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 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. Stations below Lower Muskrat Falls and below Grizzle Rapids were switched out on September 22 (22 day deployment), while stations above Upper Muskrat Falls and below Metchin River were switched out on September 23 (23 day deployment).
- A transmission error at the station below Lower Muskrat Falls between August 31 and September 23, prevented data from being available on the real-time webpage. All water quality data was retrieved from the instruments' internal log file upon removal on September 23. Water quantity data will be retrieved at the next site visit by Environment Canada.

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 all stations, all parameters ranked 'excellent' or 'good' at both installation and removal.

Table 1: QA/QC Data Comparison Rankings upon installation on September 1 and removal on September 22/23, 2009.

				Instrument Comparison Ranking				
Churchill River Station	Date	Action	Instrument Serial Number	Temperature	pH	Specific Conductivity	Dissolved Oxygen	Turbidity
Below Muskrat Falls	01-Sep-09	Installation	45700	Good	Good	Excellent	Excellent	Good
	22-Sep-09	Removal		Good	Good	Excellent	Excellent	Excellent
Above Muskrat Falls	01-Sep-09	Installation	45042	Excellent	Excellent	Excellent	Excellent	Good
	23-Sep-09	Removal		Good	Excellent	Excellent	Excellent	Good
Below Metchin River	01-Sep-09	Installation	45707	Excellent	Excellent	Excellent	Excellent	Excellent
	23-Sep-09	Removal		Excellent	Good	Excellent	Excellent	Excellent
Below Grizzle Rapids	01-Sep-09	Installation	45699	Excellent	Excellent	Excellent	Excellent	Excellent
	22-Sep-09	Removal		Good	Good	Excellent	Excellent	Excellent

Data Interpretation

Churchill River 6.15km below Lower Muskrat Falls

Temperature

Water temperature decreases throughout the deployment period (Figure 1). This trend is excepted as ambient air temperatures are also decreasing during this time of year. Temperature ranges between 19.81°C and 8.61°C, averaging at 11.56°C.

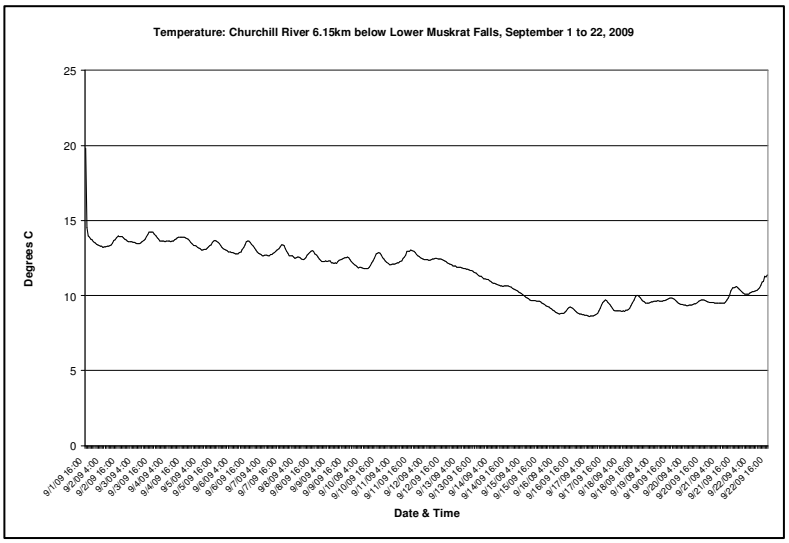

Figure 1: Water temperature for Lower Muskrat Falls Station, September 1 to 22, 2009.

pH

pH remains stable throughout the first two weeks of the deployment period ranging between 7.21 and 7.00 (Figure 2). On September 15, the instrument recorded a significant drop in pH (circled in red) from and average of 7.09 units to 6.93 units. pH continues to be stable for the remainder of the deployment period averaging around 6.94. The drop is likely due to a large rainfall event in the area (Appendix 1). Despite this noticeable drop, all values are within the acceptable limits according to the CCME guidelines for the Protection of Aquatic Life (>6.5 and <9.0).

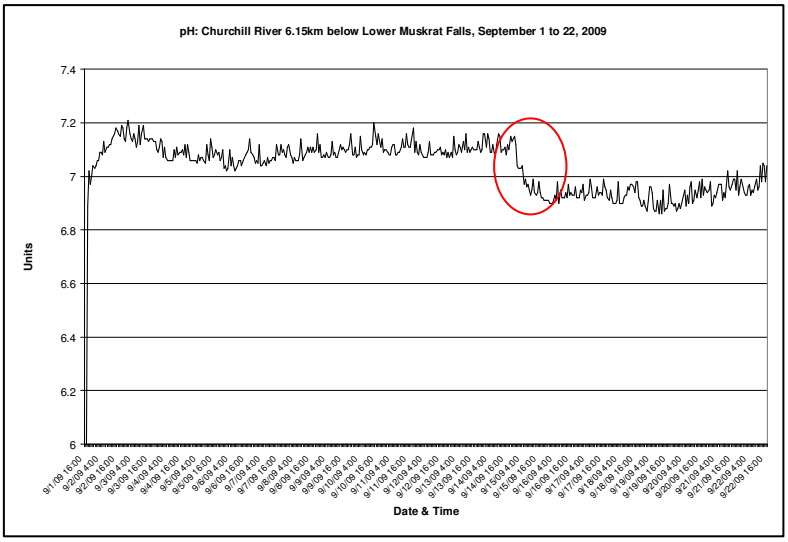

Figure 2: pH for Lower Muskrat Falls Station, September 1 to 22, 2009.

Specific Conductivity and Total Dissolved Solids

Values for specific conductance in the instruments internal log file are recorded to 0 decimal places. Programming and log file set up will be investigated to avoid this error in the future. Specific conductance values are normally recorded to at least 1 decimal place to provide sufficient detail for examining water quality. From the data provided by the instrument deployed at this station, a general fluctuating pattern can be interpreted (Figure 3). Specific conductance values range between 16uS/cm and 21uS/cm.

Total dissolved solid values were not available due to the same programming issue. All TDS values were recorded as 0 during the deployment period.

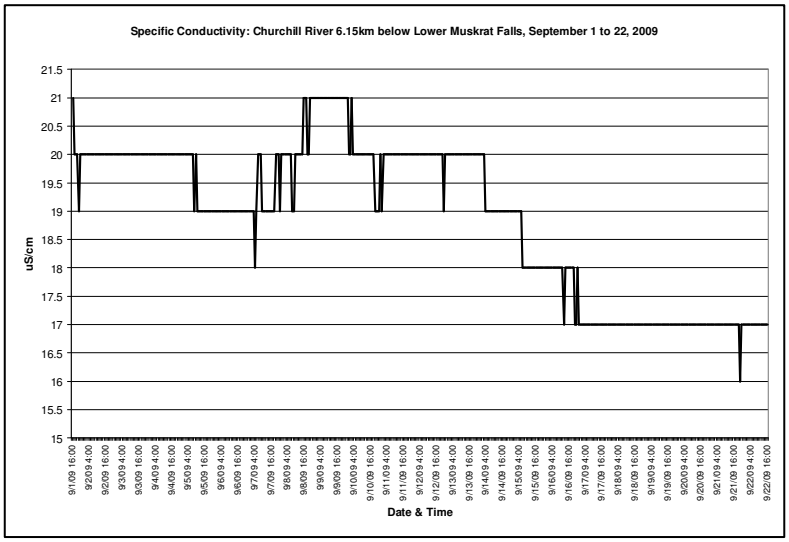

Figure 3: Specific Conductivity for Lower Muskrat Falls Station, September 1 to 22, 2009.

