Real Time Water Quality Report

Labrador Iron Mines
Schefferville Network

Deployment Period
2013-08-06 to 2013-09-10

Newfoundland Labrador

Government of Newfoundland & Labrador
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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. On August 8th, 2013, one additional real-time water quality and water quantity station was established in close proximity to the Houston Property deposits, near Schefferville, QC.
- 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 August 6, 2013 to September 10, 2013, and Houston Creek station from August 08, 2013 to September 9, 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	2013-08-06	2013-09-10	2013-08-06	2013-09-10	2013-08-06	2013-09-09
Temperature	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
pH	Excellent	Good	Excellent	Good	Excellent	Excellent
Specific Conductivity	Excellent	Excellent	Excellent	Good	Excellent	Excellent
Dissolved Oxygen	Excellent	Good	Excellent	Good	Excellent	Good
Turbidity	Good	Poor	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 August 6, 2013 at 9:15 am and at James Creek on the same date at 10:30 am. Monitoring at Houston Creek started at 11:15 am on August 8, 2013. Continuous real-time monitoring continued at all three sites without any significant operational issues until September 9, 2013 at Houston Creek station, and September 10, 2013, at James Creek and Unnamed tributary Stations, when the instruments were removed for routine calibration and maintenance.

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 515.91 m at James Creek and from 517.09 m to 517.20 m at Unnamed Tributary from August 6, 2013 to September 10, 2013 (Figures 1 & 2). Stage values ranged from 1.30 m to 1.41 m at Houston Creek from August 8, 2013 to September 9, 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.
- There are no distinct monthly trends for either station however regular daily fluctuations were observed at James Creek and Unnamed Tributary stations. These diurnal fluctuations are most likely attributed to dewatering operations from the mine site. There was very limited diurnal variation at the Houston Creek station.
- For James Creek there is a marked spike in flow around August 11(see inside red oval – Figure 1) which is related to a significant rainfall at that time (Climate data is located in Appendix B).
- The Stage Height at Unnamed tributary is dominated by water discharged from mine dewatering operations. Because of the prevalence of this discharge water it is difficult to see any natural fluctuations in flow.
- While there is a slight declining trend in stage height at Houston Creek over the deployment period, the deployment graph is dominated by a series of sharp spikes in stage (see inside red ovals – Figure 3) at several points in the deployment. These spikes correspond very well with significant rainfall events for the corresponding times.
- 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.

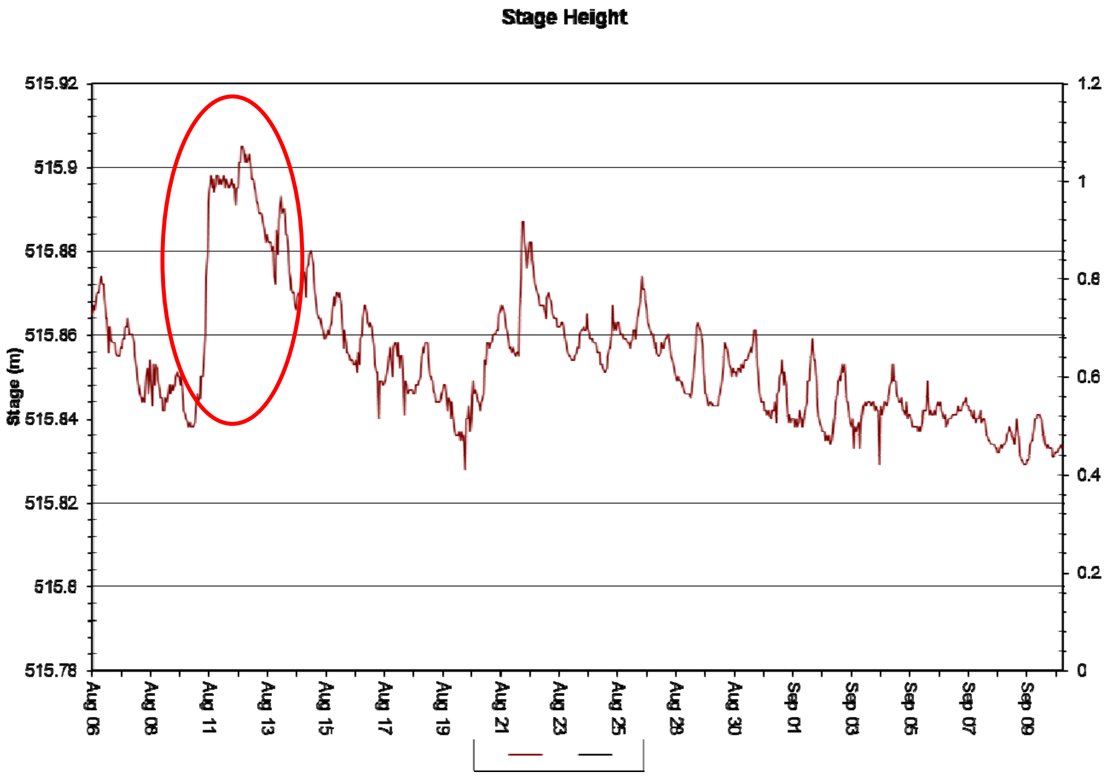

Figure 1: Stage Height (m) at James Creek from Aug. 6, 2013 to Sept. 10, 2013

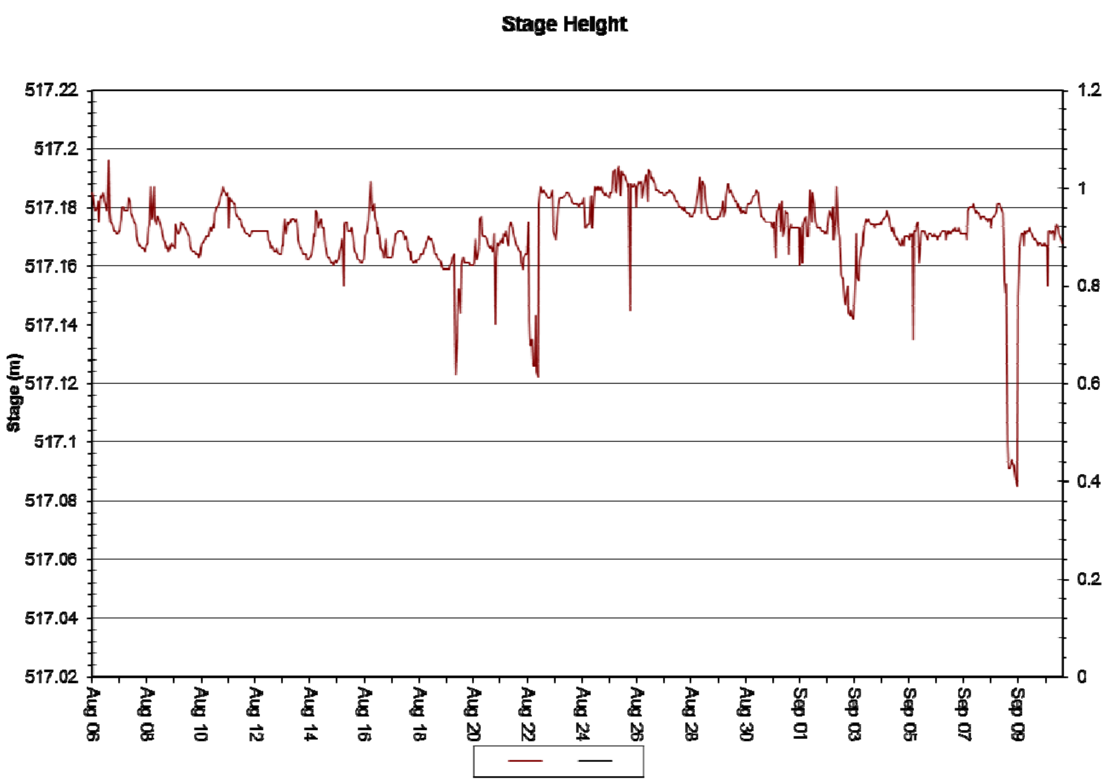

Figure 2: Stage Height (m) at Unnamed Tributary from Aug. 6, 2013 to Sept. 10, 2013

