Real Time Water Quality Report

Labrador Iron Mines
Schefferville Network

Deployment Period
2014-07-15 to 2014-08-12

Newfoundland Labrador

Government of Newfoundland & Labrador
Department of Environment and Conservation
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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 July 15, 2014, to August 12, 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	2014-07-15	2014-08-12	2014-07-15	2013-08-12
Temperature	Good	Good	Excellent	Excellent
pH	Fair	Excellent	Good	Excellent
Specific Conductivity	Excellent	Excellent	Excellent	Excellent
Dissolved Oxygen	Excellent	Excellent	Excellent	Excellent
Turbidity	Excellent	Good	Excellent	Excellent

The performances of all sensors were rated fair to excellent at the beginning of the deployment period. At Houston Creek all of the sensors rated excellent upon removal, however at James Creek two sensors rated good, and three excellent (Table 1).

Deployment Notes

- Water quality monitoring for this deployment period started at Houston Creek on July 15, 2014 at 10:50 am and on the same date at James Creek at 3:45 pm. Continuous real-time monitoring continued at both sites without any significant operational issues until August 12, 2014, when the instruments were removed for 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 515.74 m to 515.80 m at James Creek (Figure 1) and from 1.28 m to 1.34 m at Houston Creek (Figure 2) from July 15, 2014 to August 12, 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.

