General

- The Water Resources Management Division staff monitors the real-time web page on a daily basis.
- NALCOR Energy will be informed of any significant water quality events in the form of a monthly deployment report.
- This monthly deployment report interprets the data from all 4 water quality monitoring stations along the Lower Churchill River. These stations are located 6.15km below lower Muskrat Falls, above Muskrat Falls, below Grizzle Rapids and below Metchin River. The 4 real-time water quality stations were deployed on June 24 to July 20, 2009, a period of 26 days.
- 3 of 4 stations experienced a transmission error from July 8 at 7:30pm to July 11, at 7:30pm. This event was due to an error with the type of data logger at stations below Muskrat Falls, below Grizzle Rapids and below Metchin River. The VEDAS II data logger has now been replaced with the SAT LINK II data logger at each of these Churchill River Stations. Missing data between the above mentioned dates was successfully retrieved from log files set to log data internally from Datasondes s/n 45707 and s/n 45699 at station below Metchin River and below Grizzle rapids respectively. The log file on Datasonde s/n 45700, deployed below Muskrat Falls failed to activate, therefore data for these three days has been lost.
- During the deployment period, the Upper Muskrat Falls station and below Metchin River experienced a dramatic decrease in stage level, leaving the instrument exposed to air on the beach. Data collected between July 4 and 16 at the Upper Muskrat station data and between July 4 and 20 at the station below Metchin River is extraneous. At the Upper Muskrat station, during a visit by Environment Canada on July 16, staff placed the instrument which was exposed on the beach back in the water. QA/QC values were taken to investigate the impact of an exposed instrument being reemerged in the water. During this visit at both stations Above Upper Muskrat Falls and Below Metchin River, conduit and cable lengths were extended 7m to allow the instrument to be deployed deeper in the water when the stage level is very low.

Quality Assurance and Quality Control

- As part of the installation and removal process, parameters are recorded from both the field sonde (in situ) and a similar, newly-calibrated QA sonde (placed side by side). The parameters from both instruments are compared and their variability is ranked as part of the QA/QC protocol (see Table 1).
- At the Lower Muskrat station, QA/QC comparisons report temperature, pH, specific conductivity and dissolved oxygen ranking “good” or “excellent” at installation and removal. Turbidity was ranked “poor” at installation likely caused by disturbance to the silty bottom when entering the water to retrieve the QA/QC values. Turbidity was ranked “excellent” at removal on July 20, 2009.
- At the Upper Muskrat station, all parameters are ranked “excellent” or “good” at installation. At removal, temperature, specific conductivity and dissolved oxygen are still ranked “excellent” or “good” despite the instrument being exposed for 12 days. pH and turbidity are ranked “marginal”. The discrepancy in pH and turbidity is likely due to the instrument being exposed to air for such a long period of time.

- The station below Grizzle Rapids reported "excellent" or "good" rankings for all parameters except turbidity at installation. An error while performing the 2 point calibration on the turbidity sensor caused the instrument to report 50 NTU to turbidity throughout the entire deployment period and therefore the QAQC ranking at removal is also ranked poor. Temperature, specific conductivity and dissolved oxygen are ranked "excellent" or "good" at removal. pH is ranked "poor". This may be due to pH sensor drift throughout the deployment period.
- All parameters at installation at the station below Metchin River were ranked "excellent" or "good". No QA/QC values were taken at the time of removal as the instrument was exposed to air on the beach.

Table 1: QA/QC Data Comparison Rankings upon installation on June 24 and removal on July 20, 2009.

				Instrument Comparison Ranking				
Churchill River Station	Date	Action	Instrument Serial Number	Temperature	pH	Specific Conductivity	Dissolved Oxygen	Turbidity
Below Muskrat Falls	24-Jun-09	Installation	45700	Good	Excellent	Excellent	Excellent	Fair
	20-Jul-09	Removal		Excellent	Good	Excellent	Excellent	Excellent
Above Muskrat Falls	24-Jun-09	Installation	47589	Excellent	Excellent	Excellent	Excellent	Good
	20-Jul-09	Removal		Good	Marginal	Excellent	Excellent	Marginal
Below Grizzle Rapids	24-Jun-09	Installation	45699	Excellent	Good	Excellent	Excellent	Poor
	20-Jul-09	Removal		Good	Poor	Excellent	Excellent	Poor
Below Metchin River	24-Jun-09	Installation	45707	Good	Excellent	Excellent	Excellent	Excellent
	20-Jul-09	Removal		Instrument out of water. No QA/QC taken.				

Data Interpretation

Churchill River 6.15km below Lower Muskrat Falls

For this station, data between July 8 and 11 are missing and could not be retrieved through a log file.

Temperature

Generally temperature increases slightly throughout the deployment period (Figure 1). The initial spike in temperature at the very beginning of the deployment is before the new instrument is deployed on June 24. Temperature ranges between 9.48 and 17.98 °C, averaging at 13.78 °C.

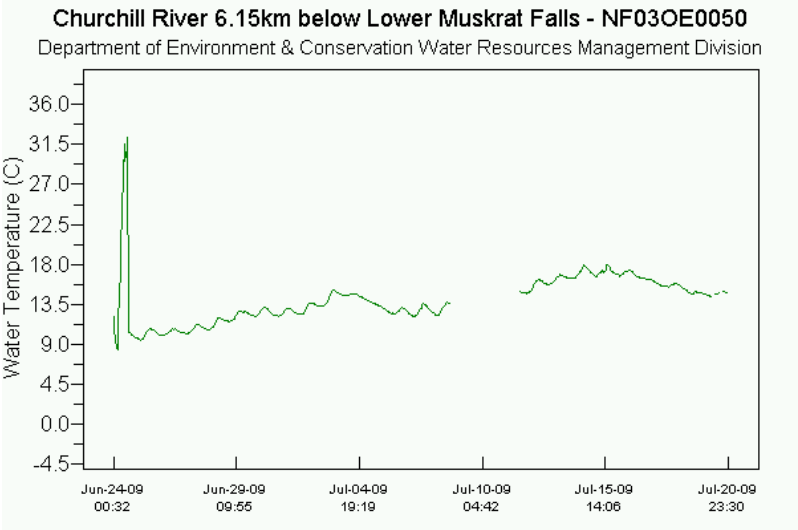

Figure 1: Water temperature for Lower Muskrat Falls Station, June 24 to July 20, 2009.

pH

pH remains relatively stable throughout the deployment period just inside the lower acceptable limit for pH as suggested by the CCME Guidelines for the Protection of Aquatic Life (Figure 2). The spike at the beginning is during the instrument switch out on June 24. pH ranges between 6.21 and 7.14 units, averaging at 6.8 units.

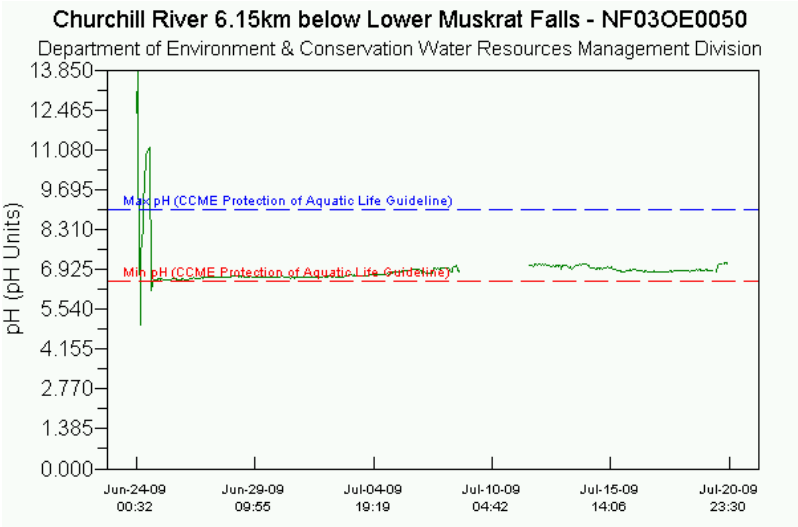

Figure 2: pH for Lower Muskrat Falls Station, June 24 to July 20, 2009.

Specific Conductivity and Total Dissolved Solids

Specific conductance continues showing a general increasing trend throughout the deployment period with values ranging from 14.9 µS/cm to 21.2 µS/cm (Figure 3).

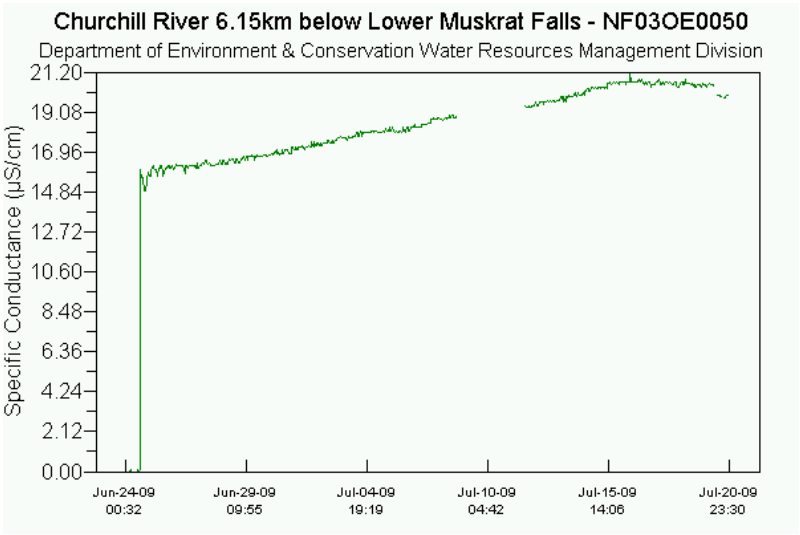

Figure 3: Specific Conductivity for Lower Muskrat Falls Station, June 24 to July 20, 2009.