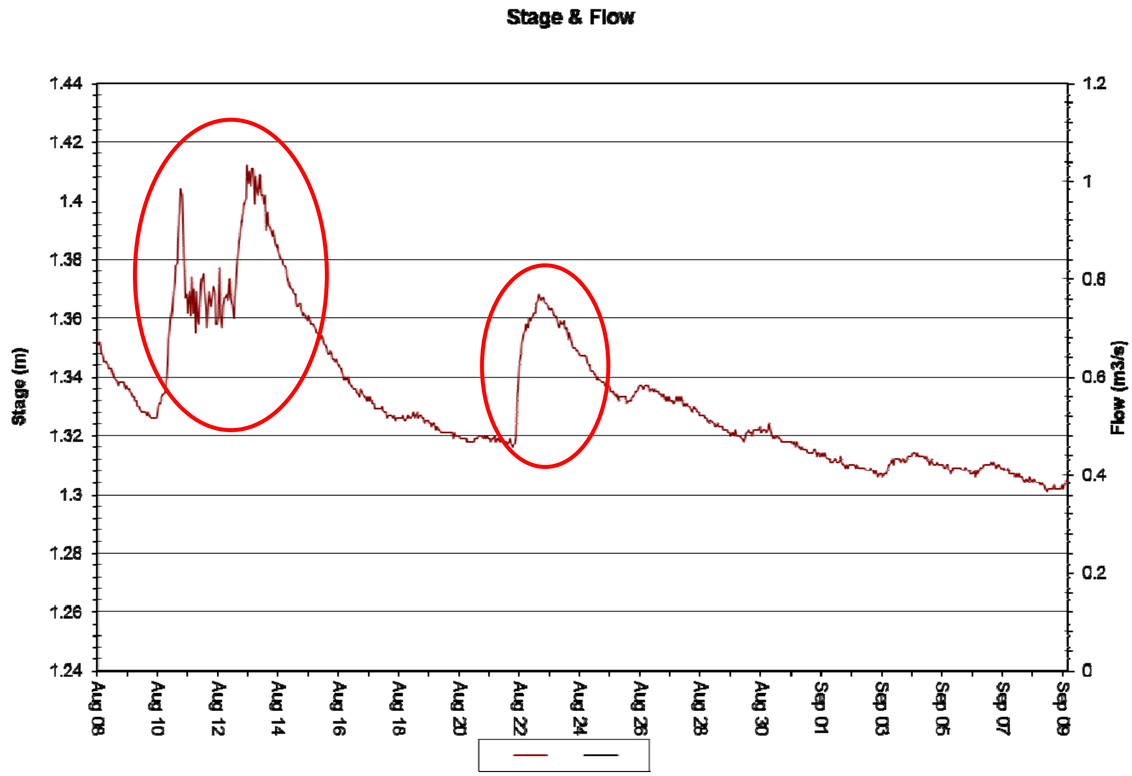

Figure 3: Stage Height (m) at Houston Creek from Aug. 8, 2013 to Sept. 9, 2013

Temperature

- Water temperature ranged from 4.20˚C to 13.80˚C at James Creek and from 1.40˚C to 5.10˚C at Unnamed Tributary from August 6, 2013 to September 10, 2013 (Figures 4 & 5). Water temperature ranged from 4.30˚C to 15.7˚C at Houston Creek from August 8, 2013 to September 9, 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. It should be noted that diurnal trends can be reduced significantly during periods of increased flow (see inside red ovals - figures 4 & 6).
- Temperatures at James Creek and Houston Creek showed a gentle declining trend typical of the transition from summer to fall. At Unnamed Tributary temperatures remained relatively stable over the deployment period with no obvious increasing or decreasing trends.
- Water temperatures at the Unnamed Tributary were on average 5.97^{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.

