Real Time Water Quality Report

Labrador Iron Mines
Schefferville Network

Deployment Period
2013-09-10 to 2013-10-07

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 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., and one real-time water quality and water quantity stations in close proximity to the Houston Property deposits.
- 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.
- 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 destine 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.
- Houston Creek station monitors water outflow from a brownfield area which was previously mined for iron ore and is scheduled for renewed open pit mining activity. This station will collect baseline water quality/quantity information prior to the onset of mining activities in this area
- 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 September 10, 2013, to October 7, 2013 and Houston Creek station from September 9, 2013 to October 7, 2013.

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 the deployment

	James Creek		Unnamed Tributary		Houston Creek	
Stage of deployment	**Beginning**	**End**	**Beginning**	**End**	**Beginning**	**End**
Date	2013-09-10	2013-10-07	2013-09-10	2013-10-07	2013-09-09	2013-10-07
Temperature	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
pH	Good	Good	Good	Excellent	Excellent	Excellent
Specific Conductivity	Good	Good	Good	Poor	Excellent	Excellent
Dissolved Oxygen	Fair	Fair	Good	Fair	Excellent	Good
Turbidity	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent

- The performances of all sensors were rated good to excellent at the beginning of the deployment period. The majority of the sensors rated good to excellent upon removal with the exception of the turbidity sensor at James Creel Station (Table 1). The poor rating for turbidity at the end of the James Creek deployment could be the result of a variety of variables such as; organic debris accumulated on the sensors after a month long deployment, short term variation in turbidity between the area where the field sonde was located and where the QA/QC reading was taken, the field turbidity sensor drifting significantly off calibration, or some other undetermined variable.

Deployment Notes

- Water quality monitoring for this deployment period started at Unnamed Tributary on September 10, 2013 at 10:20 am and at James Creek on the same date at 3:30 pm. Monitoring at Houston Creek started at 5:00 pm on September 9, 2013. Continuous real-time monitoring continued at all three sites without any significant operational issues until October 7, 2013 when the instruments were removed for the winter months.

Data Interpretation

- 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)

Stage

- Stage values ranged from 515.83 m to 515.86 m at James Creek and from 517.10 m to 517.22 m at Unnamed Tributary from September 10, 2013 to October 7, 2013 (Figures 1 & 2). Stage values ranged from 1.30 m to 1.34 m at Houston Creek from September 9, 2013 to October 7, 2013 (Figure 3). Stage height is directly related to the volume of flow in a stream as defined by a rating curve which is unique for every site.
- For both James Creek and Unnamed Tributary there appears to be a gentle rising trend throughout the deployment period. In addition, regular daily fluctuations were observed at both stations. These diurnal fluctuations are most likely attributed to dewatering operations from the mine site.
- For Houston Creek, the stage height graph is dominated by a series of peaks (see inside red ovals – Figure 3) which all correspond with significant precipitation events.
- 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.

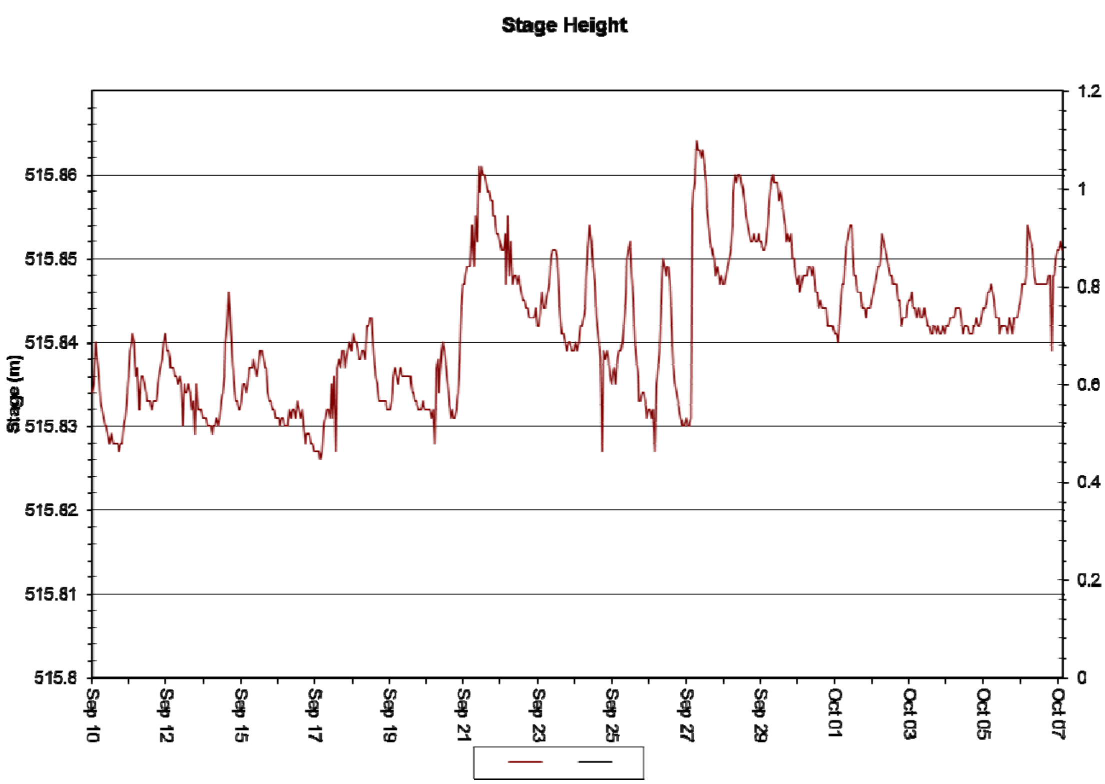

Figure 1: Stage Height (m) at James Creek from Sept. 10, 2013 to Oct. 7, 2013

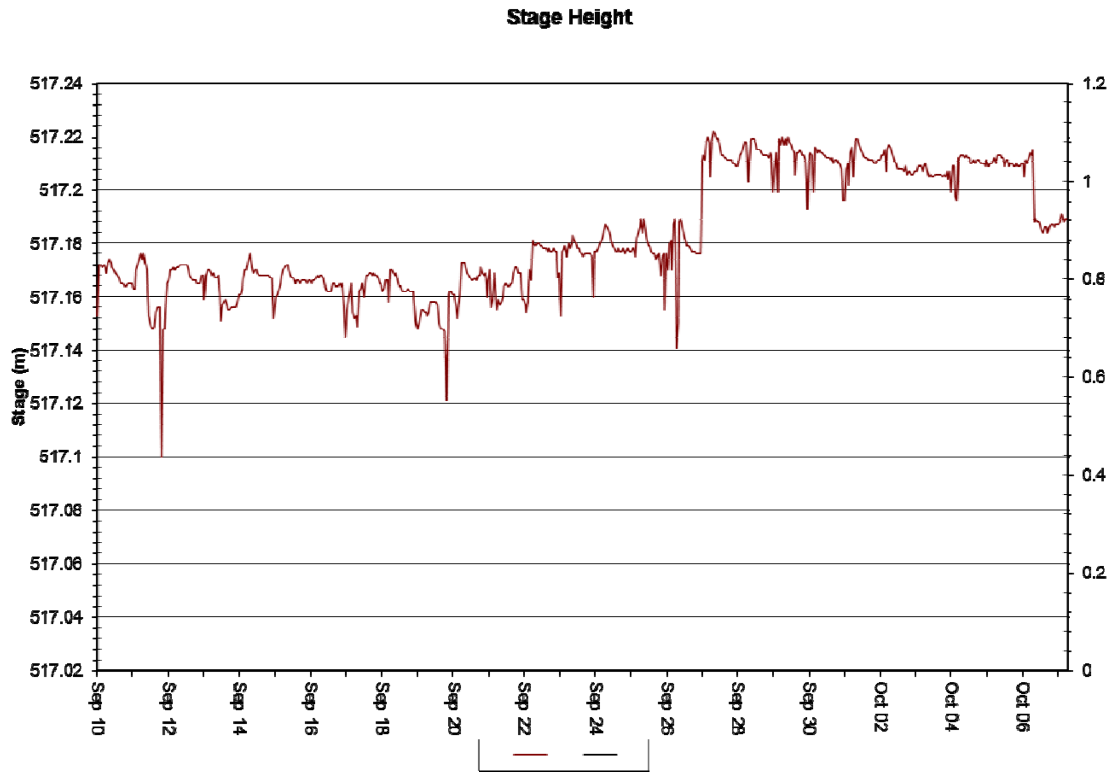

Figure 2: Stage Height (m) at Unnamed Tributary from Sept. 10, 2013 to Oct. 7, 2013