Dissolved Oxygen and Percent Saturation

Dissolved oxygen values are rising throughout the deployment period (Figure 4). This trend is expected as air and water temperatures are decreasing during this time (Figure 1, Appendix 1). Values range between 9.09mg/L and 12.67mg/L. All values are above the lower acceptable limit for dissolved oxygen content as suggested y the CCME guidelines for the Protection of Aquatic Life (>9.0mg/L)

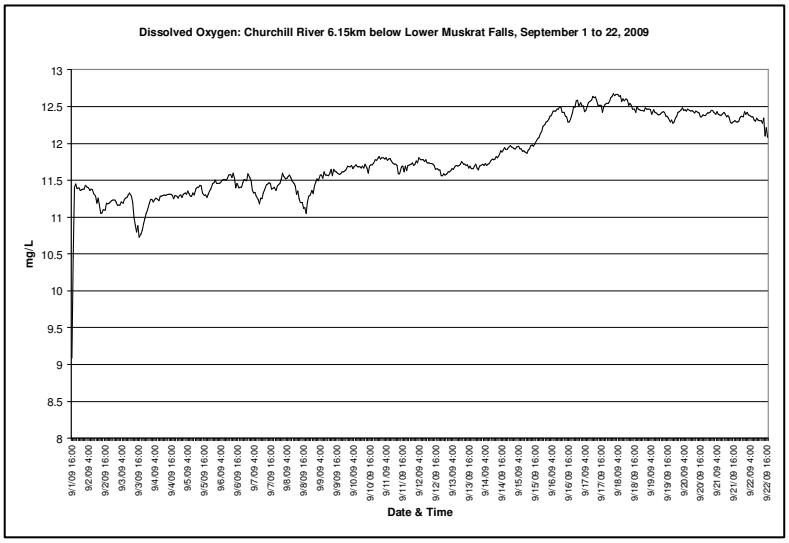

Figure 4: Dissolved Oxygen for Lower Muskrat Falls Station, September 1 to 22, 2009.

Percent saturation values are derived from dissolved oxygen and water temperature. Between September 1 and 22, percent saturation ranges between 99.6% and 111.8% (Figure 5).

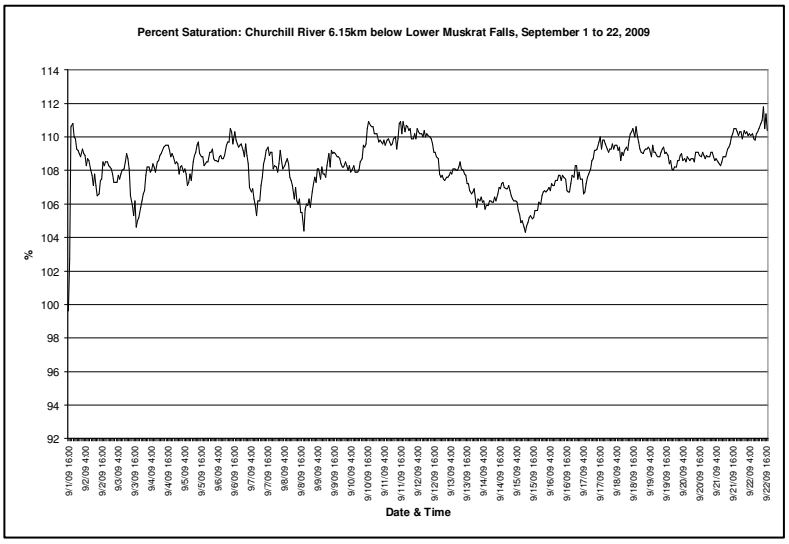

Figure 5: Percent Saturation for Lower Muskrat Falls Station, September 1 to 22, 2009.

Turbidity

Turbidity values range between 3 and 177.1NTU throughout the deployment period (Figure 6). Turbidity values are variable throughout the deployment which is normal at this site due to the silty nature in the lower reaches of the River. The red arrow highlights a spike occurring on September 3, up to 177.1NTU. This event is preceded by a rainfall event (11.2mm) on September 2. The green arrow shows a spike lasting around 12 hours and reaching values of 64.7NTU on September 9. There is no indication of a weather event associated with this spike. Circled in red is lengthy event that occurs between September 15 and 18 with values recorded up to 50.5NTU. A rainfall event between September 12 and 15 produced more than 80mm of rain contributing to the increase in turbidity. Finally, the blue arrow indicated a large spike up to 154NTU. This value is not sustained for any length of time and can likely be attributed to a rainfall event of 4.4mm the previous day.

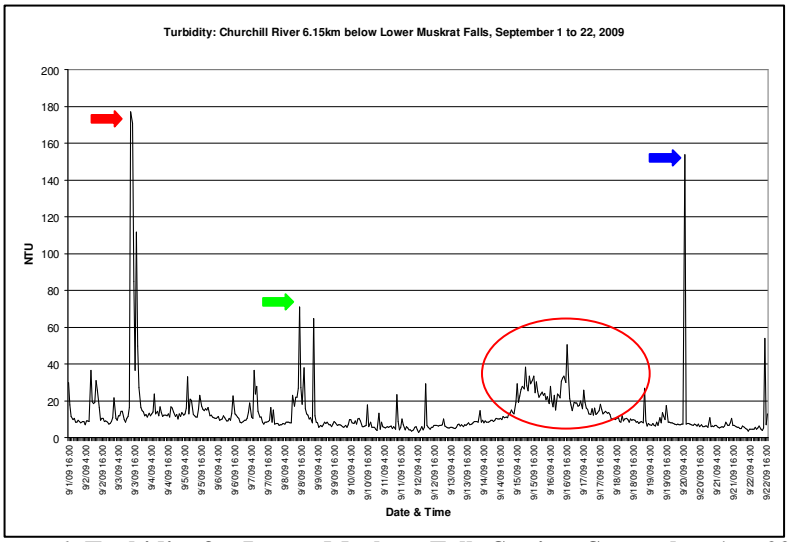

Figure 6: Turbidity for Lower Muskrat Falls Station, September 1 to 22, 2009.

Stage

Stage data is unavailable for this station due to the transmission error between August 31 and September 23. Data will be manually downloaded from the data logger during the next site by Environment Canada.

Churchill River above Upper Muskrat Falls

Temperature

Temperature values remain stable throughout beginning of the deployment period before decreasing slightly around September 11 (Figure 8). Values show a slight increasing trend in the last week of deployment. Temperature values range between 14.21°C and 7.66°C, averaging at 11.41°C.

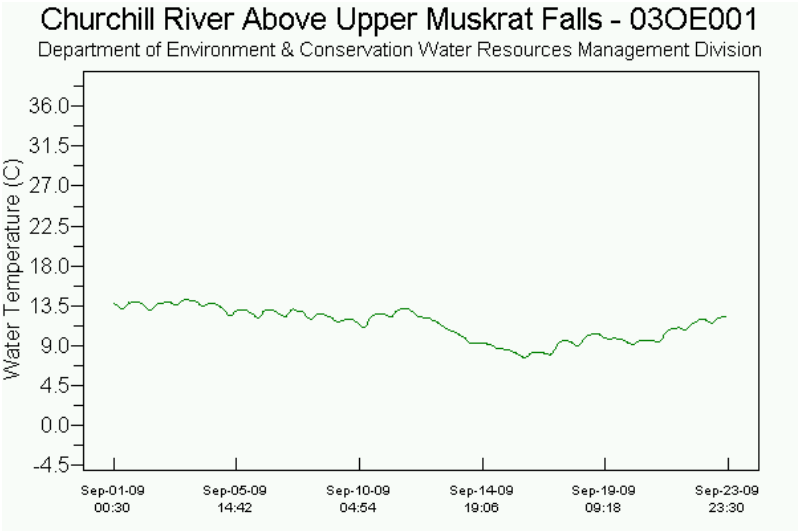

Figure 8: Water Temperature for Upper Muskrat Falls Station, September 1 to 23, 2009.

pH

pH values at this station remain stable ranging between 6.66 and 7.11 units, averaging 6.96 units (Figure 9). There is a slight decrease in pH (red arrow) around September 14. This decrease corresponds with a decrease in temperature, specific conductance and large increase in turbidity and follows a 3 day 80mm+ rainfall event in the area. All values are within the acceptable limits according to the CCME Guidelines for the Protection of Aquatic Life.

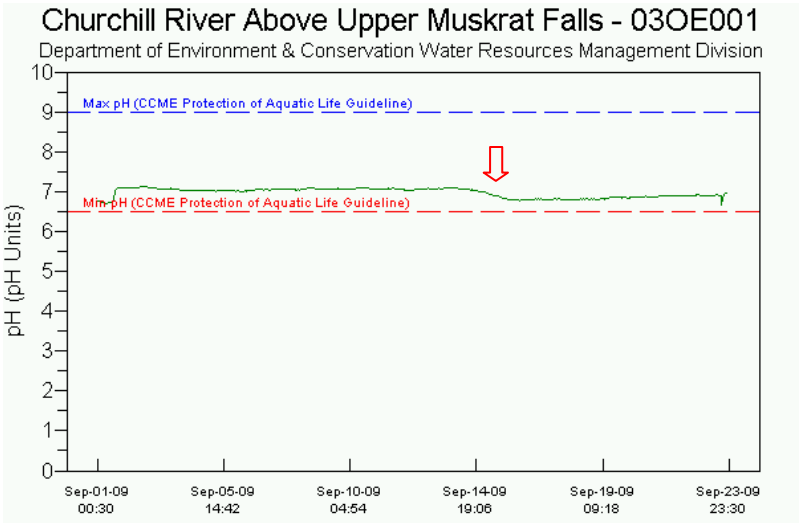

Figure 9: pH for Upper Muskrat Falls Station, September 1 to 23, 2009.

