Real Time Water Quality Report

Labrador Iron Mines Schefferville Network

Deployment Period
2013-06-04 to 2013-07-01

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 and water quantity stations in close proximity to the James Property deposits, near Schefferville, QC.
- The official name of each station is *James Creek Above Bridge* and *Unnamed Tributary Below Settling Pond*, hereafter referred to as the James Creek station and the Unnamed Tributary 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 destined 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.
- 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 June 4, 2013 to July 1, 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	
Stage of deployment	Beginning	End		Beginning	End
Date	2013-06-04	2013-07-01		2013-06-04	2013-07-01
Temperature	Excellent	Excellent		Excellent	Excellent
pH	Excellent	Excellent		Excellent	Excellent
Specific Conductivity	Excellent	Excellent		Excellent	Excellent
Dissolved Oxygen	Excellent	Good		Excellent	Good
Turbidity	Excellent	Good		Good	Excellent

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

Deployment Notes

- Water quality monitoring for the 2013 field season started at James Creek on June 4, 2013 at 8:30 am and at Unnamed Tributary on the same date at 9:10 am. Continuous real-time monitoring continued at both sites without any significant operational issues until July 1, 2013 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 (°C)
  (iii.) pH
  (iv.) Specific conductivity (µS/cm)
  (v.) Dissolved oxygen (mg/l)
  (vi.) Turbidity (NTU)

Stage

- Stage values ranged from 515.82 m to 515.86 m at James Creek and from 517.16 m to 517.24 m at Unnamed Tributary from June 4, 2013 to July 1, 2013 (Figures 1 & 2). 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.
- Daily fluctuations were observed at both stations. These diurnal fluctuations are most likely attributed to dewatering operations from the mine site.
- For James Creek there appears to be a gentle declining trend in stage height over the duration of the deployment while for Unnamed Tributary the stage height shows a gentle increasing trend.
- 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.

