Real Time Water Quality Report

Labrador Iron Mines Schefferville Network

Annual Deployment Report 2013

2013-06-04 to 2013-10-07

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

Prepared by:

Ian Bell
Environmental Scientist

Department of Environment & Conservation
Water Resources Management Division
Government of Newfoundland & Labrador
3rd Floor, Noton Building
PO Box 2006, Corner Brook, NL, A2H 6J8

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

Acknowledgements

The Real-Time Water Quality/Quantity Monitoring Program at the James deposit near Schefferville is fully funded by Labrador Iron Mines (LIM) and its success is dependent on a joint partnership between LIM, Environment Canada (EC), and the Newfoundland & Labrador Department of Environment & Conservation (ENVC). Managers and program leads from each organization, namely Renee Paterson (ENVC), Larry Ledrew (LIM), and Howie Wills (EC), are committed to the operation of this network and ensuring that it continually provides meaningful and accurate water quality/quantity data.

In addition to funding this program, LIM also provided support to ENVC and EC staff during site visits, including transportation, food, workspace, tools, and field assistance. LIM also provided storage facilities, information on LIM mining operations, and station checks when water quality events arise. LIM employees involved in carrying out these duties included Leah Butler and Karen Phong.

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 James deposit, 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. Instrument performance evaluation and repairs, during the winter of 2013-2014, is being conducted in-house by Ryan Pugh.

Introduction

- The Newfoundland & Labrador Department of Environment & Conservation (ENVC), in partnership with Labrador Iron Mines (LIM) and Environment Canada (EC), established two real-time water quality/quantity (RTWQ) stations in September 2010 at the James Iron Ore deposit in western Labrador, near Schefferville, QC. An Additional station was established in 2013 at Houston Creek, near the Houston deposit (Figure 1).

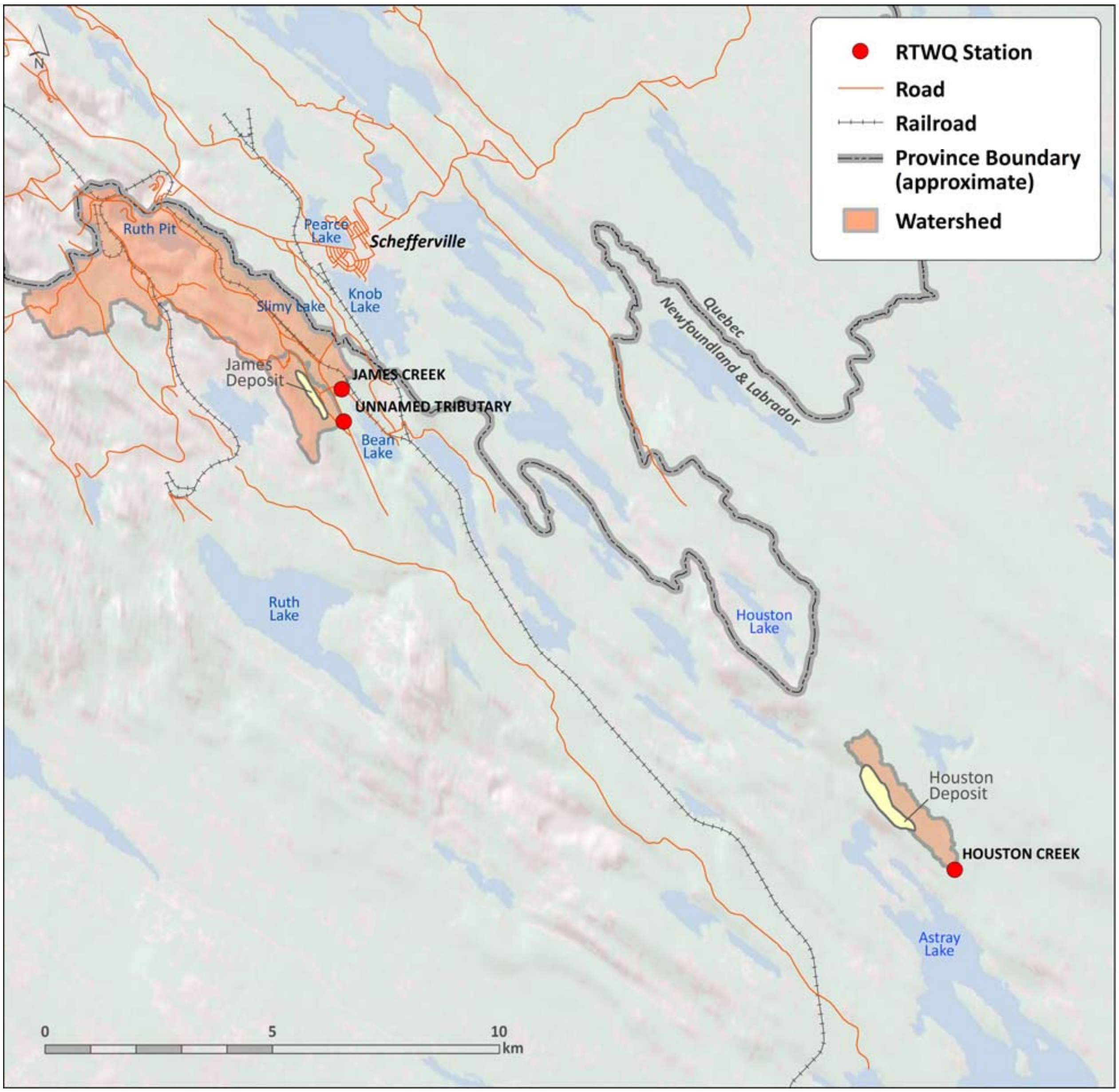

Figure 1. Map of Schefferville Project Area in Western Labrador showing three RTWQ Monitoring Stations at James Creek , Unnamed Tributary and Houston Creek.

