Real Time Water Quality Report

Labrador Iron Mines
Schefferville Network

Deployment Period
2014-09-08 to 2014-10-07

Newfoundland Labrador

Government of Newfoundland & Labrador
Department of Environment and Conservation
Water Resources Management Division
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General

- The Water Resources Management Division, in partnership with Labrador Iron Mines Ltd. and Environment Canada, maintain two real-time water quality/quantity stations in close proximity to the James Property deposits, near Schefferville, QC., and one real-time water quality/quantity station 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.
- The Unnamed Tributary station is currently idled as dewatering operations have ceased and the brook is dry.
- James Creek station monitors water outflow from the multi-cell retention and settling pond system mentioned below, as well as 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 Houston Creek stations from September 8, 2014, to October 7, 2014.

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		Houston Creek	
Stage of deployment	**Beginning**	**End**	**Beginning**	**End**
Date	2014-09-10	2014-10-06	2014-09-08	2013-10-07
Temperature	Excellent	Excellent	Excellent	Excellent
pH	Good	Excellent	Excellent	Excellent
Specific Conductivity	Excellent	Excellent	Excellent	Excellent
Dissolved Oxygen	Excellent	Excellent	Excellent	Fair
Turbidity	Excellent	Good	Excellent	Excellent

The performances of all sensors were rated good to excellent at the beginning of the deployment period and from fair to excellent at removal (Table 1).

Deployment Notes

- Water quality monitoring for this deployment period started at Houston Creek on September 8, 2014 at 6:30 pm and at James Creek on September 10, 2014 at 4:35 pm. Continuous real-time monitoring continued at both sites without any significant operational issues until October 6, 2014, for James Creek, and October 7, 2014 for Houston Creek, when the instruments were removed for the end of the 2014 field season.

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 515.73 m to 515.79 m at James Creek (Figure 1) from September10, 2014 to October 6, 2014 and from 1.29 m to 1.38 m at Houston Creek (Figure 2) from September 8, 2014 to October 7, 2014. 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.
- Fairly regular daily fluctuations were observed at James Creek which are most likely attributed to dewatering operations from the mine site.

- For Houston Creek there are a number of noticeable peaks in stage height with two of the more significant peaks highlighted inside red ovals. Review of the precipitation data in Appendix B shows these peaks 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.

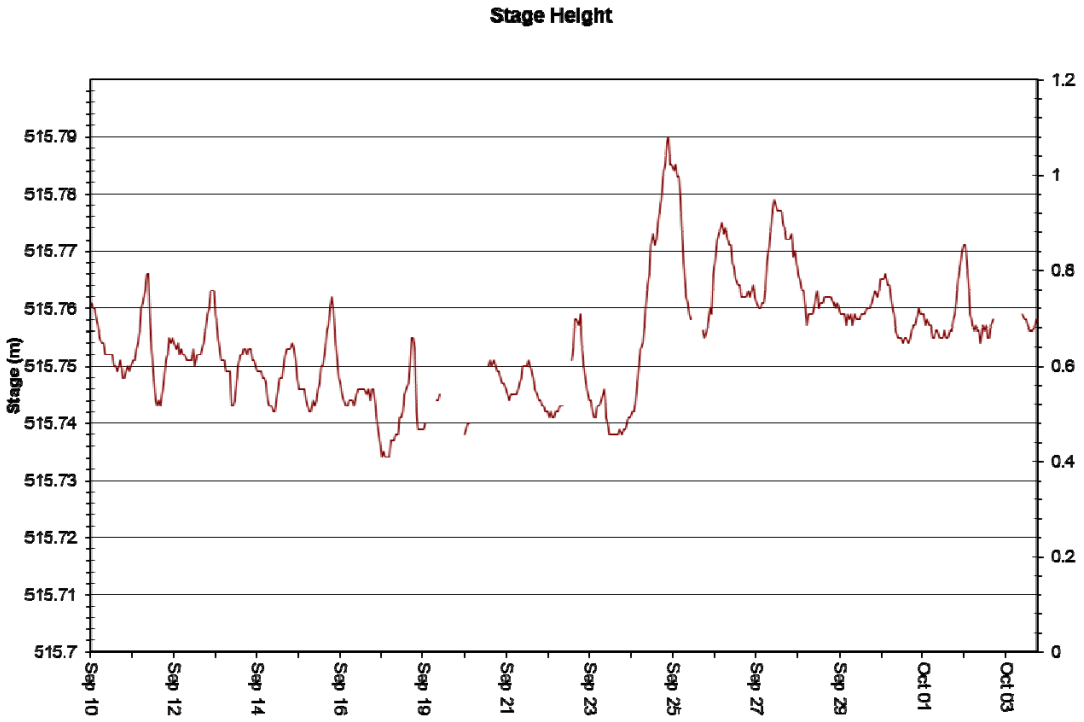

Figure 1: Stage Height (m) at James Creek from September 10, 2014 to October 6, 2014