Total dissolved solid concentrations are derived from specific conductance and show a similar pattern throughout the deployment period with values ranging between 0.010 g/L and 0.014 g/L.

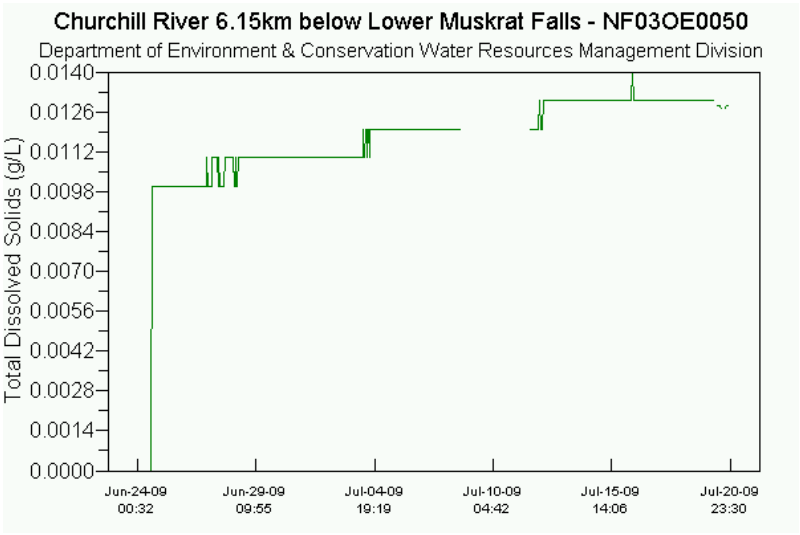

Figure 4: Specific Conductivity for Lower Muskrat Falls Station, June 1 to 24, 2009.

Dissolved Oxygen and Percent Saturation

Dissolved oxygen content remains stable throughout the deployment period ranging between 10.28mg/L and 12.38 mg/L (Figure 5). All values are above the lower acceptable limit of 9.0mg/L as per the CCME Guidelines for the Protection of Aquatic Life.

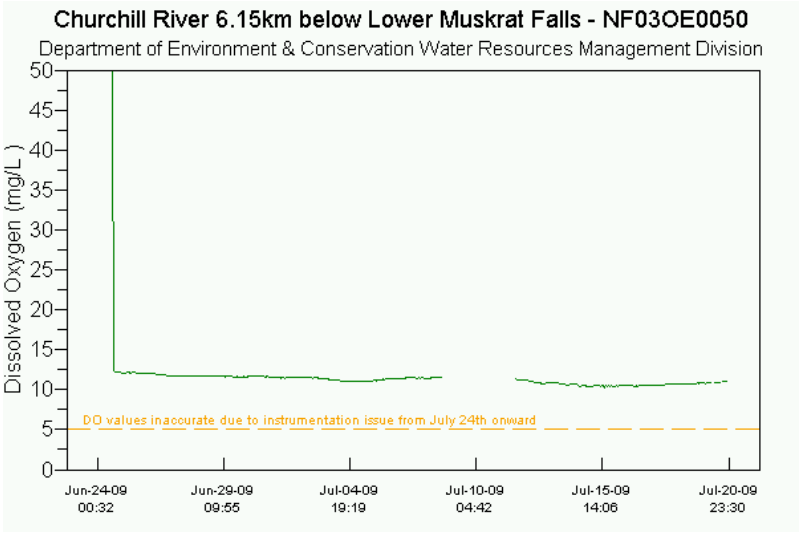

Figure 5: Specific Conductivity for Lower Muskrat Falls Station, June 24 to July 20, 2009.

Percent saturation values also remain stable ranging between 103.1% and 113.1% for the duration of the deployment period (Figure 6).

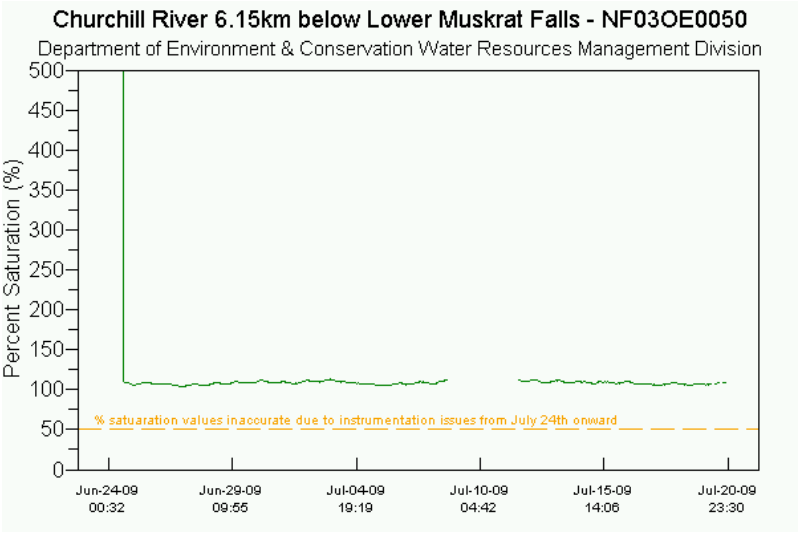

Figure 6: Specific Conductivity for Lower Muskrat Falls Station, June 24 to July 20, 2009.

Turbidity

Turbidity values range between 8.4 and 188.9 NTU throughout the deployment period (Figure 7). It is expected at this station that the turbidity be elevated as the water is visible cloudy and the river bottom very silty. A few spikes in turbidity are experienced on June 26, July 5 and July 17 and correspond with rainfall events in the area (Appendix 1).

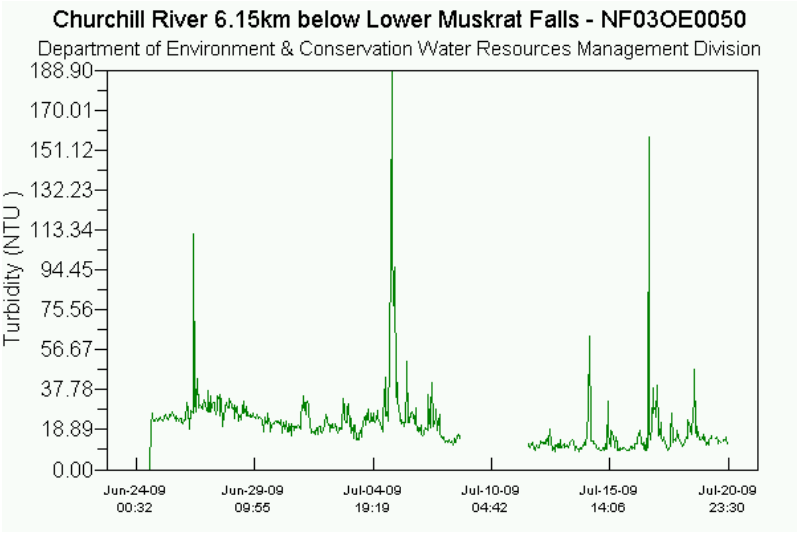

Figure 7: Turbidity for Lower Muskrat Falls Station, June 24 to July 20, 2009.

Stage

Stage values continue to decrease throughout the month of July (Figure 8). When the instrument was deployed, stage level was at 2.646m. When the instrument was retrieved, the stage level was at 2.235m, and had dropped to as low as 2.1477m during the deployment.

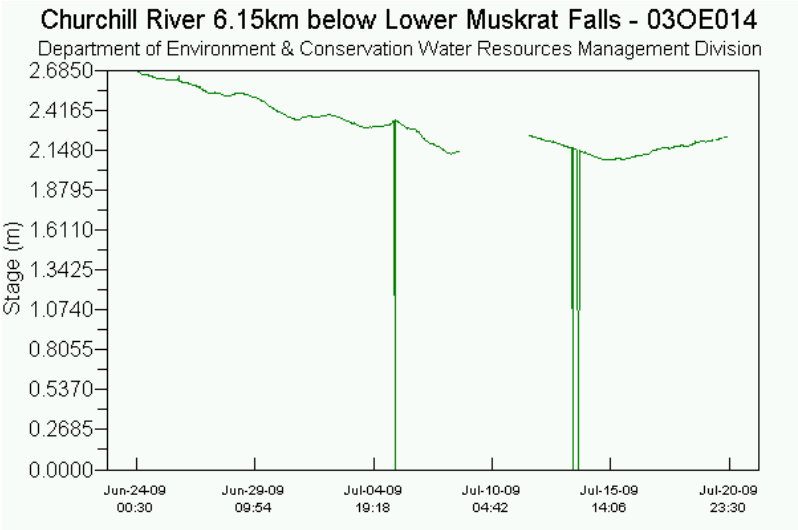

Figure 8: Stage Level for Lower Muskrat Falls Station, June 24 to July 20, 2009.