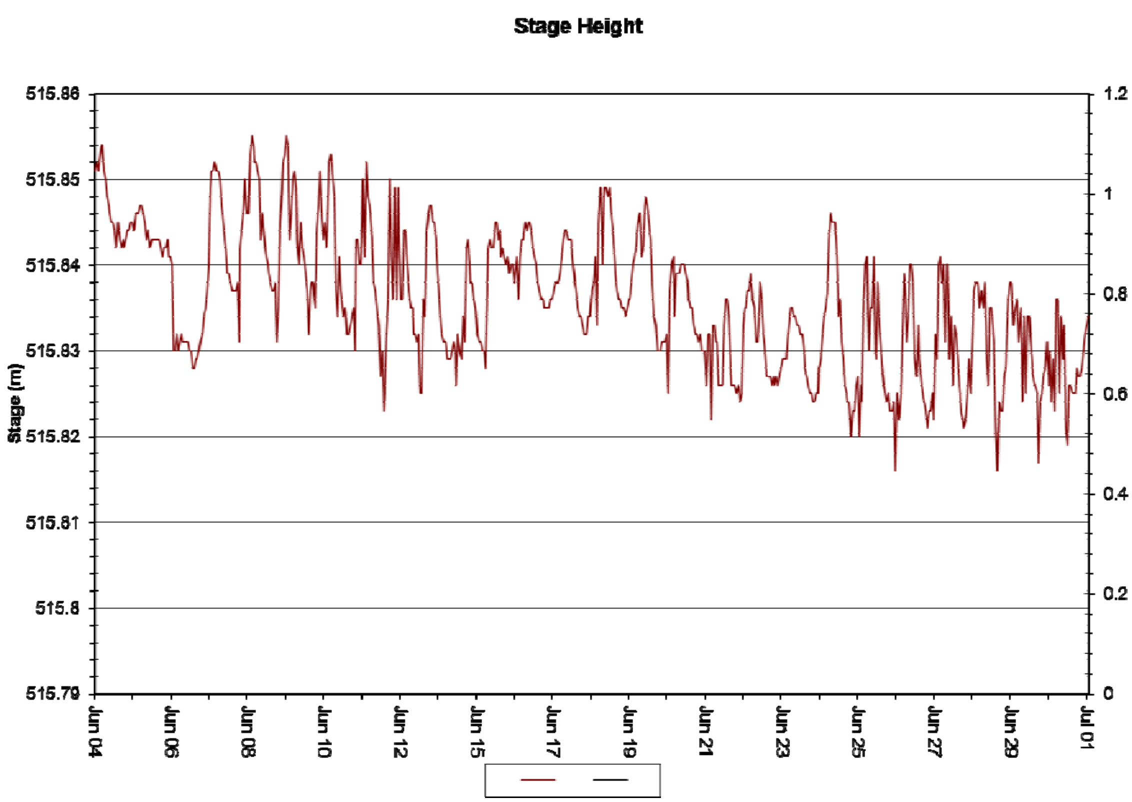

Figure 1: Stage Height (m) at James Creek from June 4, 2013 to July 1, 2013

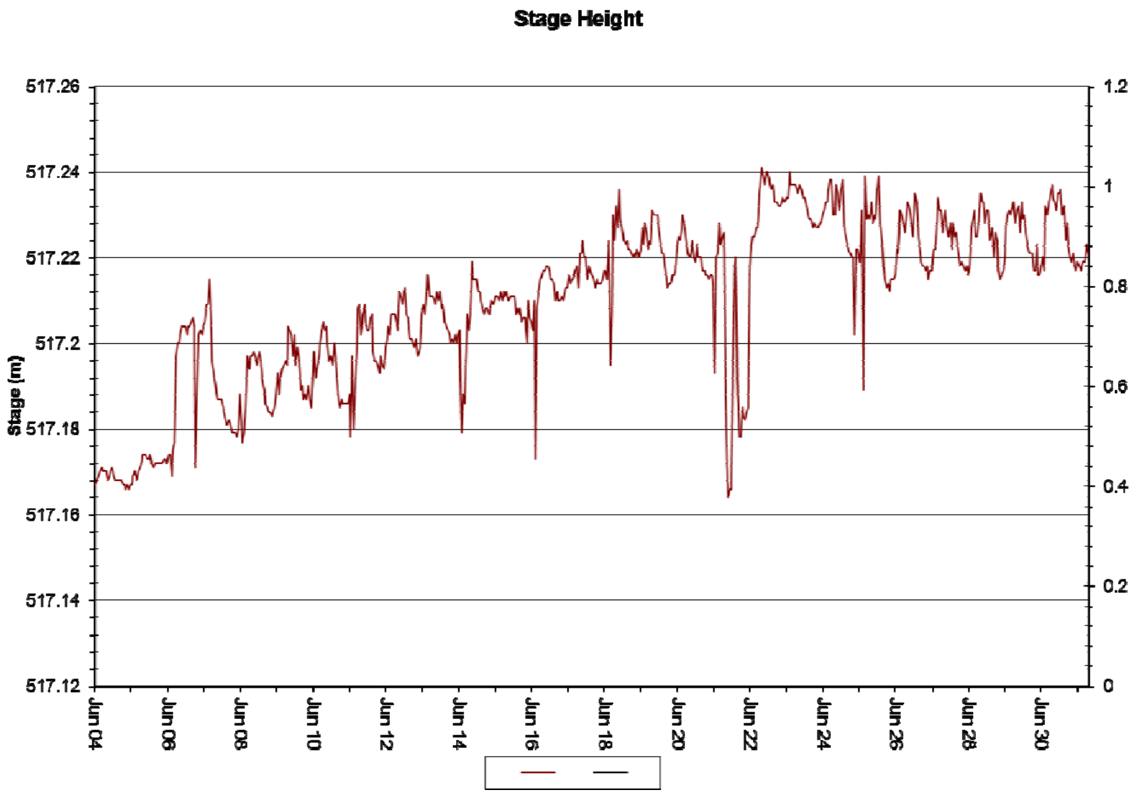

Figure 2: Stage Height (m) at Unnamed Tributary from June 4, 2013 to July 1, 2013

Temperature

- Water temperature ranged from 2.80˚C to 14.30˚C at James Creek and from 1.70˚C to 5.60˚C at Unnamed Tributary from June 4, 2013 to July 1, 2013 (Figures 3 & 4).
- 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 James Creek there appears to be a slight warming trend over the deployment period while at Unnamed Tributary temperature remains relatively stable over the deployment period.
- Water temperatures at the Unnamed Tributary were on average 5.52^{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.

