Real Time Water Quality Report

Labrador Iron Mines Schefferville Network

Deployment Period 2014-06-10 to 2014-07-15

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

Prepared by:

Ian Bell
Environmental Scientist

Department of Environment & Conservation
Water Resources Management Division
PO Box 2006, Corner Brook, NL, A2H 6J8

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

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 June 10, 2014, to July 15, 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	2014-06-10	2014-07-15	2014-06-10	2013-07-15
Temperature	Good	Good	Excellent	Excellent
pH	Good	Marginal	Excellent	Excellent
Specific Conductivity	Excellent	Poor	Excellent	Excellent
Dissolved Oxygen	Excellent	Excellent	Excellent	Excellent
Turbidity	Excellent	Poor	Excellent	Excellent

- The performances of all sensors were rated good to excellent at the beginning of the deployment period. At Houston Creek all of the sensors rated excellent upon removal, however at James Creel two sensors rated poor, one marginal, one good and one excellent (Table 1). The poor and marginal ratings at James Creek upon removal of the instrument were most likely related to the significant sediment load in this brook. This sediment accumulates on the sensors over the deployment period both throwing off readings and causing sensors to drift significantly off calibration.

Deployment Notes

- Water quality monitoring for this deployment period started at James Creek on June 10, 2014 at 11:00 am and on the same date at Houston Creek at 3:10 pm. Continuous real-time monitoring continued at both sites without any significant operational issues until July 15, 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 515.71 m to 515.79 m at James Creek (Figure 1) and from 1.28 m to 1.32 m at Houston Creek (Figure 2) from June 10, 2014 to July 15, 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.

- For both James Creek and Houston Creek there appears to be an overall gentle declining trend throughout the deployment period which is consistent with the transition from late spring to summer.
- 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.