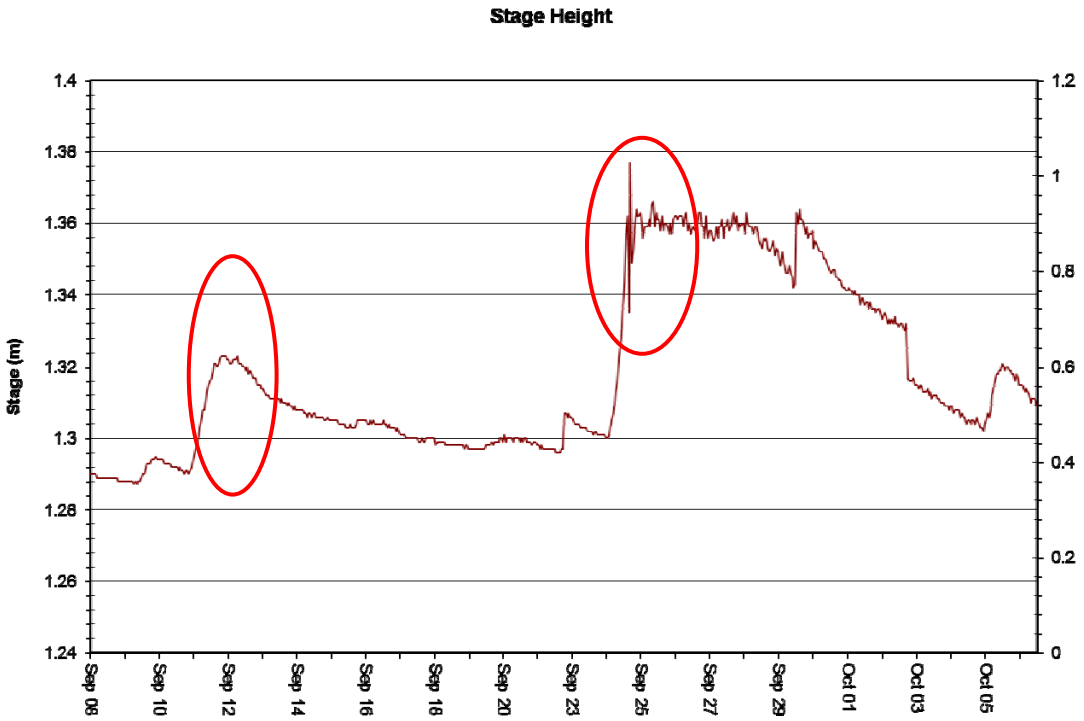

Figure 2: Stage Height (m) at Houston Creek from September 8, 2014 to October 7, 2014

Temperature

- Water temperature ranged from 1.00˚C to 8.70˚C at James Creek (Figure 3) from September 10, 2014 to October 6, 2014 and from 1.00˚C to 12.90˚C at Houston Creek (Figure 4) from September 8, 2014 to October 7, 2014.
- Water temperatures at both stations display large diurnal variations. This is typical of shallow water streams and ponds that are highly influenced by diurnal variations in ambient air temperatures.
- There were declining temperatures trends at both stations over the deployment period which is consistent with declining air temperature trends during the transition from the end of summer to the beginning of fall.

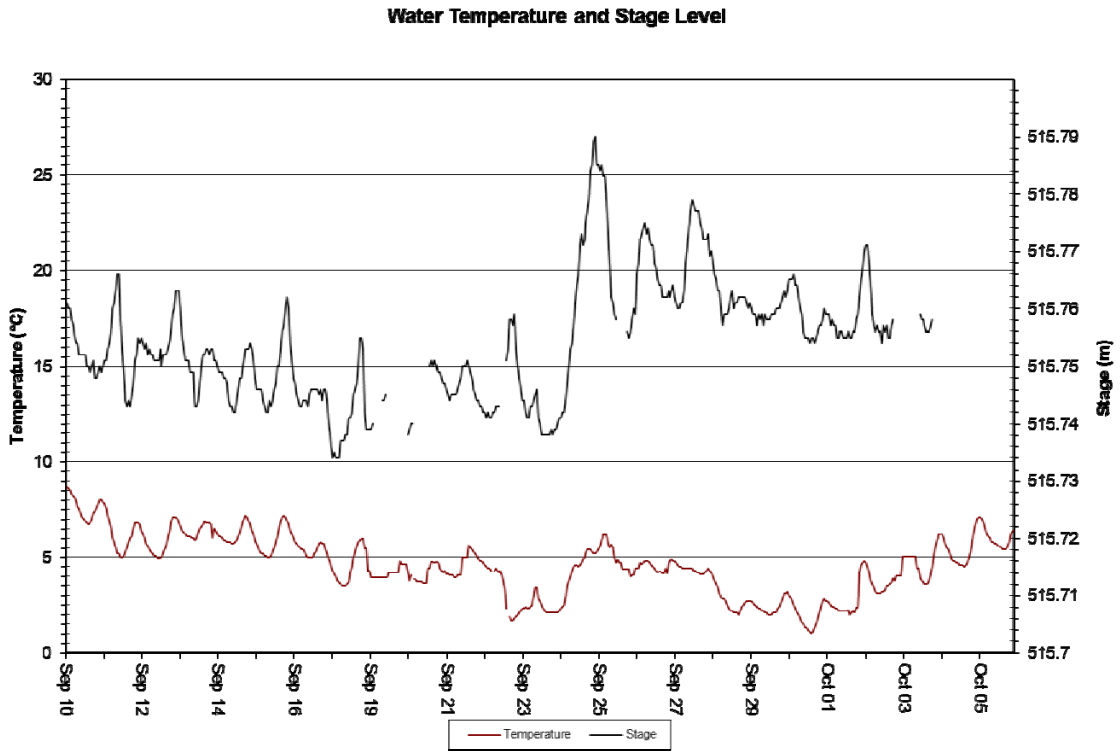

Figure 3: Temperature (°C) at James Creek from September 10, 2014 to October 6, 2014