Specific Conductivity and Total Dissolved Solids

Specific conductance varies throughout the deployment period ranging between 16.5µS/cm and 21.8µS/cm (Figure 10). Specific conductance falls significantly from 21.8µS/cm to 17.6µS/cm on September 14 following a 3 day 80mm+ rainfall event in the Goose Bay area. Values drop on September 23 when the instrument is removed.

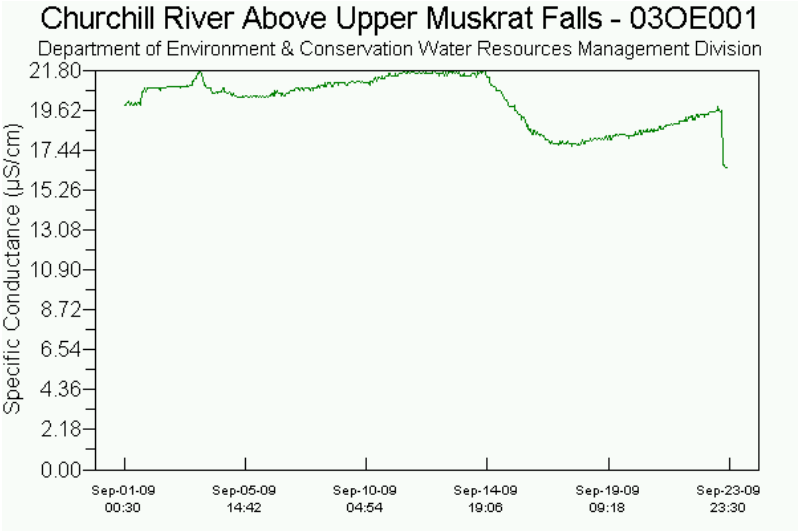

Figure 10: Specific Conductance for Upper Muskrat Falls Station, September 1 to 23, 2009.

Total dissolved solid concentrations in the water column are derived from the specific conductance. Values range between 0.0140g/L and 0.0106g/L during the deployment (Figure 11).

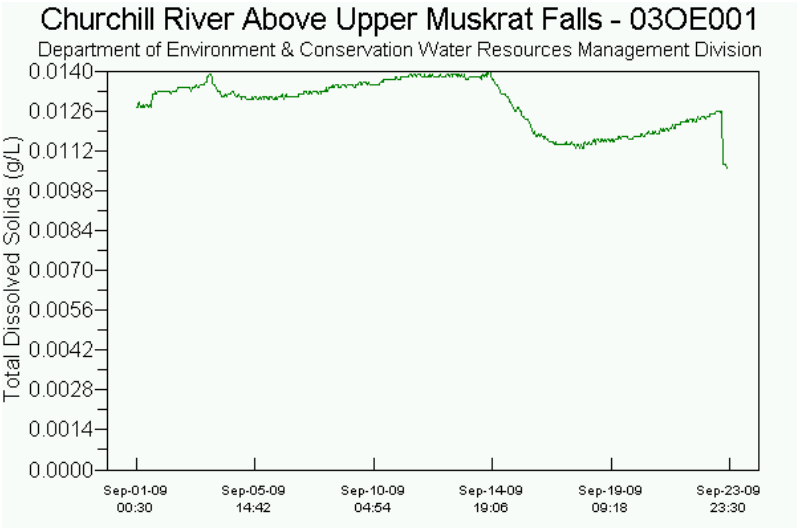

Figure 11: Total Dissolved Solids for Upper Muskrat Falls Station, September 1 to 23, 2009.

Dissolved Oxygen and Percent Saturation

Dissolved Oxygen values increase slightly throughout the deployment period (Figure 12). This trend is expected as water and air temperatures are decreasing during this time of year (Figure 8, Appendix 1). Values range between 9.84mg/L and 11.31mg/L, averaging 10.49mg/L. All values are above the lower acceptable limit (9.0mg/L) pertaining to the CCME Guideline for the Protection of Aquatic Life.

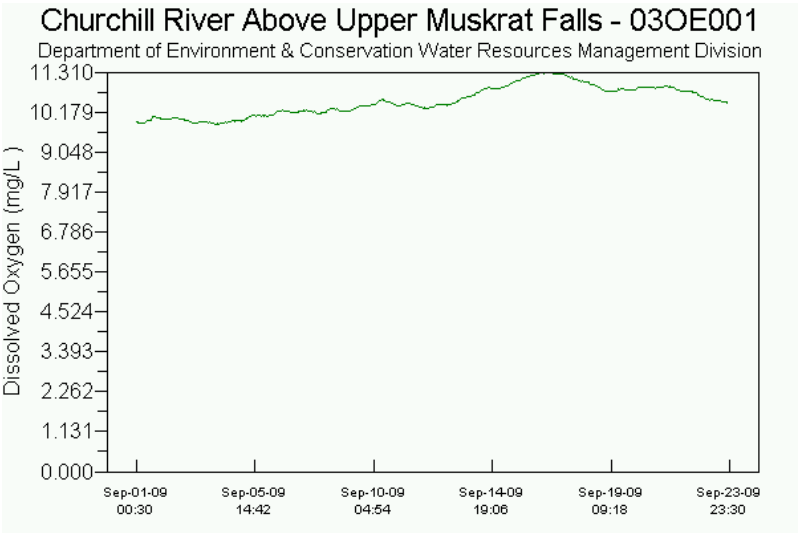

Figure 12: Dissolved Oxygen for Upper Muskrat Falls Station, September 1 to 23, 2009.

Percent saturation remains stable throughout the deployment period with values ranging between 93.6% and 99.1% (Figure 13).

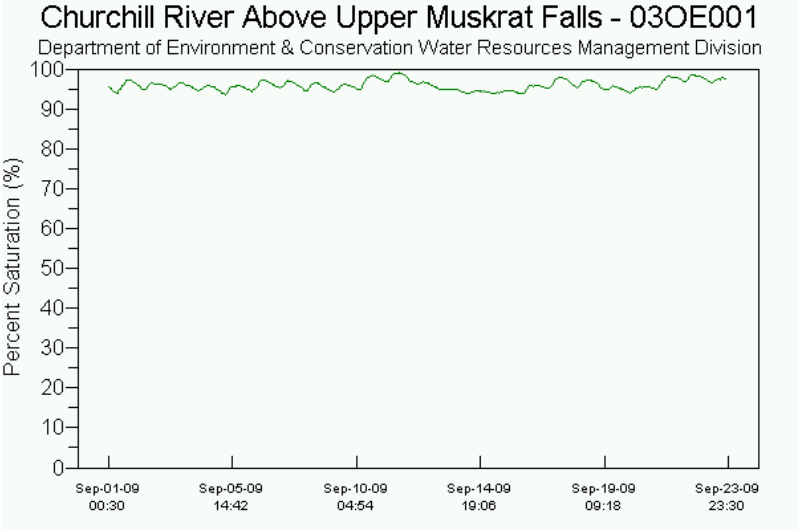

Figure 13: Percent Saturation for Upper Muskrat Falls Station, September 1 to 23, 2009.

Turbidity

Turbidity varies throughout the deployment period at the station above Upper Muskrat Falls (Figure 14). Values range between 2NTU and 40NTU. 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. The large spike near the beginning (circled in red) on September 3, follows a rainfall event in the Goose Bay area (Appendix 1). Another spike on September 15 also follow a rainfall event last 3 days that generated more than 80mm of precipitation (Appendix 1).

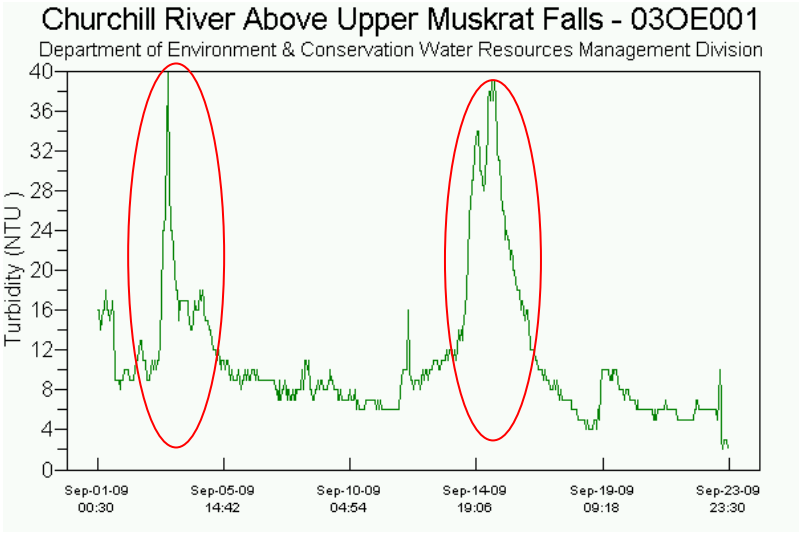

Figure 14: Turbidity for Upper Muskrat Falls Station, September 1 to 23, 2009.