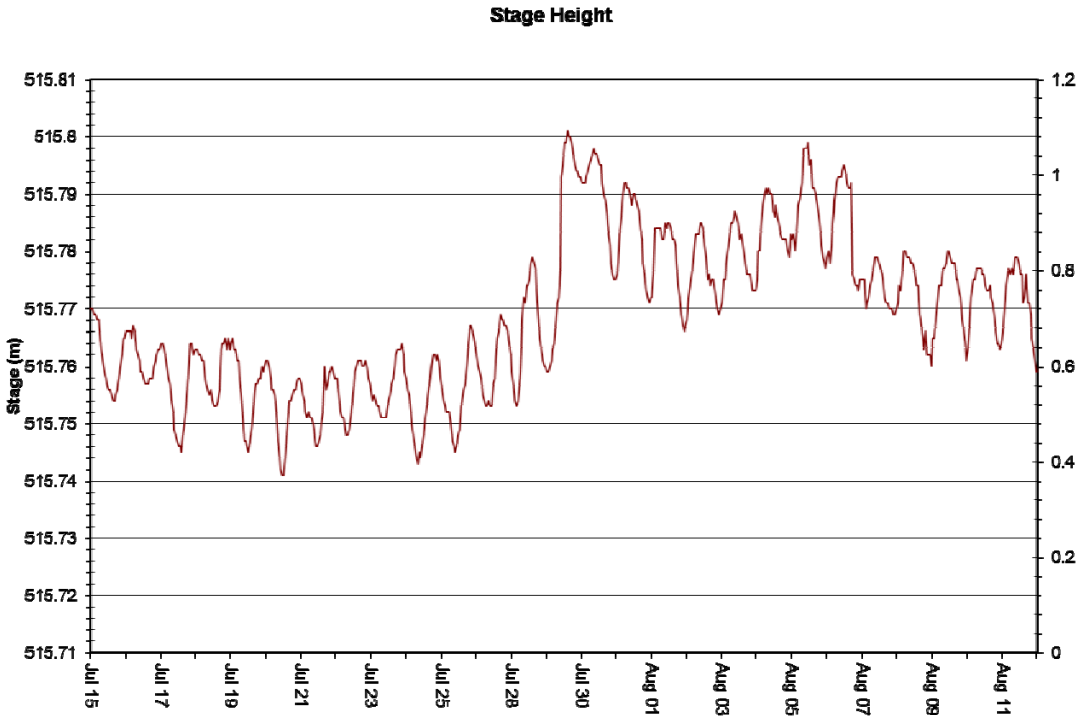

Figure 1: Stage Height (m) at James Creek from July 15, 2014 to August 12, 2014

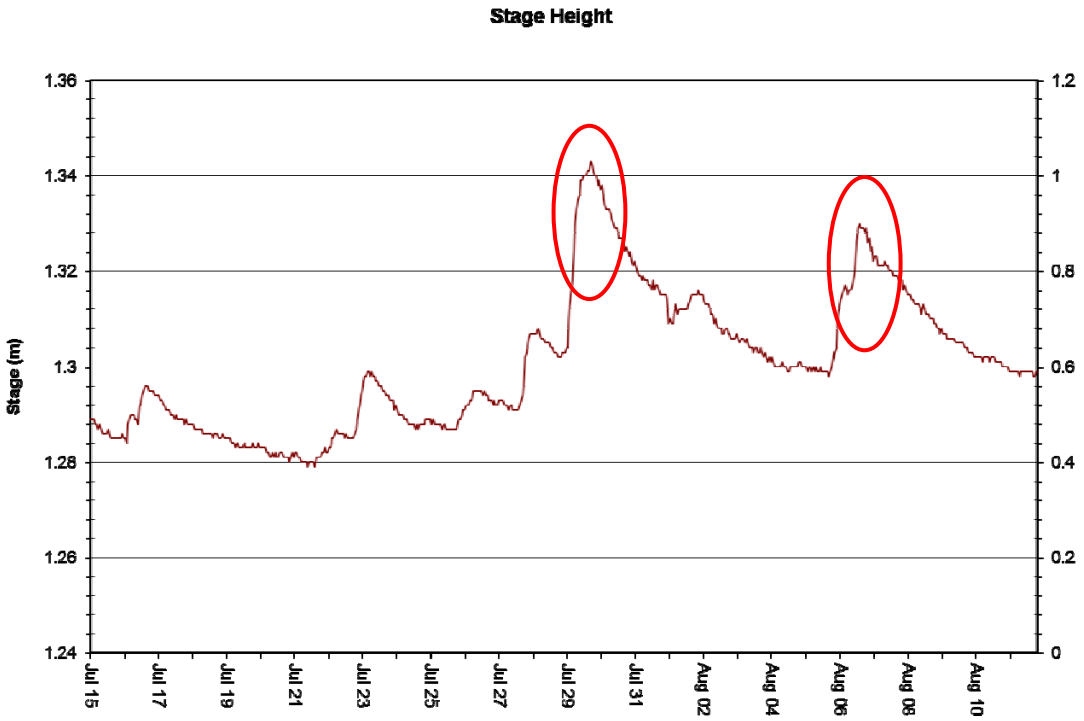

Figure 2: Stage Height (m) at Houston Creek from July 15, 2014 to August 12, 2014

Temperature

- Water temperature ranged from 10.70˚C to 18.50˚C at James Creek (Figure 3) and from 9.80˚C to 19.30˚C at Houston Creek (Figure 4) from July 15, 2014 to August 12, 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 was no distinct increasing or declining temperatures trends at either station over the deployment period.