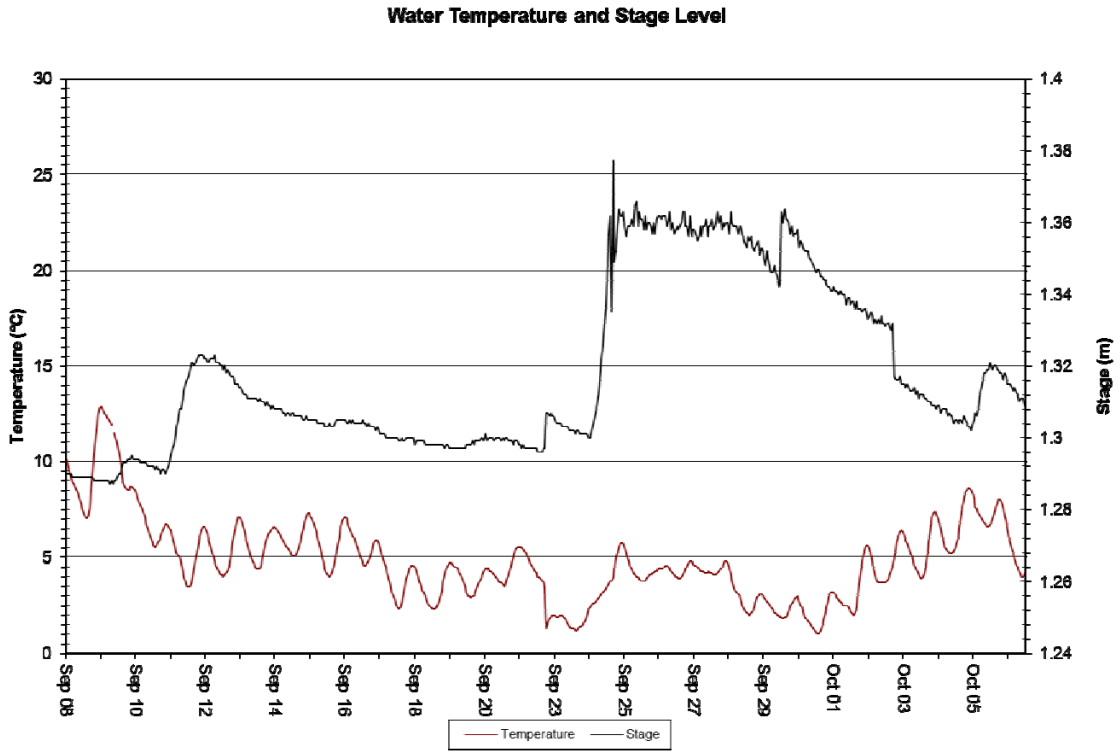

Figure 4: Temperature (°C) at Houston Creek from September 8, 2014 to October 7, 2014

pH

- pH values ranged from 7.99 units to 8.49 units at James Creek (Figure 5) from September 10, 2014 to October 6, 2014 and from 6.49 units to 7.08 units at Houston Creek (Figure 6) from September 8, 2014 to October 7, 2014.
- pH values at both stations show regular diurnal fluctuations which are related to the diurnal temperature fluctuations.
- pH was relatively stable throughout the deployment period at both stations.
- With a mean value of 8.17, 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 6.82, pH values recorded at Houston Creek were also within these guidelines.

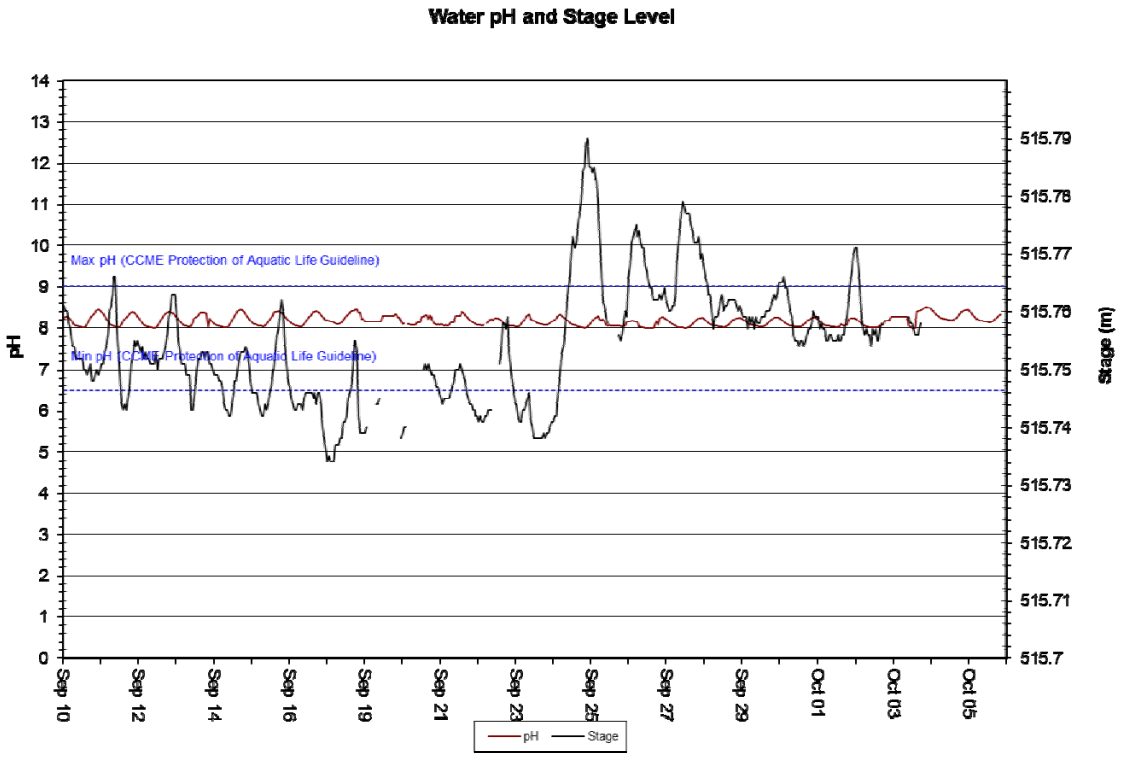

Figure 5: pH values recorded at James Creek from September 10, 2014 to October 6, 2014

