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 July 20 to September 1, 2009, a period of 42 days. Poor weather conditions prevented DOEC staff from visiting the stations during the previous week as originally planned therefore the deployment period is slightly longer than the preferred 30 days.

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 all parameters as ranking “good” or “excellent” at installation. At removal, temperature, pH, and specific conductivity also rank “good” or “excellent”. Dissolved oxygen is ranked “poor” due to a sensor issue that occurred on July 24. Since that date until the end of the deployment period, no accurate data has been collected for dissolved oxygen or percent saturation. Turbidity is also ranked “poor”. This is also likely due to a sensor error as the values were fluctuating between 30 and 0 at the time of removal. The sensor will be recalibrated and checked before future deployments.
- At the Upper Muskrat station and the station below Metchin River, all parameters are ranked “excellent” or “good” at installation and removal.
- The station below Grizzle Rapids reported “excellent” or “good” rankings for all parameters at installation. At removal, temperature, specific conductivity and turbidity are all ranked “excellent” or “good”. pH is ranked “fair”. True side by side readings were not available from this site due to a problem with the ground cable connection. The field sonde readings were retrieved from the RTWQ website and compared to the QA/QC sonde readings taken in the field. It is likely that the pH sensor on the QA/QC sonde did not have time to stabilize completely before the reading was taken creating a discrepancy for the ranking.

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

				Instrument Comparison Ranking				
Churchill River Station	Date	Action	Instrument Serial Number	Temperature	pH	Specific Conductivity	Dissolved Oxygen	Turbidity
Below Muskrat Falls	20-Jul-09	Installation	45708	Excellent	Good	Excellent	Excellent	Excellent
	01-Sep-09	Removal		Excellent	Good	Excellent	Poor	Poor
Above Muskrat Falls	20-Jul-09	Installation	47588	Good	Excellent	Excellent	Excellent	Good
	01-Sep-09	Removal		Excellent	Excellent	Excellent	Excellent	Good
Below Metchin River	20-Jul-09	Installation	45701	Excellent	Good	Excellent	Excellent	Excellent
	01-Sep-09	Removal		Excellent	Excellent	Excellent	Excellent	Excellent
Below Grizzle Rapids	20-Jul-09	Installation	45709	Good	Excellent	Excellent	Excellent	Excellent
	01-Sep-09	Removal		Good	Fair	Excellent	Poor	Excellent

Data Interpretation

Churchill River 6.15km below Lower Muskrat Falls

Temperature

Water temperature is stable throughout the deployment period and begins to decrease in the second half of the deployment (Figure 1). Temperature ranges between 13.1°C and 18.9°C, averaging at 16.77°C.

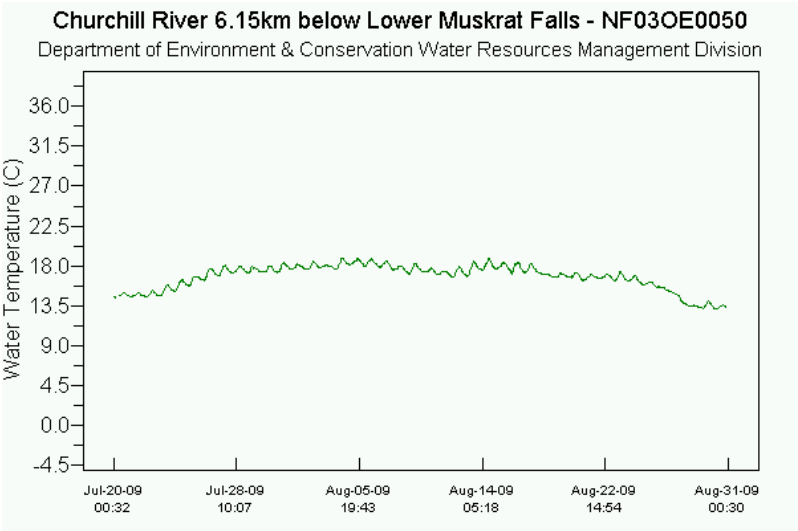

Figure 1: Water temperature for Lower Muskrat Falls Station, July 20 to September 1, 2009.

pH

pH remains stable throughout the deployment period ranging between 6.82 and 7.24 units. All values are within the acceptable limits according to the CCME guidelines for the Protection of Aquatic Life.

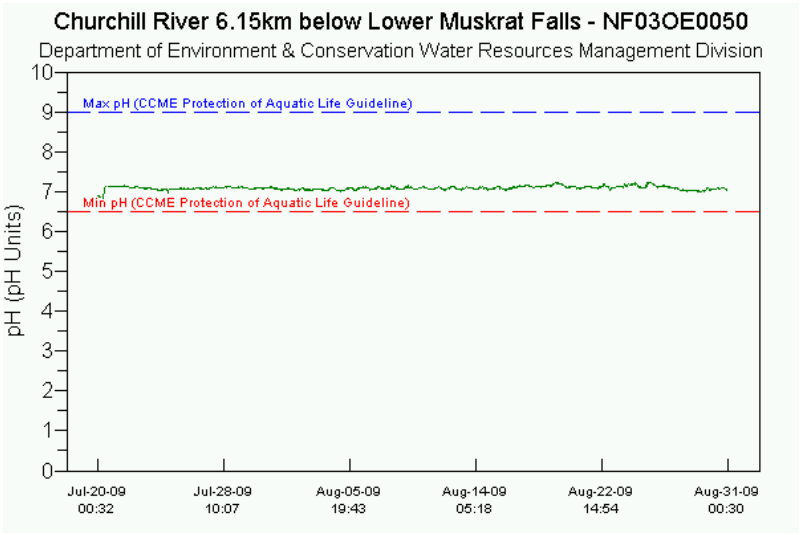

Figure 2: pH for Lower Muskrat Falls Station, July 20 to September 1, 2009.

Specific Conductivity and Total Dissolved Solids

Specific conductance varies slightly throughout the deployment period with several drops followed by periods of increasing values (Figure 3). Sharp decreases are circled in red and occur on August 5, 22 and 29. Each of these events correspond with rainfall events recorded in the Happy Valley Goose Bay area by Environment Canada (Appendix 1).

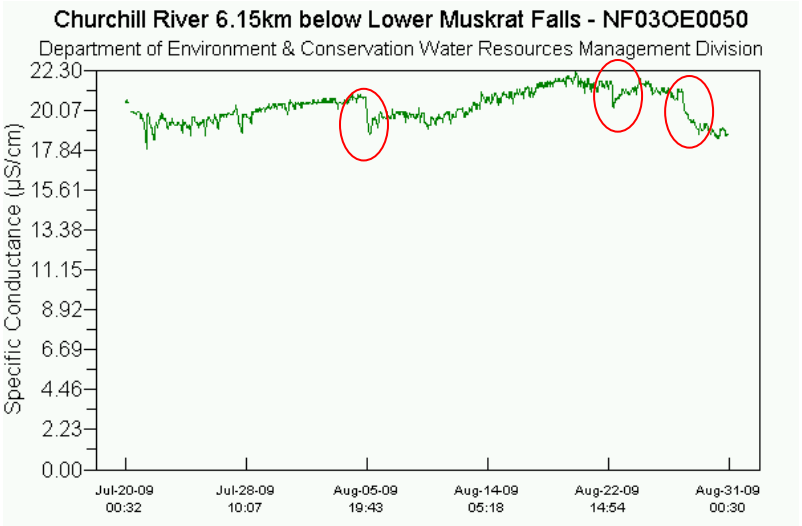

Figure 3: Specific Conductivity for Lower Muskrat Falls Station, July 20 to September 1, 2009.

Total dissolved solid concentrations are derived from specific conductance and show a similar pattern throughout the deployment period with values ranging between 0.0143 g/L and 0.0115 g/L.

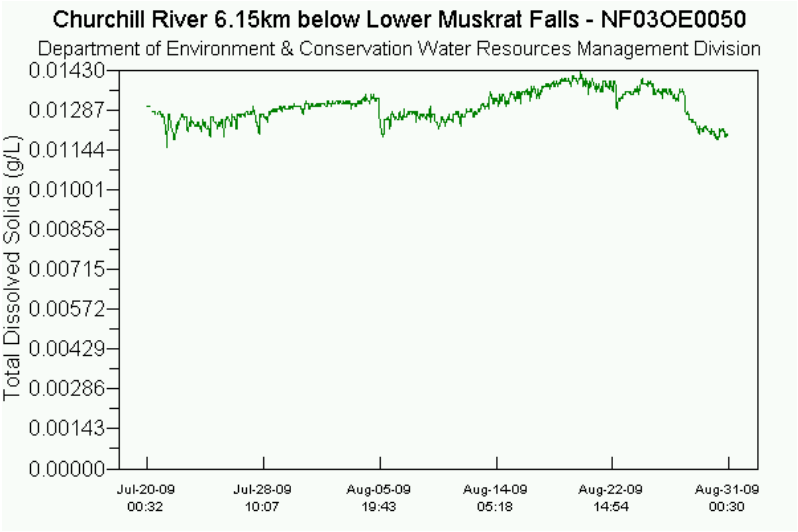

Figure 4: Total dissolved solids for Lower Muskrat Falls Station, July 20 to September 1, 2009.