Churchill River above Upper Muskrat Falls

All data collected between July 4 and July 16 at this station will not be included in the summary statistics as the instrument was exposed to air, not water. Red lines indicate when the instrument was out of the water.

Temperature

Temperature values recorded above Upper Muskrat Falls remain stable throughout the deployment period until the instrument became exposed (Figure 9). The spike at the beginning is from the last day of the previous deployment where the instrument was exposed. Temperature values range between 12.03°C and 17.62°C, averaging at 14.13°C during the July deployment.

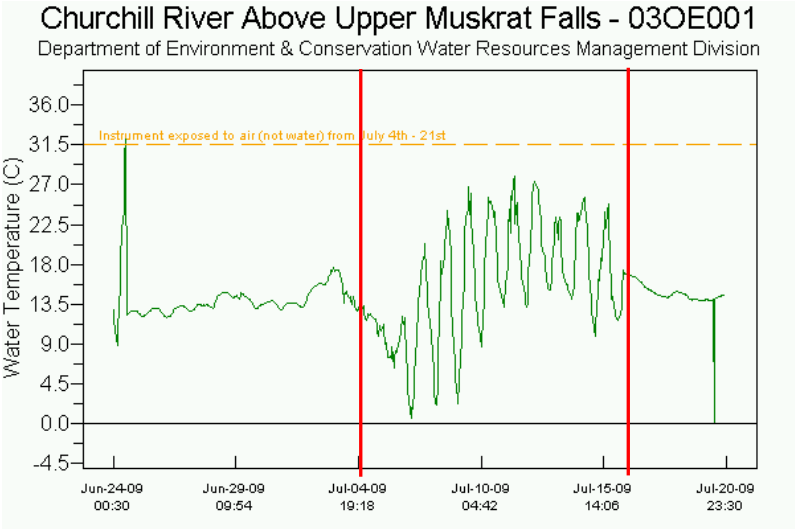

Figure 9: Water Temperature for Upper Muskrat Falls Station, June 24 to July 20, 2009.

pH

pH values collected between June 24 and July 4 at this station remain stable ranging between 7.74 and 6.59 units averaging 7.12 units (Figure 10). Once the instrument is put back in the water on July 16, pH values appear similar ranging between 7.07 and 7.35 averaging at 7.25 units. This indicates that the exposure to air did not likely have significant effects on the pH sensor.

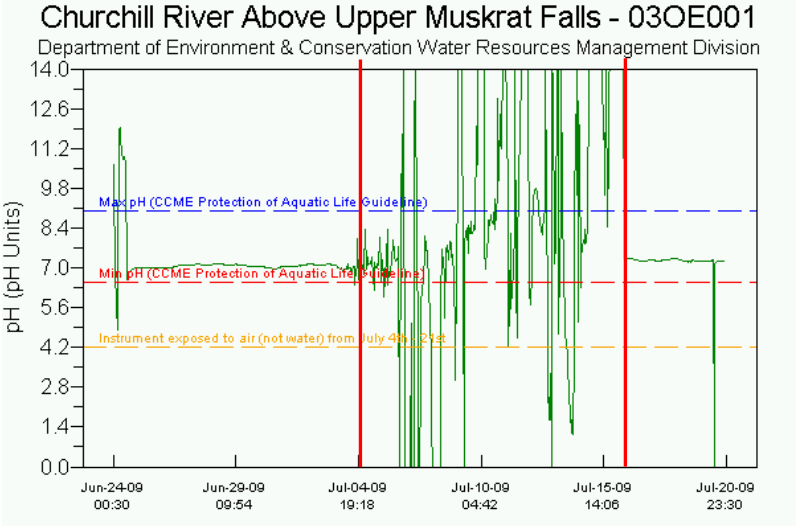

Figure 10: pH for Upper Muskrat Falls Station, June 24 to July 20, 2009.

Specific Conductivity and Total Dissolved Solids

Specific conductance is increasing for the first week of the deployment before exposure to air with values ranging between 16.2 and 21.6µS/cm averaging 17.45µS/cm (figure 11). When specific conductance begins recording again on July 16, values are on average higher (20.80µS/cm) however it is inconclusive whether or not this has to do with the general increasing trend of the data or due to error of the conductivity sensor from exposure.

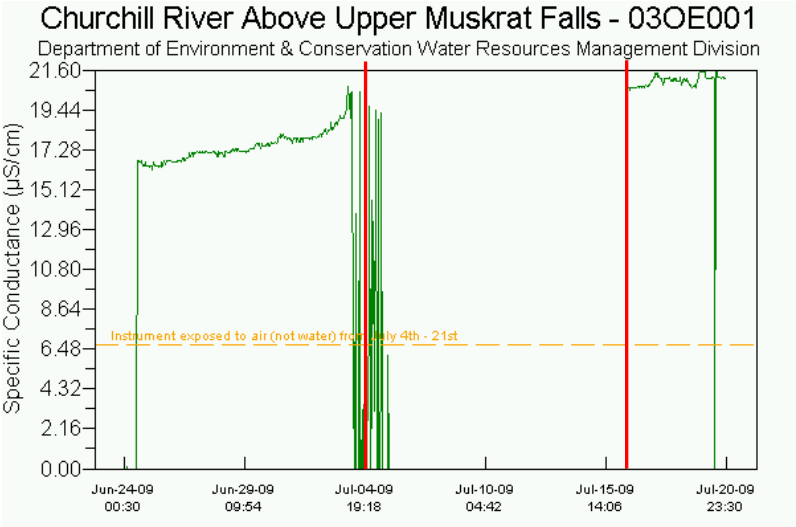

Figure 11: Specific Conductance for Upper Muskrat Falls Station, June 24 to July 20, 2009.

Total dissolved solid concentrations in the water column are derived from the specific conductance. Values range between 0.0104g/L and 0.0139g/L during the time the instrument was submerged (Figure 12).

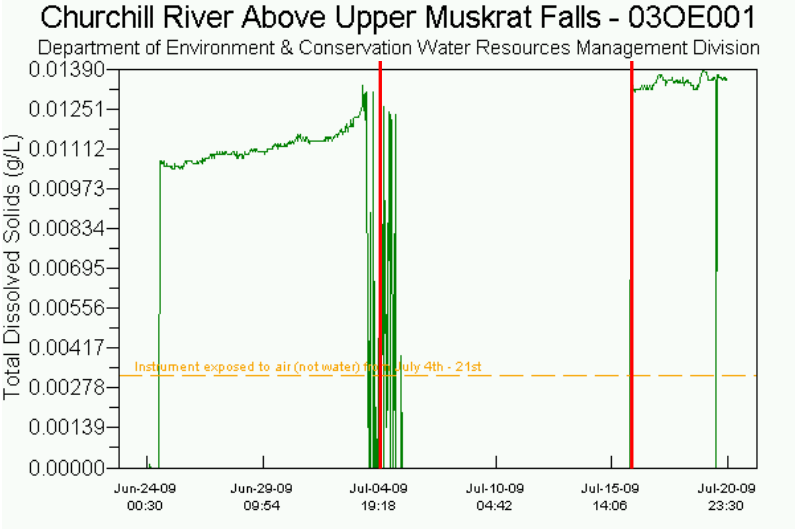

Figure 12: Total Dissolved Solids for Upper Muskrat Falls Station, June 24 to July 20, 2009.

Dissolved Oxygen and Percent Saturation

Dissolved Oxygen data between June 24 and July 4 remain stable and always above the lower limit of 9.0mg/L according to the CCME Guidelines for the Protection of Aquatic Life (Figure 13). Values range between 9.68mg/L and 10.86mg/L, averaging 10.38mg/L. After July 16, when the instrument is placed back in the water, values for dissolved oxygen are similar, averaging 9.66mg/L. This is likely accurate as the water temperature was also warmer during this time as well (14.71°C between July 16 and July 20 as compared to 13.08°C between June 26 and July 4). The dissolved oxygen sensor does not appear to be significantly affected by the exposure to air.

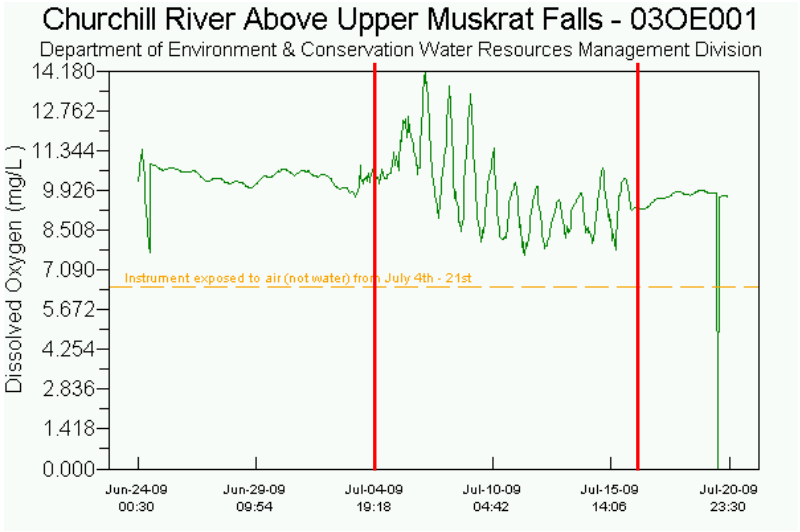

Figure 13: Dissolved Oxygen for Upper Muskrat Falls Station, June 24 to July 20, 2009.