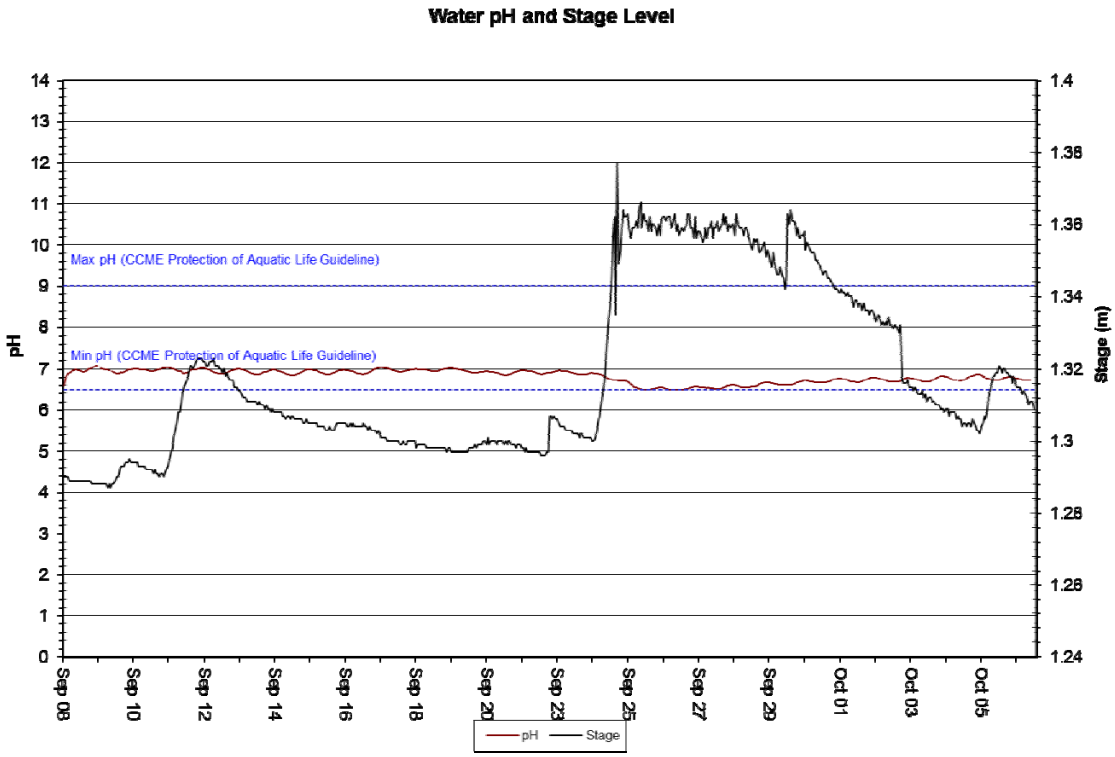

Figure 6: pH values recorded at Houston Creek from September 8, 2014 to October 7, 2014

Specific Conductivity

- Specific Conductivity ranged from 143.0 µS/cm to 154.0 µS/cm at James Creek (Figure 7) from September 10, 2014 to October 6, 2014, and from 27.0 µS/cm to 43.1 µS/cm at Houston Creek (Figure 8) from September 8, 2014 to October 7, 2014.
- At both James Creek and Houston Creek there are noticeable diurnal fluctuations in specific conductivity which are related to the diurnal temperature fluctuations.
- At Houston Creek there is a noticeable dip in specific conductivity from about September 24 to September 27, which is related to a significant increase in stage height which is related to significant precipitation events for several days.
- On average, specific conductivity was 148.6 µS/cm at James Creek and 35.6 µS/cm at Houston Creek. This difference could be attributed to natural variation as well as the increased concentration of dissolved solids from the iron ore tailings deposited into Ruth Pit, which feeds into James Creek.