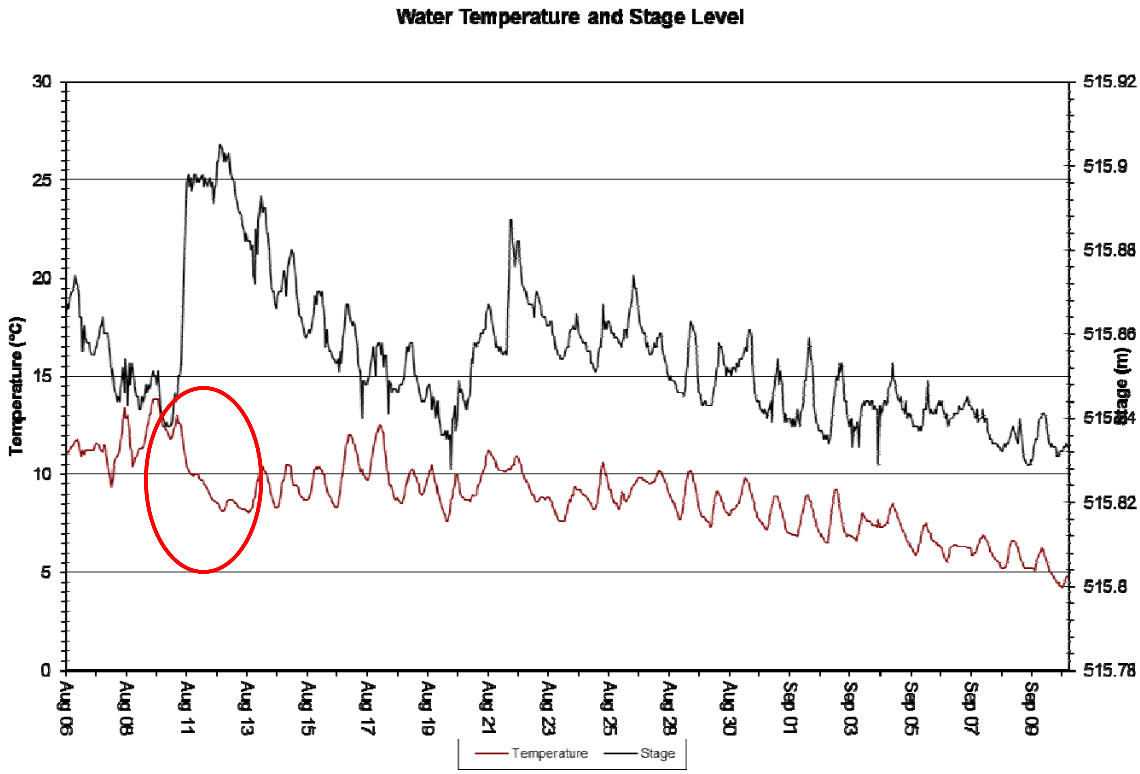

Figure 4: Temperature (°C) at James Creek from Aug. 6, 2013 to Sept. 10, 2013

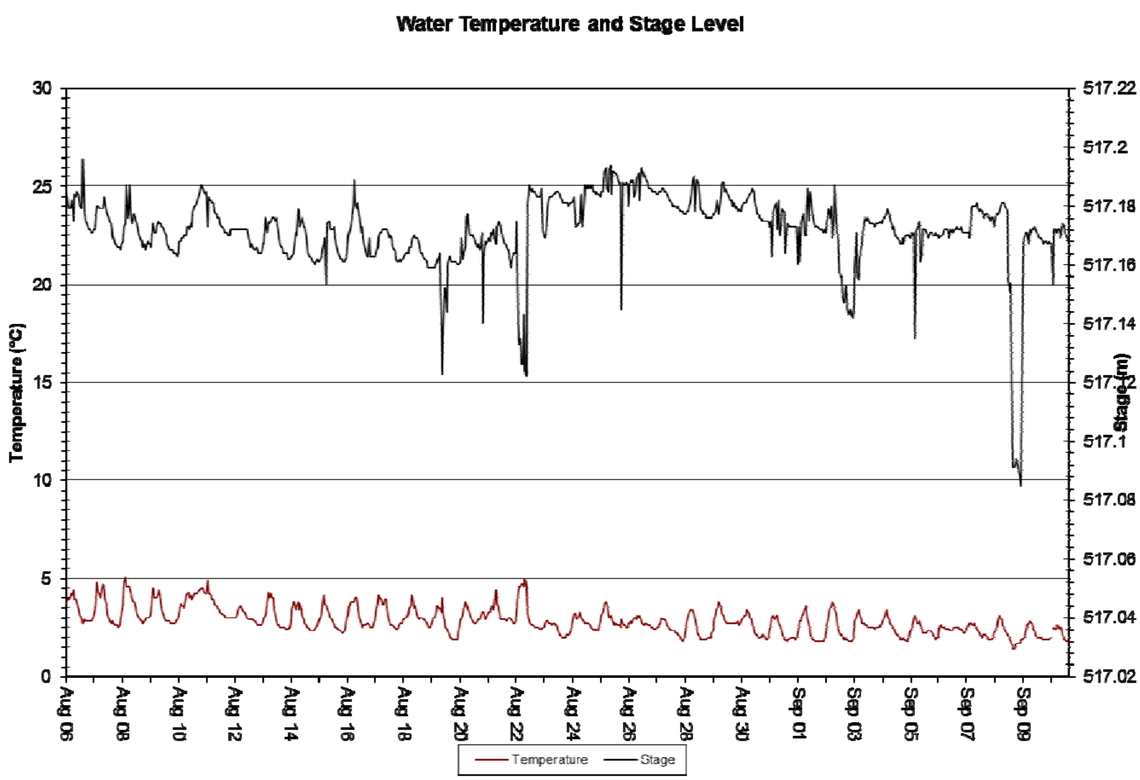

Figure 5: Temperature (°C) at Unnamed Tributary from Aug. 6, 2013 to Sept. 10, 2013

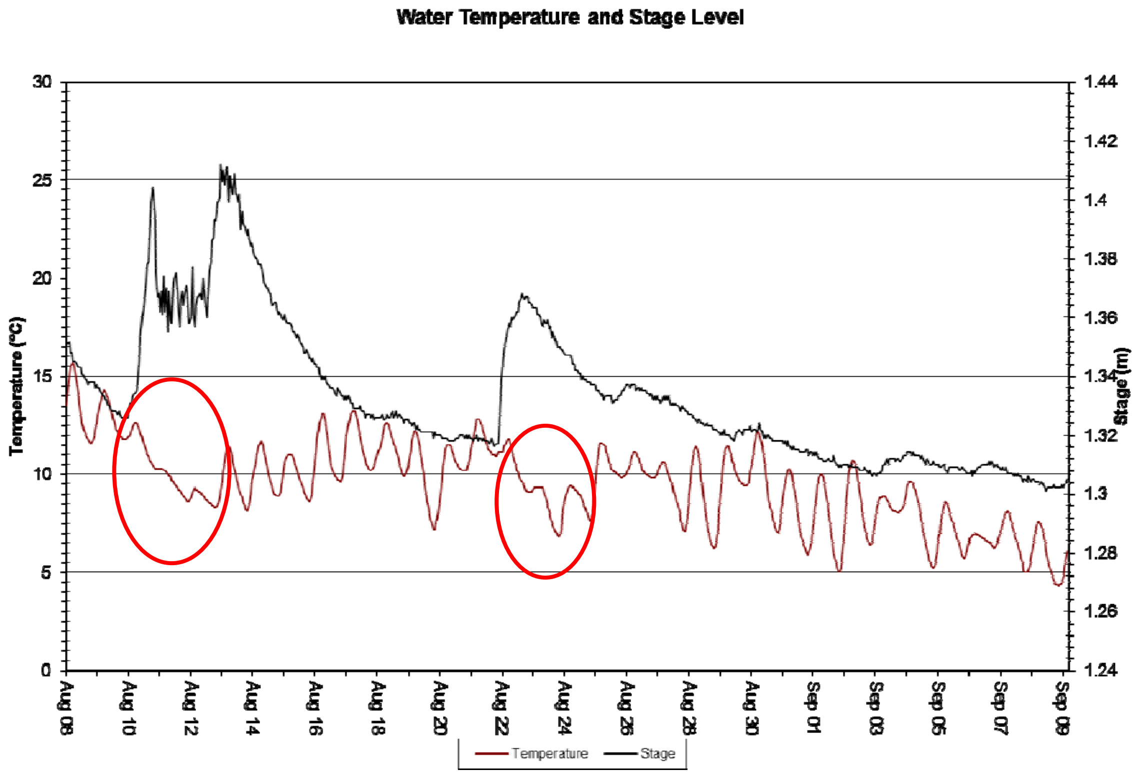

Figure 6: Temperature (°C) at Houston Creek from Aug. 8, 2013 to Sept. 9, 2013

pH

- pH values ranged from 7.07 units to 8.22 units at James Creek and from 6.46 units to 7.03 units at Unnamed Tributary from August 6, 2013 to September 10, 2013 (Figures 7 & 8). pH values ranged from 6.04 units to 6.65 units at Houston Creek from August 8, 2013 to September 9, 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 both James Creek and Unnamed Tributary. pH at Houston Creek was relatively stable throughout the deployment period, however during periods of significantly increased flow it is possible to discern a slight dip in pH (see inside red oval – Figure 9).
- With a mean value of 7.69, 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 6.76, pH values recorded at Unnamed Tributary were also at or within these guidelines. With a mean value of 6.29, pH values recorded at Houston Creek were at or slightly below the guideline. 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.

