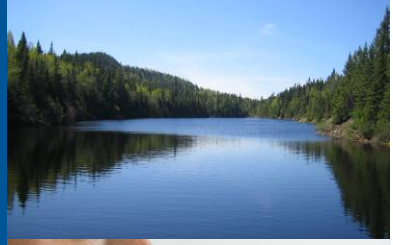




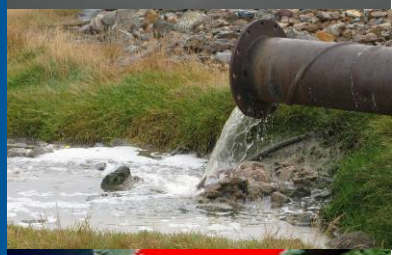


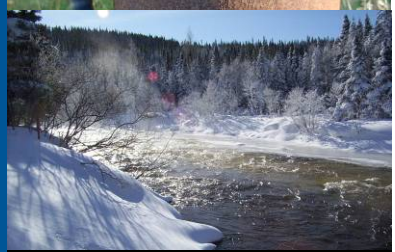

Real Time Water Quality Report

Tata Steel Minerals Canada

Elross Lake Network

Deployment Period
2016-08-04 to 2015-09-02

Government of Newfoundland & Labrador
Department of Environment and Conservation
Water Resources Management Division
St. John's, NL, A1B 4J6 Canada

Prepared by:

Ian Bell
Environmental Scientist

Department of Environment & Conservation
Water Resources Management Division
PO Box 2006, Corner Brook, NL, A2H 6J8

t. 709.637.2431
f. 709.637.2541
e. ianbell@gov.nl.ca

General

- During the 2015 field season the Water Resources Management Division, in partnership with Tata Steel Minerals Canada Limited and Environment Canada, maintained two real-time water quality and water quantity stations in close proximity to the Elross Lake Iron Ore Mine in western Labrador, near Schefferville, QC.
- The official name of each station is ELROSS CREEK BELOW PINETTE LAKE INFLOW and GOODREAM CREEK 2KM NORTHWEST OF TIMMINS 6, hereafter referred to as the *Elross Creek Station* and the *Goodream Creek Station*, respectively.
- Station sites were selected to monitor all surface water outflows from the Elross Lake mining site. The Elross Creek Station is situated downstream of the Timmins 1 pit, and downstream of Pinette Lake. The Goodream Creek Station will serve to monitor potential impacts from groundwater flowing from Timmins 6 pit into the surface water of Goodream Creek.
- The Water Resources Management Division will inform Tata Steel Minerals Canada Limited of any significant water quality events by email notification and by monthly deployment reports.
- This monthly deployment report, presents water quality and water quantity data recorded at the Elross Creek and Goodream Creek stations from August 4, 2015 to September 2, 2015, which was the third deployment period for the 2015 field season.

Quality Assurance / Quality Control

- Water quality instrument performance is tested at the beginning and end of its deployment period. The process is outlined in Appendix A.
- Instruments are assigned a performance rating (i.e., poor, marginal, fair, good or excellent) for each water quality parameter measured.
- Table 1 shows the performance ratings of five water quality parameters (i.e., temperature, pH, specific conductivity, dissolved oxygen and turbidity) measured by instruments deployed at the water monitoring stations.
- **With the exception of water quantity data (stage height), all data used in the preparation of the graphs and subsequent discussion below adhere to this stringent QA/QC protocol. The stage data is raw data that is transmitted via satellite and published on our web page. It has not been corrected for backwater effect. Water Survey of Canada is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request**.

Table 1: Water quality instrument performance at the beginning and end of deployment

	Elross Creek			Goodream Creek	
Stage of deployment	Beginning	End		Beginning	End
Date	2015-08-05	2015-09-01		2015-08-04	2015-09-02
Temperature	Excellent	Excellent		Excellent	Good
pH	Excellent	Good		Excellent	Good
Specific Conductivity	Excellent	Excellent		Excellent	Excellent
Dissolved Oxygen	Excellent	Excellent		Excellent	Excellent
Turbidity	Good	Good		Excellent	Excellent

- The performance of all sensors at both Elross and Goodream Creeks were within acceptable limits during this deployment period (Table 1).

Deployment Notes

- Water quality monitoring for this deployment period season started at Goodream Creek on August 4th, 2015 and at Elross Creek on August 5th, 2015. Continuous real-time monitoring continued at both sites without any significant operational issues until September 1st , 2015 at Elross Creek and September 2nd, 2015 at Goodream Creek, when the instruments were removed for maintenance and calibration.