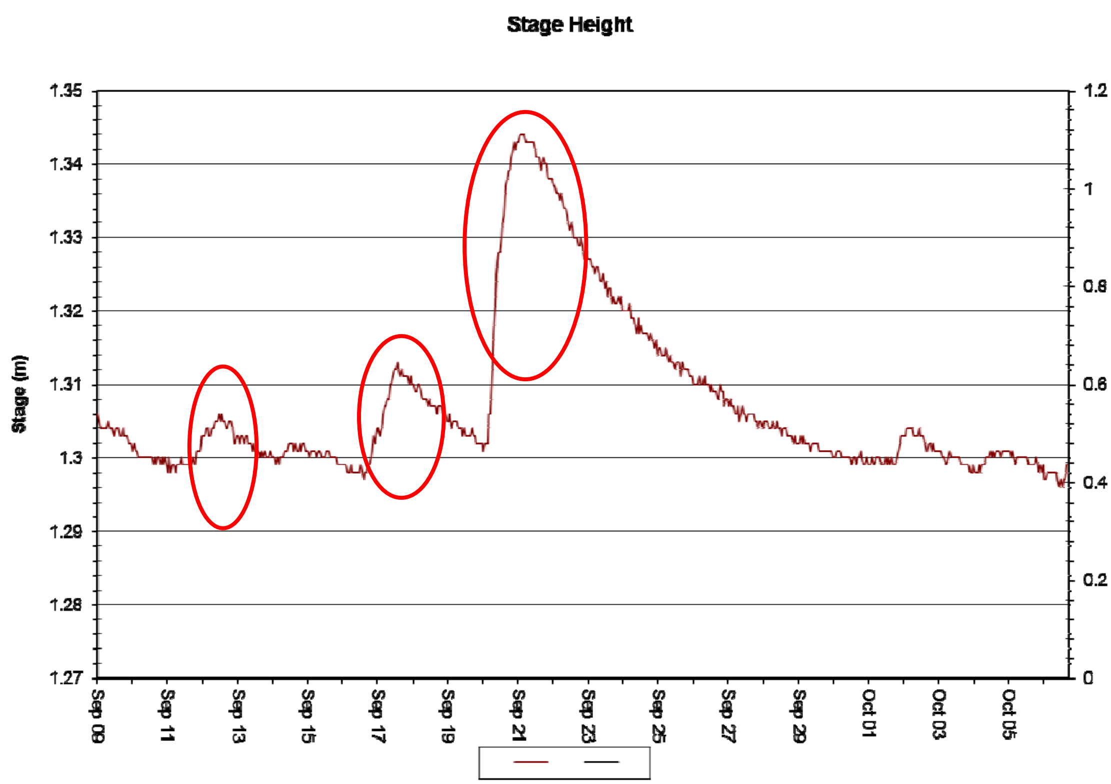

Figure 3: Stage Height (m) at Houston Creek from Sept. 9, 2013 to Oct. 7, 2013

Temperature

- Water temperature ranged from 2.90˚C to 8.70˚C at James Creek and from 1.50˚C to 3.90˚C at Unnamed Tributary from September 10, 2013 to October 7, 2013 (Figures 4 & 5). Water temperature ranged from 2.30˚C to 10.80˚C at Houston Creek from September 9, 2013 to October 7, 2013 (Figure 6)
- 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.
- There was no distinct increasing or declining temperatures trends at either station over the deployment period.
- Water temperatures at the Unnamed Tributary were on average 3.03^{o}C colder than water temperatures at James Creek. This temperature difference is largely due to a large volume of ground water which is discharged into Unnamed Tributary from deep groundwater dewatering wells which make up the majority of flow in this stream. While there is some groundwater discharged into James Creek it is not as significant a volume and its impact is attenuated by the natural surface drainage.