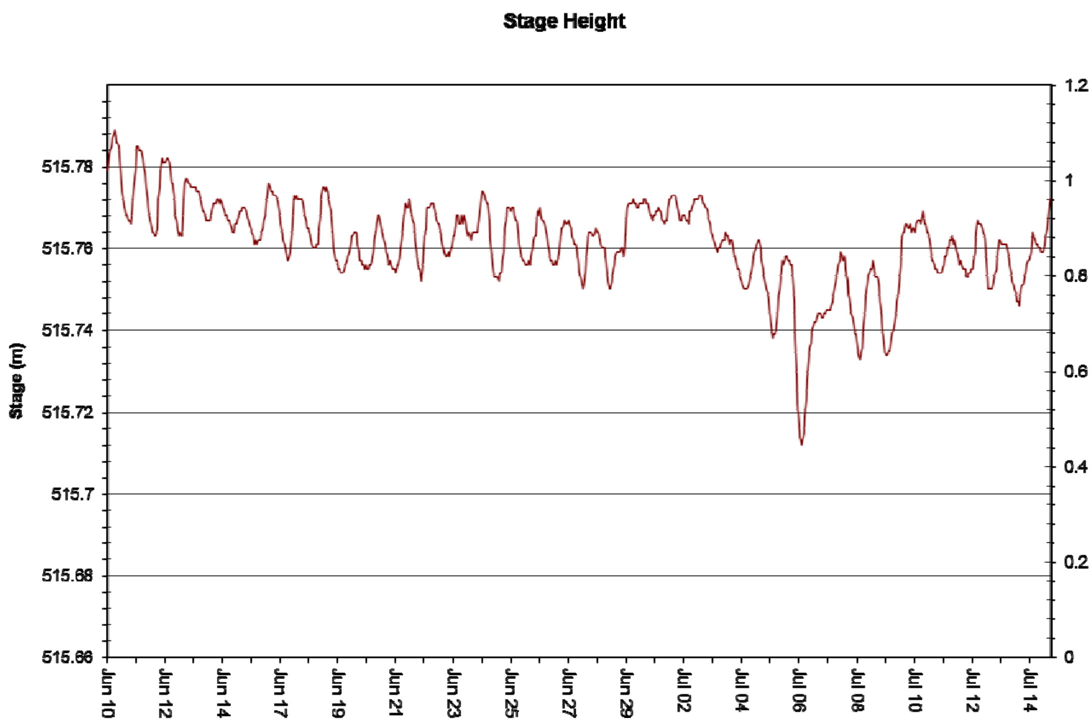

Figure 1: Stage Height (m) at James Creek from June 10, 2014 to July 15, 2014

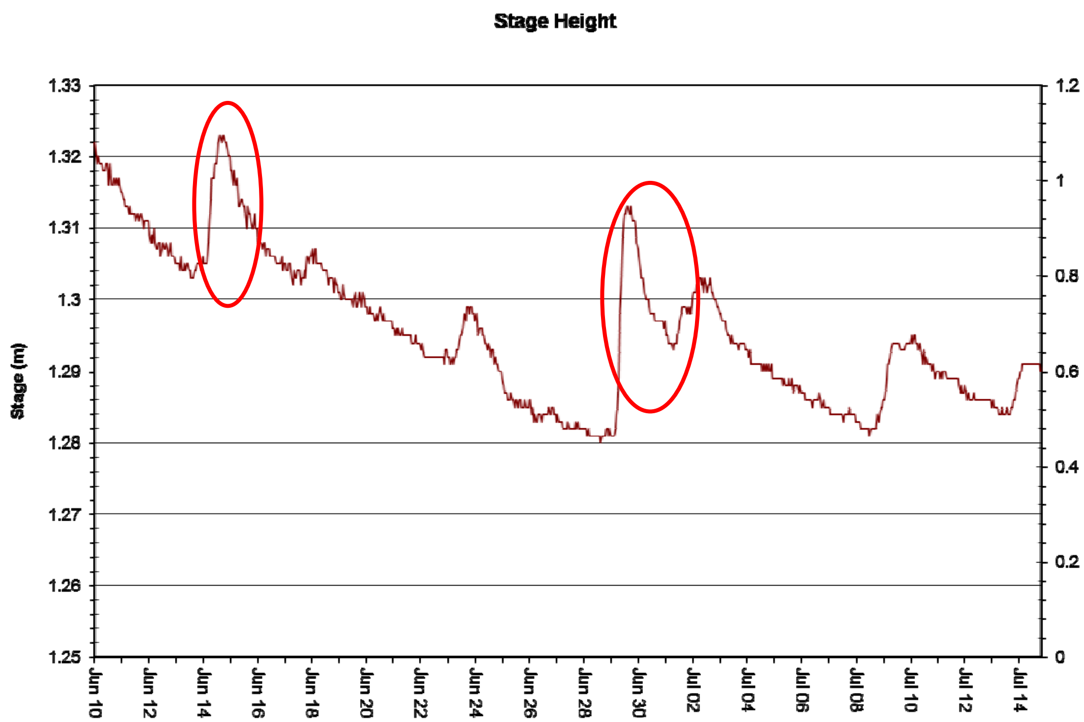

Figure 2: Stage Height (m) at Houston Creek from June 10, 2014 to July 15, 2014

Temperature

- Water temperature ranged from 8.10˚C to 18.30˚C at James Creek (Figure 3) and from 6.40˚C to 19.00˚C at Houston Creek (Figure 4) from June 10, 2014 to July 15, 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.
- At Houston Creek when Stage peaks due to precipitation events there is an associated slight decrease in the water temperature (See inside red ovals).
- There was no distinct increasing or declining temperatures trends at either station over the deployment period.

