

## Real Time Water Quality Report

# Labrador Iron Mines Schefferville Network

Deployment Period  
2012-08-22 to 2012-09-26



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 Labrador Iron Mines Ltd. and Environment Canada, maintain two real-time water quality and water quantity stations in close proximity to the James Property deposits, near Schefferville, QC.
- The official name of each station is *James Creek Above Bridge* and *Unnamed Tributary Below Settling Pond*, hereafter referred to as the *James Creek* station and the *Unnamed Tributary* station, respectively.
- Unnamed Tributary station monitors water outflow from a series of multi-cell retention and settling ponds.
- James Creek station monitors water outflow from the multi-cell retention and settling pond system mentioned above, as well as monitors outflow from Ruth Pit.
- The retention and settling pond system is comprised of four smaller man-made ponds that receive water primarily from groundwater wells constructed along the periphery of the James Property, in addition to storm water from the beneficiation area, flush water from the reject rock pipeline, and in case of pump failure, reject rock inside the pipeline that was destined to Ruth Pit. Outflow from the retention and settling pond system is directed into the Unnamed Tributary and James Creek. Priority is given to the outflow leading into the Unnamed Tributary, with surplus water directed into James Creek.
- Ruth Pit is used as a settling pond for reject rock originating from the beneficiation area at the Silver Yard, as well as receives water from pit dewatering pumps. The outflow from Ruth Pit is the start of James Creek.
- The Water Resources Management Division will inform Labrador Iron Mines Ltd. 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 James Creek and Unnamed Tributary stations from August 22, 2012 to September 26, 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 James Creek and Unnamed Tributary stations.

	James Creek (Sonde 49199)		Unnamed Tributary (Sonde 49200)	
	Beginning	End	Beginning	End
Stage of deployment	Beginning	End	Beginning	End
Date	2012-08-22	2012-09-26	2012-08-22	2012-09-26
Temperature	Excellent	Excellent	Excellent	Excellent
pH	Good	Fair	Excellent	Excellent
Specific Conductivity	Excellent	Excellent	Excellent	Excellent
Dissolved Oxygen	Excellent	Good	Excellent	Excellent
Turbidity	Excellent	Excellent	Excellent	Good

- The performances of all sensors were rated fair to excellent at the beginning and end of the deployment period (Table 1).
- The James Creek pH sensor was given a fair performance rating at the end of its deployment on September 26, 2012. Indeed, the recorded pH reading of the Field Instrument (7.09 units) was 0.66 units less than the recorded pH reading of the QA/QC Instrument (7.75 units). It was suspected that the drop in pH was due to a faulty pH sensor.

## Deployment Notes

- No mine tailings were discharged into Ruth Pit after August 16, 2012.
- Transmission errors occurred sporadically throughout the deployment period at the James Creek station, resulting in the loss of 144 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 144 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 internal log file. Data gaps are apparent in the specific conductivity, TDS, and stage graphs shown in this report.

## Data Interpretation

- Data records were interpreted for each station during the deployment period for the following seven parameters:
 

(i.) Stage (m)	(v.) Total dissolved solids (g/l)
(ii.) Temperature (°C)	(vi.) Dissolved oxygen (mg/l)
(iii.) pH	(vii.) Turbidity (NTU)
(iv.) Specific conductivity (µS/cm)	
- A description of each parameter is provided in Appendix B.

## Stage

- Stage values ranged from 0.817 m to 0.857 m at James Creek and from 1.098 m to 1.130 m at Unnamed Tributary from August 22, 2012 to September 26, 2012 (Figure 1).
- Daily fluctuations were observed at both stations with increases occurring in the afternoon and decreases occurring at night. These diurnal fluctuations were attributed to temperature-related atmospheric pressure changes.
- Rainfall events caused some minor spikes in stage at both stations. For example, rainfall activity on August 4, 2012 (8.9 mm) and between August 7, 2012 and August 9, 2012 (34.5 mm) caused some minor disturbances in stage.
- 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.