Data Interpretation

- Data records were interpreted for each station during the deployment period for the following six parameters:

  (i.) Stage (m)
  (ii.) Temperature (°C)
  (iii.) pH
  (iv.) Specific conductivity (□S/cm)
  (v.) Dissolved oxygen (mg/l)
  (vi.) Turbidity (NTU)

Stage

- During the deployment periods covered by this report, stage height values ranged from 1.08 m to 1.18 m at Elross Creek and from 1.77 m to 1.98 m at Goodream Creek (Figures 1 and 2). Stage height is directly related to the volume of flow in a stream, as defined by a rating curve which is unique for every site.

- For both Elross Creek and Goodream Creek the stage height is typical for the summer season, when hydrological conditions are affected by rainfall events which cause spikes that are relatively short lived. The deployment starts with a spike in stage height (See inside red ovals) which is related to significant rainfall for the Schefferville area from August 3rd to August 5th. (Climate data located in Appendix B). For the remainder of the deployment there are several lesser spikes which are related to additional rainfall events.
- During this deployment period stage height at Goodream Creek dipped down to a critically low level from about August 24th to August 28th (See inside green oval). This low flow condition at Goodream Creek is a natural occurrence during the summer months and when it occurs it impacts several of the water quality parameters being monitored. Low flow can affect water quality and have an impact on indicator parameters such as pH, dissolved oxygen, and specific conductivity, tending to push them outside their normal range.