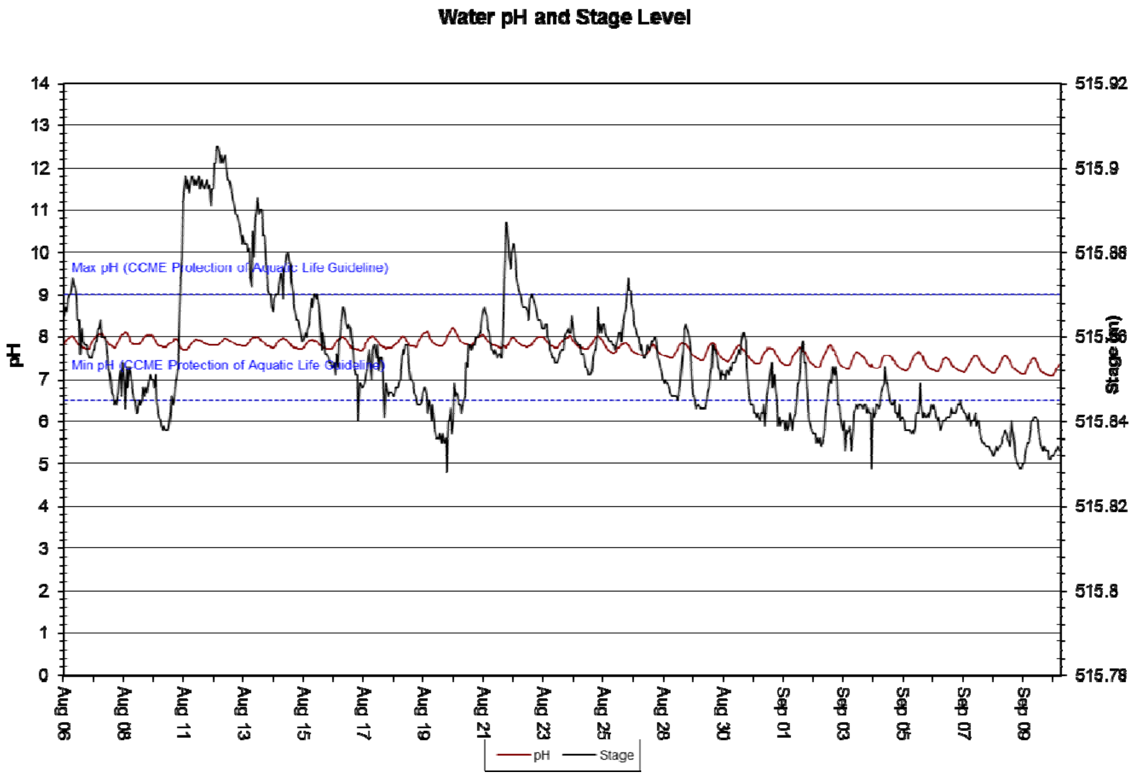

Figure 7: pH values recorded at James Creek from Aug. 6, 2013 to Sept. 10, 2013

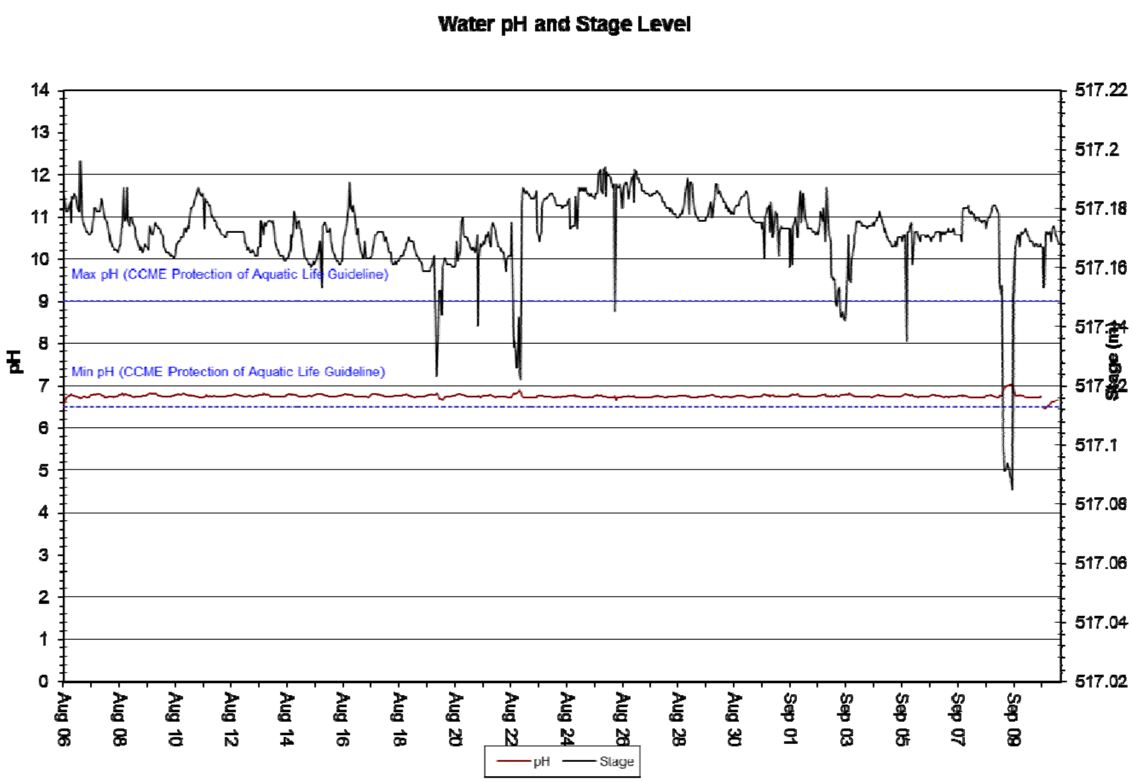

Figure 8: pH values recorded at Unnamed Tributary from Aug. 6, 2013 to Sept. 10, 2013

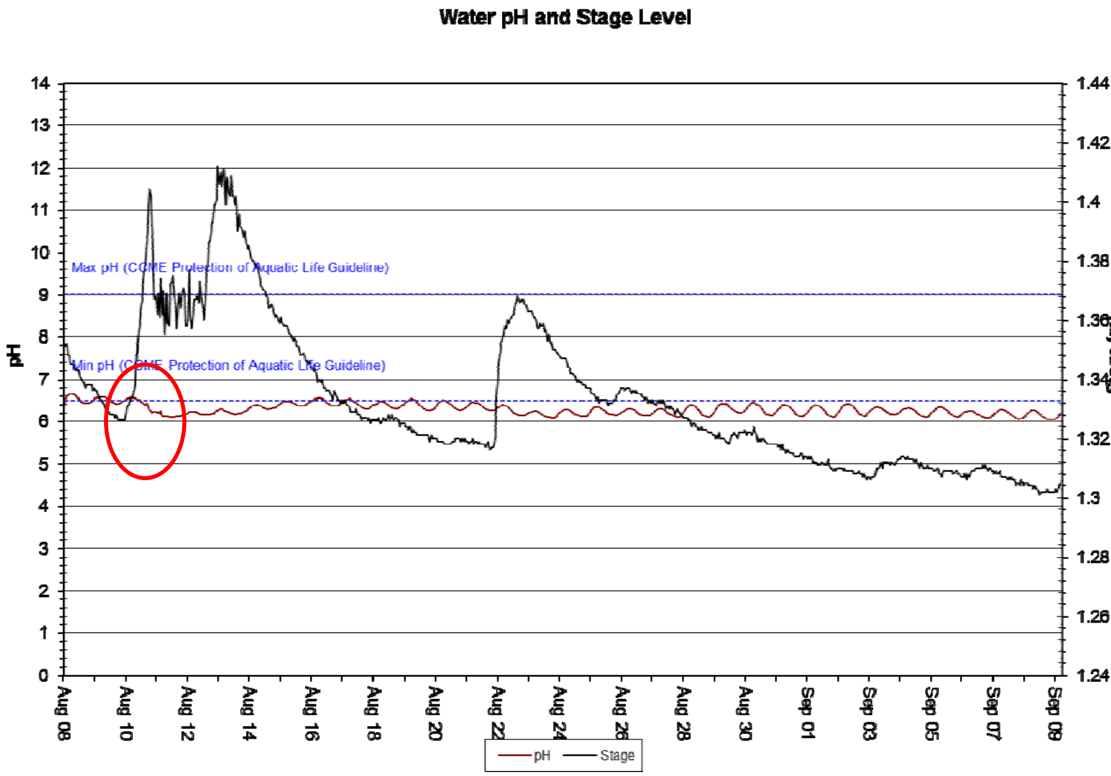

Figure 9: pH values recorded at Houston Creek from Aug. 8, 2013 to Sept. 9, 2013

Specific Conductivity

- Specific Conductivity ranged from 123.5 µS/cm to 146.2 µS/cm at James Creek and from 16.0 µs/cm to 70.5 µS/cm at Unnamed Tributary from August 6, 2013 to September 10, 2013 (Figures 10 & 11). Specific Conductivity ranged from 19.3 µS/cm to 36.7 µS/cm at Houston Creek from August 8, 2013 to September 9, 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 136.1 µS/cm at James Creek and 47.6 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 the average specific conductivity was relatively low at 30.6 µS/cm, which reflects the fact that there is currently no mining activity in the area.
- At Houston Creek specific conductivity values show regular diurnal fluctuations which are related to the diurnal temperature fluctuations
- At Houston Creek specific conductivity readings were subject to significant changes in relation to substantial increases in flow (see inside red ovals – Figure 12). On two occasions during this deployment specific conductivity took a substantial dip in relation to a significant increase in stage height and flow.

