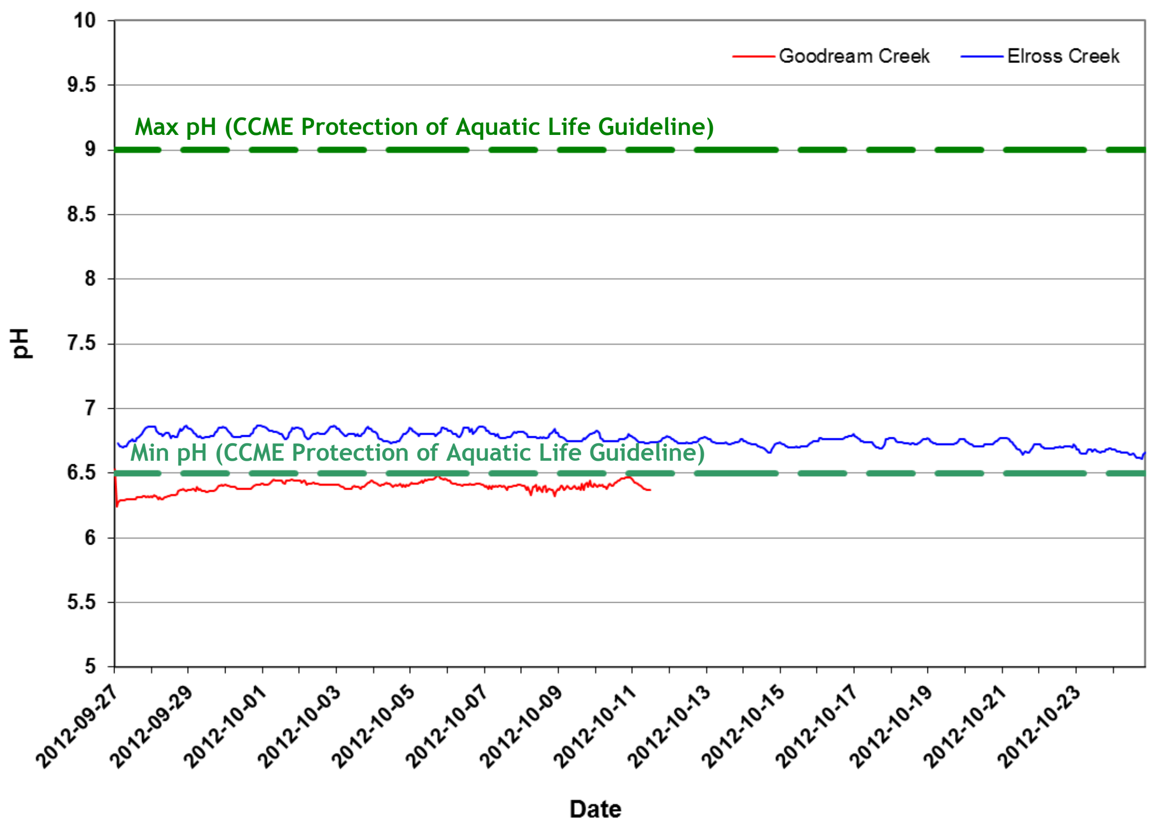

Figure 3. Hourly pH values recorded at Elross Creek and Goodream Creek from September 27, 2012 to October 25, 2012.

Specific Conductivity

- Specific Conductivity ranged from 16.3 μs/cm to 20.4 μs/cm at Elross Creek and from 5.0 μs/cm to 7.0 μs/cm at Goodream Creek from September 27, 2012 to October 25, 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 13.9 μS/cm higher at Elross Creek than at Goodream Creek.

