Lower Churchill
Real Time Water Monitoring Network
2009Annual Report

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Acknowledgements

The Real-Time Water Quality Monitoring Network on the Lower Churchill River is successful in tracking emerging water quality issues as well as creating a database of baseline water quality data due to the hard work and diligence of certain individuals. The management and staff of Nalcor work in cooperation with the management and staff of the Department of Environment and Conservation (ENVC) as well as Environment Canada (EC) to ensure the protection of ambient water resources along the Lower Churchill River.

Various individuals from ENVC have been integral in ensuring the smooth operation of such a technologically advanced network. In 2009, ENVC Environmental Scientist, Grace Gillis, was responsible for deployment and removal of instruments including cleaning/calibration and preparation of monthly deployment reports.

Environment Canada staff, under the Meteorological Service of Canada Water Survey Canada (Perry Pretty, Bill Mullins, and Brent Ruth) play an essential role in the data logging/communication aspect of the network. These individuals visit the site regularly to ensure the data logging equipment is operating properly and transmitting the data efficiently. Finally, they play the lead role in dealing with hydrological quantity and flow issues.

The managers from each agency (Marion Organ – Nalcor; Renee Paterson and Amir Ali Khan - ENVC; Howie Wills – EC) are fully committed to improving this network and ensuring it provides meaningful and accurate water quality/quantity data that can be used in the decision-making process. This network is only successful due the cooperation of all three agencies involved.

Introduction

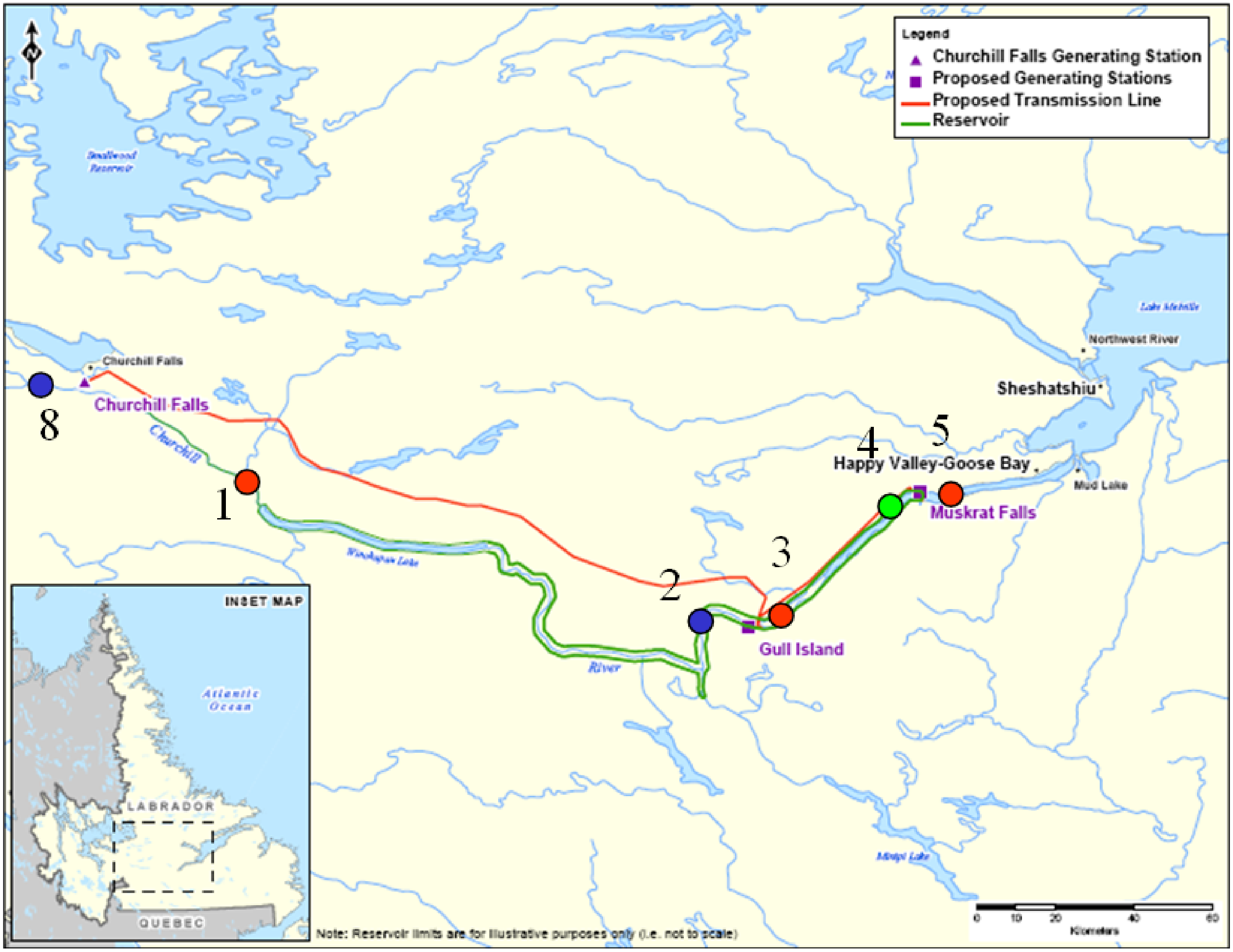
- The real-time water quality monitoring (RTWQM) network on the Lower Churchill was successfully established by Department of Environment and Conservation (ENVC) and Environment Canada (EC) staff in cooperation with Nalcor Energy employees in fall 2008.
- The objective of the network is to identify and track any emerging water quality or quantity management issues and ensure protection of ambient water resources along the Lower Churchill River. The information currently being collected will serve as a baseline from which changes throughout the several phases of the Lower Churchill Hydroelectric Generation Project can be monitored.
- Continuous monitoring recommenced in spring 2009 when ice conditions permitted. This report summarizes the data collected and water quality events captured during the 2009 deployment season (June to November 2009).
- The RTWQM network consists of 4 stations along the Churchill River from just below the confluence with Metchin River to just below Muskrat Falls. These stations measure water quality parameters such as water temperature, pH, specific conductivity, dissolved oxygen, and turbidity. Two additional parameters, total dissolved solids and percent saturation are calculated from measured parameters.
- These stations as well as 2 additional stations along the Lower Churchill record continuous stage level and flow rate data. These parameters are the responsibility of Environment Canada, however, if needed, ENVC staff reporting on water quality will have access to water quantity information to understand and explain water quality fluctuations.
- The locations, names and parameters recorded at each station are summarized in **Table 1**.

Table 1: Station Names, coordinates and parameters measured for Churchill River real-time water monitoring network.

Station Name Churchill River	**Latitude**	**Longitude**	**Owner**	**Water Quantity***	**Water Quality****
6.15km below Lower Muskrat Falls	53 14 15.5	60 40 30.8	Nalcor	♦	♦
Below Grizzle Rapids	52 57 50	61 24 29.8	DOEC	♦	♦
Above Grizzle Rapids	52 58 12.3	61 26 43.4	Nalcor	♦	
Below Metchin River	53 14 22.4	63 17 5.7	Nalcor	♦	♦
Above Churchill Falls Tailrace	53 31 28.7	64 06 53.8	Nalcor	♦	
Above Upper Muskrat Falls	53 14 52	60 47 21	Nalcor	♦	♦

* Water quantity includes water level and flow data
** Water quality includes data for water temperature, pH, dissolved oxygen, percent saturation, turbidity, TDS, and specific conductivity data

- Real time water quality instruments (often referred to by its manufacturer's name, Datasonde) were deployed between June 1 and November 2, 2009. Due to the intense winters in the Labrador Region, the RTWQ instrumentation is deployed from late spring to mid fall depending on the ice conditions. The hydrological equipment at all 6 stations, which records water quantity, remains in the river year round.
- The four RTWQ sites are equipped with protection shelters to house equipment and data loggers as well as certified helicopter landing pads. All four sites are helicopter accessible only.



- 🔴 Real Time Water Quality and Quantity Station (Nalcor)
- 🟢 Real Time Water Quality and Quantity Station (ENVC)
- 🔵 Real Time Water Quantity only station

Figure 1: Map of Churchill River in Labrador showing Real Time Water Quality and Quantity monitoring stations. (See Table 2 for station numbering).

Table 2: Station name and map number.

Station Name	Map Number
Below Metchin River	1
Above Grizzle Rapids	2
Below Grizzle Rapids	3
Above Upper Muskrat Falls	4
6.15km Below Lower Muskrat Falls	5
Above Churchill Falls Tailrace	8

Maintenance and Calibration of RTWQ Instrumentation

- It is recommended that regular maintenance and calibration take place on a monthly basis to ensure accurate data collection. This procedure is the responsibility of the ENVC staff and is performed preferably every 30 days.
- Maintenance includes a thorough cleaning of the instrument and replacement of any small sensor parts that are damaged or unsuitable for reuse. Once the instrument is cleaned, ENVC staff carefully calibrates each sensor attachment for pH, specific conductivity, dissolved oxygen and turbidity.
- On an annual basis, all RTWQ instrumentation is sent to the manufacturer for performance evaluation testing and any necessary repairs.
- An extended deployment period (>30 days) can result in Datasonde sensor drift which may result in skewed data. The Datasonde sensors will still work to capture any water quality event even though the exact data values collected may be inaccurate.
- Installation and removal dates for each station in the 2009 deployment season are summarized in **Table 3**.

Table 3: Installation and removal dates for Deployment Periods.

Installation	Removal	Days
June 1, 2009	June 24, 2009	24
June 24, 2009	July 20, 2009	26
July 20, 2009	Sept. 1, 2009	42
Sept. 1, 2009	Sept. 22/23, 2009	22/23
Sept. 22/23, 2009	Nov. 2, 2009	39/40

Quality Assurance and Quality Control

- Quality Assurance and Quality Control is a very important component of the RTWQM program and is regarded as an essential procedure to be preformed attentively by ENVC staff during installation and removal. These measures have been put in place to ensure that the instruments are collecting accurate data. There are 2 main components to the QA/QC measures performed by ENVC staff.

  i. Data from the water quality monitoring instrument in-situ (Datasonde) are compared to data from the QA/QC Datasonde at the time of deployment after maintenance/calibration procedures have been performed; data must fall within a specified range and are ranked from excellent to poor (**Table 4**).

  ii. Water grab samples are taken from each station at the time of redeployment and sent to a CALA certified laboratory for analysis. The results are then compared to those of the water quality monitoring instrument in-situ (Datasonde) and must fall within a specified range to receive a ranking (**Table 4**). Only three readings available from the lab for comparison – pH; conductivity; turbidity.

Table 4: Comparison Ranking Table. Differences between parameter values from in-situ field Datasonde and QA/QC Datasonde or laboratory results from grab samples are ranked from excellent to poor.

Parameters	Excellent	Good	Fair	Marginal	Poor
Temperature (^oC)	≤±0.2	≥±0.2 to 0.5	≥±0.5 to 0.8	≥±0.8 to 1.0	≥±1.0
pH (unit)	≤±0.2	≥±0.2 to 0.5	≥±0.5 to 0.8	≥±0.8 to 1.0	≥±1.0
Dissolved Oxygen (mg/L)	≤±0.3	≥±0.3 to 0.5	≥±0.5 to 0.8	≥±0.8 to 1.0	≥±1.0
Conductance **<35µS/cm (µS/cm)** **>35µS/cm (%)**	 ≤±3 ≤±3	 ≥±3 to 10 ≥±3 to 10	 ≥±10 to 15 ≥±10 to 15	 ≥15 to 20 ≥15 to 20	 ≥±20 ≥±20
Turbidity **<40 NTU (NTU)** **>40 NTU (%)**	 ≤±2 ≤±5	 ≥±2 to 5 ≥±5 to 10	 ≥±5 to 8 ≥±10 to 15	 ≥8 to 10 ≥15 to 20	 ≥±10 ≥±20

- QA/QC data comparisons by instrument and laboratory analysis for each station are summarized in Tables 5-8.

Table 5: QA/QC rankings for QA/QC and field sondes and laboratory data for Below Lower Muskrat Falls

Below Lower Muskrat Falls	Parameter	QAQC Sonde	Field Sonde	Laboratory Analysis	QAQC-Field Comparison	Field-Laboratory Comparison	Comments
1-Jun-09 (installation)	Temp (°C)	4.04	2.46	-	Poor	-	
	pH (units)	6.09	6.08	6.73	Excellent	Fair	
	Conductivity (µS/cm)	12.8	12.77	15	Excellent	Excellent	
	Dissolved Oxygen (mg/L)	13.48	50	-	Poor	-	Error with DO sensor
	Turbidity (NTU)	46.4	17.7	3	Poor	Poor	
24-Jun-09 (removal)	Temp (°C)	n/a	n/a	-	n/a	-	Instrument exposed at time of removal
	pH (units)	n/a	n/a	-	n/a	-	
	Conductivity (µS/cm)	n/a	n/a	-	n/a	-	
	Dissolved Oxygen (mg/L)	n/a	n/a	-	n/a	-	
	Turbidity (NTU)	n/a	n/a	-	n/a	-	
24-Jun-09 (installation)	Temp (°C)	10.29	10.59	-	Good	-	
	pH (units)	6.08	6.06	6.78	Excellent	Fair	
	Conductivity (µS/cm)	16	15.8	18	Excellent	Excellent	
	Dissolved Oxygen (mg/L)	12.38	12.3	-	Excellent	-	
	Turbidity (NTU)	22.2	28.7	2	Fair	Poor	
20-Jul-09 (removal)	Temp (°C)	14.49	14.43	-	Excellent	-	
	pH (units)	6.5	6.94	-	Good	-	
	Conductivity (µS/cm)	20.7	20.4	-	Excellent	-	
	Dissolved Oxygen (mg/L)	10.8	10.96	-	Excellent	-	
	Turbidity (NTU)	14.5	15.9	-	Excellent	-	
20-Jul-09 (installation)	Temp (°C)	14.53	14.57	-	Excellent	-	
	pH (units)	7.01	6.68	6.79	Good	Excellent	
	Conductivity (µS/cm)	20.57	20	21	Excellent	Excellent	
	Dissolved Oxygen (mg/L)	10.83	10.96	-	Excellent	-	
	Turbidity (NTU)	14.1	15.1	2.3	Excellent	Poor	
1-Sep-09 (removal)	Temp (°C)	14.31	14.13	-	Excellent	-	
	pH (units)	6.99	7.03	-	Excellent	-	
	Conductivity (µS/cm)	20.7	19	-	Excellent	-	
	Dissolved Oxygen (mg/L)	11.4	n/a	-	n/a	-	Do probe not working
	Turbidity (NTU)	10.8	n/a	-	n/a	-	Turbidity jumping values
1-Sep-09 (installation)	Temp (°C)	14.33	14.01	-	Good	-	
	pH (units)	6.99	6.73	6.94	Good	Good	
	Conductivity (µS/cm)	20.8	20	21	Excellent	Excellent	
	Dissolved Oxygen (mg/L)	11.37	11.44	-	Excellent	-	
	Turbidity (NTU)	14.8	9.9	2.4	Good	Fair	
22-Sep-09 (removal)	Temp (°C)	11.6	11.3	-	Good	-	
	pH (units)	6.64	7.05	-	Good	-	
	Conductivity (µS/cm)	18.2	16.8	-	Excellent	-	
	Dissolved Oxygen (mg/L)	12.01	12.17	-	Excellent	-	
	Turbidity (NTU)	8.7	9.3	-	Excellent	-	
23-Sep-09 installation	Temp (°C)	11.64	11.7	-	Excellent	-	
	pH (units)	6.8	6.41	6.88	Good	Good	
	Conductivity (µS/cm)	18.2	19.1	20	Excellent	Excellent	
	Dissolved Oxygen (mg/L)	12.02	11.98	-	Excellent	-	
	Turbidity (NTU)	0.8	4.4	1.1	Good	Good	
2-Nov-09 (removal)	Temp (°C)	3.54	3.44	-	Excellent	-	
	pH (units)	6.65	7	-	Good	-	
	Conductivity (µS/cm)	18.4	19	-	Excellent	-	
	Dissolved Oxygen (mg/L)	13.92	14.5	-	Fair	-	
	Turbidity (NTU)	14.9	13.6	-	Excellent	-	

Table 6: QA/QC rankings for QA/QC and field sondes and laboratory data for Above Upper Muskrat Falls

Above Upper Muskrat Falls	Parameter	QAQC Sonde	Field Sonde	Laboratory Analysis	Sonde Comparison Ranking	Field-Laboratory Comparison	Comments
1-Jun-09 (installation)	Temp (°C)	4.64	4.32	-	Good	-	
	pH (units)	6.21	5.93	6.68	Good	Fair	
	Conductivity (µS/cm)	12	11.7	15	Excellent	Good	
	Dissolved Oxygen (mg/L)	12.74	12.9	-	Excellent	-	
	Turbidity (NTU)	15.1	5	1.7	Poor	Good	
24-Jun-09 (removal)	Temp (°C)	n/a	n/a	-	n/a	-	Sonde exposed at time of removal
	pH (units)	n/a	n/a	-	n/a	-	
	Conductivity (µS/cm)	n/a	n/a	-	n/a	-	
	Dissolved Oxygen (mg/L)	n/a	n/a	-	n/a	-	
	Turbidity (NTU)	n/a	n/a	-	n/a	-	
24-Jun-09 (installation)	Temp (°C)	12.19	12.1	-	Excellent	-	
	pH (units)	6.07	6.19	6.59	Excellent	Good	
	Conductivity (µS/cm)	16.2	17	18	Excellent	Excellent	
	Dissolved Oxygen (mg/L)	11.07	10.8	-	Excellent	-	
	Turbidity (NTU)	18.7	21.9	2	Good	Poor	
20-Jul-09 (removal)	Temp (°C)	13.85	14.1	-	Good	-	
	pH (units)	6.45	7.26	-	Marginal	-	
	Conductivity (µS/cm)	21.6	21.1	-	Excellent	-	
	Dissolved Oxygen (mg/L)	9.96	9.85	-	Excellent	-	
	Turbidity (NTU)	18.3	26.8	-	Marginal	-	
20-Jul-09 (installation)	Temp (°C)	13.85	14.1	-	Good	-	
	pH (units)	7.03	6.87	7.02	Excellent	Excellent	
	Conductivity (µS/cm)	21.5	22	22	Excellent	Excellent	
	Dissolved Oxygen (mg/L)	9.93	9.68	-	Excellent	-	
	Turbidity (NTU)	19.4	23.1	3.3	Good	Poor	
1-Sep-09 (removal)	Temp (°C)	13.93	13.9	-	Excellent	-	
	pH (units)	6.93	7.05	-	Excellent	-	
	Conductivity (µS/cm)	20.8	20	-	Excellent	-	
	Dissolved Oxygen (mg/L)	10.13	9.94	-	Excellent	-	
	Turbidity (NTU)	11.7	14.9	-	Good	-	
1-Sep-09 (installation)	Temp (°C)	14	13.8	-	Excellent	-	
	pH (units)	6.93	6.97	6.8	Excellent	Excellent	
	Conductivity (µS/cm)	20.7	21	21	Excellent	Excellent	
	Dissolved Oxygen (mg/L)	10.14	10.1	-	Excellent	-	
	Turbidity (NTU)	12.4	9.2	1.7	Good	Poor	
23-Sep-09 (removal)	Temp (°C)	12.34	12.1	-	Good	-	
	pH (units)	6.8	6.92	-	Excellent	-	
	Conductivity (µS/cm)	18.6	19.6	-	Excellent	-	
	Dissolved Oxygen (mg/L)	10.48	10.5	-	Excellent	-	
	Turbidity (NTU)	2.9	6.1	-	Good	-	
23-Sep-09 (installation)	Temp (°C)	12.35	12.3	-	Excellent	-	
	pH (units)	6.8	6.57	6.89	Good	Good	
	Conductivity (µS/cm)	18.7	16.6	20	Excellent	Good	
	Dissolved Oxygen (mg/L)	10.45	10.5	-	Excellent	-	
	Turbidity (NTU)	3.3	2.7	1.4	Excellent	Excellent	
2-Nov-09 (removal)	Temp (°C)	3.27	3.21	-	Excellent	-	
	pH (units)	6.18	7.21	-	Poor	-	
	Conductivity (µS/cm)	18.6	17	-	Excellent	-	
	Dissolved Oxygen (mg/L)	12.59	12.9	-	Excellent	-	
	Turbidity (NTU)	24.5	21.5	-	Good	-	

Table 7: QA/QC rankings for QA/QC and field sondes and laboratory data for Below Grizzle Rapids

Below Grizzle Rapids	Parameter	QAQC Sonde	Field Sonde	Laboratory Analysis	Sonde Comparison Ranking	Field-Laboratory Comparison	Comments
24-Jun-09 (installation)	Temp (°C)	11	11.01	-	Excellent	-	
	pH (units)	6.2	6.7	6.54	Good	Excellent	
	Conductivity (µS/cm)	16	16.2	18	Excellent	Excellent	
	Dissolved Oxygen (mg/L)	11	11.14	-	Excellent	-	
	Turbidity (NTU)	0	50	0.3	Poor	Excellent	Error with Turbidity Sensor
20-Jul-09 (removal)	Temp (°C)	14	14.29	-	Good	-	
	pH (units)	6.5	7.49	-	Poor	-	
	Conductivity (µS/cm)	19	18.7	-	Excellent	-	
	Dissolved Oxygen (mg/L)	10	10.41	-	Excellent	-	
	Turbidity (NTU)	0	50	-	Poor	-	Error with Turbidity Sensor
20-Jul-09 (installation)	Temp (°C)	14	13.8	-	Good	-	
	pH (units)	6.8	6.69	6.93	Excellent	Good	
	Conductivity (µS/cm)	19	18.7	20	Excellent	Excellent	
	Dissolved Oxygen (mg/L)	10	10.47	-	Excellent	-	
	Turbidity (NTU)	0	0	0.4	Excellent	Excellent	
1-Sep-09 (removal)	Temp (°C)	13	14.9	-	Good	-	
	pH (units)	6.5	6.98	-	Fair	-	
	Conductivity (µS/cm)	21	21.4	-	Excellent	-	
	Dissolved Oxygen (mg/L)	10	0.07	-	Poor	-	Error with DO sensor
	Turbidity (NTU)	0	0	-	Excellent	-	
1-Sep-09 (installation)	Temp (°C)	15	14.93	-	Excellent	-	
	pH (units)	7.1	6.98	7.08	Excellent	Excellent	
	Conductivity (µS/cm)	21	21	22	Excellent	Excellent	
	Dissolved Oxygen (mg/L)	10	10.14	-	Excellent	-	
	Turbidity (NTU)	0	0	0.5	Excellent	Excellent	
23-Sep-09 (removal)	Temp (°C)	12	12.3	-	Excellent	-	
	pH (units)	6.8	7.3	-	Good	-	
	Conductivity (µS/cm)	19	20.7	-	Excellent	-	
	Dissolved Oxygen (mg/L)	11	10.79	-	Excellent	-	
	Turbidity (NTU)	0	0	-	Excellent	-	
23-Sep-09 (installation)	Temp (°C)	12	12.3	-	Excellent	-	
	pH (units)	6.8	6.68	6.89	Excellent	Good	
	Conductivity (µS/cm)	19	19.7	21	Excellent	Excellent	
	Dissolved Oxygen (mg/L)	11	10.67	-	Excellent	-	
	Turbidity (NTU)	0	0	0.2	Excellent	Excellent	
2-Nov-09 (removal)	Temp (°C)	3.8	3.74	-	Excellent	-	
	pH (units)	6.4	6.88	-	Good	-	
	Conductivity (µS/cm)	18	18	-	Excellent	-	
	Dissolved Oxygen (mg/L)	13	12.71	-	Excellent	-	
	Turbidity (NTU)	0	0	-	Excellent	-	