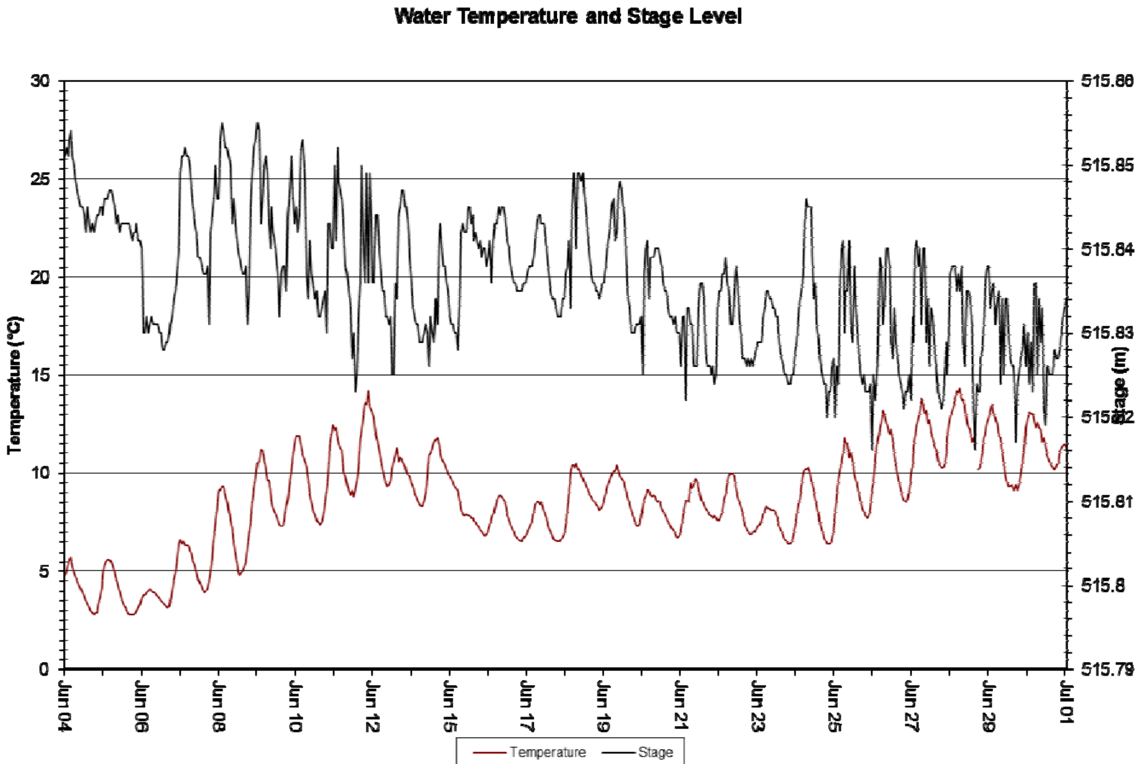

Figure 3: Temperature (^{o}C) at James Creek from June 4, 2013 to July 1, 2013

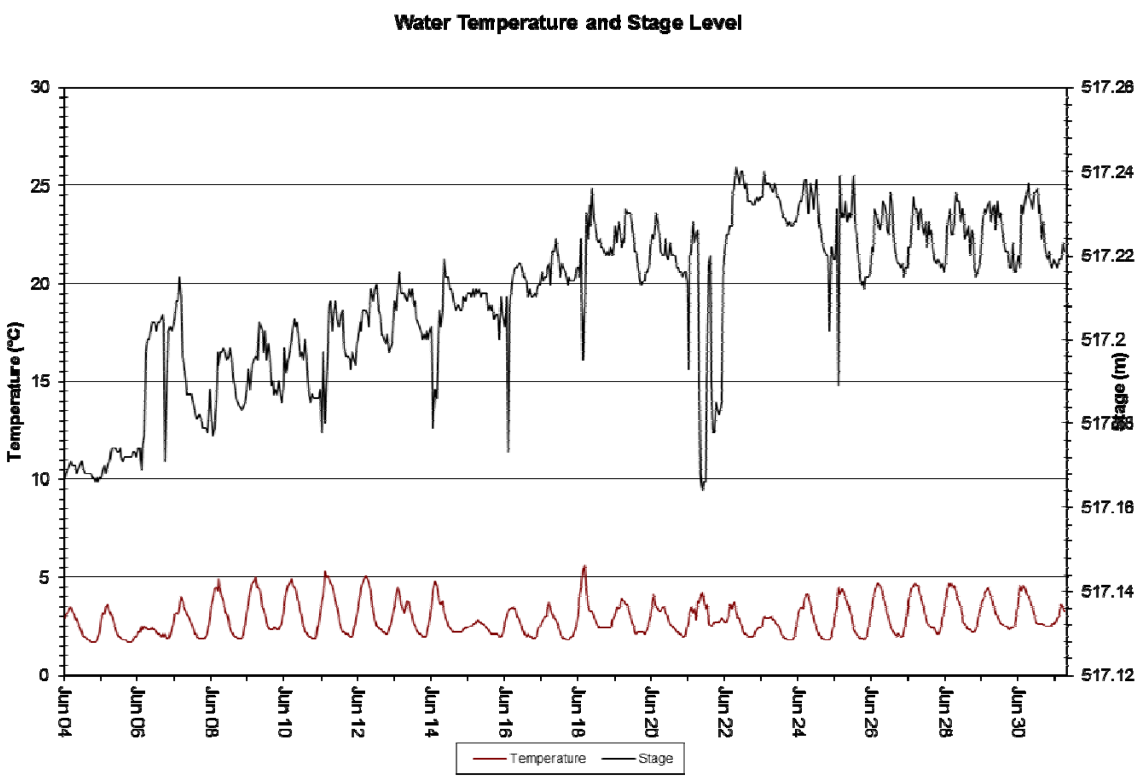

Figure 4: Temperature (^{o}C) at Unnamed Tributary from June 4, 2013 to July 1, 2013

pH

- pH values ranged from 7.75 units to 8.42 units at James Creek and from 6.29 units to 6.97 units at Unnamed Tributary from June 4, 2013 to July 1, 2013 (Figures 5 & 6).
- pH values at both stations show regular diurnal fluctuations which are related to the diurnal temperature fluctuations.
- pH was very stable throughout the deployment period at both James Creek and Unnamed Tributary.
- With a mean value of 8.0,7 pH values recorded at James Creek were within the guidelines set 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 6.54, pH values recorded at Unnamed Tributary were at, or slightly below the 6.5 minimum 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.