Stage

Stage level rises and falls throughout the deployment period (Figure 15). Maximum stage level recorded was 16.616m and the minimum 15.852m. There is an increase in stage between September 15 and 18 during the time of the rainfall event (Appendix 1).

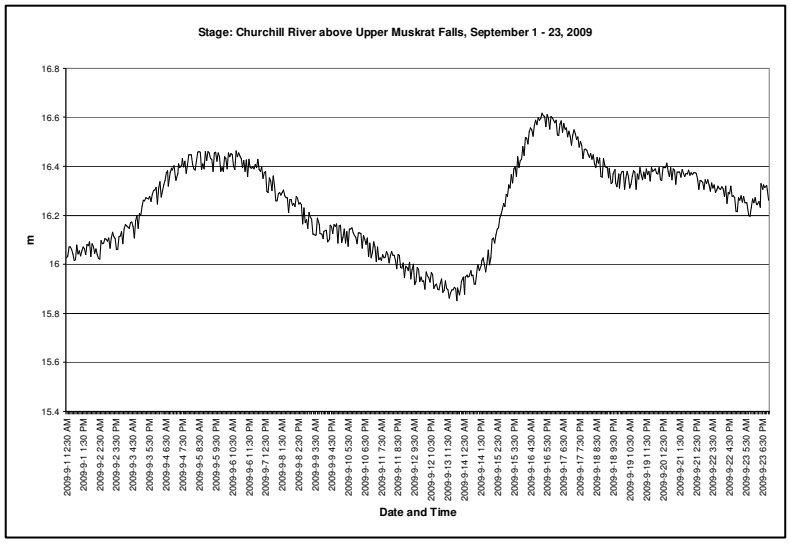

Figure 15: Stage level for Upper Muskrat Falls Station, September 1 to 23, 2009.

Churchill River below Grizzle Rapids

Temperature

Temperature values remain stable throughout the deployment period (Figure 16). Values range between 15.3 and 9.0°C, averaging at 11.97°C.

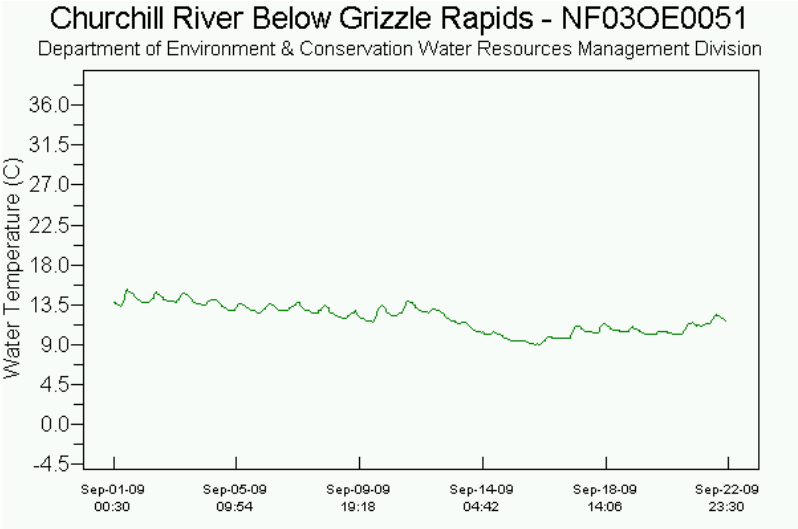

Figure 16: Water Temperature below Grizzle Rapids, September 1 to 22, 2009.

pH

pH values remain stable throughout the deployment period ranging between 6.82 and 7.45 units (Figure 17). The figure below shows pH dropping for one measurement to 6.42 units on September 1, at 1:30pm. This is when the instrument was beginning deployed. All values after this are within the CCME Guidelines for the Protection of Aquatic Life (>6.5 and <9.0).

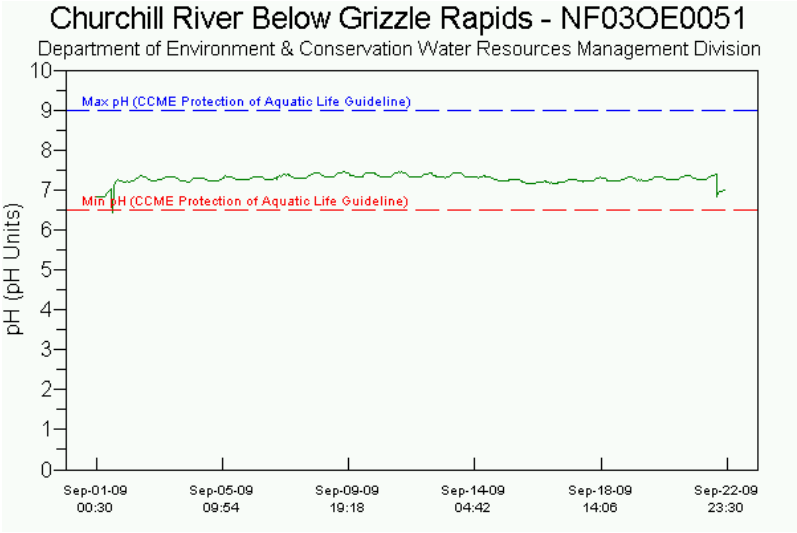

Figure 17: pH below Grizzle Rapids, September 1 to 22, 2009.

Specific Conductivity

Specific conductivity values remain stable throughout the beginning of the deployment before decreasing significantly around September 14 (circled in red) (Figure 18). This decrease corresponds with a significant rainfall event in the Goose Bay area that last 3 days and produced 80mm+ of precipitation. Values range between 19.0 µS/cm and 22.0 µS/cm.

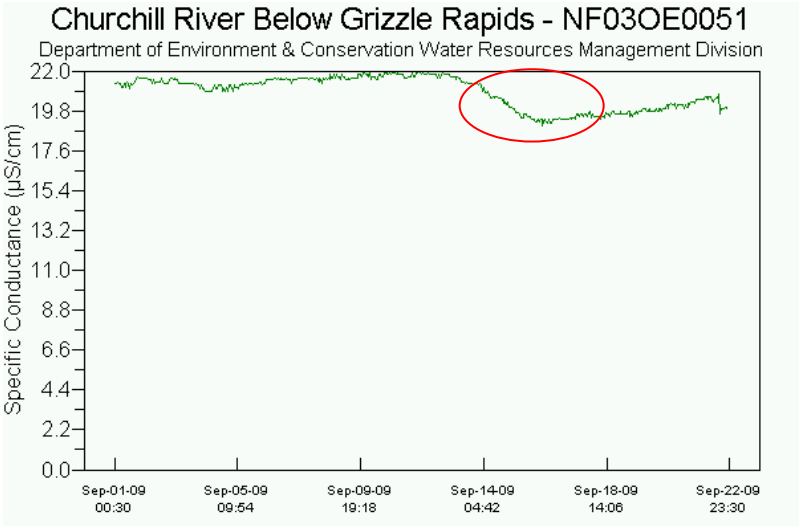

Figure 18: Specific Conductance below Grizzle Rapids, September 1 to 22, 2009.

Total dissolved solid concentration is derived from specific conductance (Figure 19). Values range between 0.0122g/L and 0.0141g/L.