Table 8: QA/QC rankings for QA/QC and field sondes and laboratory data for Below Metchin River

Below Metchin River	Parameter	QAQC Sonde	Field Sonde	Laboratory Analysis	Sonde Comparison Ranking	Field-Laboratory Comparison	Comments
1-Jun-09 (installation)	Temp (°C)	3.48	3.39	-	Excellent	-	
	pH (units)	6.21	6.63	6.66	Excellent	Good	
	Conductivity (µS/cm)	16	15.7	18	Excellent	Excellent	
	Dissolved Oxygen (mg/L)	12.66	13.05	-	Good	-	
	Turbidity (NTU)	0	0	0.3	Excellent	Excellent	
24-Jun-09 (removal)	Temp (°C)	12.5	12.27	-	Good	-	
	pH (units)	6.63	6.95	-	Good	-	
	Conductivity (µS/cm)	19.6	22	-	Excellent	-	
	Dissolved Oxygen (mg/L)	10.72	11.29	-	Fair	-	
	Turbidity (NTU)	0	0	-	Excellent	-	
24-Jun-09 (installation)	Temp (°C)	12.52	12.3	-	Good	-	
	pH (units)	6.78	6.72	7.03	Excellent	Good	
	Conductivity (µS/cm)	19	19	22	Excellent	Excellent	
	Dissolved Oxygen (mg/L)	10.86	10.78	-	Excellent	-	
	Turbidity (NTU)	0	0	0.5	Excellent	Excellent	
20-Jul-09 (removal)	Temp (°C)	n/a	n/a	-	n/a	-	Sonde exposed at time of removal
	pH (units)	n/a	n/a	-	n/a	-	
	Conductivity (µS/cm)	n/a	n/a	-	n/a	-	
	Dissolved Oxygen (mg/L)	n/a	n/a	-	n/a	-	
	Turbidity (NTU)	n/a	n/a	-	n/a	-	
20-Jul-09 (installation)	Temp (°C)	15.43	15.52	-	Excellent	-	
	pH (units)	6.41	6.72	6.82	Good	Excellent	
	Conductivity (µS/cm)	21.1	21	22	Excellent	Excellent	
	Dissolved Oxygen (mg/L)	9.73	9.63	-	Excellent	-	
	Turbidity (NTU)	0	0	0.5	Excellent	Excellent	
1-Sep-09 (removal)	Temp (°C)	11.96	11.8	-	Excellent	-	
	pH (units)	6.89	6.87	-	Excellent	-	
	Conductivity (µS/cm)	23.4	23	-	Excellent	-	
	Dissolved Oxygen (mg/L)	10.14	10.01	-	Excellent	-	
	Turbidity (NTU)	0	0	-	Excellent	-	
1-Sep-09 (installation)	Temp (°C)	12.02	11.93	-	Excellent	-	
	pH (units)	6.89	6.84	7.13	Excellent	Good	
	Conductivity (µS/cm)	23.2	23	24	Excellent	Excellent	
	Dissolved Oxygen (mg/L)	10.15	10.05	-	Excellent	-	
	Turbidity (NTU)	0	0	0.6	Excellent	Excellent	
23-Sep-09 (removal)	Temp (°C)	9.74	9.4	-	Good	-	
	pH (units)	6.88	7.23	-	Good	-	
	Conductivity (µS/cm)	22.8	23.8	-	Excellent	-	
	Dissolved Oxygen (mg/L)	10.7	10.65	-	Excellent	-	
	Turbidity (NTU)	0	0	-	Excellent	-	
23-Sep-09 installation	Temp (°C)	9.71	9.62	-	Excellent	-	
	pH (units)	6.89	7.04	7	Excellent	Excellent	
	Conductivity (µS/cm)	22.9	22.4	25	Excellent	Excellent	
	Dissolved Oxygen (mg/L)	10.73	10.64	-	Excellent	-	
	Turbidity (NTU)	0	0	0.5	Excellent	Excellent	
2-Nov-09 (removal)	Temp (°C)	0.65	0.03	-	Fair	-	
	pH (units)	6.43	7.23	-	Marginal	-	
	Conductivity (µS/cm)	21.5	21	-	Excellent	-	
	Dissolved Oxygen (mg/L)	13.56	13.88	-	Good	-	
	Turbidity (NTU)	0	0	-	Excellent	-	

Data Interpretation

Churchill River below Lower Muskrat Falls

- This station is located approximately 6.15km below Lower Muskrat Falls and about 10km upstream of the Trans Labrador Highway Bridge.
- An instrument was deployed on June 1 but due to a significant decrease in the stage level during the month of June, the instrument became exposed to air on June 21. The instrument was retrieved and replaced with a newly calibrated instrument on June 24.
- Dissolved oxygen and percent saturation values are unavailable for the deployment period between June 1 and June 24 due to an error during calibration with the luminescent dissolved oxygen sensor.
- Dissolved oxygen and percent saturation values are unavailable from July 24, 3:30pm to September 1, 4:30pm due to sensor failure during deployment.
- The station experienced several short data transmission errors throughout the deployment season. These data gaps are usually caused by satellite communication failure. Missing data gaps for water quality data are filled by using the instruments internal log file if it is available. Water quantity data (stage) is not captured by the log file.

Figure 2: Datasonde within protective metal housing lying exposed to air on the beach at station below Lower Muskrat Falls after stage level dropped significantly in the month of June.

Temperature

- The water temperature follows a seasonal pattern from June to November, rising throughout the spring and summer month and peaking in early to mid-August (**Figure 3**). Water temperature then begins to decrease through late summer and fall.
- Water temperature is closely related to air temperature. For this station, weather data recorded by Environment Canada in Goose Bay is used to help explain trends and fluctuations in water quality. Weather data is summarized in Appendix A.
- Temperatures ranged between 1.69°C to 18.9°C. Monthly averages, minimums and maximums for water temperature can be found in **Table 9**.

Table 9: Summary statistics for water temperature at station below Lower Muskrat Falls

Temperature (°C)	June	July	August	September	October	June to November
Average	6.50	15.45	16.79	11.40	6.11	11.28
Max	13.22	18.40	18.90	14.51	10.90	18.90
Min	1.69	12.13	13.10	8.61	2.80	1.69

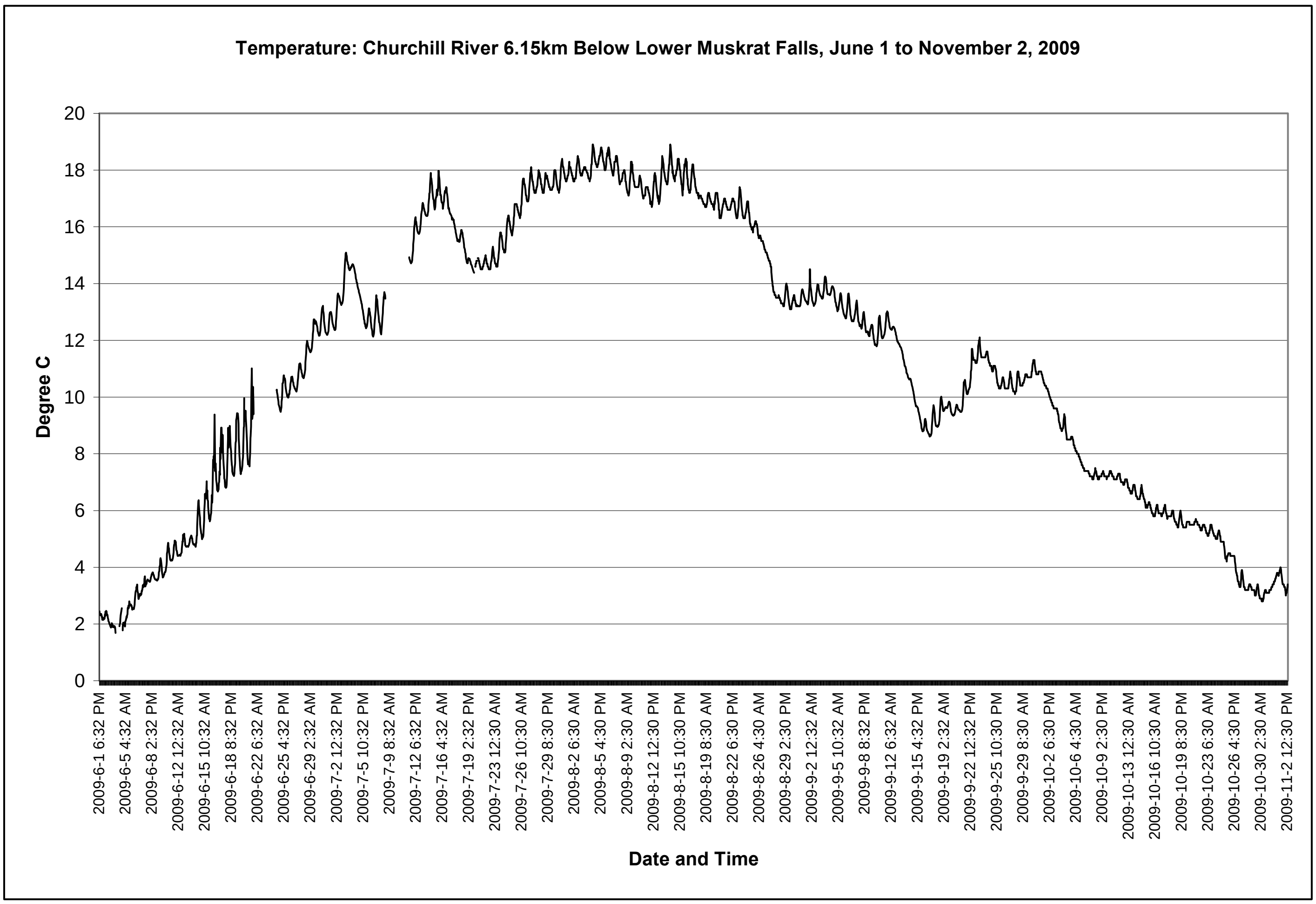


Figure 3: Water temperature for station below Lower Muskrat Falls, June to November 2009.

Dissolved Oxygen and Percent Saturation

- Dissolved oxygen content is inversely related to water temperature. At the station below Lower Muskrat Falls, dissolved oxygen content displays a decreasing trend during the spring and early summer to as low as 10.28mg/L on July 15 (**Figure 4**). From early September onward, dissolved oxygen content displays an increasing trend. These trends are expected and normal based on water temperature increase and decrease.
- Dissolved oxygen and percent saturation values are unavailable from July 24, 3:30pm to September 1, 4:30pm due to sensor failure during deployment.
- Percent Saturation is a function of dissolved oxygen content and water temperature. Percent saturation values remain relatively stable throughout the deployment season (**Figure 4**).
- Dissolved Oxygen ranged between 10.28mg/L and 14.72mg/L. Monthly averages, minimums and maximums for dissolved oxygen and percent saturation can be found in **Table 10**.

Table 10: Summary statistics for dissolved oxygen and percent saturation at station below Lower Muskrat Falls

DO (mg/L) and %Sat (%)	June		July		August		September		October		June-November	
	DO	%Sat	DO	%Sat	DO	%Sat	DO	%Sat	DO	%Sat	DO	%Sat
Average	11.82	107.56	11.03	108.86	No Data		11.89	108.55	13.43	108.02	12.25	108.36
Maximum	12.38	111.60	11.69	114.30			12.67	111.80	14.72	111.50	14.72	114.30
Minimum	11.58	103.90	10.28	105.10			10.46	102.70	12.01	101.40	10.28	101.40

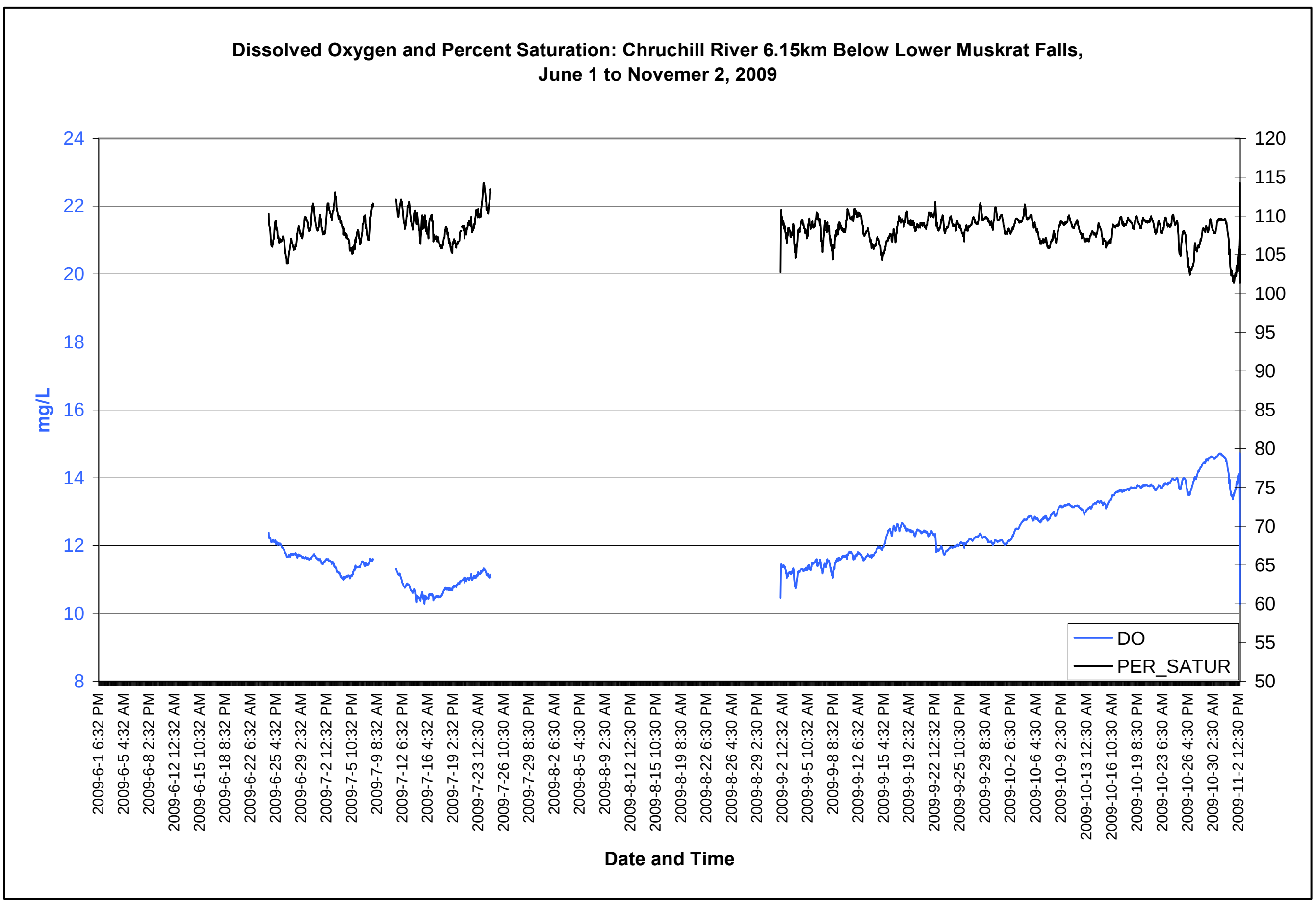


Figure 4: Dissolved oxygen and percent saturation for station below Lower Muskrat Falls, June to November 2009.

pH

- pH begins to rise throughout the late spring and early summer until it levels off for the remainder of the deployment season (**Figure 5**).
- Daily fluctuations are clearly observed throughout the deployment season from June until November.
- Considerable fluctuations in pH are visible on the graph from June 14 to 21 (circled in red). This is the period of time right before the instrument became exposed to air so it is likely that the instrument was in shallow water at the shore line which had highly variable conditions. The sensor would unlikely perform correctly in that type of situation as the most accurate sensor readings are recorded when the instrument in submerged in flowing water.
- pH ranges between 6.10 and 7.24 throughout the deployment season. Monthly averages, maximums and minimums are summarized in **Table 11**.

Table 11: Summary statistics for pH at station below Lower Muskrat Falls

pH	June	July	August	September	October	June to November
Average	6.60	6.95	7.08	7.01	7.00	6.94
Maximum	7.19	7.15	7.24	7.21	7.07	7.24
Minimum	6.10	6.62	6.99	6.77	6.95	6.10

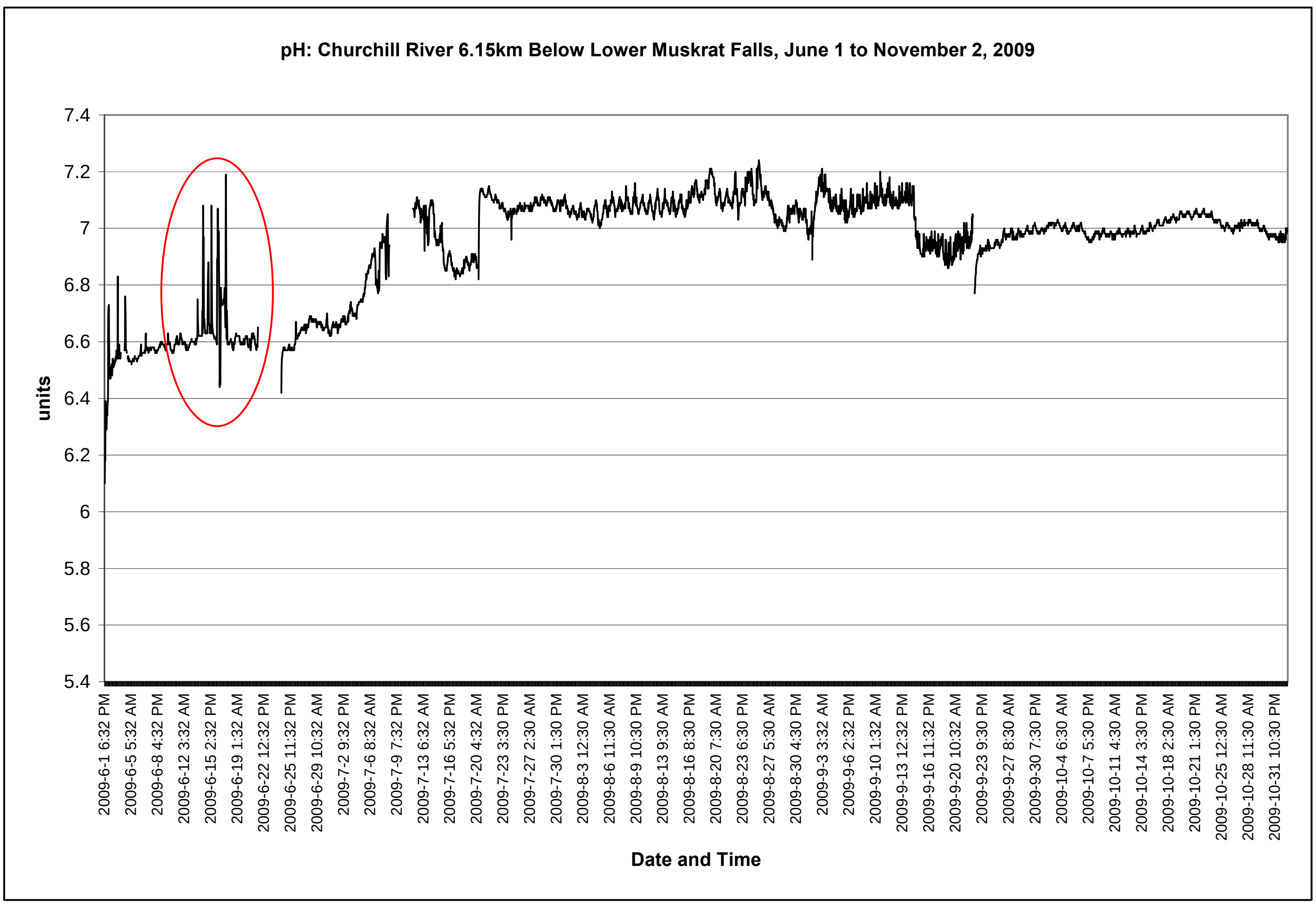


Figure 5: pH for station below Lower Muskrat Falls, June to November 2009.

Specific Conductivity

- Specific conductance rises throughout the late spring and early summer before beginning to level off for the remainder of the deployment season around mid July (**Figure 6**).
- Values fluctuated day to day and during precipitation events (**Appendix A**).
- Specific conductance values range between 11.70 µS/cm and 22.30 µS/cm throughout the deployment seasons. Monthly averages, maximums and minimums are summarized in **Table 12**.

Table 12: Summary statistics for Specific Conductivity at station below Lower Muskrat Falls

SpCond (µS/cm)	June	July	August	September	October	June to November
Average	14.43	19.37	20.45	18.91	19.76	18.72
Maximum	17.10	21.20	22.30	21.00	20.80	22.30
Minimum	11.70	16.90	18.00	16.00	17.50	11.70

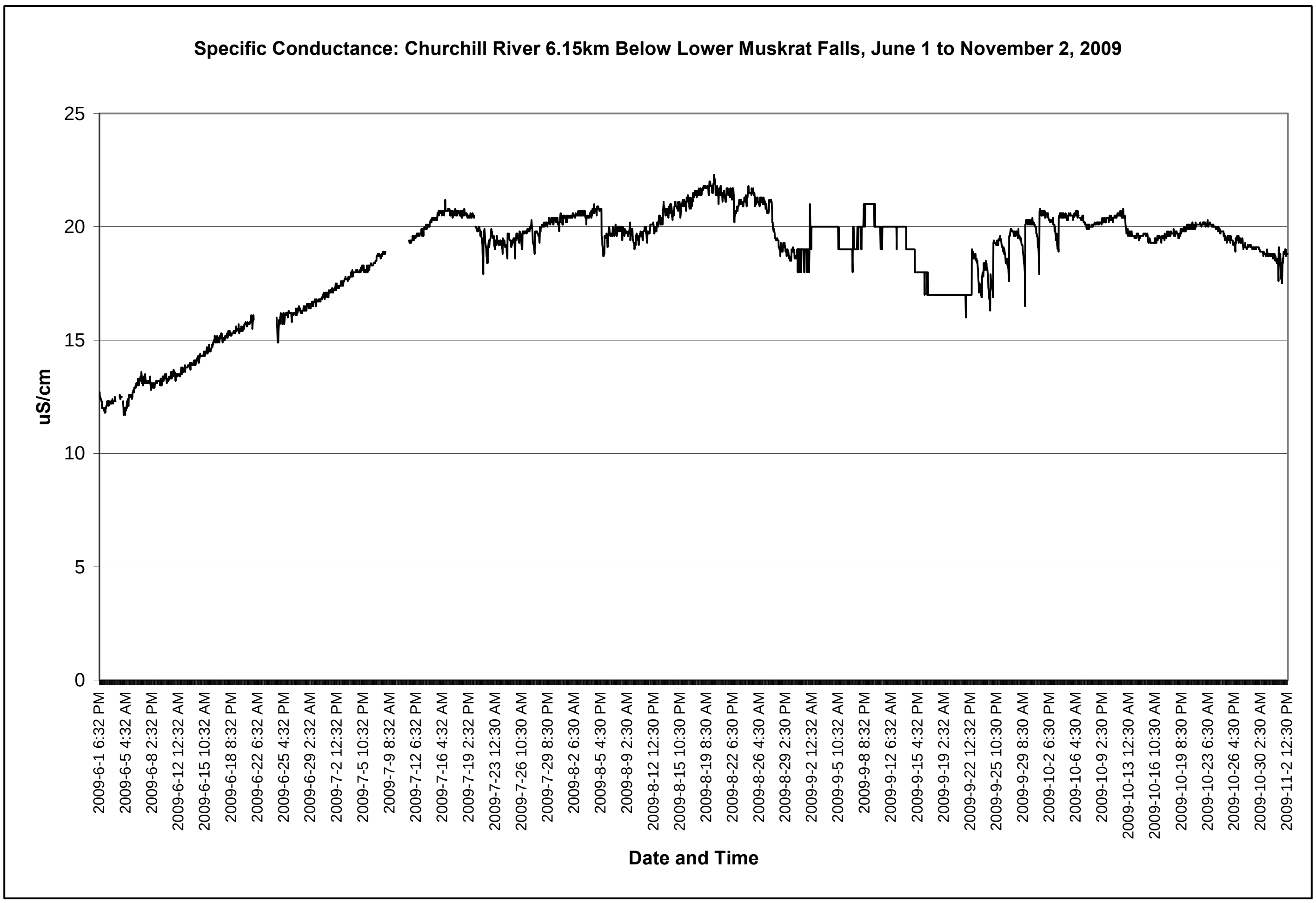


Figure 6: Specific Conductivity for station below Lower Muskrat Falls, June to November 2009.