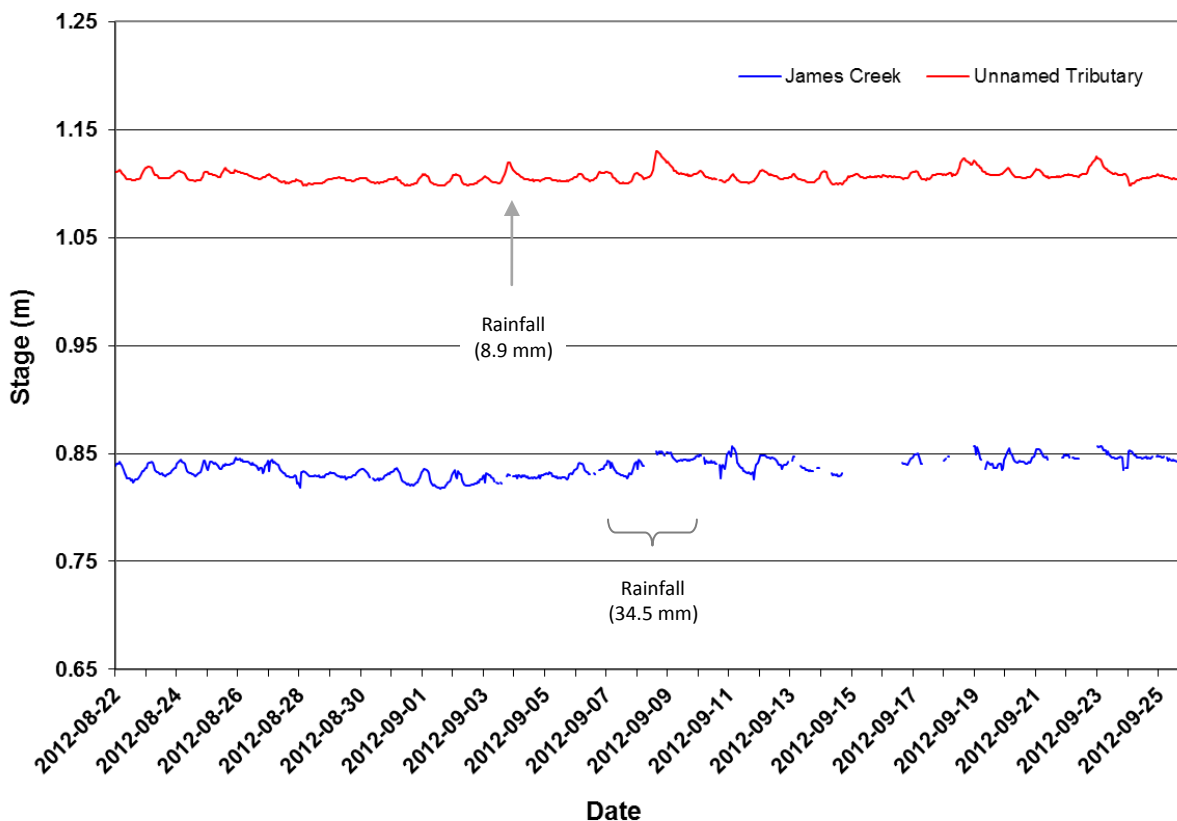


Figure 1. Hourly stage (m) values recorded at James Creek and Unnamed Tributary from August 22, 2012 to September 26, 2012.

## Temperature

- Water temperature ranged from 4.93°C to 12.93°C at James Creek and from 2.60°C to 12.70°C at Unnamed Tributary from August 22, 2012 to September 26, 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 corresponded well with ambient air temperatures recorded by Environment Canada at the Schefferville weather station (Figure 2 inset, Appendix C).
- Water temperatures at the Unnamed Tributary were on average 1.56°C colder than water temperatures at James Creek. Indeed, water flowing into the Unnamed Tributary is close to its groundwater source, and has less exposure to ambient air temperatures, as compared to the surface water source that primarily feeds into James Creek.