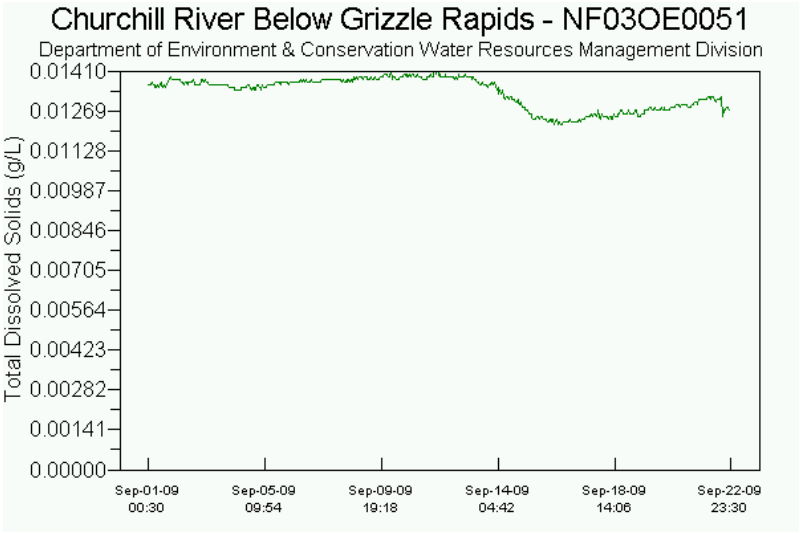

Figure 19: Total Dissolved Solids below Grizzle Rapids, September 1 to 22, 2009.

Dissolved Oxygen and Percent Saturation

Dissolved oxygen concentration is stable throughout the deployment period slightly increasing over the 22 day deployment (Figure 20). There is a sharp decrease recorded on September 16, when dissolved oxygen content drops from 11.2mg/L to 10.14mg/L. The decrease is sustained for only one hour before returning to 11.15mg/L. Between September 1 and 23, values range between 9.9 mg/L and 11.21 mg/L averaging 10.52mg/L. All values are above the minimum values for dissolved oxygen according to the CCME guidelines for the Protection of Aquatic Life (>9.0mg/L).

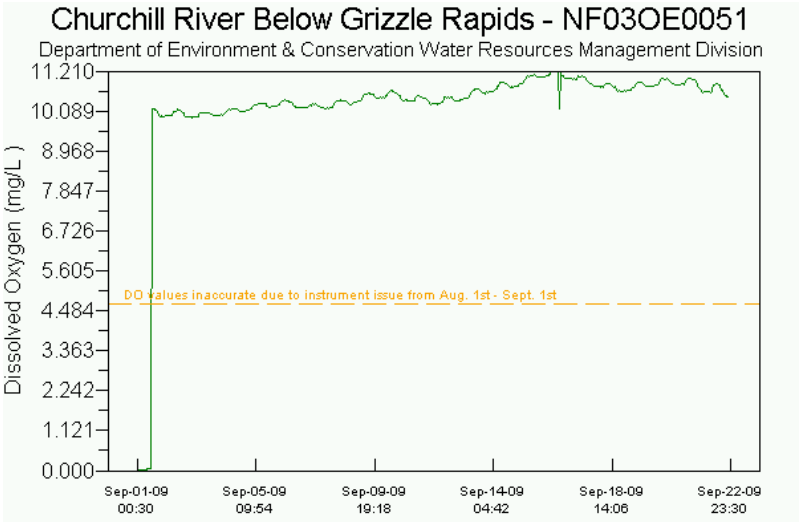

Figure 20: Dissolved Oxygen below Grizzle Rapids, September 1 to 22, 2009.

Percent saturation values are derived from the dissolved oxygen and temperature sensors. Values ranges between 101.7% and 94.8% and drop once to 89.6% on September 16 (Figure 21).

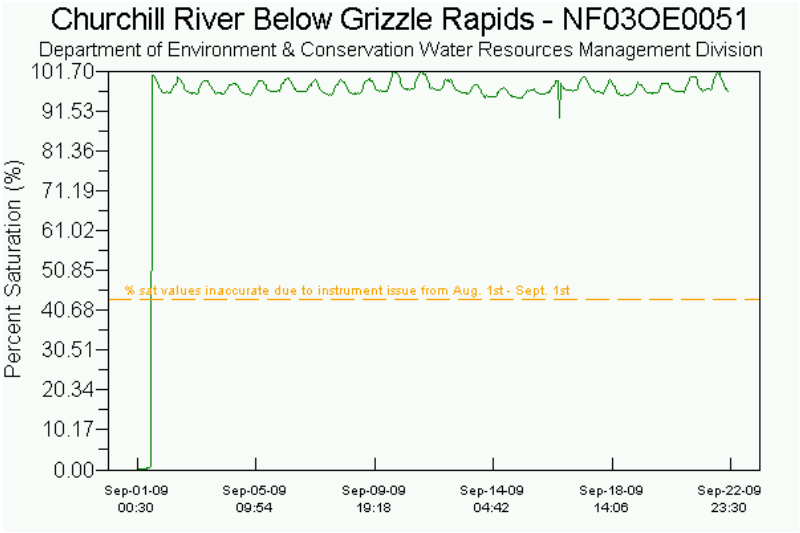

Figure 21: Percent Saturation below Grizzle Rapids, September 1 to 22, 2009.

Turbidity

Turbidity values are 0NTU for the entire deployment period except for 1 measurement on September 7 recording 3.2NTU (Figure 22).

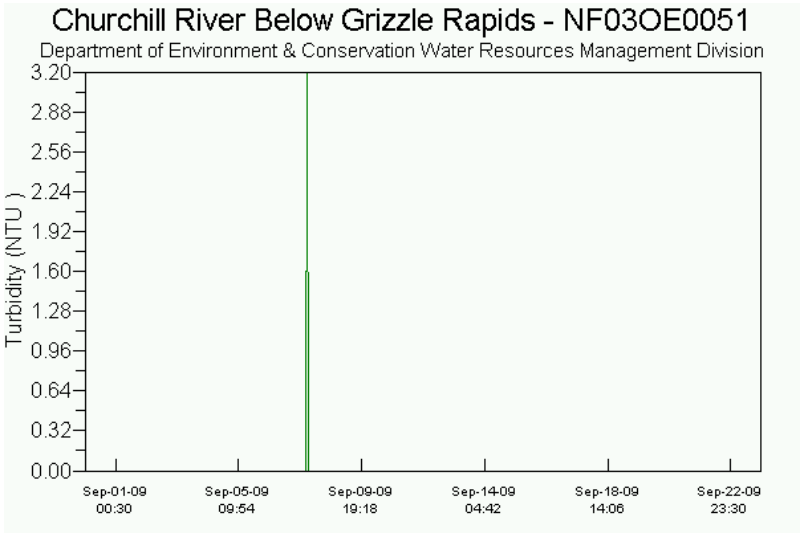

Figure 22: Turbidity below Grizzle Rapids, September 1 to 22, 2009.

Stage

Stage level rises and falls slightly throughout the deployment period (Figure 23). Maximum stage level during the deployment was 33.514m and the minimum was 33.306m. Stage level increase between September 15 and 18 during the rainfall event (Appendix 1).

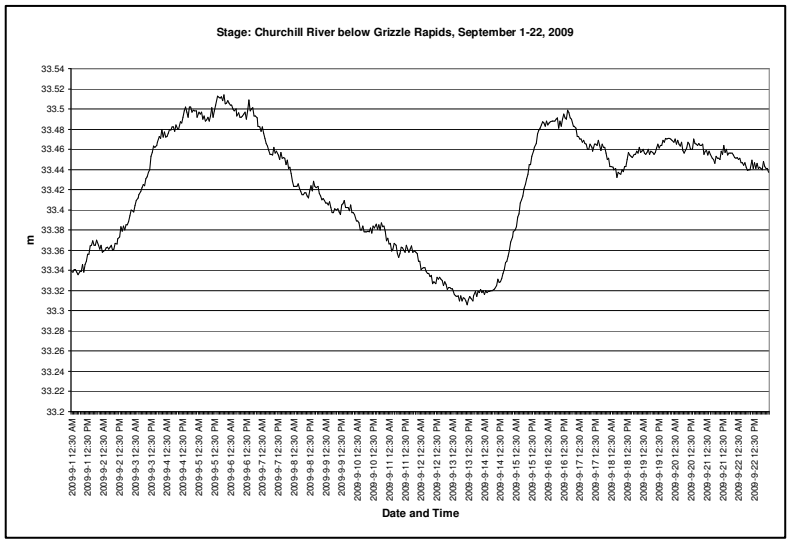

Figure 23: Stage level below Grizzle Rapids, September 1 to 22, 2009.

Churchill River below Metchin River

Temperature

Temperature decreases slightly throughout the deployment period (Figure 24). The temperature values between September 1 and 23, averages 10.50°C, ranging between 12.4°C and 8.5°C.