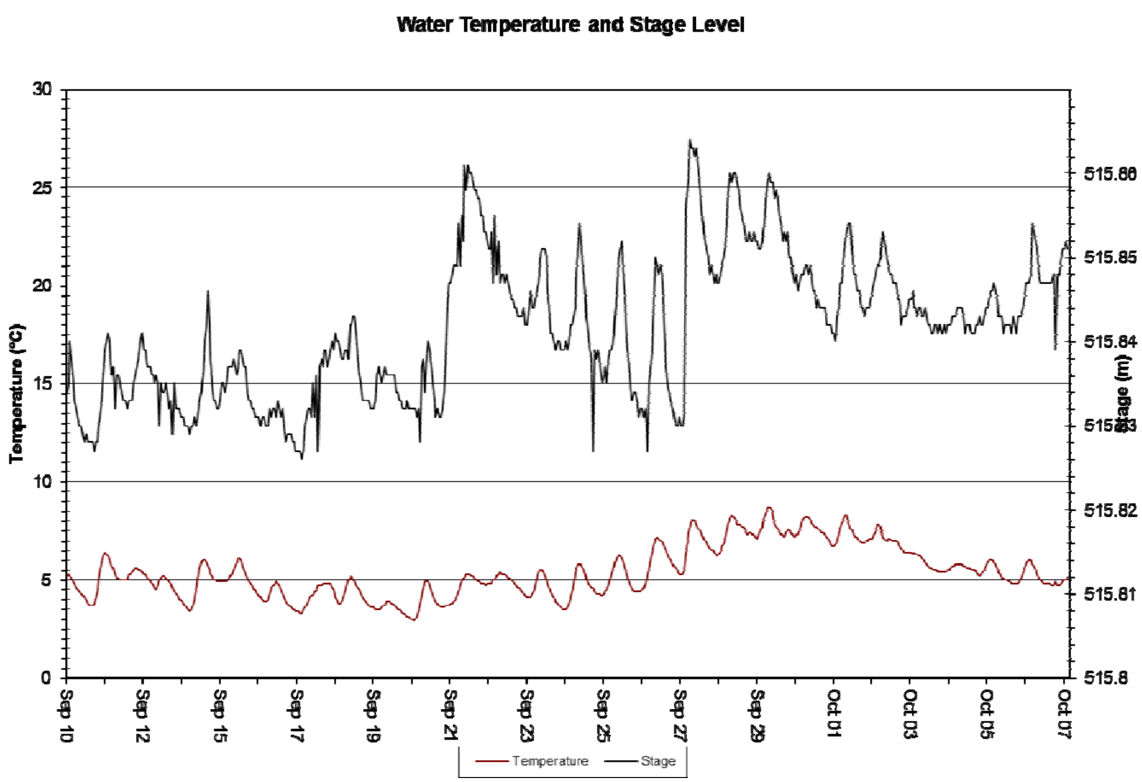

Figure 4: Temperature (^{o}C) at James Creek from Sept. 10, 2013 to Oct. 7, 2013

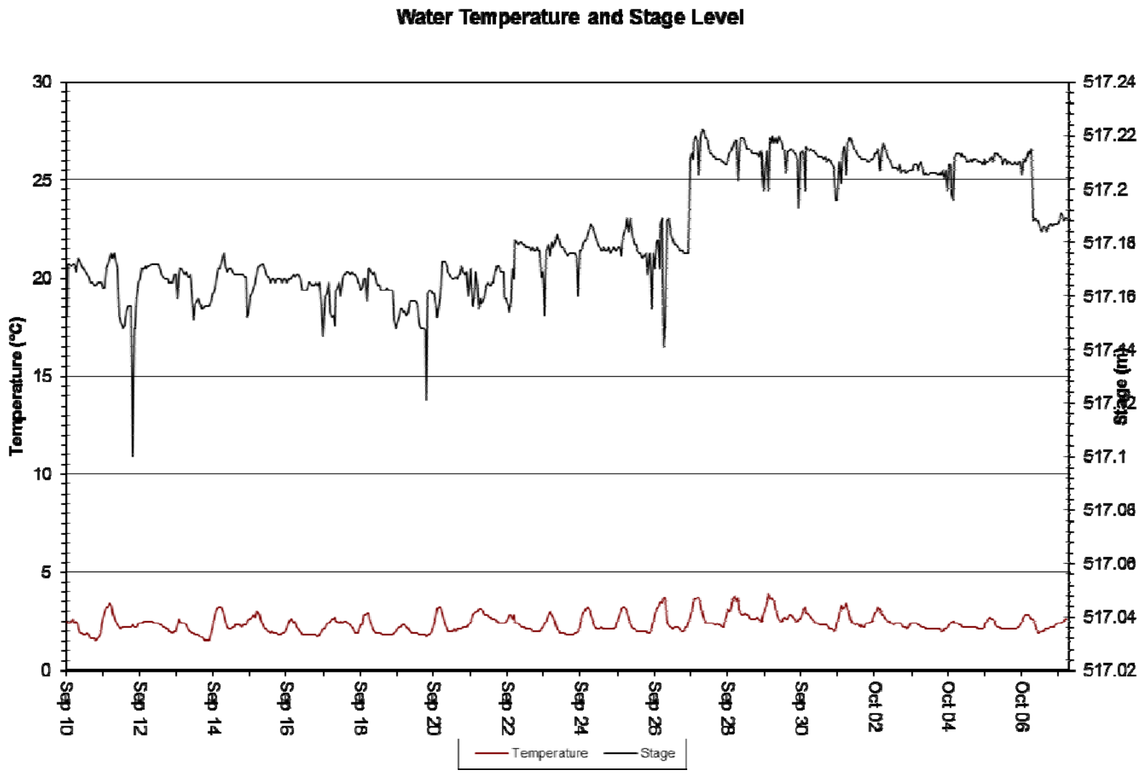

Figure 5: Temperature (°C) at Unnamed Tributary from Sept. 10, 2013 to Oct. 7, 2013

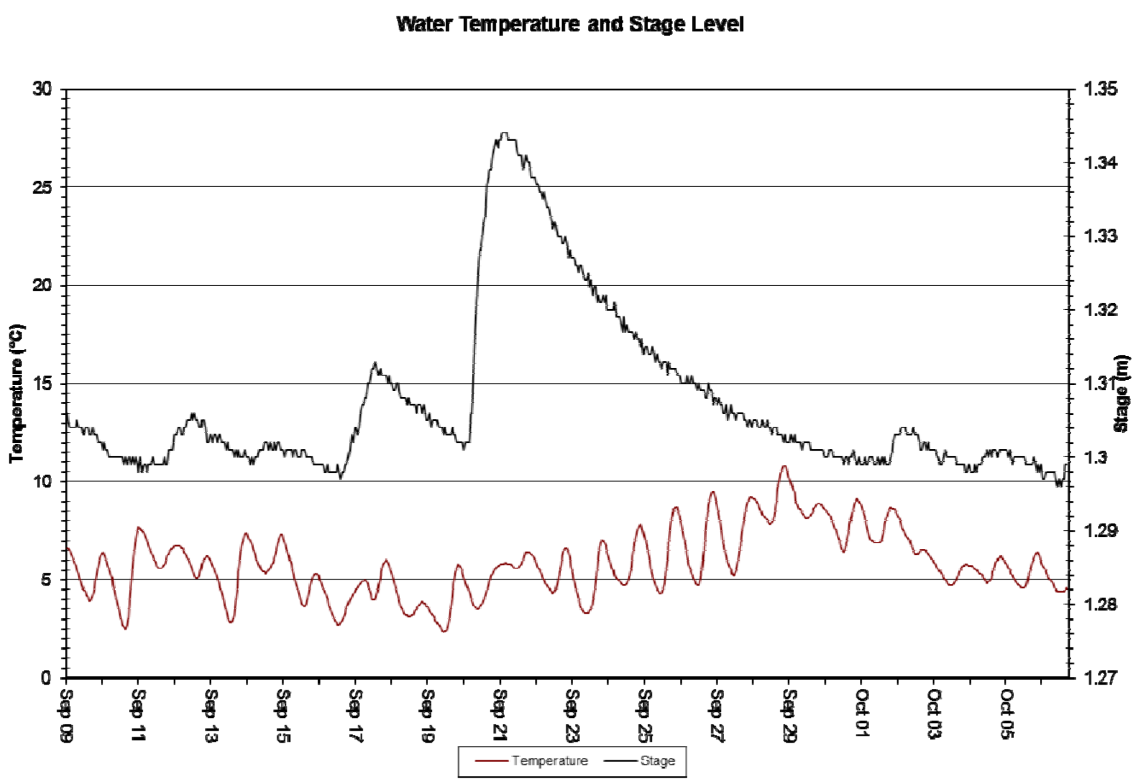

Figure 6: Temperature (°C) at Houston Creek from Sept. 9, 2013 to Oct. 7, 2013

pH

- pH values ranged from 7.86 units to 9.04 units at James Creek and from 6.46 units to 7.06 units at Unnamed Tributary from September 10, 2013 to October 7, 2013 (Figures 7 & 8). pH values ranged from 6.59 units to 6.89 units at Houston Creek from September 10, 2013 to October 7, 2013 (Figure 9)
- pH values at all three stations show regular diurnal fluctuations which are related to the diurnal temperature fluctuations.
- pH was relatively stable throughout the deployment period at all three stations.
- With a mean value of 8.25, pH values recorded at James Creek were within the guidelines for pH 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). With a mean value of 6.85, pH values recorded at Unnamed Tributary were also at or within these guidelines. Likewise with a mean value of 6.74, pH values recorded at Houston Creek were within these guidelines.