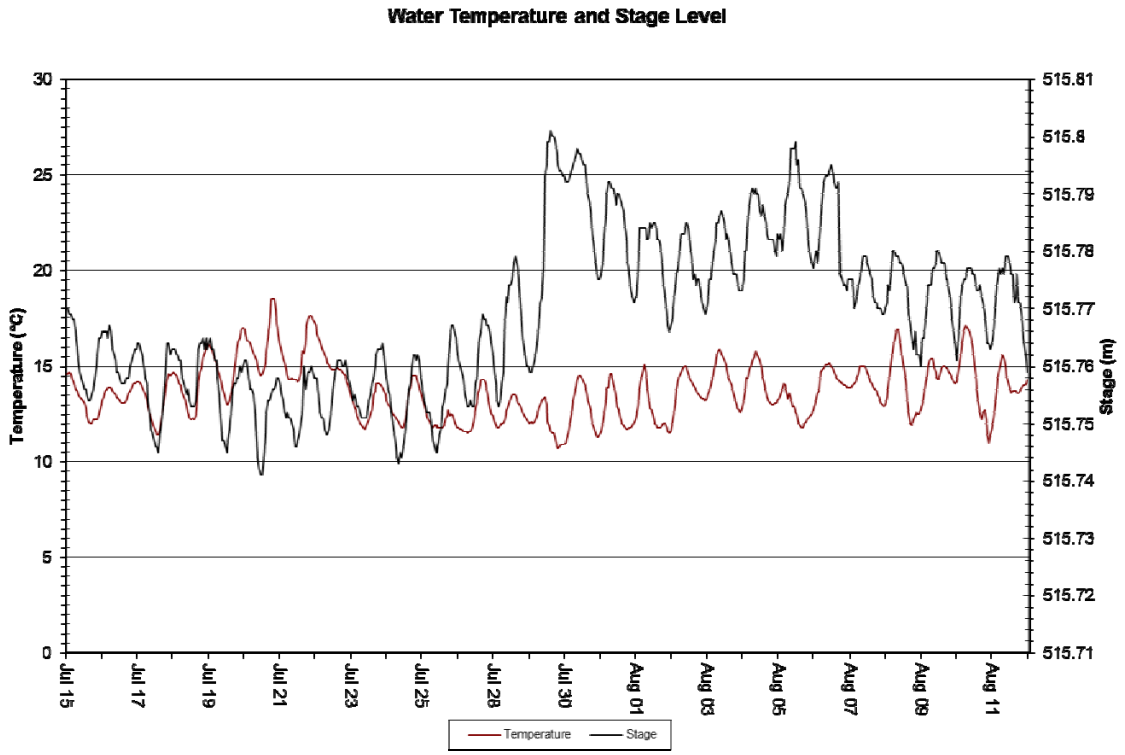

Figure 3: Temperature (°C) at James Creek from July 15, 2014 to August 12, 2014

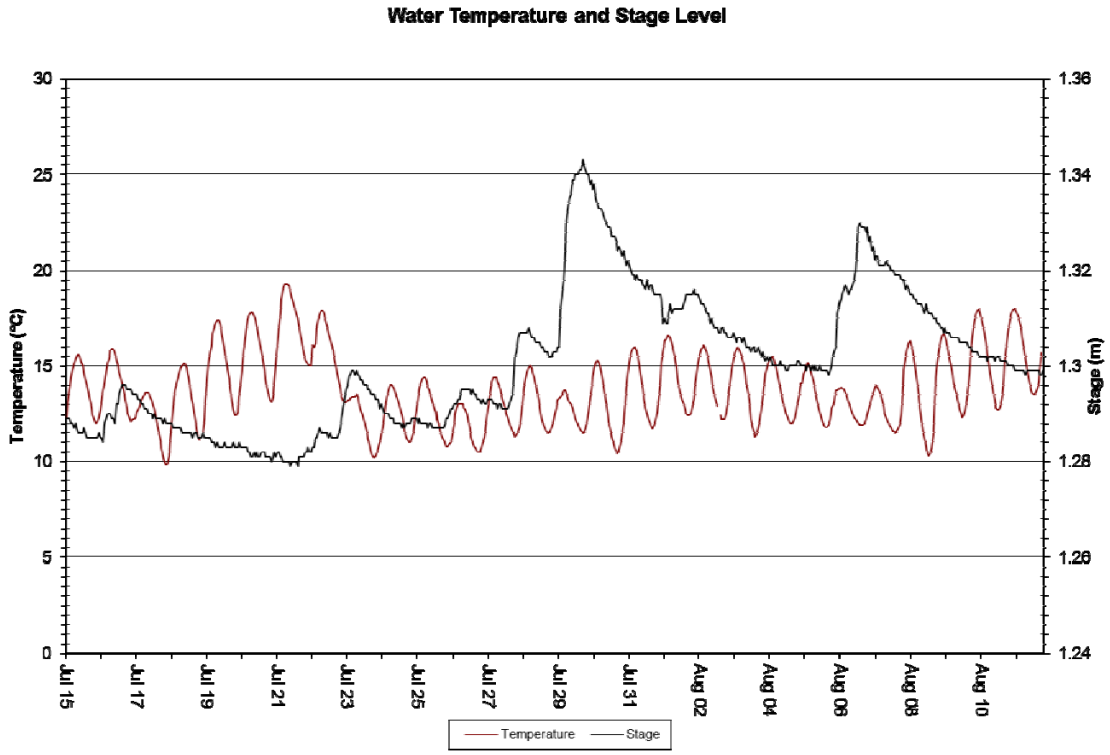

Figure 4: Temperature (°C) at Houston Creek from July 15, 2014 to August 12, 2014

pH

- pH values ranged from 7.74 units to 8.65 units at James Creek (Figure 5) and from 6.39 units to 6.83 units at Houston Creek (Figure 6) from July 15, 2014 to August 12, 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 8.12, 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 6.64, pH values recorded at Houston Creek were at, or slightly below, these guidelines.

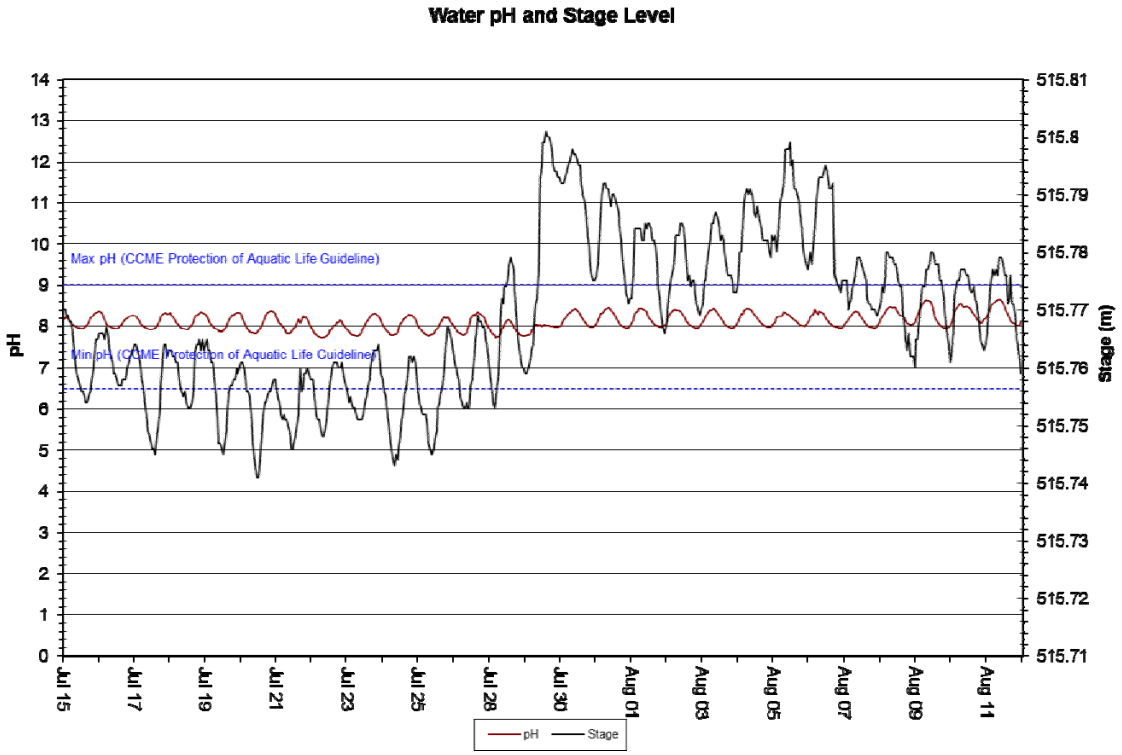

Figure 5: pH values recorded at James Creek from July 15, 2014 to August 12, 2014