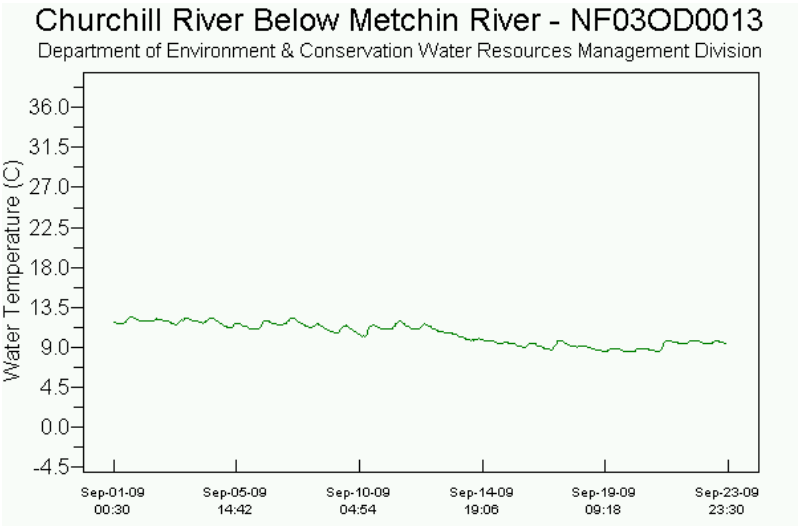

Figure 24: Water Temperature below Metchin River, September 1 to 23, 2009.

pH

pH values remain stable throughout the deployment period ranging between 6.84 and 7.36 units, averaging at 7.27 units (Figure 25). All values are within the acceptable limits for pH according to the CCME Guideline for the Protection of Aquatic Life (>9.0 units).

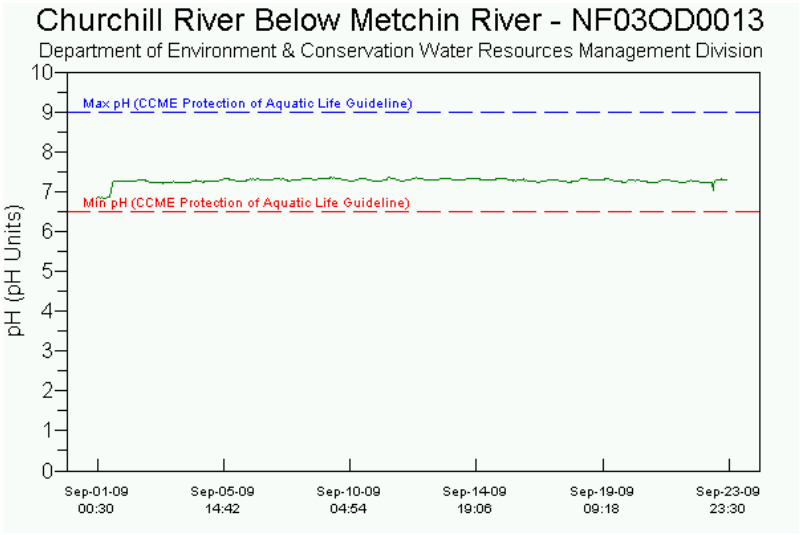

Figure 25: pH below Metchin River, September 1 to 23, 2009.

Specific Conductivity

Specific conductivity values remain stable throughout the deployment period with no significant increases or decreases (Figure 26). Values range between 22.1µS/cm and 23.9µS/cm, averaging at 23.09µS/cm.

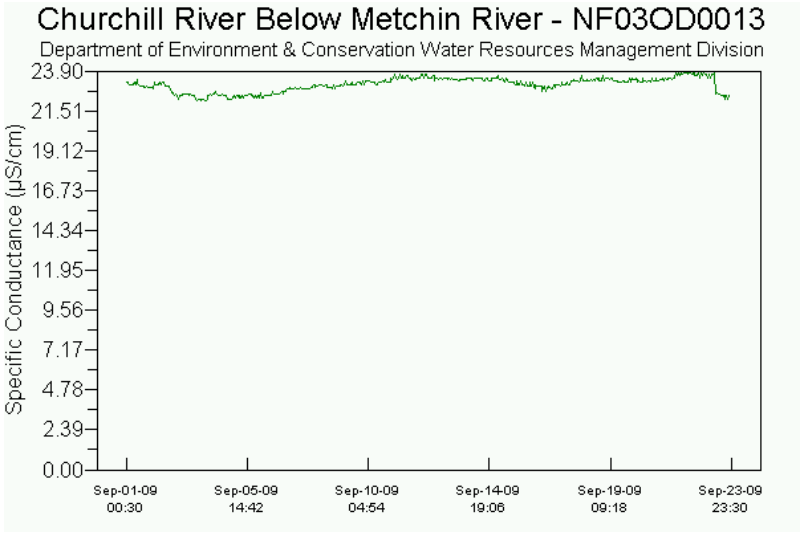

Figure 26: Specific Conductance below Metchin River, September 1 to 23, 2009

Total Dissolved solid concentrations are derived from specific conductance (Figure 27). Values range between 0.0153g/L and 0.0141g/L.

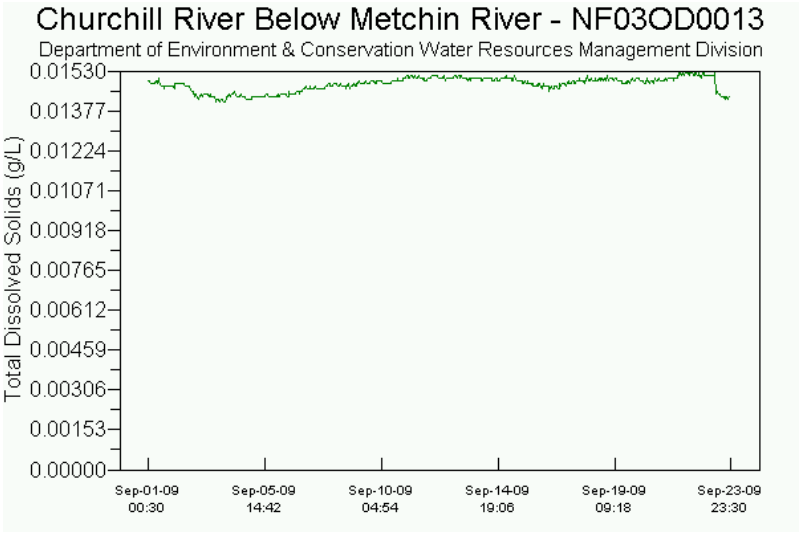

Figure 27: Total Dissolved Solids below Metchin River, September 1 to 23, 2009.

Dissolved Oxygen and Percent Saturation

Dissolved oxygen values increase slightly throughout the deployment period ranging between 9.91mg/L and 10.99mg/L (Figure 28). This trend is expected as water and air temperatures are decreasing during this time (Figure 24, Appendix 1). All values for dissolved oxygen are within the lower acceptable limit for dissolved oxygen content in cold waters (9.0mg/L).

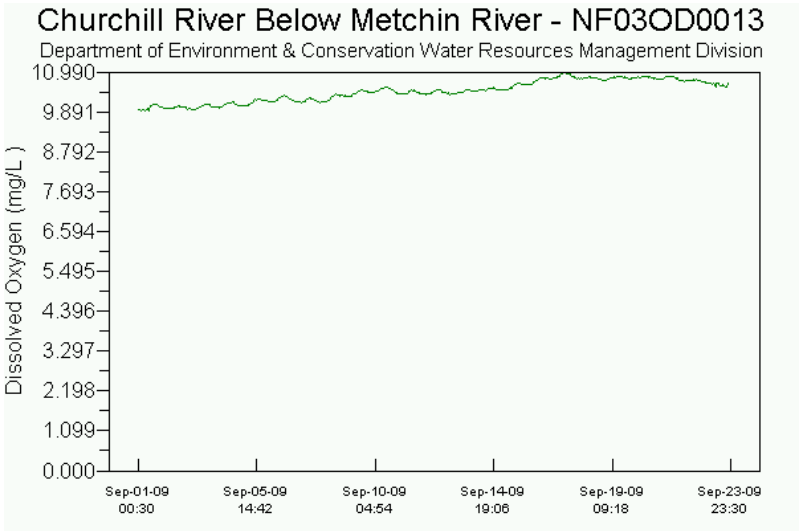

Figure 28: Dissolved Oxygen below Metchin River, September 1 to 23, 2009.

Percent saturation values are derived from the dissolved oxygen and temperature readings. Values range between 97.0% and 91.3% (Figure 29).