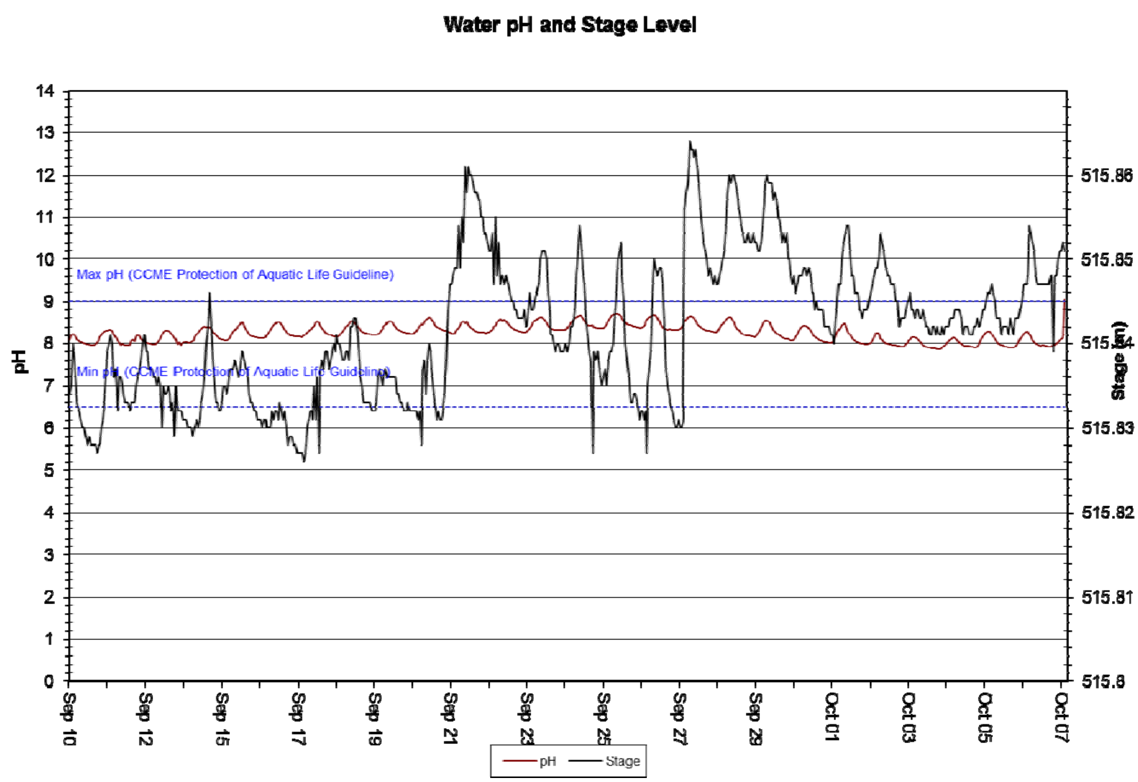

Figure 7: pH values recorded at James Creek from Sept. 10, 2013 to Oct. 7, 2013

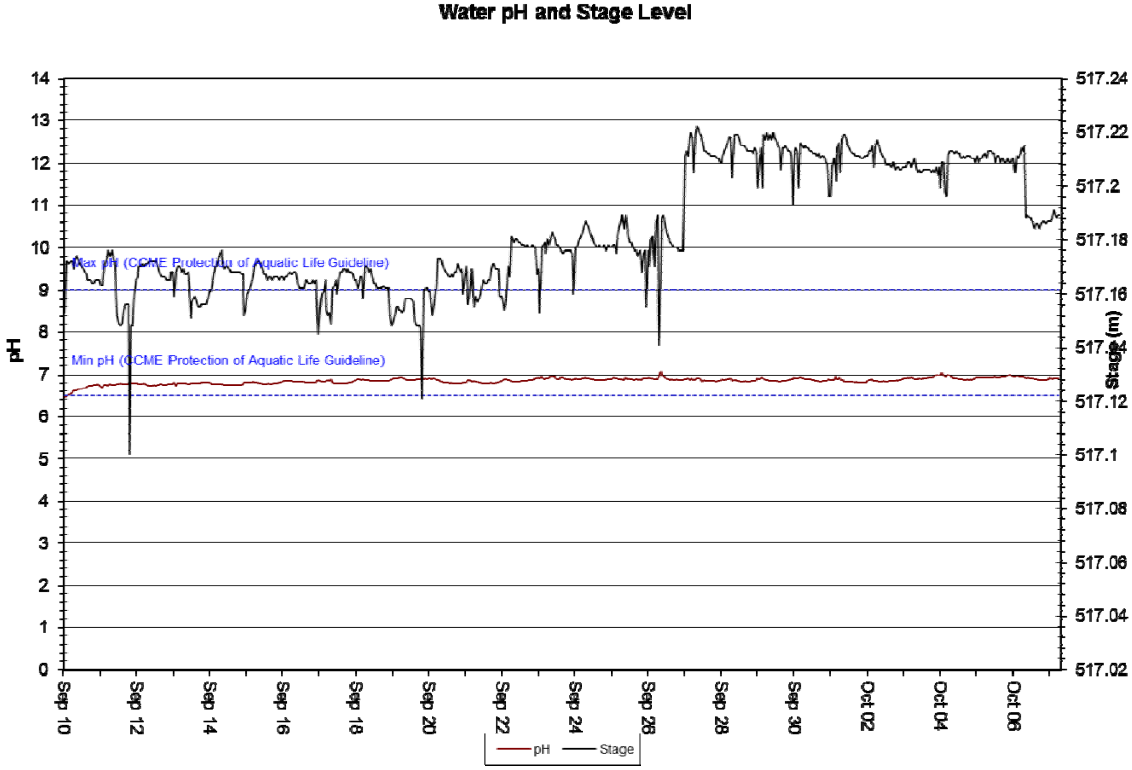

Figure 8: pH values recorded at Unnamed Tributary from Sept. 10, 2013 to Oct. 7, 2013

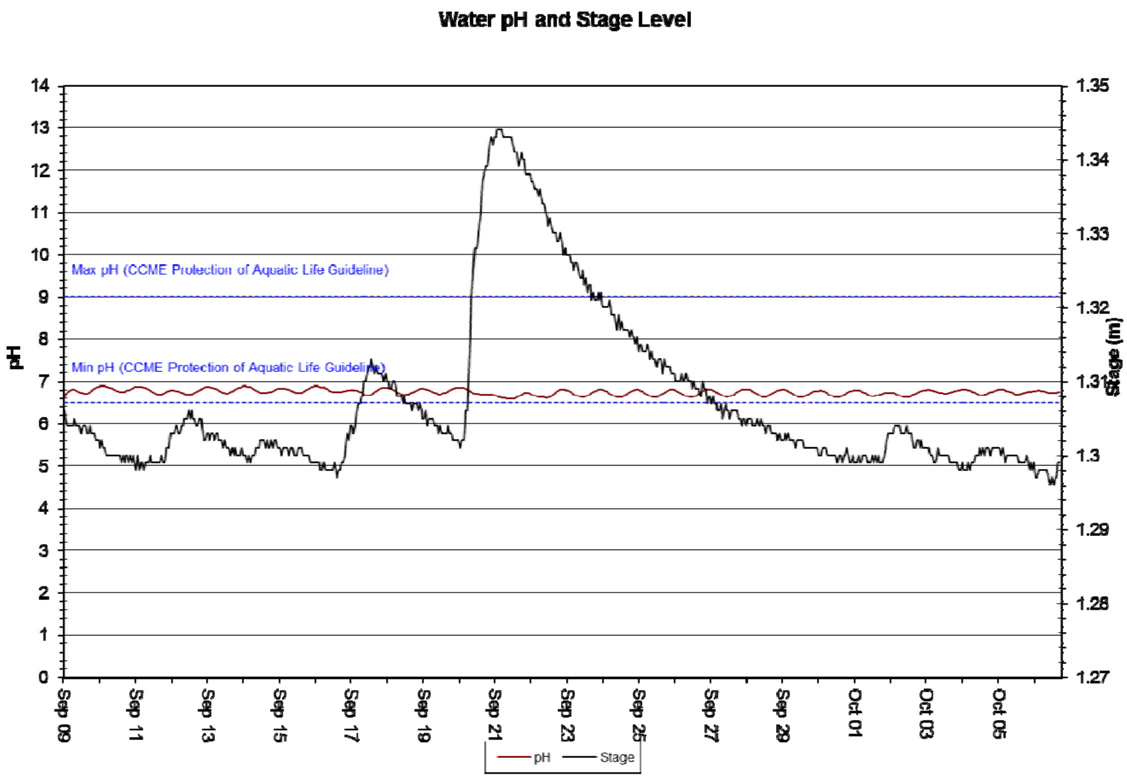

Figure 9: pH values recorded at Houston Creek from Sept. 9, 2013 to Oct. 7, 2013

Specific Conductivity

- Specific Conductivity ranged from 135.7 µS/cm to 148.0 µS/cm at James Creek and from 7.1 µs/cm to 60.9 µS/cm at Unnamed Tributary from September 10, 2013 to October 7, 2013 (Figures 10 & 11). Specific Conductivity ranged from 30.9 µS/cm to 38.1 µS/cm at Houston Creek from September 9, 2013 to October 7, 2013 (Figure 12)
- Specific conductivity readings were fairly stable at James Creek during the deployment period; however at Unnamed Tributary they were highly variable. Due to the high variability of the data, the specific conductivity sensor on this instrument will be tested during the winter months to determine if there is a sensor related issue.
- On average, specific conductivity was 140.8 µS/cm at James Creek and 39.5 µS/cm at Unnamed Tributary. This difference could be attributed to the increased concentration of dissolved solids from the iron ore tailings deposited into Ruth Pit, which feeds into James Creek.
- At Houston Creek there are noticeable diurnal fluctuations which are related to the diurnal temperature fluctuations. There is also a noticeable dip in specific conductivity (see inside red oval – Figure 12) coinciding with a significant spike in flow.