Dissolved Oxygen and Percent Saturation

Due to an error with the dissolved oxygen sensor, data was only collected for the first 4 days of deployment (Figure 5). Values during this time range between 11.3mg/L and 10.87mg/L. Values between July 24 and the end of the deployment, September 1, are inaccurate. The sensor will be inspected for water under the sensor cap and recalibrated before any future deployments.

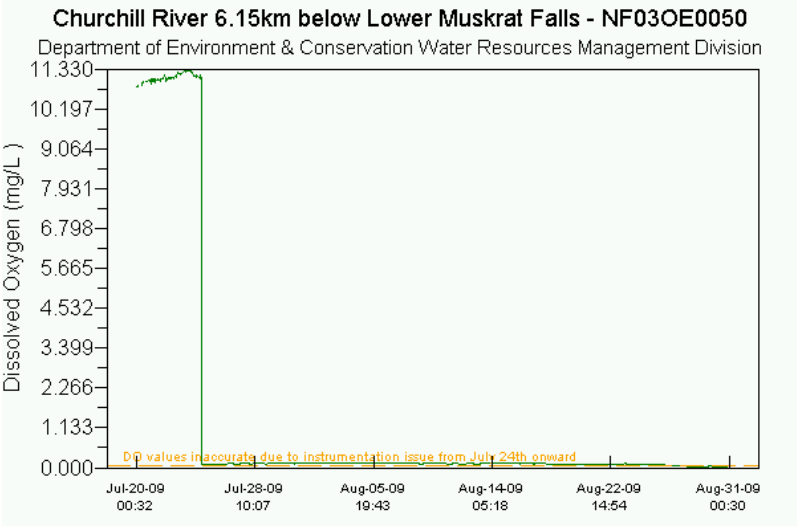

Figure 5: Dissolved Oxygen for Lower Muskrat Falls Station, July 20 to September 1, 2009.

Percent saturation values are derived from dissolved oxygen and water temperature. Between July 20 and 24, percent saturation ranges between 106.8% and 114.3%. Due to the error with the dissolved oxygen sensor, percent saturation values after July 24 are inaccurate (Figure 6).

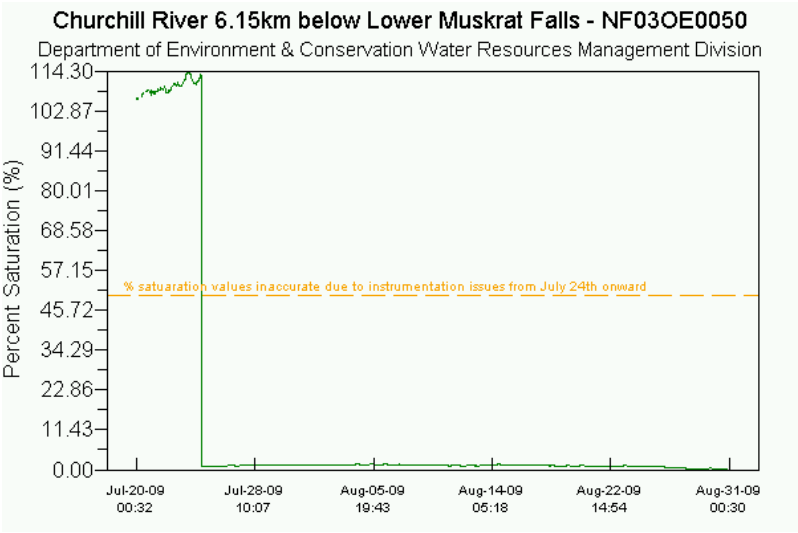

Figure 6: Percent Saturation for Lower Muskrat Falls Station, July 20 to September 1, 2009.

Turbidity

Turbidity values range between 0 and 163.9 NTU throughout the deployment period (Figure 7). A sensor error reported readings of 3000NTU on August 8, from 5:30 AM to 10:30 PM. These values have been removed from the data for graphing purposes. This is a common error in which it is likely that a piece of debris was affecting the sensors readings during this time. Turbidity values are variable throughout the deployment which is normal at this site. The sensor will be inspected and recalibrated as the QA/QC reading at removal was "poor" due to fluctuating readings.

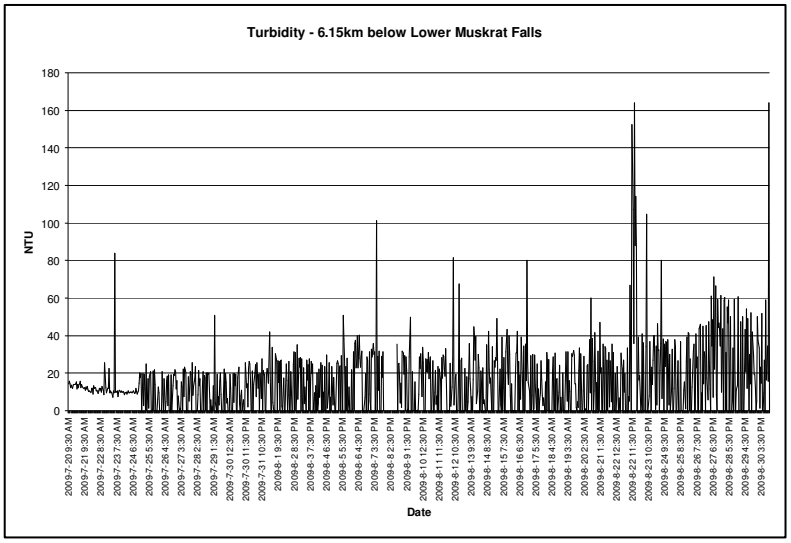

Figure 7: Turbidity for Lower Muskrat Falls Station, July 20 to September 1, 2009.

Stage

Stage values are stable throughout the deployment and begin to rise in the last week of August (Figure 8). When the instrument was deployed, stage level was at 2.22m. When the instrument was retrieved, the stage level was at 2.522m.

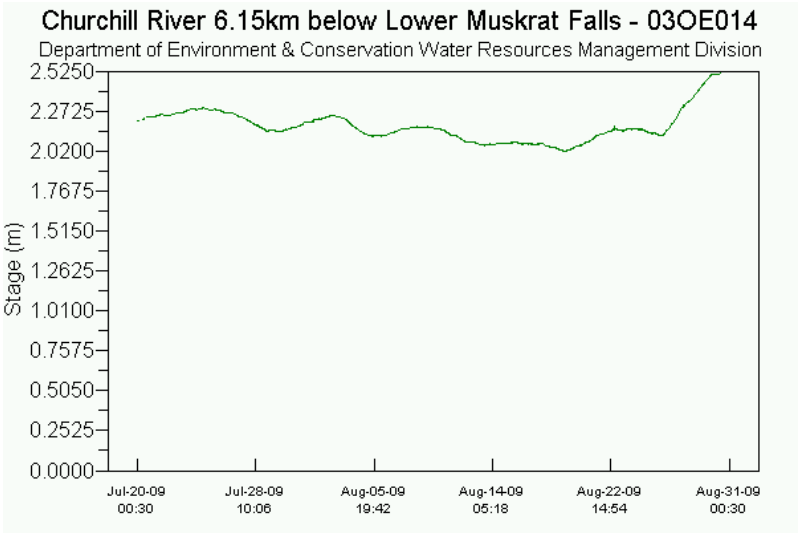

Figure 8: Stage Level for Lower Muskrat Falls Station, July 20 to September 1, 2009.

Churchill River above Upper Muskrat Falls

Temperature

Temperature values recorded above Upper Muskrat Falls remain stable throughout the deployment period until decreasing slightly in the last week of August (Figure 9). Temperature values range between 12.63°C and 19.26°C, averaging at 16.66°C.

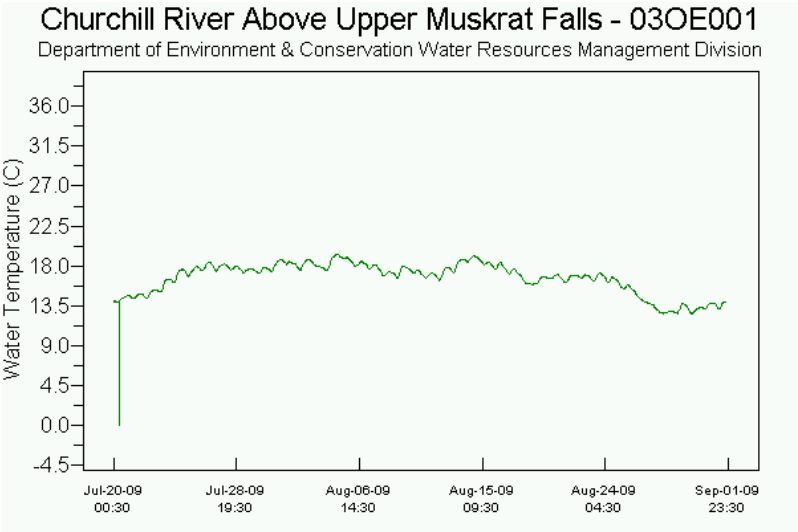

Figure 9: Water Temperature for Upper Muskrat Falls Station, July 20 to September 1, 2009.

pH

pH values at this station remain stable ranging between 6.69 and 7.26 units, averaging 7.08 units (Figure 10). All values are within the acceptable limits according to the CCME Guidelines for the Protection of Aquatic Life.