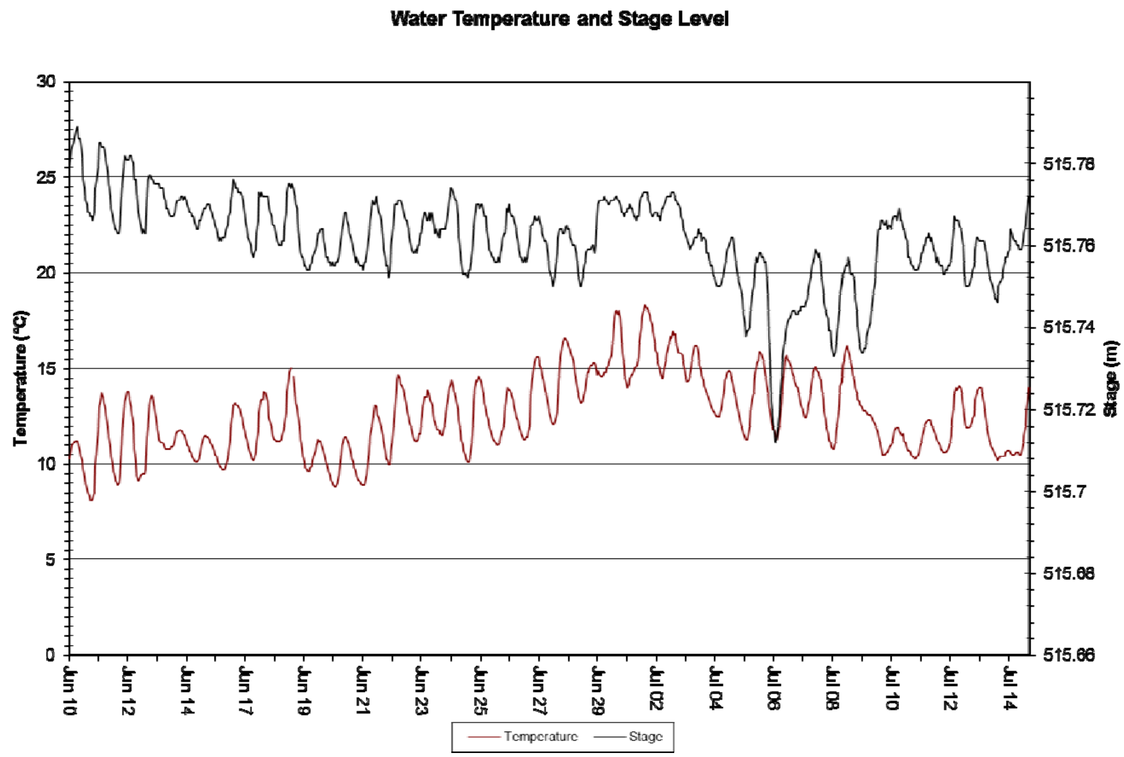

Figure 3: Temperature (°C) at James Creek from June 10, 2014 to July 15, 2014

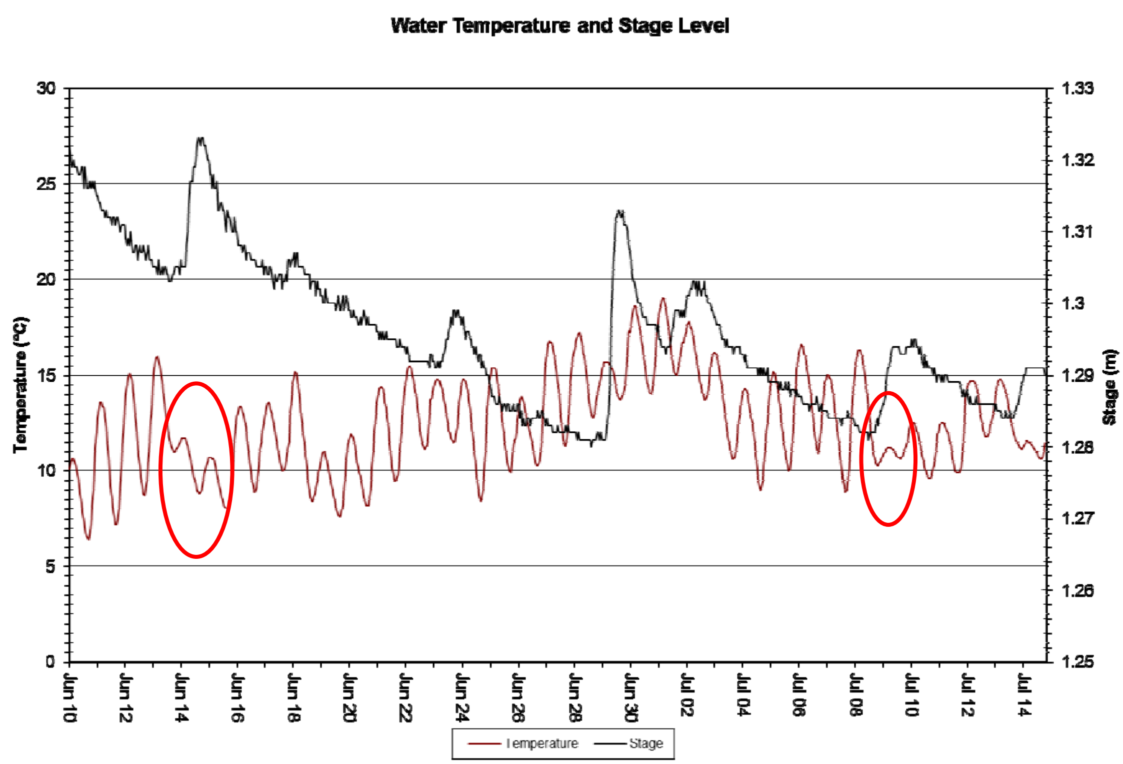

Figure 4: Temperature (°C) at Houston Creek from June 10, 2014 to July 15, 2014

pH

- pH values ranged from 6.74 units to 7.97 units at James Creek (Figure 5) and from 6.34 units to 6.83 units at Houston Creek (Figure 6) from June 10, 2014 to July 15, 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, however the sensor at James Creek begins to drift off calibration from the middle to the end of the deployment period.
- With a mean value of 7.41, 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 6.67, pH values recorded at Houston Creek were within these guidelines.