- The official name of each station is *James Creek Above Bridge*, *Unnamed Tributary Below Settling Pond*, and *Houston Creek above Road Culvert,* hereafter referred to as the *James Creek* station, the *Unnamed Tributary* station, and the *Houston Creek* station, respectively (Figure 2).

a. Unnamed Tributary b. James Creek c. Houston Creek

Figure 2. RTWQ stations are located alongside (a) the Unnamed Tributary, (b) James Creek and (c) Houston Creek.

- Unnamed Tributary station monitors water outflow from a series of multi-cell retention and settling ponds (Figure 1).
- James Creek station monitors water outflow from the multi-cell retention and settling pond system, as well as monitors outflow from Ruth Pit (Figure 1).
- Houston Creek station monitors water outflow from the Houston deposit which is scheduled for development in 2014 or 2015. The station is currently collecting baseline information (Figure 1).
- 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 destine to Ruth Pit. Outflow from the retention and settling pond system is directed into the Unnamed Tributary and James Creek (Figure 1). 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 receiving water from pit dewatering pumps. The outflow from Ruth Pit is the start of James Creek (Figure 1).

- Six water parameters are measured at each station, 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 LIM, 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 LIM 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 James Creek and Unnamed Tributary stations from June 4, 2013 to October 7, 2013, and Houston Creek from August 6, 2013 to October 7, 2013.

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].

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

- Quality assurance procedures are carried out every four to five weeks, before the start of a new deployment period. Deployment start and end dates are summarized in Table 1.

Table 1. Water quality instrument deployment start and end dates for 2013 at James Creek, Unnamed Tributary and Houston Creek.

Station	Start date	End date	Duration (days)	Instrument
James Creek	2013-06-04	2013-07-01	28	49199
	2013-07-02	2013-08-05	34	49199
	2013-08-06	2013-09-10	35	49199
	2013-09-10	2013-10-07	27	49199
Unnamed Tributary	2013-06-04	2013-07-01	28	49201
	2013-07-02	2013-08-05	34	49200
	2013-08-06	2013-09-10	35	49200
	2013-09-10	2013-10-07	27	64680
Houston Creek	2013-08-08	2013-09-09	32	64680
	2013-09-09	2013-10-07	28	49201

- 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 2 shows the performance ratings of the instrument sensors (i.e., temperature, pH, conductivity, dissolved oxygen and turbidity) deployed at James Creek, Unnamed Tributary and Houston Creek.
- Based on quality control procedures, instrument sensor performance ranged from poor-to-excellent in 2013 (Table 2).

Deployment Notes

- Mining operations for LIM's 2013 production season commenced around March 18th. Operations consisted primarily of ore removal from the James Pit at the start of the season, then subsequently and concurrently from 2 open pits with addition of full operations at the Redmond 2B pit on July 26th. Operations at Redmond ceased at the start of the fall season on September 21st while James mining operations continued into November with total production ultimately halting November 14th.

Table 2. Instrument sensor performance at the start and end of each deployment period for the James Creek, Unnamed Tributary and Houston 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)
James Creek	Start	2013-06-04	49199	Excellent	Excellent	Excellent	Excellent	Excellent
	End	2013-07-01	49199	Excellent	Excellent	Excellent	Good	Good
	Start	2013-07-02	49199	Excellent	Excellent	Excellent	Excellent	Excellent
	End	2013-08-05	49199	Excellent	Excellent	Excellent	Good	Poor
	Start	2013-08-06	49199	Excellent	Excellent	Excellent	Excellent	Good
	End	2013-09-10	49199	Excellent	Good	Excellent	Good	Poor
	Start	2013-09-10	49199	Excellent	Good	Good	Fair	Excellent
	End	2013-10-07	49199	Excellent	Good	Good	Fair	Excellent
Unnamed Tributary	Start	2013-06-04	49201	Excellent	Excellent	Excellent	Excellent	Good
	End	2013-07-01	49201	Excellent	Excellent	Excellent	Good	Excellent
	Start	2013-07-02	49201	Excellent	Excellent	Good	Fair	Excellent
	End	2013-08-05	49201	Excellent	Good	Excellent	Excellent	Good
	Start	2013-08-06	49200	Excellent	Excellent	Excellent	Excellent	Excellent
	End	2013-09-10	49200	Excellent	Good	Good	Good	Excellent
	Start	2013-09-10	49200	Excellent	Good	Good	Good	Excellent
	End	2013-10-07	49200	Excellent	Excellent	Poor	Fair	Excellent
Houston Creek	Start	2013-08-08	64680	Excellent	Excellent	Excellent	Excellent	Excellent
	End	2013-09-09	64680	Excellent	Excellent	Excellent	Good	Excellent
	Start	2013-09-09	49201	Excellent	Excellent	Excellent	Excellent	Excellent
	End	2013-10-07	49201	Excellent	Excellent	Excellent	Good	Excellent

- The dissolved oxygen sensor at the James Creek station was given a fair performance rating at the beginning and end of the fourth deployment. It should be noted that the actual difference between the two probes was only 0.51 mg/l. This relatively small difference could be due to subtle differences in oxygen levels between the location of the QA sonde and the Field sonde or slowness of the field sonde to stabilize due to the pantyhose covering the sensor head.
- The turbidity sensor at James Creek was given a poor performance rating at the end of both the second and third deployments periods. It is not unusual for a sensor to drift off calibration over a deployment period, especially in water with relatively high turbidity. At the time of the deployment the field sonde was reading 27.7 NTU and 34.7 NTU at the time of removal for the second and third deployments. At the same time the the QA/QC sonde was reading 16.7 NTU and 11.6 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 Unnamed Tributary received a fair performance rating at the beginning of the second deployment period. It should be noted that the actual difference between the two probes was only 0.72 mg/l. This relatively small difference could be due to subtle differences in oxygen levels between the location of the QA sonde and the Field sonde, or slowness of the field sonde to stabilize due to the pantyhose covering the sensor head.
- The dissolved oxygen sensor at Unnamed Tributary received a fair performance rating at the end of the fourth deployment period. It should be noted that the actual difference between the two probes was only 0.51 mg/l. It is not unusual for a sensor to drift off calibration over a deployment period, especially in water with relatively high turbidity.