Percent saturation remains stable throughout the deployment period with values ranging between 94.0% and 104.3% (Figure 14).

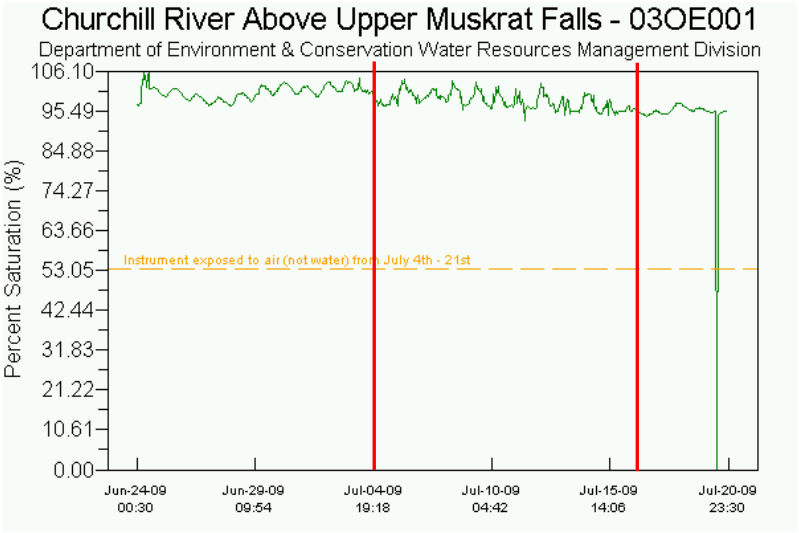

Figure 14: Percent Saturation for Upper Muskrat Falls Station, June 24 to July 20, 2009.

Turbidity

The first part of the deployment period, turbidity values range between 16 and 72 NTU (Figure 15). This is expected as water is visibly cloudy and the river bottom is very silty at this station. A few spikes are visible on the graph around July 3 and July 5. These spikes are likely due to instrument error. On July 3, the instrument would have been just under the surface before being exposed the following day. It is likely wave action on the instrument at the shore causing these spikes in turbidity to be recorded. By July 5, the instrument is exposed therefore the second spike is extraneous. When the turbidity sensor begins recording measurements when the instrument is placed back in the water on July 16, values range between 15 and 48NTU. This is comparable to the measurements at the beginning of the deployment indicating the exposure to air for 12 days did not significantly impact the functioning of the turbidity sensor.

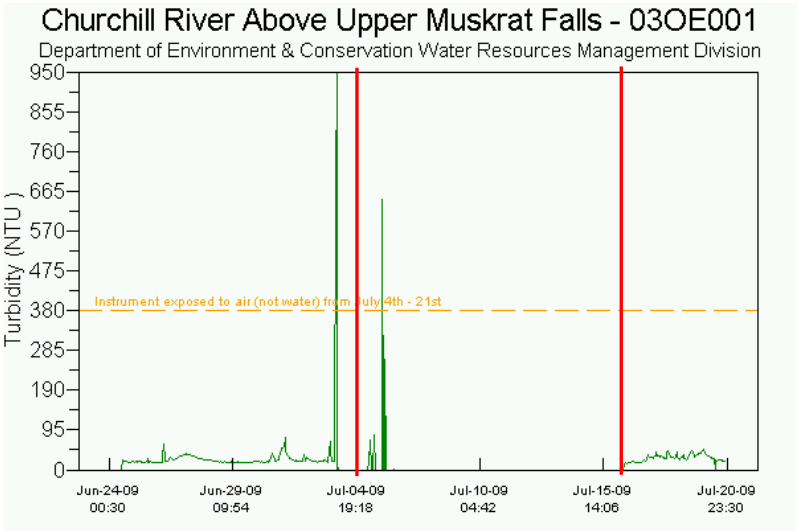

Figure 15: Turbidity for Upper Muskrat Falls Station, June 24 to July 20, 2009.

Stage

Stage level at the beginning of the deployment was 16.248m (Figure 16). At the time the instrument was exposed, stage had dropped to 15.567m, a difference of 68.1cm. Stage dropped to as low as 15.220m on July 15. At the time the instrument was retrieved the water level had increase slightly from this value to 15.589m. Stage levels are being carefully noted during this year in order to prevent the instrument from being exposed during future deployments.

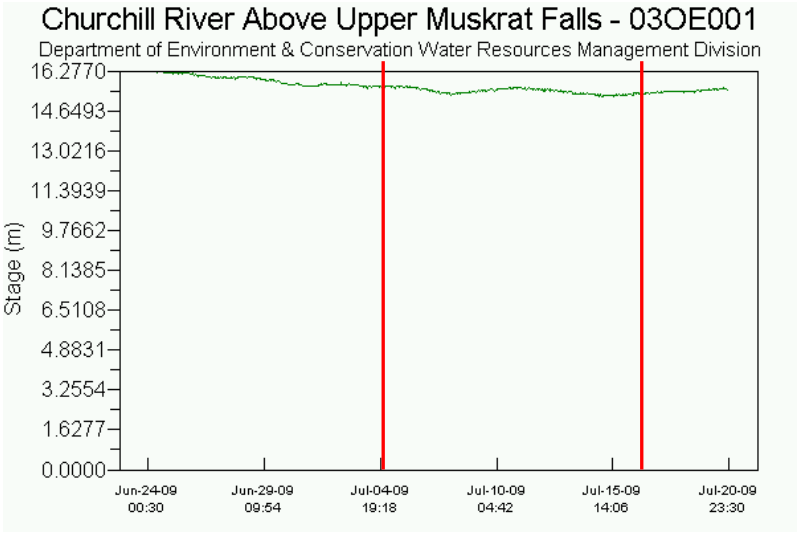

Figure 16: Stage level for Upper Muskrat Falls Station, June 24 to July 20, 2009.

Churchill River below Grizzle Rapids

Data collected from July 8 at 7:30pm to July 11 at 7:30pm was retrieved from the log file. Graphs were created in MS Excel to incorporate this data.

Temperature

Temperature values fluctuate throughout the deployment period clearly showing a diurnal pattern of increased temperatures throughout the day time (Figure 14). Values range between 6.59°C and 21.31°C averaging at 14.14°C.

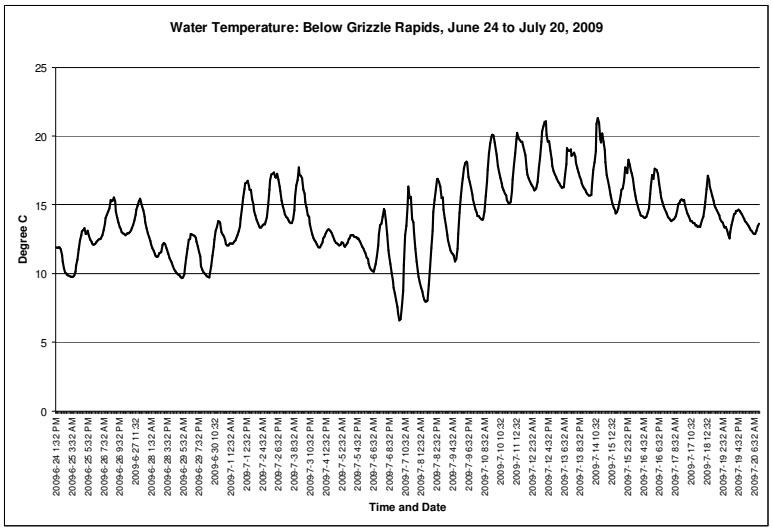

Figure 17: Water Temperature below Grizzle Rapids, June 24 to July 20, 2009.

pH

pH values remain constant throughout the deployment period ranging between 6.95 and 7.72 units (Figure 18). These values are within the acceptable limits for pH according to the CCME Guideline for the Protection of Aquatic Life.

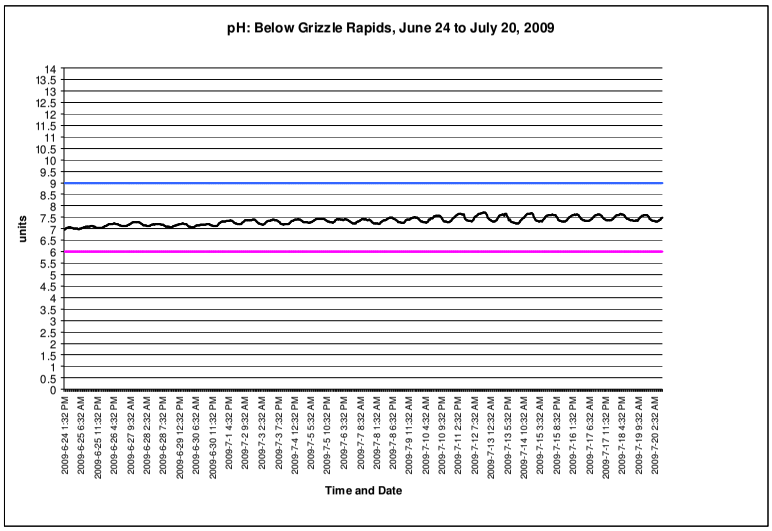

Figure 18: pH below Grizzle Rapids, June 24 to July 20, 2009.