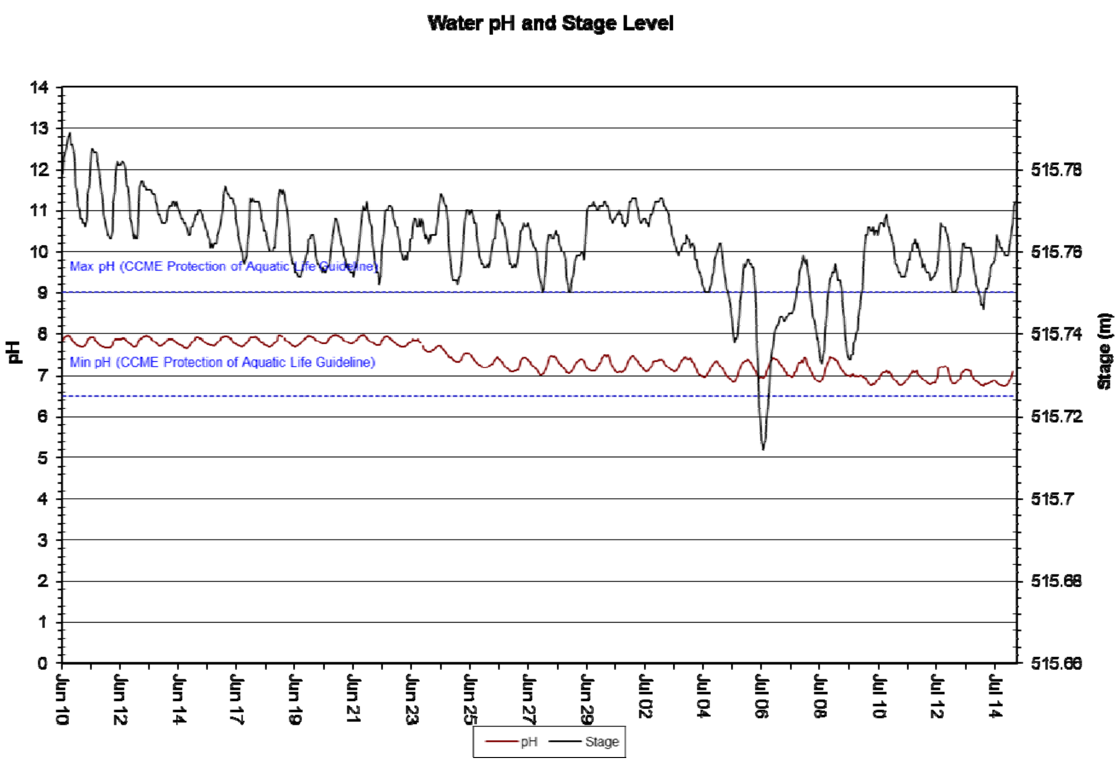

Figure 5: pH values recorded at James Creek from June 10, 2014 to July 15, 2014

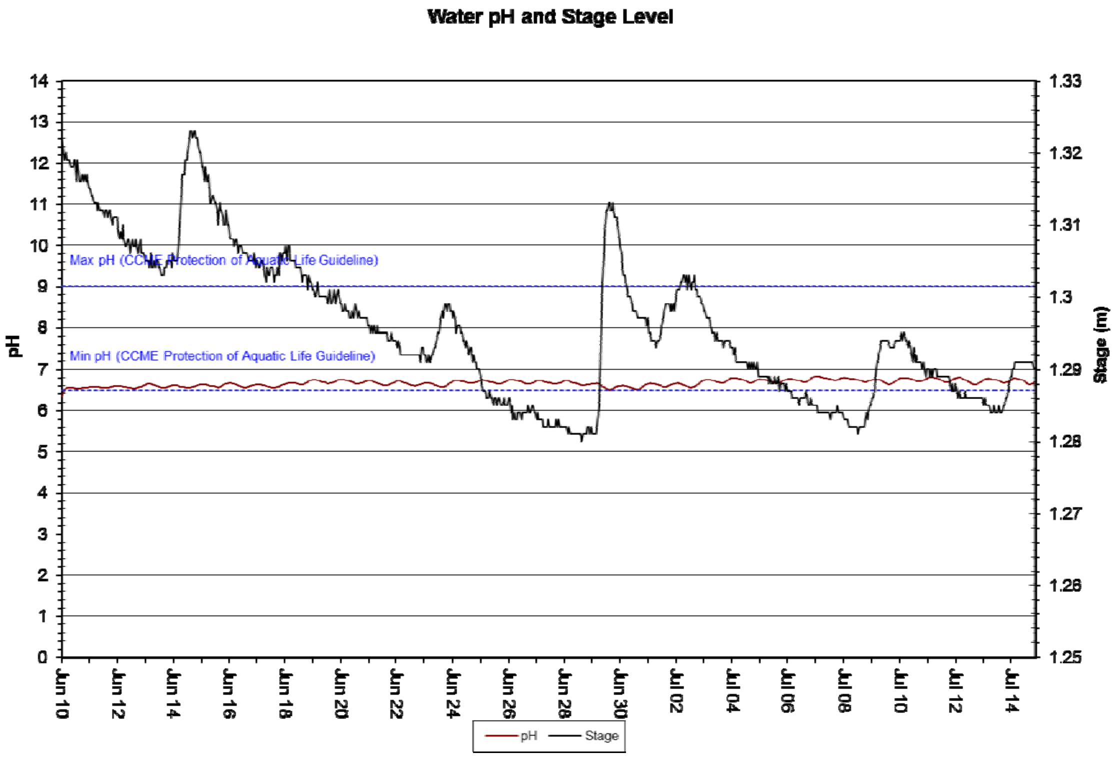

Figure 6: pH values recorded at Houston Creek from June 10, 2014 to July 15, 2014

Specific Conductivity

- Specific Conductivity ranged from 145.6 µS/cm to 205.0 µS/cm at James Creek (Figure 7) and from 32.1 µS/cm to 43.8 µS/cm at Houston Creek (Figure 8) from June 10, 2014 to July 15, 2014.
- Specific conductivity readings show a significant increase at James Creek starting around July 2, 2014 which appears to correspond with a significant drop in stage height and therefore flow.
- At Houston Creek there is a gentle increasing trend in specific conductivity over the deployment period which appears to correspond with a gentle decreasing trend in stage height and therefore flow.
- At Houston Creek there are noticeable diurnal fluctuations which are related to the diurnal temperature fluctuations.
- On average, specific conductivity was 167.4 µS/cm at James Creek and 39.1 µS/cm at Houston Creek. 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.