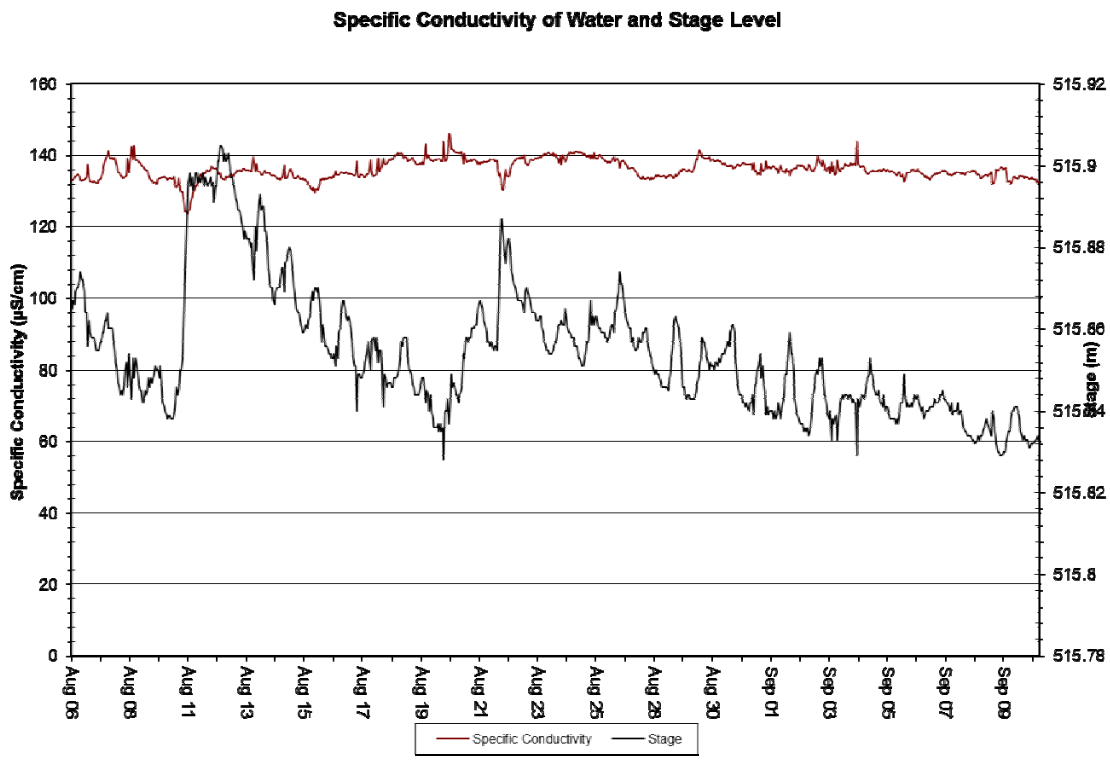

Figure 10: Specific conductivity (µs/cm) at James Creek from Aug. 6, 2013 to Sept. 10, 2013

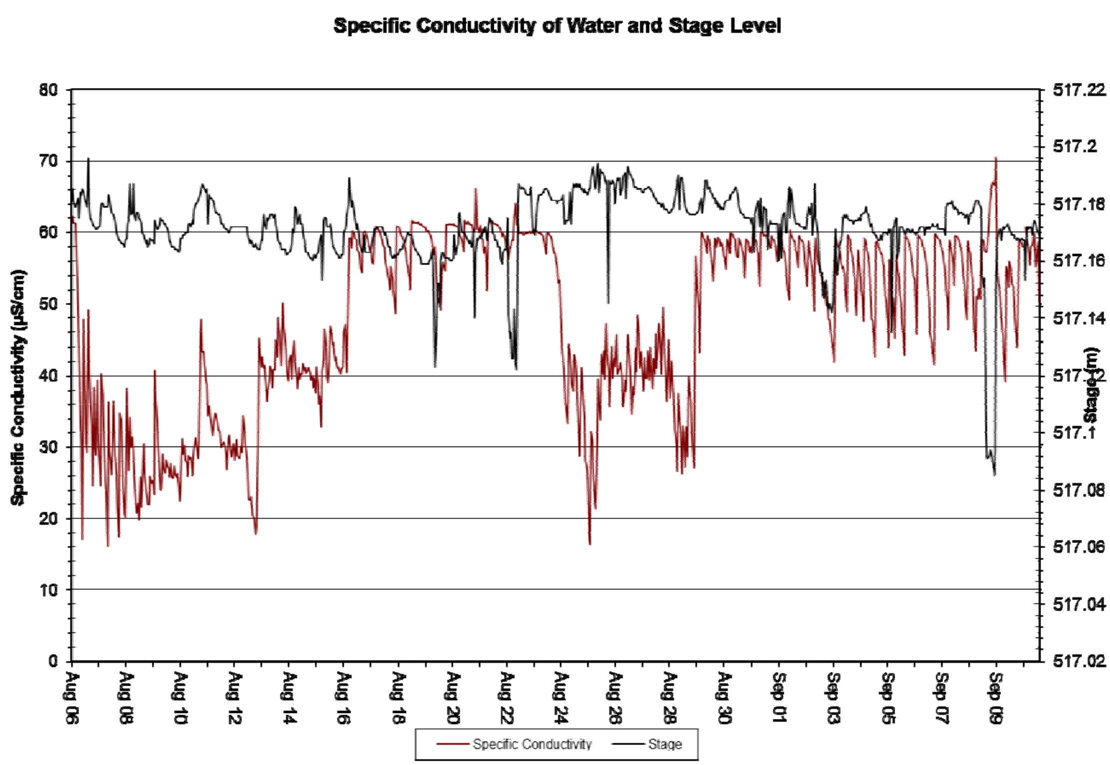

Figure 11: Specific conductivity (µs/cm) at Unnamed Tributary – Aug. 6, 2013 to Sept.10, 2013

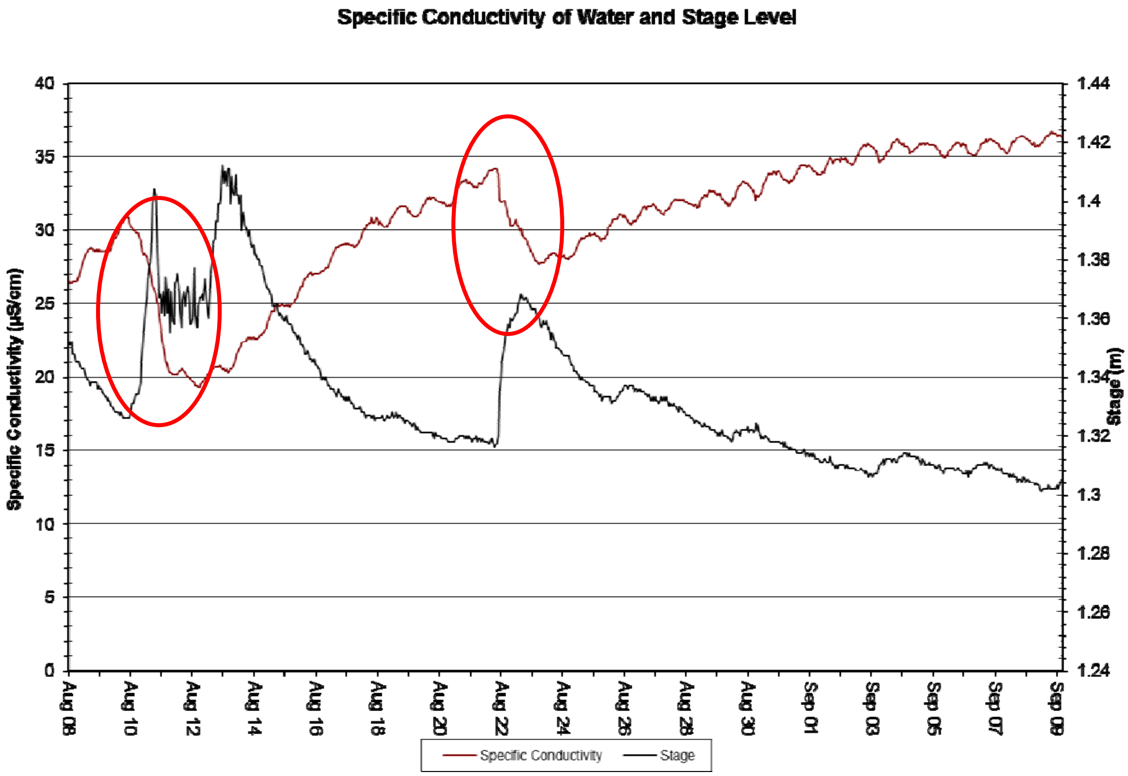

Figure 12: Specific conductivity (µs/cm) at Houston Creek from Aug. 8, 2013 to Sept. 9, 2013

Dissolved Oxygen

- Dissolved Oxygen [DO] values ranged from 9.44 mg/l (90.6% saturation) to 12.12 mg/l (103.0% saturation) at James Creek and from 10.15 mg/l (82.5% saturation) to 13.41 mg/l (103.7% saturation) at Unnamed Tributary from August 6, 2013 to September 10, 2013 (Figures 13 & 14). DO values ranged from 8.26 mg/l (76.2% saturation) to 11.33 mg/l (102.6% saturation) at Houston Creek from August 8, 2013 to September 9, 2013 (Figure 15).
- 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) shows a gentle increasing trend over the deployment period for all three stations. This trend is related to the declining temperature trend as colder water can hold more oxygen.
- The DO values at Unnamed Tributary 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). The dissolved oxygen at James Creek was at, or above, the cold water minimum guideline and well above the minimum guideline set for other life stages (6.5 mg/l). The DO values at Houston Creek were above the cold water minimum guideline set for aquatic life during other life stages (6.5 mg/l), which is the pertinent guideline for the late summer period of this deployment.