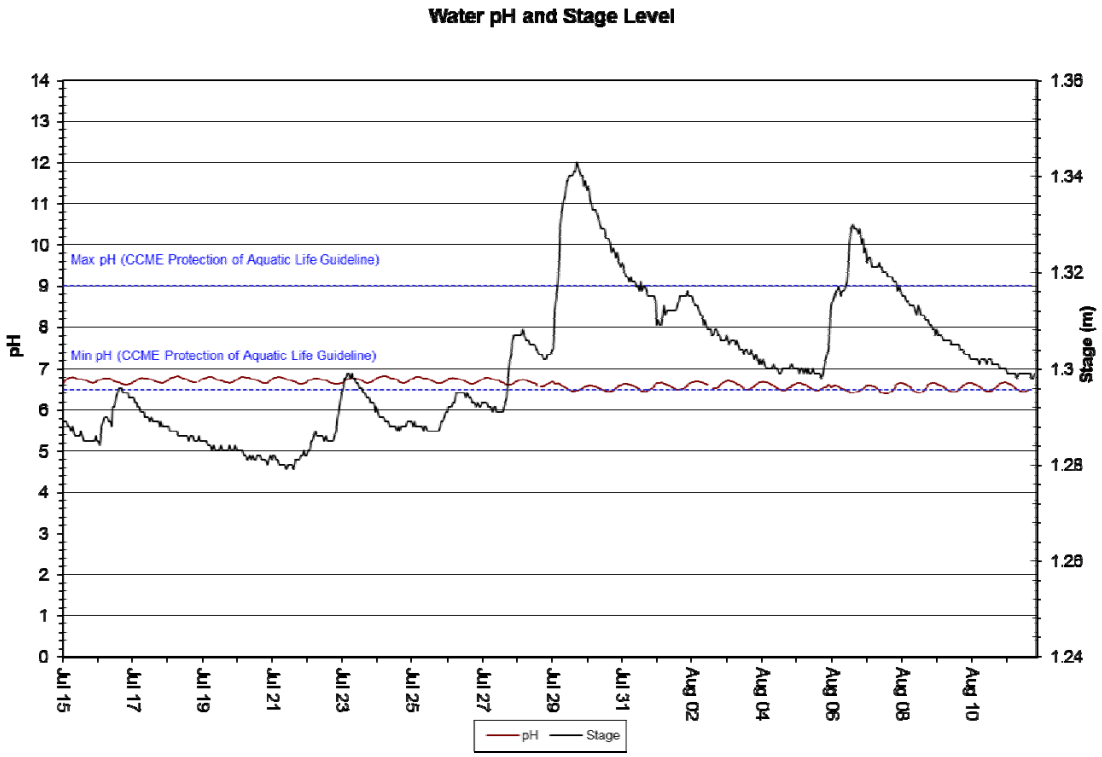

Figure 6: pH values recorded at Houston Creek from July 15, 2014 to August 12, 2014

Specific Conductivity

- Specific Conductivity ranged from 143.0 µS/cm to 161.0 µS/cm at James Creek (Figure 7) and from 37.2 µS/cm to 44.5 µS/cm at Houston Creek (Figure 8) from July 15, 2014 to August 12, 2014.
- At both James Creek and Houston Creek there are noticeable diurnal fluctuations in specific conductivity which are related to the diurnal temperature fluctuations.
- On average, specific conductivity was 152.6 µS/cm at James Creek and 40.4 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.