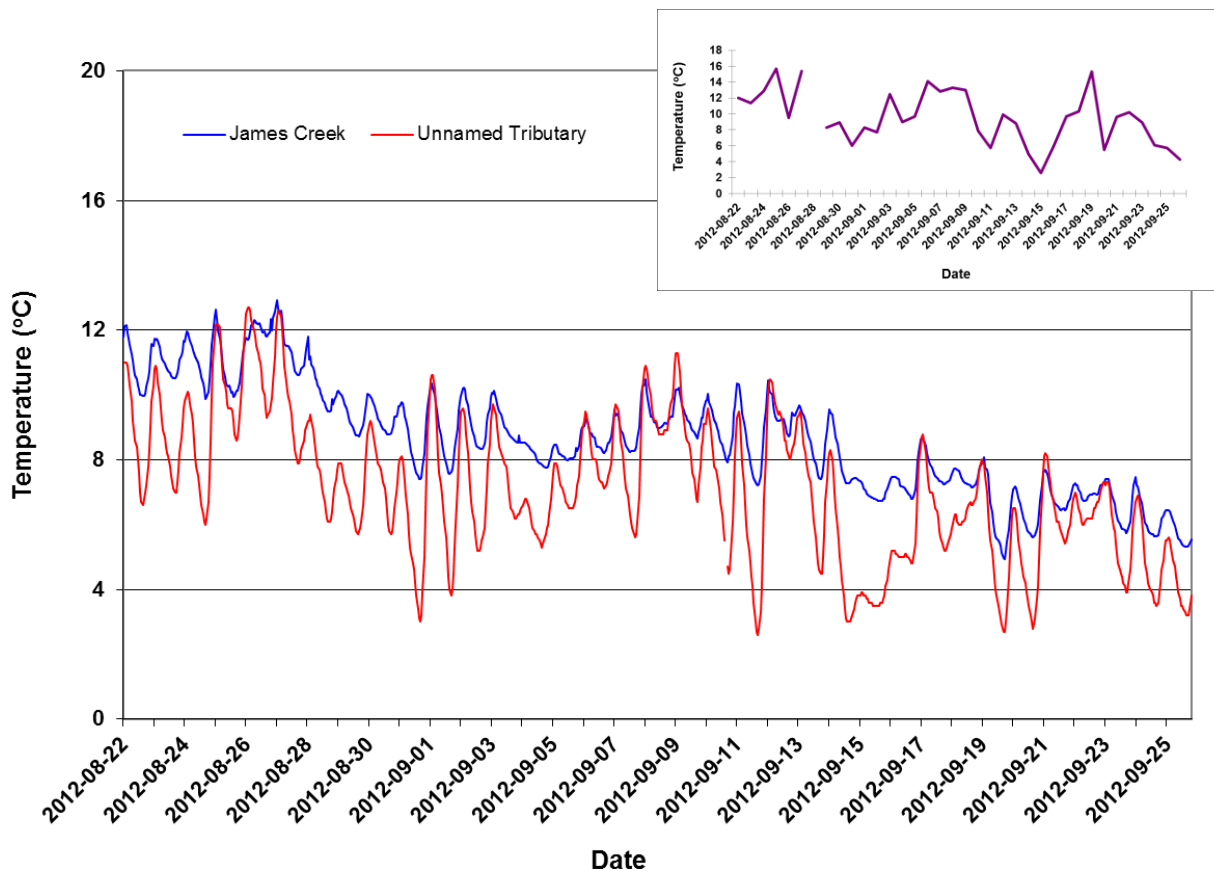


Figure 2. Hourly water temperature (°C) values recorded at James Creek and Unnamed Tributary from August 22, 2012 to September 26, 2012. The inset chart shows air temperature during the same period, as recorded by Environment Canada at the Schefferville weather station.

## pH

- pH values recorded at the James Creek station were considered inaccurate. There was a decreasing trend in pH observed at this station, starting one week after deployment (Figure 3), which was attributed to a problem with the pH sensor. The data is displayed here for the purpose of documenting a sensor issue at this station.
- pH values ranged from 6.50 units to 8.65 units at James Creek and from 7.31 units to 7.66 units at Unnamed Tributary from August 22, 2012 to September 26, 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<sub>2</sub> by aquatic organisms.
- Weekly trends in pH were apparent at the James Creek station; pH decreased abruptly from August 31, 2012 to September 5, 2012, and decreased more gradually from September 5, 2012 to the end of the deployment period. The decrease in pH was attributed to a faulty pH sensor. The Teflon junction on the pH reference probe has since been replaced on this instrument to try and remedy this problem.
- No weekly trends in pH levels were apparent at the Unnamed Tributary station.
- pH values recorded at both stations were within the acceptable range for the protection of aquatic life (i.e., 6.5 to 9.0 units), as defined by the Canadian Council of Ministers of the Environment (2007).

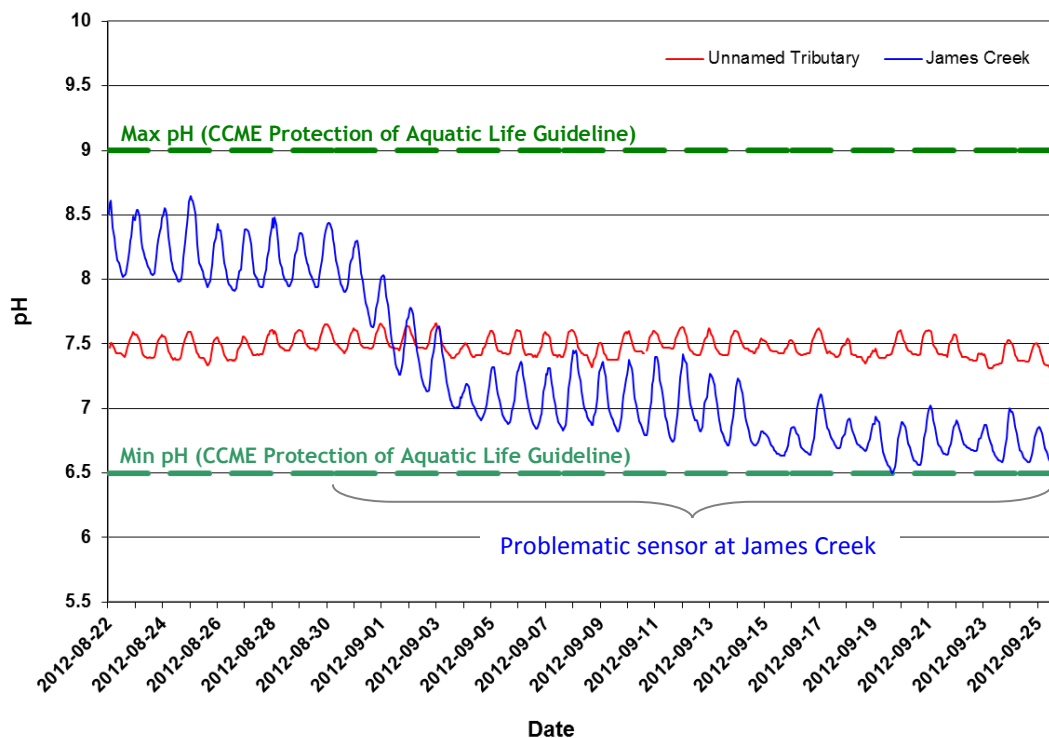


Figure 3. Hourly pH values recorded at James Creek and Unnamed Tributary from August 22, 2012 to September 26, 2012.