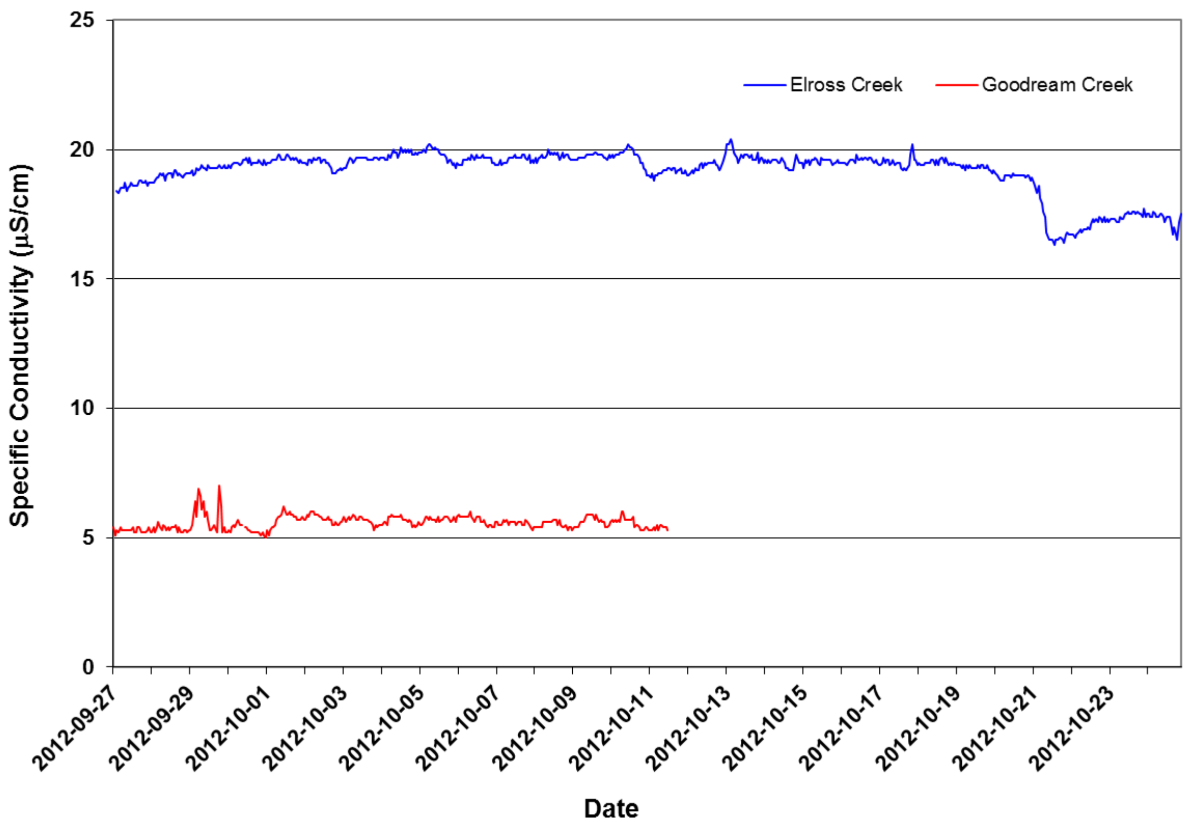

Figure 4. Hourly specific conductivity (μs/cm) values recorded at Elross Creek and Goodream Creek from September 27, 2012 to October 25, 2012.

Total Dissolved Solids

- Total Dissolved Solids (TDS) values ranged from 0.0105 g/l to 0.0130 g/l at Elross Creek and from 0.0032 g/l to 0.0045 g/l at Goodream Creek from September 27, 2012 to October 25, 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 0.0089 g/l higher at Elross Creek compared to Goodream Creek.