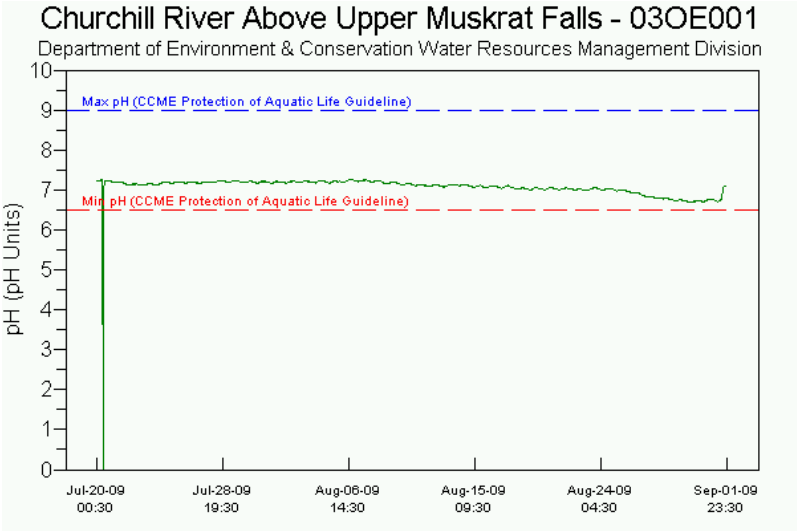

Figure 10: pH for Upper Muskrat Falls Station, July 20 to September 1, 2009.

Specific Conductivity and Total Dissolved Solids

Specific conductance varies throughout the deployment period ranging between 19.6µS/cm and 22.4µS/cm (Figure 11). Average specific conductance is 21.15µS/cm.

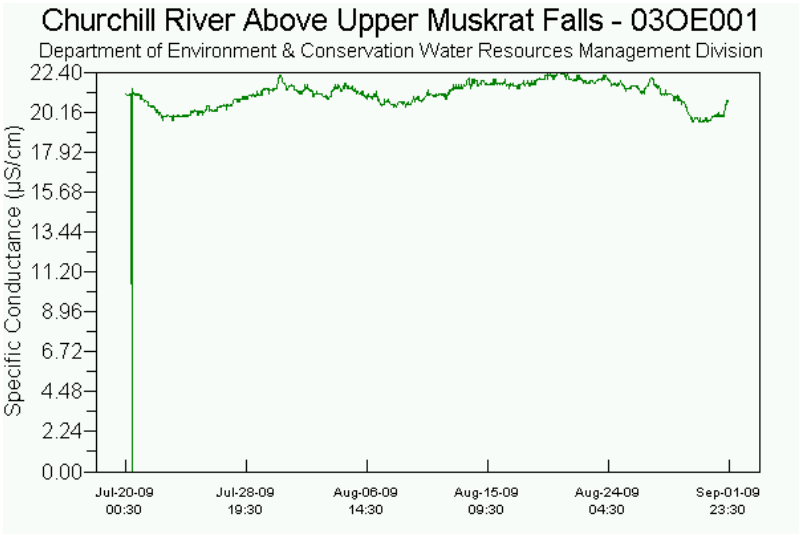

Figure 11: Specific Conductance for Upper Muskrat Falls Station, July 20 to September 1, 2009.

Total dissolved solid concentrations in the water column are derived from the specific conductance. Values range between 0.0126g/L and 0.0144g/L during the deployment (Figure 12).

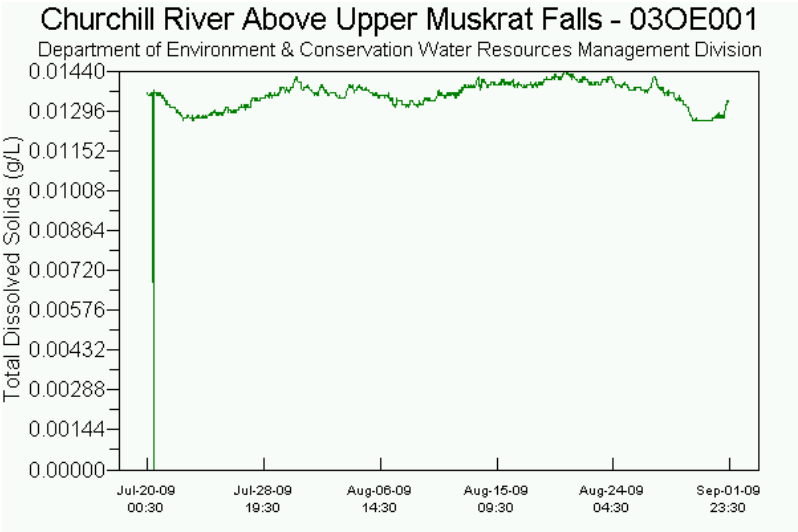

Figure 12: Total Dissolved Solids for Upper Muskrat Falls Station, July 20 to September 1, 2009.

Dissolved Oxygen and Percent Saturation

Dissolved Oxygen values remain stable throughout the deployment period, fluctuating daily (Figure 13). There is a slight increasing trend in the data near the end of the deployment as the water temperature is decreasing (Figure 9). Values range between 8.85mg/L and 10.07mg/L, averaging 9.31mg/L. Most values are above the lower acceptable limit (9.0mg/L) pertaining to the CCME Guideline for the Protection of Aquatic Life. Dissolved oxygen content does slip below the guideline (9.0mg/L) for a few hours each day on August 1 – 3, and 5 – 8.

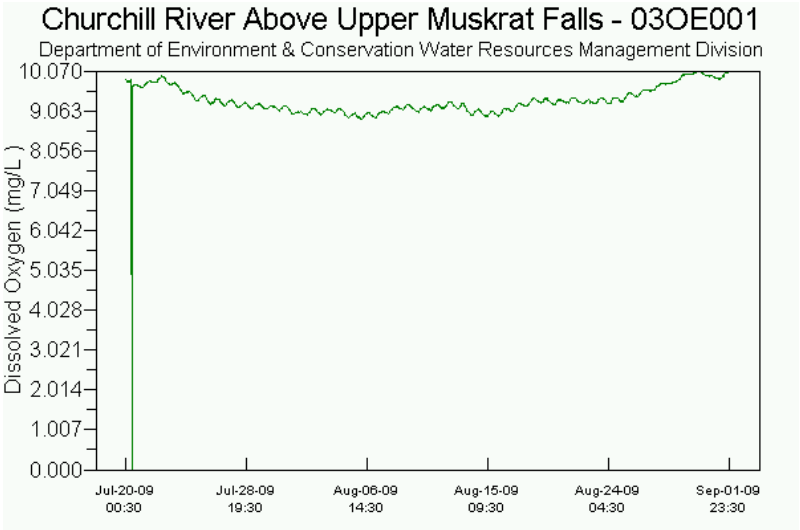

Figure 13: Dissolved Oxygen for Upper Muskrat Falls Station, July 20 to September 1, 2009.

Percent saturation remains stable throughout the deployment period with values ranging between 91.7% and 99.5% (Figure 14).

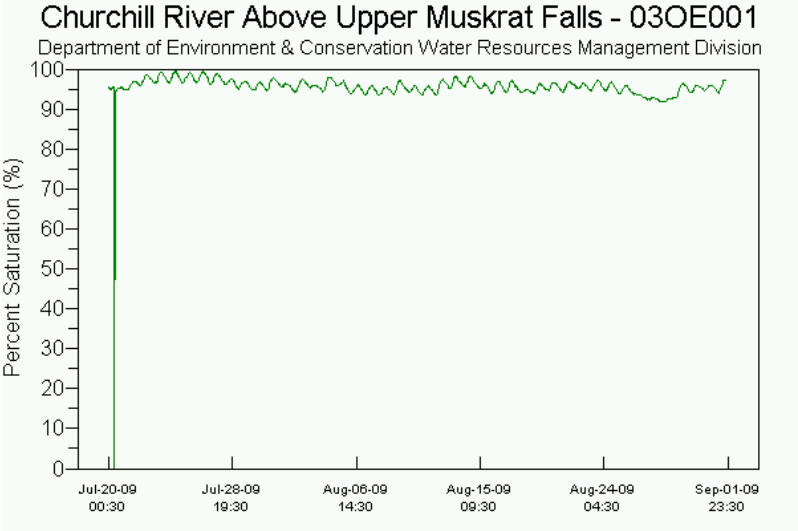

Figure 14: Percent Saturation for Upper Muskrat Falls Station, July 20 to September 1, 2009.

Turbidity

Turbidity varies throughout the deployment period at the station above Upper Muskrat Falls (Figure 15). Values range between 10NTU and 94NTU. The large spike near the end (circled in red) corresponds with a significant rainfall event in Happy Valley Goose Bay (Appendix 1). Turbidity values are elevated for some time during and after this event. Generally, at this station it is normal to see such variable turbidity values due to the silty nature of the river bed. Water is typically visibly cloudy at this station.