- The specific conductivity sensor at Unnamed Tributary received a poor performance rating at the end of the fourth deployment period. It is not unusual for a sensor to drift off calibration over a deployment period, especially in water with relatively high turbidity where sediment can accumulate in a thin layer on the sensor head interfering with accurate readings.

Data Interpretation

- Performance issues and data records were interpreted for each station during the deployment period for the following six parameters:
  - (i.) Stage (m)
  - (ii.) Temperature (^{o}C)
  - (iii.) pH
  - (iv.) Specific conductivity (μS/cm)
  - (v.) Dissolved oxygen (mg/l)
  - (vi.) Turbidity (NTU)

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

Stage

- Figure 4 displays stage values recorded at James Creek and Unnamed Tributary from June 4, 2013 to October 7, 2013, and from Houston Creek from August 8, 2013 to October 7, 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 0.585 m to 0.742 m at Unnamed Tributary, and from 0.302 m to 0.405 m at James Creek from June 4, 2013 to October 7, 2013. Stage values ranged from 0.496 m to 0.612 m at Houston Creek from August 8, 2013 to October 7, 2013.
- Weekly trends in stage at the James Creek and Houston Creek stations corresponded well with rainfall events (Figure 4 inset). Spikes in the stage height associated with several rainfall events are highlighted on the graph.
- Weekly trends in stage were not as apparent at the Unnamed Tributary station, since the flow of this stream is highly regulated.
- 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. To facilitate graphing, stage values from all three stations were adjusted to be in the 0 to 1 range.

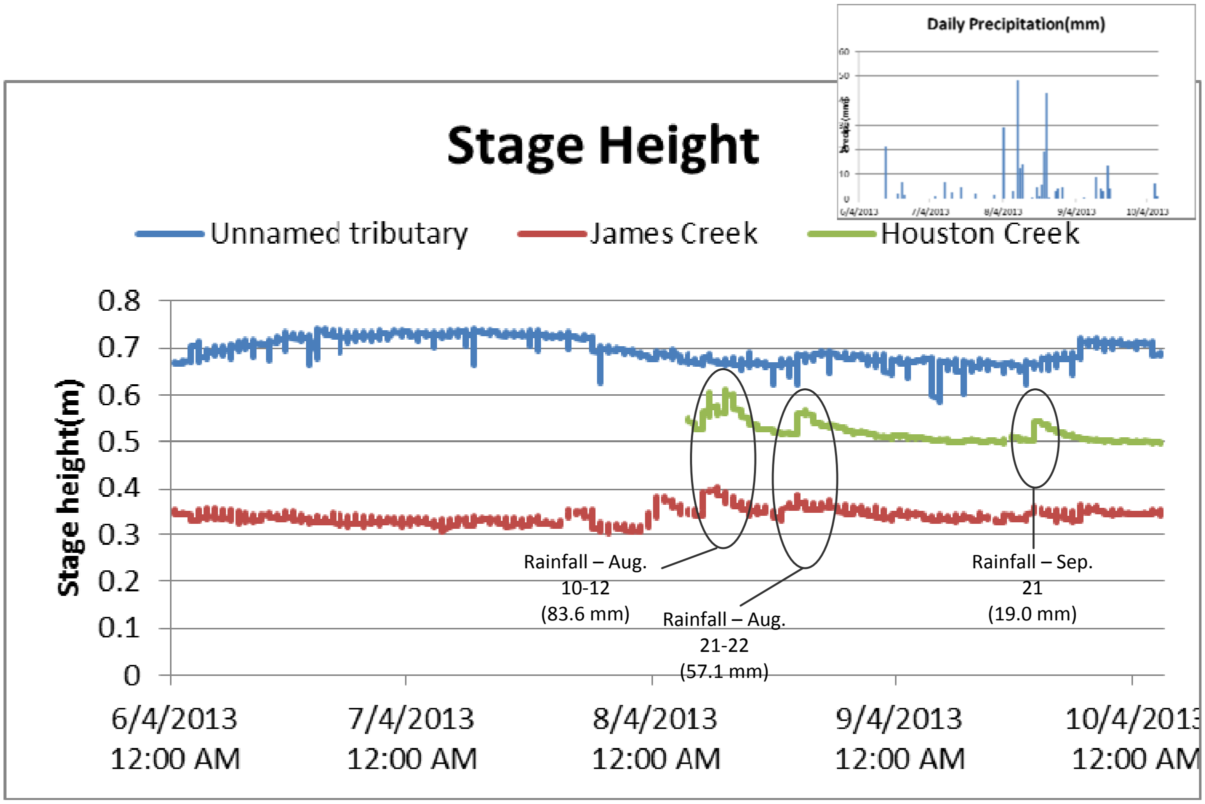

Figure 4. Hourly stage (m) values recorded at Unnamed Tributary, James Creek, and Houston Creek from June 4, 2013 to October 7, 2013. The inset chart shows total precipitation (mm) recorded at the Schefferville weather station during the same time period. All data was recorded by Environment Canada.

Temperature

- Water temperature ranged from 1.4˚C to 5.6˚C at Unnamed Tributary and from 2.8˚C to 15.9˚C at James Creek from June 4, 2013 to October 7, 2013. Water temperature ranged from 2.3 ˚C to 15.7˚C at Houston Creek from August 8, 2013 to October 7, 2013. (Figure 5).
- Water temperatures at all three 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 5 inset & Appendix C).
- Water temperatures at the Unnamed Tributary station were stable for the entire deployment period and were considerably cooler that the other two stations. A significant portion of the flow in Unnamed Tributary is from water pumped from a number of deep groundwater dewatering wells. This groundwater has a constant temperature year-round which masks any natural temperature variability in Unnamed Tributary.