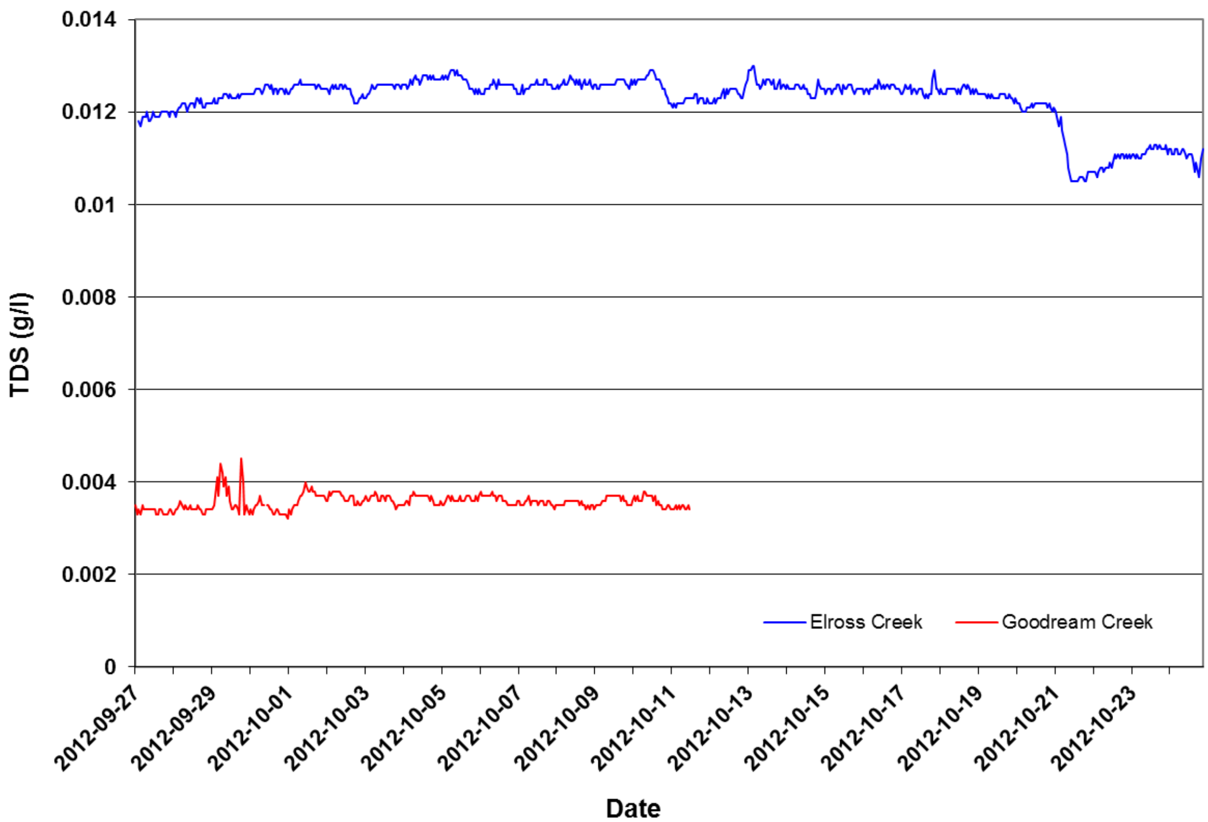

Figure 5. Hourly TDS (g/l) values recorded at Elross Creek and Goodream Creek September 27, 2012 to October 25, 2012.

Dissolved Oxygen

- Dissolved Oxygen [DO] values ranged from 10.83 mg/l to 13.37 mg/l at Elross Creek and from 10.43 mg/l to 12.91 mg/l at Goodream Creek from September 27, 2012 to October 25, 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 0.23 mg/l lower at Elross Creek compared to Goodream Creek.
- DO values at both stations were above cold water minimum guidelines set for aquatic life during early life stages (9.5 mg/l), and above minimum guidelines set for other life stages (6.5 mg/l), as determined by the Canadian Council of Ministers of the Environment (2007).