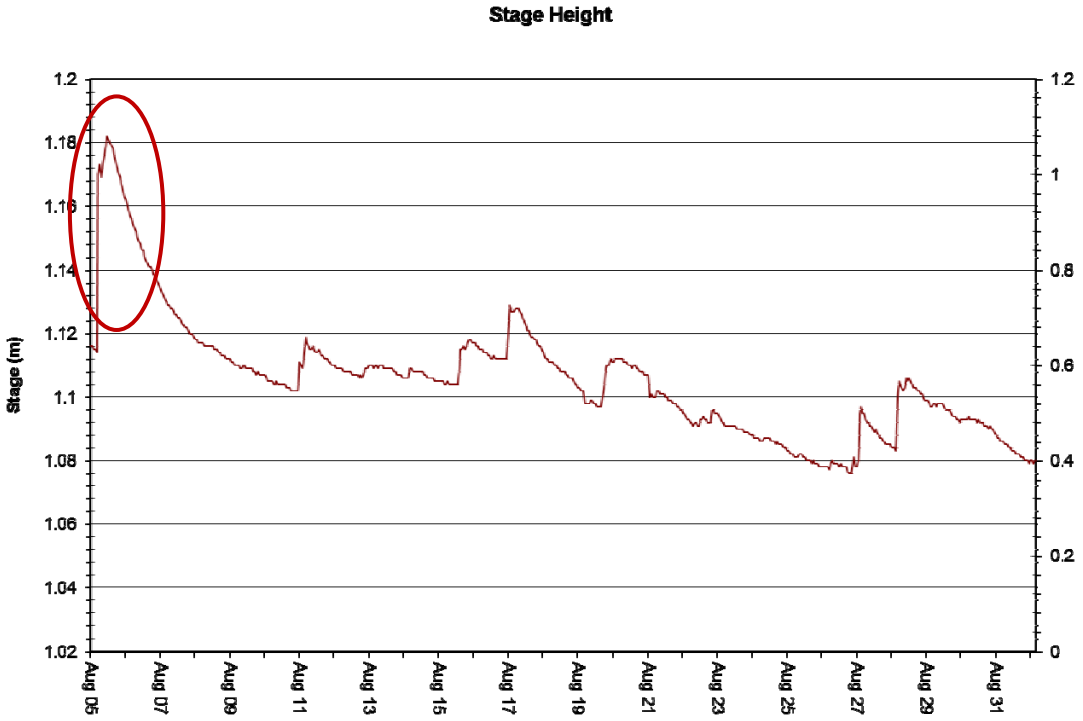

Figure 1: Stage Height (m) at Elross Creek –August 5, 2015 to September 1, 2015

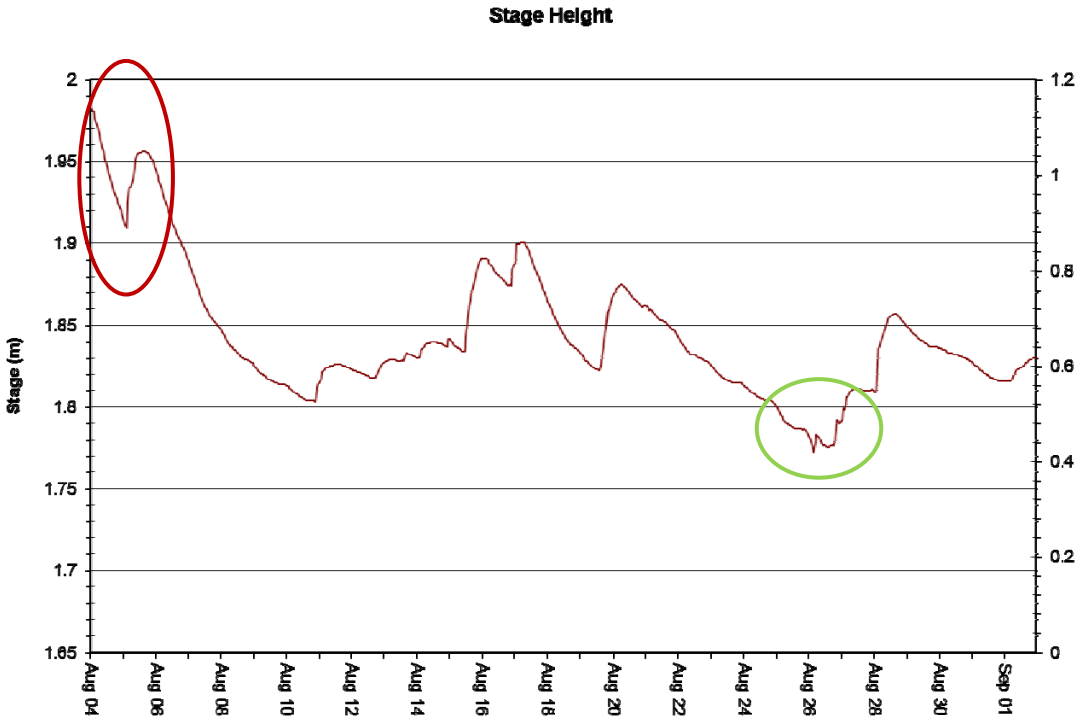

Figure 2: Stage Height (m) at Goodream Creek – August 4, 2015 to September 2, 2015

Temperature

- During the deployment periods covered by this report, water temperature ranged from 7.50˚C to 15.80˚C at Elross Creek and from 5.50˚C to 18.10˚C at Goodream Creek (Figures 3 & 4).
- Both Goodream and Elross stations display noticeable diurnal variations, typical of shallow water streams and ponds that are highly influenced by diurnal variations in ambient air temperatures.
- For both Elross and Goodream Creeks the temperature is relatively stable for the first three weeks of the deployment and then begins to decrease over the last week of the deployment as the summer season came to an end.