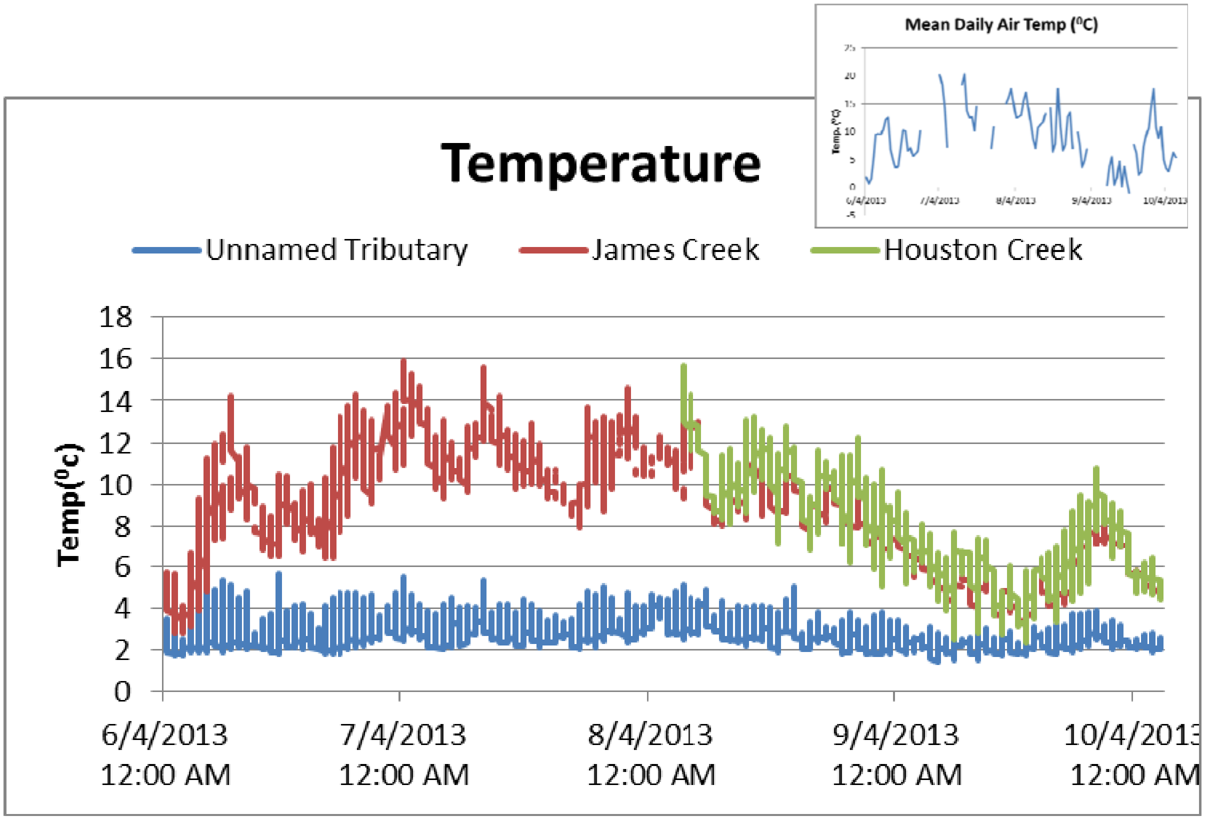

Figure 5. Hourly water temperature (°C) values recorded at James Creek, Unnamed Tributary and Houston Creek from June 4, 2013 to October 7, 2013. Inset chart shows air temperature during the same period, as recorded by Environment Canada at the Schefferville weather station.

pH

- pH values ranged from 6.29 units to 7.12 units at Unnamed Tributary and from 7.07 units to 8.69 units at James Creek from June 4, 2013 to October 7, 2013. pH values ranged from 6.04 units to 6.89 units at Houston Creek from August 8, 2013 to October 7, 2013. (Figure 6)
- While most of the pH values 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), some were below the lower limit of 6.5. It should be noted that acidic waters are quite common in Canada, particularly in boreal and northern ecoregions, and pH is often naturally below this 6.5 unit guideline.
- pH values at all stations fluctuated daily with peaks typically occurring in the late afternoon/ early evening. These variations coincide with diurnal temperature trends as well as the photosynthetic cycling of CO_2 by aquatic organisms.