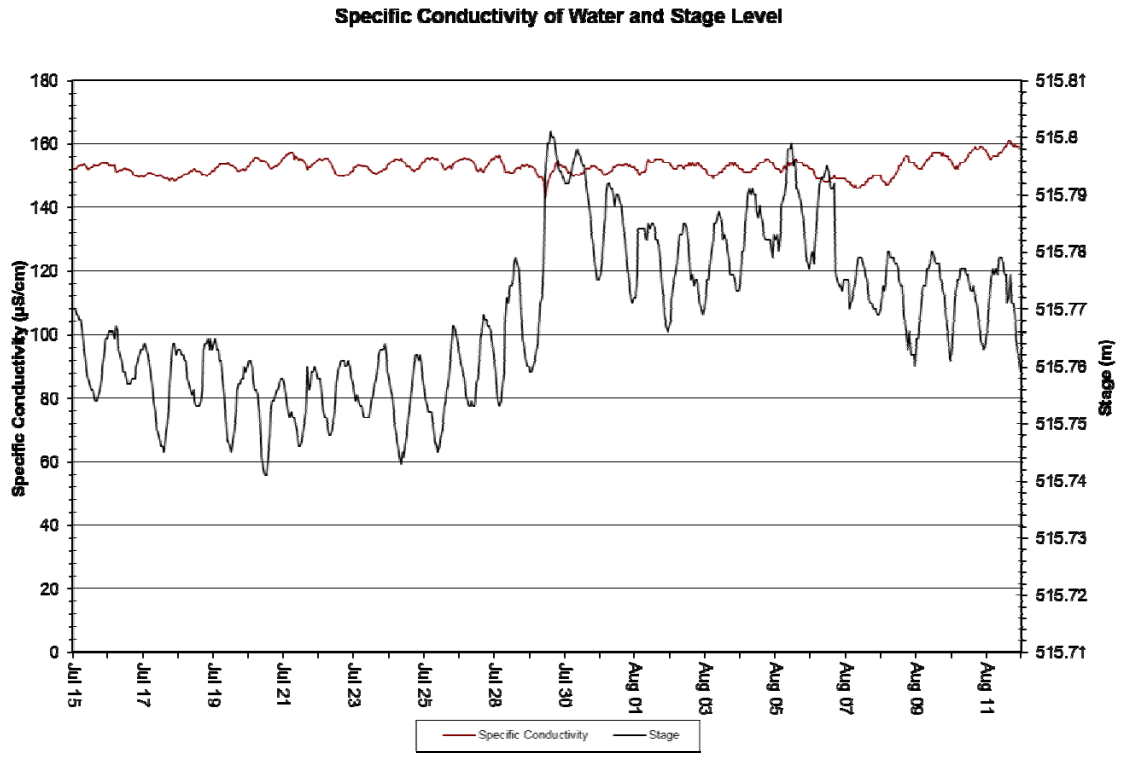

Figure 7: Specific conductivity (µs/cm) at James Creek from July 15, 2014 to August 12, 2014

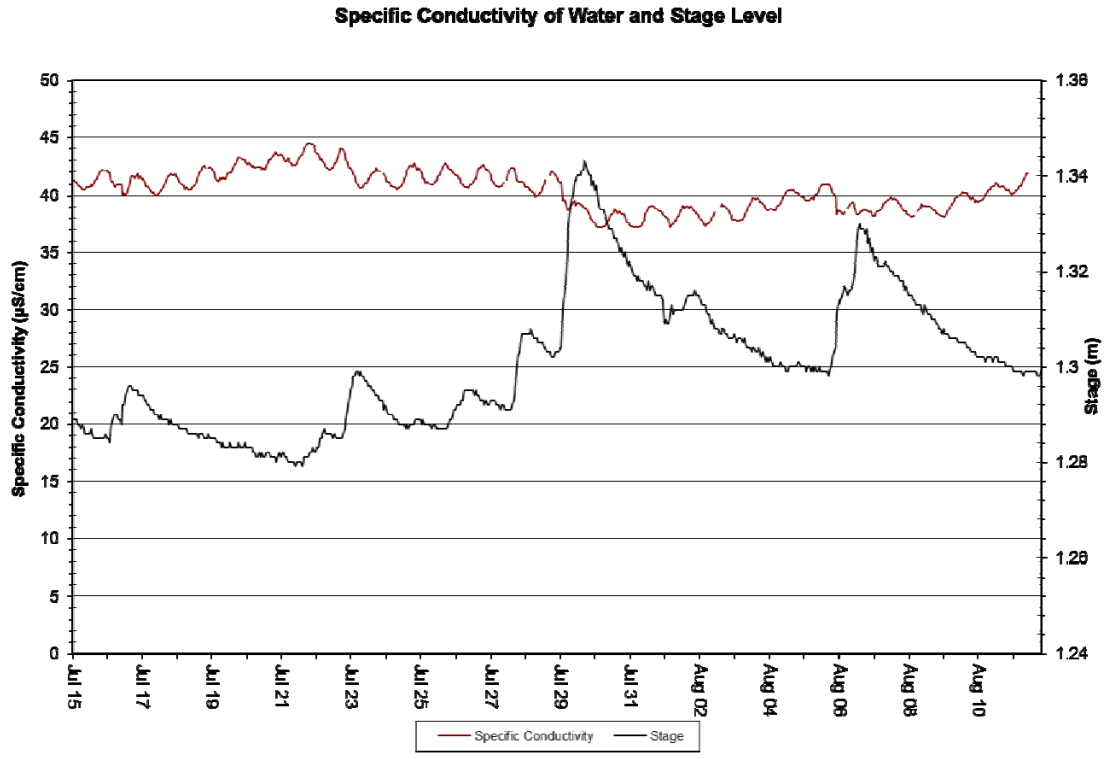

Figure 8: Specific conductivity (µs/cm) at Houston Creek from July 15, 2014 to August 12, 2014

Dissolved Oxygen

- Dissolved Oxygen [DO] values ranged from 8.37 mg/l (89.9% saturation) to 10.47 mg/l (108.1% saturation) at James Creek (Figure 9) and from 8.10 mg/l (82.5% saturation) to 10.05 mg/l (104.5% saturation) at Houston Creek (Figure10) from July 15, 2014 to August 12, 2014.
- DO (mg/l & % saturation) shows a clear diurnal fluctuation at both stations. These diurnal fluctuations can be attributed to the diurnal temperature fluctuations.
- DO (mg/l & % saturation) is relatively stable over the deployment period for both stations.
- The DO values at both stations were near or above the cold water minimum guideline set for aquatic life during early life stages (9.5 mg/l), and well above minimum guideline set for other life stages (6.5 mg/l), as determined by the Canadian Council of Ministers of the Environment (2007).