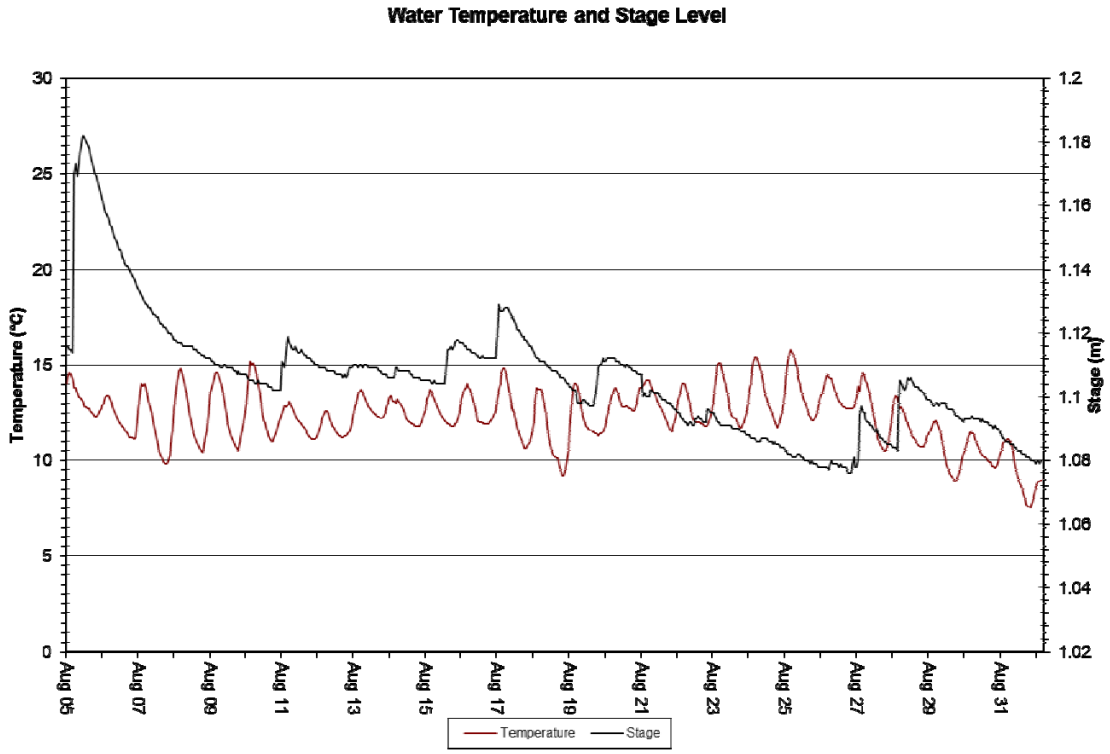

Figure 3: Temperature (°C) - Elross Creek – August 5, 2015 to September 1, 2015

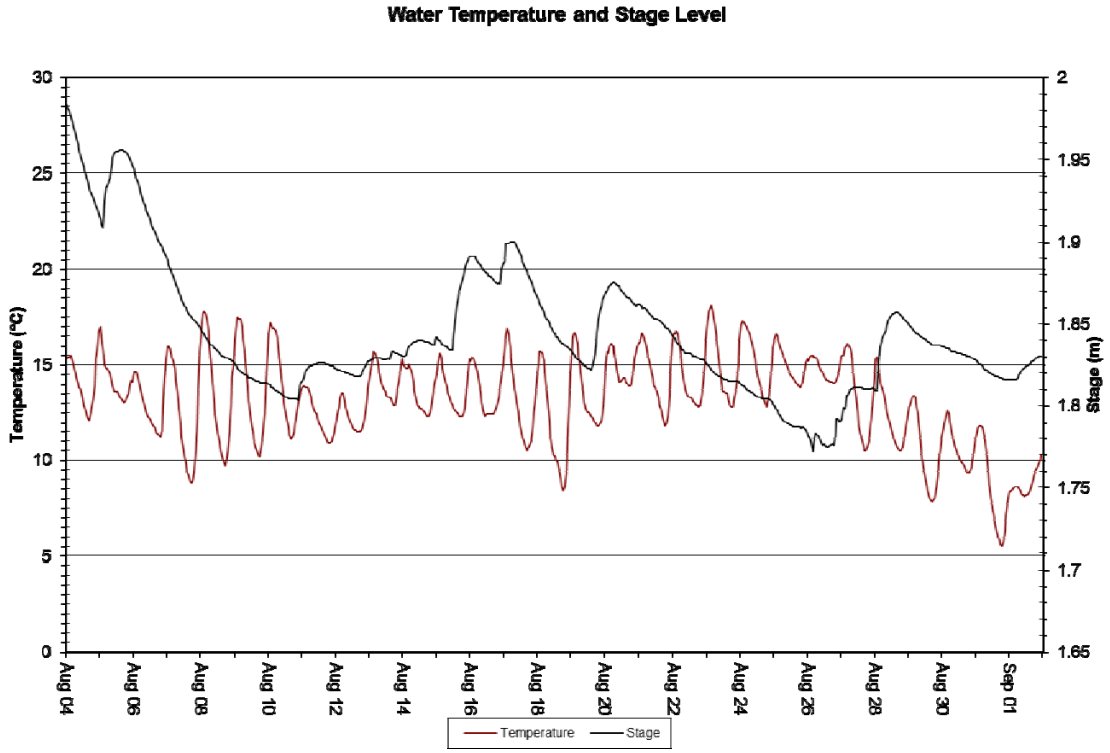

Figure 4: Temperature (°C) - Goodream Creek - August 4, 2015 to September 2, 2015

pH

- During the deployment periods covered by this report, pH values ranged from 6.23 units to 6.81 units at Elross Creek, and from 5.44 units to 6.46 units at Goodream Creek (Figures 5 & 6).
- pH tends to show a diurnal trend which is related to the diurnal temperature trend. This diurnal trend is fairly weak during this deployment period and difficult to see at Goodream Creek; however it is visible at Elross Creek.
- At Goodream Creek it appears that pH was affected by low flow conditions (see inside green oval) from about August 24th to August 28th. During low flow conditions it appears that pH was lower and more variable than normal.
- With a median value of 6.52, pH at Elross Creek is very close to the minimum guideline set for the protection of aquatic life (i.e., 6.5 units), as defined by the Canadian Council of Ministers of the Environment (CCME) (2007). At Goodream Creek pH is slightly below this guideline. It should be noted that acidic waters are quite common in Canada, particularly in boreal and northern ecoregions, and pH is often naturally below this 6.5 unit guideline.