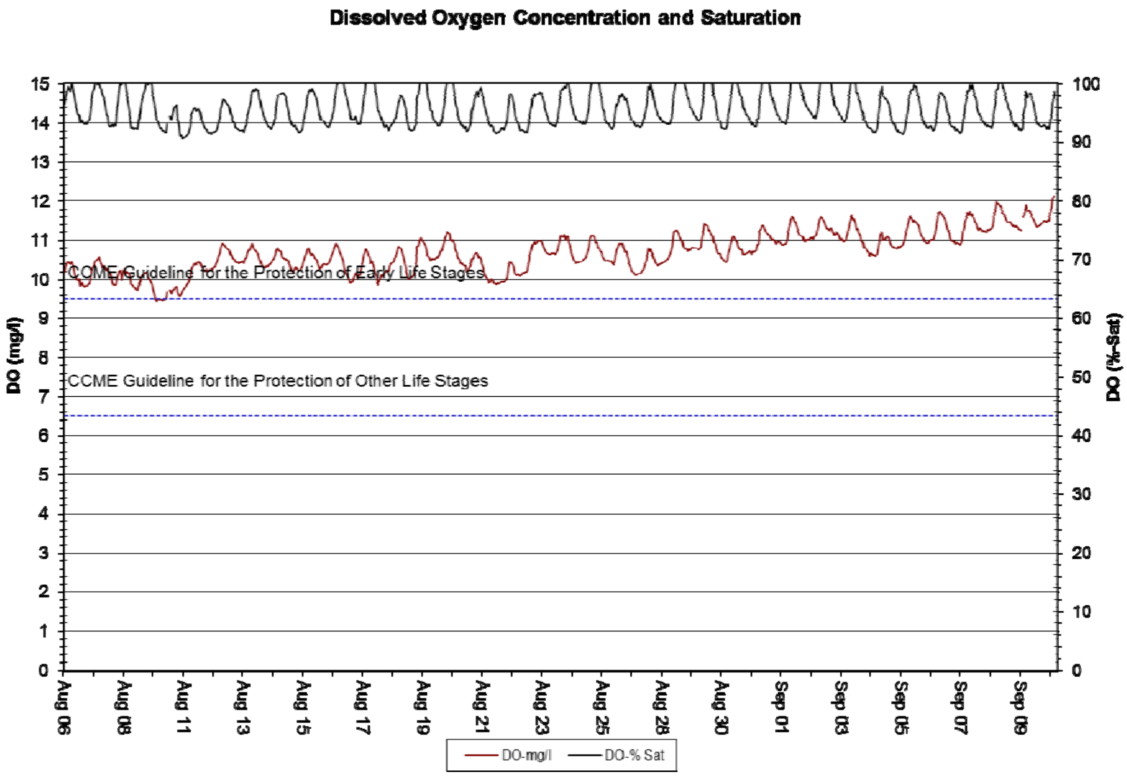

Figure 13: DO (mg/l & % saturation) at James Creek from Aug. 6, 2013 to Sept.10, 2013

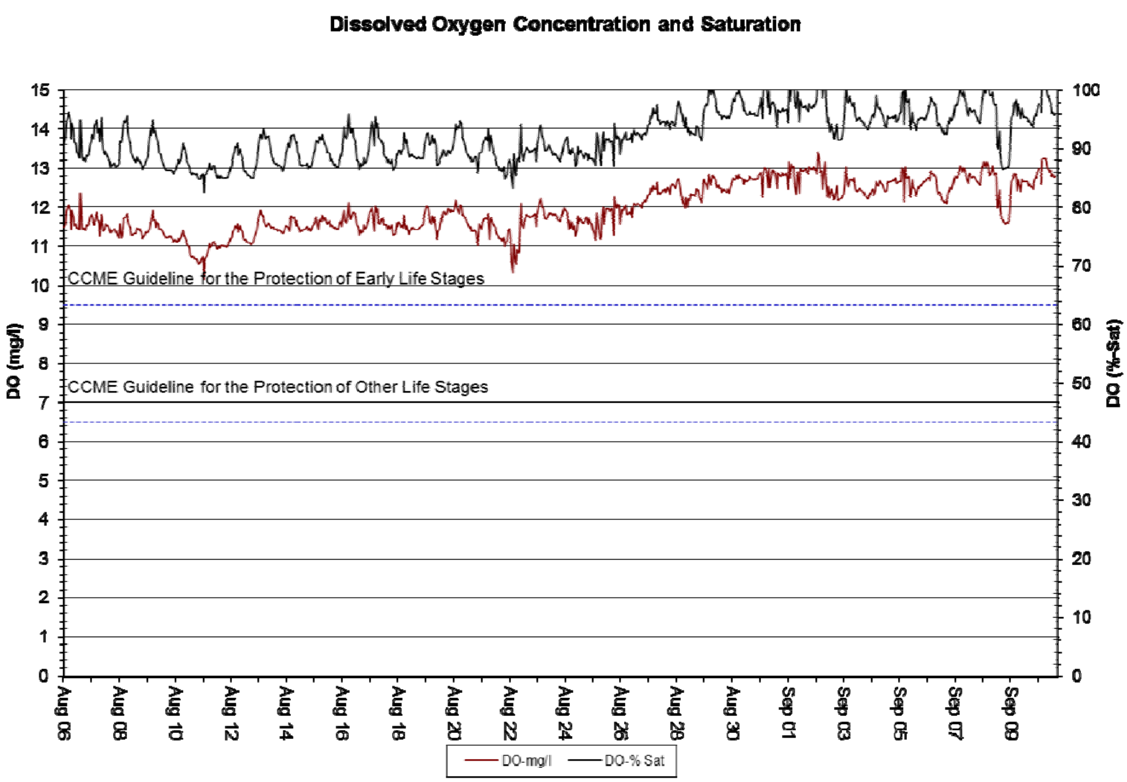

Figure 14: DO (mg/l & % saturation) at Unnamed Tributary from Aug.6, 2013 to Sept. 10, 2013