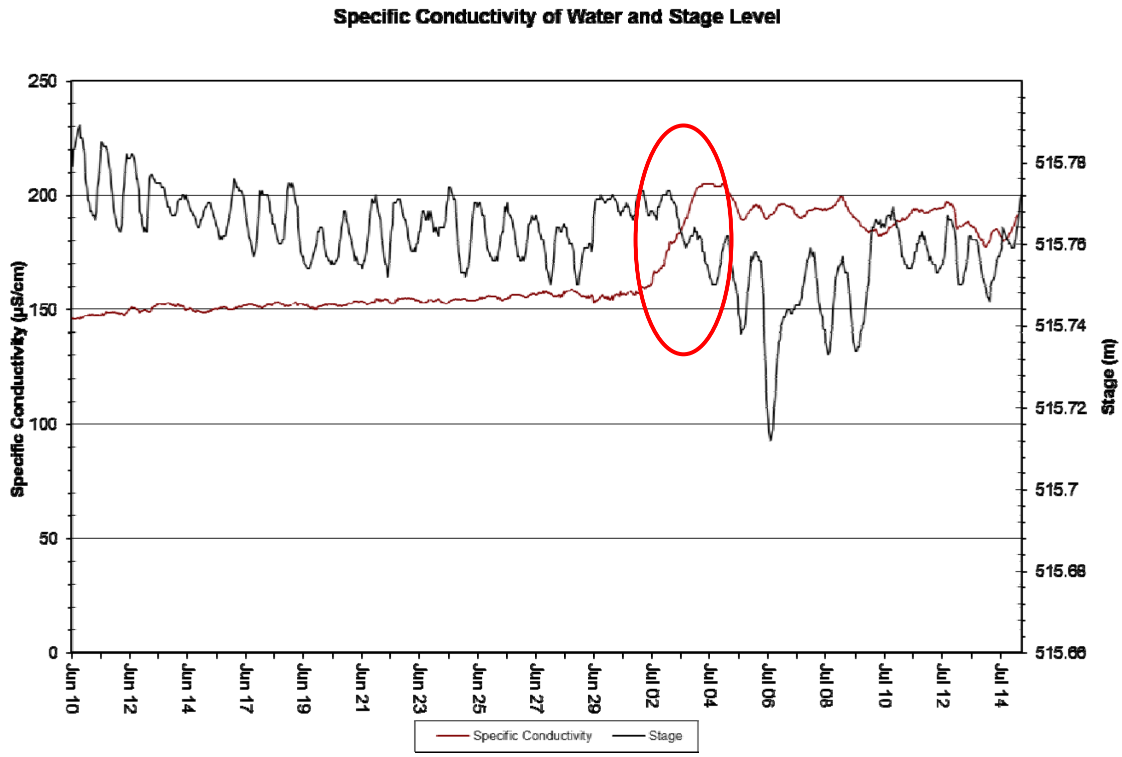

Figure 7: Specific conductivity (µs/cm) at James Creek from June 10, 2014 to July 15, 2014

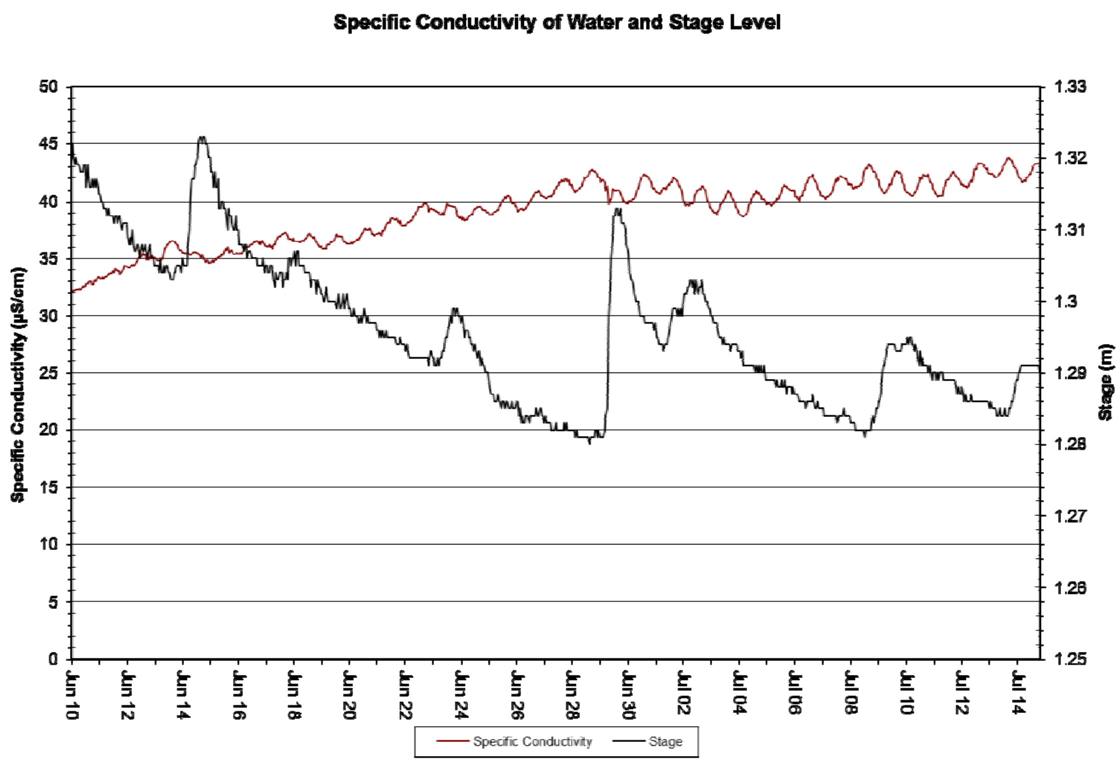

Figure 8: Specific conductivity (µs/cm) at Houston Creek from June 10, 2014 to July 15, 2014

Dissolved Oxygen

- Dissolved Oxygen [DO] values ranged from 8.19 mg/l (85.4% saturation) to 10.71 mg/l (101.8% saturation) at James Creek (Figure 9) and from 7.53 mg/l (78.5% saturation) to 10.20 mg/l (97.7% saturation) at Houston Creek (Figure10) from June 10, 2014 to July 15, 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).