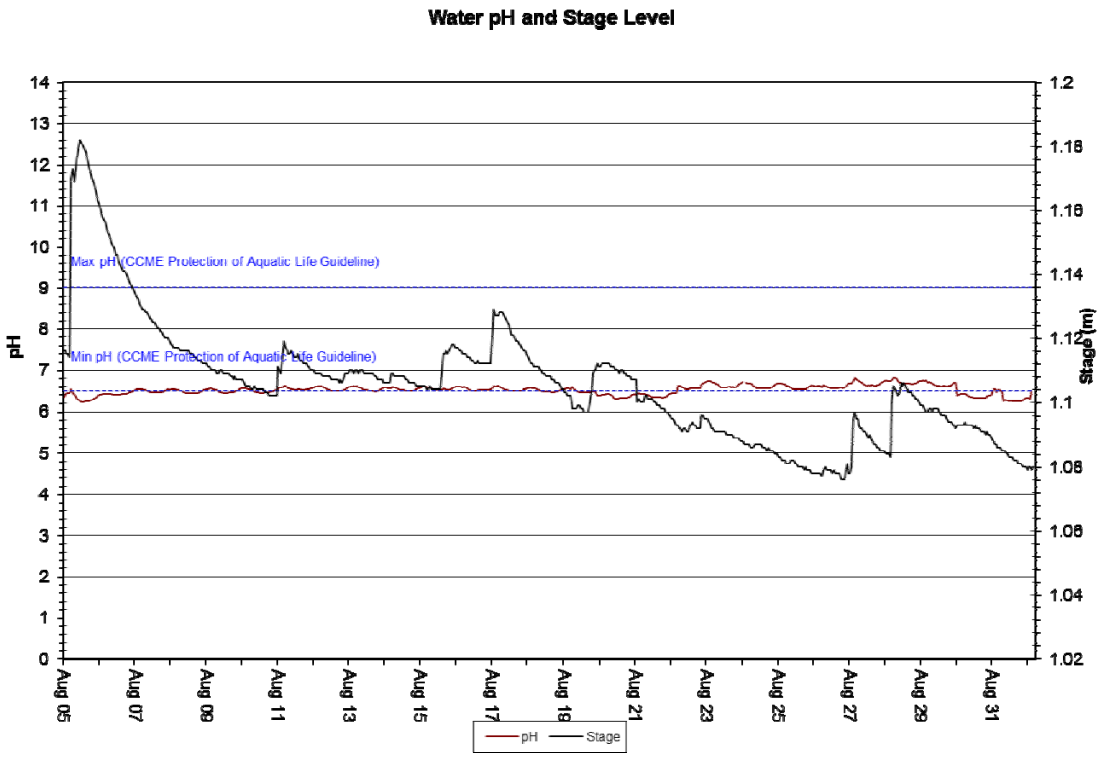

Figure 5: pH at Elross Creek – August 5, 2015 to September 1, 2015

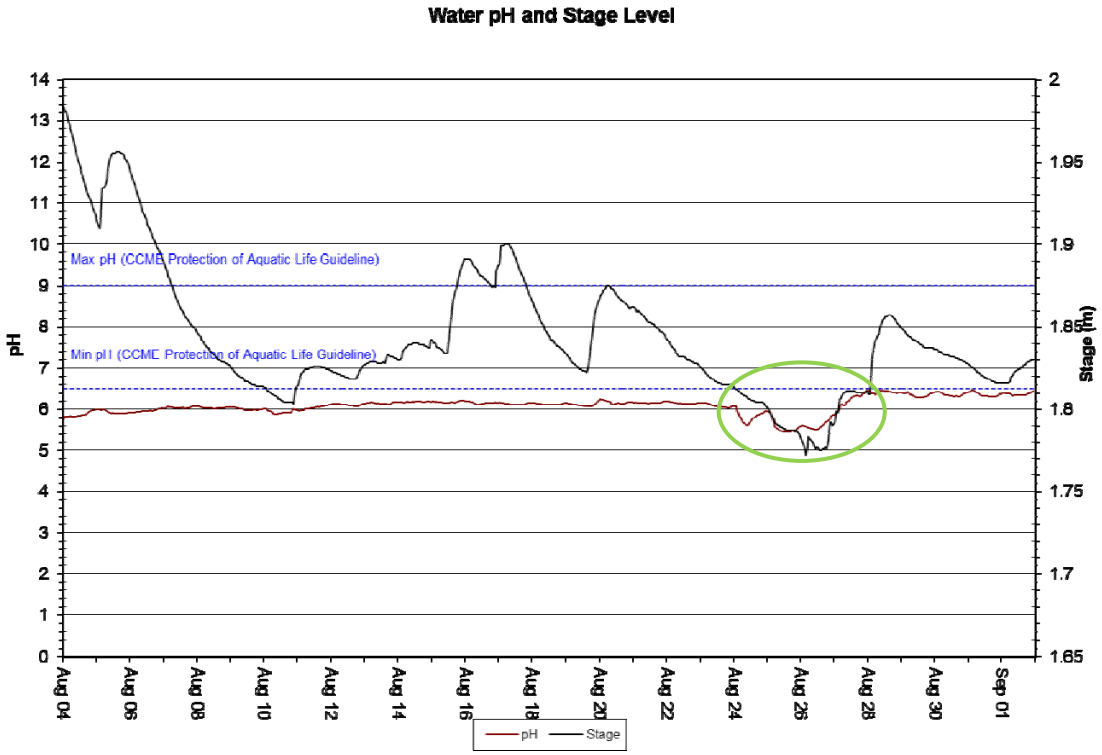

Figure 6: pH at Goodream Creek – August 4, 2015 to September 2, 2015

Specific Conductivity

- During the deployment periods covered by this report, specific conductivity ranged from 9.8 µs/cm to 15.2 µs/cm at Elross and 3.8 µs/cm to 8.4 µs/cm at Goodream Creek (Figures 7 & 8).
- At both Elross and Goodream creeks, specific conductivity shows diurnal trends which are related to the diurnal temperature trend.
- At Goodream Creek specific conductivity was impacted by low flow conditions (see inside green oval). It appears that during low flow conditions from about August 24th to August 28th specific conductivity was slightly elevated and also tended to be more variable than usual.