Turbidity

- Turbidity values are variable throughout the deployment season which appears to be normal due to the sandy and silty nature of the River at this site and the turbulence created by Muskrat Falls (**Figures 7 a and b**).
- Figure 7a shows Turbidity events ranging between 0 and 700NTU. There is a significant turbidity spike recorded between June 16 and 17. These elevated readings occur just a couple of days before the instrument became exposed to air. It is likely that the shallow conditions near the shore and the wave action caused this spike in turbidity.
- On August 8, for a period of 18 hours, the turbidity sensor recorded an error reading of 3000NTU. This is likely due to a piece of debris lodged on the sensor. Data values return to normal on August 9.
- Figure 6b shows a closer look at the turbidity events ranging between 0 and 200NTU. This accounts for many of the fluctuations in turbidity.
- Between July 20 and September 1 (circled in red), the turbidity sensor appears to be malfunctioning which is supported by poor QA/QC rankings at removal. This turbidity sensor displayed jumping values upon removal so it is likely that data collected during this deployment period was compromised to some degree. The DO sensor also malfunctioned during this time.
- Monthly averages, maximums and minimums are summarized in **Table 13**.

Table 13: Summary statistics for Turbidity at station Below Lower Muskrat Falls

Turbidity (NTU)	June	July	August	September	October	June to November
Average	31.4	16.0	17.9	10.5	4.8	30.7
Maximum	693	188.9	163.9	177.1	383.6	693
Minimum	6.7	0	0	0	0	0

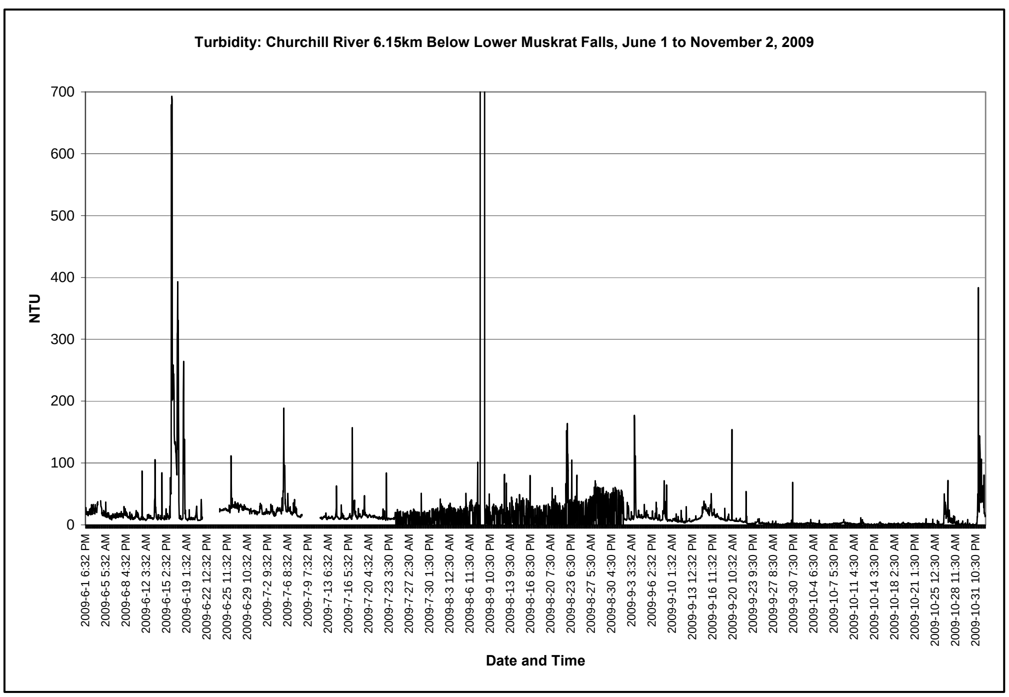


Figure 7a: Turbidity ranging between 0 and 700NTU for station below Lower Muskrat Falls, June to November 2009.

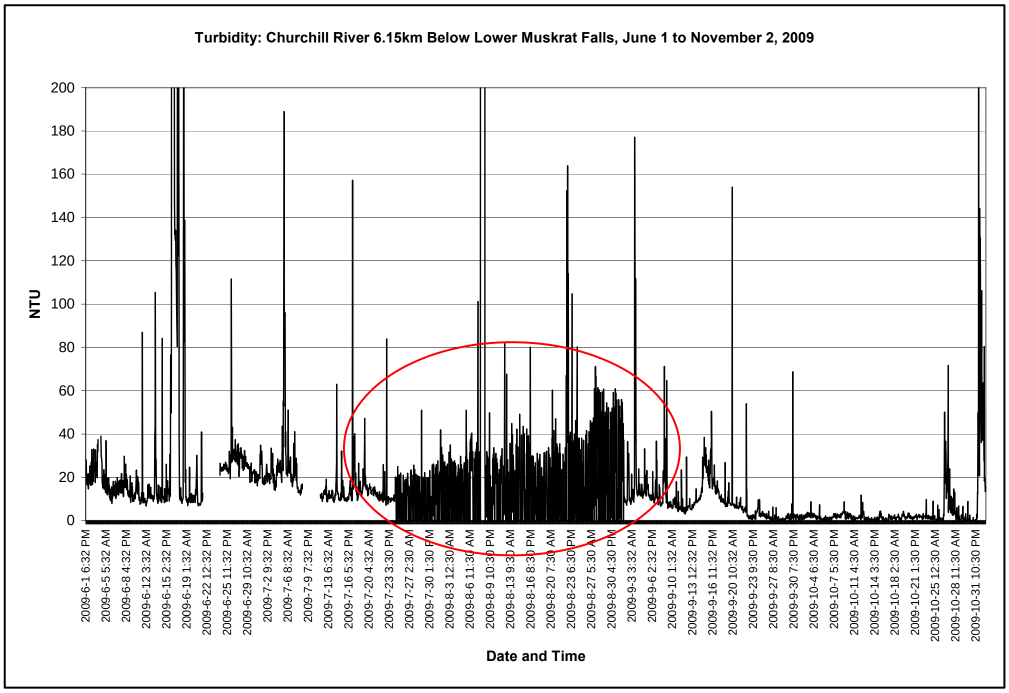


Figure 7b: Turbidity ranging between 0 and 200NTU for station below Lower Muskrat Falls, June to November 2009.

Stage

- Stage decreased throughout the late spring and early summer before levelling out between mid-July to late August. Stage level then begins to increase slightly throughout September and level off again for the remainder to the deployment season (**Figure 8**).
- Stage level is very important to the success of the RTWQM program on the Lower Churchill River due to the high water level fluctuation. The instrument at Muskrat Falls became exposed to air on June 21 and was retrieved on June 24. Stage levels will be closely monitored during deployment in 2010.
- Monthly averages, maximums and minimums are summarized in **Table 14.**

Table 14: Summary statistics for stage at station below Lower Muskrat Falls

Stage (m)	June	July	August	September	October	June to November
Average	3.162	2.223	2.161	2.627	2.653	2.556
Maximum	4.088	2.385	2.525	2.652	2.745	4.088
Minimum	2.368	2.08	2.019	2.597	2.581	2.019

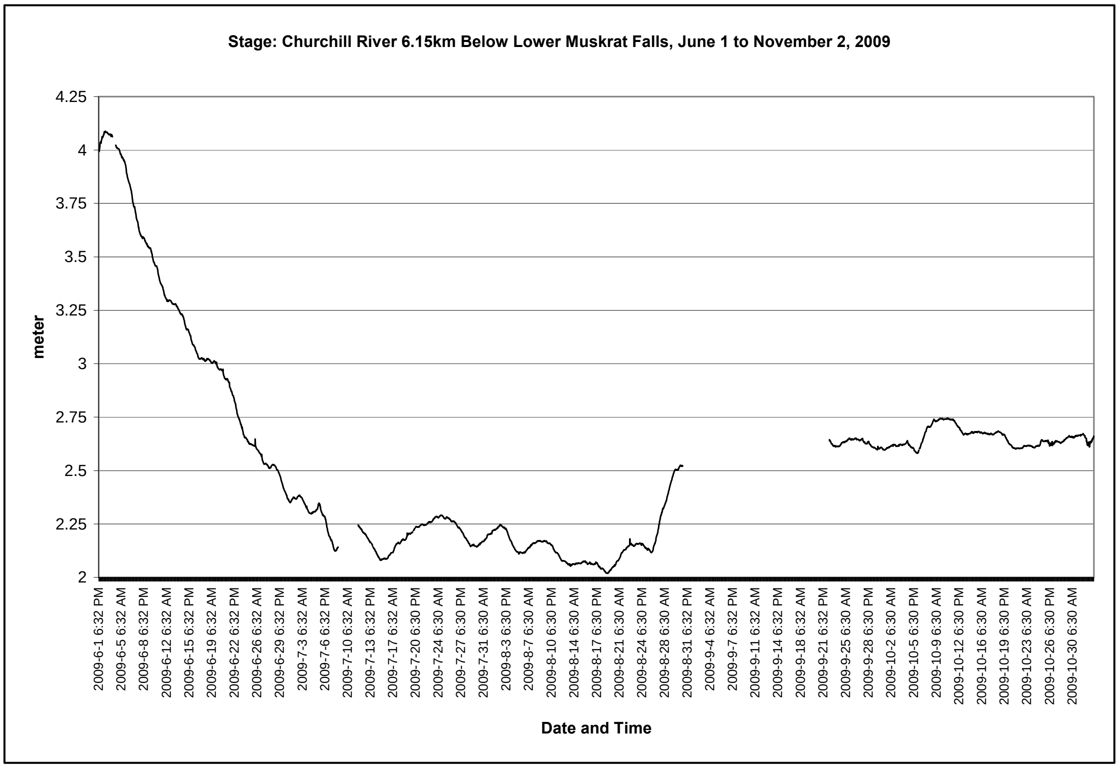


Figure 8: Stage levels for station below Lower Muskrat Falls, June to November 2009.

Churchill River above Upper Muskrat Falls

- This station is located about 100m upstream from Upper Muskrat Falls.
- An instrument was deployed on June 1 but due to a significant decrease in the stage level during the month of June, the instrument became exposed to air on June 15. This instrument was retrieved on June 24.
- During the July deployment, the instrument also became exposed between July 4 and July 17 after a considerable stage decrease. The instrument was retrieved on July 20.

Figure 9: RWTQ Monitoring Station above Upper Muskrat Falls

Temperature

- Temperature increases throughout the late spring and early summer until peaking at 19.26°C on August 5 (**Figure 10**). From this date onwards, temperature begins to decrease throughout the late summer and early fall till removal on November 2.
- Water temperature is closely related to air temperature. For this station, weather data recorded by Environment Canada in Goose Bay is used to help explain trends and fluctuations in water quality. Weather data is summarized in **Appendix A**.
- Temperatures ranged between 2.54°C to 19.26°C. Monthly averages, minimums and maximums for water temperature can be found in **Table 15.**

Table 15: Summary statistics for water temperature at station above Upper Muskrat Falls

Temperature °C	June	July	August	September	October	June to November
Average	7.78	16.04	16.68	11.21	5.85	11.32
Maximum	14.85	18.66	19.26	14.21	11.32	19.26
Minimum	3.32	12.88	12.63	7.66	2.54	2.54

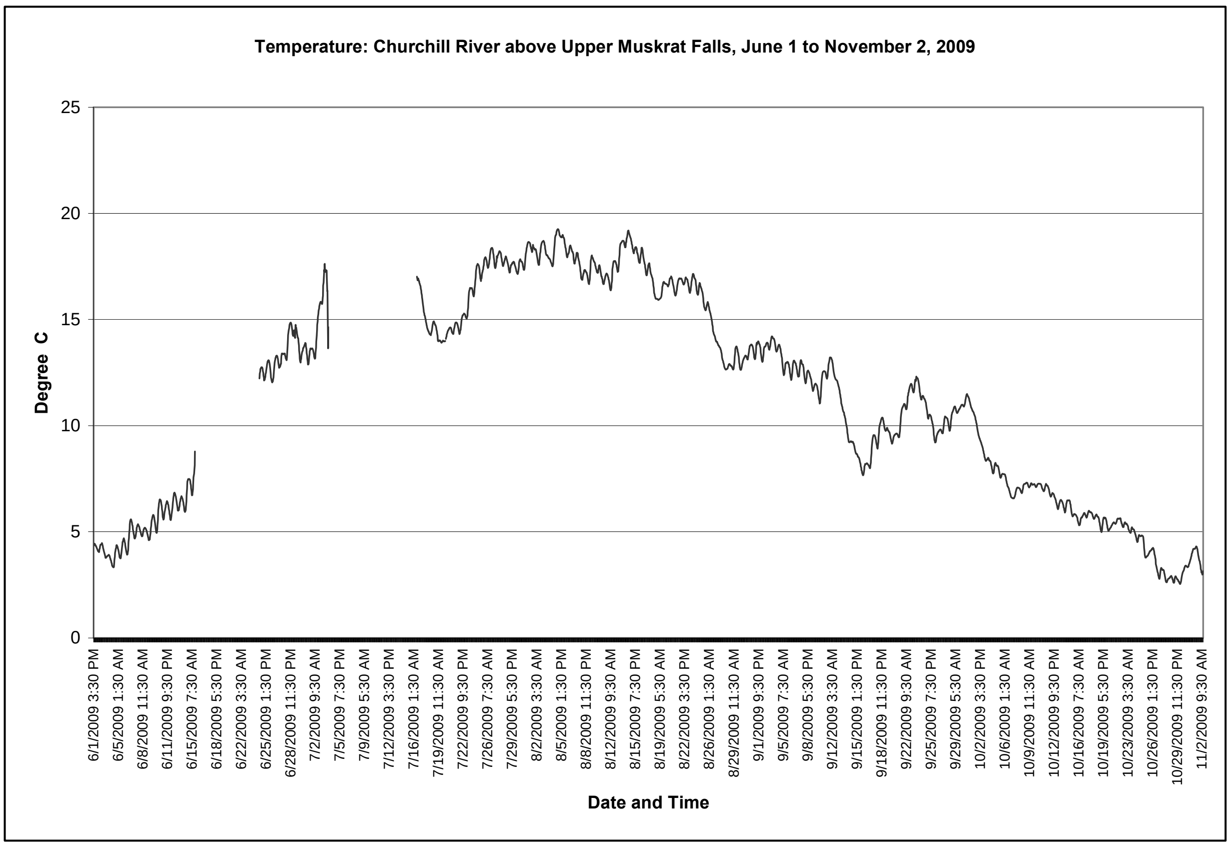


Figure 10: Water temperature for station above Upper Muskrat Falls, June to November 2009.

Dissolved Oxygen and Percent Saturation

- Dissolved oxygen content is inversely related to water temperature. At the station above Upper Muskrat Falls, dissolved oxygen content displays a decreasing trend during the spring and early summer to as low as 8.85mg/L on August 6 (**Figure 11**). From mid-August onward, dissolved oxygen content displays an increasing trend. These trends are expected and normal based on water temperature increase and decrease.
- Percent Saturation is a function of dissolved oxygen content and water temperature. Percent saturation values remain relatively stable, decreasing slightly throughout the beginning of the deployment season (**Figure 11**).
- Dissolved Oxygen ranged between 8.85mg/L and 13.07mg/L. Monthly averages, minimums and maximums for dissolved oxygen and percent saturation can be found in **Table 16**.

Table 16: Summary statistics for dissolved oxygen and percent saturation at station above Upper Muskrat Falls

DO (mg/L) and %Sat (%)	June		July		August		September		October		June to November	
	DO	%Sat	DO	%Sat	DO	%Sat	DO	%Sat	DO	%Sat	DO	%Sat
Average	11.95	99.67	9.62	97.39	9.27	95.20	10.56	96.09	12.03	96.09	10.70	96.62
Maximum	12.93	103.40	10.83	104.30	10.07	98.30	11.31	99.10	13.07	98.00	13.07	104.30
Minimum	10.02	96.60	9.05	94.00	8.85	91.70	9.84	93.60	10.66	94.10	8.85	91.70

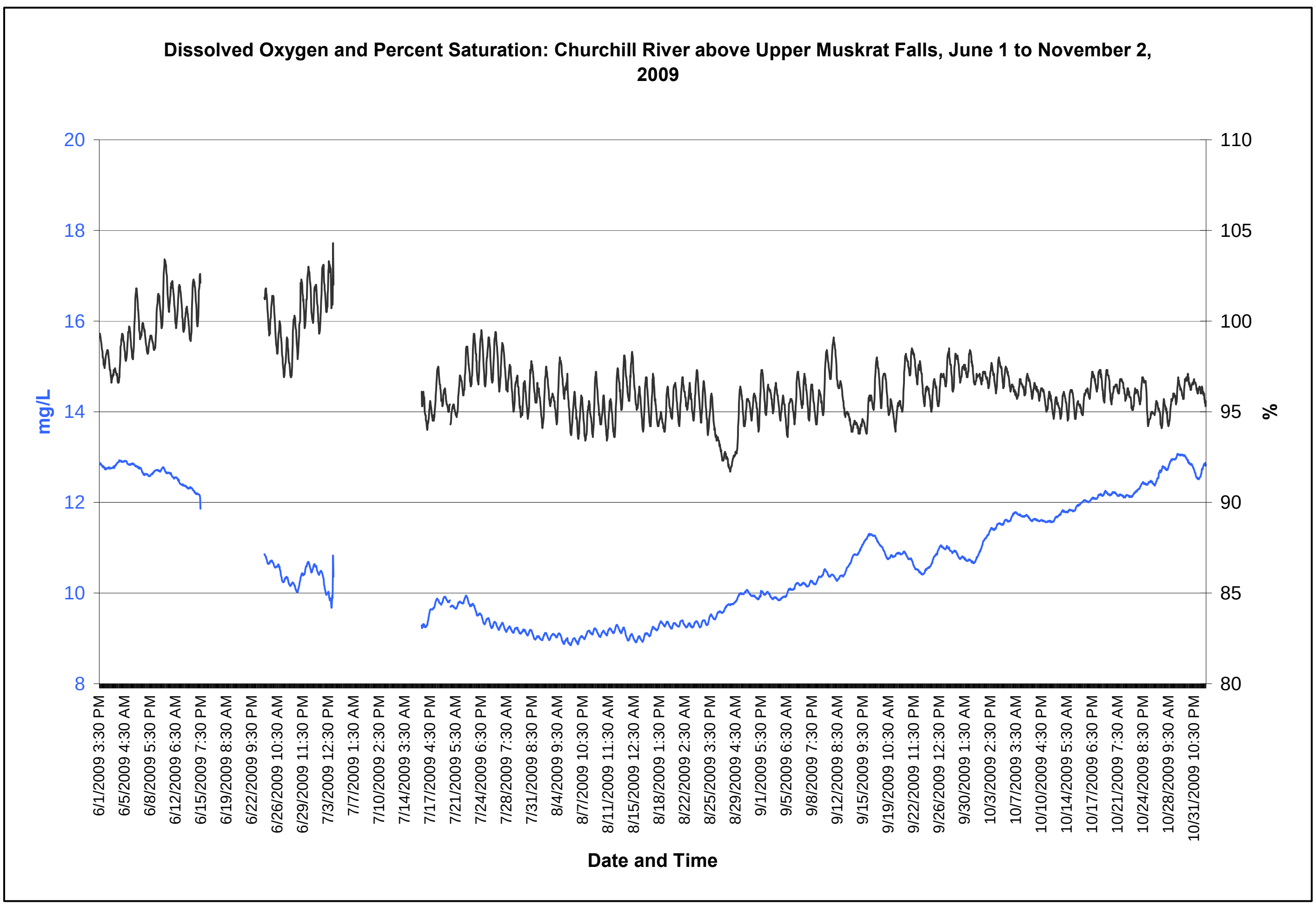


Figure 11: Dissolved Oxygen and Percent Saturation for station above Upper Muskrat Falls, June to November 2009.

pH

- pH rises throughout the late spring and early summer. pH values decrease slightly throughout early August before rising again throughout the fall (**Figure 12**).
- Daily fluctuations are clearly observed throughout the deployment season from June until November.
- The event circled in red on Figure 12 is likely caused by a significant rainfall event in which more than 80mm of rainfall was recorded at Goose Bay Airport (**Appendix A**).
- Monthly averages, maximums and minimums are summarized in **Table 17**.

Table 17: Summary statistics for pH at station above Upper Muskrat Falls

pH	June	July	August	September	October	June-November
Average	6.79	7.18	7.05	6.98	7.18	7.04
Maximum	7.14	7.74	7.26	7.11	7.27	7.74
Minimum	6.46	6.85	6.69	6.66	7.07	6.46

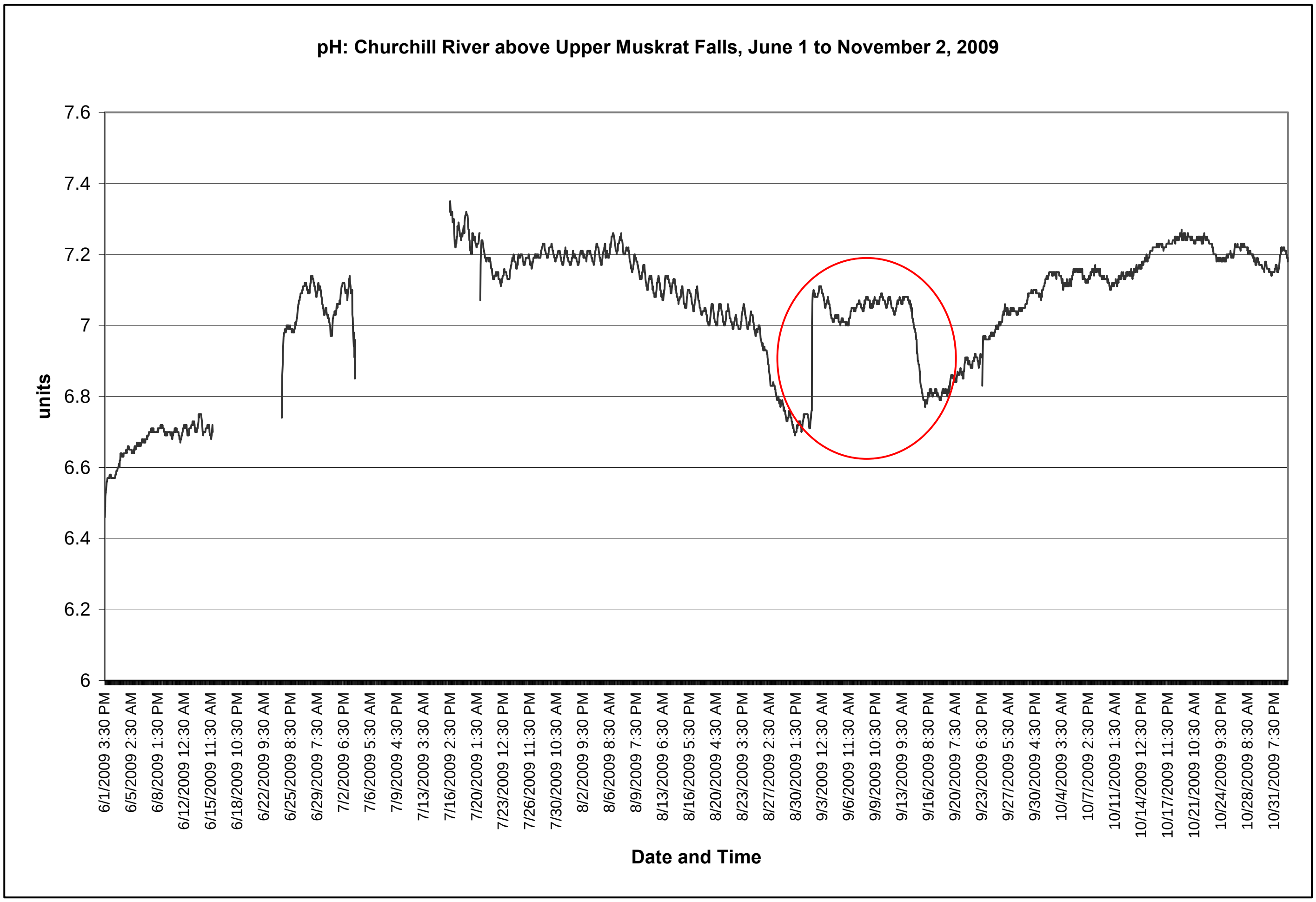


Figure 12: pH for station above Upper Muskrat Falls, June to November 2009.