## Specific Conductivity

- Specific Conductivity ranged from 136.0  $\mu\text{S}/\text{cm}$  to 146.8  $\mu\text{S}/\text{cm}$  at James Creek and from 55.6  $\mu\text{S}/\text{cm}$  to 61.4  $\mu\text{S}/\text{cm}$  at Unnamed Tributary from August 22, 2012 to September 26, 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  $\text{CO}_2$  by aquatic organisms, with peaks coinciding with a presumed increase in major ions (e.g.,  $\text{HCO}_3^-$ ) during the night.
- There were no apparent weekly trends in specific conductivity observed during the deployment period for both stations.
- On average, specific conductivity was 82.2  $\mu\text{S}/\text{cm}$  higher at James Creek than at Unnamed Tributary. This difference can be attributed to higher concentrations of dissolved solids entering into James Creek from Ruth Pit due to surface runoff from adjacent disturbed areas, as well as from iron ore tailings deposited into Ruth Pit.

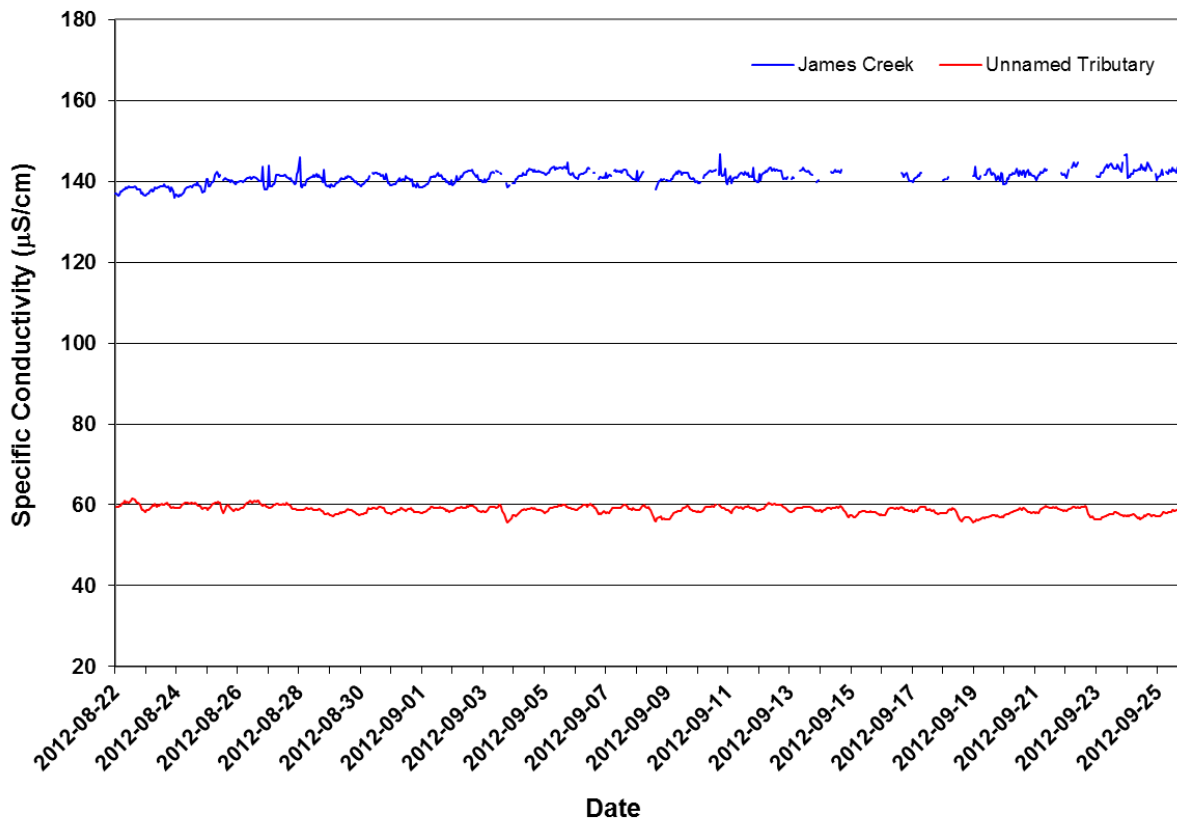


Figure 4. Hourly specific conductivity ( $\mu\text{S}/\text{cm}$ ) values recorded at James Creek and Unnamed Tributary from August 22, 2012 to September 26, 2012.



## Total Dissolved Solids

- Total Dissolved Solids (TDS) values ranged from 0.0871 g/l to 0.0940 g/l at James Creek and from 0.0356 g/l to 0.0393 g/l at Unnamed Tributary from August 22, 2012 to September 26, 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 0.0526 g/l higher at James Creek compared to Unnamed Tributary. This difference can be attributed to surface runoff from adjacent disturbed areas, as well as from iron ore tailings deposited into Ruth Pit.