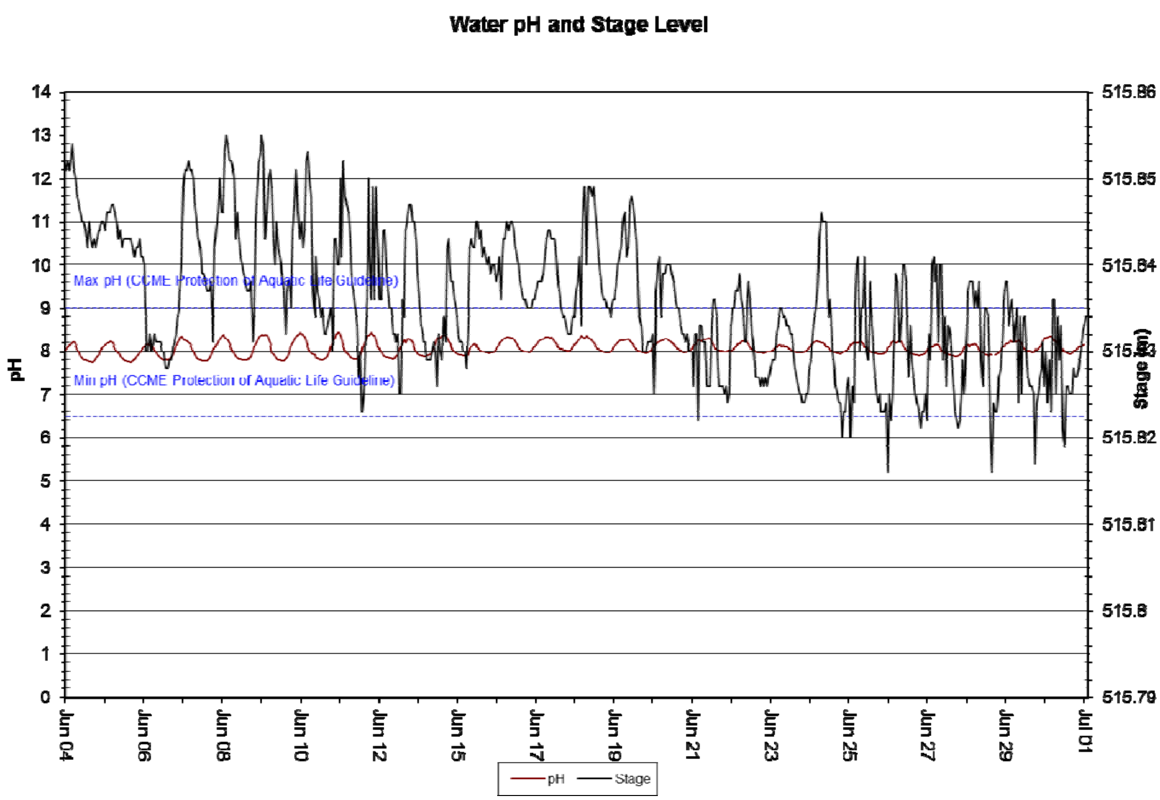

Figure 5: pH values recorded at James Creek from June 4, 2013 to July 1, 2013

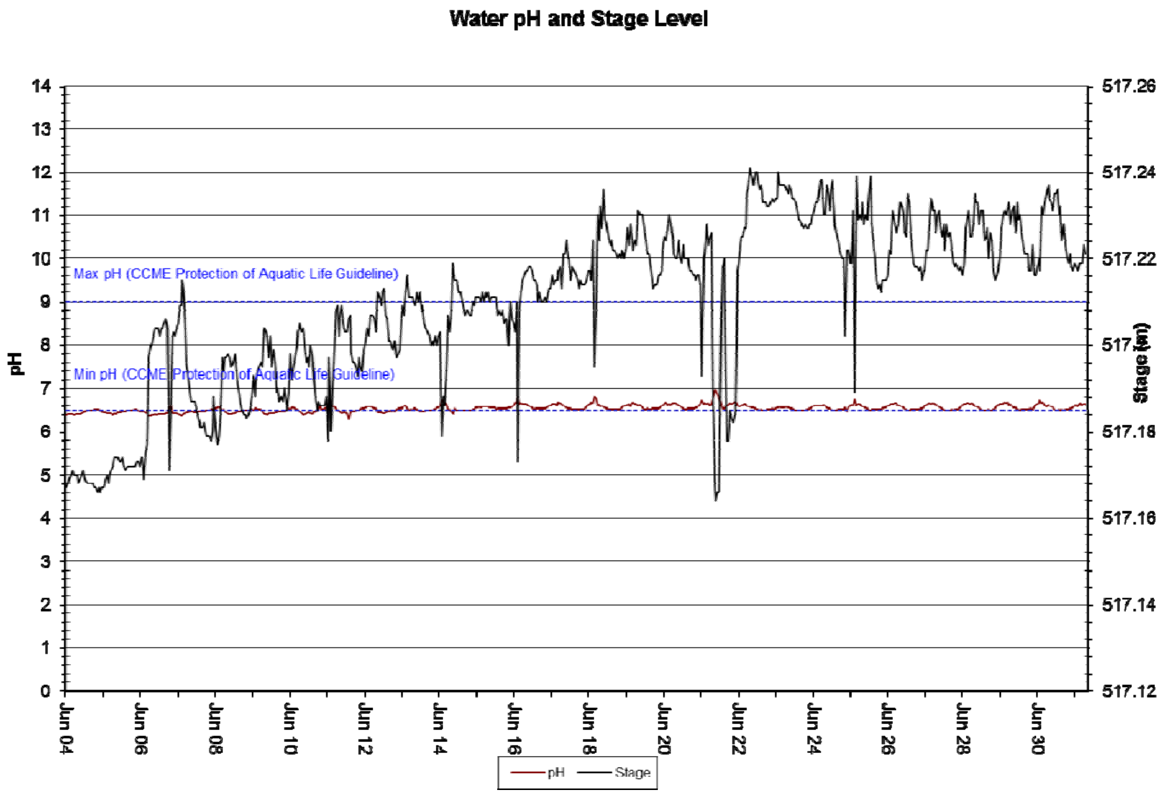

Figure 6: pH values recorded at Unnamed Tributary from June 4, 2013 to July 1, 2013

Specific Conductivity

- Specific Conductivity ranged from 126.7 µS/cm to 148.8 µS/cm at James Creek and from 2.0 µs/cm to 81.8 µS/cm at Unnamed Tributary from June 4, 2013 to July 1, 2013 (Figures 7 & 8).
- Specific conductivity readings were fairly consistent at James Creek during the deployment period; however at Unnamed Tributary they were highly variable. Due to this high variability 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 138.6 µS/cm at James Creek and 46.5 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.