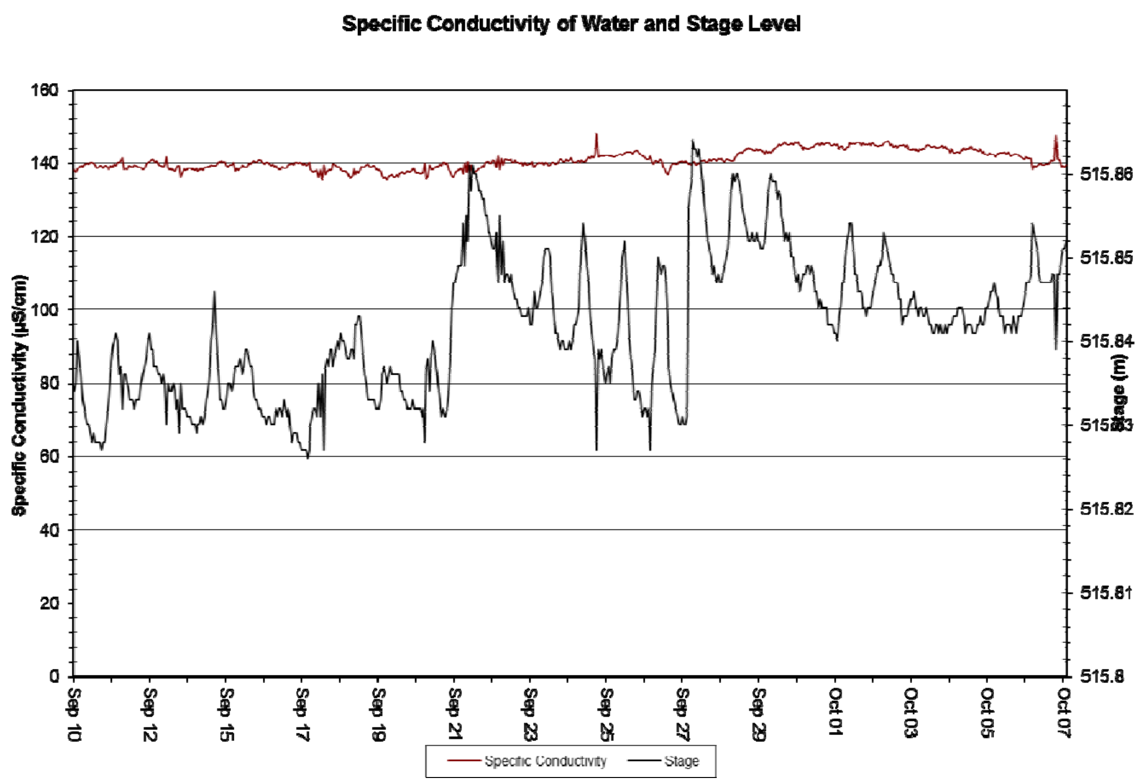

Figure 10: Specific conductivity (µs/cm) at James Creek from Sept. 10, 2013 to Oct. 7, 2013

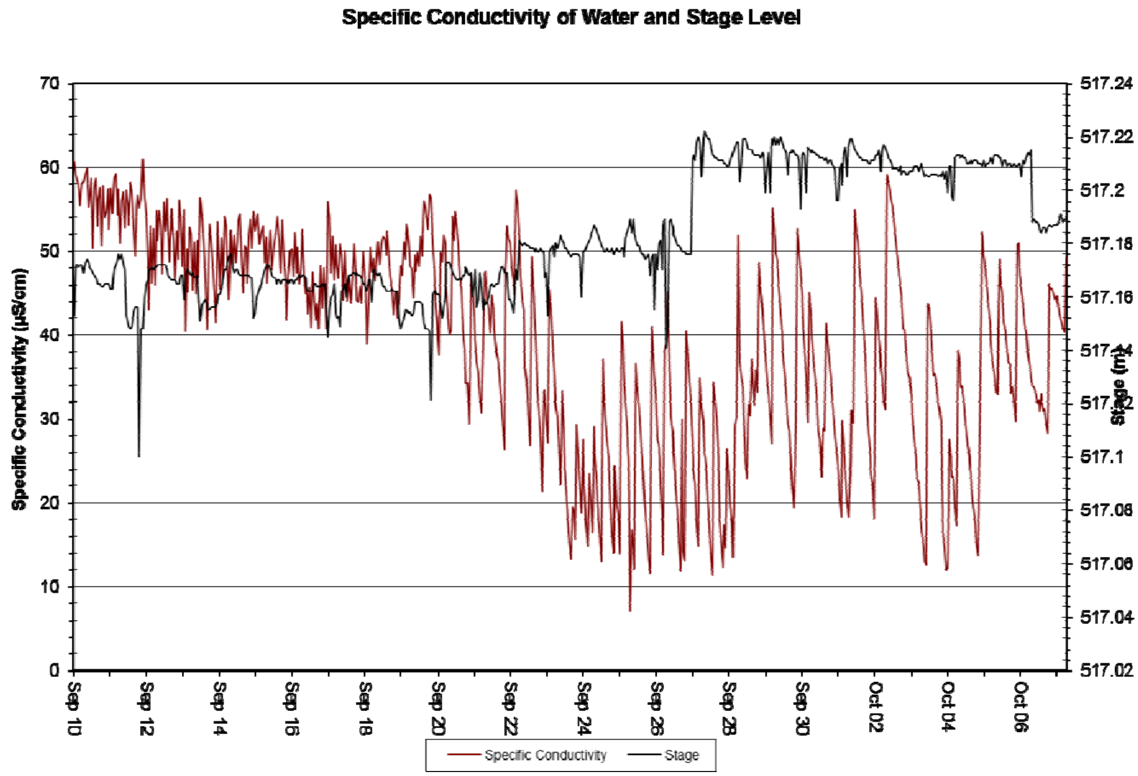

Figure 11: Specific conductivity (µs/cm) at Unnamed Tributary - Sept.10, 2013 to Oct. 7, 2013

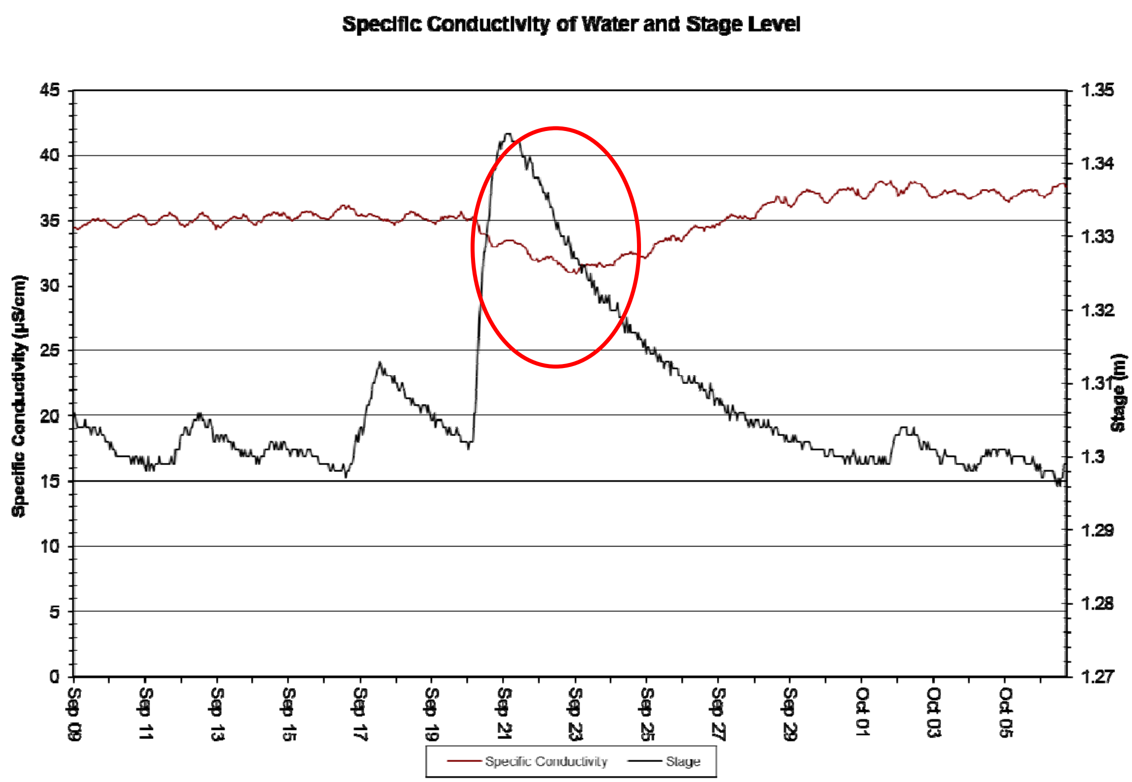

Figure 12: Specific conductivity (µs/cm) at Houston Creek - Sept.9, 2013 to Oct. 7, 2013

Dissolved Oxygen

- Dissolved Oxygen [DO] values ranged from 10.40 mg/l (89.0% saturation) to 12.39 mg/l (100.2% saturation) at James Creek and from 11.65 mg/l (89.3% saturation) to 13.64 mg/l (105.4% saturation) at Unnamed Tributary from September 10, 2013 to October 7, 2013 (Figures 13 & 14). Dissolved Oxygen [DO] values ranged from 9.76 mg/l (84.5% saturation) to 12.31 mg/l (102.2% saturation) at Houston Creek from September 9, 2013 to October 7, 2013 (Figure15).
- DO (mg/l & % saturation) shows a clear diurnal fluctuation at all three stations. These diurnal fluctuations can be attributed to the diurnal temperature fluctuations.
- DO (mg/l & % saturation) is relatively stable over the deployment period for all three stations.
- The DO values at all three stations were above the cold water minimum guideline set for aquatic life during early life stages (9.5 mg/l), and above minimum guideline set for other life stages (6.5 mg/l), as determined by the Canadian Council of Ministers of the Environment (2007).