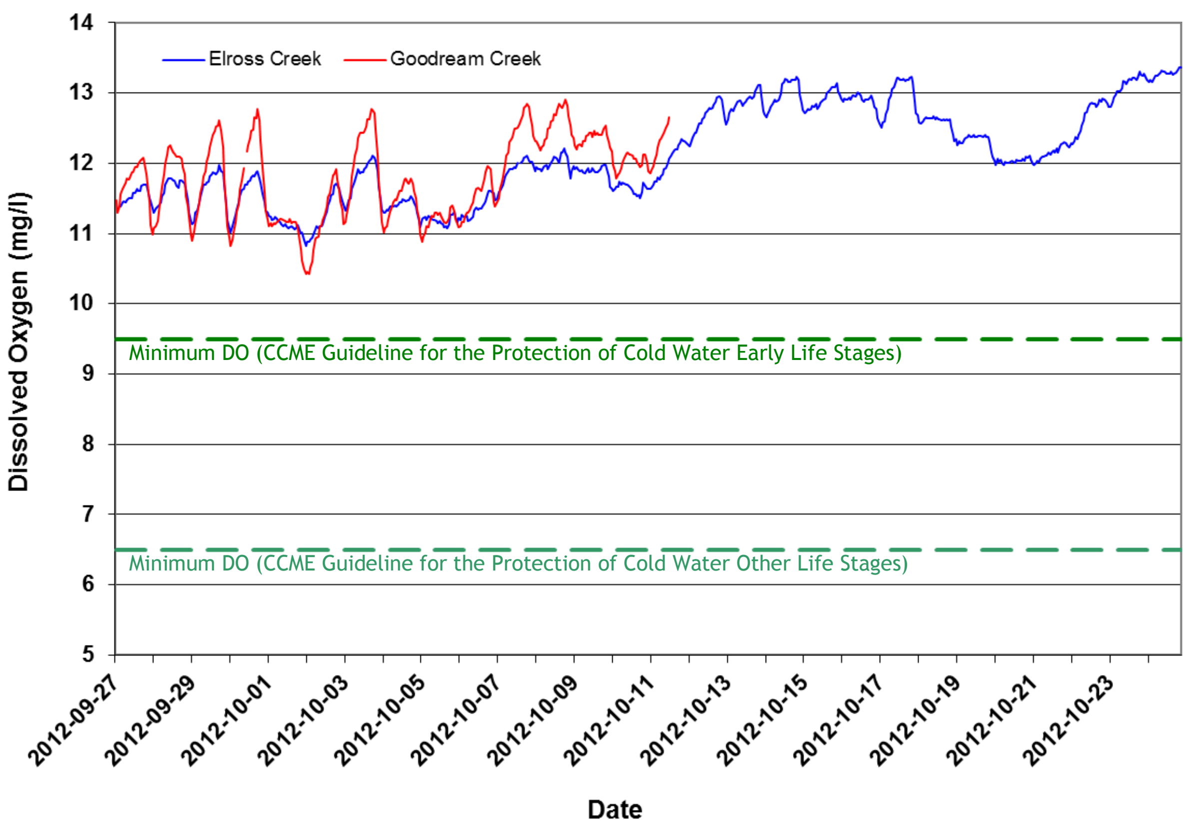

Figure 6. Hourly dissolved oxygen (mg/l) values recorded at Elross Creek and Goodream Creek from September 27, 2012 to October 25, 2012.

Turbidity

- Turbidity values ranged from 1.7 NTU to 686.0 NTU at Elross Creek and from 0.0 NTU to 10.6 NTU at Goodream Creek from September 27, 2012 to October 25, 2012 (Figure 7).
- The large spike in turbidity recorded at Elross Creek on October 21, 2012, coincided with a rainfall event (10.4 mm), which likely generated increased stream sediment loads.