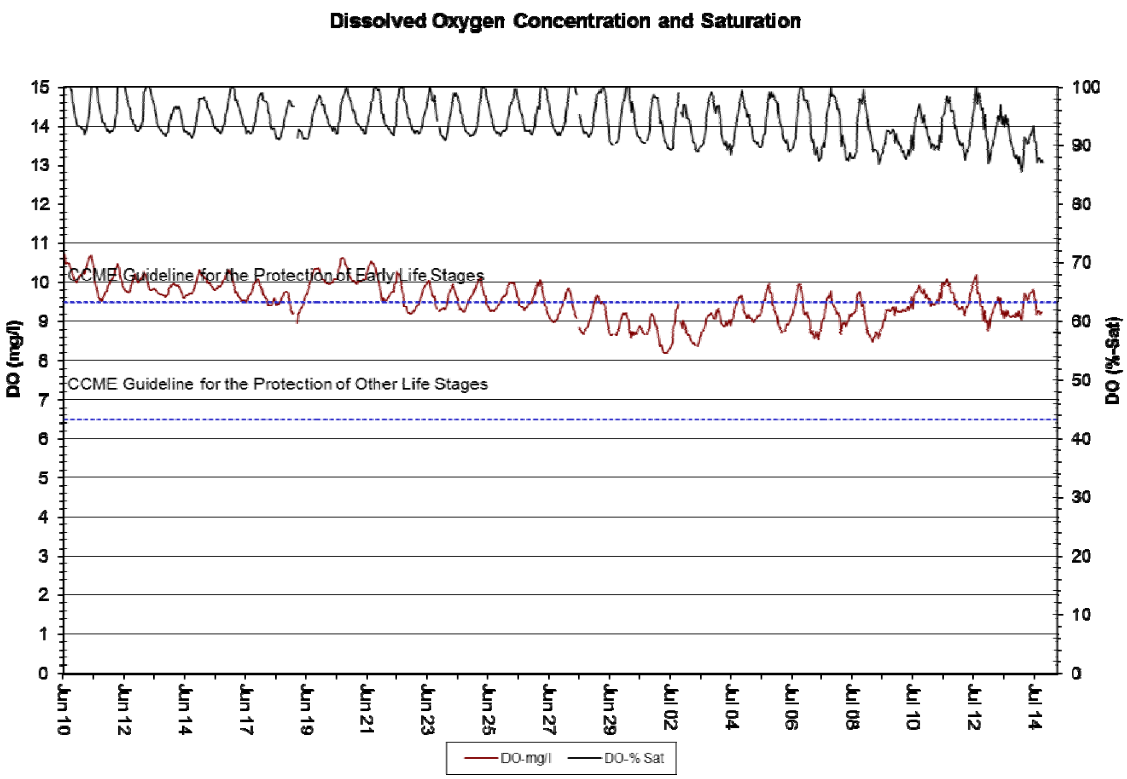

Figure 9: DO (mg/l & % saturation) at James Creek from June 10, 2014 to July 15, 2014

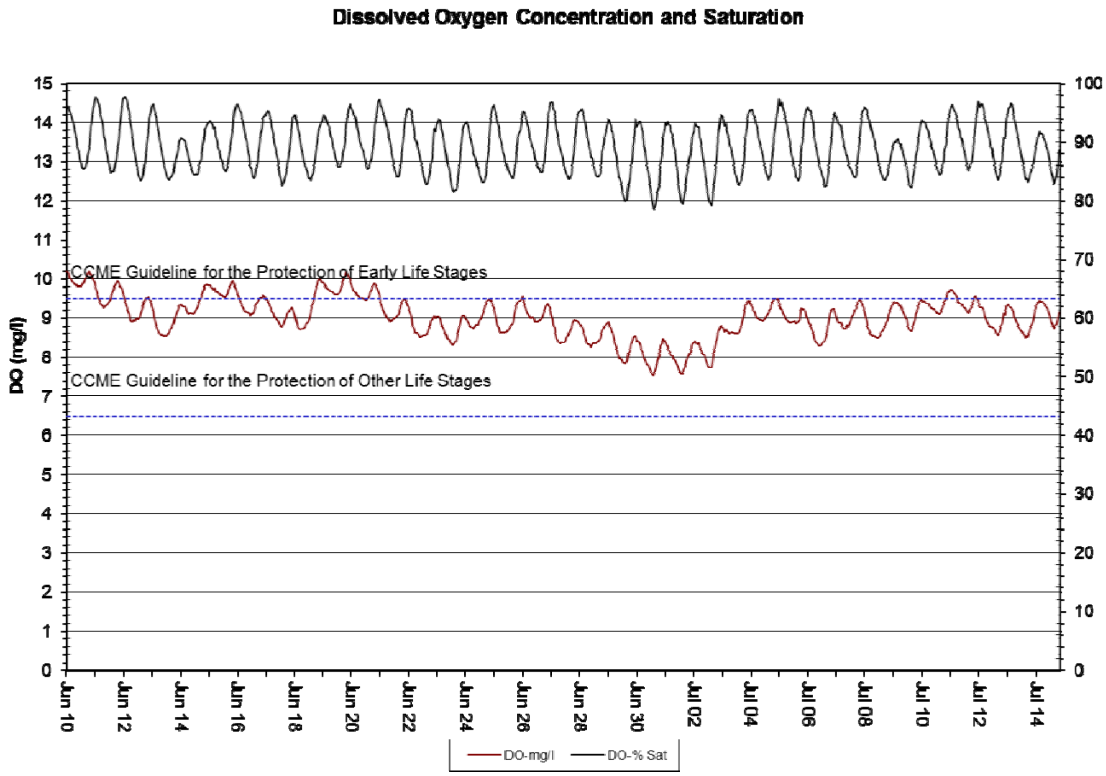

Figure 10: DO (mg/l & % saturation) at Houston Creek from June 10, 2014 to July 15, 2014

Turbidity

- Turbidity values ranged from 3.2 NTU to 229.2 NTU at James Creek (Figure 11) and from 0.0 NTU to 4.3 NTU at Houston Creek (Figure 12) from June 10, 2014 to July 15, 2014.
- There were numerous turbidity events at James Creek which are indicative of the siltation impacts associated with the mining activity in the headwaters area.
- 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.