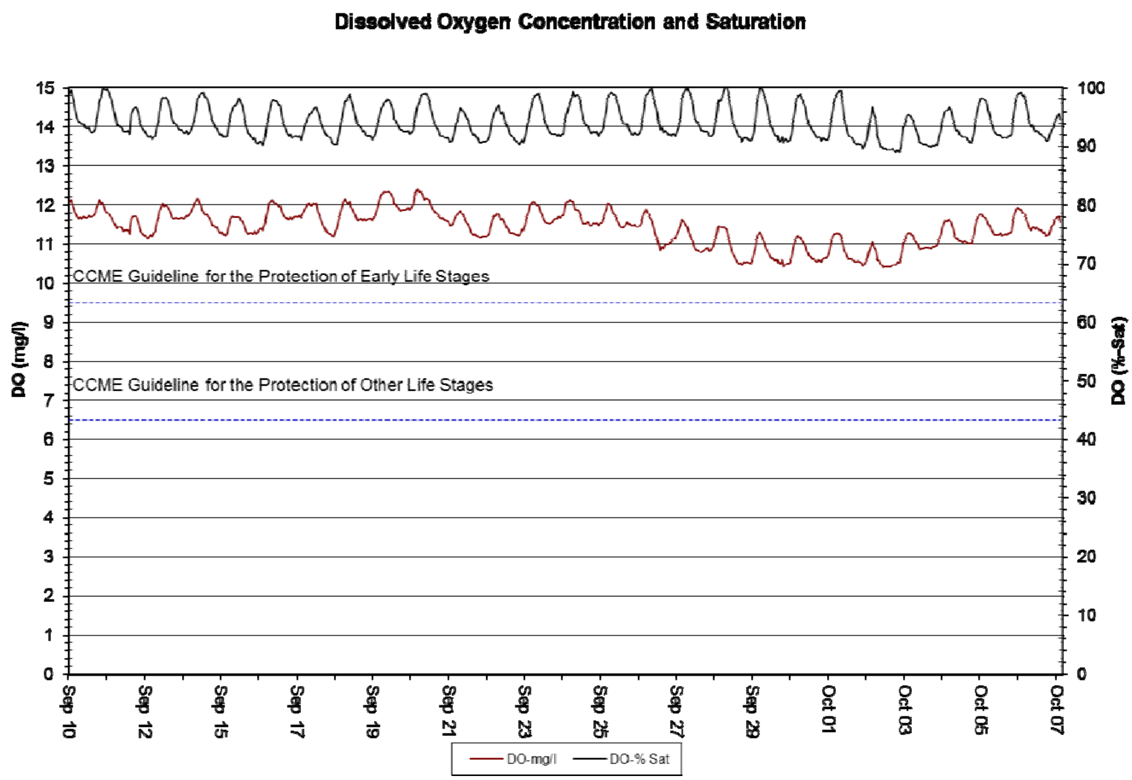

Figure 13: DO (mg/l & % saturation) at James Creek from Sept. 10, 2013 to Oct. 7, 2013

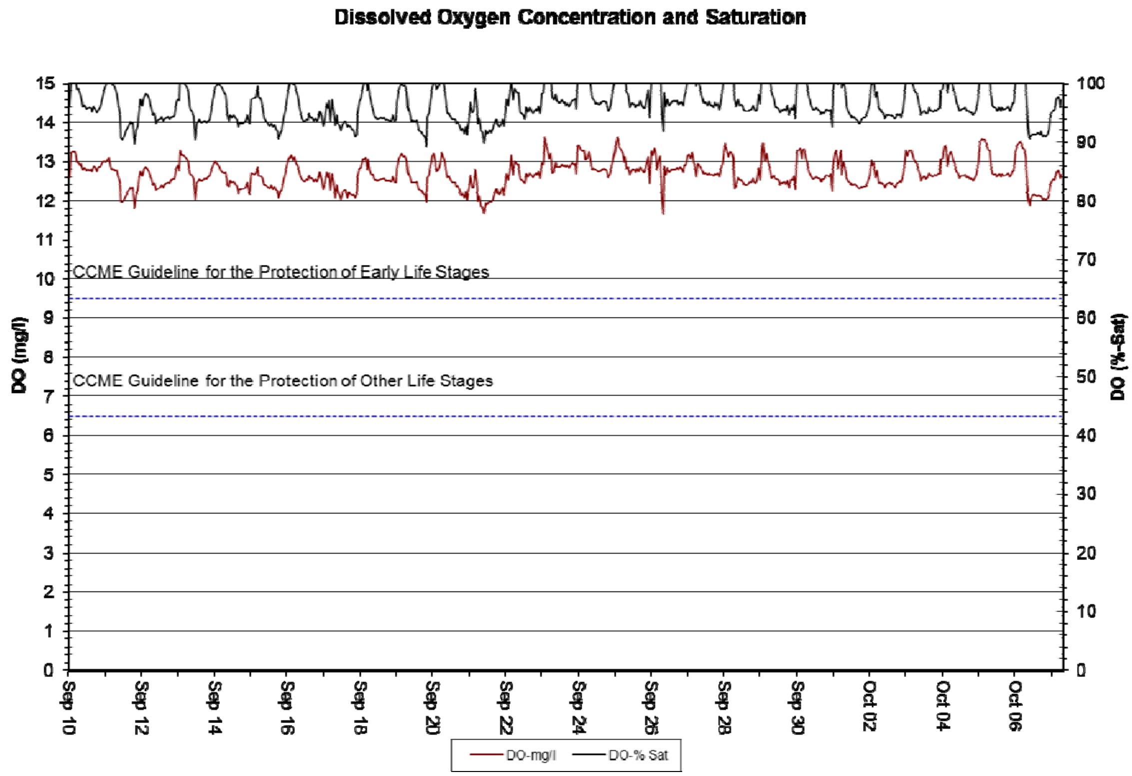

Figure 14: DO (mg/l & % saturation) at Unnamed Tributary Sept. 10, 2013 to Oct. 7, 2013