Specific Conductivity

Specific conductivity values display a slight increasing trend through out the deployment period. Values range between 16.1 µS/cm and 22 µS/cm (Figure 19).

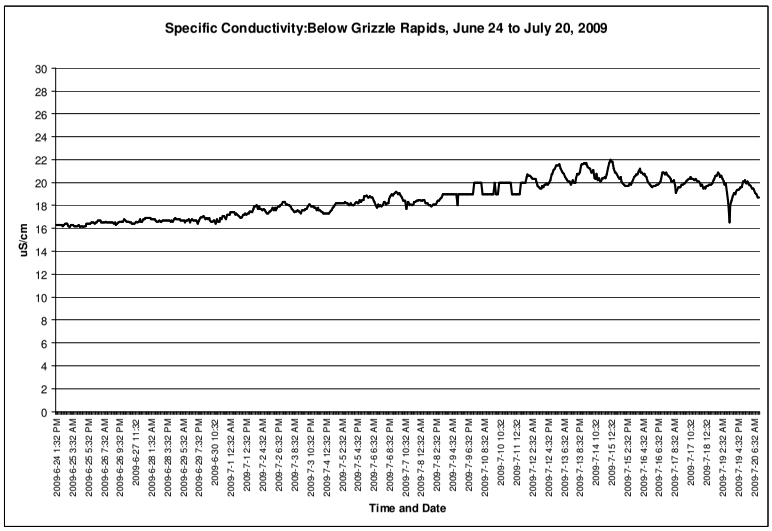

Figure 19: Specific Conductance below Grizzle Rapids, June 24 to July 20, 2009.

Total dissolved solid concentration mirror the increases in specific conductance (Figure 20). TDS values are unavailable from the log file between July 8 and July 11.

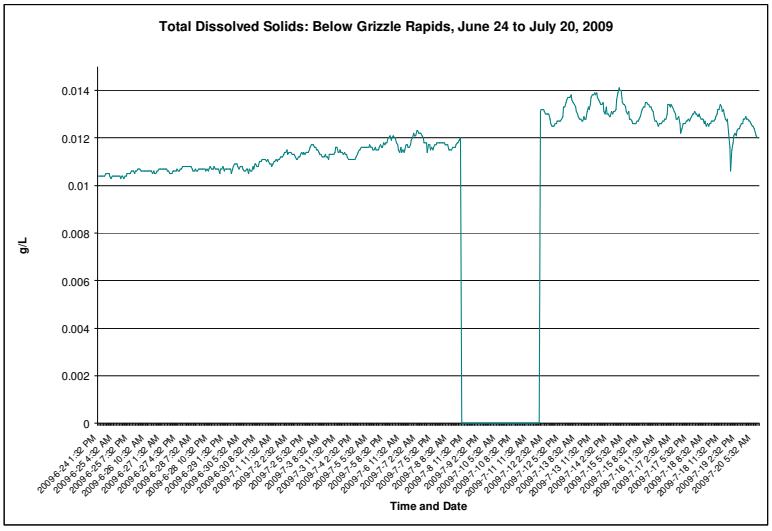

Figure 20: Total Dissolved Solids below Grizzle Rapids, June 24 to July 20, 2009.

Dissolved Oxygen and Percent Saturation

Dissolved oxygen values range from 8.87mg/L and 11.7mg/L during the deployment period (Figure 21). Between July 12 and July 14, dissolved oxygen values dipped slightly below the lower acceptable limit (9.0mg/L) for dissolved oxygen content in cold waters.

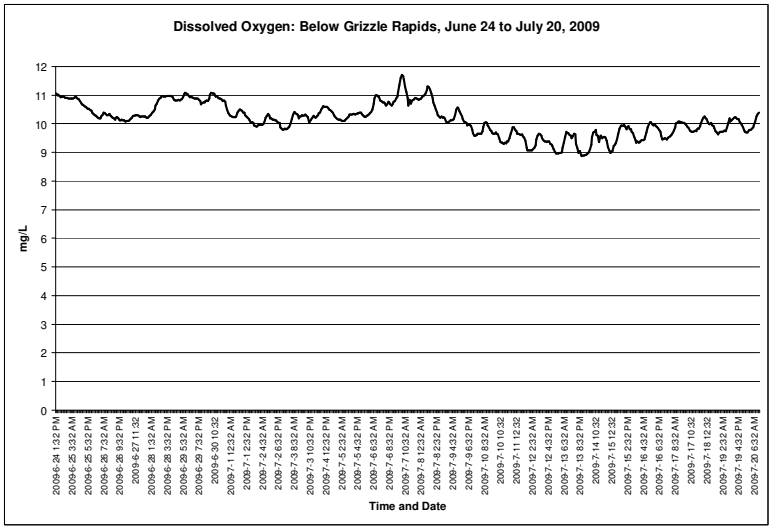

Figure 21: Dissolved Oxygen below Grizzle Rapids, June 24 to July 20, 2009.

Percent saturation fluctuates daily between 89.9% and 108.7% (Figure 22)

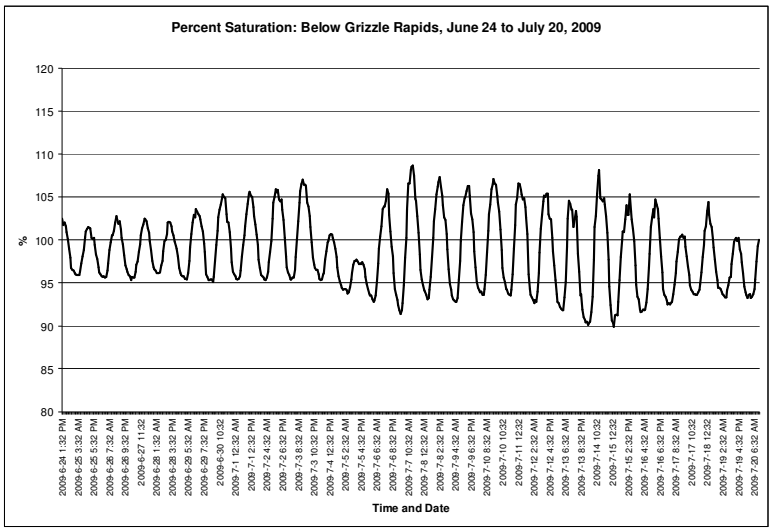

Figure 22: Percent Saturation below Grizzle Rapids, June 24 to July 20, 2009.

Turbidity

Due to an issue while calibrating the turbidity sensor on this instrument (s/n 45699), the turbidity sensor failed to capture any information. The sensor reported 50NTU for the entire deployment period which is the value of the solution used to calibrate the instrument. The issue has been rectified and the instrument is ready for its next deployment.

Stage

Stage level decreased throughout the deployment period (Figure 23). At the beginning of the deployment, stage level was recorded at 33.105m. When the instrument was retrieved, stage had dropped to 32.830m. During the deployment stage level dropped as low as 32.741m.

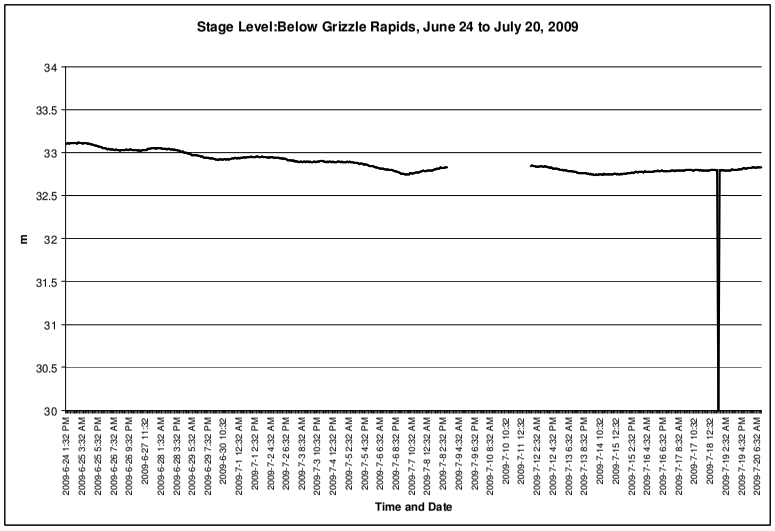

Figure 23: Stage level below Grizzle Rapids, June 24 to July 20, 2009.

Churchill River below Metchin River

The instrument was exposed to air at this site between July 4 and July 20, therefore these values are not included in the summary statistics. The red line indicates when the instrument became exposed. Data lost during the transmission error has been recovered from the log file.

Temperature

Temperature is increasing slightly throughout the beginning of the deployment period and clearly showing a diurnal fluctuation of increased water temperatures during the day. The temperature between June 26 and July 4 averages 15.01°C, ranging between 12.47°C and 20.54°C.