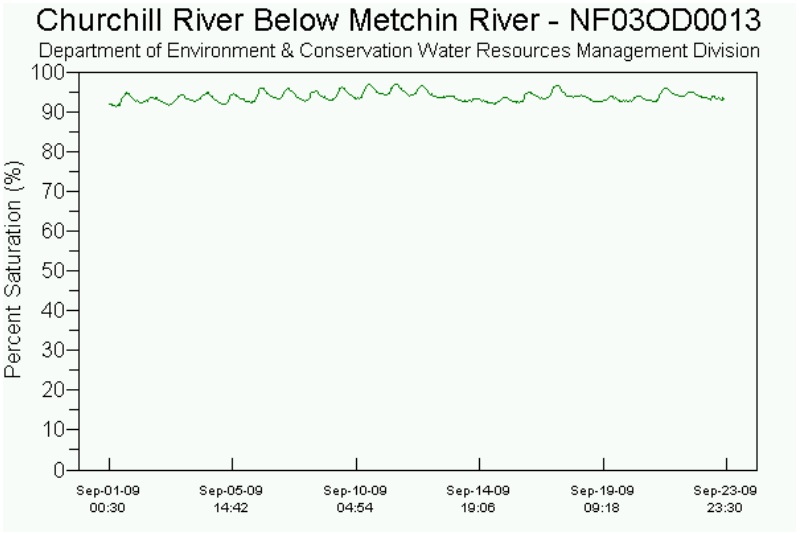

Figure 29: Percent Saturation below Metchin River, September 1 to 23, 2009.

Turbidity

Turbidity values remain at 0NTU for the entire deployment period (Figure 30).

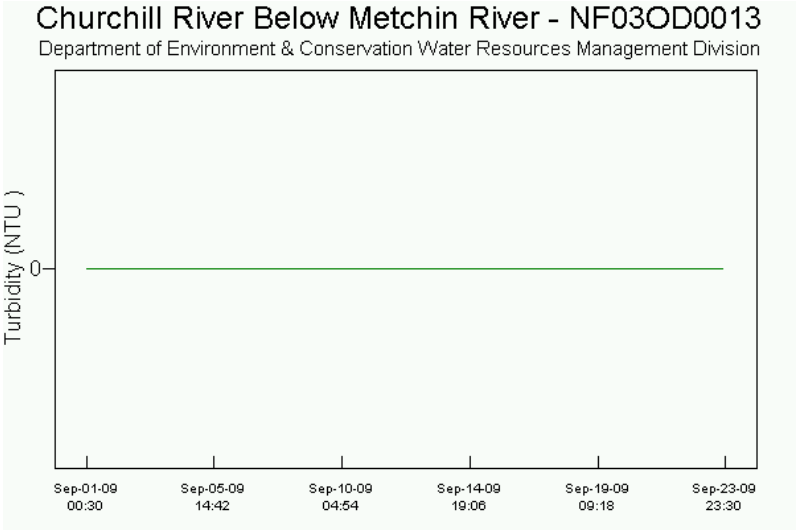

Figure 30: Turbidity below Metchin River, September 1 to 23, 2009.

Stage

Stage levels rise and fall throughout the deployment period (Figure 32). Maximum stage level is recorded at 112.888m and the minimum level at 112.424m.

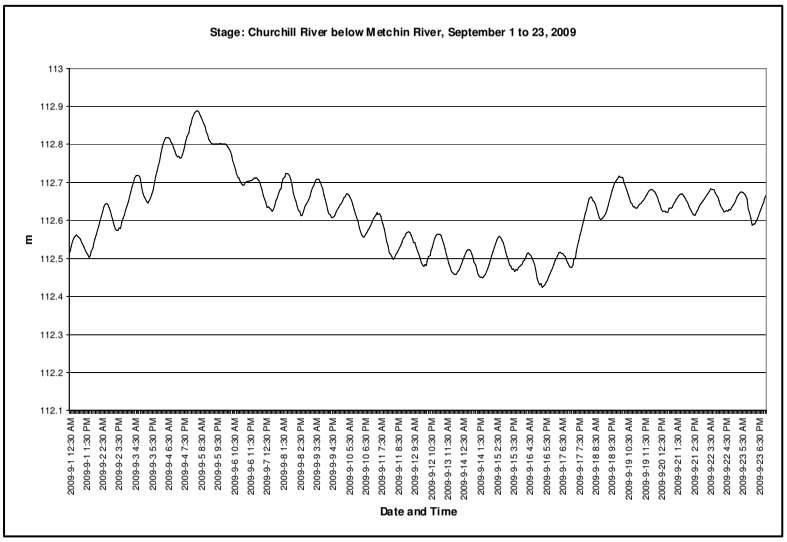

Figure 31: Stage level below Metchin River, September 1 to 23, 2009.

Conclusions

Water quality monitoring stations located on the Lower Churchill River at 6.15km below Lower Muskrat Falls and below Grizzle Rapids were deployed between September 1 and 22. Stations above upper Muskrat Falls and below Metchin River were deployed between September 1 and 23. All stations reported data for water quality parameters; temperature, pH, specific conductivity (total dissolved solids), dissolved oxygen (percent saturation), and turbidity

At the station below Lower Muskrat Falls, a data transmission error prevented data from being sent and graphed on the real time webpage during the deployment. All data was retrieved from the instruments internal log file. Because of an error with the log file programming, specific conductivity and total dissolved solids are only measured to 0 decimal places.

Precipitation events recorded by Environment Canada for Goose Bay and Churchill Falls can be used to explain most fluctuations in water quality. A significant rainfall event recorded in Goose Bay between September 12 and 15 produced more than 80mm of rain in the area. This event is likely the cause of the decreases in pH at stations below Muskrat Falls, and above Muskrat Falls, and specific conductivity above Muskrat Falls and below Grizzle Rapids. Increases in turbidity and stage level are also noticed at stations below Muskrat Falls and above Muskrat Falls.

Despite all natural fluctuations in water quality along the Lower Churchill River between September 1 and 23, all values recorded for pH and dissolved oxygen are within the recommend range as stated by the CCME Guidelines for the Protection of Aquatic Health.

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Appendix 1 – Weather Data

Table A-1: Weather for Happy Valley Goose Bay – September 1 to September 23, 2009

	Max Temp °C	*Min Temp °C*	*Mean Temp °C*	*Total Precip mm*	*Dir of Max Gus 10's Deg t*	*Spd of Max Gust km/h*
2-Sep	20.7	7.9	14.3	11	23E	52E
3-Sep	19.4	9.8	14.6	T	25E	61E
4-Sep	14	3	8.5	1.2		<31
5-Sep	14.2	2.8	8.5	0	30E	46E
6-Sep	17	3.6	10.3	0	24E	54E
7-Sep	16.5	6.5	11.5	T	25E	56E
8-Sep	14.1	5.1	9.6	T	27E	52E
9-Sep	12.9	3.1	8	T	34E	48E
10-Sep	23.2	5	14.1	0	24E	39E
11-Sep	23.2	7.8	15.5	0	25E	35E
12-Sep	11	2.2	6.6	3.4	4E	37E
13-Sep	4.6	2	3.3	18.8	4E	39E
14-Sep	5.8	3.3	4.6	58.4	34E	59E
15-Sep	6.3	-0.6	2.9	1.6	33E	67E
16-Sep	9.5	-0.9	4.3	T	26E	37E
17-Sep	19.3	7.9	13.6	0	23E	44E
18-Sep	18.8	6	12.4	2		<31
19-Sep	9.3	1.2	5.3	4.4	35E	41E
20-Sep	11.6	1.8	6.7	0		<31
21-Sep	21.9	8.4	15.2	0	24E	48E
22-Sep	25.2	14.7	20	T	M	M
23-Sep	22.4	3.6	13	17.4	33E	56E

Table A-2: Weather for Churchill Falls – September 1 to September 23, 2009

	Max Temp°C	*Min Temp°C*	*Mean Temp°C*	*Total Precip mm*	*Dir of Max Gust10's Deg*	*Spd of Max Gust km/h*
1-Sep	16.3	2.8	9.6	0.5		<31
2-Sep	16	7.6	11.8	14	23	33
3-Sep	15	6.5	10.8	3.5	27E	48E
4-Sep	11.1	2.1	6.6	1.5	30	32
5-Sep	10.7	2.2	6.5	0	30	41
6-Sep	15.7	4.4	10.1	3	25	44
7-Sep	12.5	3.8	8.2	3	33	46