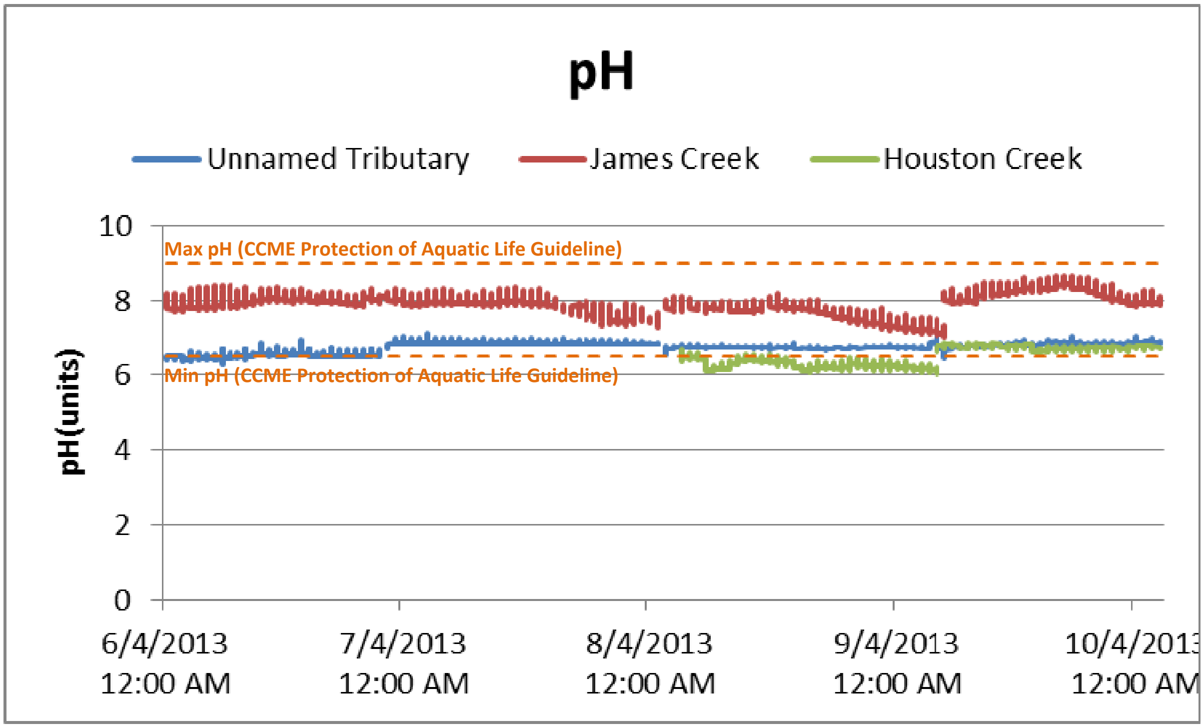

Figure 6. Hourly pH values recorded at James Creek, Unnamed Tributary and Houston Creek from June 4, 2013 to October 7, 2013.

Specific Conductivity

- Specific Conductivity ranged from 2 µs/cm to 81.8 µs/cm at Unnamed Tributary and from 123.5 µs/cm to 150.4 µs/cm at James Creek from June 4, 2013 to October 7, 2013. Specific Conductivity ranged from 19.3 µs/cm to 38.1 µs/cm at Houston Creek from August 8, 2013 to October 7, 2013 (Figure 7).
- Specific conductivity values at all three stations fluctuated daily with peaks typically occurring late evening/early morning. Diurnal fluctuations could be attributed to a number of variables including the diurnal temperature fluctuations as well as photosynthetic cycling of CO_2 by aquatic organisms.
- Rainfall events, and the resulting increases in stage, caused some variation in specific conductivity values at all stations. Several examples of rainfall events causing a noticeable drop in specific conductivity are highlighted in Figure 7.
- Specific conductivity was consistently higher at James Creek than at Unnamed Tributary or Houston Creek. This difference could be attributed to the past and present deposit of iron ore tailings into Ruth Pit, upstream of James Creek.

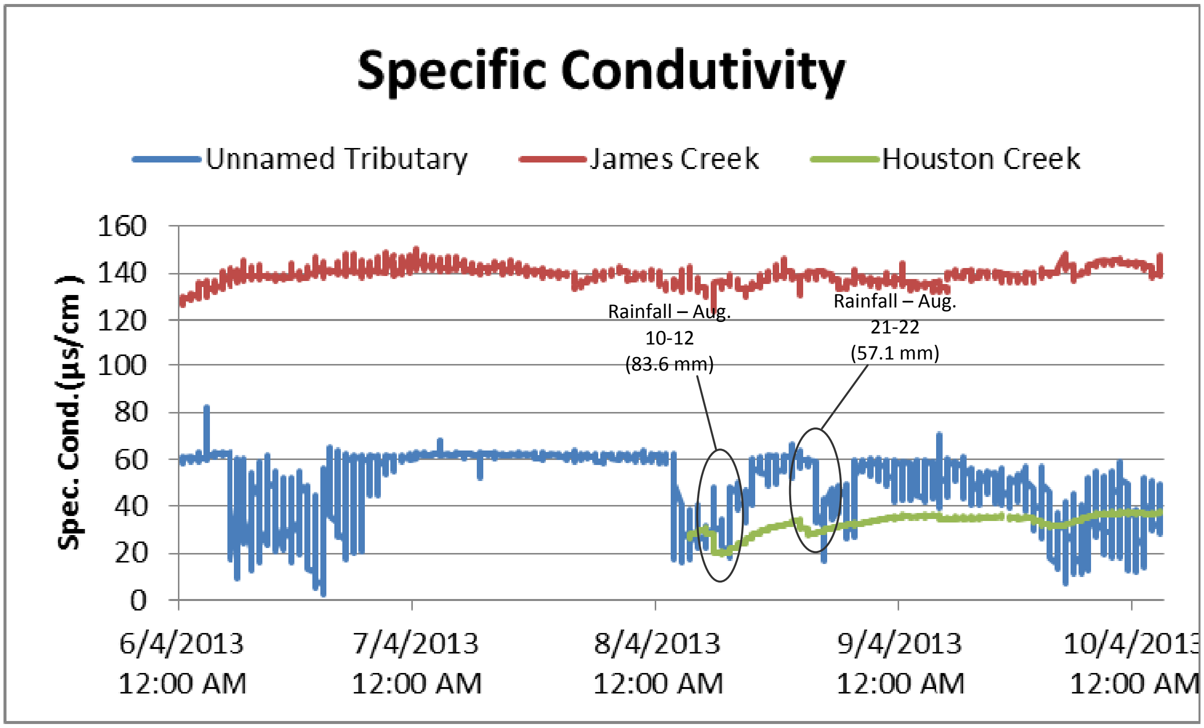

Figure 7. Hourly specific conductivity (µS/cm) values recorded at James Creek, Unnamed Tributary and Houston Creek from June 4, 2013 to October 7, 2013.