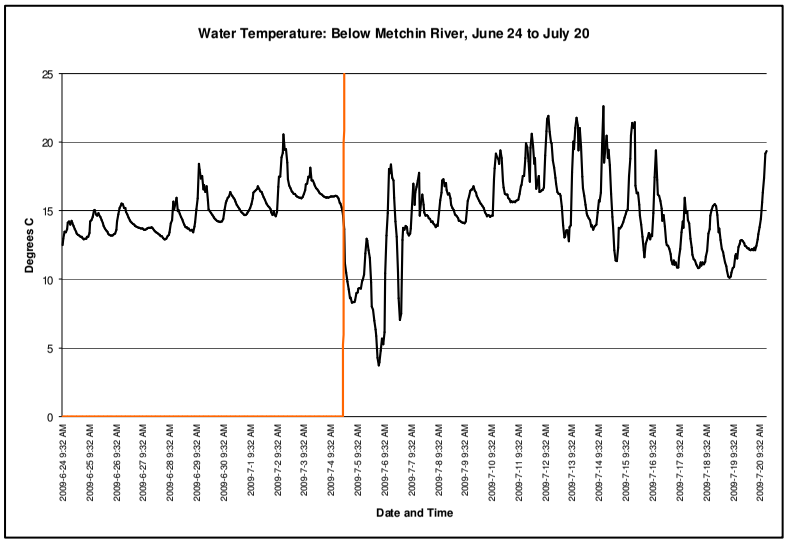

Figure 24: Water Temperature below Metchin River, June 24 to July 20, 2009.

pH

pH values remain constant throughout the deployment period between June 24 and July 4 (Figure 25). Values range between 6.99 and 7.37 units. These values are within the acceptable limits for pH according to the CCME Guideline for the Protection of Aquatic Life.

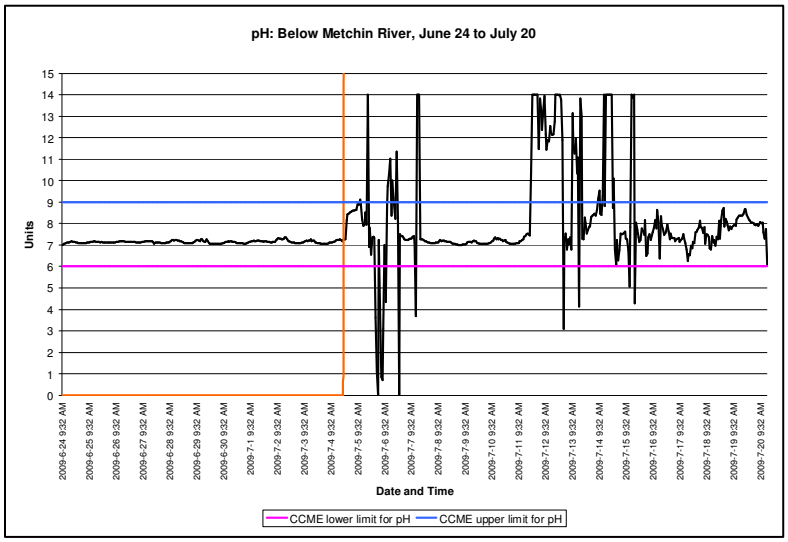

Figure 25: pH below Metchin River, June 24 to July 20, 2009.

Specific Conductivity

Specific conductivity values fluctuate throughout the first part of the deployment period between June 24 and July 4 with values ranging between 14.6µS/cm and 34.5µS/cm. (Figure 26). There is a significant spike in conductivity (up to 34.5µS/cm) around June 29. The spike is likely caused by a rainfall event recorded in the Churchill Falls area that lasted nearly 3 days and amounted to over 25mm of precipitation (Appendix 1). Another spike is recorded later in the deployment on July 2 (up to 29.1µS/cm), before the instrument became exposed. This event is also likely caused by a precipitation event.

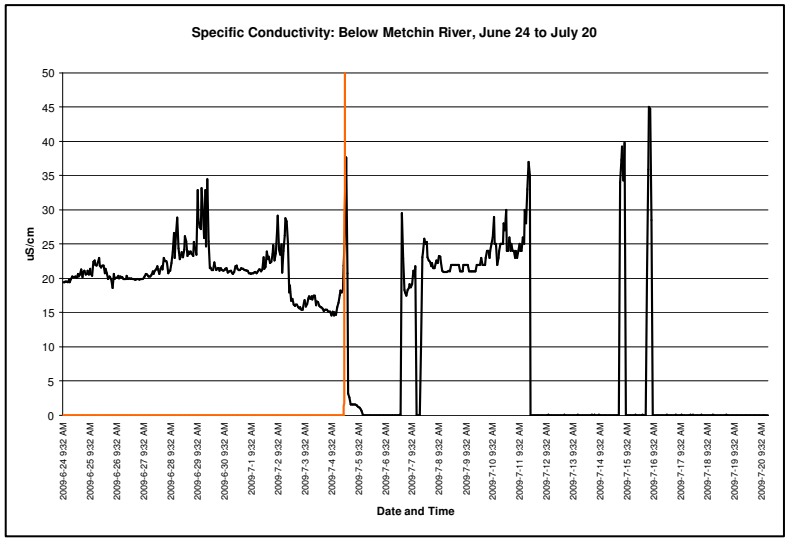

Figure 26: Specific Conductance below Metchin River, June 24 to July 20, 2009

Total Dissolved solid concentrations are derived from specific conductance (Figure 27). Values range between 0.009g/L and 0.022g/L.

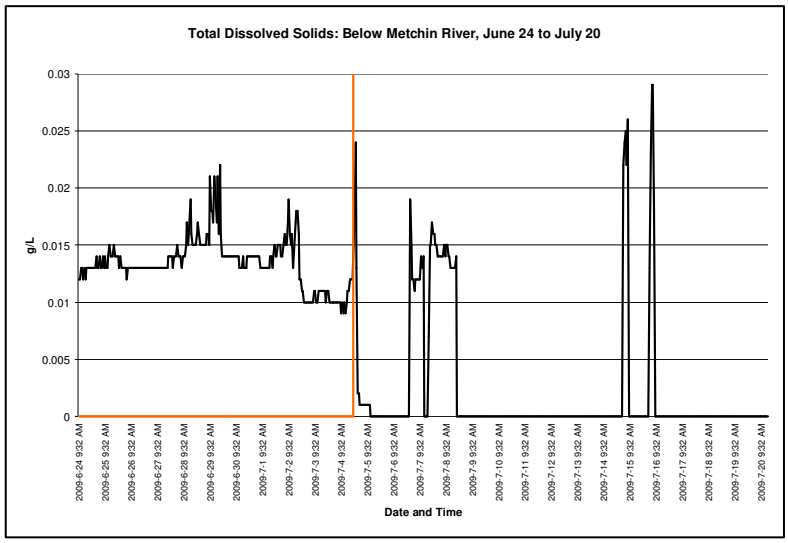

Figure 27: Total Dissolved Solids below Metchin River, June 24 to July 20, 2009.

Dissolved Oxygen and Percent Saturation

Dissolved oxygen values show a decreasing trend between June 24 and July 4. This trend is expected due to the increasing water temperature (Figure 24, 28). Dissolved oxygen values range between 10.82mg/L and 9.24mg/L. This is above the lower acceptable limit for dissolved oxygen content in cold waters (9.0mg/L).

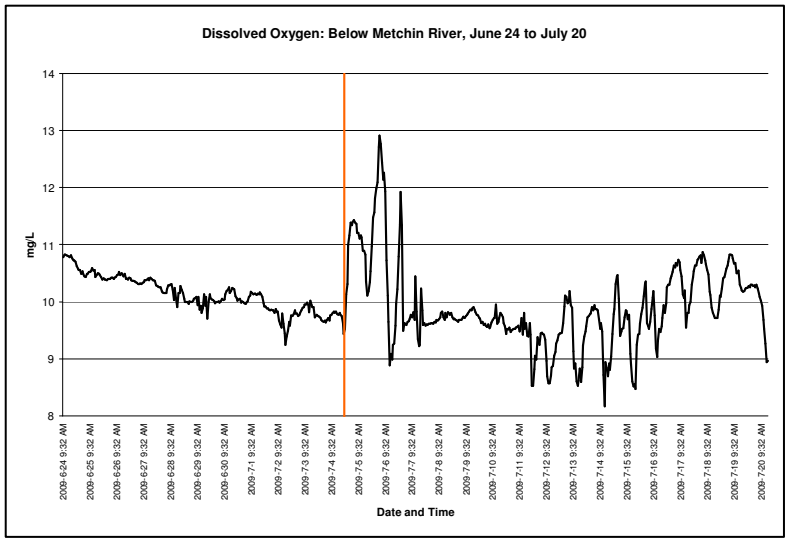

Figure 28: Dissolved Oxygen below Metchin River, June 24 to July 20, 2009.

Percent saturation values show a diurnal fluctuation and range between 93.2% and 105.3% (Figure 29).

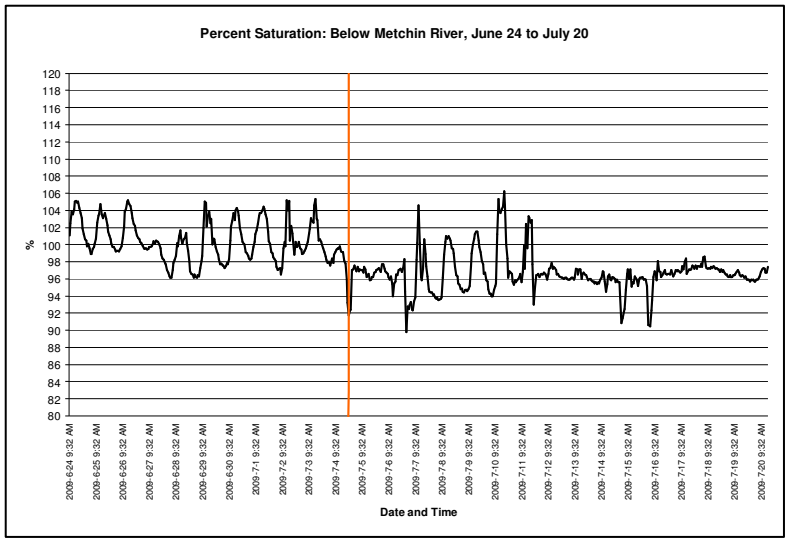

Figure 29: Percent Saturation below Metchin River, June 24 to July 20, 2009.