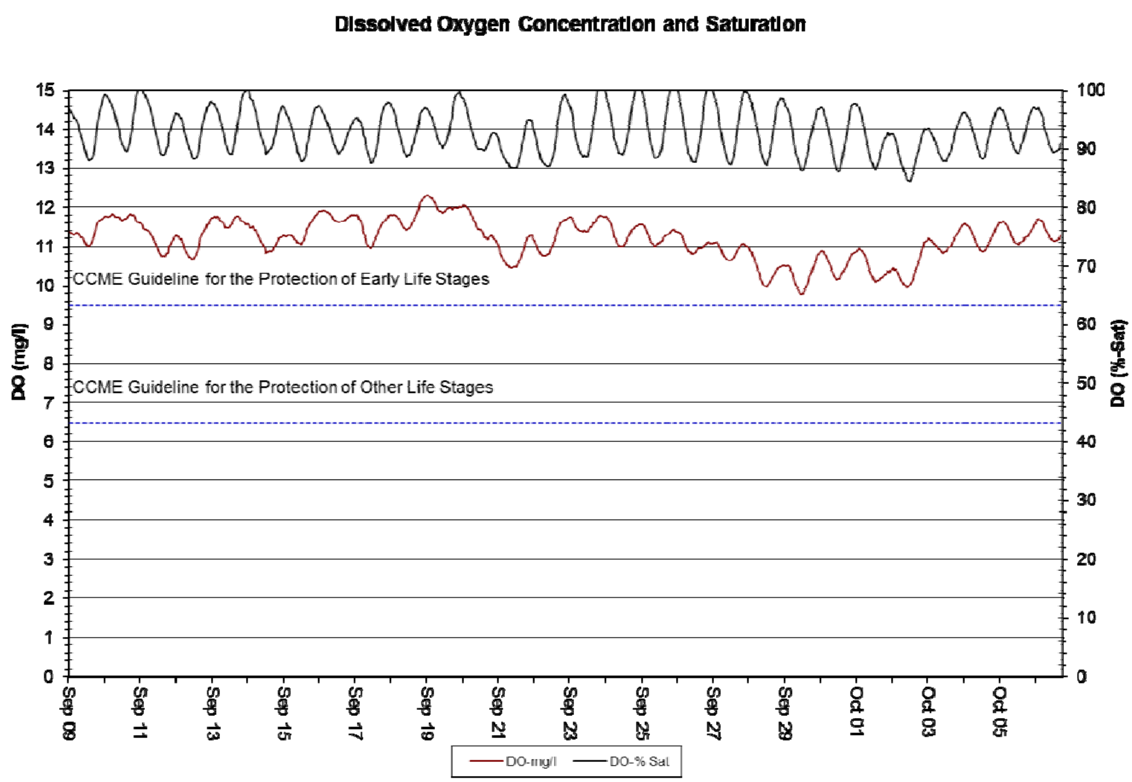

Figure 15: DO (mg/l & % saturation) at Houston Creek Sept. 9, 2013 to Oct. 7, 2013

Turbidity

- Turbidity values ranged from 0.1 NTU to 49.0 NTU at James Creek and from 0.0 NTU to 10.5 NTU at Unnamed Tributary from September 10, 2013 to October 7, 2013 (Figures 16 & 17). Turbidity values ranged from 0.0 NTU to 5.9 NTU at Houston Creek from September 9, 2013 to October 7, 2013 (Figure 18).
- There were several turbidity events at James Creek and unnamed Tributary (see inside red ovals Figures 16 & 17) which coincide with increases in flow that are due to significant rainfall events. Given the level of ground disturbance related to mining activity inside these drainage areas, it is not surprising that significant rainfall events cause siltation and elevate turbidity levels.
- At Houston Creek, turbidity was low and stable during the deployment period reflecting the relatively stable and naturalized conditions of this area which has not seen any mining activity in approximately 30 years.

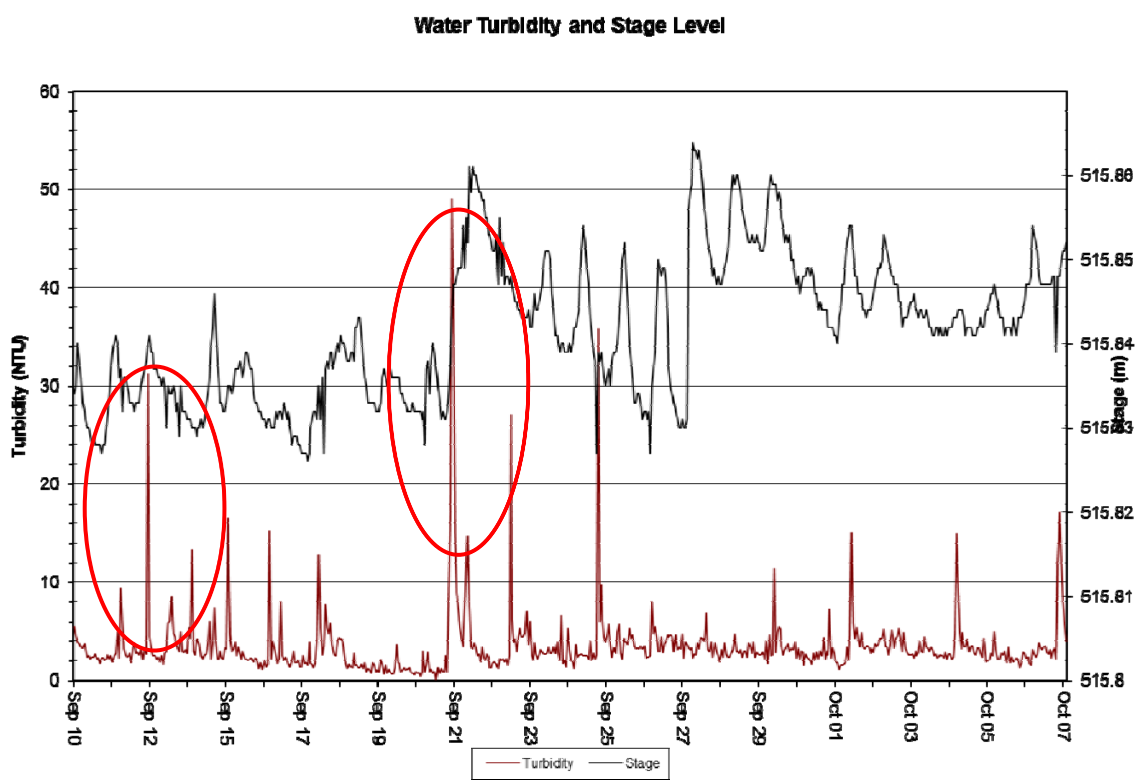

Figure 16: Turbidity (NTU) at James Creek from Sept. 10, 2013 to Oct. 7, 2013

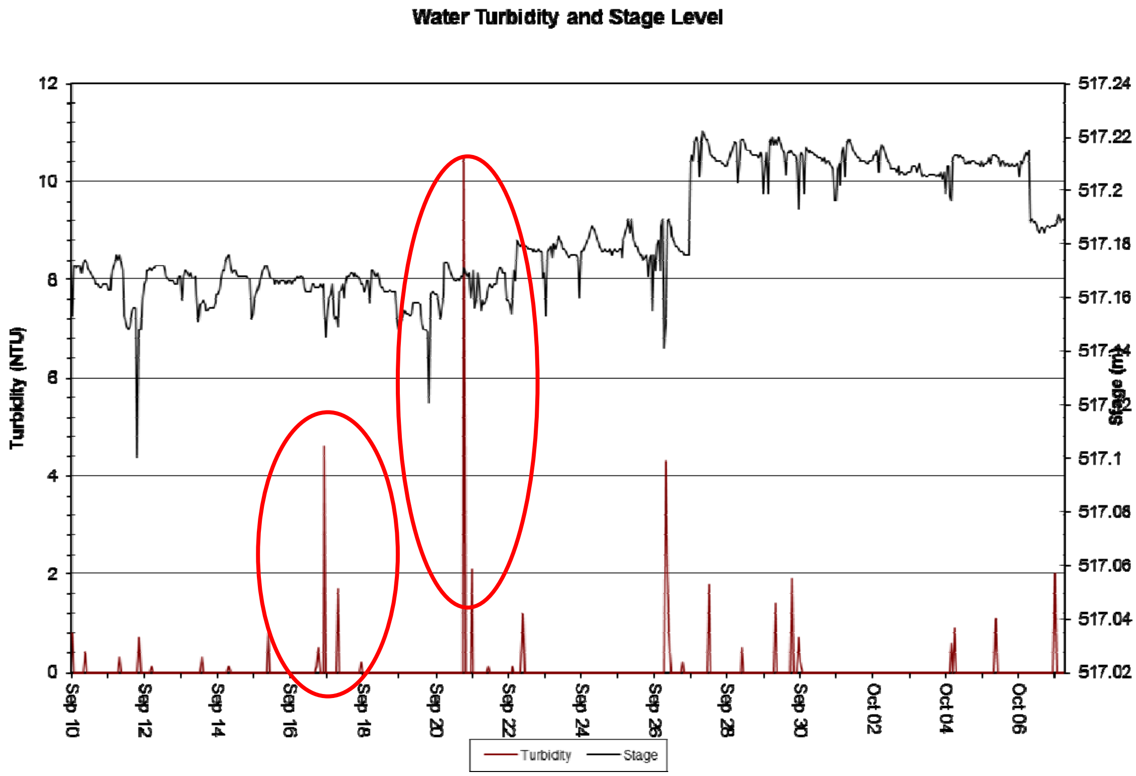

Figure 17: Turbidity (NTU) at Unnamed Tributary from Sept. 10, 2013 to Oct. 7, 2013