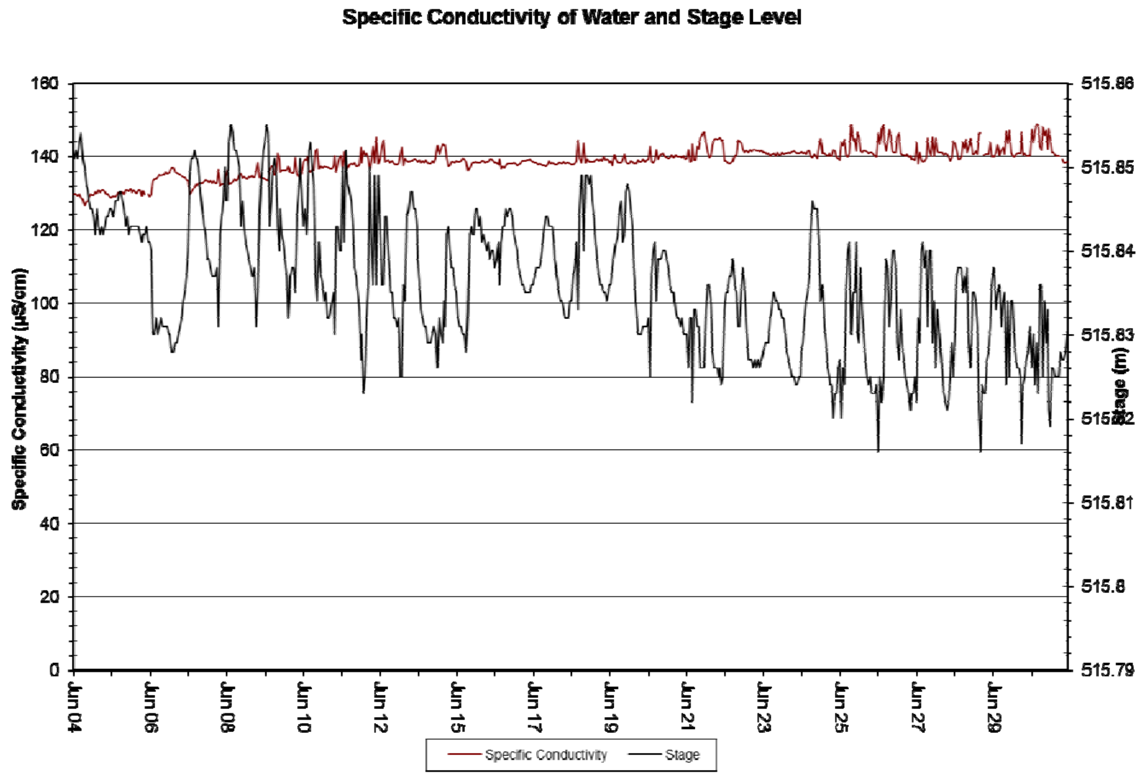

Figure 7: Specific conductivity (µs/cm) at James Creek from June 4, 2013 to July 1, 2013

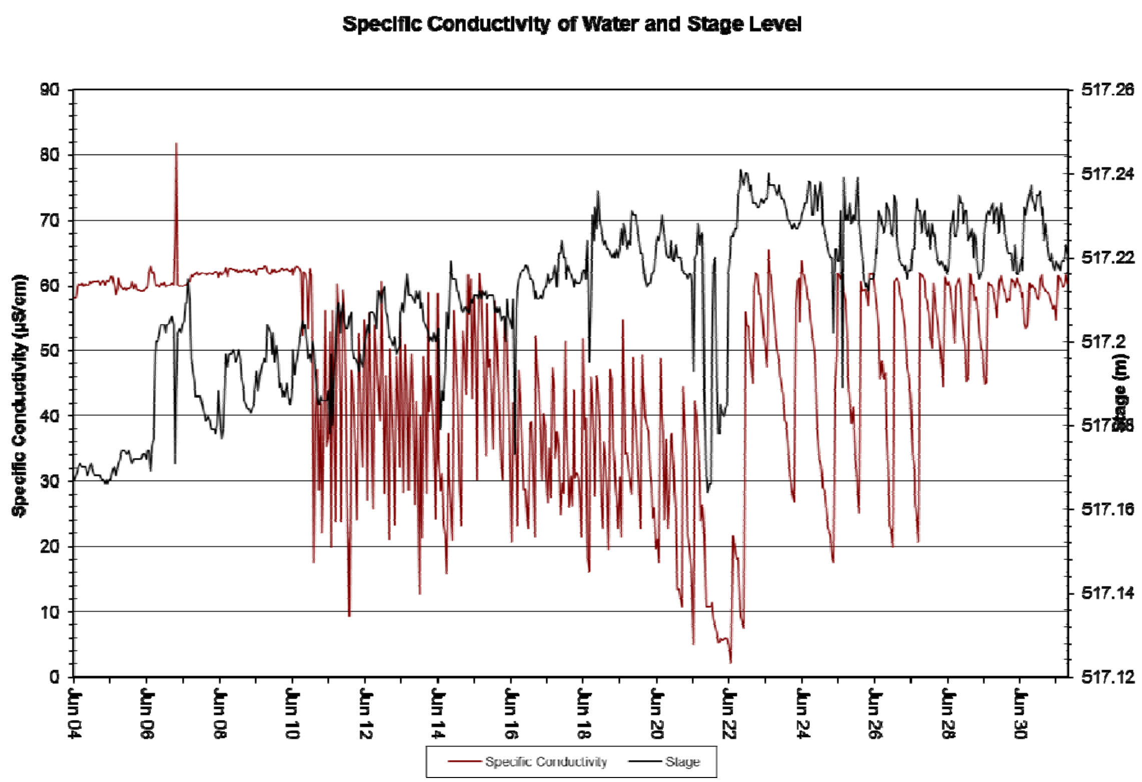

Figure 8: Specific conductivity (µs/cm) at Unnamed Tributary from June 4, 2013 to July 1, 2013

Dissolved Oxygen

- Dissolved Oxygen [DO] values ranged from 10.13 mg/l (94.9% saturation) to 13.98 mg/l (112.3% saturation) at James Creek and from 11.65 mg/l (85.2% saturation) to 14.50 mg/l (110.4% saturation) at Unnamed Tributary from June 4, 2013 to July 1, 2013 (Figures 9 & 10).
- DO (mg/l & % saturation) shows a clear diurnal fluctuation at both James Creek and Unnamed Tributary. These diurnal fluctuations can be attributed to the diurnal temperature fluctuations.
- DO (mg/l & % saturation) remained relatively stable for the duration of the deployment for both James Creek and Unnamed Tributary.
- The DO values at both James Creek and Unnamed Tributary were above the cold water minimum guideline set for aquatic life during early life stages (9.5 mg/l), and above minimum guidelines set for other life stages (6.5 mg/l), as determined by the Canadian Council of Ministers of the Environment (2007).