Specific Conductivity

- Specific conductance rises throughout the late spring and early summer before beginning to level off for the remainder of the deployment season around mid July (**Figure 13**).
- Values generally fluctuated day to day and during precipitation events (**Appendix A**).
- Monthly averages, maximums and minimums are summarized in **Table 18**.

Table 18: Summary statistics for specific conductivity at station above Upper Muskrat Falls

SpCond (µS/cm)	June	July	August	September	October	June to November
Average	14.36	20.33	21.35	19.34	17.25	18.67
Maximum	18.00	22.20	22.40	21.80	18.30	22.40
Minimum	11.40	17.60	19.60	16.50	16.50	11.40

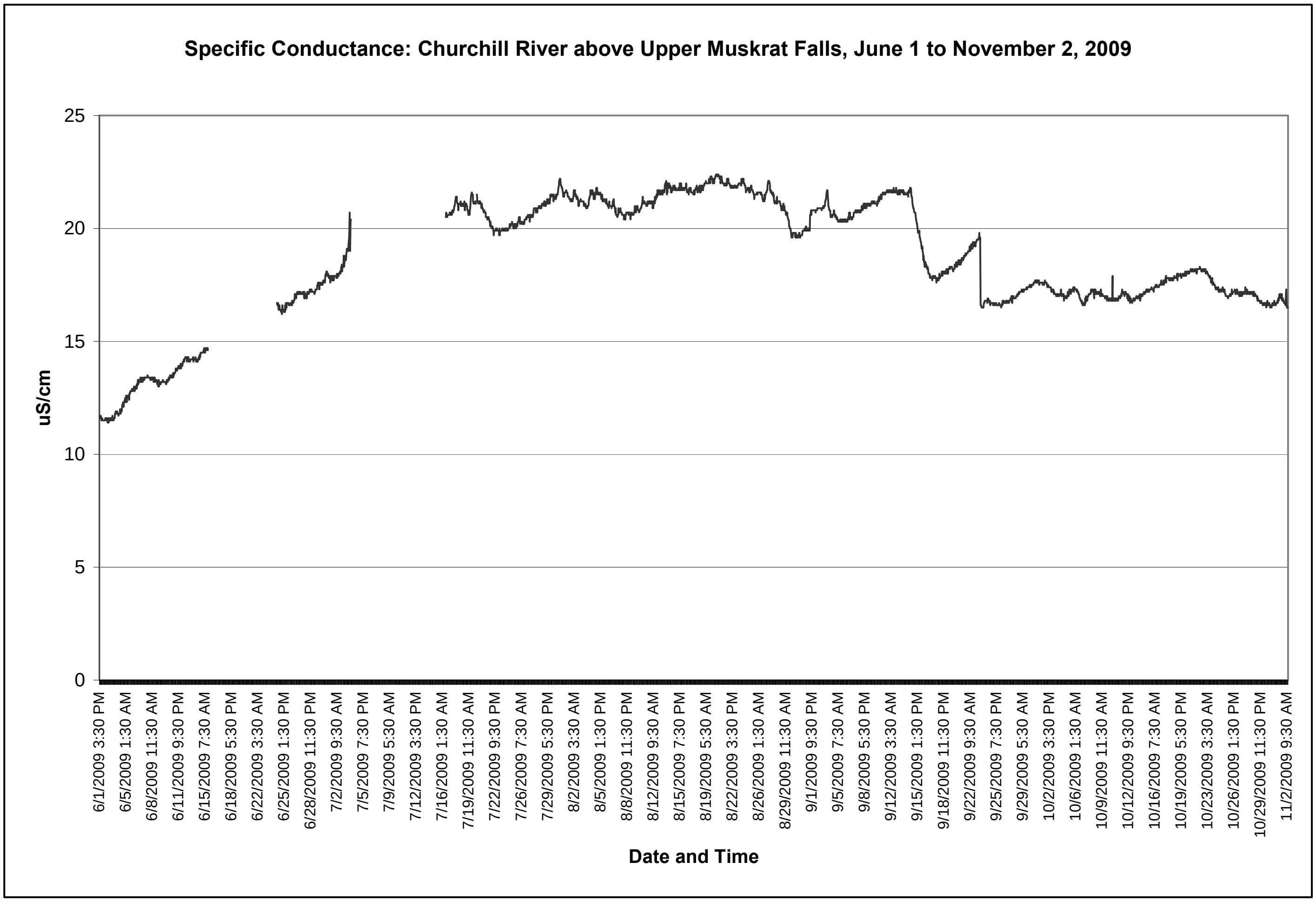


Figure 13: Specific Conductivity for station above Upper Muskrat Falls, June to November 2009.

Turbidity

- Turbidity values are variable which appears to be normal due to the sandy and silty nature of the River at this site (**Figure 14**).
- Figure 14 shows turbidity events ranging between 0 and 100NTU. There is a significant turbidity spike recorded on July 3 up to 950NTU (off the graph). This elevated reading occurs just before the instrument became exposed to air. It is likely that the shallow conditions near the shore and the wave action caused this spike in turbidity.
- Other significant spikes occur from August 23-27 which corresponds clearly with a significant rainfall of nearly 60mm (**Appendix A**).
- Monthly averages, maximums and minimums are summarized in **Table 19**.

Table 19: Summary statistics for turbidity at station above Upper Muskrat Falls

Turbidity (NTU)	June	July	August	September	October	June to November
Average	10.8	23.0	19.6	9.3	3.7	12.5
Maximum	61.0	950.0	94.0	40.0	79.0	950.0
Minimum	1.0	0.0	11.0	0.0	0.0	0.0

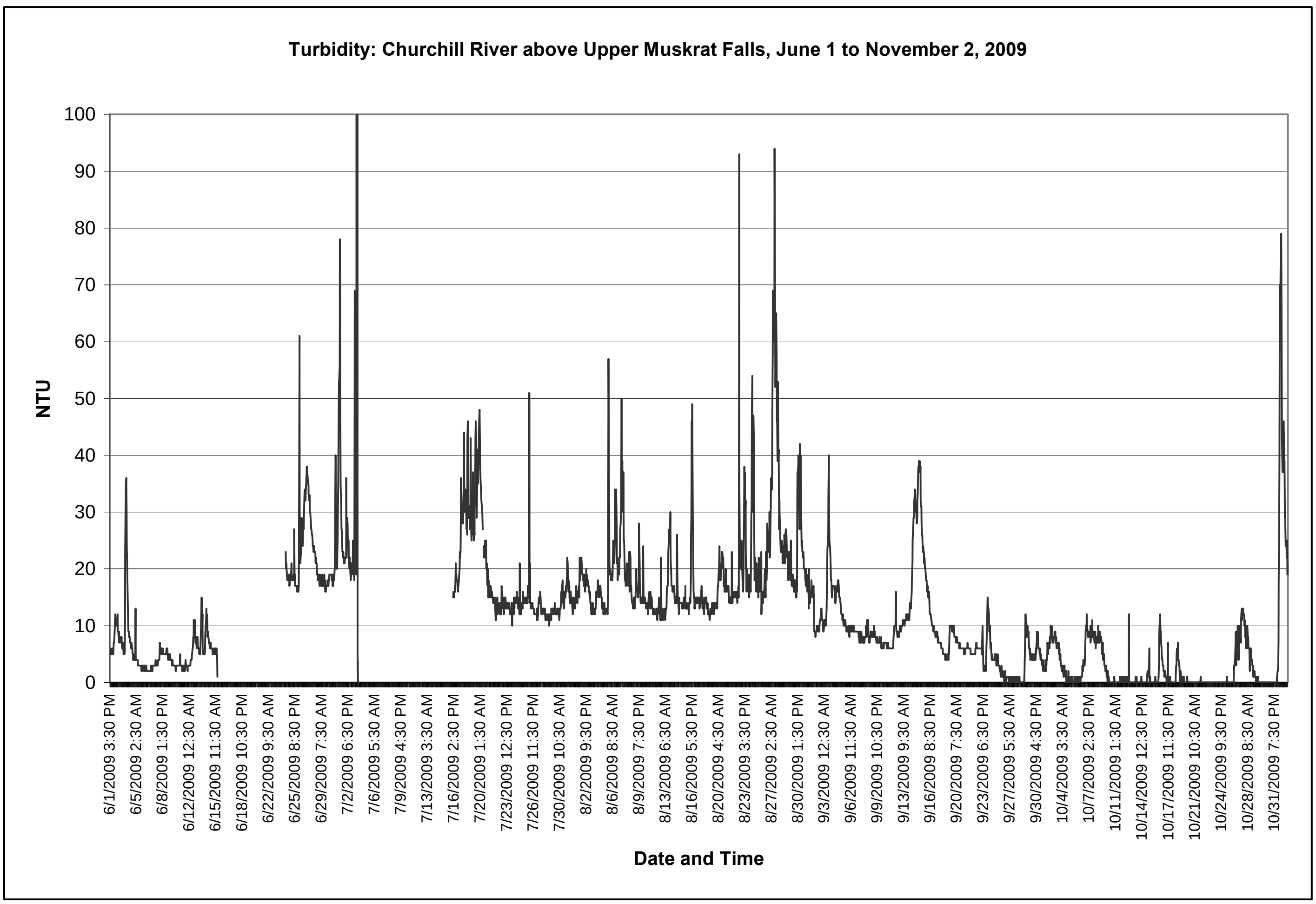


Figure 14: Turbidity for station above Upper Muskrat Falls, June to November 2009.

Stage

- Stage decreased throughout the late spring and early summer before levelling out between mid-July to late August. Stage level then begins to increase slightly throughout September and level off again for the remainder to the deployment season (**Figure 15**).
- Stage level is very important to the success of the RTWQM program on the Lower Churchill River due to the high water level fluctuation. The instrument at the station above Upper Muskrat Falls became exposed to air between June 15-24 and July 4-20. Stage levels will be closely monitored during deployment in 2010.
- Monthly average, maximums and minimums are summarized in **Table 20**.

Table 20: Summary statistics for stage level at station above Upper Muskrat Falls

Stage (m)	June	July	August	September	October	June to November
Average	17.083	15.516	15.485	16.270	16.398	16.142
Maximum	18.561	15.794	16.090	16.616	16.551	18.561
Minimum	15.687	15.220	15.184	15.852	16.197	15.184

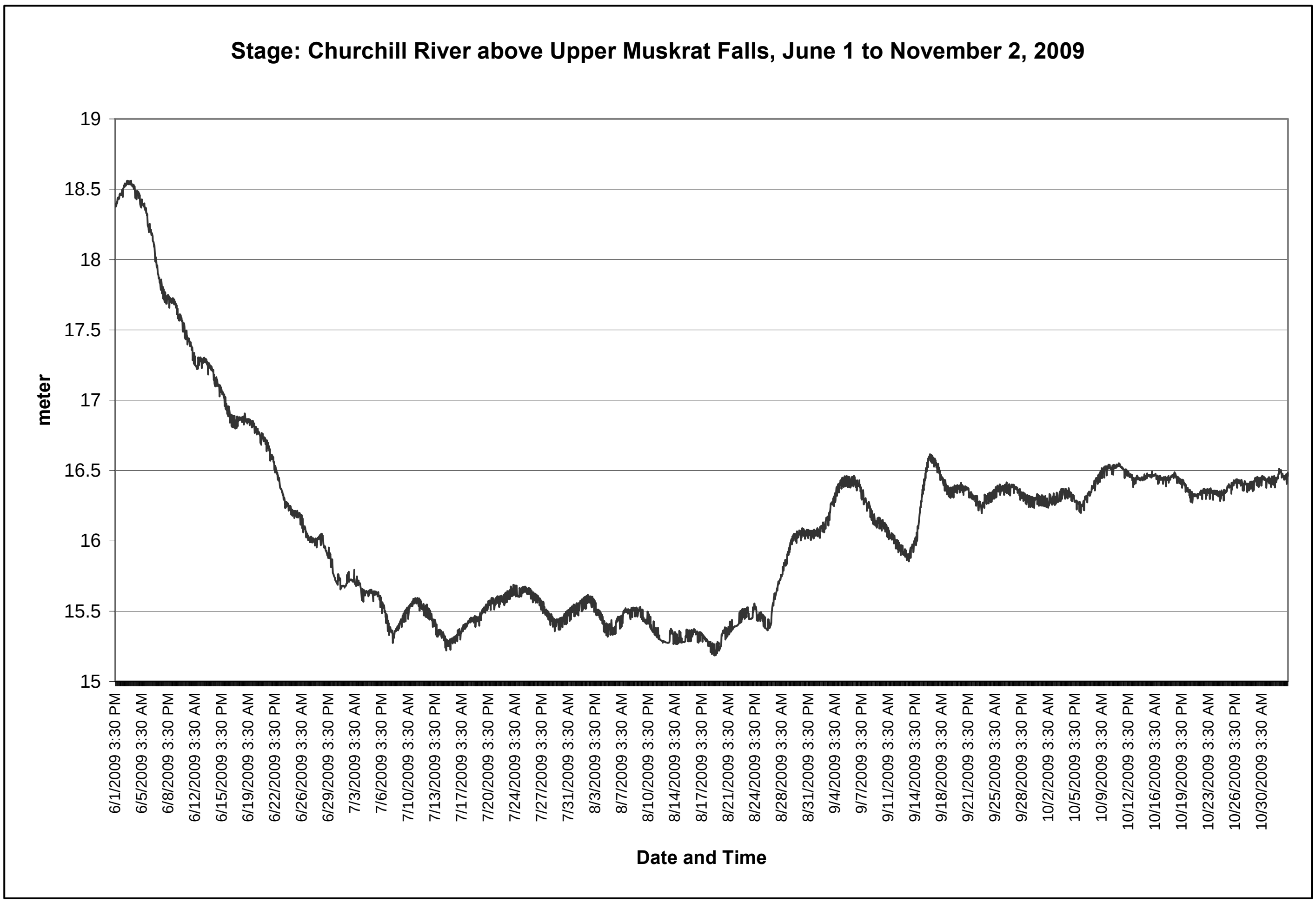


Figure 15: Stage level for station above Upper Muskrat Falls, June to November 2009.

Churchill River below Grizzle Rapids

- This station is located just below Grizzle Rapids and about 1km downstream from the water quantity station with remote iridium camera, above Grizzle Rapids. The camera was installed in early December 2009 and provides real-time photography on an hourly basis of the Churchill River at the future site of the Gull Island Dam. This information will be used for ice and water level monitoring.
- No instrument was deployed during the month of June due to a large ice wall that remained from the winter season preventing safe access to the river edge to deploy the instrument. An instrument was first deployed at this station on June 24 (**Figure 16**).
- There is no dissolved oxygen or percent saturation data available between August 2, and September 1 due to a malfunction with the sensor. This malfunction also affected turbidity data collected. The instrument has since been sent for repair and the DO sensor was replaced under warranty.

Figure 16: Deployment at station below Grizzle Rapids on June 24. This is what remained of a large ice wall that prevented deployment in early June. The ice wall was located on the shore between the edge of the water and the high water mark.

Temperature

- Temperature increases throughout the early summer until peaking at 21.70°C on August 13 (**Figure 17**). From this date onwards, temperature begins to decrease throughout the late summer and early fall till removal on November 2.
- Water temperature is closely related to air temperature. For this station, weather data recorded by Environment Canada in Goose Bay is used to help explain trends and fluctuations in water quality. Weather data is summarized in **Appendix A**.
- Temperatures ranged between 3.45°C to 21.70°C. Monthly averages, minimums and maximums for water temperature can be found in **Table 21.**

Table 21: Summary statistics for water temperature at station below Grizzle Rapids

Temperature (°C)	July	August	September	October	July to November
Average	15.27	16.49	11.58	6.44	12.36
Maximum	21.31	21.70	15.30	10.22	21.70
Minimum	6.59	12.70	9.00	3.45	3.45

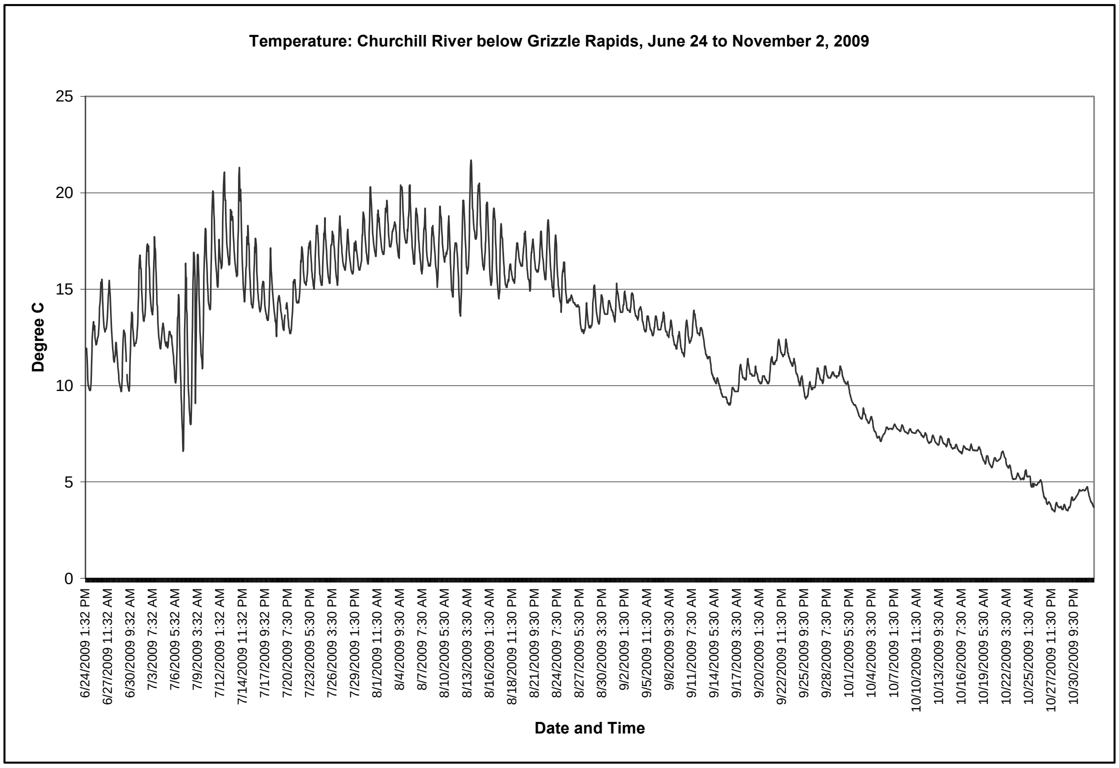


Figure 17: Water Temperature for station below Grizzle Rapids, June to November 2009.

Dissolved Oxygen and Percent Saturation

- Dissolved oxygen content is inversely related to water temperature. At the station below Grizzle Rapids, dissolved oxygen content is low when the instrument is first installed in late June and decreases slightly to as low as 8.87mg/L on July 13 (**Figure 18**). From early September onward, dissolved oxygen content displays an increasing trend. These trends are expected and normal based on water temperature increase and decrease.
- Percent Saturation is a function of dissolved oxygen content and water temperature. Percent saturation values remain relatively stable throughout the deployment season (**Figure 18**).
- There is no data available between August 2 and September 1 due to instrument error.
- Dissolved Oxygen ranged between 8.87mg/L and 12.71mg/L. Monthly averages, minimums and maximums for dissolved oxygen and percent saturation can be found in **Table 22**.

Table 22: Summary statistics for dissolved oxygen and percent saturation level at station below Grizzle Rapids

DO (mg/L) and % Sat (%)	July		August		September		October		July to November	
	DO	% Sat	DO	% Sat	DO	% Sat	DO	% Sat	DO	% Sat
Average	9.90	98.58	9.36	98.21	10.59	97.20	11.82	95.90	10.77	97.32
Maximum	11.70	108.70	9.63	103.30	11.21	101.70	12.71	99.00	12.71	108.70
Minimum	8.87	89.30	9.11	94.50	9.90	89.60	10.82	93.80	8.87	89.30

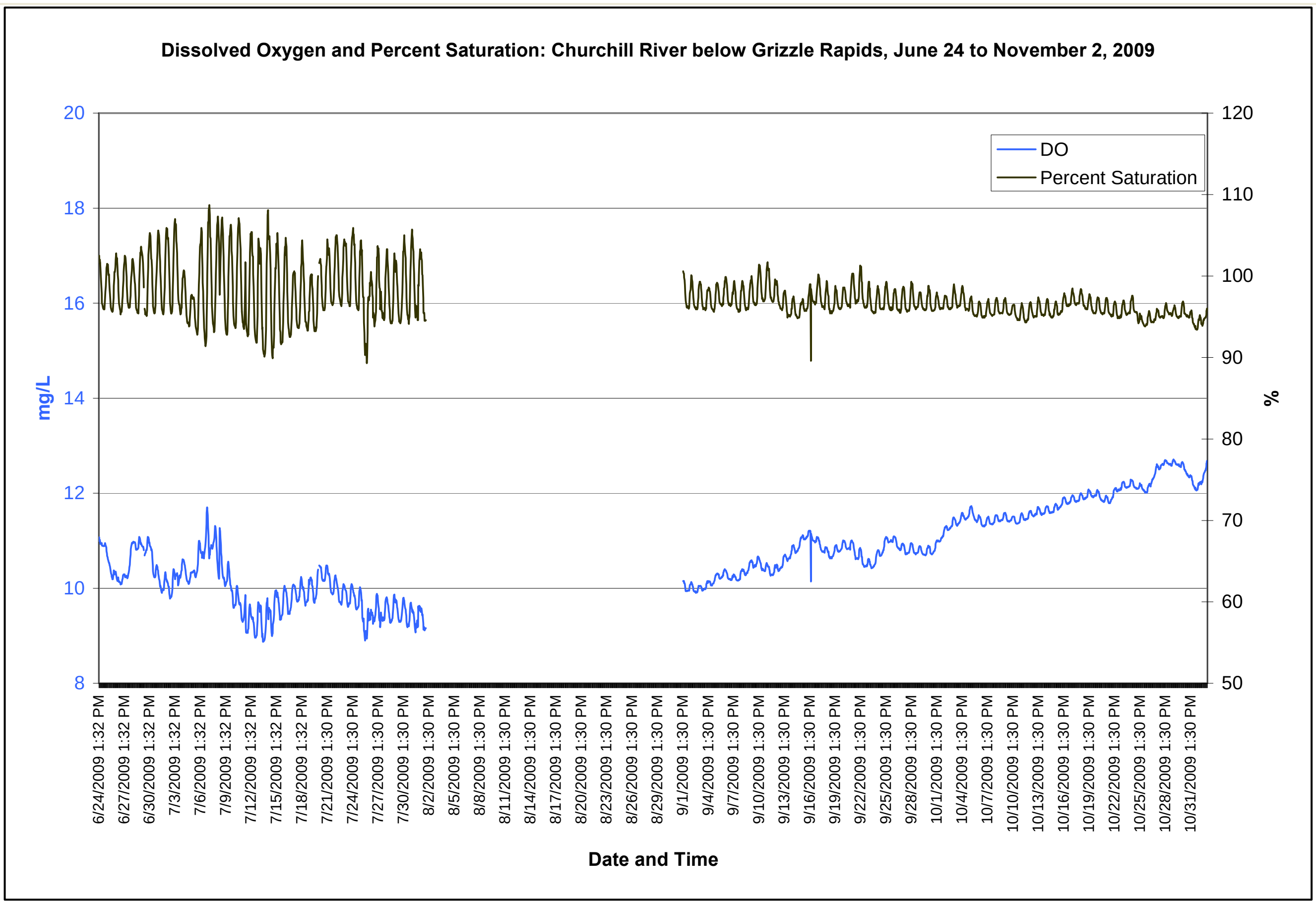


Figure 18: Dissolved oxygen and percent saturation for station below Grizzle Rapids, June to November 2009.

pH

- pH varies throughout the deployment season at this station (**Figure 19**). pH appears to rise throughout the first monthly deployment period (June 24 to July 20). During the next deployment, pH values are slightly lower and more stable. This is likely due to the instrument change.
- The cause of a sharp decrease (5.52) recorded on August 2 is unknown and subsequently causes the turbidity sensor to malfunction for the remainder of the deployment (**Figure 21**). The September deployment shows slightly higher pH levels before returning to more neutral state during the October deployment.
- Monthly averages, maximums and minimums are summarized in **Table 23**.