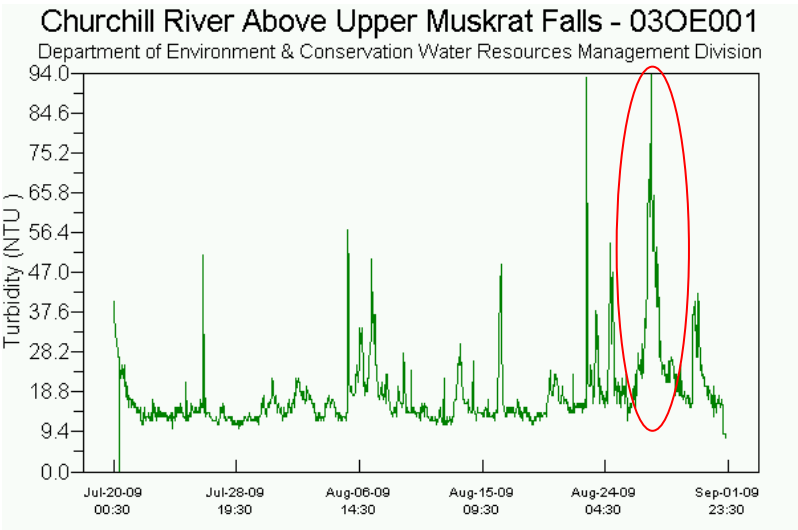

Figure 15: Turbidity for Upper Muskrat Falls Station, July 20 to September 1, 2009.

Stage

Stage level remains stable throughout the deployment period and appears to increase slightly during the last week of the deployment (Figure 16). At the time the instrument was deployed on July 20, stage level was 15.1m. At removal on September 1, stage level was recorded at 16.063m.

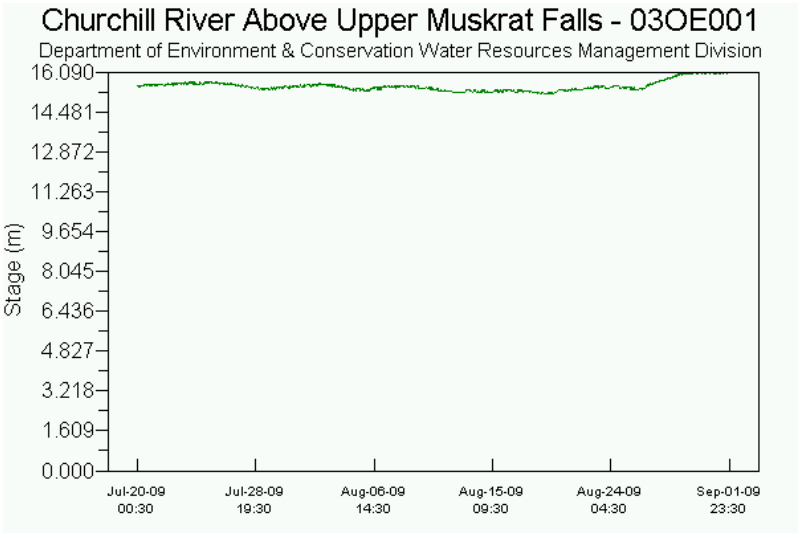

Figure 16: Stage level for Upper Muskrat Falls Station, July 20 to September 1, 2009.

Churchill River below Grizzle Rapids

Temperature

Temperature values fluctuate throughout the deployment period clearly showing a diurnal pattern of increased temperatures throughout the day time (Figure 17). Generally, temperature begins to decrease in the latter half of the deployment. Values range between 12.7°C and 21.7°C averaging at 16.40°C.

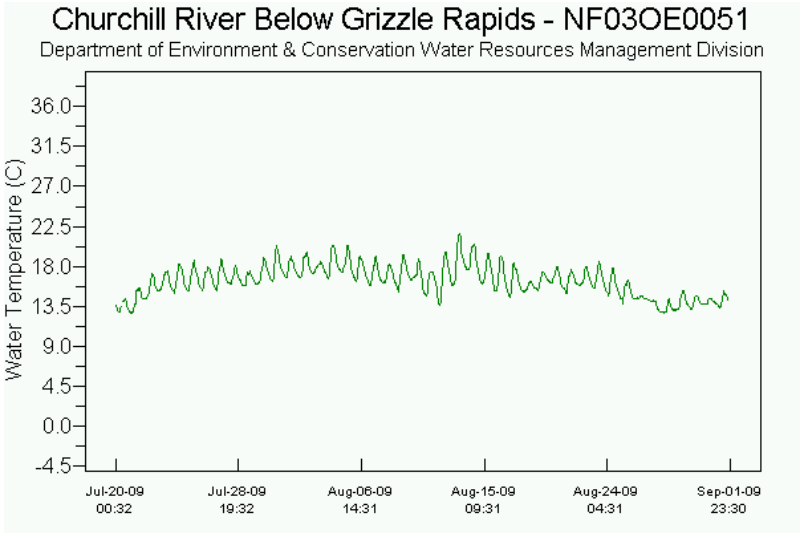

Figure 17: Water Temperature below Grizzle Rapids, July 20 to September 1, 2009.

pH

pH values for the most part remain stable throughout the deployment period ranging between 6.79 and 7.16 units (Figure 18). There is an event where pH values drop to as low as 5.52 units on August 2 between 12:30AM and 4:30AM (circled in red). The cause of this event is unknown. After 4:30AM, pH values resume as normal.

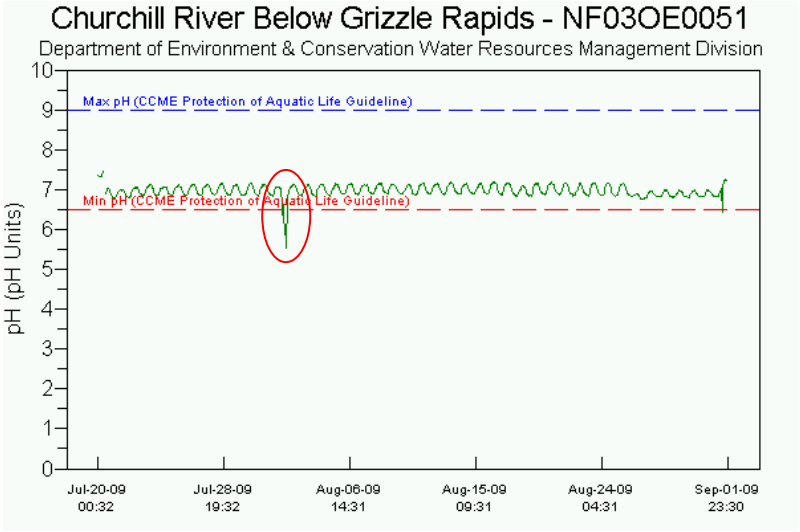

Figure 18: pH below Grizzle Rapids, July 20 to September 1, 2009.

Specific Conductivity

Specific conductivity values display a slight increasing trend throughout the deployment period and fluctuate diurnally (Figure 19). Values range between 18.3 µS/cm and 22.5 µS/cm (Figure 19).

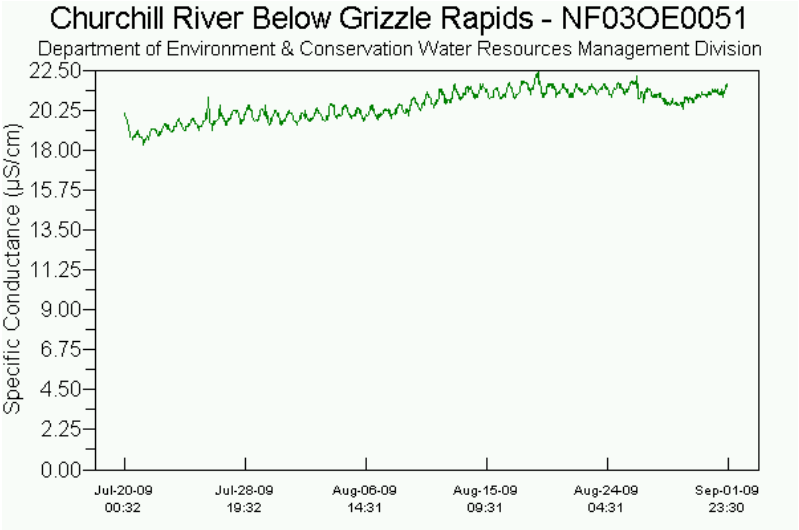

Figure 19: Specific Conductance below Grizzle Rapids, July 20 to September 1, 2009.

Total dissolved solid concentration is derived from specific conductance (Figure 20). Values range between 0.0117g/L and 0.0144g/L.

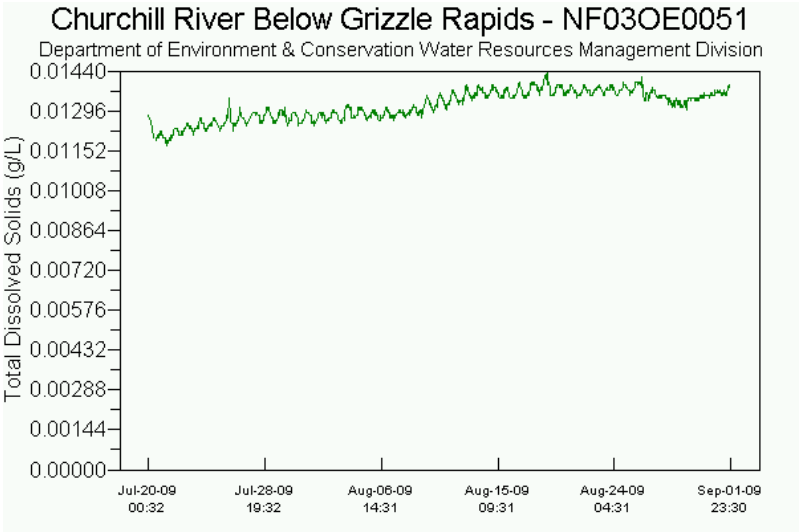

Figure 20: Total Dissolved Solids below Grizzle Rapids, July 20 to September 1, 2009.