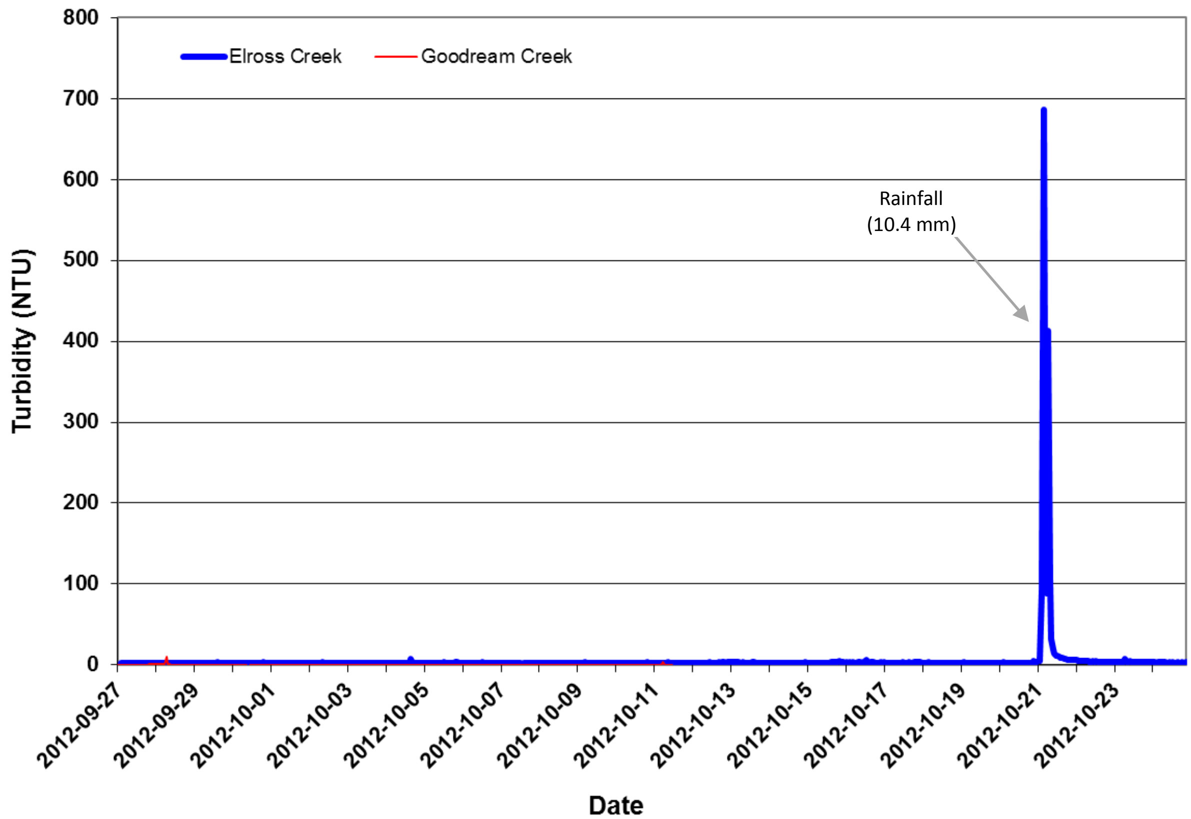

Figure 7. Hourly turbidity (NTU) values recorded at Elross Creek from September 27, 2012 to October 25, 2012.