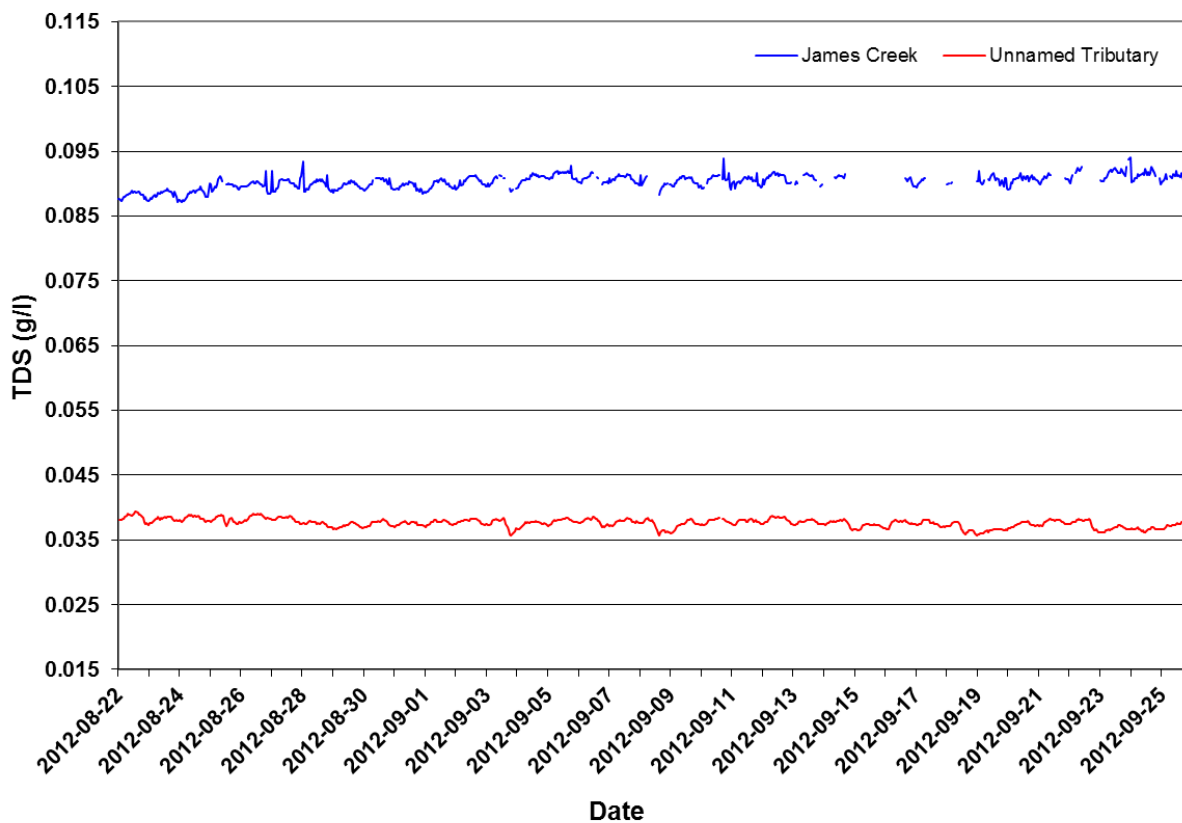


Figure 5. Hourly TDS (g/l) values recorded at James Creek and Unnamed Tributary from August 22, 2012 to September 26, 2012

## Dissolved Oxygen

- Dissolved Oxygen [DO] values ranged from 9.96 mg/l to 12.48 mg/l at James Creek and from 9.65 mg/l to 13.27 mg/l at Unnamed Tributary from August 22, 2012 to September 26, 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 0.40 mg/l higher at Unnamed Tributary compared to James Creek. This difference can be attributed to colder water temperatures at Unnamed Tributary than at James Creek (Figure 2).
- 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).