Turbidity

Turbidity values generally remained at 0 NTU throughout the deployment period with a few spikes recorded between June 24 and July 4 (Figure 30). The large spike recorded on June 29 is also likely due to the rainfall event between June 24 and 27 in the Churchill Falls area (Appendix 1). Another spike, lasting for the entire day on July 2 is also likely caused by a rainfall event. Specific conductivity during these two events was also elevated for a similar time period (Figure 26).

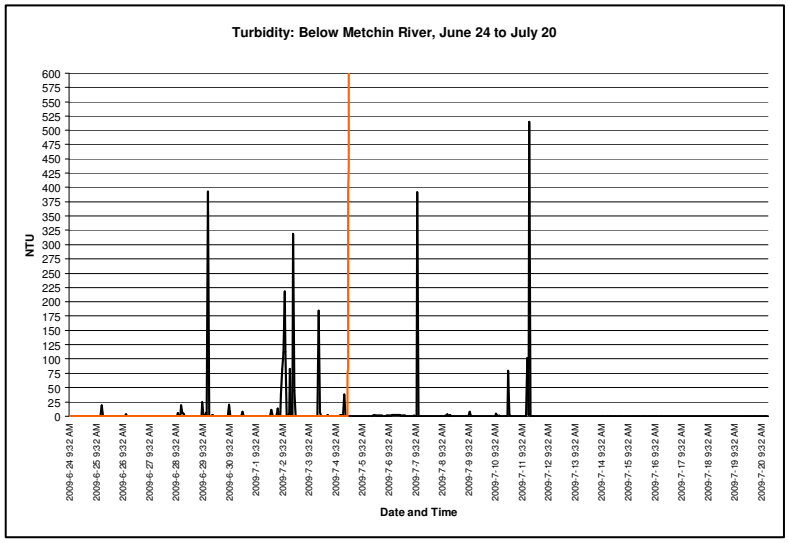

Figure 30: Turbidity below Metchin River, June 24 to July 20, 2009.

Stage

Stage level dropped significantly throughout the deployment period. When the instrument was first deployed, stage was recorded at 112.686m. When the instrument was exposed, stage level had dropped over 50cm to 112.149. By the time the instrument was retrieved at the end of the deployment on July 20, the stage level had dropped another 25cm to 111.900m. During this deployment stage drops to as low as 111.782m on July 6.

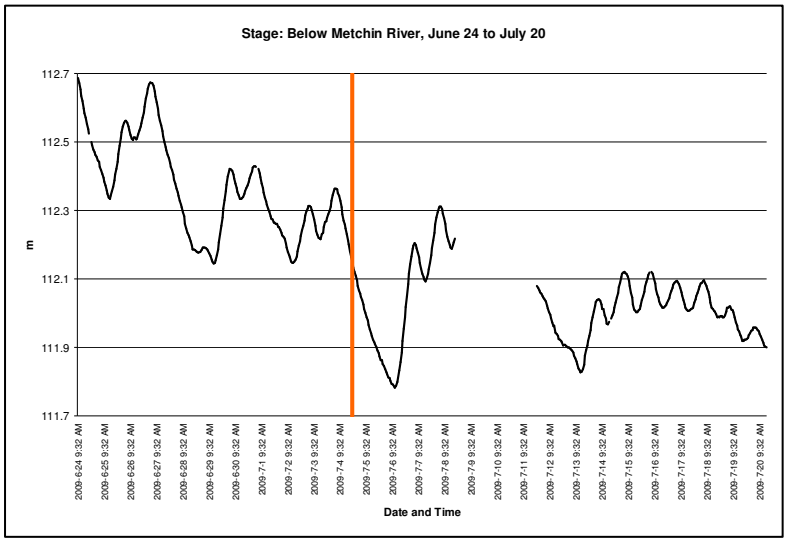

Figure 31: Stage level below Metchin River, June 24 to July 20, 2009.

Conclusions

Between June 24 and July 20, 2009, four of four real time water quality monitoring instruments were deployed along the Lower Churchill River at stations 6.15km below Lower Muskrat Falls, above Upper Muskrat Falls, below Grizzle Rapids and below Metchin River. A transmission error caused by the data logger in three of the four stations caused a gap in data between July 8 and July 11. Data loggers in these stations have since been replaced to prevent further interruption. At stations below Grizzle Rapids and below Metchin River, the missing data was recovered from the instruments internal log file.

At stations above Upper Muskrat and below Metchin River, fluctuations in stage level caused these two instruments to become exposed to air on July 4. The instrument above Upper Muskrat was placed back in the water (without being re-calibrated) by Environment Canada staff on their visit on July 16. With most parameters, the exposure to air for 12 days did not appear to significantly affect the sensors' accuracy. Stage levels continue to be carefully noted throughout the Lower Churchill River to prevent future exposures to air. Conduit and cable lengths have been extended at these two stations to allow the instrument to be placed in deeper water.

No water quality events were captured during this deployment period. In most cases, increases in specific conductivity and turbidity can be related back to precipitation events in the area recorded by Environment Canada and available through the National Climate Data and Information Archive. All values for dissolved oxygen content and pH were within the CCME Guideline for the Protection of Aquatic Life with the exception of the station below Grizzle Rapids where dissolved oxygen content dipped just slightly below the lower acceptable limit (9.0mg/L) to 8.87mg/L between July 12 and July 14.

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Appendix 1 – Weather Data

Table A-1: Weather for Happy Valley Goose Bay – June 24 to July 20, 2009

	Max Temp (C)	Min Temp (C)	Mean Temp (C)	Total Rain (mm)	Total Snow (cm)	Total Precip (mm)	Wind Dir	Wind Speed (km/h)
24-Jun-09	32.7	11.1	21.9	0	0	0	20E	35E
25-Jun-09	31.3	17.9	24.6	0	0	0		<31
26-Jun-09	17.9	9.1	13.5	0	0	0	9E	41E
27-Jun-09	17.6	8.6	13.1	0	0	0		<31
28-Jun-09	24.2	10.1	17.2	0	0	0		<31
29-Jun-09	30.4	13.2	21.8	0	0	0		<31
30-Jun-09	32.1	13.2	22.7	0	0	0		<31
1-Jul-09	17.3	10.6	14	0	0	0	7	33
2-Jul-09	23.7	9.4	16.6	0	0	0		<31
3-Jul-09	31.2	10.1	20.7	5.2	0	5.2	10	48
4-Jul-09	10.3	7	8.7	0.8	0	0.8	5	48
5-Jul-09	8.8	3.3	6.1	2.2	0	2.2	6	56
6-Jul-09	12.1	3.3	7.7	1.2	0	1.2	8	37
7-Jul-09	17.2	2.8	10	0	0	0	1	32
8-Jul-09	19.5	2.5	11	0	0	0		<31
9-Jul-09	24.4	4.7	14.6	0	0	0		<31
10-Jul-09	26.6	9.8	18.2	T	0	T		<31
11-Jul-09	28.3	13.7	21	0.2	0	0.2		<31
12-Jul-09	29.1	17.4	23.3	T	0	T	21	57
13-Jul-09	23.7	16	19.9	5	0	5	21	37
14-Jul-09	24	13.7	18.9	0	0	0	20	44
15-Jul-09	20.5	11.1	15.8	0.8	0	0.8		<31
16-Jul-09	16.5	10	13.3	0.4	0	0.4		<31
17-Jul-09	11	9.4	10.2	16.8	0	16.8	5	46
18-Jul-09	17.7	9.4	13.6	0.8	0	0.8	12	35
19-Jul-09	12.7	8.2	10.5	31	0	31	9	35
20-Jul-09	13.9	9.5	11.7	0.8	0	0.8		<31