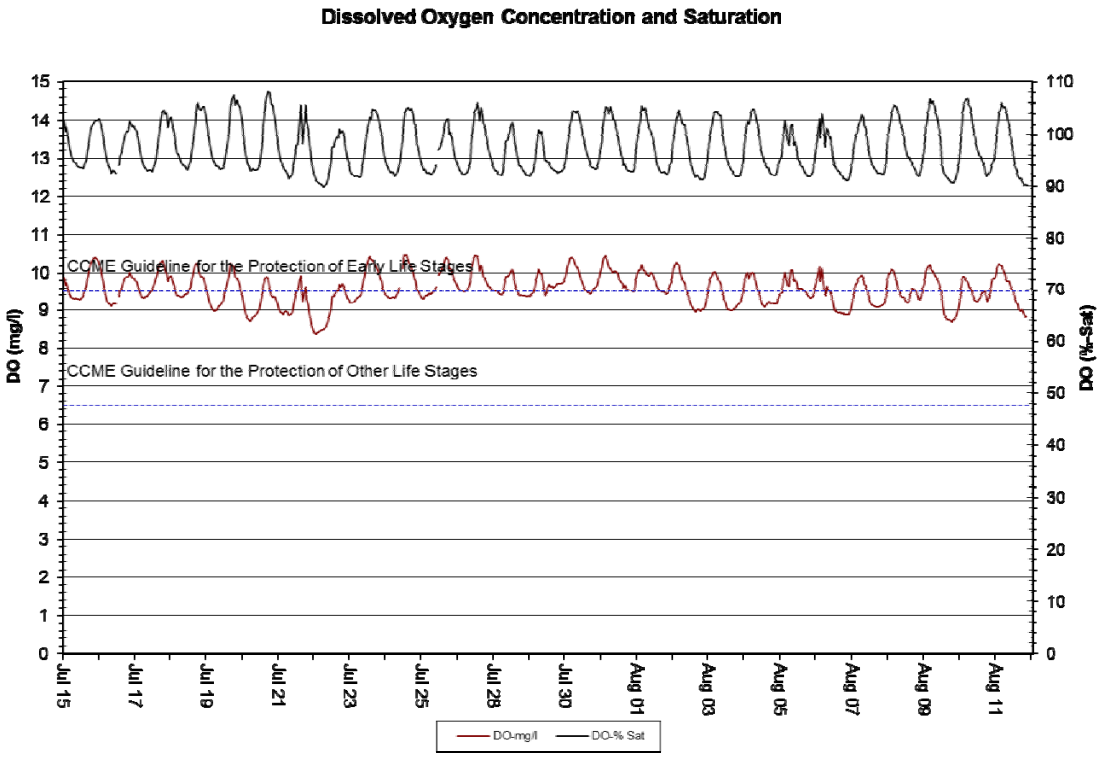

Figure 9: DO (mg/l & % saturation) at James Creek from July 15, 2014 to August 12, 2014

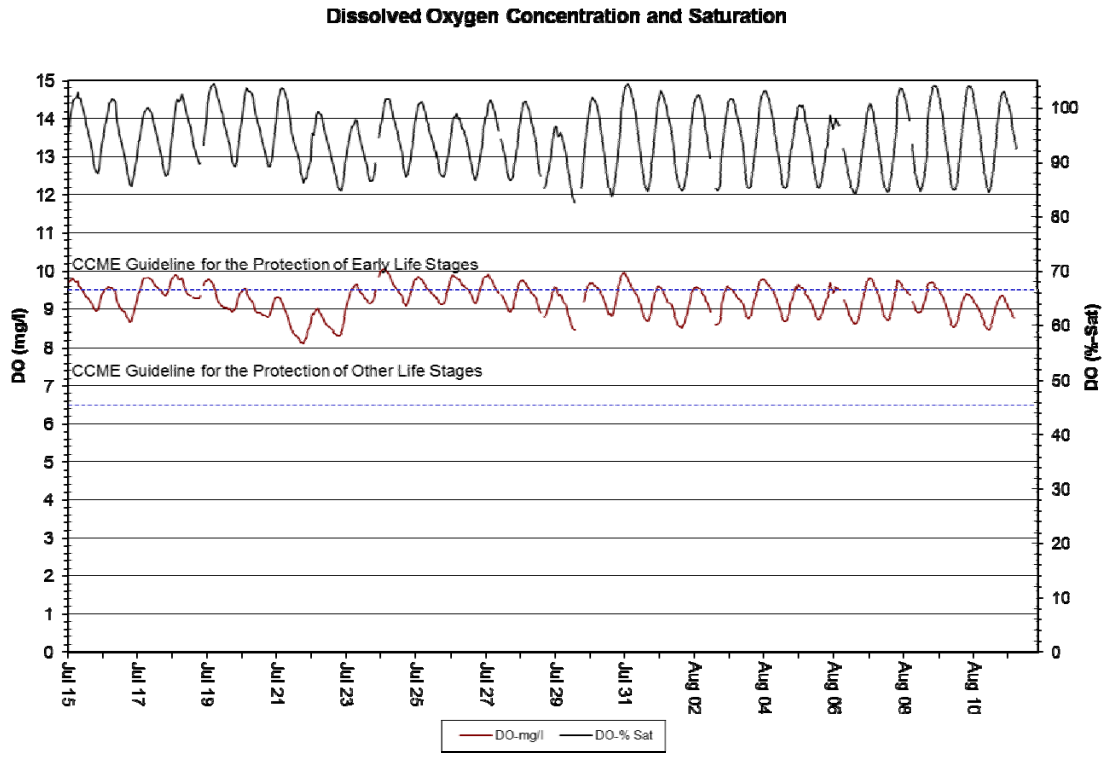

Figure 10: DO (mg/l & % saturation) at Houston Creek from July 15, 2014 to August 12, 2014