Table 23: Summary statistics for pH at station below Grizzle Rapids

pH	July	August	September	October	July to November
Average	7.24	6.97	7.21	6.97	7.10
Maximum	7.72	7.19	7.45	7.11	7.72
Minimum	6.79	5.52	6.42	6.84	5.52

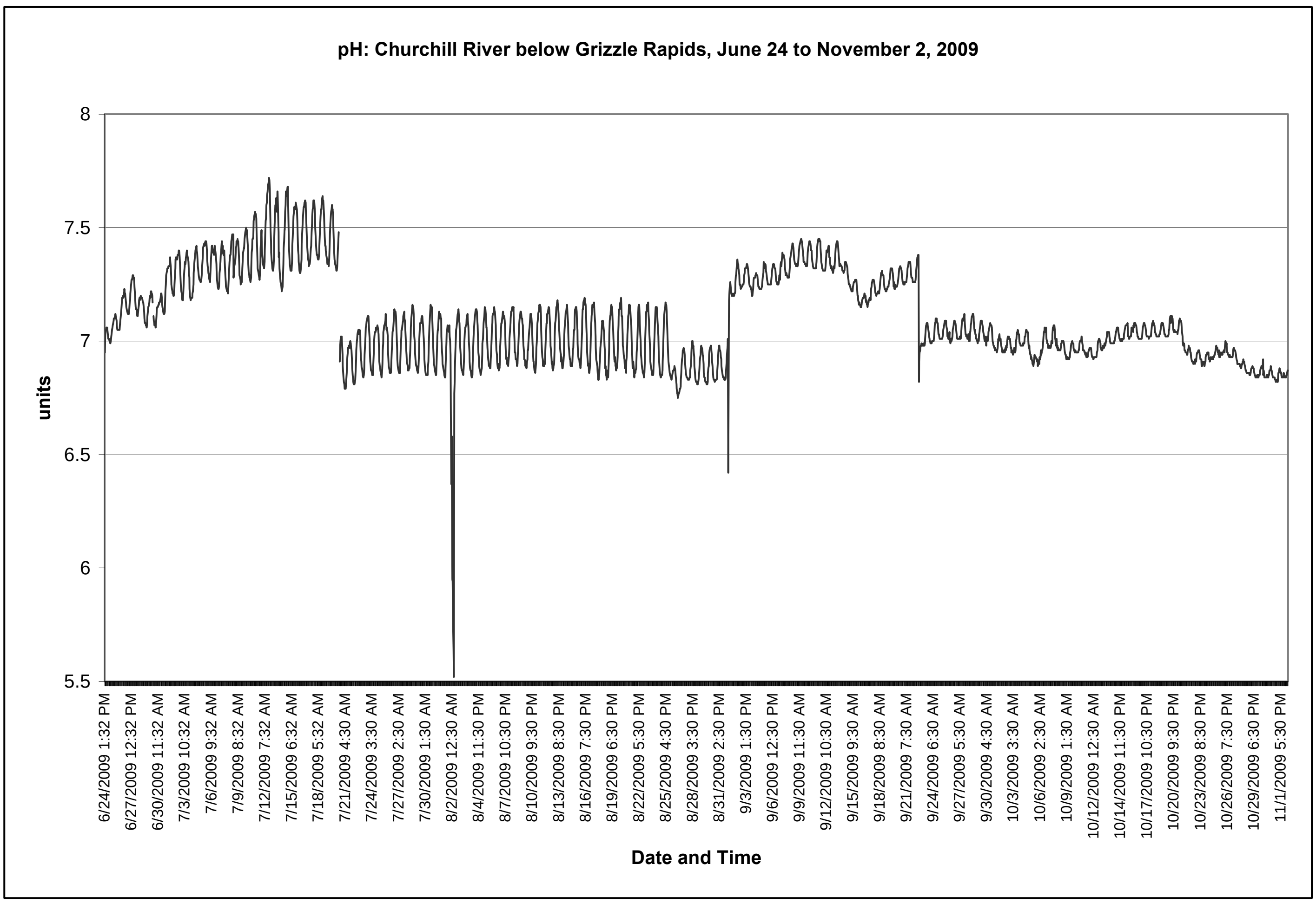


Figure 19: Dissolved oxygen and percent saturation for station below Grizzle Rapids, June to November 2009.

Specific Conductivity

- Specific conductance rises throughout the early summer before beginning to level off for the remainder of the deployment season around mid July (**Figure 20**).
- The cause of a sharp decrease on July 20 correlates with a rainfall event recorded in Goose Bay on July 19 (30mm+) (**Appendix A**). Values generally fluctuated day to day and during precipitation events.
- Monthly averages, maximums and minimums are summarized in **Table 24**.

Table 24: Summary statistics for specific conductivity at station below Grizzle Rapids

SpCond (µS/cm)	July	August	September	October	July to November
Average	19.29	20.87	20.62	20.03	20.01
Maximum	22.00	22.50	22.00	21.00	22.50
Minimum	16.50	19.40	19.00	19.00	16.10

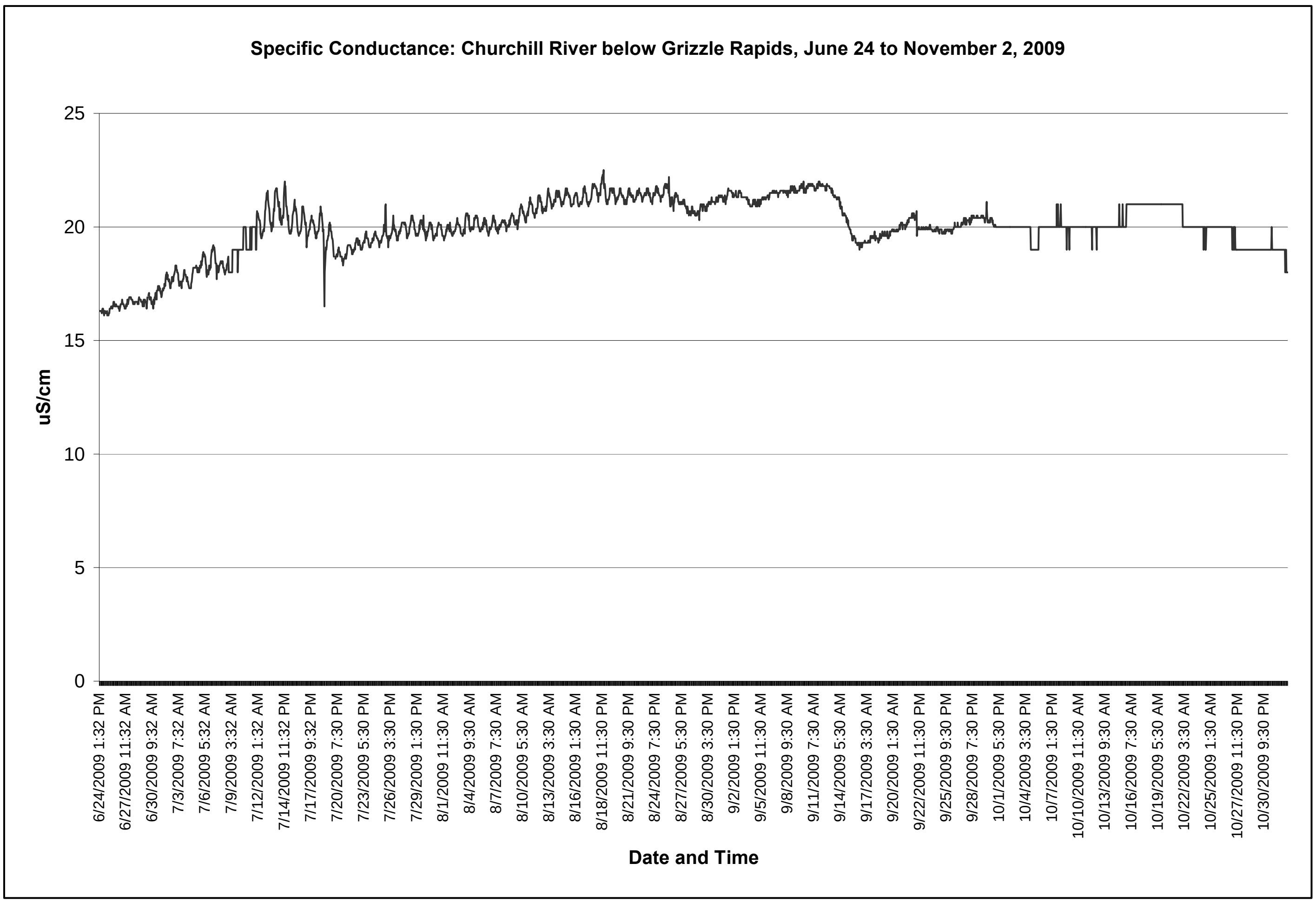


Figure 20: Specific conductivity for station below Grizzle Rapids, June to November 2009.

Turbidity

- Turbidity values are generally 0NTU at this site (**Figure 21**).
- The turbidity sensor malfunctioned between August 2 and September 1. The error was caused by a circuiting error within the instrument and corresponds with the dissolved oxygen sensor malfunction. The instrument has since been sent for repair.
- Monthly average, maximums and minimums are summarized in **Table 25**.

Table 25: Summary statistics for turbidity at station below Grizzle Rapids

Turbidity (NTU)	July	August	September	October	July to November
Average	0.0	10.0	0.0	0.0	2.9
Maximum	0.0	364.7	3.2	3.1	364.7
Minimum	0.0	0.0	0.0	0.0	0.0

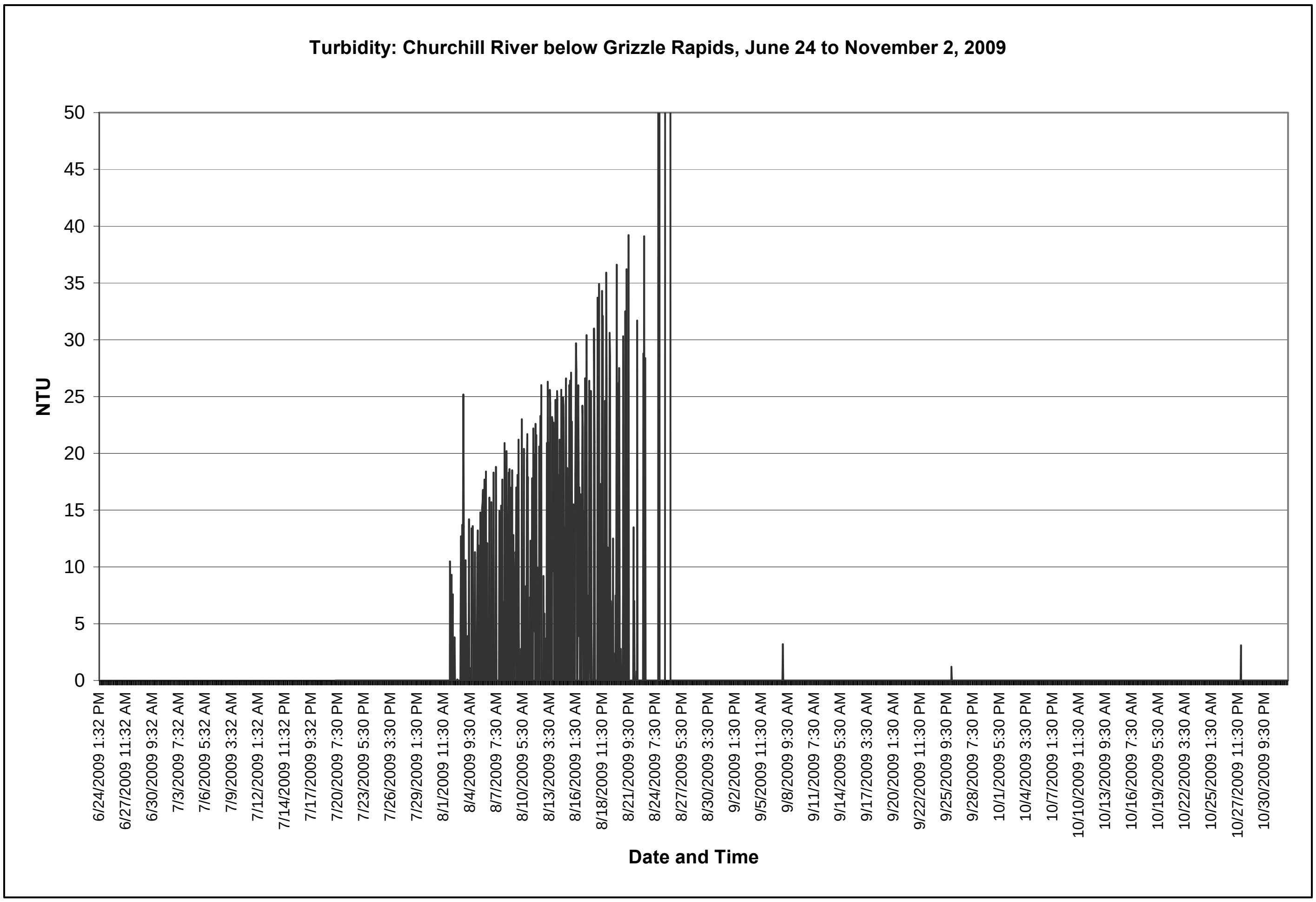


Figure 21: Turbidity for station below Grizzle Rapids, June to November 2009.

Stage

- Stage decreased throughout the early summer before levelling out between mid-July to late August. Stage level then begins to increase slightly throughout September and level off again for the remainder to the deployment season (**Figure 22**).
- The jump in stage level (circled in red) is a benchmark adjustment made by Environment Canada during the site visit in late June to correct for stage level.
- Stage level is very important to the success of the RTWQM program on the Lower Churchill River due to the high water level fluctuation. Stage levels will be closely monitored during deployment in 2010.
- Monthly averages, maximums and minimums are summarised in **Table 26**.

Table 26: Summary statistics for stage level at station below Grizzle Rapids

Stage (m)	July	August	September	October	July to November
Average	32.968	33.145	33.431	No data	33.185
Maximum	33.254	33.342	33.514		33.543
Minimum	32.741	33.040	33.306		32.741

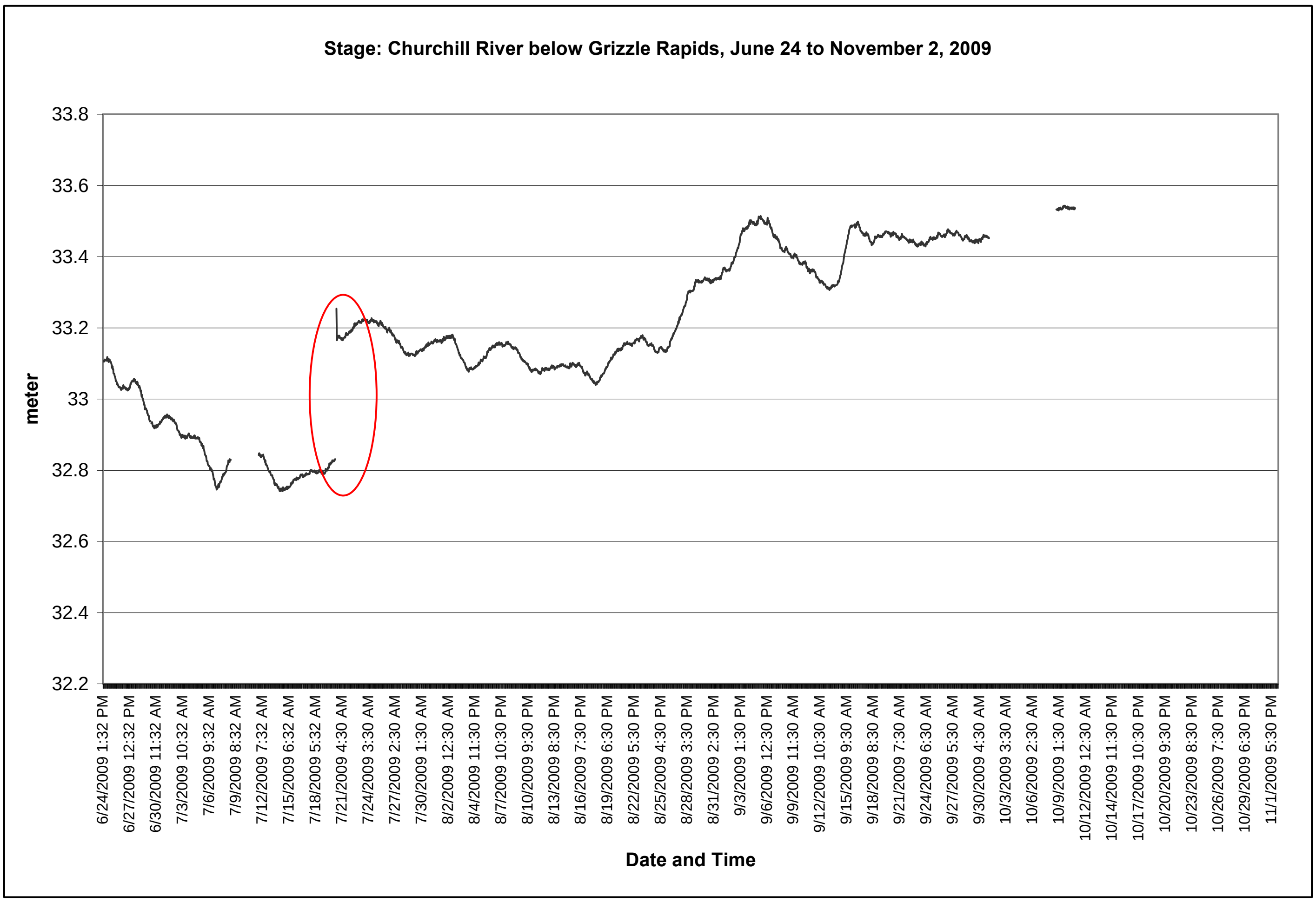


Figure 22: Stage level for station below Grizzle Rapids, June to November 2009.

Churchill River below Metchin River

- This station is located just below the confluence of the Lower Churchill River and Metchin River (**Figure 23**).
- The instrument deployed at the station on June 24 became exposed on July 4 and was not retrieved until July 20. The conduit length was extended approximately 7m to reach the river edge at times of low flow.

Figure 23: RTWQ monitoring station below Metchin River.

Temperature

- Temperature increases throughout the late spring and early summer until peaking at 20.54°C on July 2 (**Figure 24**). From this date onwards, temperature begins to decrease throughout the late summer and early fall till removal on November 2.
- Water temperature is closely related to air temperature. For this station, weather data recorded by Environment Canada in Churchill Falls is used to help explain trends and fluctuations in water quality. Weather data is summarized in **Appendix A**.
- Temperatures ranged between -0.10°C to 20.54°C. Monthly averages, minimums and maximums for water temperature can be found in **Table 27.**

Table 27: Summary statistics for water temperature at station below Metchin River

Temperature (°C)	June	July	August	September	October	June to November
Average	8.12	16.57	15.66	10.10	4.28	10.27
Maximum	18.42	20.54	18.10	12.40	9.10	20.54
Minimum	2.67	14.59	11.70	8.30	-0.10	-0.10

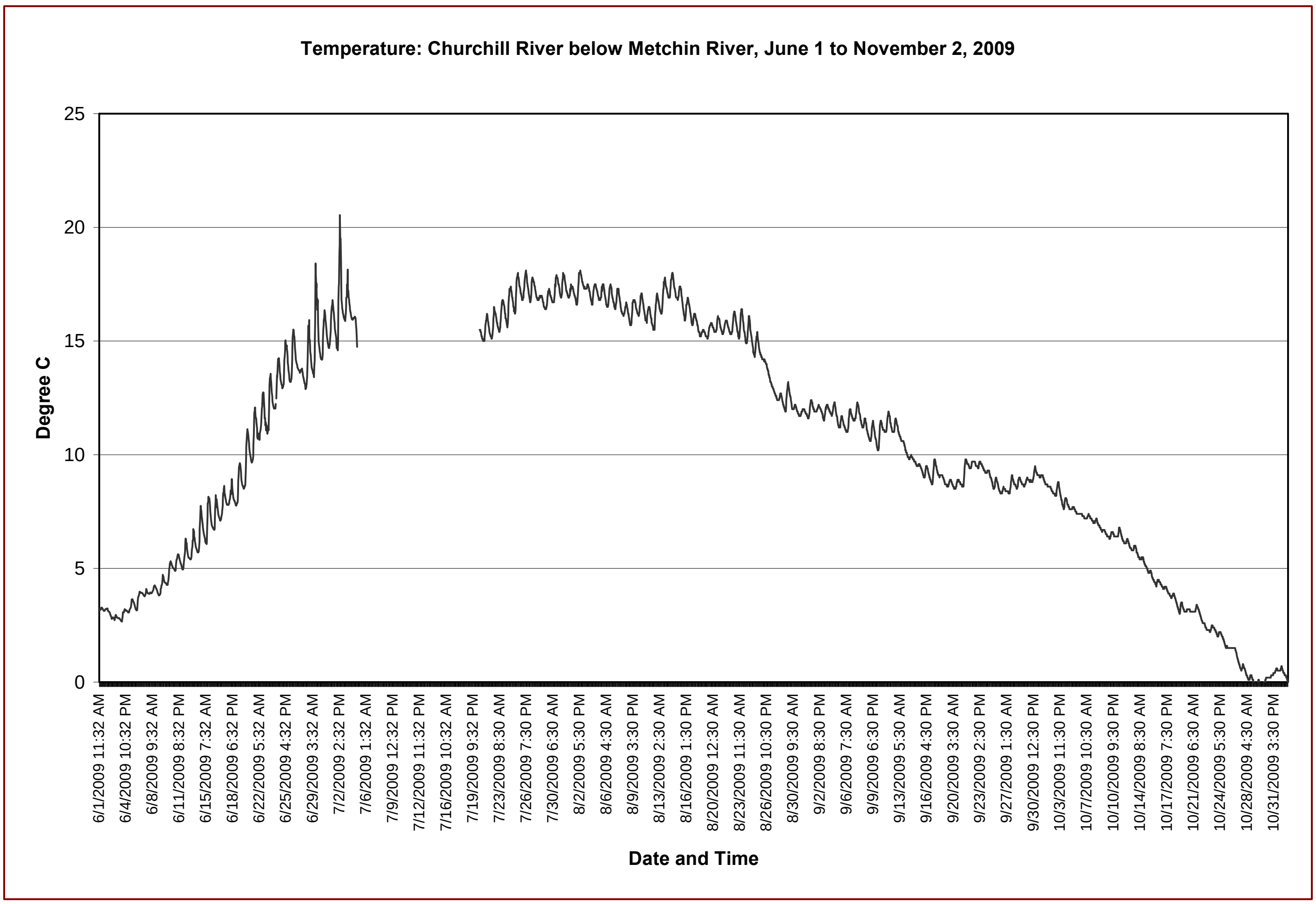


Figure 24: Water temperature for station below Metchin River, June to November 2009.