8-Sep	9.1	3.9	6.5	0	32	54
9-Sep	11.2	0.6	5.9	0.5	33	39
10-Sep	20.9	0	10.5	0.5	26	35
11-Sep	19.1	5.8	12.5	0	31	33
12-Sep	13.9	3.8	8.9	0.5		<31
13-Sep	4.2	1.4	2.8	0	8	33
14-Sep	2.8	0.8	1.8	9	36	39
15-Sep	6.2	0.3	3.3	1	36	52
16-Sep	8.3	0.3	4.3	0	26	39
17-Sep	17.3	5.2	11.3	0	22	39
18-Sep	8.9	2.9	5.9	3	31	41
19-Sep	7.5	2.5	5	1	1	46
20-Sep	12.1	3.1	7.6	1.5	27	41
21-Sep	22.3	3.8	13.1	0	24	39
22-Sep	18.6	12.3	15.5	0	23	48
23-Sep	13.7	3.6	8.7	11	35	39

M = Missing data

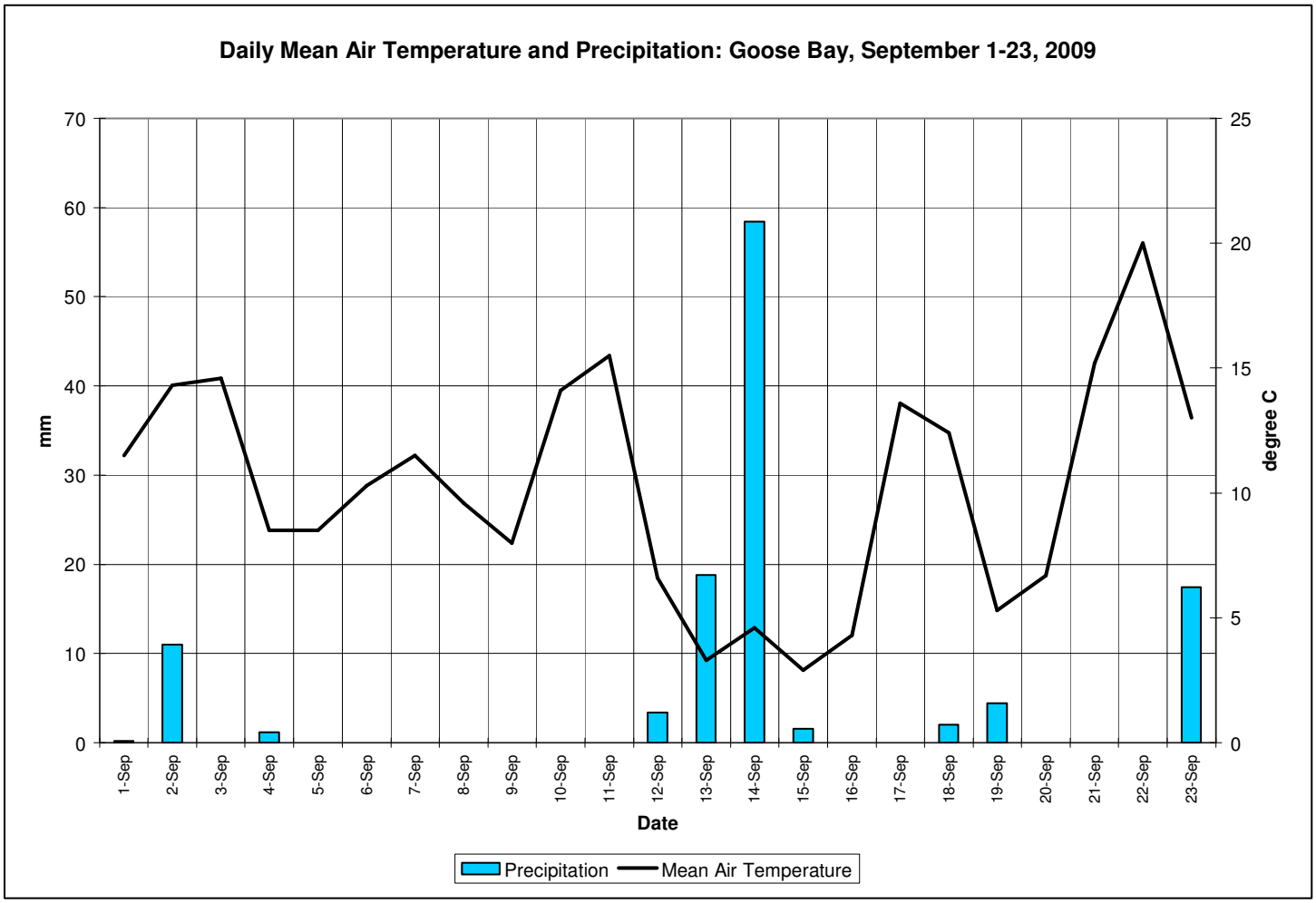

Figure A-1: Mean daily air temperature and precipitation for Happy Valley Goose Bay area, September 1 to September 23, 2009.

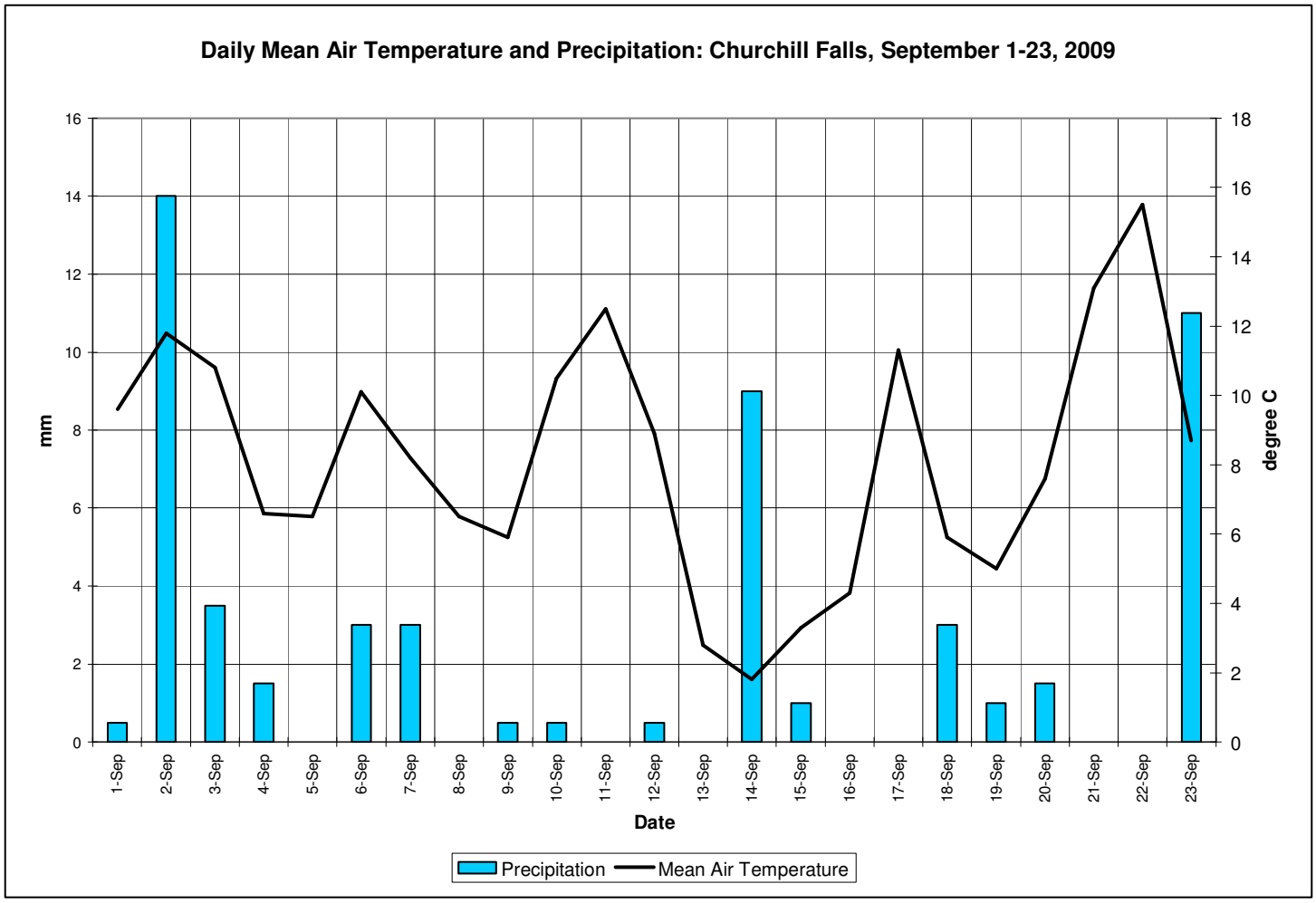

Figure A-2: Mean daily air temperature and precipitation for Churchill Falls area, September 1 to September 23, 2009.