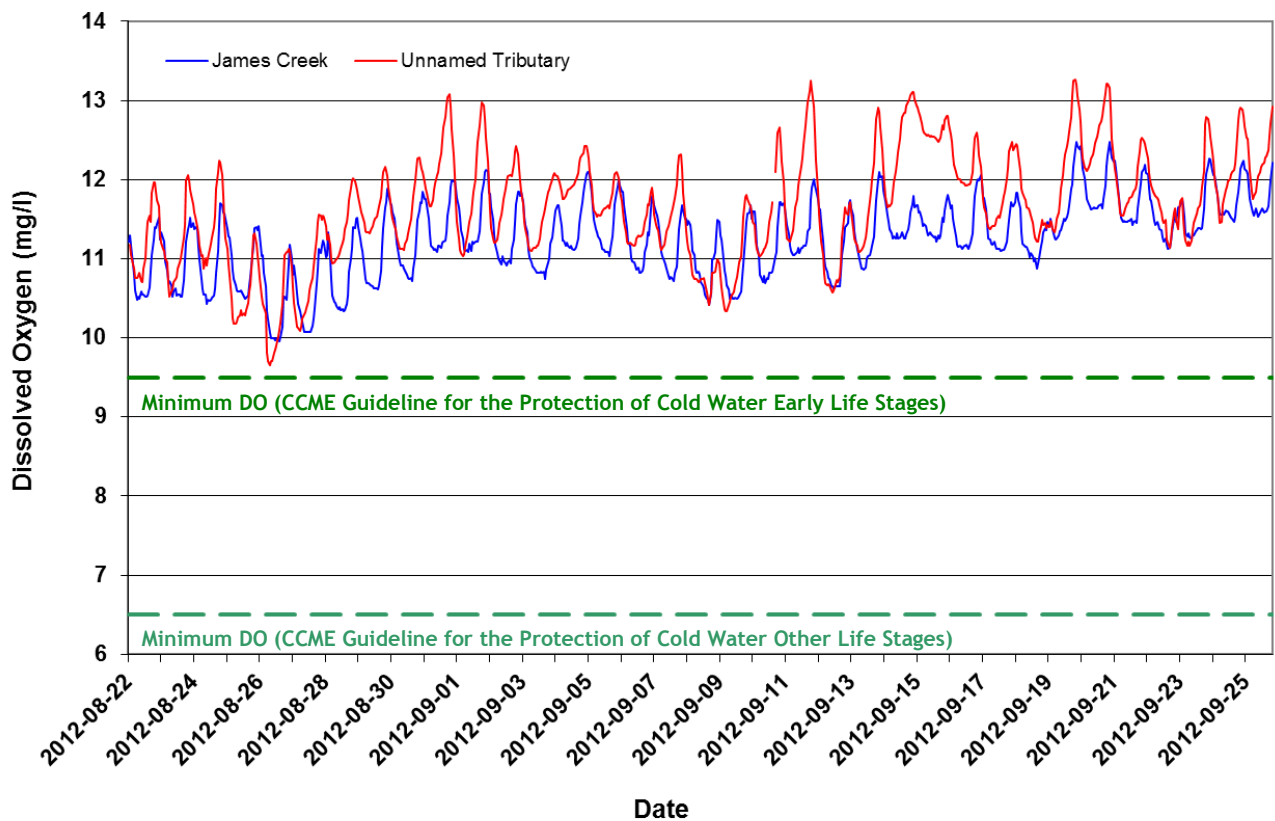


Figure 6. Hourly dissolved oxygen (mg/l) values recorded at James Creek and Unnamed Tributary from August 22, 2012 to September 26, 2012.

## Turbidity

- Turbidity values ranged from 0.0 NTU to 36.5 NTU at James Creek and from 0.0 NTU to 107.5 NTU at Unnamed Tributary from August 22, 2012 to September 26, 2012 (Figure 7).
- There were several turbidity events measured at the James Creek and Unnamed Tributary stations. Most of these events coincided with rainfall activity. Other turbidity events were generally short-lived, and as such, were not of any great concern. These events may be attributed to biofouling, since biofouling caused by algae, leaves, periphyton, and other organic materials are common at these stations.

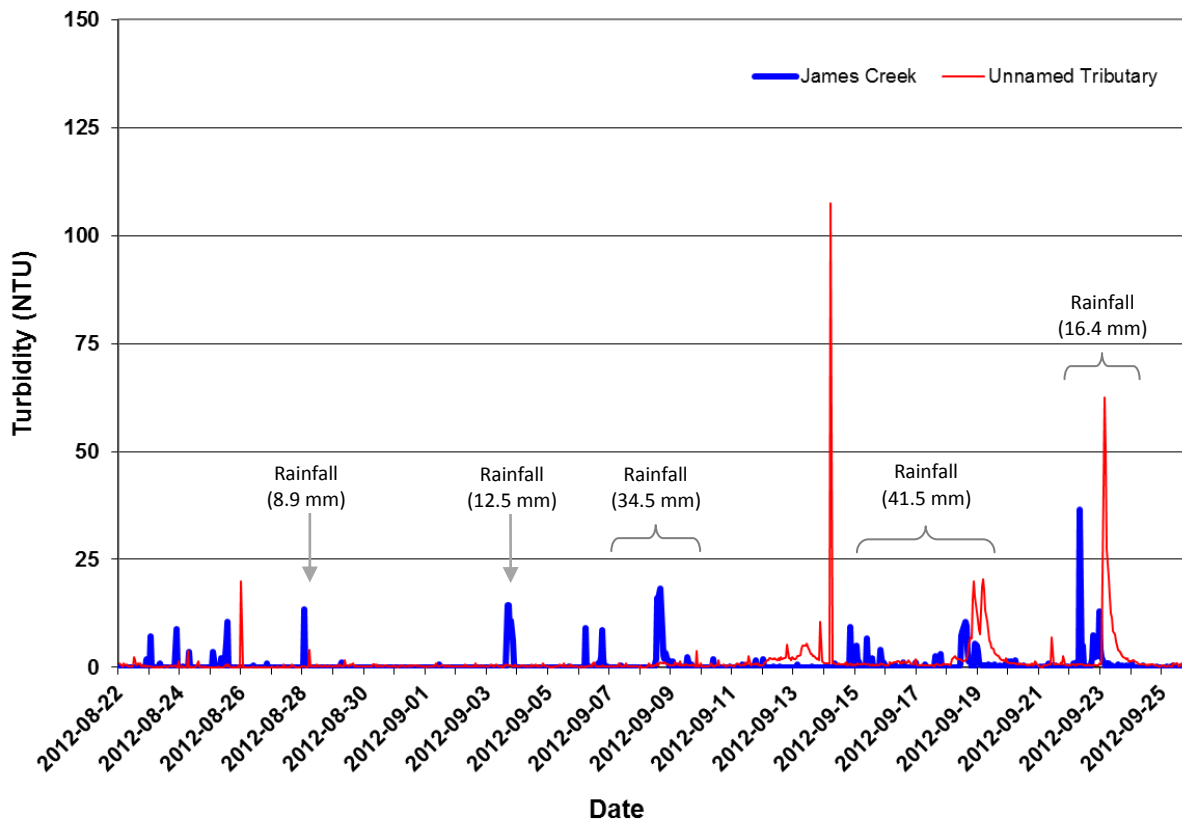


Figure 7. Hourly turbidity (NTU) values recorded at James Creek and Unnamed Tributary from August 22, 2012 to September 26, 2012.