Dissolved Oxygen and Percent Saturation

Due to an error with the dissolved oxygen sensor, values recorded after August 2 are inaccurate (Figure 21). This error with the sensor begins immediately after the sudden drop in pH (Figure 18). Between July 20 and August 2, dissolved oxygen content values range between 8.9mg/L and 10.48mg/L, averaging at 9.65mg/L. The sensor will be inspected and recalibrated before any future deployment

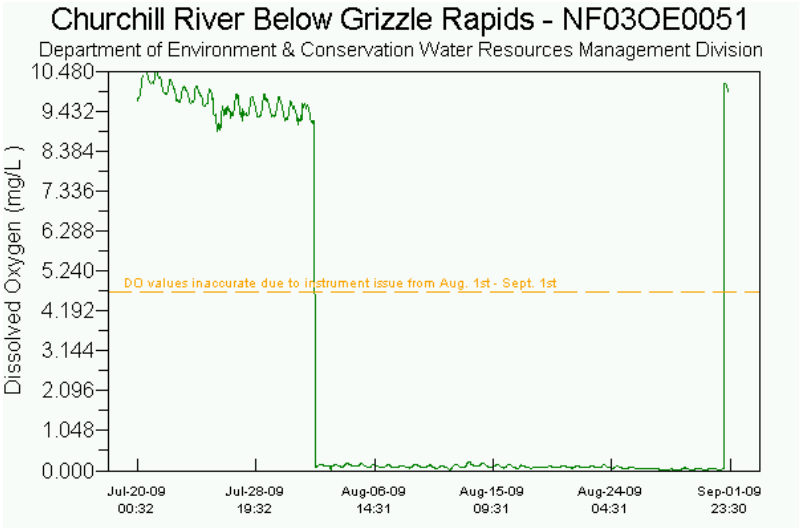

Figure 21: Dissolved Oxygen below Grizzle Rapids, July 20 to September 1, 2009.

Percent saturation values are derived from the dissolved oxygen and temperature sensors. Between July 20 and August 2, percent saturation ranges between 89.3% and 105.9% (Figure 22). Values after August 2 are inaccurate due to a problem with the dissolved oxygen sensor.

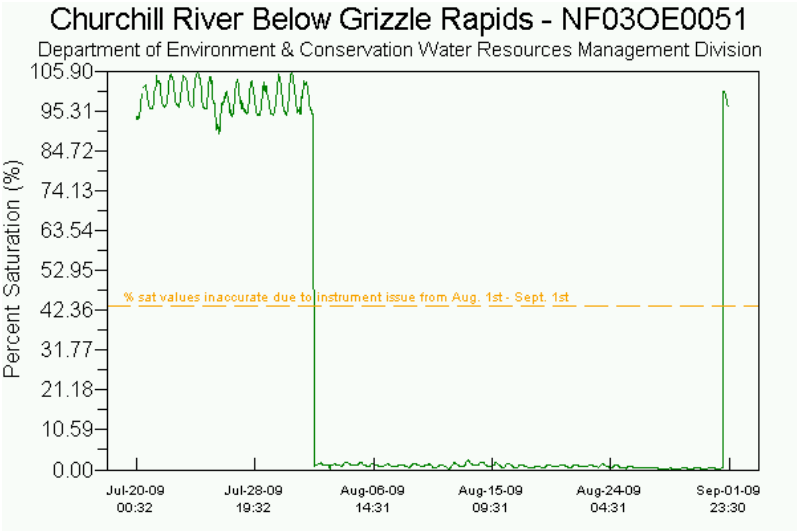

Figure 22: Percent Saturation below Grizzle Rapids, July 20 to September 1, 2009.

Turbidity

Turbidity values are 0NTU for the first 13 days of deployment. On August 2, turbidity values start to spike for the remainder of the deployment period (Figure 23). This event corresponds with the drop in pH and the failure of the dissolved oxygen sensor so it is likely that the three events are related and due to sensor malfunction. Turbidity spikes up to 364NTU on August 25, but normally averages about 16NTU.

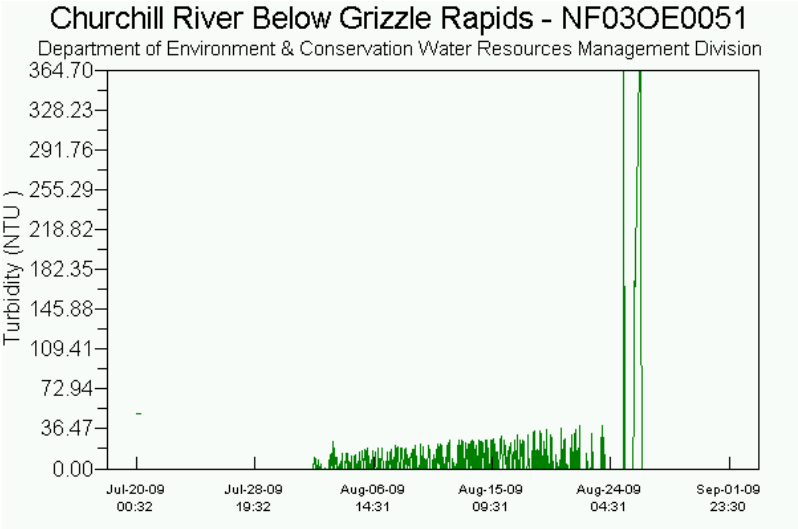

Figure 23: Turbidity below Grizzle Rapids, July 20 to September 1, 2009.

Stage

Stage level fluctuates throughout the month of August before increasing the last third of the deployment (Figure 24). At the beginning of the deployment, stage level was recorded at 33.254m. When the instrument was retrieved, stage had increased to 33.356m. During the deployment stage level dropped as low as 33.040m.

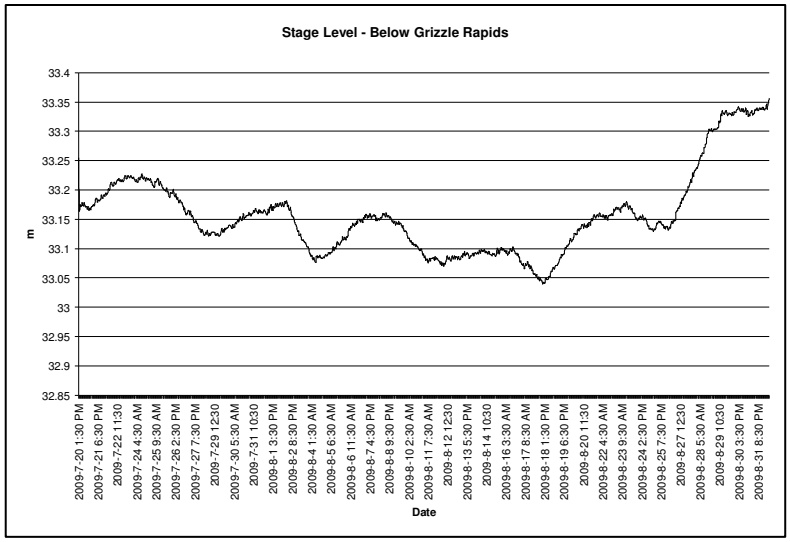

Figure 24: Stage level below Grizzle Rapids, July 20 to September 1, 2009.

Churchill River below Metchin River

Temperature

Temperature is stable throughout the deployment period and begins to decrease in the last third of the deployment period (Figure 25). The temperature between July 20 and September 1 averages 15.89°C, ranging between 11.6°C and 18.1°C.

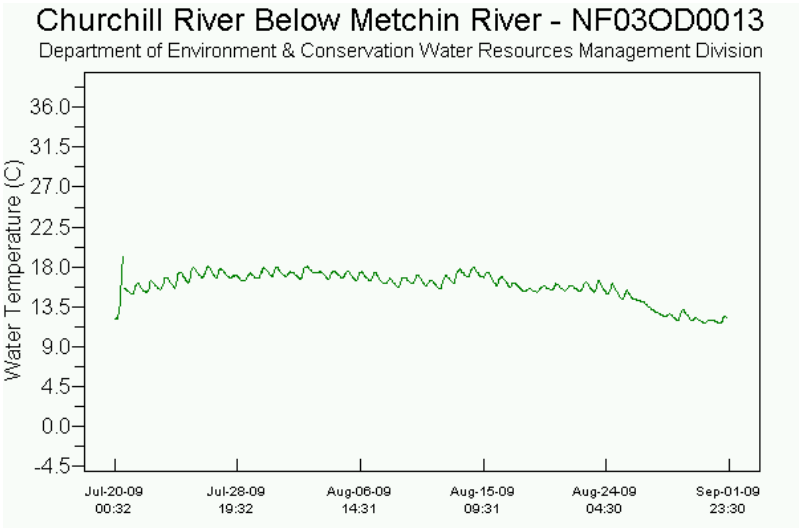

Figure 25: Water Temperature below Metchin River, July 20 to September 1, 2009.

pH

pH values remain stable throughout the deployment period ranging between 6.79 and 7.04 units, averaging at 6.92 units.(Figure 26). The drop in pH near the beginning of the deployment is during a visit to the site to replace the instrument. The pH sensor can require significant time in order to stabilize readings. All values are within the acceptable limits for pH according to the CCME Guideline for the Protection of Aquatic Life.