Dissolved Oxygen

- Dissolved Oxygen (DO) values ranged from 10.15 mg/l to 14.5 mg/l at Unnamed Tributary and from 8.55 mg/l to 13.98 mg/l at James Creek from June 4, 2013 to October 7, 2013. Dissolved Oxygen (DO) values ranged from 8.26 mg/l to 12.31 mg/l at Houston Creek from June 4, 2013 to October 7, 2013 (Figure 8).
- DO levels at all stations were, for the majority of time, above cold water minimum guidelines set for aquatic life during early life stages (9.5 mg/l) period, 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).
- DO levels fluctuated daily, with increases in DO observed in the afternoon and decreases observed at night. These diurnal variations can be attributed to a number of variables including temperature and the photosynthetic activity of aquatic organisms.
- Weekly trends in DO corresponded well with the inverse of water temperature (Figure 5), since colder water has a greater potential to dissolve oxygen compared to warmer water.
- On average, DO values were consistently higher at Unnamed Tributary compared to James and Houston Creeks. This difference can be attributed to colder water temperatures at Unnamed Tributary than at James Creek and Houston Creek (Figure 5).

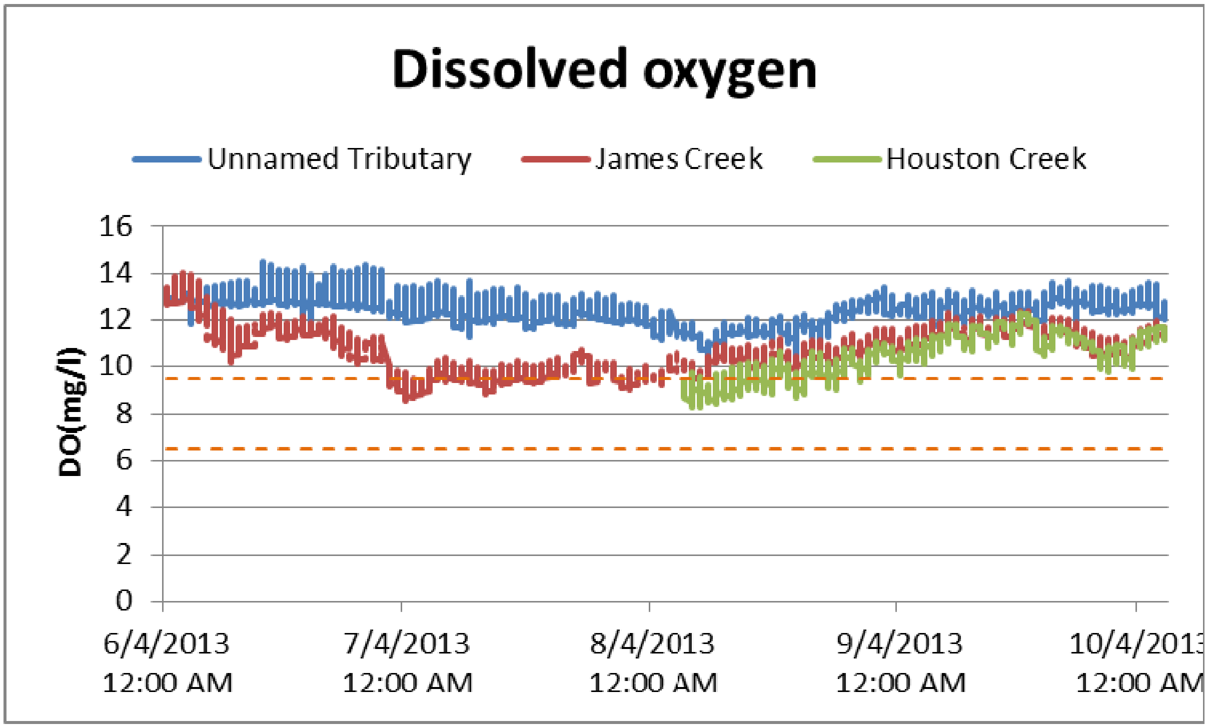

Figure 8. Hourly dissolved oxygen (mg/l) values recorded at James Creek, Unnamed Tributary and Houston Creek from June 4, 2013 to October 7, 2013.

Turbidity

- Turbidity values ranged from 0.0 NTU to 2869 NTU at Unnamed Tributary and from 0.1 NTU to 2967 NTU at James Creek from June 4, 2013 to October 7, 2013. Turbidity values ranged from 0.0 NTU to 5.9 NTU at Houston Creek from August 8, 2013 to October 7, 2013. (Figure 9)
- There were numerous turbidity events measured at the James Creek and Unnamed Tributary stations; however Houston Creek appears to have no significant turbidity events. Some of the turbidity events at James Creek and Unnamed Tributary may be related to rainfall events and others may be related to ongoing mining and related land use activities in the watershed areas.