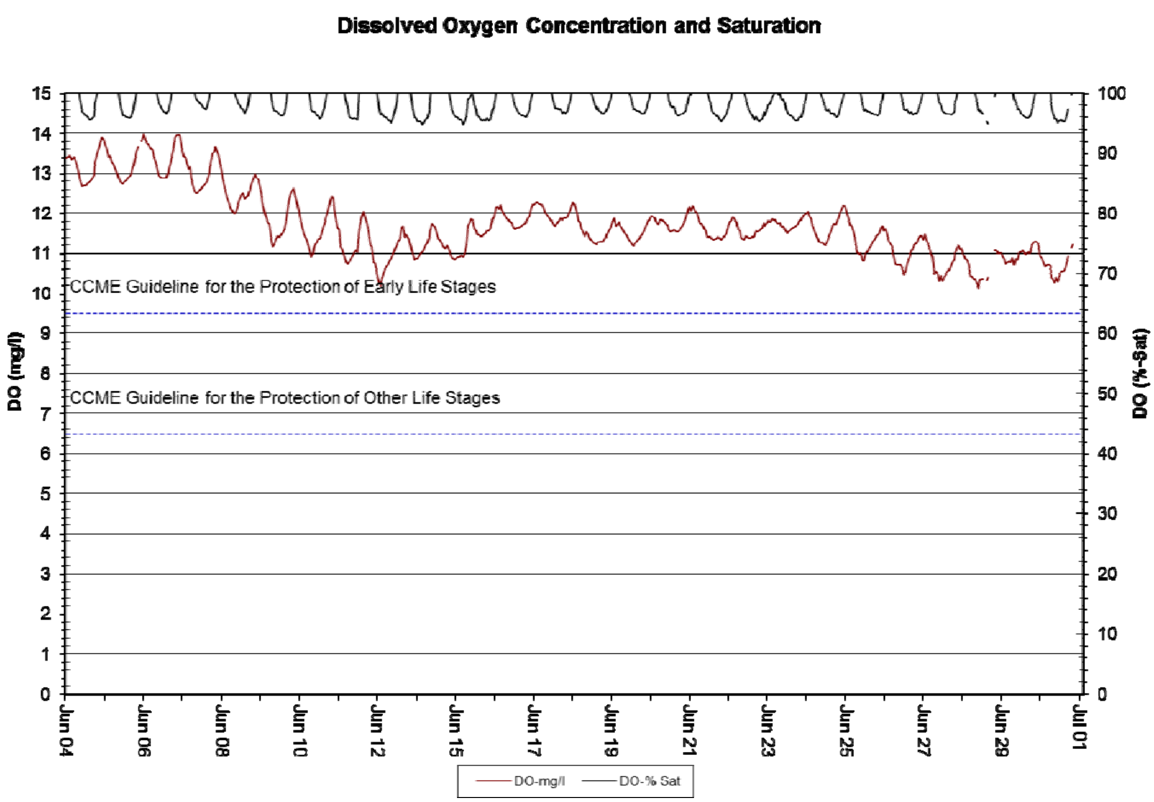

Figure 9: DO (mg/l & % saturation) at James Creek from June 4, 2013 to July 1, 2013