Conclusion

- This monthly deployment report, presents water quality and water quantity data recorded at the Elross Creek and Goodream Creek stations from September 27, 2012 to October 25, 2012.
- Water quality monitoring ceased at Goodream Creek on October 12, 2012 at 3:30 am. It was suspected that freezing temperatures and ice formation caused water to come in contact with the instrument's electrical components, resulting in an electrical short and the instrument to stop recording data.
- The performances of all sensors were rated in the range of fair 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, with some abrupt fluctuations caused by vertical reference system calibration and ice formation.
  - 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.
  - Daily variations in specific conductivity and TDS values could be attributed to the photosynthetic cycling of CO_2 by aquatic organisms and weekly variations corresponded well with changes in stage, which is influenced by rainfall and runoff.
  - DO (mg/l) variations were related to changes in water temperature and the photosynthetic activity and aerobic respiration of aquatic organisms.
  - The one major turbidity event at Elross Creek coincided with a rainfall event, which likely caused an increase in stream sediment loads.
- Field instruments for both stations will undergo Proficiency, Testing, and Evaluation, and are scheduled for redeployment in late spring (i.e., June 2013).
- An annual deployment report will be circulated in March 2013, which will summarize all water quality/quantity data recorded at both stations from June 5, 2012, to October 25, 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 (°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 (September 27, 2012 to October 25, 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
2012-09-27	6.8	1.8	4.3	13.7	0	-	-	5.1	-	14.5	323.3
2012-09-28	8.2	0.6	4.4	13.6	0	-	-	0.3	-	10.5	269.2
2012-09-29	11.5	1.7	6.6	11.4	0	-	-	0	-	9.8	189.1
2012-09-30	14.1	0.3	7.2	10.8	0	-	-	0	-	12.5	221.7
2012-10-01	10.8	-1.9	4.5	13.5	0	-	-	7.6	-	4.9	75.2
2012-10-02	13	5.7	9.4	8.6	0	-	-	1.6	-	9.5	197.0
2012-10-03	7.2	-1.1	3.1	14.9	0	-	-	0	-	14.0	282.2
2012-10-04	11.5	-1.1	5.2	12.8	0	-	-	0	-	11.3	159.6
2012-10-05	9.1	3.4	6.3	11.7	0	-	-	3.5	-	10.7	128.3
2012-10-06	8.7	3	5.9	12.1	0	-	-	3.6	-	16.3	200.4
2012-10-07	4.4	-0.5	2	16	0	-	-	0.3	-	25.0	255.8
2012-10-08	2.7	-0.9	0.9	17.1	0	-	-	0	-	14.8	220.0
2012-10-09	3.6	0.2	1.9	16.1	0	-	-	0.8	-	18.8	217.9
2012-10-10	8.8	2.3	5.6	12.4	0	-	-	0	-	22.6	171.3
2012-10-11	5.4	-1.1	2.2	15.8	0	-	-	5.8	-	23.2	261.3
2012-10-12	0.2	-4	-1.9	19.9	0	-	-	0	-	34.7	298.8
2012-10-13	-0.2	-5.2	-2.7	20.7	0	-	-	0	-	36.2	301.7
2012-10-14	-1.1	-7.6	-4.4	22.4	0	-	-	0	-	23.4	307.8
2012-10-15	-1.9	-9.5	-5.7	23.7	0	-	-	0	-	8.6	290.0
2012-10-16	-3	-5.3	-4.2	22.2	0	-	-	1.1	-	15.4	65.0
2012-10-17	0.7	-6.1	-2.7	20.7	0	-	-	0.8	-	17.2	307.9
2012-10-18	3.1 (E)	-10 (E)	-3.5 (E)	21.5 (E)	0 (E)	-	-	0	-	7.5	151.3
2012-10-19	4.2	-0.1	2.1	15.9	0	-	-	0	-	9.0	137.7
2012-10-20	5.9	0.9	3.4	14.6	0	-	-	0	-	13.0	152.1
2012-10-21	4.2	0.9	2.6	15.4	0	-	-	9.6	-	9.6	142.3
2012-10-22	1.7	-2.9	-0.6	18.6	0	-	-	0.8	-	19.8	334.2
2012-10-23	-1.9	-5.8	-3.9	21.9	0	-	-	0	-	29.5	322.5
2012-10-24	-5	-8.6	-6.8	24.8	0	-	-	0	-	24.8	313.8
2012-10-25	-0.8	-9.6	-5.2	23.2	0	-	-	0	-	9.4	212.9

- = 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 (September 27, 2012 to October 25, 2012)