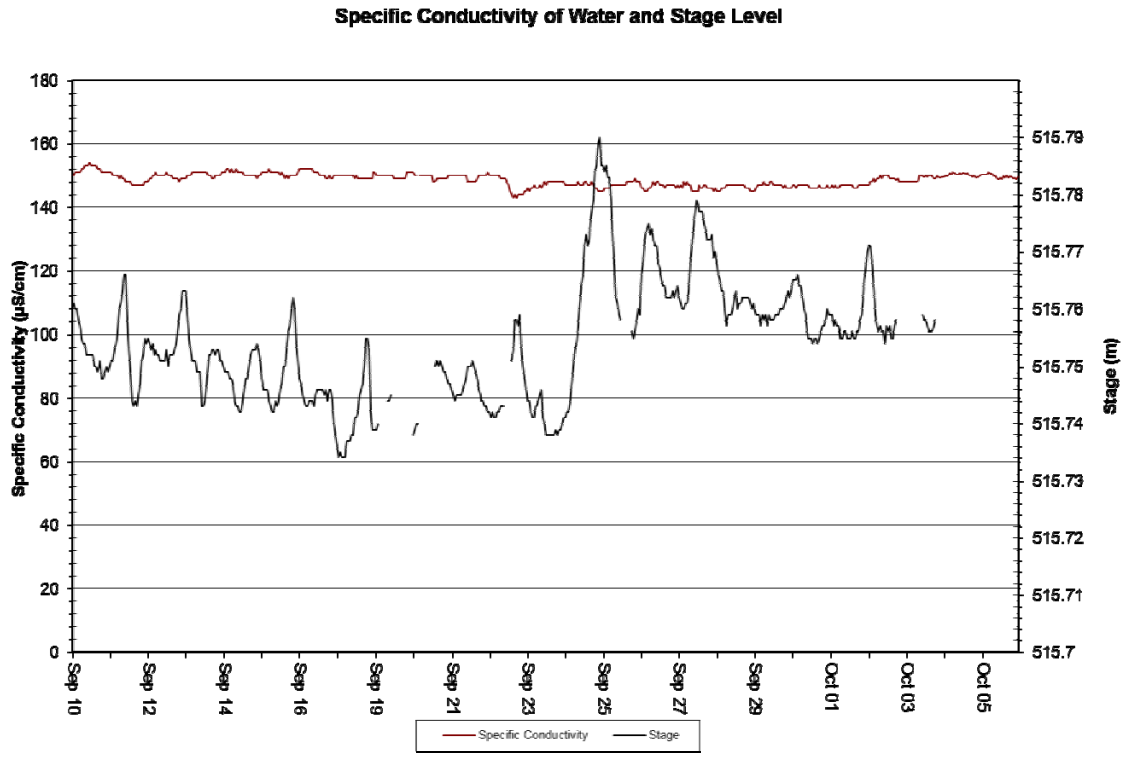

Figure 7: Specific conductivity (µs/cm) at James Creek from September 10, 2014 to October 6, 2014

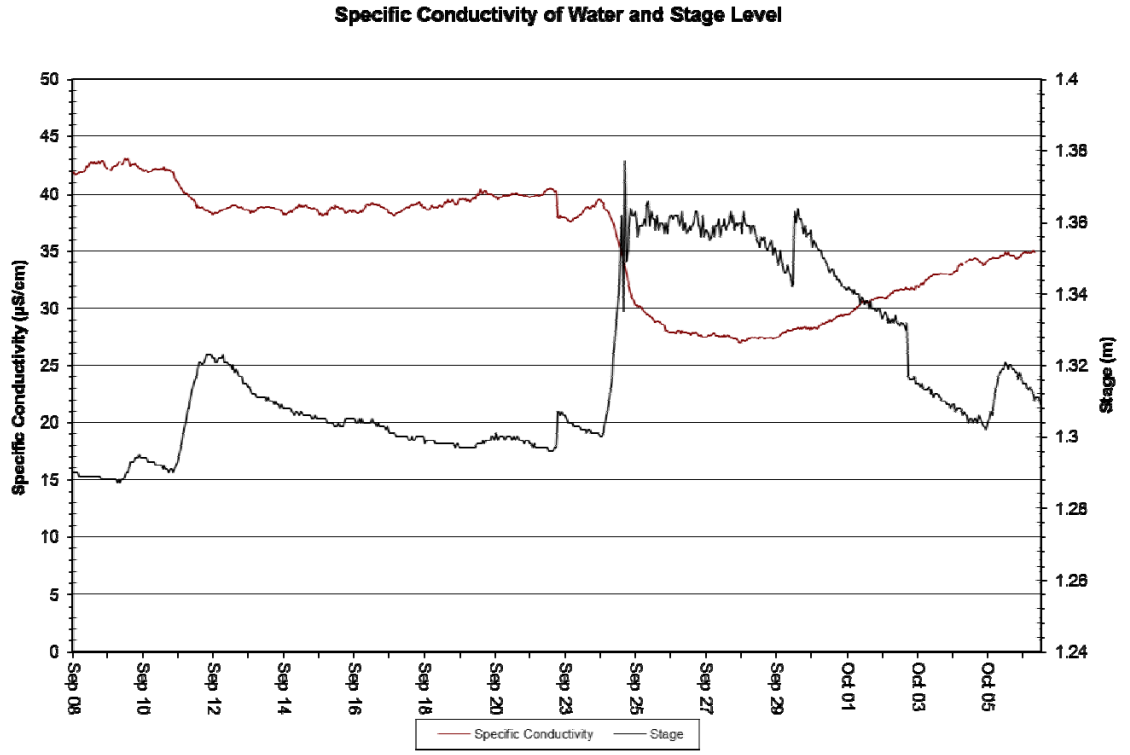

Figure 8: Specific conductivity (µs/cm) at Houston Creek from September 8, 2014 to October 7, 2014

Dissolved Oxygen

- Dissolved Oxygen [DO] values ranged from 10.51 mg/l (90.4% saturation) to 12.89 mg/l (103.0% saturation) at James Creek (Figure 9) from September 10, 2014 to October 6, 2014, and from 8.88 mg/l (81.0% saturation) to 11.83 mg/l (96.2% saturation) at Houston Creek (Figure10) from September 8, 2014 to October 7, 2014.
- DO (mg/l & % saturation) shows a clear diurnal fluctuation at both stations. These diurnal fluctuations can be attributed to the diurnal temperature fluctuations.
- The DO values at both stations were above the cold water minimum guideline set for aquatic life during other life stages (6.5 mg/l), as determined by the Canadian Council of Ministers of the Environment (2007). At James Creek Do values were also above the 9.5 mg/l guideline for the Protection of Early Life Stages.