## Conclusion

- This monthly deployment report, presents water quality and water quantity data recorded at the James Creek and Unnamed Tributary stations from August 22, 2012 to September 26, 2012.
- No tailings were discharged into Ruth Pit after August 16, 2012.
- Sensor performance was rated fair to excellent at both stations at the beginning and end of the deployment period.
- The James Creek pH sensor was given a fair performance rating at the end of its deployment on September 26, 2012. Its fair performance was attributed to a faulty pH sensor, which caused pH values to decrease during the deployment period. The Teflon junction on the pH reference sensor was replaced on September 26, 2012, to try and fix this problem.
- Transmission errors occurred sporadically throughout the deployment period at the James Creek station, resulting in the loss of 144 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 144 incomplete data transmissions. A more complete dataset was obtained from the Field Instrument's internal log file.
- Variations in water quality/quantity values recorded at each station are summarized below:
  - Variations in stage were attributed to temperature-related atmospheric pressure changes and to rainfall events.
  - Fluctuations in water temperature corresponded with fluctuations in air temperature.
  - Daily variations in pH were attributed to the photosynthetic cycling of CO<sub>2</sub> by aquatic organisms, while the cause of weekly trends in pH at the James Creek station were attributed to problems with the pH sensor.
  - Daily variations in specific conductivity and TDS values could be attributed to the photosynthetic cycling of CO<sub>2</sub> by aquatic organisms and weekly variations were negligible.
  - DO (mg/l) variations were related to changes in water temperature and the photosynthetic activity and aerobic respiration of aquatic organisms.
  - Turbidity events were mostly attributed to rainfall activity.
- Field instruments for both stations were calibrated and redeployed on September 26, 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)<sup>1</sup>.
- 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.

Parameter	Rating				
	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

<sup>1</sup> 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<sub>2</sub> (Allan 2010).

**Specific conductivity** - Specific conductivity ( $\mu\text{S}/\text{cm}$ ) is a measure of water's ability to conduct electricity, with values normalized to a water temperature of 25°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 (°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 22, 2012 to September 26, 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
2012-08-22	15.4	8.6	12	6	0	-	-	1.5	-	-	-
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	-	-	-

- = 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 22, 2012 to September 26, 2012)