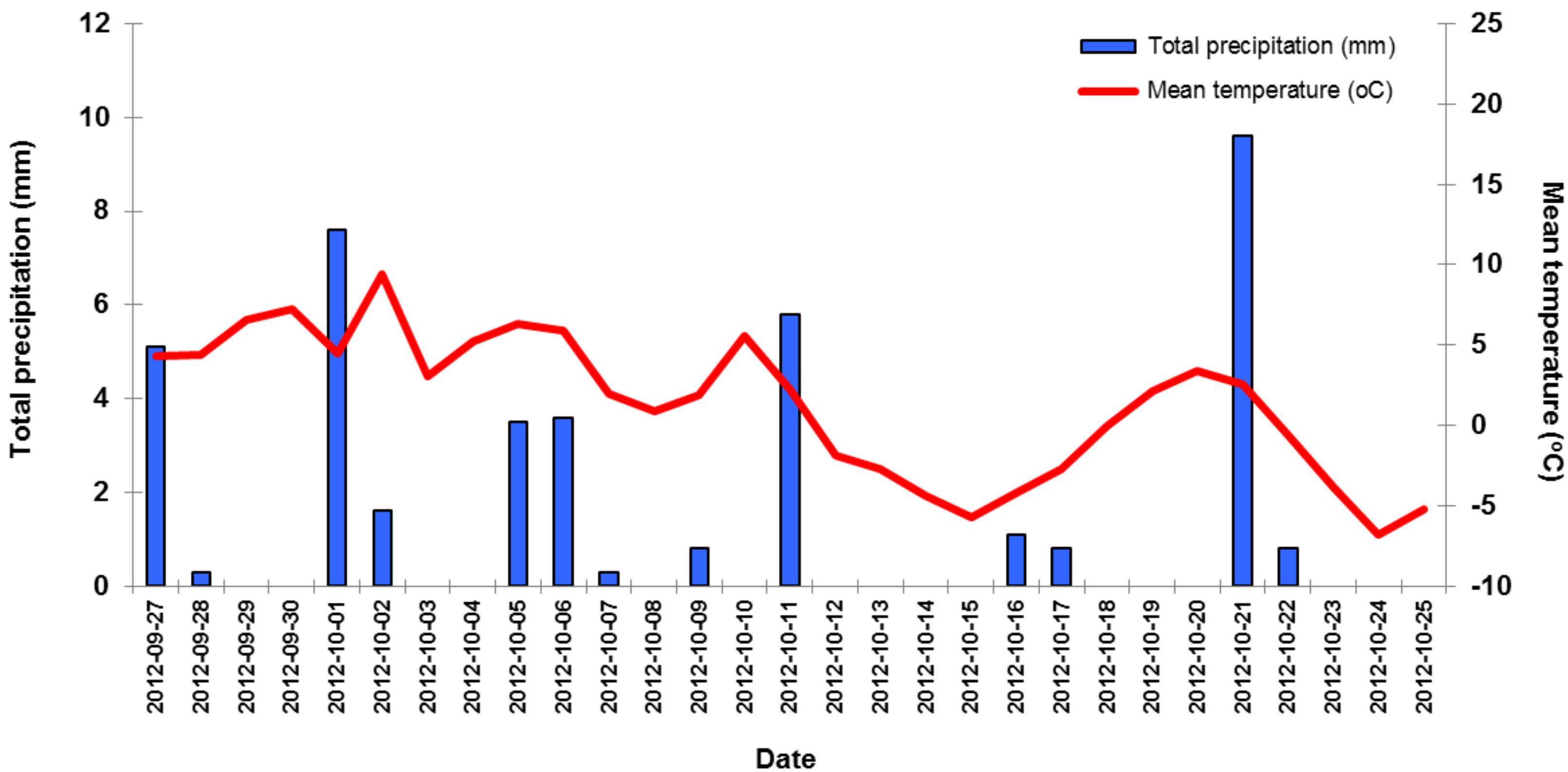

Figure 1. Daily precipitation and mean temperature recorded at the Schefferville Weather Station by Environment Canada from September 27, 2012 to October 25, 2012.

APPENDIX C (continued...)