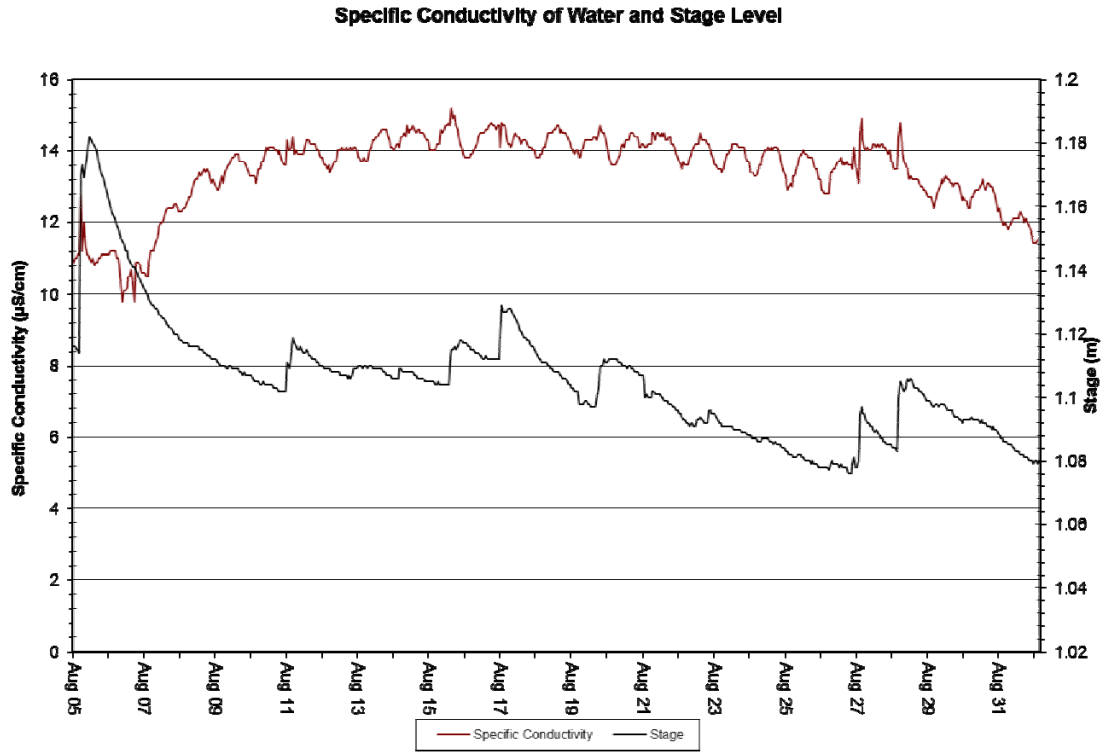

Figure 7: Specific conductivity (us/cm) - Elross Creek – August 5, 2015 to Sept. 1, 2015