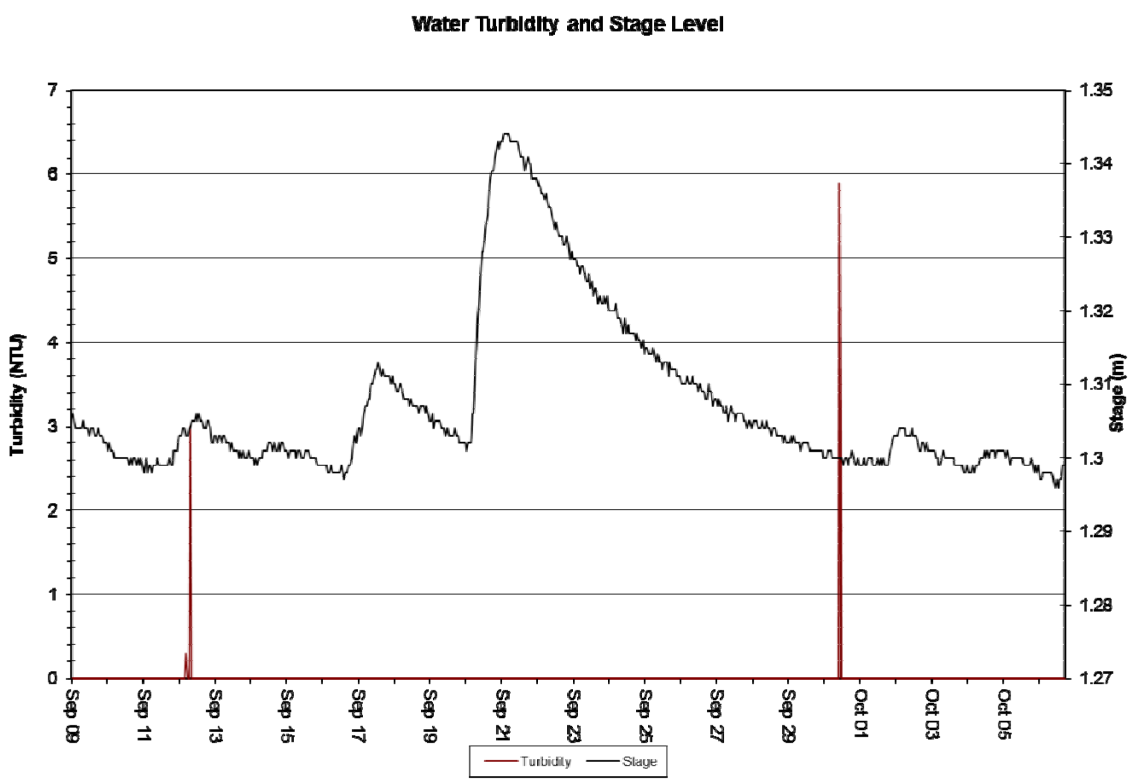

Figure 18: Turbidity (NTU) at Houston Creek from Sept. 9, 2013 to Oct. 7, 2013

Conclusion

- This monthly deployment report presents water quality and water quantity data recorded at the James Creek and Unnamed Tributary stations from September 10, 2013 to October 7, 2013, and Houston Creek station from September 9, 2013 to October 7, 2013.

- The performances of all sensors were rated good to excellent at the beginning of the deployment period. The majority of the sensors rated good to excellent upon removal with the exception of the turbidity sensor at James Creel Station. The poor rating for turbidity at the end of the James Creek deployment could be the result of a variety of variables such as; organic debris accumulated on the sensors after a month long deployment, short term variation in turbidity between the area where the field sonde was located and where the QA/QC reading was taken, the field turbidity sensor drifting significantly off calibration, or some other undetermined variable.

- Variations in water quality/quantity values recorded at each station are summarized below:
  - For both James Creek and Unnamed Tributary there appears to be a gentle rising trend in stage height throughout the deployment period. In addition, regular daily fluctuations were observed at both stations. These diurnal fluctuations are most likely attributed to dewatering operations from the mine site.
  - For Houston Creek, the stage height graph is dominated by a series of peaks which all correspond with significant precipitation events.
  - There are no distinct monthly temperature trends for either station, however regular diurnal fluctuations were observed at all three stations. These diurnal water temperature trends are related to diurnal air temperature trends.
  - Water temperatures at the Unnamed Tributary were on average 3.03^{o}C colder than water temperatures at James Creek. This temperature difference is largely due to a large volume of ground water which is discharged into Unnamed Tributary from deep groundwater dewatering wells which make up the majority of flow in this stream. While there is some groundwater discharged into James Creek it is not as significant a volume and its impact is attenuated by the natural surface drainage.
  - pH was very stable throughout the deployment period at all three stations, however all three show regular diurnal fluctuations which are related to the diurnal temperature fluctuations.
  - Specific conductivity readings were fairly stable at James Creek during the deployment period; however at Unnamed Tributary they were highly variable. Due to the high variability of the data, the specific conductivity sensor on this instrument will be tested during the winter months to determine if there is a sensor related issue.
  - At Houston Creek, there are noticeable diurnal fluctuations in specific conductivity which are related to the diurnal temperature fluctuations. There is also a noticeable dip in specific conductivity coinciding with a significant spike in flow.

- DO (mg/l & % saturation) is relatively stable over the deployment period for all three stations. DO (mg/l & % saturation) shows clear diurnal fluctuation at all three stations. These diurnal fluctuations can be attributed to the diurnal temperature fluctuations.
- There were several turbidity events at James Creek and unnamed Tributary which coincide with increases in flow that are due to significant rainfall events. Given the level of ground disturbance related to mining activity inside these drainage areas, it is not surprising that significant rainfall events cause siltation and elevate turbidity levels.
- At Houston Creek turbidity was low and stable during the deployment period reflecting the relatively stable and naturalized conditions of this area which has not seen any mining activity in approximately 30 years.

References

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/)

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

Environment Canada Weather Data – Schefferville (September 10, 2013 to October 7, 2013)

Date/Time	Max Temp (°C)	Min Temp (°C)	Mean Temp (°C)	Heat Deg Days (°C)	Cool Deg Days (°C)	Total Rain Flag	Total Snow Flag	Total Precip (mm)
9/10/2013	3.8	-2.1	0.9	17.1	0	M	M	0
9/11/2013	11.8	-3.5	4.2	13.8	0	M	M	0
9/12/2013	8.1	3.1	5.6	12.4	0	M	M	10.1
9/13/2013	3.1	-2	0.6	17.4	0	M	M	0
9/14/2013	8.7	-4.2	2.3	15.7	0	M	M	4
9/15/2013	8.8	0.5	4.7	13.3	0	M	M	2.9
9/16/2013	2.5	-1.9	0.3	17.7	0	M	M	0.3
9/17/2013	9.4	-2.1	3.7	14.3	0	M	M	15.8
9/18/2013	4.4	-2	1.2	16.8	0	M	M	4.3
9/19/2013	0.3	-2	-0.9	18.9	0	M	M	0
9/20/2013	4.6	-2.5	1.1	16.9	0	M	M	6.3
9/21/2013	13.2	2.4	7.8	10.2	0	M	M	19
9/22/2013	8.7	1.1	4.9	13.1	0	M	M	0.3
9/23/2013	5.9	-1.4	2.3	15.7	0	M	M	0
9/24/2013	8.7	-3.4	2.7	15.3	0	M	M	0
9/25/2013	12.4	2.1	7.3	10.7	0	M	M	0
9/26/2013	17.4	1.6	9.5	8.5	0	M	M	0
9/27/2013	19.7	1.7	10.7	7.3	0	M	M	0
9/28/2013	22.2	7.1	14.7	3.3	0	M	M	0
9/29/2013	22.1	13.6	17.9	0.1	0	M	M	0
9/30/2013	13.7	7.6	10.7	7.3	0	M	M	0
10/1/2013	15.7	2.9	9.3	8.7	0	M	M	0
10/2/2013	14.4	7.3	10.9	7.1	0	M	M	8.5
10/3/2013	7.7	2.4	5.1	12.9	0	M	M	0.3
10/4/2013	5.4	1.6	3.5	14.5	0	M	M	0.9
10/5/2013	4.6	1	2.8	15.2	0	M	M	3.8
10/6/2013	7.3	2.1	4.7	13.3	0	M	M	0
10/7/2013	9.2	3.7	6.5	11.5	0	M	M	6.8