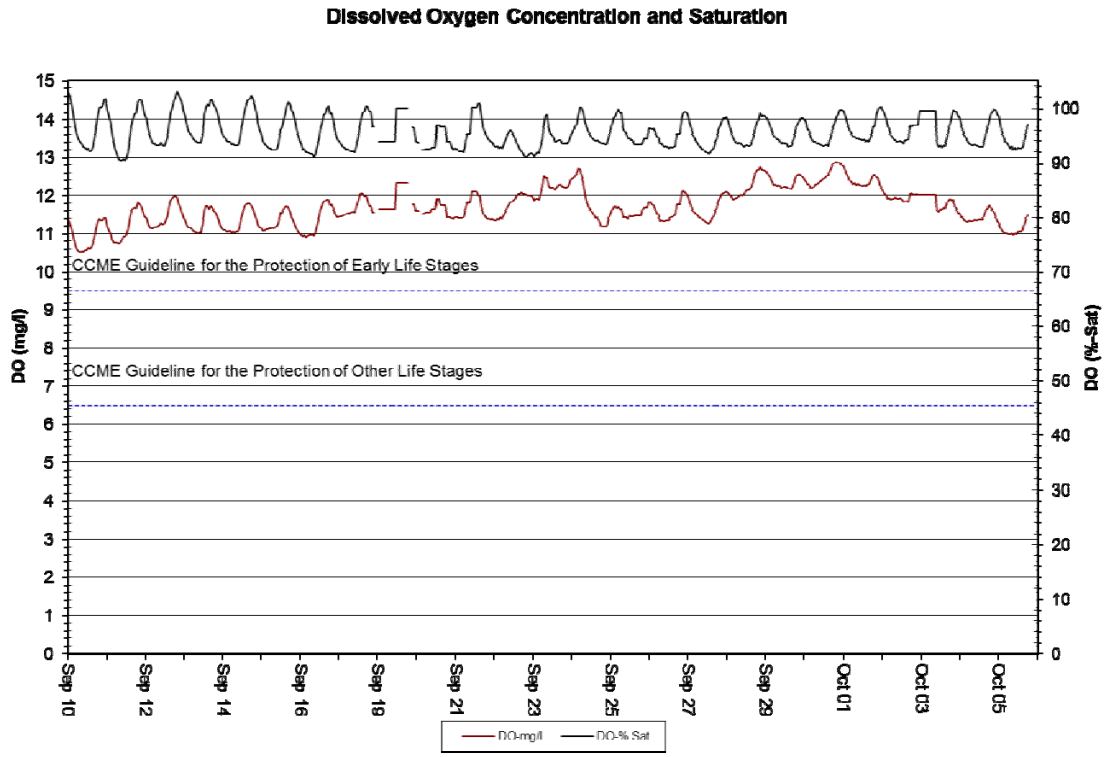

Figure 9: DO (mg/l & % saturation) at James Creek from September 10, 2014 to October 6, 2014

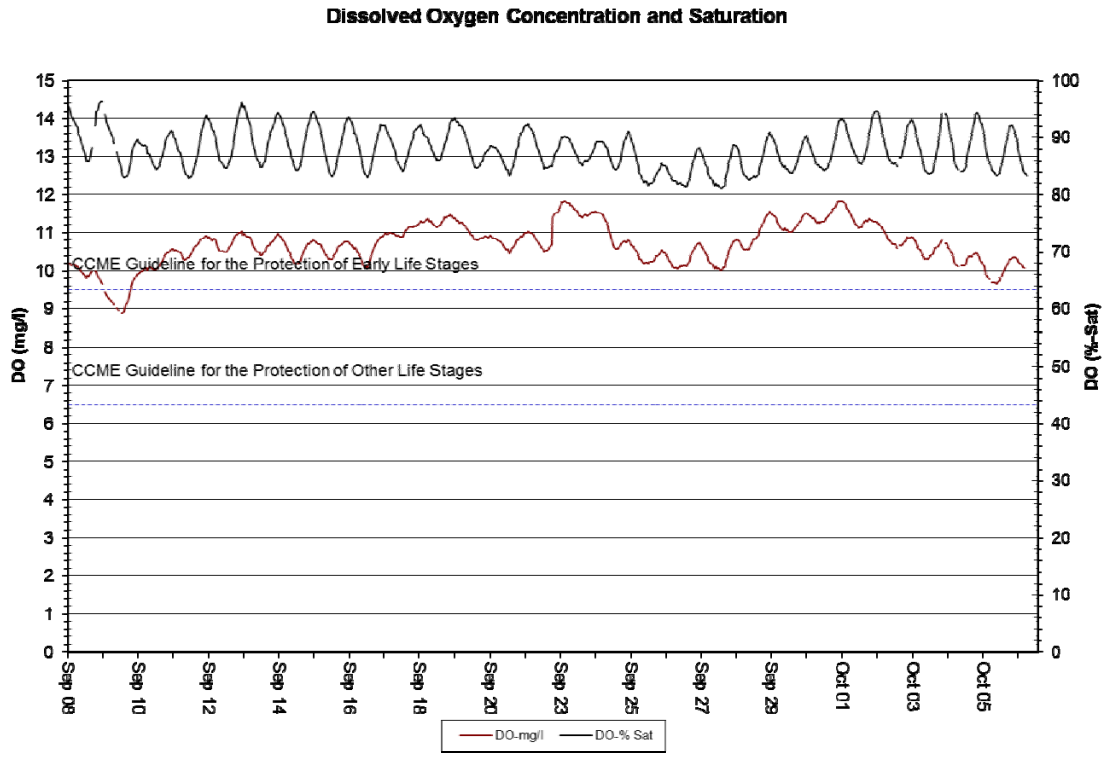

Figure 10: DO (mg/l & % saturation) at Houston Creek from September 8, 2014 to October 7, 2014

Turbidity

- Turbidity values ranged from 0.0 NTU to 59.6 NTU at James Creek (Figure 11) from September10, 2014 to October 6, 2014, and from 0.0 NTU to 1.2 NTU at Houston Creek (Figure 12) from September 8, 2014 to October 7, 2014.
- There were numerous turbidity events at James Creek which are most likely indicative of the siltation impacts associated with ongoing and historical mining activity in the headwaters area.
- At Houston Creek there is a period with increased turbidity from around September 25 to 29 which is related to several days of significant rainfall for the corresponding period.