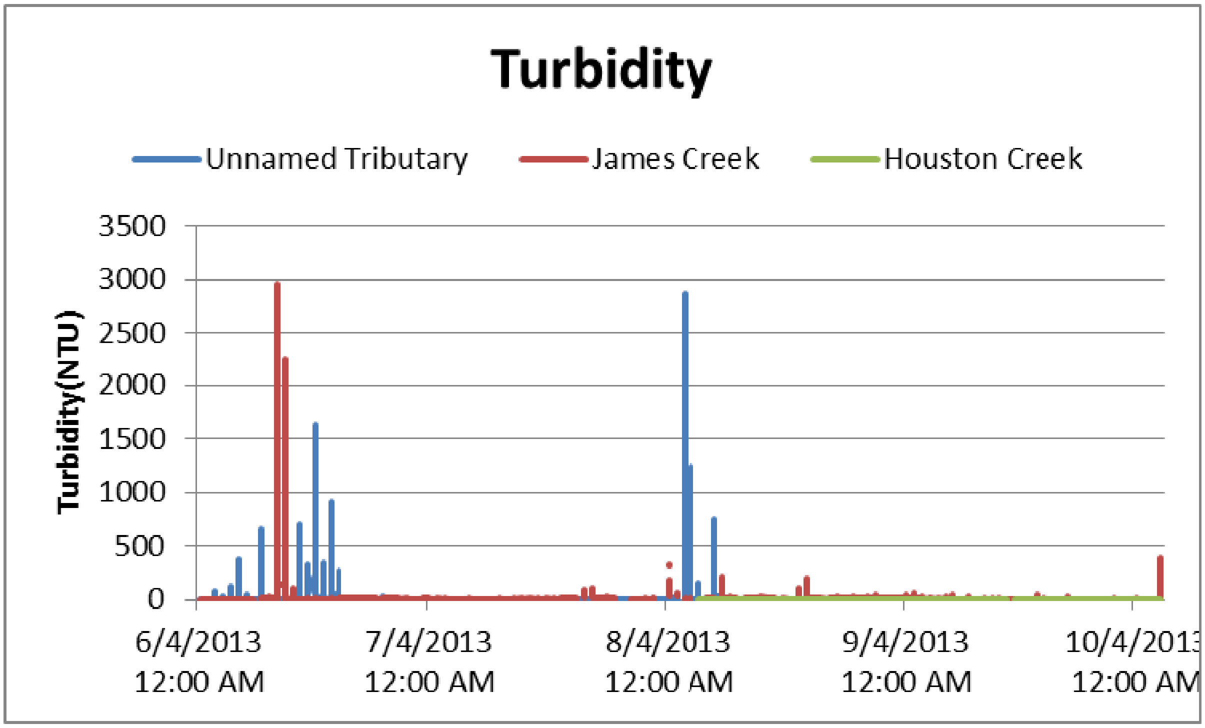

Figure 9. Hourly turbidity (NTU) values recorded at James Creek, Unnamed Tributary and Houston Creek from June 4, 2013 to October 7, 2013.

Conclusions

- Water quality monitoring instruments were deployed at two stations near the James Deposit Iron Ore Mines between June 4, 2013 and October 7, 2013. The stations are located on James Creek and the Unnamed Tributary. Water quality monitoring instruments were also deployed at one station near the Houston Deposit on Houston Creek between August 8, 2013 and October 7, 2013.
- Mining activity was ongoing at the James deposit throughout the full deployment period during the 2013 field season.
- The performance ratings of all instrument sensors ranged between poor to excellent at the beginning and end of each of the four deployment periods.
- Variations in water quality/quantity values recorded at each station are summarized below:

  STAGE: Stage values ranged from 0.585 m to 0.742 m at Unnamed Tributary, and from 0.302 m to 0.405 m at James Creek from June 4, 2013 to October 7, 2013. Stage values ranged from 0.496 m to 0.612 m at Houston Creek from August 8, 2013 to October 7, 2013. Weekly trends in stage at the James Creek and Houston Creek stations corresponded well with rainfall events, while weekly trends in stage were not as apparent at the Unnamed Tributary station where flow is highly regulated.

WATER TEMPERATURE: Water temperature ranged from 1.4˚C to 5.6˚C at Unnamed Tributary and from 2.8˚C to 15.9˚C at James Creek from June 4, 2013 to October 7, 2013. Water temperature ranged from 2.3 ˚C to 15.7˚C at Houston Creek from August 8, 2013 to October 7, 2013. Water temperatures at all three stations display large diurnal variations which are 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. Water temperatures at the Unnamed Tributary station were stable for the entire deployment period and were considerably cooler that the other two stations because of significant imput from dewatering a number of deep groundwater wells.

pH: pH values ranged from 6.29 units to 7.12 units at Unnamed Tributary and from 7.07 units to 8.69 units at James Creek from June 4, 2013 to October 7, 2013. pH values ranged from 6.04 units to 6.89 units at Houston Creek from August 8, 2013 to October 7, 2013. While most of the pH values were within the acceptable range for the protection of aquatic life, some were below the lower limit of 6.5, which is fairly common in boreal and northern ecoregions. pH values at all three stations showed diurnal fluctuations.

SPECIFIC CONDUCTIVITY: Specific Conductivity ranged from 2 μs/cm to 81.8 μs/cm at Unnamed Tributary and from 123.5 μs/cm to 150.4 μs/cm at James Creek from June 4, 2013 to October 7, 2013. Specific Conductivity ranged from 19.3 μs/cm to 38.1 μs/cm at Houston Creek from August 8, 2013 to October 7, 2013. Specific conductivity values at both stations fluctuated daily with peaks typically occurring late evening/early morning. Rainfall events, and the resulting increases in stage, caused some variation in specific conductivity values at both stations, with noticeable dips most visible at Unnamed Tributary and Houston Creek. Specific conductivity was consistently higher at James Creek than at Unnamed Tributary or Houston Creek. This difference could be attributed to the past and present deposit of iron ore tailings into Ruth Pit, upstream of James Creek.

DISSOLVED OXYGEN: DO values ranged from 10.15 mg/l to 14.5 mg/l at Unnamed Tributary and from 8.55 mg/l to 13.98 mg/l at James Creek from June 4, 2013 to October 7, 2013. DO values ranged from 8.26 mg/l to 12.31 mg/l at Houston Creek from June 4, 2013 to October 7, 2013. DO levels at both stations were, for the majority of time, above cold water minimum guidelines set for aquatic life during early life stages (9.5 mg/l) period. DO levels showed diurnal fluctuations which can be attributed to a number of variables, including temperature and the photosynthetic activity of 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. Due to cooler temperatures DO values were consistently higher at Unnamed Tributary compared than James and Houston Creeks.

TURBIDITY: Turbidity values ranged from 0.0 NTU to 2869 NTU at Unnamed Tributary and from 0.1 NTU to 2967 NTU at James Creek from June 4, 2013 to October 7, 2013. Turbidity values ranged from 0.0 NTU to 5.9 NTU at Houston Creek from August 8, 2013 to October 7, 2013. There were numerous turbidity events measured at the James Creek and Unnamed Tributary stations; however Houston Creek appears to have no significant turbidity events. Some of the turbidity events at James Creek and Unnamed Tributary may be related to rainfall events and others may be related to ongoing mining and related land use activities in the watershed areas.