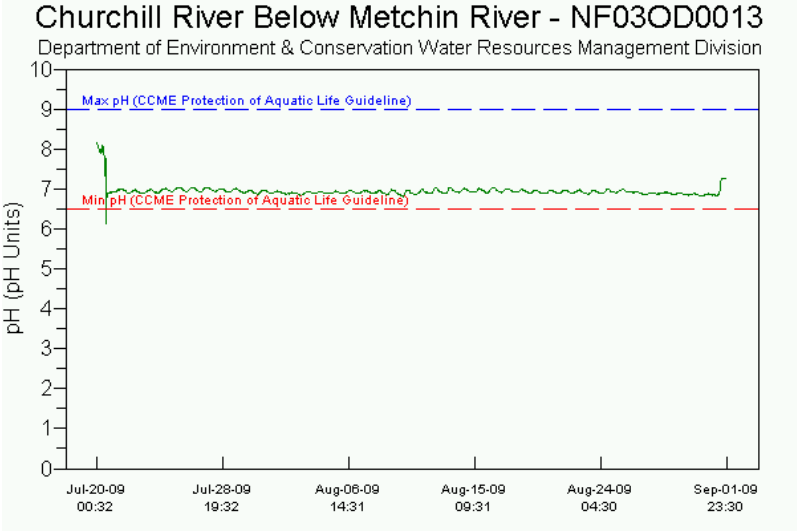

Figure 26: pH below Metchin River, July 20 to September 1, 2009.

Specific Conductivity

Specific conductivity values slightly increase throughout the deployment period (Figure 27). Values range between 20.7µS/cm and 24.5µS/cm, averaging at 22.93µS/cm.

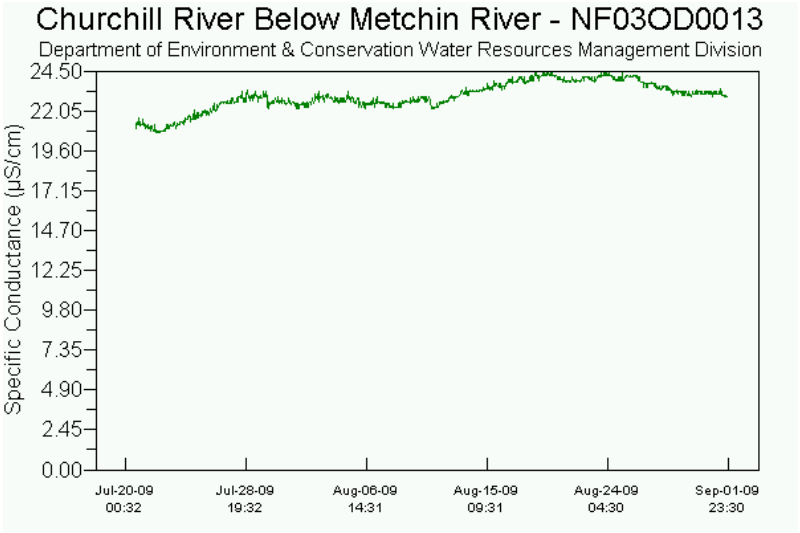

Figure 27: Specific Conductance below Metchin River, July 20 to September 1, 2009

Total Dissolved solid concentrations are derived from specific conductance (Figure 28). Values range between 0.0157g/L and 0.0132g/L.

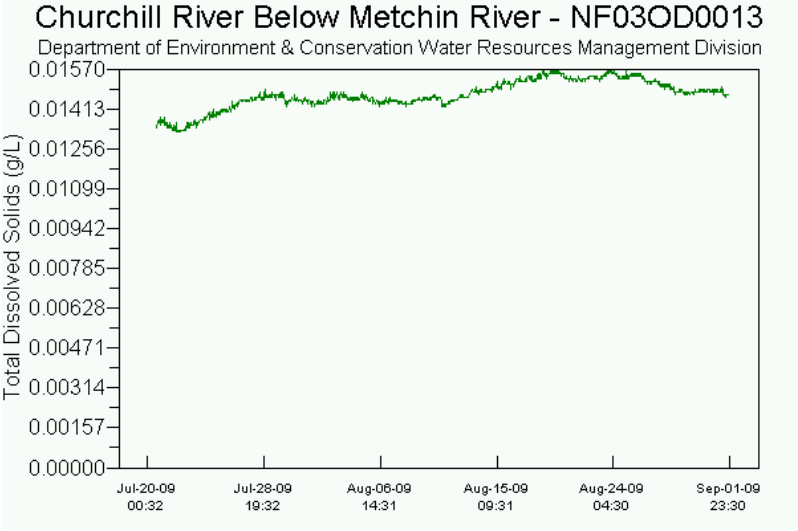

Figure 28: Total Dissolved Solids below Metchin River, July 20 to September 1, 2009.

Dissolved Oxygen and Percent Saturation

Dissolved oxygen values remain stable throughout the deployment period ranging between 9.0mg/L and 10.11mg/L (Figure 29). This is within the lower acceptable limit for dissolved oxygen content in cold waters (9.0mg/L).

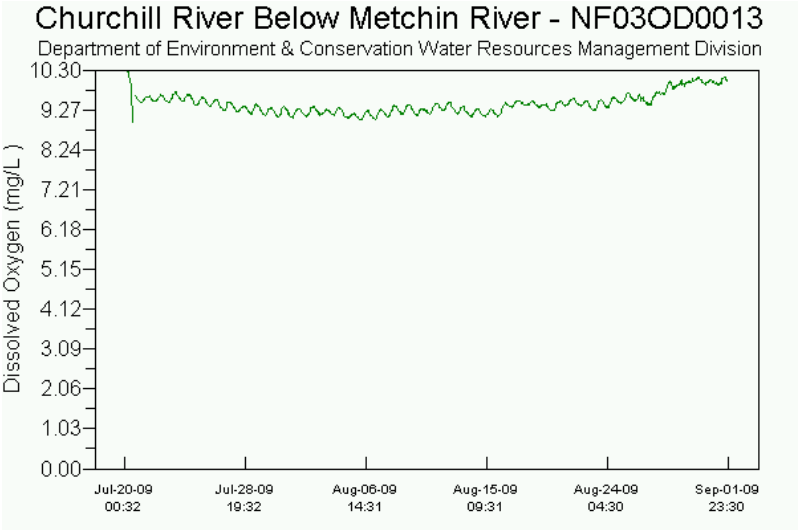

Figure 29: Dissolved Oxygen below Metchin River, July 20 to September 1, 2009.

Percent saturation values are derived from the dissolved oxygen and temperature readings. Values show a diurnal fluctuation and range between 94.21% and 101.3% (Figure 30).

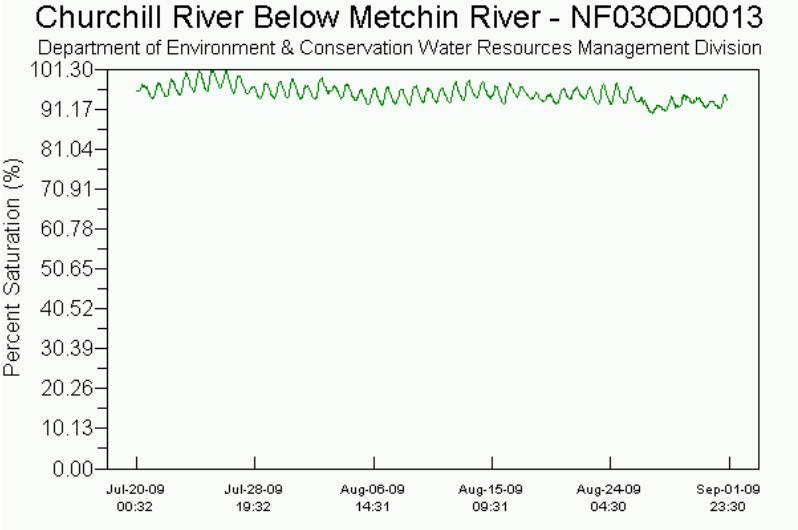

Figure 30: Percent Saturation below Metchin River, July 20 to September 1, 2009.

Turbidity

Turbidity values generally remained at 0 NTU throughout the deployment period with a few small spikes recorded (up to 10NTU) on July 23, 30 and August 5 (Figure 31). With rainfall vents recorded nearly everyday in Churchill Falls throughout the deployment period. It is unclear weather or not these turbidity spikes were caused by precipitation events.