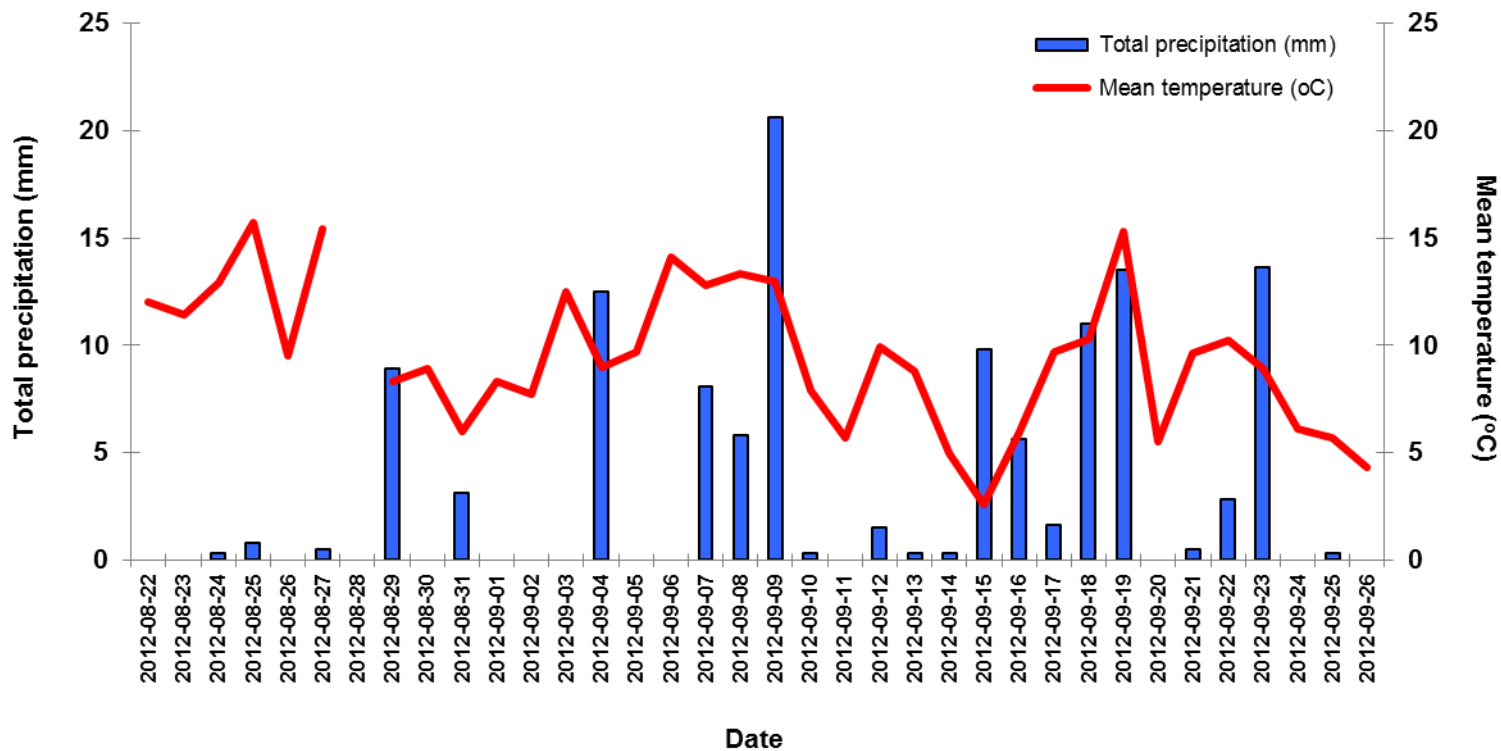


Figure 1. Daily precipitation and mean temperature recorded at the Schefferville Weather Station by Environment Canada from August 22, 2012 to September 26, 2012.

**APPENDIX C (continued...)**

**Environment Canada Weather Data - Schefferville (August 22, 2012 to September 26, 2012)**

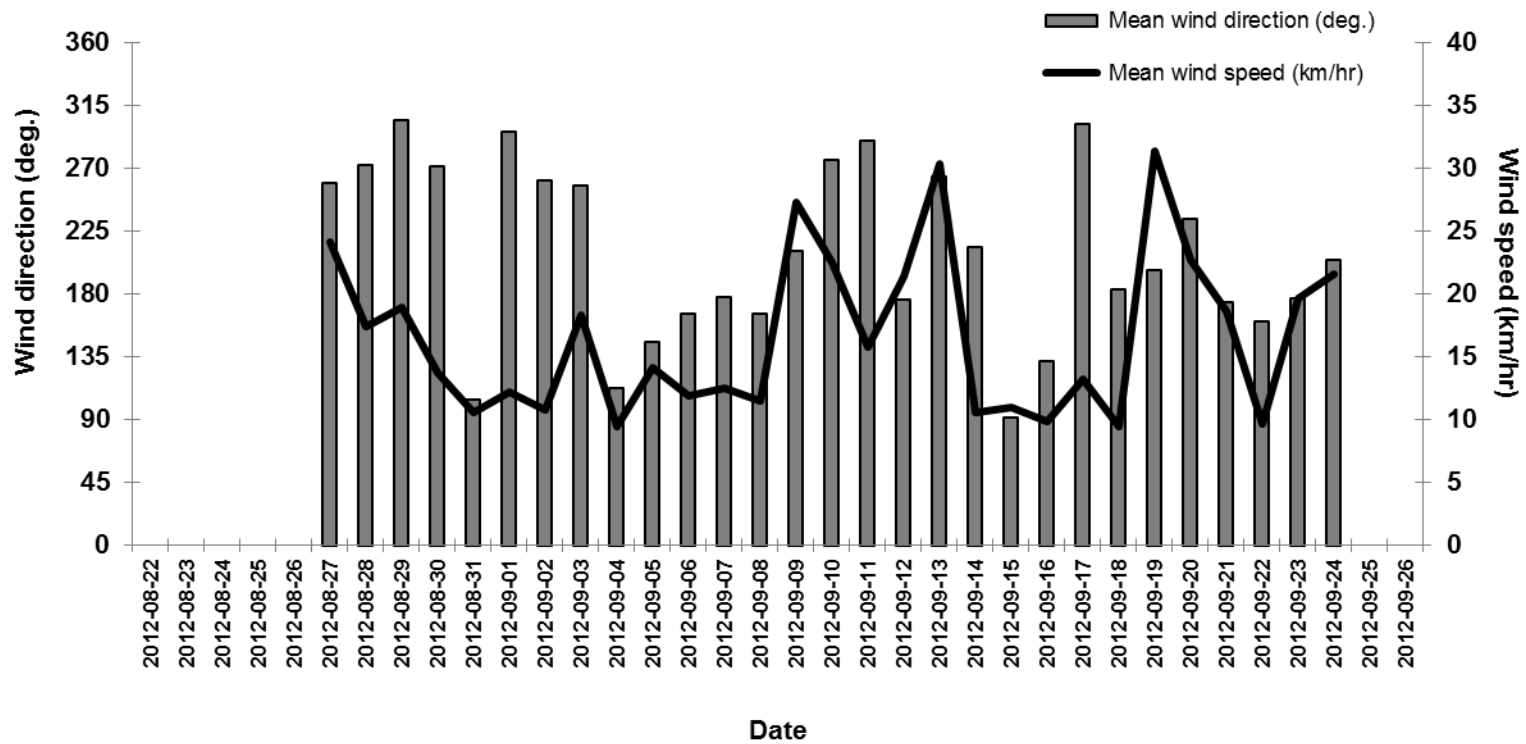


Figure 2. Mean daily wind direction and wind speed recorded at the Schefferville Weather Station by Environment Canada from August 22, 2012 to September 26, 2012.