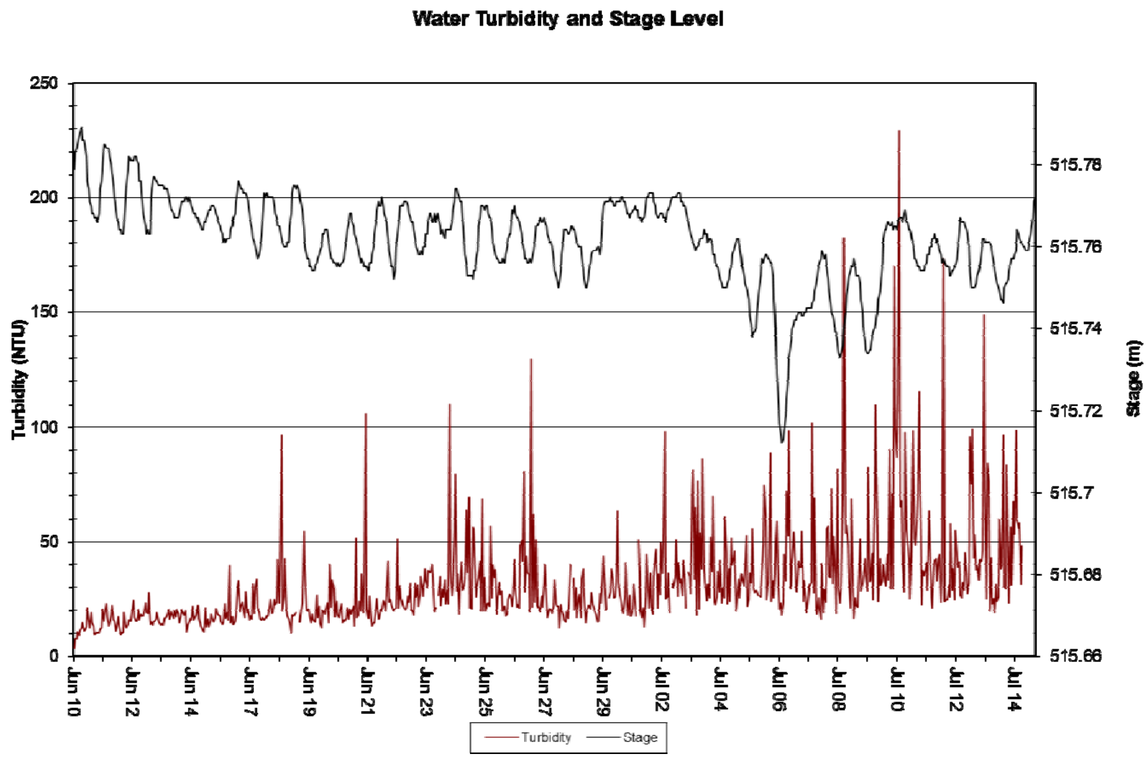

Figure 11: Turbidity (NTU) at James Creek from June 10, 2014 to July 15, 2014

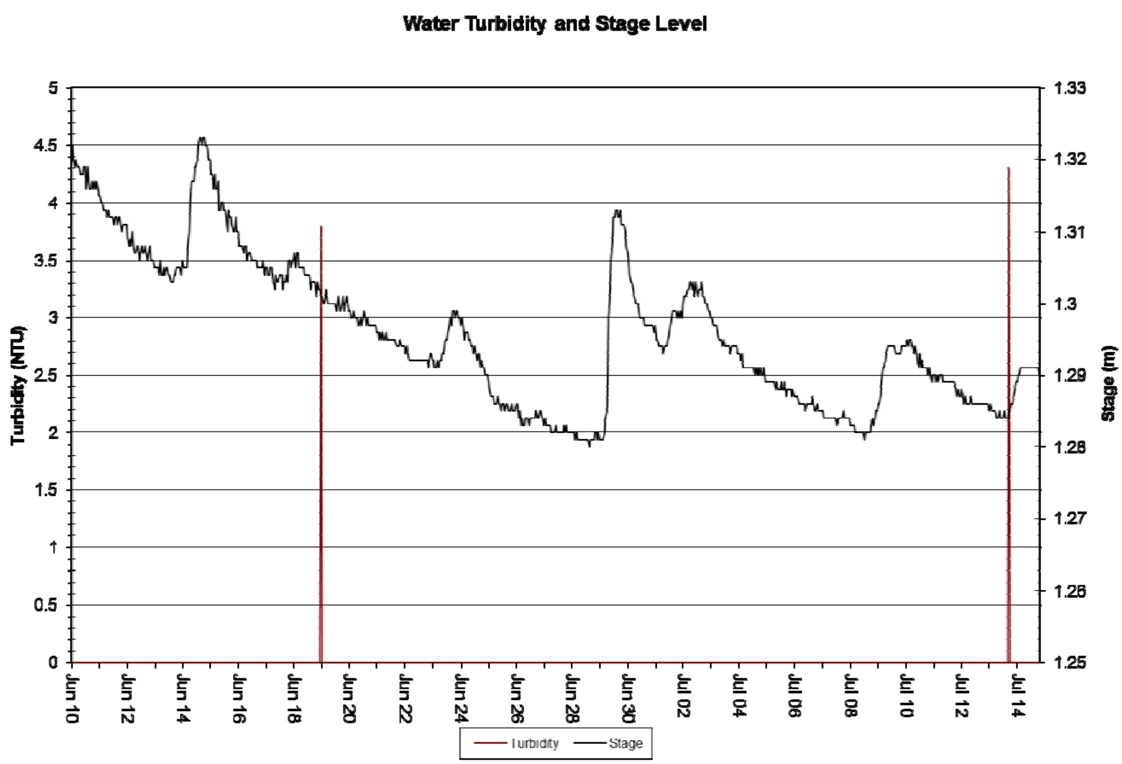

Figure 12: Turbidity (NTU) at Houston Creek from June 10, 2014 to July 15, 2014

Conclusion

- This monthly deployment report presents water quality and water quantity data recorded at the James Creek and Houston Creek station from June 10, 2014 to July 15, 2014.

- The performances of all sensors were rated good to excellent at the beginning of the deployment period. At Houston Creek all of the sensors rated excellent upon removal, however at James Creel two sensors rated poor, one marginal, one good and one excellent (Table 1). The poor and marginal ratings at James Creek upon removal of the instrument were most likely related to the significant sediment load in this brook. This sediment accumulates on the sensors over the deployment period both throwing off readings and causing sensors to drift significantly off calibration.

- Variations in water quality/quantity values recorded at each station are summarized below:
  - For both James Creek and Houston Creek there appears to be an overall gentle declining trend in stage height throughout the deployment period which is consistent with the transition from late spring to summer.
  - 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, however the sensor at James Creek begins to drift off calibration from the middle to the end of the deployment period.
  - With a mean value of 7.41, 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 6.67, pH values recorded at Houston Creek were within these guidelines.
  - Specific conductivity readings show a significant increase at James Creek starting around July 2, 2014 which appears to correspond with a significant drop in stage height and therefore flow.