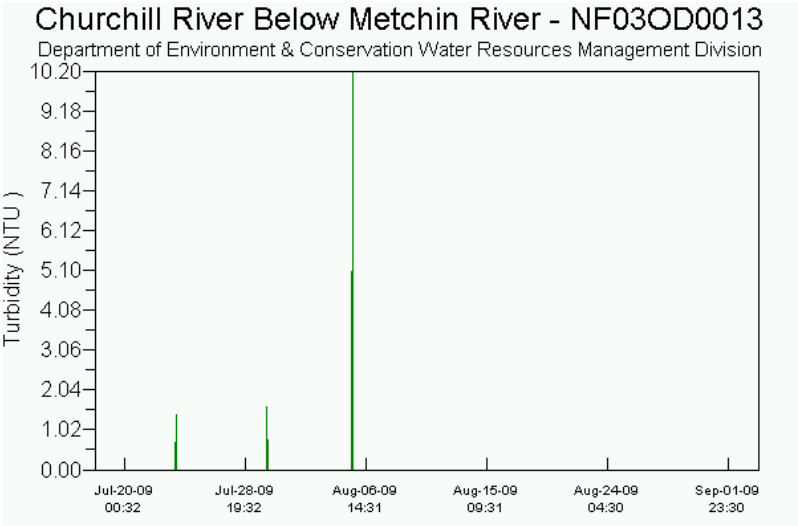

Figure 31: Turbidity below Metchin River, July 20 to September 1, 2009.

Stage

Stage level remains stable for most of the deployment period before beginning to increase in the last half of the deployment (Figure 32). When the instrument was first deployed, stage was recorded at 111.920m. When the instrument was retrieved on September 1, stage had risen to 112.536m.

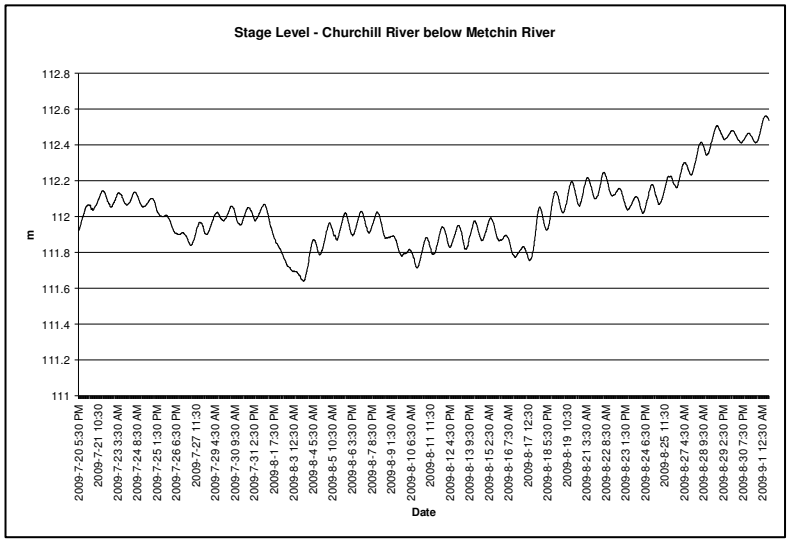

Figure 32: Stage level below Metchin River, July 20 to September 1, 2009.

Conclusions

Between July 20 and September 1, 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.

Dissolved Oxygen sensors on instruments deployed below Lower Muskrat Falls and below Grizzle Rapids experienced malfunction on July 24 and August 2 respectively. No data after these dates at each of these stations is available for dissolved oxygen or percent saturation. All sensors will be inspected and recalibrated before future deployment. A sharp decrease in pH (sustained for 4 hours) preceded the dissolved oxygen sensor malfunction at the station below Grizzle Rapids. As well, after August 2, turbidity values began to spike intermittently for the remainder of the deployment. The reason for the drop in pH is unknown as is the reason for the dissolved oxygen sensor failure and the elevated turbidity readings. All sensors will be inspected and recalibrated before another deployment.

Stage level at all stations is increasing now so no instruments were left exposed to air during this deployment. The lowest level for each of the stations has been noted and will be used during the 2010 deployment season to help eliminate instruments becoming exposed between site visits.

Data for all stations follow a typical seasonal pattern and 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 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 8.9mg/L between July 25 and July 26 and at the station above Upper Muskrat Falls where dissolved oxygen content dropped as low as 8.85mg/L between August 1-3 and August 5-8 for several hours each day. pH values were all within the CCME Guidelines for the Protection of Aquatic Life with the exception of the pH drop at Grizzle Rapids on August 2.

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Appendix 1 – Weather Data

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

Date	Max Temp	Min Temp	Mean Temp	Total Precip	Dir of Max Gust	Spd of Max Gust
	℃	℃	℃	mm	10's Deg	km/h
20-Jul-09	13.9	9.5	11.7	0.8		<31
21-Jul-09	15.9	10.7	13.3	3		<31
22-Jul-09	17.1	10.3	13.7	T		<31
23-Jul-09	21.1	10.6	15.9	0		<31
24-Jul-09	21.4	9.3	15.4	0		<31
25-Jul-09	23.8	8.2	16	0.2		<31
26-Jul-09	25.5	11	18.3	0		<31
27-Jul-09	28.3	11	19.7	0		<31
28-Jul-09	21.7	14.8	18.3	0		<31
29-Jul-09	21.2	14	17.6	6.2		<31
30-Jul-09	26.6	17.2	21.9	1.2	25E	32E
31-Jul-09	29.4	15.2	22.3	18.6	25E	72E
1-Aug-09	17	12.1	14.6	0.4		<31
2-Aug-09	21.5	11.9	16.7	0		<31
3-Aug-09	19.7	15.1	17.4	9.6		<31
4-Aug-09	26.5	12.6	19.6	0	24	33
5-Aug-09	25.1	12.9	19	3.2	27	95
6-Aug-09	22.5	12.2	17.4	0	26	48
7-Aug-09	21.8	13.3	17.6	0	25	41
8-Aug-09	19.8	11.9	15.9	T		<31
9-Aug-09	24.6	9.9	17.3	0.4	25	56
10-Aug-09	19.3	9.8	14.6	7	25	37
11-Aug-09	16.7	8.3	12.5	T		<31
12-Aug-09	23.8	8.1	16	0	25	33
13-Aug-09	31.1	14.8	23	2.2	25	57
14-Aug-09	25.3	14.8	20.1	0.4		<31
15-Aug-09	20.4	10.2	15.3	0.2		<31
16-Aug-09	19.9	8.7	14.3	0	29	46
17-Aug-09	14.8	6.5	10.7	T		<31
18-Aug-09	13.7	9.2	11.5	2.6		<31
19-Aug-09	18.4	11.9	15.2	14		<31
20-Aug-09	20.8	12.1	16.5	1.4	27	32
21-Aug-09	19.5	12.4	16	T		<31
22-Aug-09	20.5	13.9	17.2	5.2	25	39
23-Aug-09	21.6	9.3	15.5	0	29	41
24-Aug-09	18.3	6.7	12.5	0	29	46
25-Aug-09	15.2	4.4	9.8	0	34E	32E
26-Aug-09	11.3	3.3	7.3	43.4	4	35
27-Aug-09	8.2	4.1	6.2	16.6	32	54
28-Aug-09	9.9	4.7	7.3	4.2	30	41

29-Aug-09	17.2	5.2	11.2	T		<31
30-Aug-09	13.6	2.8	8.2	1		<31
31-Aug-09	13.6	8.2	10.9	2.6		<31
1-Sep-09	17.5	5.5	11.5	0.2	29	33

Table A-2: Weather for Churchill Falls – July 20 to September 1, 2009

Date	Max Temp ℃	Min Temp ℃	Mean Temp ℃	Total Rain mm	Total Precip mm	Dir of Max Gust 10's Deg	Spd of Max Gust km/h
20-Jul-09	16.5	10.4	13.5	M	1		<31
21-Jul-09	19.1	7.4	13.3	M	12.5	32	35
22-Jul-09	21.1	6.3	13.7	M	0		<31
23-Jul-09	19.7	8.9	14.3	M	0.5		<31
24-Jul-09	23.1	7	15.1	M	0		<31
25-Jul-09	24	11.1	17.6	M	0		<31
26-Jul-09	24.8	12.9	18.9	M	0		<31
27-Jul-09	23.3	11.3	17.3	M	6	14	32
28-Jul-09	16.7	12.1	14.4	M	1.5		<31
29-Jul-09	20.3	12.4	16.4	M	1.5	17	35
30-Jul-09	25.1	13	19.1	M	0	25	35
31-Jul-09	23.2	11.1	17.2	M	6.5		<31
1-Aug-09	19.5	10	14.8	M	7.5	30E	33E
2-Aug-09	23	9.3	16.2	M	0.5		<31
3-Aug-09	19.3	13.1	16.2	M	16	22	35
4-Aug-09	18.3	12	15.2	M	2	19	32
5-Aug-09	21.9	11.1	16.5	M	14.5	25	48
6-Aug-09	18.5	10.2	14.4	M	3.5	27	39
7-Aug-09	15.4	10.4	12.9	M	2.5	29	46
8-Aug-09	16.7	8.2	12.5	M	2.5	31	39
9-Aug-09	21.7	9.7	15.7	M	1.5	27	41
10-Aug-09	16.6	10.6	13.6	M	1.5	31	39
11-Aug-09	16	8.4	12.2	M	1	32	33
12-Aug-09	23	7.9	15.5	M	0		<31
13-Aug-09	26.9	13.2	20.1	M	3.5	25	52
14-Aug-09	21.3	12.4	16.9	M	0	31	33
15-Aug-09	18	8.9	13.5	M	8	30	41
16-Aug-09	15.3	8.1	11.7	M	0	31	39
17-Aug-09	11.6	5.6	8.6	M	6	1	35
18-Aug-09	12.5	7.3	9.9	M	7	11	37
19-Aug-09	18.4	11.9	15.2	M	9		<31
20-Aug-09	16.9	10.4	13.7	M	1		<31
21-Aug-09	17	9.8	13.4	M	4.5		<31