Environment Canada Weather Data - Schefferville (September 27, 2012 to October 25, 2012)

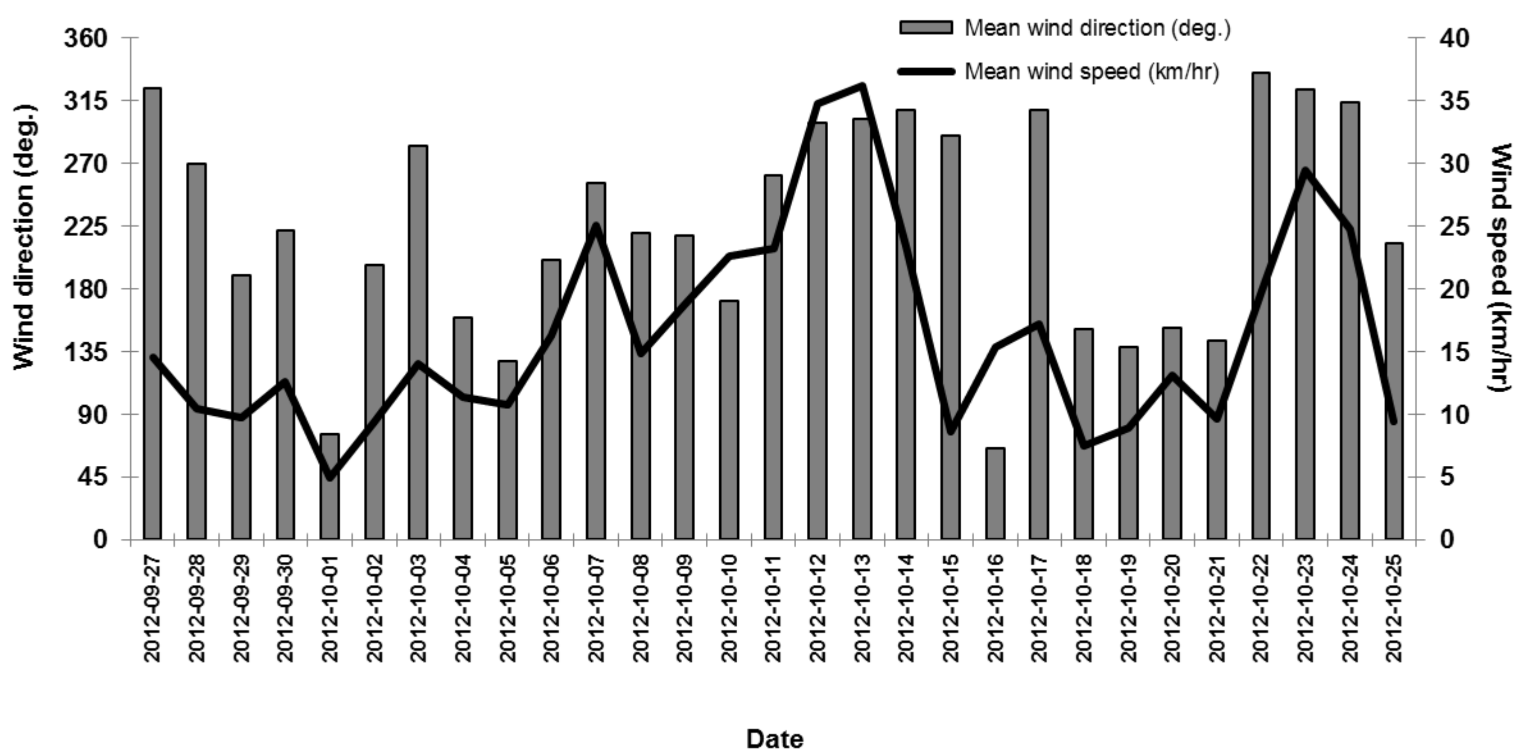

Figure 2. Mean daily wind direction and wind speed recorded at the Schefferville Weather Station by Environment Canada from September 27, 2012 to October 25, 2012.