  - At Houston Creek there is a gentle increasing trend in specific conductivity over the deployment period which appears to correspond with a gentle decreasing trend in stage height and therefore flow.
  - At Houston Creek there are noticeable diurnal fluctuations in specific conductivity which are related to the diurnal temperature fluctuations.
  - 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.

- There were numerous turbidity events at James Creek which are indicative of the siltation impacts associated with the mining activity in the headwaters area.
- 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 (June 10, 2014 to July 15, 2014)

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)
6/10/2014	15.7	1.6	8.7	9.3	0	M	M	0
6/11/2014	17.4	1.6	9.5	8.5	0	M	M	
6/12/2014	21.6	2	11.8	6.2	0	M	M	0
6/13/2014	23.2	6.7	15	3	0	M	M	0
6/14/2014	14.5	6.5	10.5	7.5	0	M	M	8.6
6/15/2014	13	5.1	9.1	8.9	0	M	M	1.2
6/16/2014	19.6	6.7	13.2	4.8	0	M	M	0
6/17/2014	19.5	6.5	13	5	0	M	M	0
6/18/2014	18.4	4.5	11.5	6.5	0	M	M	
6/19/2014	8.8	2.5	5.7	12.3	0	M	M	0
6/20/2014	10.1	3.5	6.8	11.2	0	M	M	0.2
6/21/2014	17.7	6	11.9	6.1	0	M	M	0
6/22/2014	22.7	5.4	14.1	3.9	0	M	M	0
6/23/2014	23.7	11.8	17.8	0.2	0	M	M	4.1
6/24/2014	13.5	4.6	9.1	8.9	0	M	M	3.9
6/25/2014	17.7	4.4	11.1	6.9	0	M	M	0
6/26/2014	20.4	10.9	15.7	2.3	0	M	M	0
6/27/2014	25.2	10.7	18	0	0	M	M	0
6/28/2014	25.7	11.6	18.7	0	0.7	M	M	0
6/29/2014	25.9	15.2	20.6	0	2.6	M	M	15.2
6/30/2014	25.5	15.9	20.7	0	2.7	M	M	2.8
7/1/2014	25	14.8	19.9	0	1.9	M	M	4.2
7/2/2014	22.2	15.3	18.8	0	0.8	M	M	4.6
7/3/2014	15.5	6.9	11.2	6.8	0	M	M	0.4
7/4/2014	12.6	5.4	9	9	0	M	M	0.9
7/5/2014	18.7	6.1	12.4	5.6	0	M	M	0
7/6/2014	19	7.4	13.2	4.8	0	M	M	0
7/7/2014	14.9	3.8	9.4	8.6	0	M	M	0.5
7/8/2014	18.4	2.7	10.6	7.4	0	M	M	0.2
7/9/2014	13.6	7.1	10.4	7.6	0	M	M	11.3
7/10/2014	14.3	8.8	11.6	6.4	0	M	M	3.4
7/11/2014	12.9	8.1	10.5	7.5	0	M	M	1.3
7/12/2014	19.3	8	13.7	4.3	0	M	M	1.1
7/13/2014	19	11.5	15.3	2.7	0	M	M	0.3
7/14/2014	11.5	9.2	10.4	7.6	0	M	M	13.8
7/15/2014	17.4	10	13.7	4.3	0	M	M	2.2