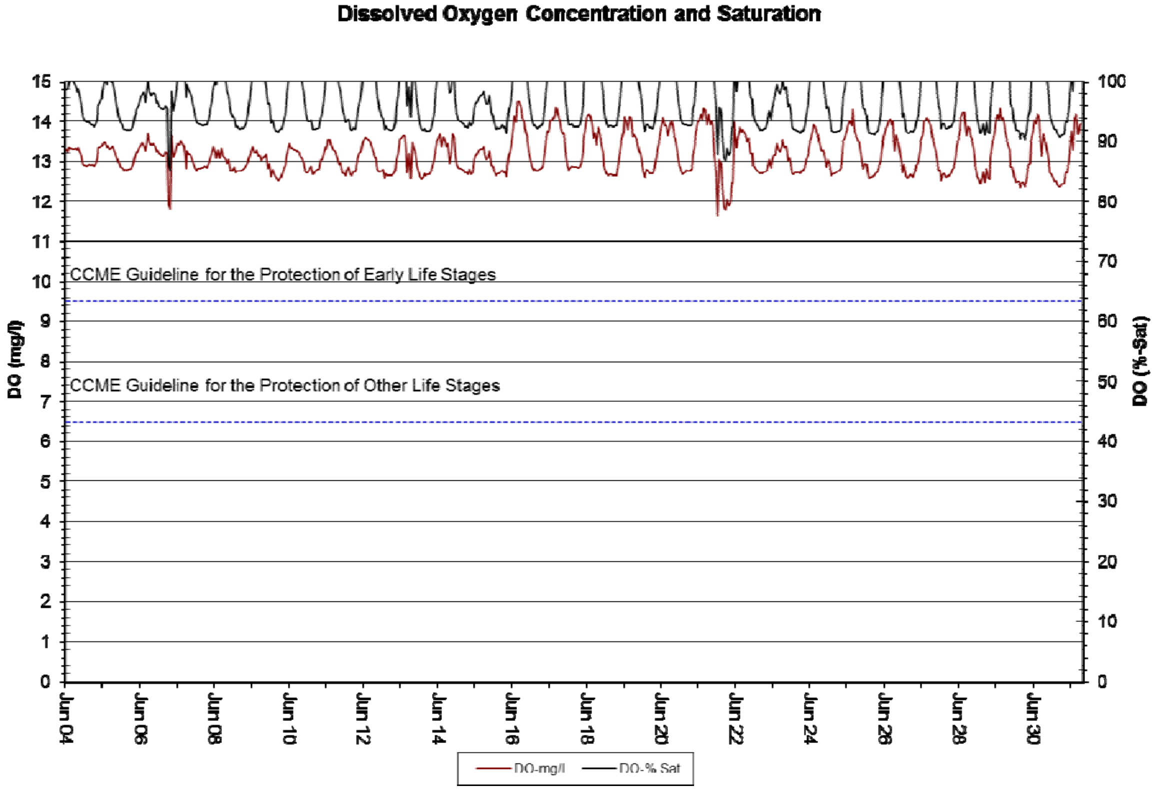

Figure 10: DO (mg/l & % saturation) at Unnamed Tributary from June 4, 2013 to July 1, 2013

Turbidity

- Turbidity values ranged from 1.5 NTU to 2967.0 NTU at James Creek and from 0.0 NTU to 1636.0 NTU at Unnamed Tributary from June 4, 2012 to July 1, 2013 (Figures 11 & 12).
- There were several turbidity events at James Creek and numerous peaks and a sustained period of high turbidity at Unnamed Tributary. Some turbidity events could be attributed to rainfall events, such as the events around June 15 at James Creek (see inside red oval Figure 11) which corresponds with a heavy rainfall event, while others may be related to biofouling which is common at these stations. However, it should be noted that these are impacted sites which experience turbidity in relation to ongoing mining activity.