Dissolved Oxygen and Percent Saturation

- Dissolved oxygen content is inversely related to water temperature. At the station below Metchin River, dissolved oxygen content decreases throughout the late spring and early summer to as low as 9.00mg/L on August 6 (**Figure 25**). From this date onward, dissolved oxygen content displays an increasing trend. These trends are expected and normal based on water temperature increase and decrease (**Appendix A**).
- Percent Saturation is a function of dissolved oxygen content and water temperature. Percent saturation values remain relatively stable throughout the deployment season (**Figure 25**).
- Dissolved Oxygen ranged between 9.00mg/L and 13.89mg/L. Monthly averages, minimums and maximums for dissolved oxygen and percent saturation can be found in **Table 28**.

Table 28 Summary statistics for dissolved oxygen and percent saturation at station below Metchin River

DO (mg/L) & %Sat (%)	June		July		August		September		October		June to Nov.	
	DO	%Sat	DO	%Sat	DO	%Sat	DO	%Sat	DO	%Sat	DO	%Sat
Average	12.03	101.06	9.52	97.67	9.40	94.47	10.56	93.72	12.20	93.30	10.88	95.79
Maximum	13.30	110.50	10.17	105.30	10.11	99.20	11.08	97.00	13.89	96.00	13.89	110.50
Minimum	9.70	96.10	9.09	93.20	9.00	90.10	9.91	91.30	10.84	91.10	9.00	90.10

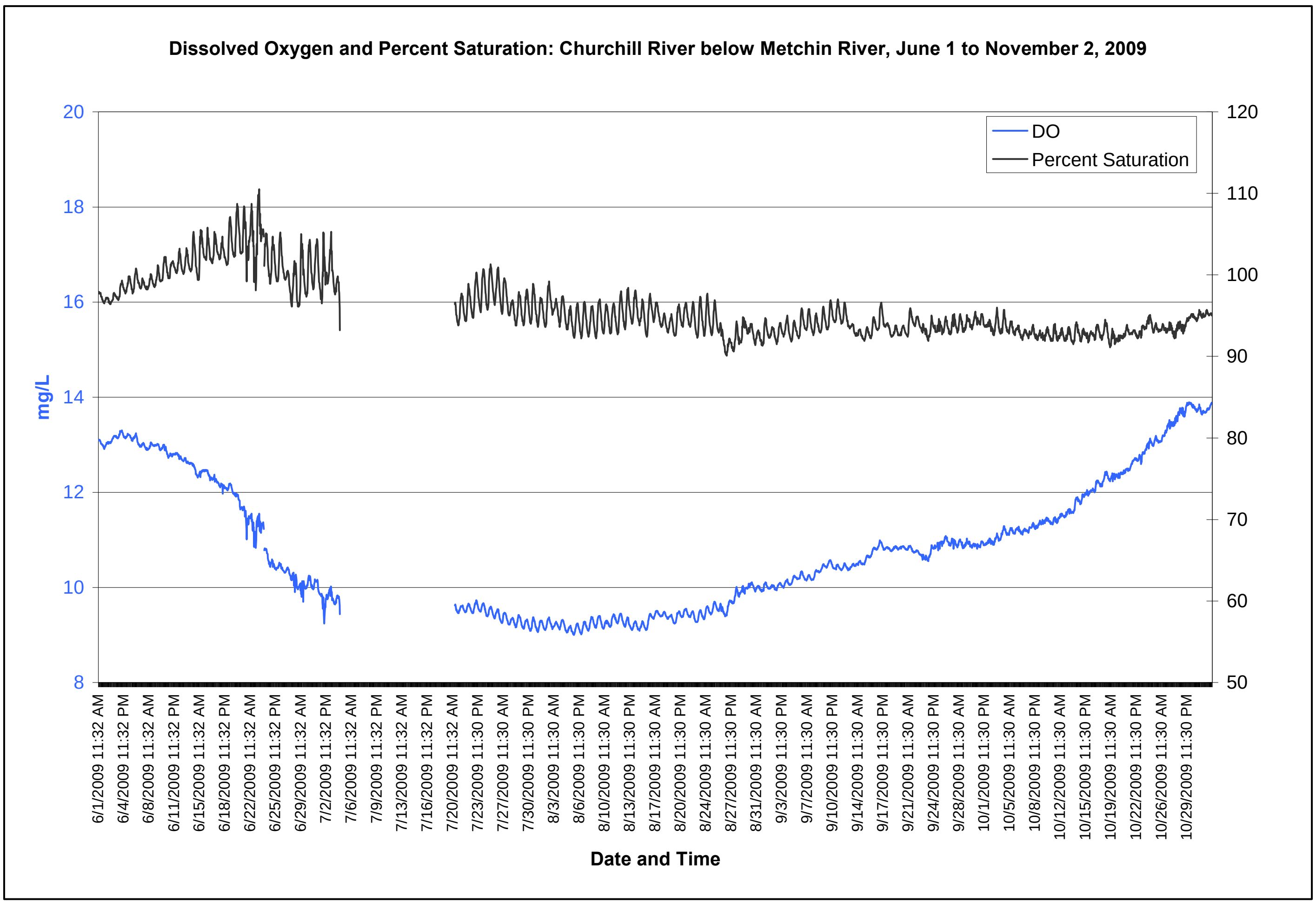


Figure 25: Dissolved oxygen and percent saturation for station below Metchin River, June to November 2009.

pH

- pH varies throughout the deployment season at this station (**Figure 26**). pH appears to rise throughout the first monthly deployment period (June 24 to July 20). During the next deployment, pH values are slightly lower and more stable.
- The September and October deployments show slightly higher pH values and remain relatively stable.
- Monthly average, maximums and minimums are summarized in **Table 29**.

Table 29: Summary statistics for pH at station below Metchin River

pH	June	July	August	September	October	June to November
Average	6.93	7.01	6.92	7.27	7.26	7.09
Maximum	7.26	7.37	7.04	7.36	7.32	7.37
Minimum	6.50	6.79	6.80	6.84	7.21	6.50

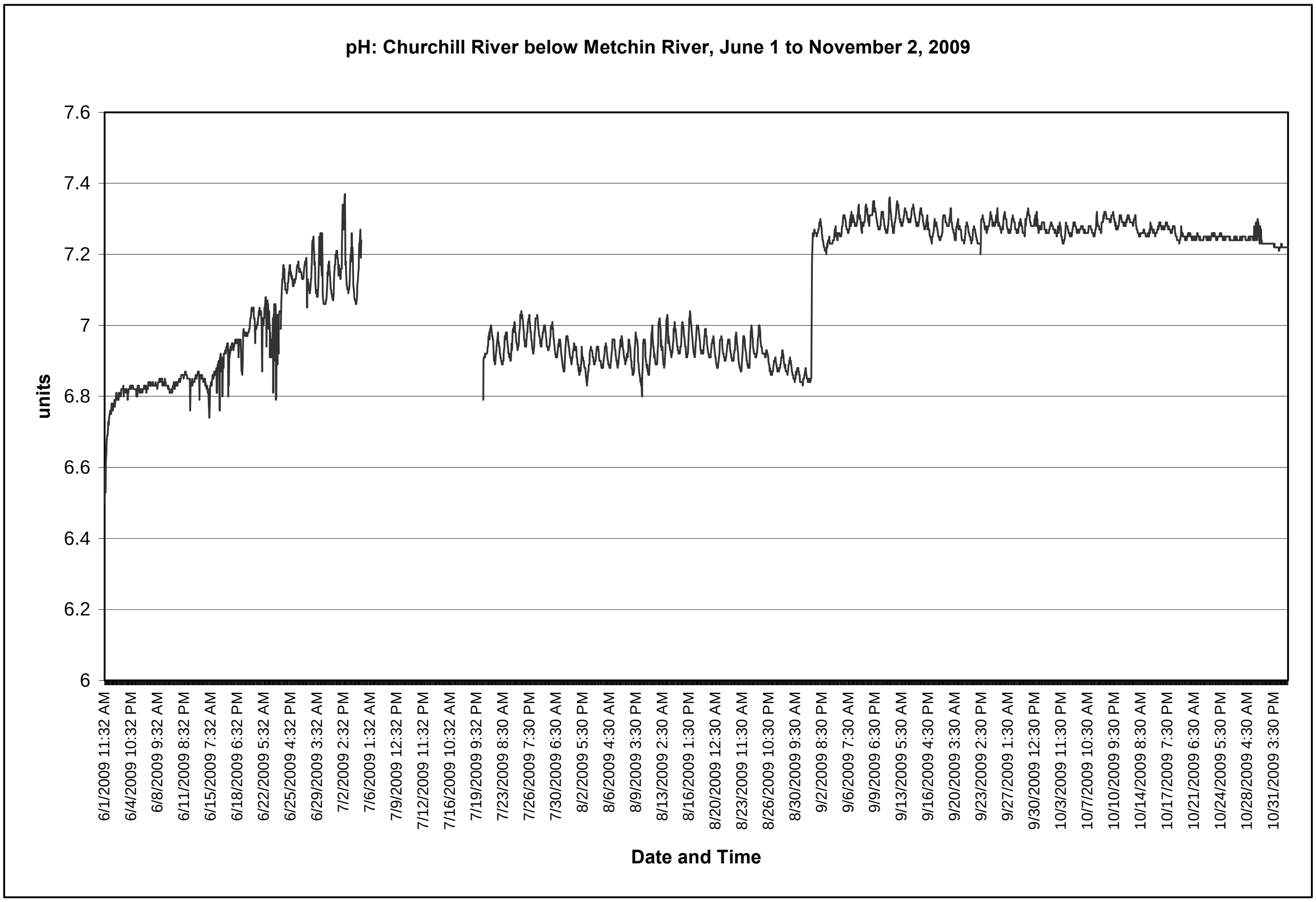


Figure 26: pH level for station below Metchin River, June to November 2009.

Specific Conductivity

- Specific conductance is quite variable throughout the first deployment period (**Figure 27**). This is likely due to the instrument being exposed by the end of the deployment.
- After this incident, specific conductivity appears to be rather stable throughout the remainder of the deployment season until removal in November.
- Monthly averages, maximums and minimums are summarized in **Table 30**.

Table 30: Summary statistics for specific conductivity at station below Metchin River

SpCond (µS/cm)	June	July	August	September	October	June to November
Average	18.25	21.32	23.27	22.93	21.65	21.53
Maximum	34.50	29.10	24.50	24.00	22.70	34.50
Minimum	14.70	14.60	22.20	22.10	20.50	14.60

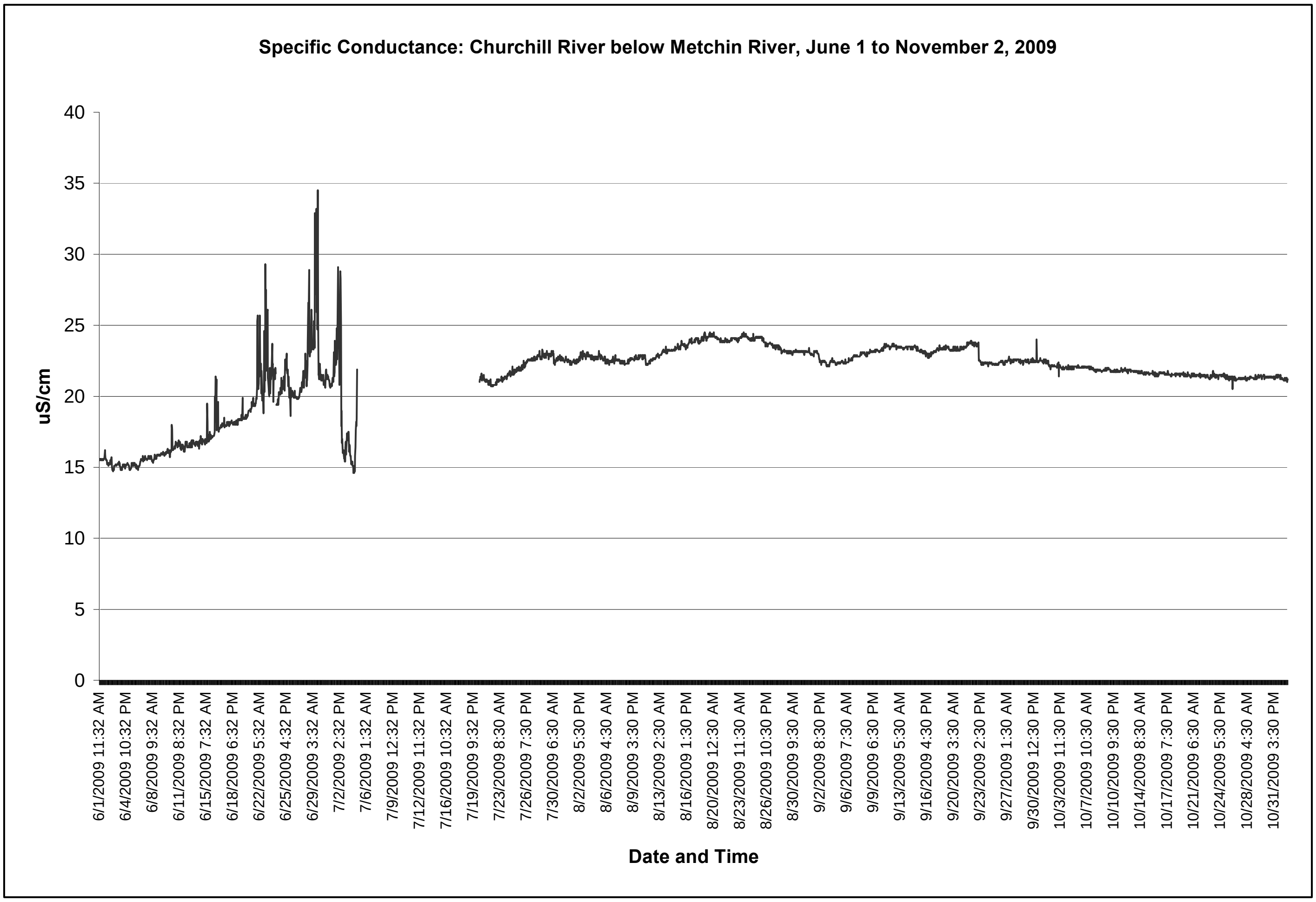


Figure 27: Specific conductivity for station below Metchin River, June to November 2009.

Turbidity

- Turbidity values are most often 0NTU at this site with very few turbidity events recorded (**Figure 28**).
- There is significant turbidity spikes recorded from June 23 to July 3 up to 928NTU (off the graph). These elevated readings occur just before the instrument became exposed to air. It is likely that the shallow conditions near the shore and the wave action caused this spike in turbidity.
- Monthly averages, maximums and minimums are summarized in **Table 31**.

Table 31: Summary statistics for turbidity at station below Metchin River

Turbidity (NTU)	June	July	August	September	October	June to November
Average	4.8	3.5	0.0	0.0	0.0	1.4
Maximum	928.0	318.9	10.2	12.7	7.8	928.0
Minimum	0.0	0.0	0.0	0.0	0.0	0.0

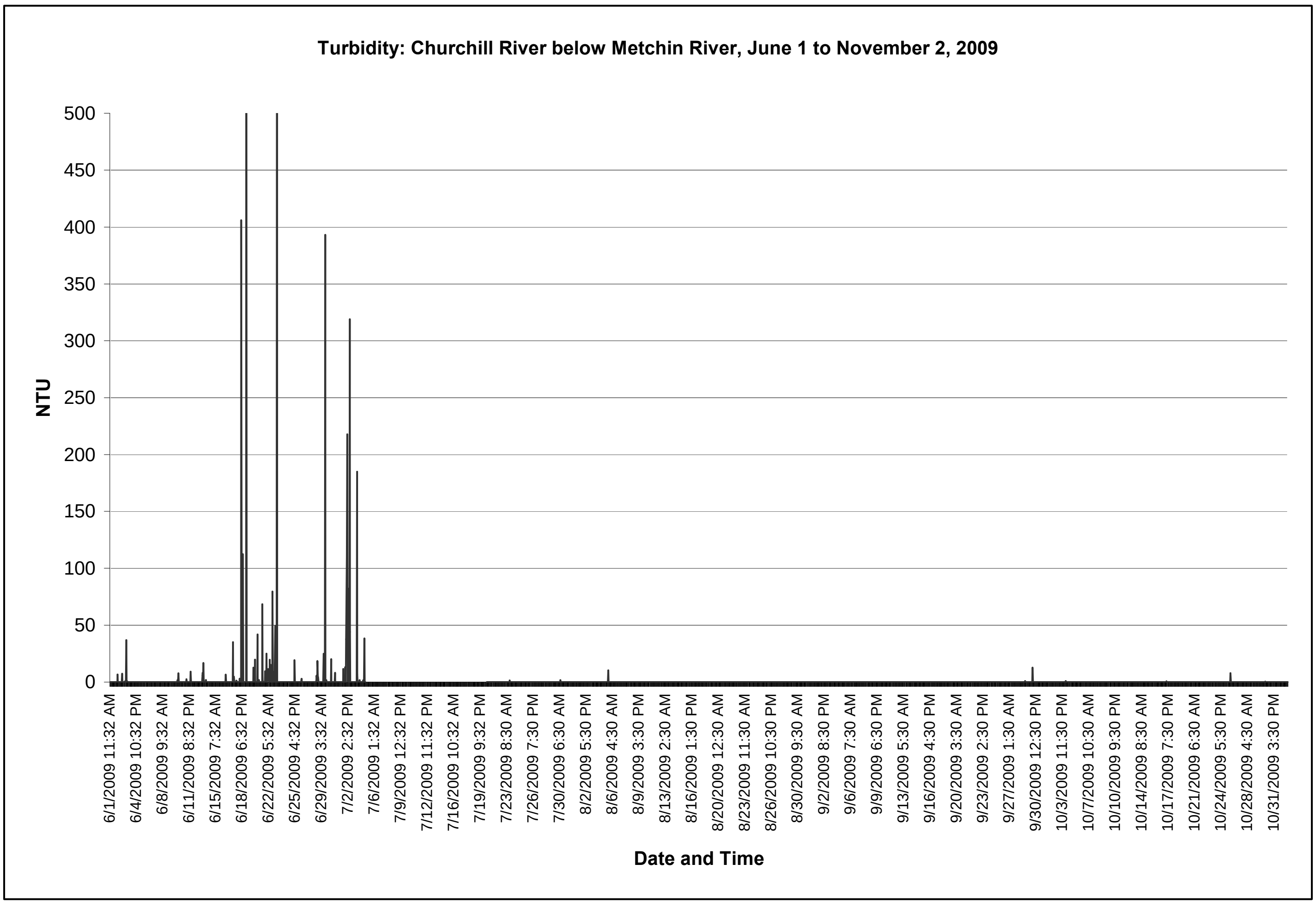


Figure 28: Turbidity for station below Metchin River, June to November 2009.

Stage

- Stage decreased throughout the late spring and early summer before levelling out between mid-July to late August. Stage level then begins to increase slightly throughout September and level off again for the remainder to the deployment season (**Figure 29**).
- Stage level is very important to the success of the RTWQM program on the Lower Churchill River due to the high water level fluctuation. The instrument at the station below Metchin River became exposed to air on July 4. Stage levels will be closely monitored during deployment in 2010.
- Monthly averages, maximums and minimums are summarized in **Table 32**.

Table 32: Summary statistics for stage level at station below Metchin River

Stage (m)	June	July	August	September	October	June to November
Average	113.113	112.051	112.024	112.652	112.993	112.576
Maximum	114.356	112.428	112.504	112.888	113.231	114.356
Minimum	112.145	111.782	111.637	112.424	112.701	111.637

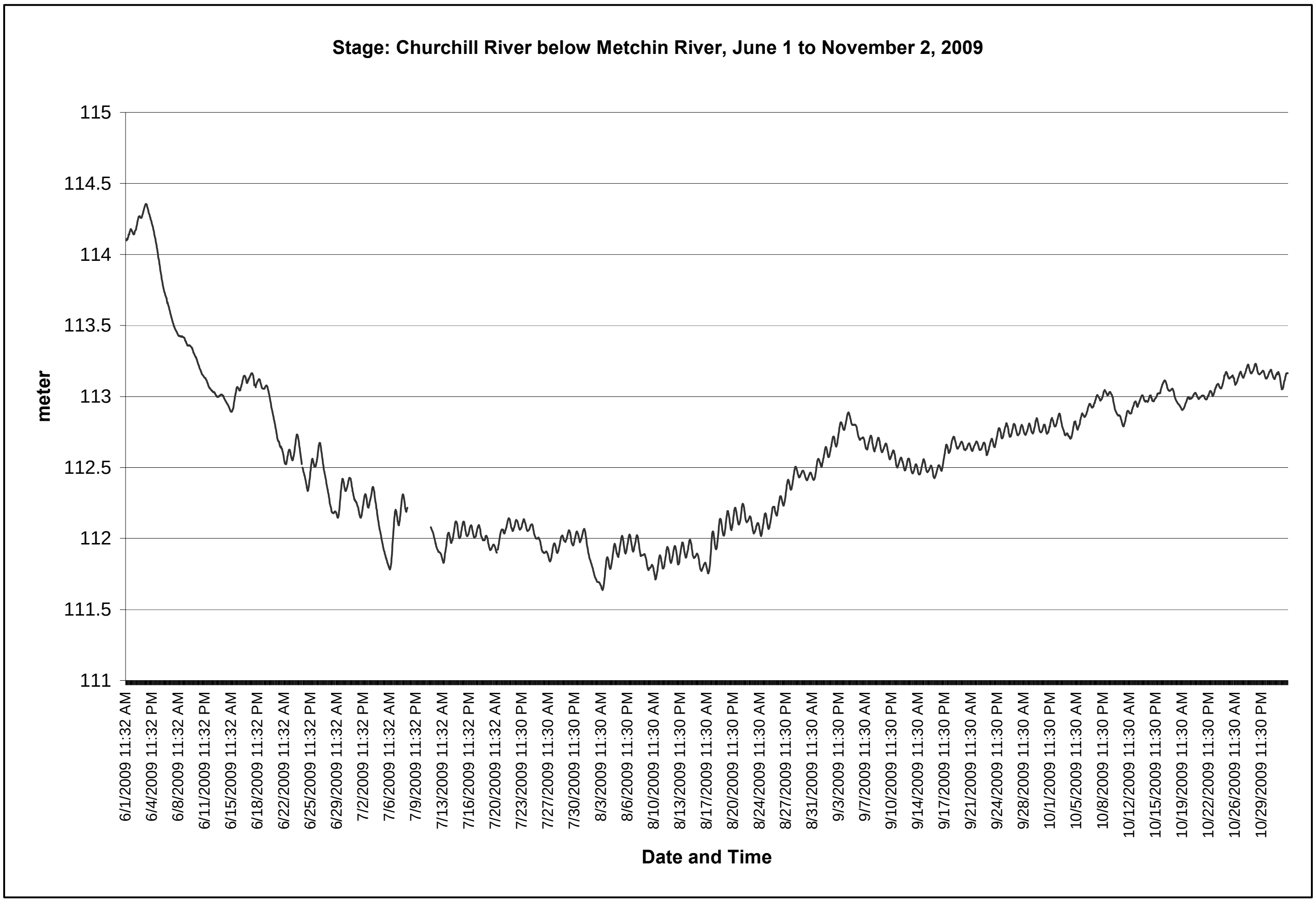


Figure 29: Stage level for station below Metchin River, June to November 2009.