Path Forward

- Field instruments for all three stations will undergo Performance Testing and Evaluation over the Winter of 2014 and any necessary repairs will be carried out to ensure they are performing effectively for the 2014 field season.
- ENVC staff will redeploy RTWQ instruments at Unnamed Tributary, James Creek and Houston Creek the in spring 2014, when site conditions are suitable. They will also carry out regular site visits throughout the 2014 deployment season, on roughly a monthly basis, for calibration and maintenance of the instruments.
- If necessary, deployment techniques will be evaluated and adapted to each site, ensuring secure and suitable conditions for RTWQ monitoring.
- ENVC staff will update LIM 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.
- LIM 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. LIM will also receive an annual report, summarizing the events of the deployment season.
- Parameter alerts will be set prior to the 2014 deployment season to notify ENVC staff by email of any emerging water quality issues.
- 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 LIM 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 (µS/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 (μS/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.7, 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
7/11/2013		14.6				1.3
7/12/2013	18.3	8.6	13.5	4.5	0	3.3

Date/Time	Max Temp (°C)	Min Temp (°C)	Mean Temp (°C)	Heat Deg Days (°C)	Cool Deg Days (°C)	Total Precip (mm)
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
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

Date/Time	Max Temp (°C)	Min Temp (°C)	Mean Temp (°C)	Heat Deg Days (°C)	Cool Deg Days (°C)	Total Precip (mm)
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
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

Date/Time	Max Temp (°C)	Min Temp (°C)	Mean Temp (°C)	Heat Deg Days (°C)	Cool Deg Days (°C)	Total Precip (mm)
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

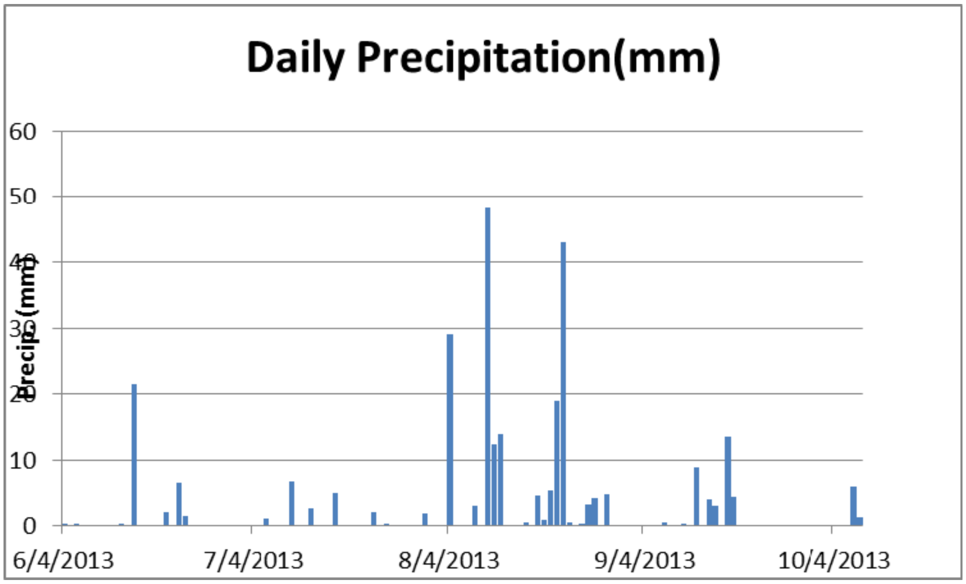

Figure 1. Daily precipitation recorded at the Schefferville Weather Station by Environment Canada from June 4, 2013 to October 7, 2013.

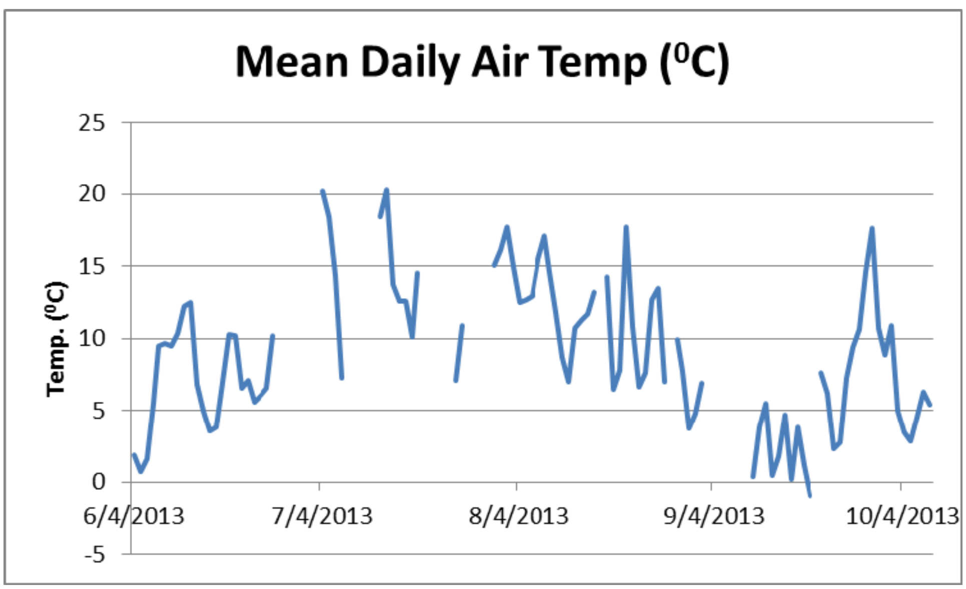

Figure 2. Mean Daily Temperature recorded at the Schefferville Weather Station by Environment Canada from June 4, 2013 to October 7, 2013.