Table A-2: Weather for Churchill Falls – June 24 to July 20, 2009

	Max Temp (C)	Min Temp (C)	Mean Temp (C)	Total Rain (mm)	Total Snow (cm)	Total Precip (mm)	Wind Dir	Wind Speed (km/h)
24-Jun-09	31	11.5	21.3	M	M	0.5	21	39
25-Jun-09	24.7	10	17.4	M	M	6.5	32	52
26-Jun-09	23.7	9.7	16.7	M	M	5	7	41
27-Jun-09	14.6	8.5	11.6	M	M	14.5	9	35
28-Jun-09	24.3	11.1	17.7	M	M	0		<31
29-Jun-09	25.6	13.9	19.8	M	M	0		<31
30-Jun-09	29.6	13.2	21.4	M	M	0		<31
1-Jul-09	27.7	14.3	21	M	M	0		<31
2-Jul-09	28.7	12.3	20.5	M	M	0	21	37
3-Jul-09	25.1	16.2	20.7	M	M	0	13	32
4-Jul-09	16.9	6.8	11.9	M	M	2	7	35
5-Jul-09	11	2.8	6.9	M	M	0.5	7	39
6-Jul-09	14.4	1.1	7.8	M	M	0	6	33
7-Jul-09	18.7	1.2	10	M	M	0.5	3	39
8-Jul-09	20.8	5.6	13.2	M	M	1.5	34	32
9-Jul-09	25	4.3	14.7	M	M	5.5	29	33
10-Jul-09	25.8	11.8	18.8	M	M	0	31	41
11-Jul-09	26.1	12.8	19.5	M	M	0	18	39
12-Jul-09	22.4	12.2	17.3	M	M	10.5	16	52
13-Jul-09	20.2	12.1	16.2	M	M	12		<31
14-Jul-09	18.4	10.6	14.5	M	M	3	18	44
15-Jul-09	19.7	9.9	14.8	M	M	12	36	35
16-Jul-09	16.5	9.6	13.1	M	M	6		<31
17-Jul-09	14.3	8.2	11.3	M	M	4	9	39
18-Jul-09	14	8	11	M	M	7	1	41
19-Jul-09	10.8	7.6	9.2	M	M	10.5	12	50
20-Jul-09	16.5	10.4	13.5	M	M	1		<31

M = Missing data

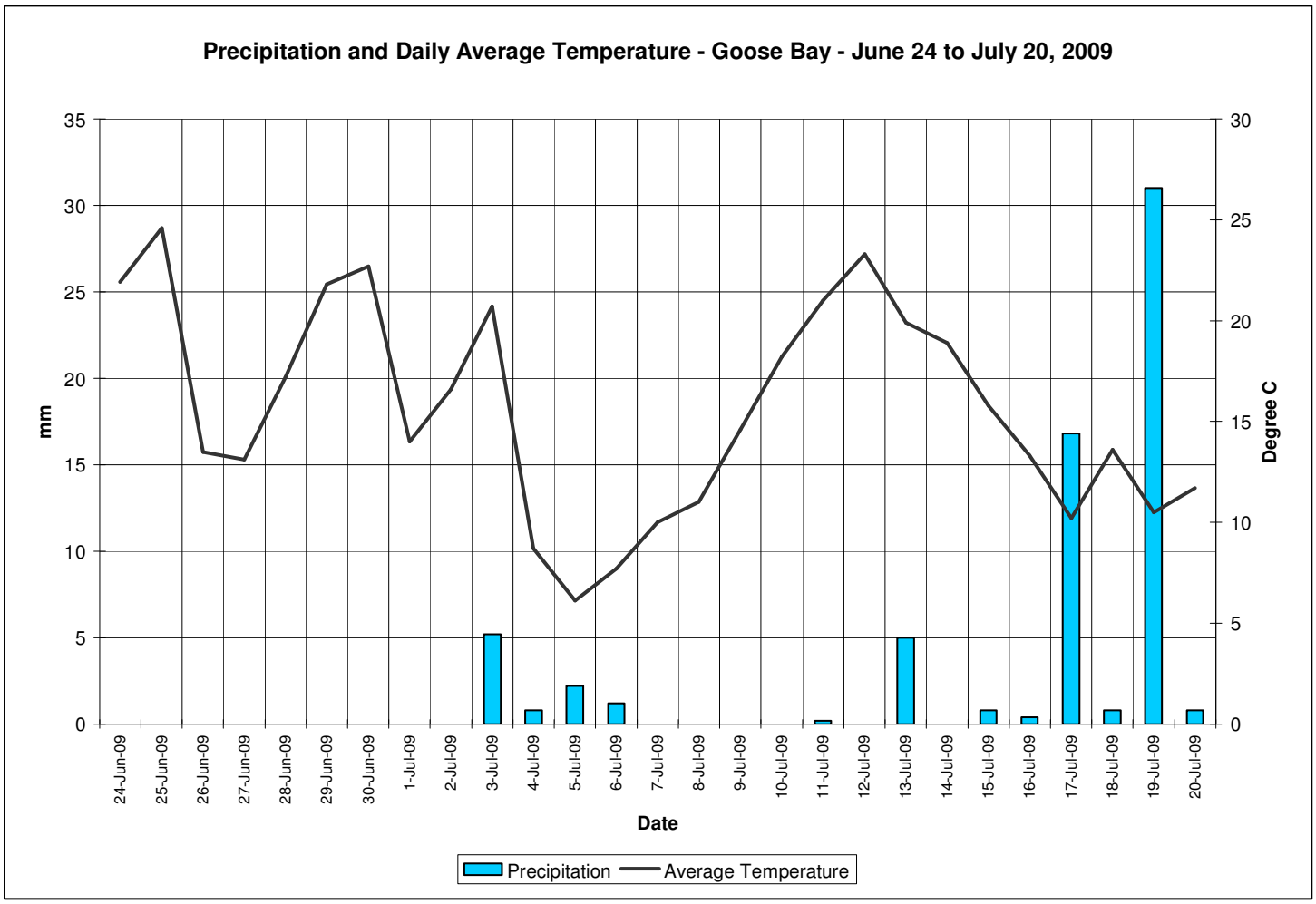

Figure A-1: Mean daily air temperature and precipitation for Happy Valley Goose Bay area, June 24 to July 20, 2009.

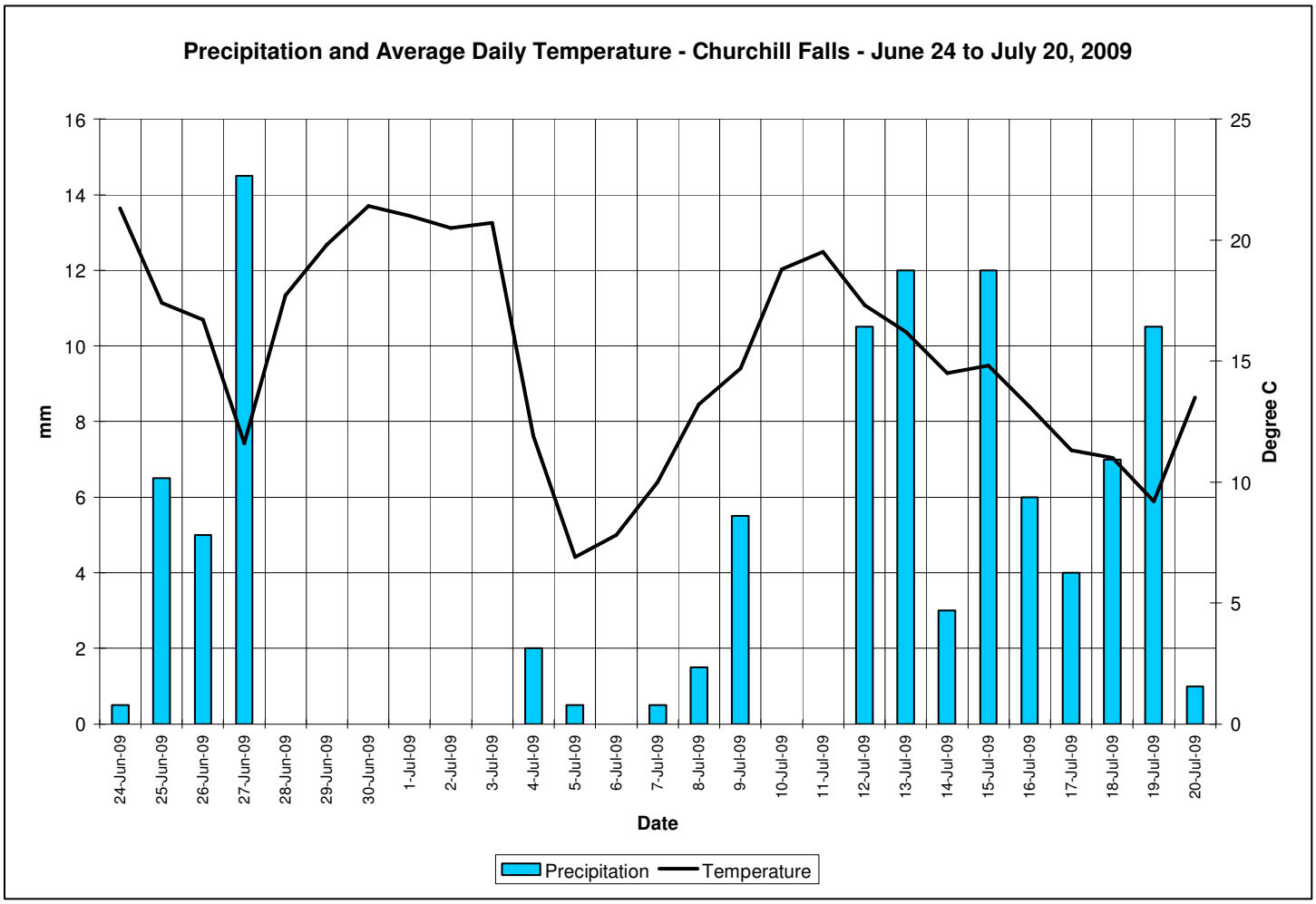

Figure A-2: Mean daily air temperature and precipitation for Churchill Falls area, June 24 to July 20, 2009.