22-Aug-09	23	8.8	15.9	M	11.5	27	48
23-Aug-09	16.2	6.3	11.3	M	0	29	35
24-Aug-09	15.1	6.1	10.6	M	3	30	48
25-Aug-09	12.6	5.5	9.1	M	0	33	39
26-Aug-09	9.4	4.5	7	M	30.5	10	44
27-Aug-09	6.7	3	4.9	M	5	2	46
28-Aug-09	11.7	3.7	7.7	M	0	33	46
29-Aug-09	13.6	1.4	7.5	M	0.5	<31	
30-Aug-09	12.1	1.2	6.7	M	3	<31	
31-Aug-09	9.3	3.7	6.5	M	4.5	<31	
1-Sep-09	16.3	2.8	9.6	M	0.5	<31	

M = Missing data

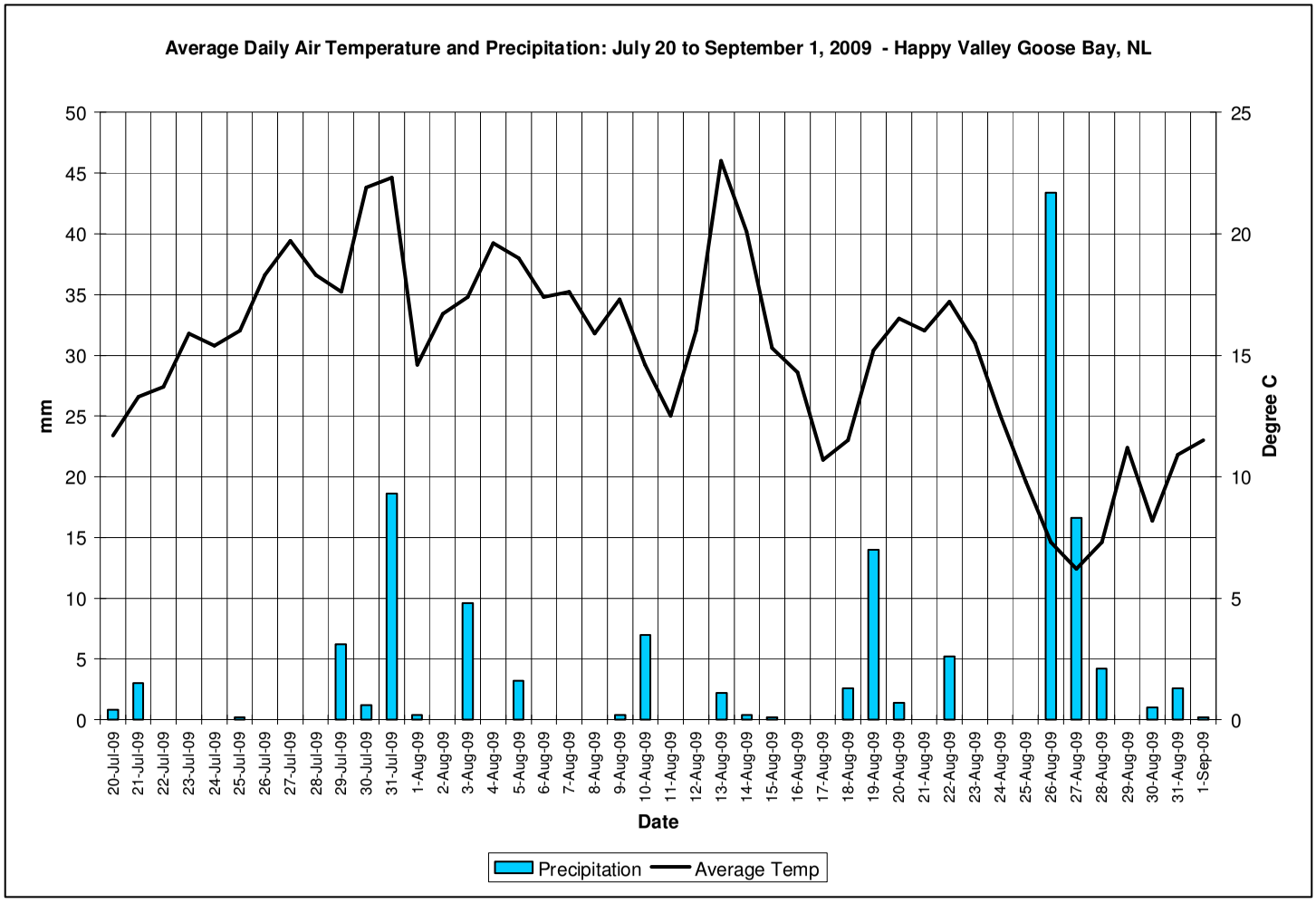

Figure A-1: Mean daily air temperature and precipitation for Happy Valley Goose Bay area, July 20 to September 1, 2009.

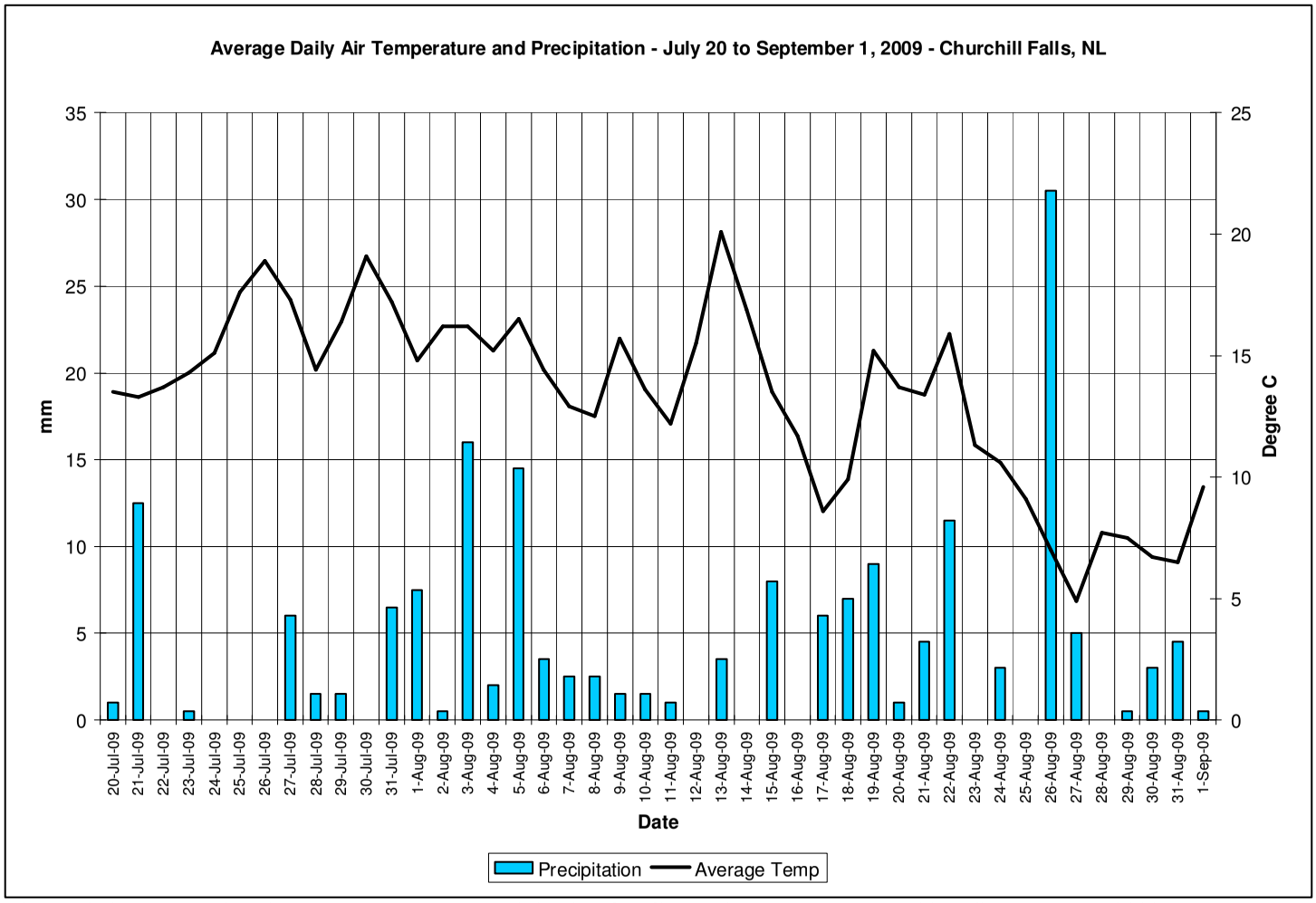

Figure A-2: Mean daily air temperature and precipitation for Churchill Falls area, July 20 to September 1, 2009.