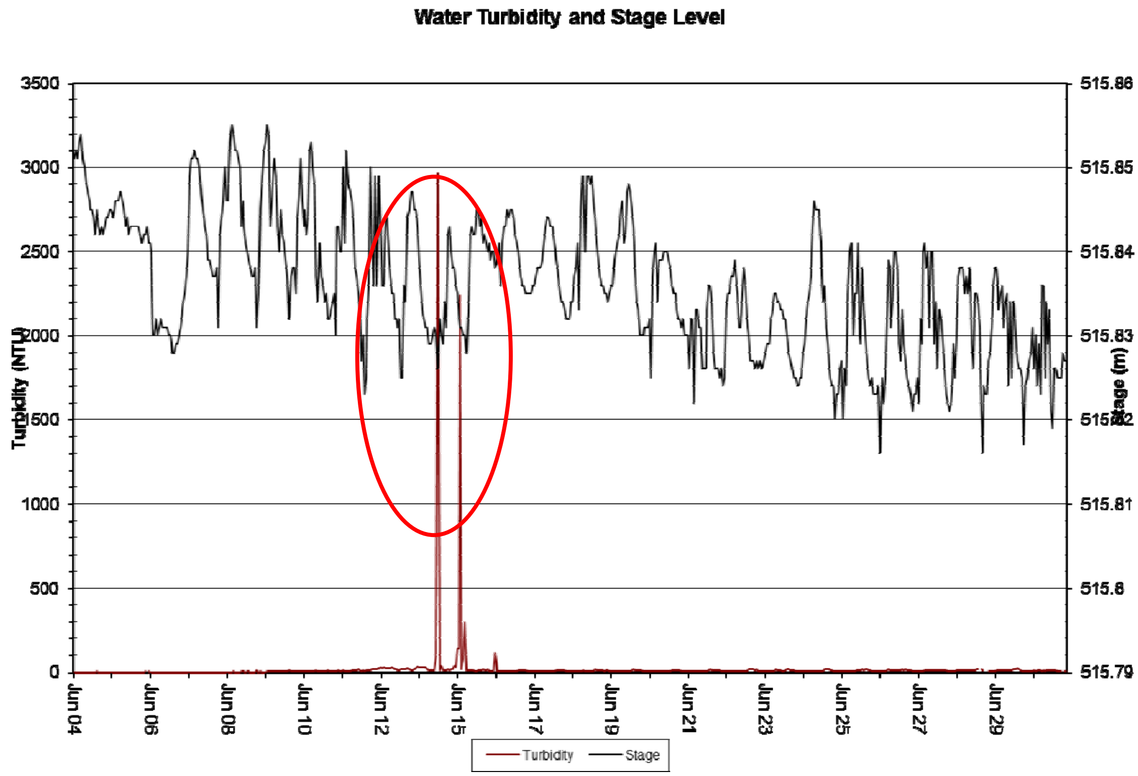

Figure 11: Turbidity (NTU) at James Creek from June 4, 2013 to July 1, 2013

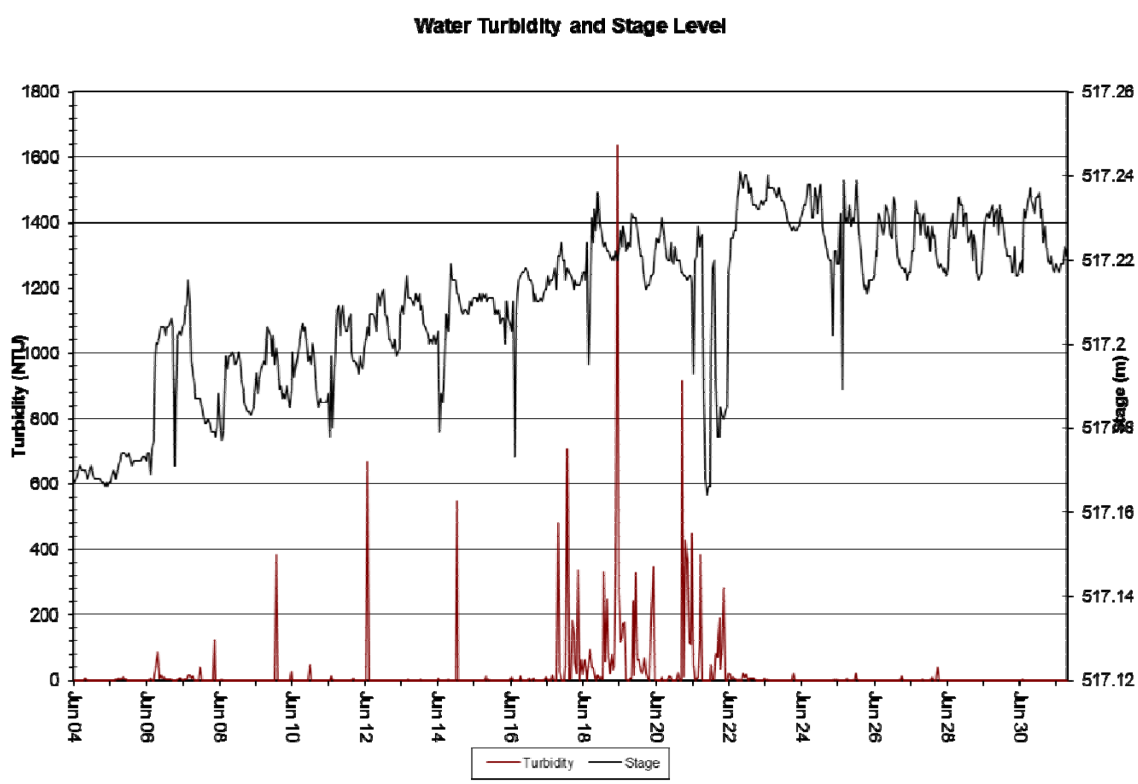

Figure 12: Turbidity (NTU) at Unnamed Tributary from June 4, 2013 to July 1, 2013

Conclusion

- This monthly deployment report presents water quality and water quantity data recorded at the James Creek and Unnamed Tributary stations from June 4, 2013 to July 1, 2013.
- All sensors for both stations were rated good to excellent at the beginning and end of the deployment period.
- Variations in water quality/quantity values recorded at each station are summarized below:
    - For James Creek there appears to be a gentle declining trend in stage height over the duration of the deployment while for Unnamed Tributary the stage height shows a gentle increasing trend.
    - At James Creek there appears to be a slight warming trend over the deployment period while at Unnamed Tributary temperature remains relatively stable over the deployment period. Diurnal fluctuations in water temperature corresponded with fluctuations in air temperature.
    - Water temperatures at the Unnamed Tributary were on average 5.52°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.
    - pH was very stable throughout the deployment period at both James Creek and Unnamed Tributary, however both stations show regular diurnal fluctuations which are related to the diurnal temperature fluctuations.
    - Specific conductivity readings were fairly consistent 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.
    - DO (mg/l & % saturation) remained relatively stable for the duration of the deployment for both James Creek and Unnamed Tributary, however clear diurnal fluctuations were visible. These diurnal fluctuations can be attributed to the diurnal temperature fluctuations.
    - There were several turbidity events at James Creek and numerous peaks and a sustained period of high turbidity at Unnamed Tributary. Some turbidity events could be attributed to rainfall events or biofouling, however it should be noted that these are impacted sites which experience turbidity in relation to ongoing mining activity.

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 (June 4, 2013 to July 1, 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)
6/4/2013	6.2	-2.3	2	16	0	M	M	1.1
6/5/2013	3.9	-2.7	0.6	17.4	0	M	M	0
6/6/2013	4.7	-1.7	1.5	16.5	0	M	M	0.8
6/7/2013	11.5	-0.5	5.5	12.5	0	M	M	0
6/8/2013	17.7	-0.4	8.7	9.3	0	M	M	0
6/9/2013	18.8	-0.2	9.3	8.7	0	M	M	0
6/10/2013	16.5	2.5	9.5	8.5	0	M	M	0
6/11/2013	19.4	1.2	10.3	7.7	0	M	M	0
6/12/2013	20.7	3.5	12.1	5.9	0	M	M	0
6/13/2013	21.4	3.9	12.7	5.3	0	M	M	0
6/14/2013	12.6	0.5	6.6	11.4	0	M	M	0
6/15/2013	7.2	2.7	5	13	0	M	M	23.9
6/16/2013	7.1	0	3.6	14.4	0	M	M	0.5
6/17/2013	7.7	-0.3	3.7	14.3	0	M	M	0
6/18/2013	14.4	-0.6	6.9	11.1	0	M	M	
6/19/2013	16.7	3.9	10.3	7.7	0	M	M	0
6/20/2013	17.4	3.1	10.3	7.7	0	M	M	3.6
6/21/2013	13	0.5	6.8	11.2	0	M	M	0
6/22/2013	10.1	4	7.1	10.9	0	M	M	7.1
6/23/2013	11.1	0.2	5.7	12.3	0	M	M	2
6/24/2013	12.3	-1.1	5.6	12.4	0	M	M	0
6/25/2013	14.1	-0.8	6.7	11.3	0	M	M	0
6/26/2013	18.8	0.8	9.8	8.2	0	M	M	0
6/27/2013	23.3	3.1	13.2	4.8	0	M	M	0
6/28/2013	24.9	5.6	15.3	2.7	0	M	M	0
6/29/2013	23.9	6.1	15	3	0	M	M	0
6/30/2013	23.4	8.5	16	2	0	M	M	0.5
7/1/2013	11.3	5.2	8.3	9.7	0	M	M	4.6