Networked Stations

- The four RTWQM stations on the Churchill River create a network. In the previous sections, each station is discussed individually however it is important to relate the stations to one another and understand some of the parameters trends that occur along the river. This section will briefly overview the five major parameters as they relate to one another over the length of the Lower Churchill.

Temperature

- Each station is very closely related to each other. When water temperature at one station, water temperature tends to increase at other stations as well.
- It is noticeable that water temperature tends to fluctuate the most diurnally at the station below Grizzle Rapids. This is likely due to the position of the sonde in the river at this station. The river at this station is quite narrow and a shelf extends out on the south side of the river. This is where the sonde is deployed. On the north side of the river is deeper channel and fast moving. Where the sonde is located is likely to experience a daytime warming and night-time cooling period that is more significant than the fast moving channel.
- Near the end of the deployment season, it is clear that water temperature at the station below Metchin River is on average less than station above and below Muskrat Falls.

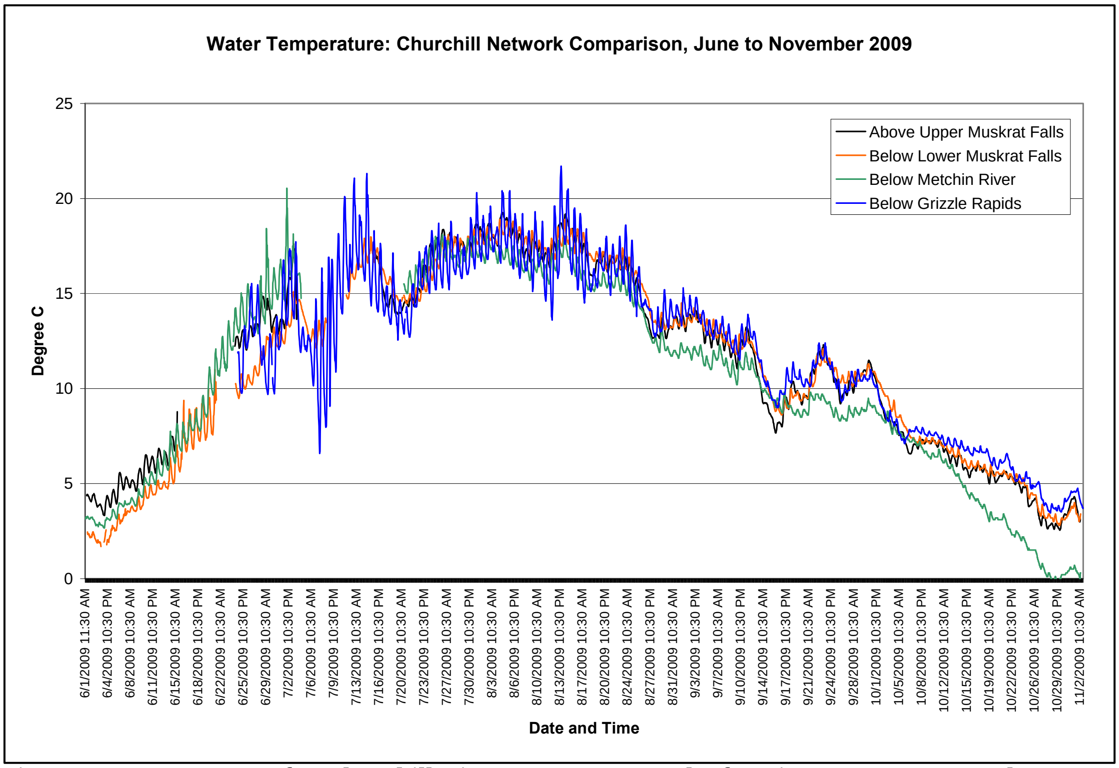


Figure 30: Temperature for Churchill River RTWQ Network of stations, June to November 2009.

Dissolved Oxygen

- Each station varies slightly regarding dissolved oxygen content. It is noticeable that dissolved oxygen content at the station below Metchin River is slightly greater than at the station above Upper Muskrat Falls in the beginning of the deployment season; however, there is no data during this time for the station below lower Muskrat Falls. From the data that is available, the station below Lower Muskrat Falls has significantly higher dissolved oxygen content than at the other stations upstream of Muskrat Falls. This is likely due to the turbulent conditions and air intrusion occurring at Muskrat Falls.

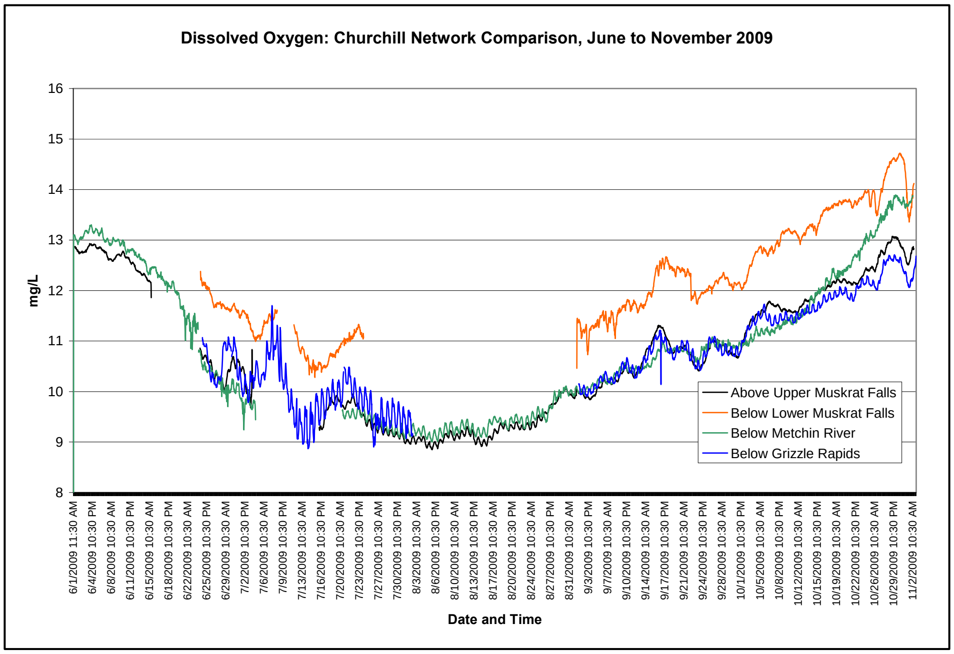


Figure 31: Dissolved Oxygen for Churchill River RTWQ Network of stations, June to November 2009.

pH

- pH varies across all stations throughout the deployment season. On average, pH at the station below Metchin River is greater than at the other station downstream and appears to fluctuate less. At the station above Upper Muskrat Falls, pH is highly variable throughout the deployment season. There is a lot of noise in the pH data collected a the station below Grizzle Rapids. This is due to the instrument malfunctioning.
- Despite noise and variations, pH at Upper Muskrat Falls and Lower Muskrat falls does appear to mimic and relate closely (see event circled in red).

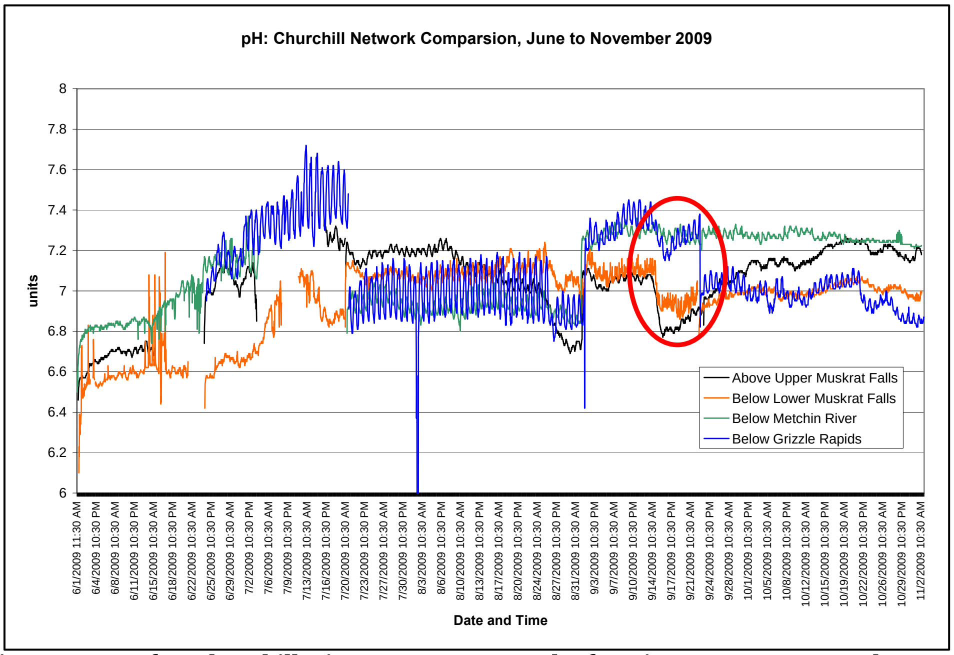


Figure 32: pH for Churchill River RTWQ Network of stations, June to November 2009.

Specific Conductivity

- Specific conductivity is slightly different at each station however increasing and decreasing patterns at each station can be related to one another. The general increasing trend through the late spring and early summer is apparent at each station. Small increases at one station usually correspond with small increases at a station further downstream.
- On average, the highest specific conductivity is found at the station below Metchin River. Specific conductivity decreases at the stations downstream. The two stations near Muskrat Falls often have the lowest conductivity.

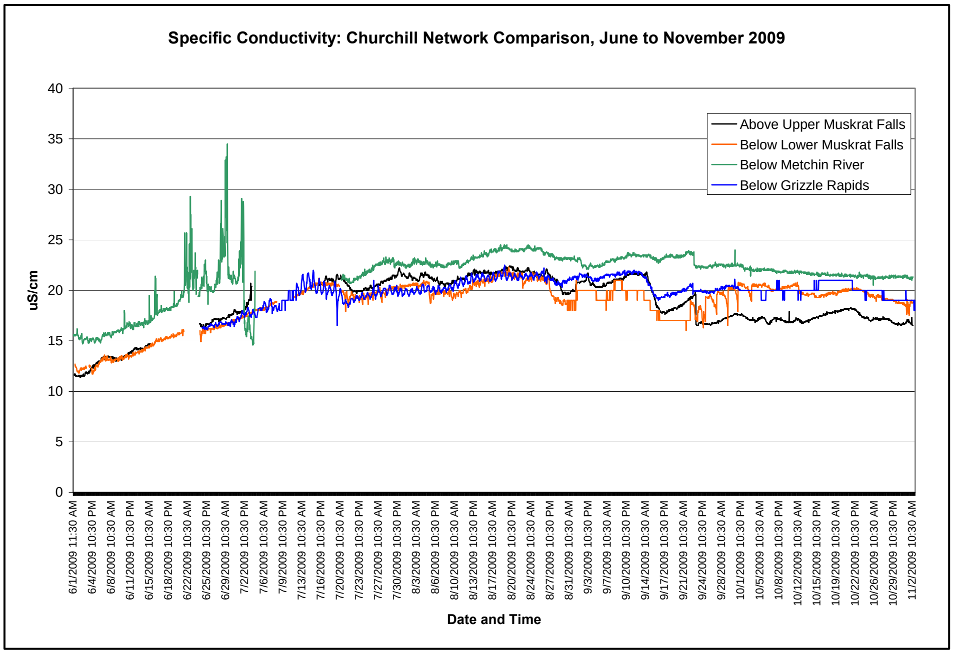


Figure 33: Specific Conductivity for Churchill River RTWQ Network of stations, June to November 2009.

Turbidity

- Turbidity events at Grizzle Rapids and below Metchin River tend to be sporadic therefore they are not considered in this analysis. Of more interest are the similarities and differences between turbidity at the stations above and below Muskrat Falls. These stations have a considerable turbidity background level. The scale is limited to 140NTU to focus on some of the smaller events that occurred during the deployment season in 2009.
- Turbidity at both stations is very closely related. When turbidity spikes at the station above Muskrat Falls, the lower station will detect the increase in the next hour. A good example of this pattern is circled in red.

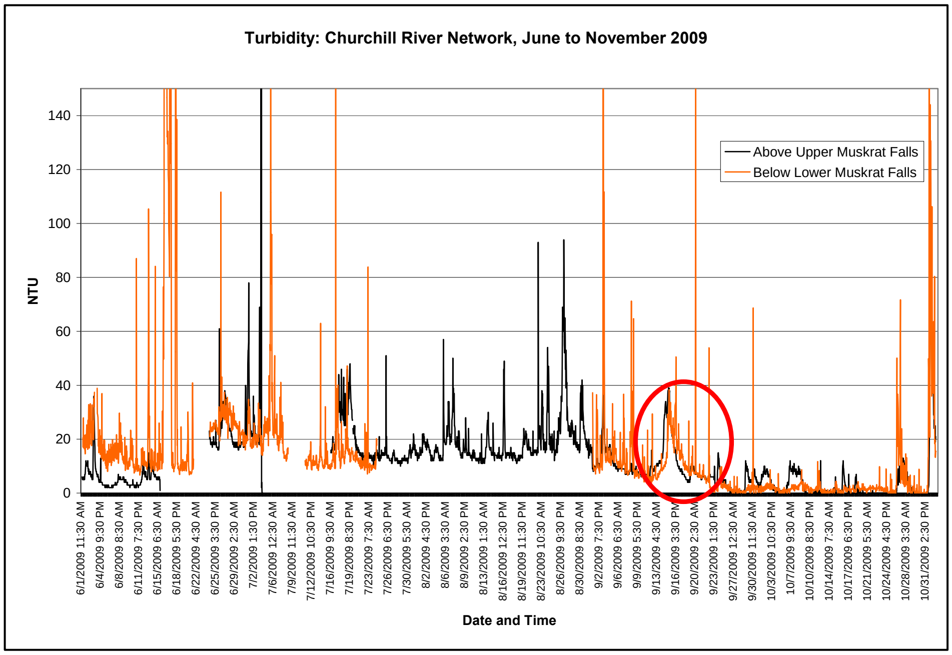


Figure 34: Turbidity for Churchill River RTWQ station above and below Muskrat Falls, June to November 2009.

Conclusions

- The Lower Churchill RTWQM Network had a successful deployment season in 2009. This was the first complete deployment season for each of the 4 RTWQ stations. There were numerous lessons learned from this past deployment season which will be used to improve the functioning of the RTWQM network in the upcoming deployment season.
- In most instances fluctuations in water quality can be attributed to weather related events as recorded in Goose Bay and Churchill Falls.
- The four stations continue to perform well at capturing water quality baseline data along different reaches of the river.
- Regular visits on a near 30 day deployment schedule have been adhered to for the most part. This has provided good quality data with limited drift.
- The main concern with the network is during June and July when the river stage level is decreasing significantly between site visits. During the first deployment season, this has left instruments exposed to air on the beach in three of the four stations. In order to rectify this, conduit lengths have been extended to account for stage level decrease however there still remains an issue of the ability to deploy the instrument in deep enough water at the time of each site visit.
- Short data transmissions have been an issue at some of the new stations along the Lower Churchill River. This is often caused by damage to cables by wildlife which causes communication error. A two foot width of thin metal siding has been placed at the bottom of each station shelter to help deter animals from destroying and entering the hut. Environment Canada is responsible for all communication aspects of the stations and is committed to maintaining this network. Internal log files will continue to be used to fill in gaps left by data transmission errors.
- Specific instrument issues particularly concerning the luminescent dissolved oxygen (LDO) sensor and the turbidity sensor have been corrected. All instruments were sent to the manufacturer for performance testing evaluation and repair upon final removal. In many cases, the LDO sensor has been replaced under warranty.

Path Forward

For the 2010 season, improvements on procedures and protocols followed by ENVC staff in the field, laboratory and office have been implemented. These improvements include:

- In–field cleaning to evaluate possible bio-fouling drift error
- Immediate laboratory calibration to evaluate calibration drift error following deployment
- Implementation of USGS data correction procedures combining bio-fouling and calibration drift errors to accurately correct data if required.

In order for this agreement to be successful, it is essential to continually evaluate and move forward. The 2009 deployment season was successful in providing baseline water quality data for the Lower Churchill Project. The following is a list of planned activities to be carried out in the upcoming year. The list also includes some multi-year activities planned in the previous year that are still in progress.

- Shipment of instruments for servicing work during the winter months
- Deploy Real Time Water Quality instruments in spring 2010 when ice conditions allow.
- Continue site visitation by ENVC staff throughout the summer and fall 2010
- If necessary, change or improve deployment techniques to adapt to each site, ensuring secure and suitable conditions for real time water quality monitoring.
- Nalcor will continue to be informed of data trends and any significant water quality events in the form of a monthly deployment report when the deployment season begins.
- Nalcor will also receive an annual report summarizing the events of the deployment season.
- Continue to maintain open communication lines between ENVC, EC and Nalcor employees involved with the agreement in order to respond to emerging issues on a proactive basis.

- RTWQ Coordinator, Renee Paterson, is currently awaiting final decision concerning potential establishment of a RTWQ station near the community of Rigolet. She will amend the agreement and bring it up to date after the decision has been made.
- ENVC plan to install a RTWQM station at Mud Lake complete with real-time weather station and camera. The camera will be positioned to photograph the section of the Churchill River used by Mud Lake residents for transportation on snowmobile and boat to and from the community. This will be useful in determining when and how ice formation and retreat occurs. Installation of this site is planned for late June 2010.
- ENVC continues to work on establishing RTWQM station in Lake Melville.
- Continue to work on Automatic Data Retrieval System to incorporate new capabilities
- Provide on-line statistical analysis of data.
- Work on extrapolation of other water quality parameters using regression analysis
- Creation of value added products using the real-time water quality data, remote sensing and water quality indices

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Appendix 1 – Weather Data

Source: Environment Canada, National Climate Data and Information Archive

Table A-1: Weather data recorded at Goose Bay, June 1 to November 2, 2009.

Daily Weather Data Report for Goose Bay Falls: June 1 to November 2, 2009								
	Max Temp °C	MinTemp °C	MeanTemp °C	Total Rain mm	Total Snow cm	TotalPrecip mm	Dir of Max Gust10's Deg	Spd of Max Gust km/h
1-Jun-09	16.8	4.7	10.8	14.6	0	14.6	7E	50E
2-Jun-09	10.7	3.6	7.2	0.8	0	0.8	26E	44E
3-Jun-09	7.8	3.2	5.5	1.2	T	1.2	29E	57E
4-Jun-09	13.1	2.3	7.7	T	0	T	27E	46E
5-Jun-09	9.9	3.1	6.5	0.6	0	0.6	32E	37E
6-Jun-09	18.1	3.2	10.7	0.8	0	0.8	6E	39E
7-Jun-09	11.3	6.1	8.7	13.2	0	13.2		<31
8-Jun-09	9.2	3.6	6.4	0.6	0	0.6	5E	39E
9-Jun-09	10.6	3.6	7.1	0.2	0	0.2	7E	32E
10-Jun-09	13.7	2.7	8.2	0	0	0		<31
11-Jun-09	16.3	3.8	10.1	8	0	8	18E	35E
12-Jun-09	13.7	5.6	9.7	7	0	7		<31
13-Jun-09	9.9	2.9	6.4	0.8	0	0.8	35E	39E
14-Jun-09	15	2.6	8.8	0	0	0		<31
15-Jun-09	20.7	1.8	11.3	0	0	0		<31
16-Jun-09	25.3	11.4	18.4	2.4	T	2.4	32E	59E
17-Jun-09	26.7	10	18.4	3.2	0	3.2	27E	50E
18-Jun-09	27.5	9.1	18.3	5.2	0	5.2	28E	65E
19-Jun-09	20.6	7.1	13.9	0	0	0		<31
20-Jun-09	18.7	7.1	12.9	0	0	0		<31
21-Jun-09	22.7	8.2	15.5	5	0	5		<31
22-Jun-09	18.6	7.1	12.9	0.8	0	0.8	35E	37E
23-Jun-09	25.4	12.1	18.8	0	0	0		<31
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	7E	33E
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	10E	48E
4-Jul-09	10.3	7	8.7	0.8	0	0.8	5E	48E
5-Jul-09	8.8	3.3	6.1	2.2	0	2.2	6E	56E
6-Jul-09	12.1	3.3	7.7	1.2	0	1.2	8E	37E
7-Jul-09	17.2	2.8	10	0	0	0	1E	32E
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	21E	57E
13-Jul-09	23.7	16	19.9	5	0	5	21E	37E
14-Jul-09	24	13.7	18.9	0	0	0	20E	44E
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	5E	46E
18-Jul-09	17.7	9.4	13.6	0.8	0	0.8	12E	35E
19-Jul-09	12.7	8.2	10.5	31	0	31	9E	35E
20-Jul-09	13.9	9.5	11.7	0.8	0	0.8		<31
21-Jul-09	15.9	10.7	13.3	3	0	3		<31
22-Jul-09	17.1	10.3	13.7	T	0	T		<31
23-Jul-09	21.1	10.6	15.9	0	0	0		<31
24-Jul-09	21.4	9.3	15.4	0	0	0		<31
25-Jul-09	23.8	8.2	16	0.2	0	0.2		<31
26-Jul-09	25.5	11	18.3	0	0	0		<31
27-Jul-09	28.3	11	19.7	0	0	0		<31
28-Jul-09	21.7	14.8	18.3	0	0	0		<31
29-Jul-09	21.2	14	17.6	6.2	0	6.2		<31
30-Jul-09	26.6	17.2	21.9	1.2	0	1.2	25E	32E
31-Jul-09	29.4	15.2	22.3	18.6	0	18.6	25E	72E
1-Aug-09	17	12.1	14.6	0.4	0	0.4		<31
2-Aug-09	21.5	11.9	16.7	0	0	0		<31
3-Aug-09	19.7	15.1	17.4	9.6	0	9.6		<31
4-Aug-09	26.5	12.6	19.6	0	0	0	24E	33E
5-Aug-09	25.1	12.9	19	3.2	0	3.2	27E	95E
6-Aug-09	22.5	12.2	17.4	0	0	0	26E	48E
7-Aug-09	21.8	13.3	17.6	0	0	0	25E	41E
8-Aug-09	19.8	11.9	15.9	T	0	T		<31
9-Aug-09	24.6	9.9	17.3	0.4	0	0.4	25E	56E
10-Aug-09	19.3	9.8	14.6	7	0	7	25E	37E
11-Aug-09	16.7	8.3	12.5	T	0	T		<31
12-Aug-09	23.8	8.1	16	0	0	0	25E	33E
13-Aug-09	31.1	14.8	23	2.2	0	2.2	25E	57E
14-Aug-09	25.3	14.8	20.1	0.4	0	0.4		<31
15-Aug-09	20.4	10.2	15.3	0.2	0	0.2		<31
16-Aug-09	19.9	8.7	14.3	0	0	0	29E	46E
17-Aug-09	14.8	6.5	10.7	T	0	T		<31
18-Aug-09	13.7	9.2	11.5	2.6	0	2.6		<31
19-Aug-09	18.4	11.9	15.2	14	0	14		<31
20-Aug-09	20.8	12.1	16.5	1.4	0	1.4	27E	32E
21-Aug-09	19.5	12.4	16	T	0	T		<31
22-Aug-09	20.5	13.9	17.2	5.2	0	5.2	25E	39E
23-Aug-09	21.6	9.3	15.5	0	0	0	29E	41E
24-Aug-09	18.3	6.7	12.5	0	0	0	29E	46E
25-Aug-09	15.2	4.4	9.8	0	0	0	M	M
26-Aug-09	11.3	3.3	7.3	43.4	0	43.4	4E	35E
27-Aug-09	8.2	4.1	6.2	16.6	0	16.6	32E	54E
28-Aug-09	9.9	4.7	7.3	4.2	0	4.2	30E	41E
29-Aug-09	17.2	5.2	11.2	T	0	T		<31
30-Aug-09	13.6	2.8	8.2	1	0	1		<31
31-Aug-09	13.6	8.2	10.9	2.6	0	2.6		<31
1-Sep-09	17.5	5.5	11.5	0.2	0	0.2	29E	33E
2-Sep-09	20.7	7.9	14.3	11	0	11	23E	52E
3-Sep-09	19.4	9.8	14.6	T	0	T	25E	61E
4-Sep-09	14	3	8.5	1.2	0	1.2		<31
5-Sep-09	14.2	2.8	8.5	0	0	0	30E	46E
6-Sep-09	17	3.6	10.3	0	0	0	24E	54E
7-Sep-09	16.5	6.5	11.5	T	0	T	25E	56E
8-Sep-09	14.1	5.1	9.6	T	0	T	27E	52E