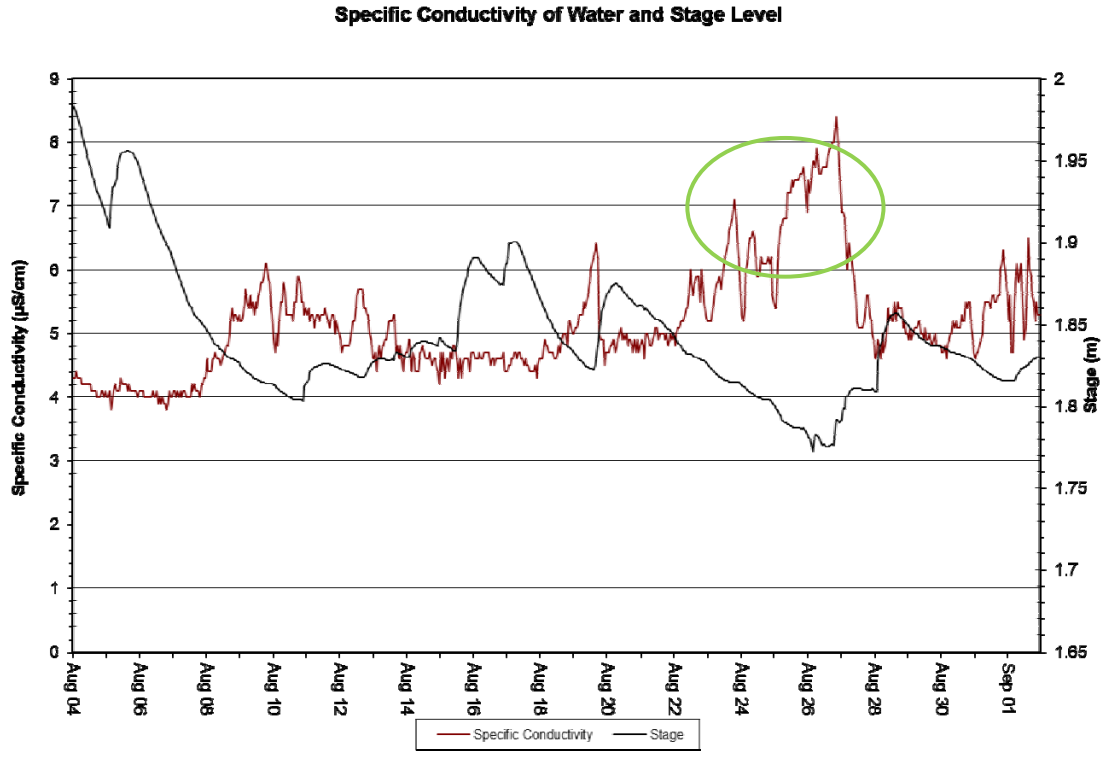

Figure 8: Specific conductivity (us/cm) - Goodream Creek – August 4, 2015 to Sept. 2, 2015

Dissolved Oxygen

- During the deployment periods covered by this report, dissolved oxygen (DO) values ranged from 8.15 mg/l (82.4% saturation) to 9.99 mg/l (94.2% saturation) at Elross Creek (Figure 9). At Goodream Creek DO values were significantly impacted by low flow conditions and ranged from 1.25 mg/l (12.9% saturation) to 10.47 mg/l (100.8% saturation) (Figure 10).
- DO was relatively stable over the deployment period for Elross Creek. At Goodream Creek DO was stable for most of the deployment period, however the impacts of low flow conditions pushed DO levels down well below normal on two occasions. On August 10th DO was affected briefly by low flow conditions (See inside red oval) and from approximately August 24th to August 28th low flow conditions had a significant impact on DO values (see inside green oval). Low flow leads to reduced turbulent flow, which is the most significant pathway for the input of oxygen into water.
- At both sites there are obvious diurnal trends in DO which are related to diurnal temperature trends.
- The DO values at Elross Creek were at, or slightly below, the minimum guideline set for cold-water biota during early life stages (9.5 mg/l), and above minimum guidelines set for other life stages (6.5 mg/l), as determined by the Canadian Council of Ministers of the Environment (2007). The same is true at Goodream Creek, with the exception of the period of extreme low flow.