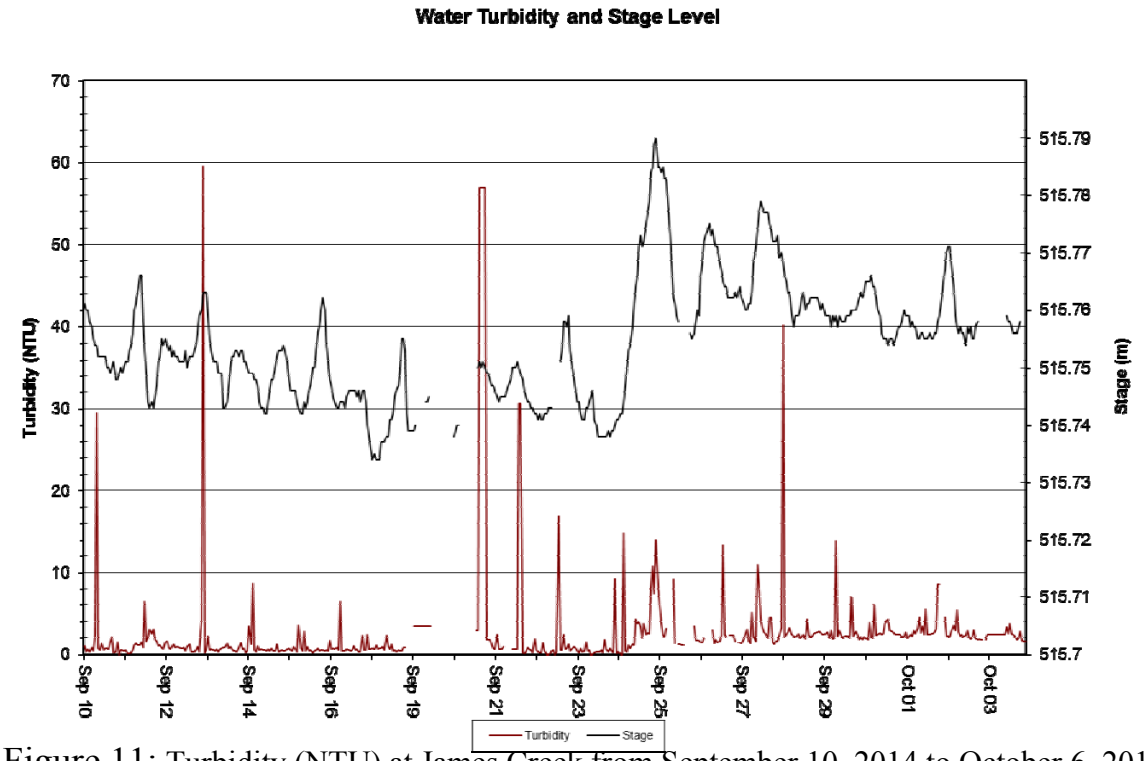

Figure 11: Turbidity (NTU) at James Creek from September 10, 2014 to October 6, 2014