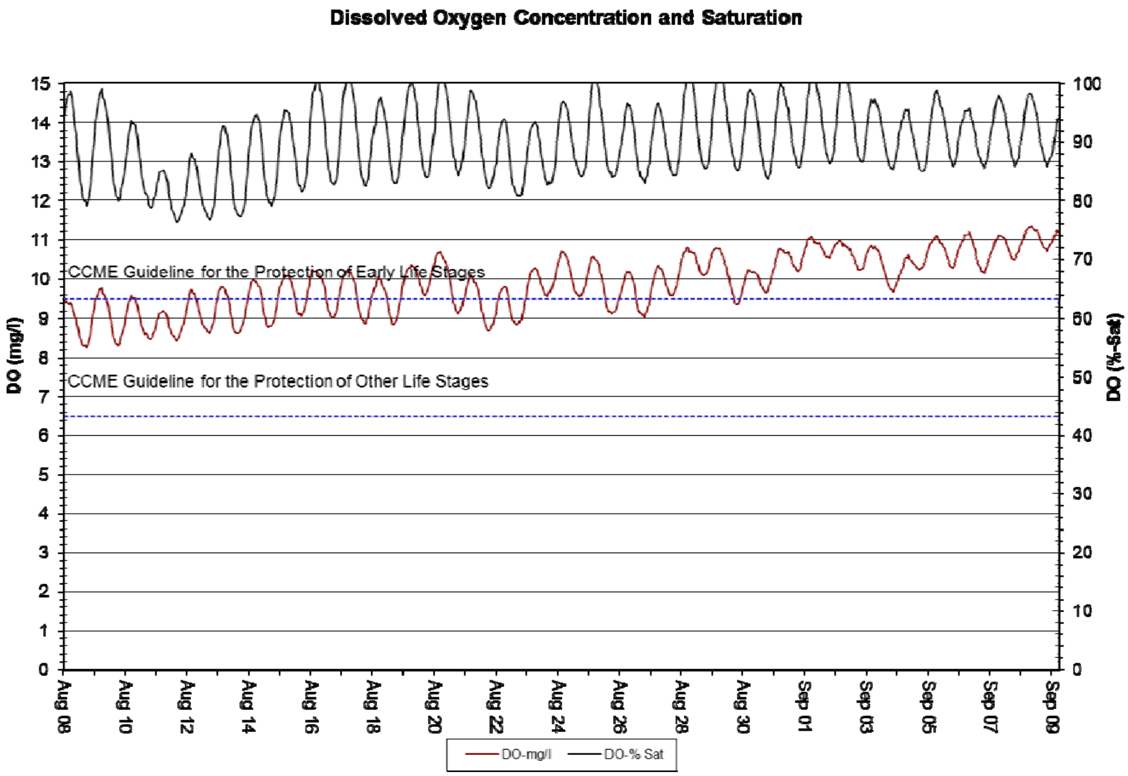

Figure 15: DO (mg/l & % saturation) at Houston Creek from Aug. 8, 2013 to Sept. 9, 2013

Turbidity

- Turbidity values ranged from 7.6 NTU to 207.4 NTU at James Creek and from 0.0 NTU to 2869.0 NTU at Unnamed Tributary from August 6, 2013 to September 10, 2013 (Figures 16 & 17). Turbidity values ranged from 0.0 NTU to 1.5 NTU at Houston Creek from August 8, 2013 to September 9, 2013 (Figure 18).
- There were several turbidity events at James Creek (see inside red ovals – Figure 16) which coincide with increases in flows that are due to significant rainfall events. Significant turbidity events at Unnamed Tributary in the first few days of the deployment (see inside red ovals – Figure 17) do not appear to coincide with rainfall events and may be related to ongoing activity at the mine. 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.

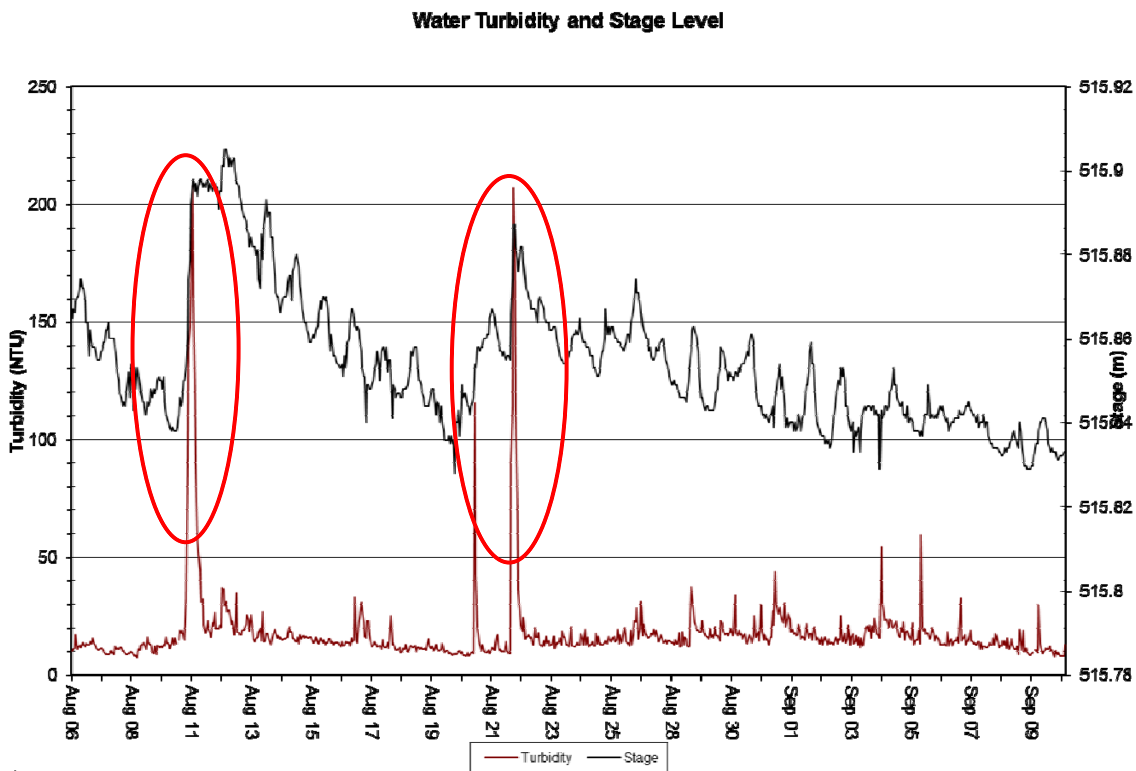

Figure 16: Turbidity (NTU) at James Creek from Aug. 6, 2013 to Sept. 10, 2013

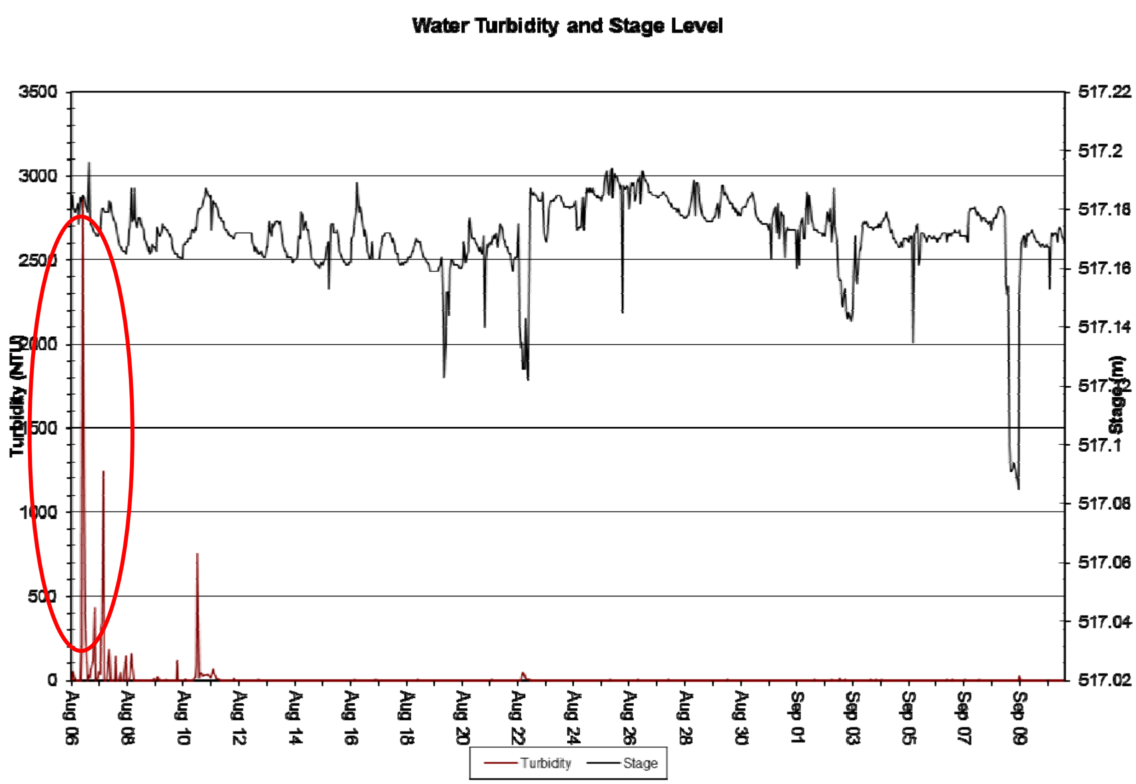

Figure 17: Turbidity (NTU) at Unnamed Tributary from Aug. 6, 2013 to Sept. 10, 2013