Turbidity

- Turbidity values ranged from 0.0 NTU to 65.3 NTU at James Creek (Figure 11) and from 0.0 NTU to 61.6 NTU at Houston Creek (Figure 12) from July 15, 2014 to August 12, 2014.
- There were numerous turbidity events at both stations which are indicative of the siltation impacts associated with ongoing and historical mining activity in the headwaters area. The largest turbidity spikes occurred near the end of July when there was significant precipitation.

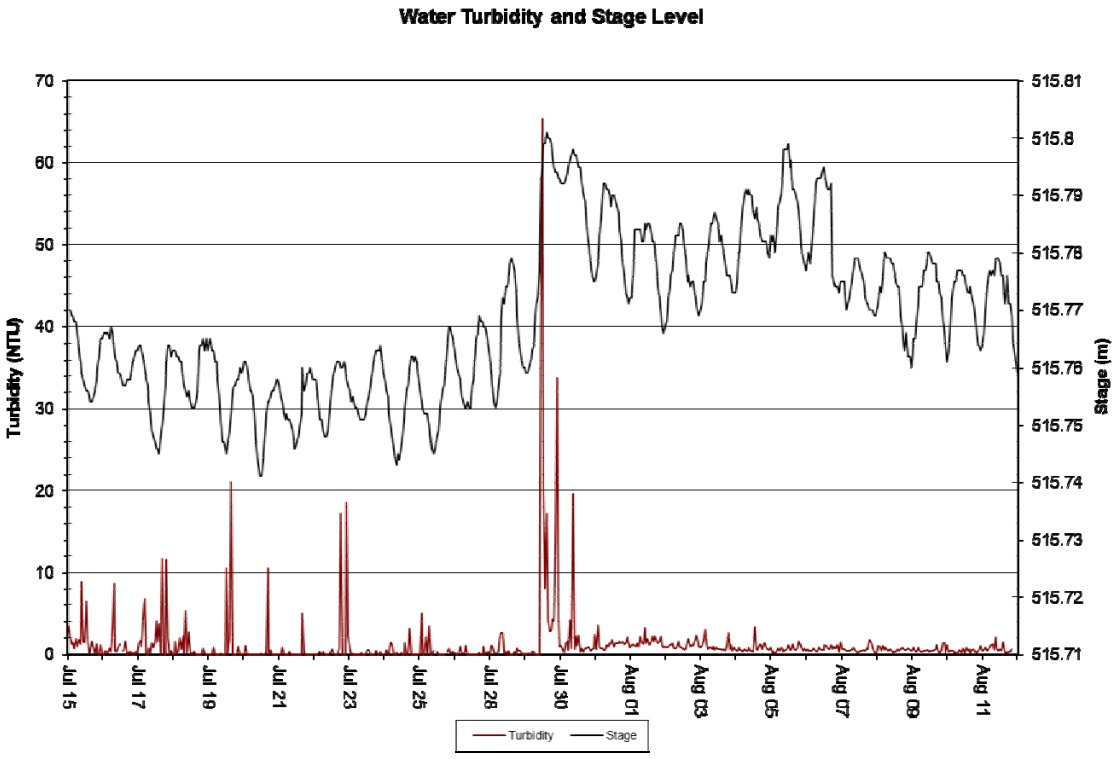

Figure 11: Turbidity (NTU) at James Creek from July 15, 2014 to August 12, 2014

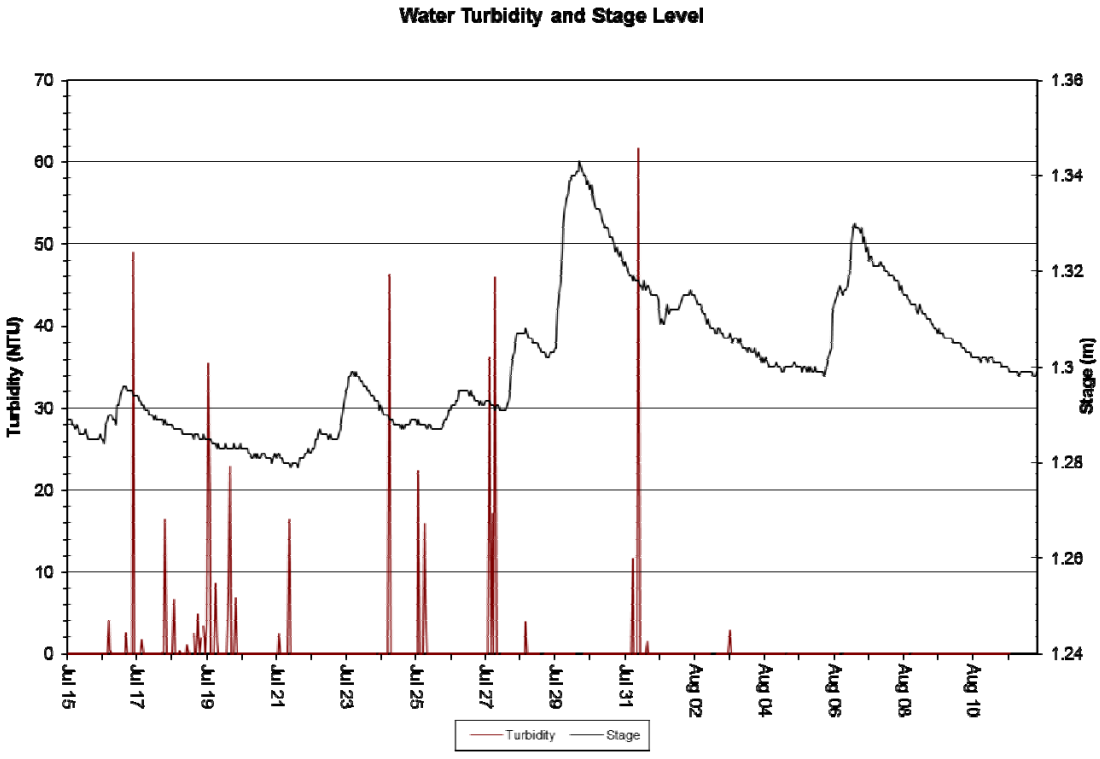

Figure 12: Turbidity (NTU) at Houston Creek from July 15, 2014 to August 12, 2014

Conclusion

- This monthly deployment report presents water quality and water quantity data recorded at the James Creek and Houston Creek station from July 15, 2014 to August 12, 2014.
- The performances of all sensors were rated fair to excellent at the beginning of the deployment period. At Houston Creek all of the sensors rated excellent upon removal, however at James Creek two sensors rated good, and three excellent.
- 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 was no distinct increasing or declining temperatures trends at either station over the deployment period.
    - 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 8.12, 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 6.64, pH values recorded at Houston Creek were at or slightly below 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.
    - On average, specific conductivity was 152.6 µS/cm at James Creek and 40.4 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. Other than these diurnal fluctuations DO (mg/l & % saturation) is relatively stable over the deployment period for both stations.