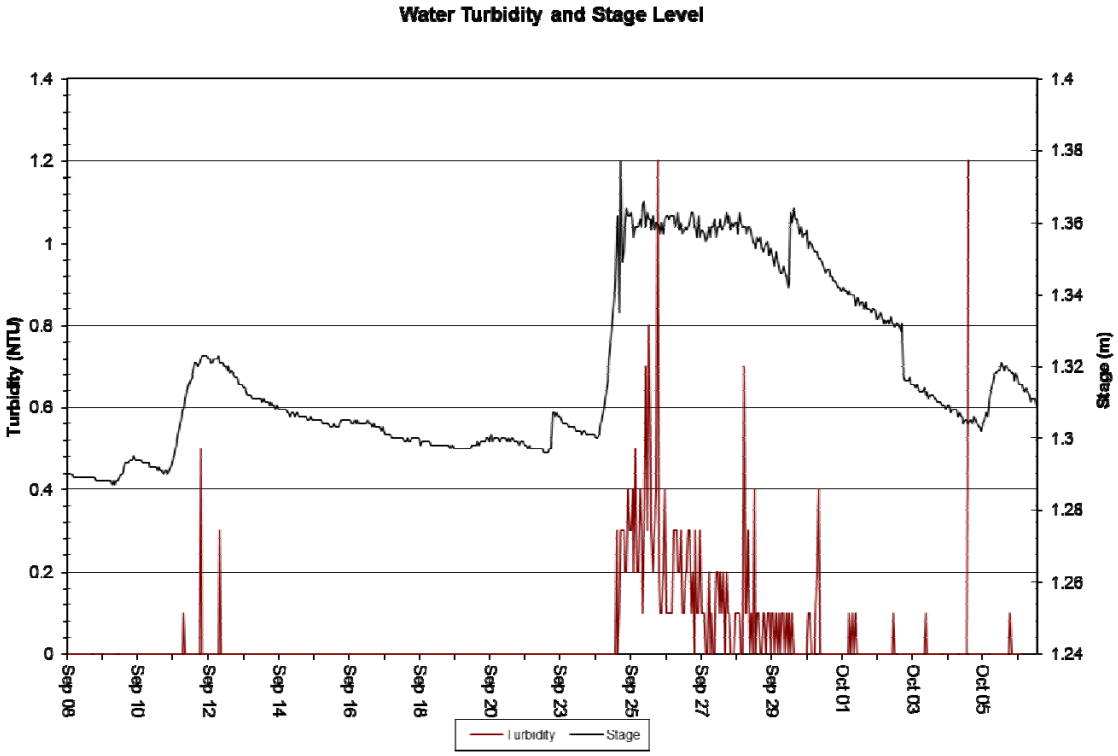

Figure 12: Turbidity (NTU) at Houston Creek from September 8, 2014 to October 7, 2014

Conclusion

- This monthly deployment report presents water quality and water quantity data recorded at the James Creek and Houston Creek station from September 10, 2014 to October 7, 2014.
- The performances of all sensors were rated good to excellent at the beginning of the deployment period and fair to excellent upon removal.
- Variations in water quality/quantity values recorded at each station are summarized below:
    - Fairly regular daily fluctuations in Stage Height were observed at James Creek which are most likely attributed to dewatering operations from the mine site.
    - For Houston Creek there are a number of noticeable peaks in stage height with two of the more significant peaks highlighted inside red ovals. Review of the precipitation data in Appendix B shows these peaks correspond with significant precipitation events.
    - Water temperatures at both stations display large diurnal variations. This is typical of shallow water streams and ponds that are highly influenced by diurnal variations in ambient air temperatures.
    - There were declining temperatures trends at both stations over the deployment period which is consistent with declining air temperature trends during the transition from the end of summer to the beginning of fall.
    - pH values at both stations show regular diurnal fluctuations which are related to the diurnal temperature fluctuations. pH was relatively stable throughout the deployment period at both stations.
    - With a mean value of 8.17, 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 6.82, pH values recorded at Houston Creek were also within these guidelines.
    - At both James Creek and Houston Creek there are noticeable diurnal fluctuations in specific conductivity which are related to the diurnal temperature fluctuations.
    - At Houston Creek there is a noticeable dip in specific conductivity from about September 24 to September 27, which is related to a significant increase in stage height which is related to significant precipitation events for several days.
    - On average, specific conductivity was 148.6 µS/cm at James Creek and 35.6 µS/cm at Houston Creek. This difference could be attributed to natural variation as well as the increased concentration of dissolved solids from the iron ore tailings deposited into Ruth Pit, which feeds into James Creek.
    - DO (mg/l & % saturation) shows a clear diurnal fluctuation at both stations. These diurnal fluctuations can be attributed to the diurnal temperature fluctuations.

- The DO values at both stations were above the cold water minimum guideline set for aquatic life during other life stages (6.5 mg/l), as determined by the Canadian Council of Ministers of the Environment (2007). At James Creek Do values were also above the 9.5 mg/l guideline for the Protection of Early Life Stages.
- There were numerous turbidity events at James Creek which are most likely indicative of the siltation impacts associated with ongoing and historical mining activity in the headwaters area.
- At Houston Creek there is a period with increased turbidity from around September 25 to 29 which is related to several days of significant rainfall for the corresponding period.

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 (°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 8, 2014 to October 7, 2014)

Date/Time	Max Temp (°C)	Min Temp (°C)	Mean Temp (°C)	Heat Deg Days (°C)	Cool Deg Days (°C)	Total Precip (mm)
9/8/2014	11	3.6	7.3	10.7	0	1
9/9/2014		3.6				
9/10/2014	7.7	1.5	4.6	13.4	0	
9/11/2014	5.5	-0.3	2.6	15.4	0	15.3
9/12/2014	5.5	-0.1	2.7	15.3	0	10.3
9/13/2014						
9/14/2014	8.2	3.6	5.9	12.1	0	0
9/15/2014	9.9	1.3	5.6	12.4	0	0
9/16/2014	10.5	0.6	5.6	12.4	0	0.5
9/17/2014	4.8	-2	1.4	16.6	0	
9/18/2014	4.8	-2.9	1	17	0	0
9/19/2014	5.1	-1	2.1	15.9	0	0
9/20/2014	7.6	0.3	4	14	0	5.1
9/21/2014	7.2	2.2	4.7	13.3	0	0.3
9/22/2014	2.6	-0.9	0.9	17.1	0	2.1
9/23/2014	0.3	-2.7	-1.2	19.2	0	3.1
9/24/2014	12.3	-1.2	5.6	12.4	0	18.5
9/25/2014	12.5	1.7	7.1	10.9	0	12.8
9/26/2014	8.6	1.6	5.1	12.9	0	9.8
9/27/2014		1.1				
9/28/2014	3.4	-3.5	-0.1	18.1	0	0.8
9/29/2014	-0.6	-4.1	-2.4	20.4	0	0
9/30/2014	3.1	-5	-1	19	0	0.3
10/1/2014	1.3	-7.3	-3	21	0	0.5
10/2/2014	13.8	-0.5	6.7	11.3	0	0
10/3/2014	15.1	8.2	11.7	6.3	0	0
10/4/2014	19	5.6	12.3	5.7	0	0
10/5/2014	16	7.4	11.7	6.3	0	8.8
10/6/2014	9.7	0.6	5.2	12.8	0	3.8
10/7/2014	13.9	1.5	7.7	10.3	0	3.6