9-Sep-09	12.9	3.1	8	T	0	T	34E	48E
10-Sep-09	23.2	5	14.1	0	0	0	24E	39E
11-Sep-09	23.2	7.8	15.5	0	0	0	25E	35E
12-Sep-09	11	2.2	6.6	3.4	0	3.4	4E	37E
13-Sep-09	4.6	2	3.3	18.8	0	18.8	4E	39E
14-Sep-09	5.8	3.3	4.6	58.4	0	58.4	34E	59E
15-Sep-09	6.3	-0.6	2.9	1.6	0	1.6	33E	67E
16-Sep-09	9.5	-0.9	4.3	T	0	T	26E	37E
17-Sep-09	19.3	7.9	13.6	0	0	0	23E	44E
18-Sep-09	18.8	6	12.4	2	0	2		<31
19-Sep-09	9.3	1.2	5.3	4.4	0	4.4	35E	41E
20-Sep-09	11.6	1.8	6.7	0	0	0		<31
21-Sep-09	21.9	8.4	15.2	0	0	0	24E	48E
22-Sep-09	25.2	14.7	20	T	0	T	M	M
23-Sep-09	22.4	3.6	13	17.4	0	17.4	33E	56E
24-Sep-09	6.4	1	3.7	2	0.4	2.4	36E	32E
25-Sep-09	6	-1.3	2.4	0	0	0		<31
26-Sep-09	12.4	-0.9	5.8	T	0	T	24E	41E
27-Sep-09	18.2	5.9	12.1	0	0	0	26E	32E
28-Sep-09	16.6	3.9	10.3	T	0	T		<31
29-Sep-09	14.2	8.7	11.5	T	0	T		<31
30-Sep-09	19.5	7.5	13.5	2.6	0	2.6	9E	37E
1-Oct-09	11.5	5.6	8.6	0.2	0	0.2	5E	46E
2-Oct-09	6.1	3.8	5	0.6	0	0.6	5E	37E
3-Oct-09	6.2	-0.3	3	0	0	0	4E	32E
4-Oct-09	6.6	-1.5	2.6	0	0	0		<31
5-Oct-09	6	-2.1	2	0	0	0		<31
6-Oct-09	5.4	2.4	3.9	26.2	0	26.2	6E	54E
7-Oct-09	6.7	3.8	5.3	4.8	0	4.8	6E	50E
8-Oct-09	7.3	2.5	4.9	1.2	0	1.2	7E	39E
9-Oct-09	4.7	1.3	3	0	T	T		<31
10-Oct-09	6	0.1	3.1	7.6	0.8	8.8		<31
11-Oct-09	5.8	0.2	3	2	1.8	3.8		<31
12-Oct-09	7.3	1.5	4.4	0	0	0	32E	35E
13-Oct-09	6.4	-0.9	2.8	T	T	T	28E	44E
14-Oct-09	6.1	-2.2	2	0	T	T	35E	39E
15-Oct-09	1.7	-3.9	-1.1	0	T	T	32E	37E
16-Oct-09	4.3	-2.8	0.8	0	0	0		<31
17-Oct-09	4.1	-2.4	0.9	0	0	0		<31
18-Oct-09	3.9	-5.9	-1	0	0	0		<31
19-Oct-09	6.3	-6	0.2	0	0	0		<31
20-Oct-09	3	-5.3	-1.2	0.2	0.4	0.6		<31
21-Oct-09	3.5	0.1	1.8	3.6	0.6	4.2		<31
22-Oct-09	0.1	-5.3	-2.6	0	0.8	0.6		<31
23-Oct-09	2.8	-7.2	-2.2	0	0	0		<31
24-Oct-09	3.5	-5.7	-1.1	0	0	0		<31
25-Oct-09	1.2	-1.8	-0.3	0	25.6	24		<31
26-Oct-09	0.5	-5.7	-2.6	0	1.2	0.8	31E	80E
27-Oct-09	-0.6	-9.2	-4.9	0	0	0	31E	54E
28-Oct-09	-1.2	-10.1	-5.7	0	0	0		<31
29-Oct-09	0.9	-6.5	-2.8	0	0	0		<31
30-Oct-09	3.9	-4.4	-0.3	0	0	0	28E	33E
31-Oct-09	9.6	1.4	5.5	5.4	T	5.4	22E	44E
1-Nov-09	9.6	-0.4	4.6	T	T	T	28E	85E
2-Nov-09	0.5	-9.3	-4.4	0	0	0	31E	39E

Table A-2: Weather data recorded at Churchill Falls, June 1 to November 2, 2009.

Daily Weather Data Report for Churchill Falls: June to November 2009								
	Max°C Temp	Min°C Temp	Mean °C Temp	Total Rain	Total cm Snow	TotalPrecip mm	Dir of Max 10's Deg Gust	Spd of Max km/h Gust
1-Jun-09	8.6	-0.3	4.2	M	M	8.5	1	33
2-Jun-09	3.9	-1.2	1.4	M	M	14.5	29	35
3-Jun-09	M	-1.2E	M	M		M	M	M
4-Jun-09	M	M	M	M	M	M	M	M
5-Jun-09	M	M	M	M	M	M	M	M
6-Jun-09	M	M	M	M	M	M	M	M
7-Jun-09	M	M	M	M	M	M	M	M
8-Jun-09	M	M	M	M	M	M	M	M
9-Jun-09	M	M	M	M	M	M	M	M
10-Jun-09	M	M	M	M	M	M	M	M
11-Jun-09	M	M	M	M	M	M	M	M
12-Jun-09	M	M	M	M	M	M	M	M
13-Jun-09	M	M	M	M	M	M	M	M
14-Jun-09	M	M	M	M	M	M	M	M
15-Jun-09	M	M	M	M	M	M	M	M
16-Jun-09	M	M	M	M	M	M	M	M
17-Jun-09	M	M	M	M	M	M	M	M
18-Jun-09	M	M	M	M	M	M	M	M
19-Jun-09	M	M	M	M	M	M	M	M
20-Jun-09	M	M	M	M	M	M		<31
21-Jun-09	25.7	13.2	19.5	M	M	0		<31
22-Jun-09	24.6	11.7	18.2	M	M	0	29	48
23-Jun-09	25.8	8.7	17.3	M	M	0		<31
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
21-Jul-09	19.1	7.4	13.3	M	M	12.5	32	35
22-Jul-09	21.1	6.3	13.7	M	M	0		<31
23-Jul-09	19.7	8.9	14.3	M	M	0.5		<31
24-Jul-09	23.1	7	15.1	M	M	0		<31
25-Jul-09	24	11.1	17.6	M	M	0		<31
26-Jul-09	24.8	12.9	18.9	M	M	0		<31
27-Jul-09	23.3	11.3	17.3	M	M	6	14	32
28-Jul-09	16.7	12.1	14.4	M	M	1.5		<31
29-Jul-09	20.3	12.4	16.4	M	M	1.5	17	35
30-Jul-09	25.1	13	19.1	M	M	0	25	35
31-Jul-09	23.2	11.1	17.2	M	M	6.5		<31
1-Aug-09	19.5	10	14.8	M	M	7.5	30E	33E
2-Aug-09	23	9.3	16.2	M	M	0.5		<31
3-Aug-09	19.3	13.1	16.2	M	M	16	22	35
4-Aug-09	18.3	12	15.2	M	M	2	19	32
5-Aug-09	21.9	11.1	16.5	M	M	14.5	25	48
6-Aug-09	18.5	10.2	14.4	M	M	3.5	27	39
7-Aug-09	15.4	10.4	12.9	M	M	2.5	29	46
8-Aug-09	16.7	8.2	12.5	M	M	2.5	31	39
9-Aug-09	21.7	9.7	15.7	M	M	1.5	27	41
10-Aug-09	16.6	10.6	13.6	M	M	1.5	31	39
11-Aug-09	16	8.4	12.2	M	M	1	32	33
12-Aug-09	23	7.9	15.5	M	M	0		<31
13-Aug-09	26.9	13.2	20.1	M	M	3.5	25	52
14-Aug-09	21.3	12.4	16.9	M	M	0	31	33
15-Aug-09	18	8.9	13.5	M	M	8	30	41
16-Aug-09	15.3	8.1	11.7	M	M	0	31	39
17-Aug-09	11.6	5.6	8.6	M	M	6	1	35
18-Aug-09	12.5	7.3	9.9	M	M	7	11	37
19-Aug-09	18.4	11.9	15.2	M	M	9		<31
20-Aug-09	16.9	10.4	13.7	M	M	1		<31
21-Aug-09	17	9.8	13.4	M	M	4.5		<31
22-Aug-09	23	8.8	15.9	M	M	11.5	27	48
23-Aug-09	16.2	6.3	11.3	M	M	0	29	35
24-Aug-09	15.1	6.1	10.6	M	M	3	30	48
25-Aug-09	12.6	5.5	9.1	M	M	0	33	39
26-Aug-09	9.4	4.5	7	M	M	30.5	10	44
27-Aug-09	6.7	3	4.9	M	M	5	2	46
28-Aug-09	11.7	3.7	7.7	M	M	0	33	46
29-Aug-09	13.6	1.4	7.5	M	M	0.5		<31
30-Aug-09	12.1	1.2	6.7	M	M	3		<31
31-Aug-09	9.3	3.7	6.5	M	M	4.5		<31
1-Sep-09	16.3	2.8	9.6	M	M	0.5		<31
2-Sep-09	16	7.6	11.8	M	M	14	23	33
3-Sep-09	15	6.5	10.8	M	M	3.5	27E	48E
4-Sep-09	11.1	2.1	6.6	M	M	1.5	30	32
5-Sep-09	10.7	2.2	6.5	M	M	0	30	41
6-Sep-09	15.7	4.4	10.1	M	M	3	25	44
7-Sep-09	12.5	3.8	8.2	M	M	3	33	46
8-Sep-09	9.1	3.9	6.5	M	M	0	32	54
9-Sep-09	11.2	0.6	5.9	M	M	0.5	33	39
10-Sep-09	20.9	0	10.5	M	M	0.5	26	35
11-Sep-09	19.1	5.8	12.5	M	M	0	31	33
12-Sep-09	13.9	3.8	8.9	M	M	0.5		<31
13-Sep-09	4.2	1.4	2.8	M	M	0	8	33
14-Sep-09	2.8	0.8	1.8	M	M	9	36	39
15-Sep-09	6.2	0.3	3.3	M	M	1	36	52
16-Sep-09	8.3	0.3	4.3	M	M	0	26	39
17-Sep-09	17.3	5.2	11.3	M	M	0	22	39
18-Sep-09	8.9	2.9	5.9	M	M	3	31	41
19-Sep-09	7.5	2.5	5	M	M	1	1	46
20-Sep-09	12.1	3.1	7.6	M	M	1.5	27	41
21-Sep-09	22.3	3.8	13.1	M	M	0	24	39
22-Sep-09	18.6	12.3	15.5	M	M	0	23	48
23-Sep-09	13.7	3.6	8.7	M	M	11	35	39
24-Sep-09	3.7	-1.1	1.3	M	M	0.5		<31
25-Sep-09	5.3	-0.5	2.4	M	M	0.5	29	37
26-Sep-09	10.4	2.5	6.5	M	M	0.5	25	35
27-Sep-09	16	8.2	12.1	M	M	0		<31
28-Sep-09	13.9	8.4	11.2	M	M	3.5		<31
29-Sep-09	11.9	8.2	10.1	M	M	7.5	1	44
30-Sep-09	14.2	4.1	9.2	M	M	4.5	21	35
1-Oct-09	9.7	2.6	6.2	M	M	4.5	7	48
2-Oct-09	4	1.6	2.8	M	M	0	7	46
3-Oct-09	8.5	-1.7	3.4	M	M	0		<31
4-Oct-09	10.1	-3.8	3.2	M	M	1.5		<31
5-Oct-09	4.8	1.4	3.1	M	M	3.5	12	32
6-Oct-09	2.6	0.8	1.7	M	M	5.5	7	33
7-Oct-09	4.7	1.7	3.2	M	M	0.5	7	41
8-Oct-09	4.4	0.6	2.5	M	M	0	8	32
9-Oct-09	3.7	0.1	1.9	M	M	1.5		<31
10-Oct-09	8.1	-0.4	3.9	M	M	0.5		<31
11-Oct-09	5.4	-0.8	2.3	M	M	1		<31
12-Oct-09	5.1	0.1	2.6	M	M	2.5	32	41
13-Oct-09	4	-2.2	0.9	M	M	0	29	44
14-Oct-09	2.2	-2.4	-0.1	M	M	2	29E	39E
15-Oct-09	-1.2	-4.7	-3	M	M	1	34	46
16-Oct-09	1.2	-6.9	-2.9	M	M	0.5		<31
17-Oct-09	-1.1	-3.5	-2.3	M	M	0		<31
18-Oct-09	-0.5	-6.4	-3.5	M	M	0		<31
19-Oct-09	4.8	-7.4	-1.3	M	M	0.5		<31
20-Oct-09	0.9	-2.1	-0.6	M	M	2		<31
21-Oct-09	1.5	-7.2	-2.9	M	M	1	32	39
22-Oct-09	-3.2	-7.3	-5.3	M	M	0	30	32
23-Oct-09	1.4	-6.7	-2.7	M	M	0		<31
24-Oct-09	1.2	-5.4	-2.1	M	M	1	12	35
25-Oct-09	0.8	-3.1	-1.2	M	M	8	12	37
26-Oct-09	0.4	-8.5	-4.1	M	M	1	33	67
27-Oct-09	-5.5	-9.9	-7.7	M	M	M		<31
28-Oct-09	-6	-15.4	-10.7	M	M	0		<31
29-Oct-09	0.3	-14.8	-7.3	M	M	0		<31
30-Oct-09	2.7	-3	-0.2	M	M	0		<31
31-Oct-09	8.4	0.6	4.5	M	M	5	2	59
1-Nov-09	5.7	-4.8	0.5	M	M	0	28	78
2-Nov-09	-1.8	-7.8	-4.8	M	M	0	29	44

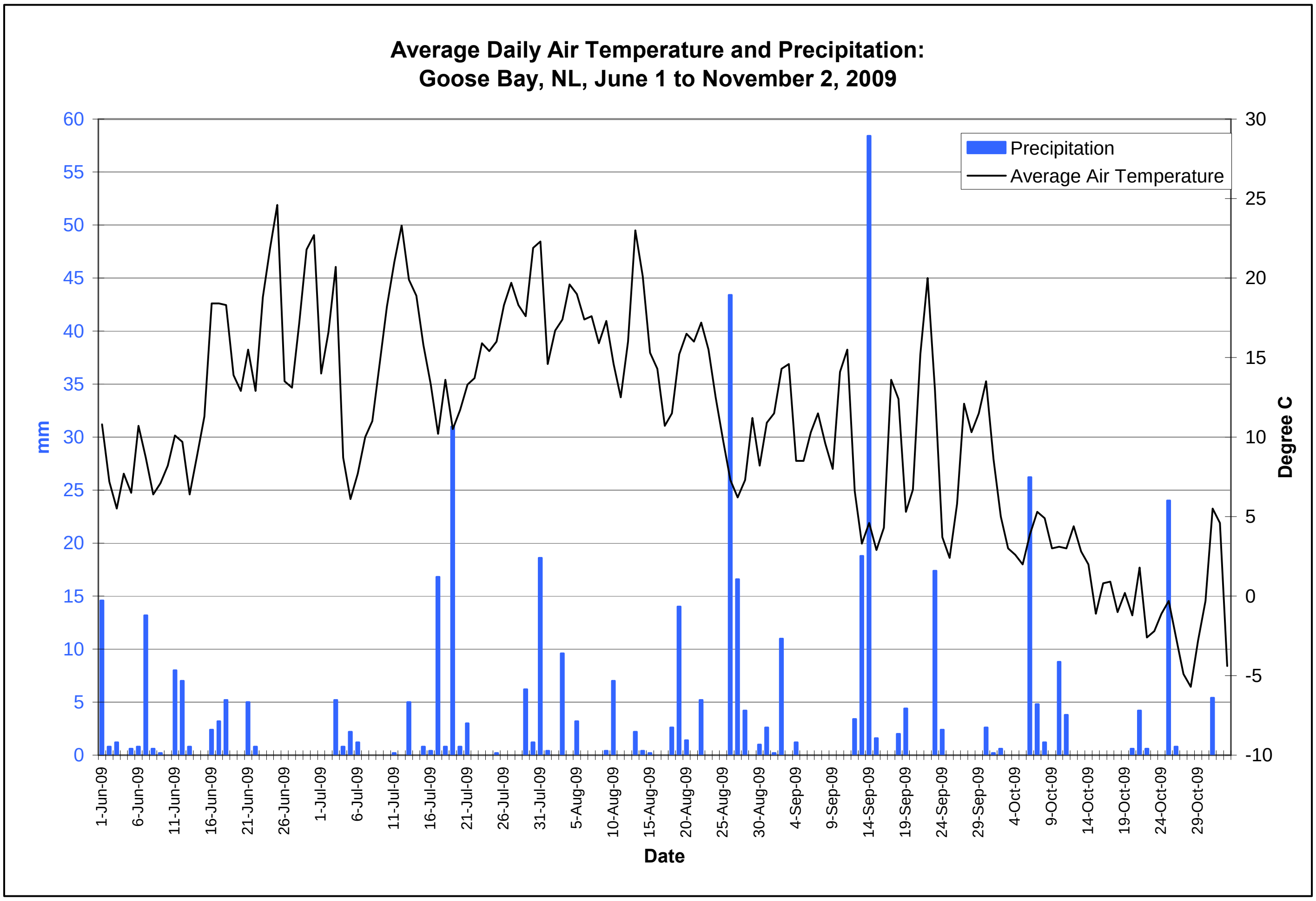

Figure A-1: Mean daily temperature and daily precipitation totals for Goose Bay, June 1 to November 2, 2009.

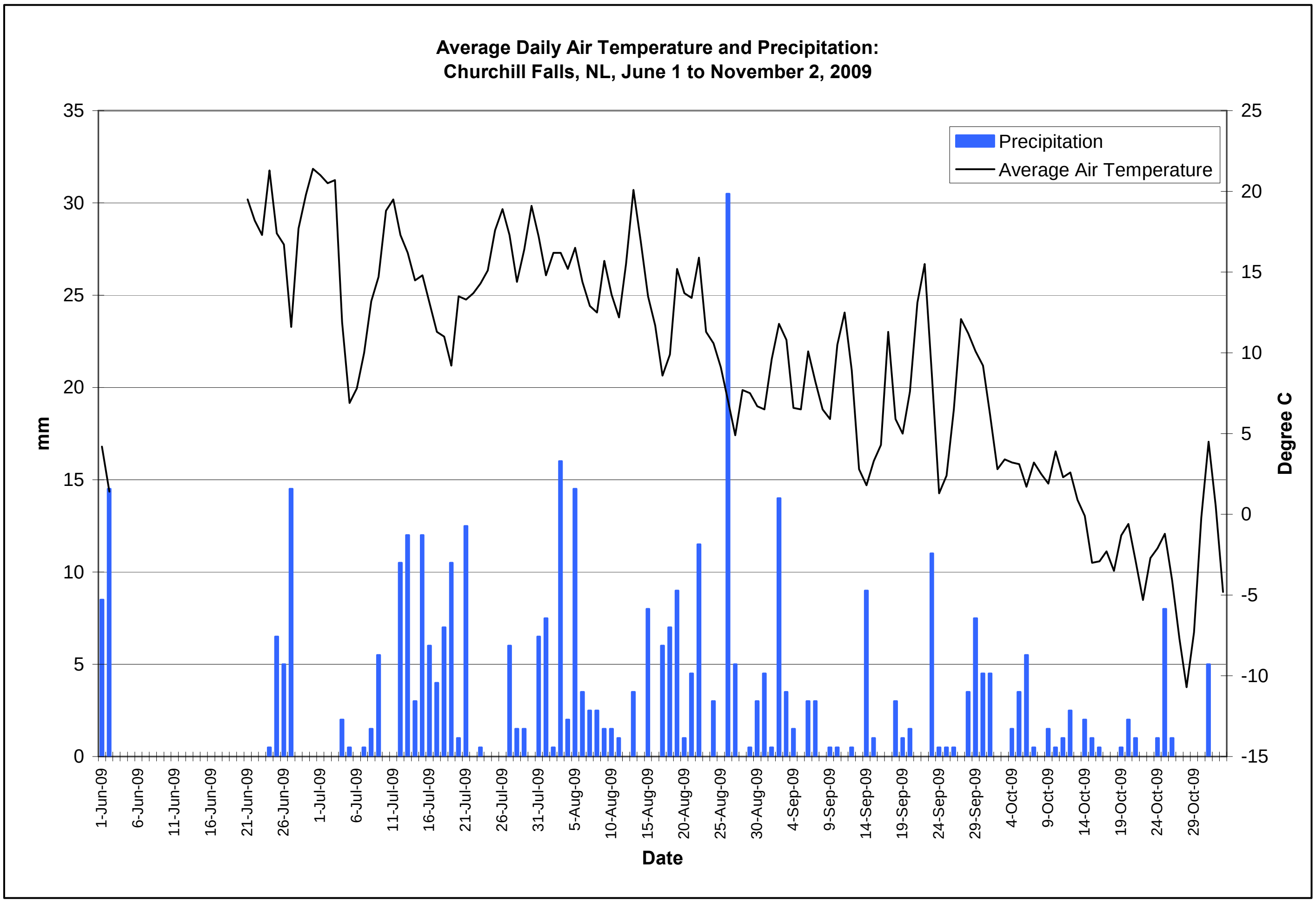

Figure A-2: Mean daily temperature and daily precipitation totals for Churchill Falls, June 1 to November 2, 2009.