- The DO values at both stations were near or above the cold water minimum guideline set for aquatic life during early life stages (9.5 mg/l), and well above minimum guideline set for other life stages (6.5 mg/l), as determined by the Canadian Council of Ministers of the Environment (2007).
- There were numerous turbidity events at both stations which are indicative of the siltation impacts associated with ongoing and historical mining activity in the headwaters area.

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

APPENDIX B
Environment Canada Weather Data – Schefferville (July 15, 2014 to August 12, 2014)

Date/Time	Max	Min	Mean	Heat	Cool	Total

[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*

	Temp (°C)	Temp (°C)	Temp (°C)	Deg Days (°C)	Deg Days (°C)	Precip (mm)
7/15/2014	17.2	10.1	13.7	4.3	0	3.3
7/16/2014	20.2	11.4	15.8	2.2	0	5.1
7/17/2014	14.5	6.2	10.4	7.6	0	0.3
7/18/2014	20.5	4.8	12.7	5.3	0	0
7/19/2014	25.7	11.4	18.6	0	0.6	
7/20/2014	27.9	13.2	20.6	0	2.6	0
7/21/2014	27.8	12.1	20	0	2	0
7/22/2014	21.8	12.9	17.4	0.6	0	5.3
7/23/2014	13.5	7.7	10.6	7.4	0	13.3
7/24/2014	14.9	5.9	10.4	7.6	0	0
7/25/2014	16.1	9.6	12.9	5.1	0	0.6
7/26/2014	14.8	8.2	11.5	6.5	0	12.5
7/27/2014	17.3	8.2	12.8	5.2	0	2.4
7/28/2014	16.6	8.9	12.8	5.2	0	13.6
7/29/2014	18.4	8.4	13.4	4.6	0	28.1
7/30/2014	19.6	8	13.8	4.2	0	0
7/31/2014	22.1	7.3	14.7	3.3	0	0
8/1/2014	21.7	11.2	16.5	1.5	0	1.8
8/2/2014	18	10.9	14.5	3.5	0	4.8
8/3/2014	18	10.4	14.2	3.8	0	0.5
8/4/2014	20.3	7.7	14	4	0	0
8/5/2014	18.2	10.5	14.4	3.6	0	6.1
8/6/2014	17.5	10.7	14.1	3.9	0	3.6
8/7/2014	16.3	10.3	13.3	4.7	0	1.5
8/8/2014	19.9	9.6	14.8	3.2	0	0
8/9/2014	23.6	9.4	16.5	1.5	0	0
8/10/2014	23.6	10.6	17.1	0.9	0	0
8/11/2014	27.5	13.8	20.7	0	2.7	0
8/12/2014	23.1	13.6	18.4	0	0.4	5.5