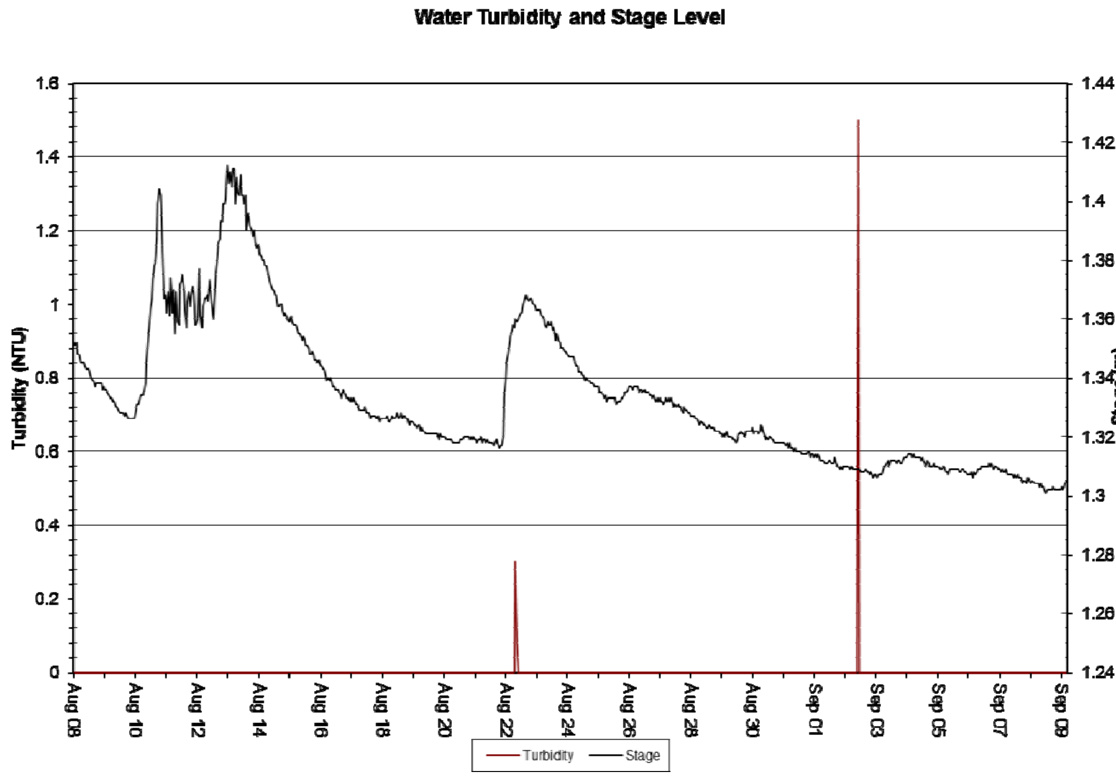

Figure 18: Turbidity (NTU) at Houston Creek from Aug. 8, 2013 to Sept. 9, 2013

Conclusion

- This monthly deployment report presents water quality and water quantity data recorded at the James Creek and Unnamed Tributary stations from August 6, 2013 to September 10, 2013, and at Houston Creek station from August 8, 2013 to September 9, 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:

  - At James Creek and Unnamed Tributary the stage/flow data show no distinct monthly trends for either station, however regular daily fluctuations were observed at both stations. These diurnal fluctuations are most likely attributed to dewatering operations from the mine site.
  - Temperatures at James Creek and Houston Creek showed a gentle declining trend typical of the transition from summer to fall. At Unnamed Tributary temperatures remained relatively stable over the deployment period with no obvious increasing or decreasing trends. Diurnal fluctuations in water temperature correspond with diurnal fluctuations in air temperature.
  - At Houston Creek water temperatures displayed large diurnal variations. This is typical of shallow water streams and ponds that are highly influenced by diurnal variations in ambient air temperatures. It should be noted that diurnal trends are reduced significantly during periods of increased flow.
  - Water temperatures at the Unnamed Tributary were on average 5.97^{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 James Creek, Unnamed Tributary and Houston Creek. All three stations show regular diurnal fluctuations which are related to the diurnal temperature fluctuations.
  - pH at Houston Creek was relatively stable throughout the deployment period, however during periods of significantly increased flow it is possible to discern a slight dip in pH
  - 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 specific conductivity values show regular diurnal fluctuations which are related to the diurnal temperature fluctuations. At Houston Creek, specific conductivity readings were subject to significant changes in relation to substantial increases in flow. On two occasions during this deployment period, specific conductivity took a substantial dip in relation to a significant increase in stage height and flow.

- DO (mg/l & % saturation) shows a gentle increasing trend over the deployment period for all three stations. This trend is related to the declining temperature trend. DO (mg/l & % saturation) shows a 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 which coincide with increases in flow that are due to significant rainfall events. Significant turbidity events at Unnamed Tributary in the first few days of the deployment do not appear to coincide with rainfall events and may be related to ongoing activity at the mine. 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 (August 6, 2013 to September 10, 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)
8/6/2013	15.7	10.5	13.1	4.9	0	M	M	1.8
8/7/2013	19.8	11.6	15.7	2.3	0	M	M	0
8/8/2013	24	11	17.5	0.5	0	M	M	3.8
8/9/2013	17.3	11.7	14.5	3.5	0	M	M	5.3
8/10/2013	14	9.7	11.9	6.1	0	M	M	53.9
8/11/2013	10.2	7.2	8.7	9.3	0	M	M	13.3
8/12/2013	9	4.7	6.9	11.1	0	M	M	16.4
8/13/2013	15.1	6.1	10.6	7.4	0	M	M	0
8/14/2013	16.6	4.4	10.5	7.5	0	M	M	0
8/15/2013	16.5	6.4	11.5	6.5	0	M	M	0
8/16/2013	19.6	6.5	13.1	4.9	0	M	M	0
8/17/2013	20.9	10.6	15.8	2.2	0	M	M	0
8/18/2013	20.1	8.8	14.5	3.5	0	M	M	5.1
8/19/2013	10.9	1.7	6.3	11.7	0	M	M	1.3
8/20/2013	15.2	1.2	8.2	9.8	0	M	M	8.8
8/21/2013	21.2	14.2	17.7	0.3	0	M	M	21.2
8/22/2013	14.6	6.9	10.8	7.2	0	M	M	35.9
8/23/2013	11.6	2.2	6.9	11.1	0	M	M	0.8
8/24/2013	13.4	3.1	8.3	9.7	0	M	M	0.3
8/25/2013	20	5.3	12.7	5.3	0	M	M	0
8/26/2013	16.1	11	13.6	4.4	0	M	M	5.5
8/27/2013		10.2				M		
8/28/2013						M	M	
8/29/2013	18.3	2.8	10.6	7.4	0	M	M	5.3
8/30/2013	13.2	0.8	7	11	0	M	M	2
8/31/2013	7.8	0	3.9	14.1	0	M	M	0.5
9/1/2013	9.5	-0.6	4.5	13.5	0	M	M	0
9/2/2013	14.2	-0.4	6.9	11.1	0	M	M	0
9/3/2013	12.2	4	8.1	9.9	0	M	M	3.6
9/4/2013	14.4	1.7	8.1	9.9	0	M	M	4.8
9/5/2013	6.9	0.7	3.8	14.2	0	M	M	2.5
9/6/2013	10.7	0.4	5.6	12.4	0	M	M	3.3
9/7/2013	7.5	1	4.3	13.7	0	M	M	0.3
9/8/2013	6	-1.7	2.2	15.8	0	M	M	0
9/9/2013	8	0.2	4.1	13.9	0	M	M	5.3
9/10/2013	3.8	-2.1	0.9	17.1	0	M	M	0