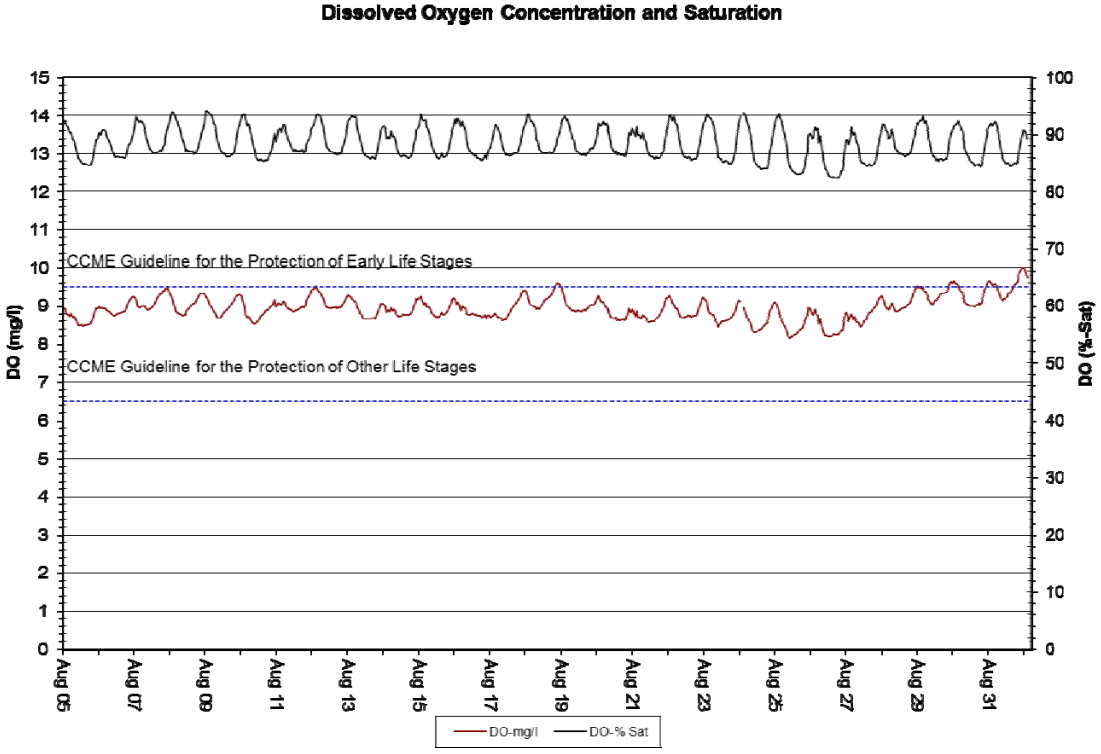

Figure 9: DO (mg/l & % saturation) at Elross Creek – August 5, 2015 to September 1, 2015

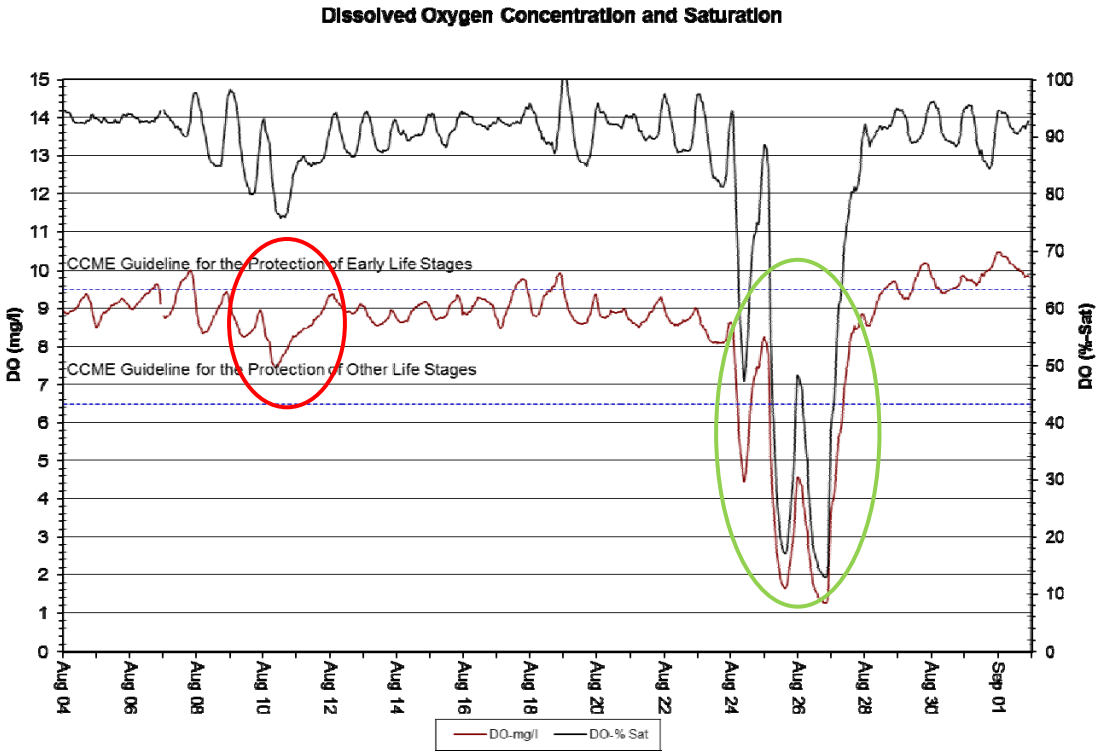

Figure 10: DO (mg/l & % saturation) at Goodream Creek – August 4, 2015 to Sept. 2, 2015

Turbidity

- During the deployment periods covered by this report, turbidity values ranged from 3.1 NTU to 2462.0 NTU at Elross Creek (Figure 11) and from 0.0 NTU to 0.4 NTU at Goodream Creek (Figure 12). In order to give a better indication of background turbidity levels at Elross Creek, Figure 13 shows only the turbidity data which was less than 100 NTU. This required removing 4 datum from the August dataset.
- The turbidity levels at Goodream Creek are typically much lower than Elross Creek and are indicative of natural background water quality in the general area. At Goodream Creek spikes in turbidity due to significant runoff events tend to be relatively small and short term.
- At Elross Creek water quality is impacted by ground disturbance, erosion and sedimentation in relation to historical mining activity in the area. As a result, background turbidity levels are higher than normal background levels for the general area (see Figure 13) and therefore the impacts of significant runoff events are more pronounced. During this deployment period peak turbidity levels at Elross Creek are well correlated with peak flows (see inside red ovals – Figures 11 & 13).

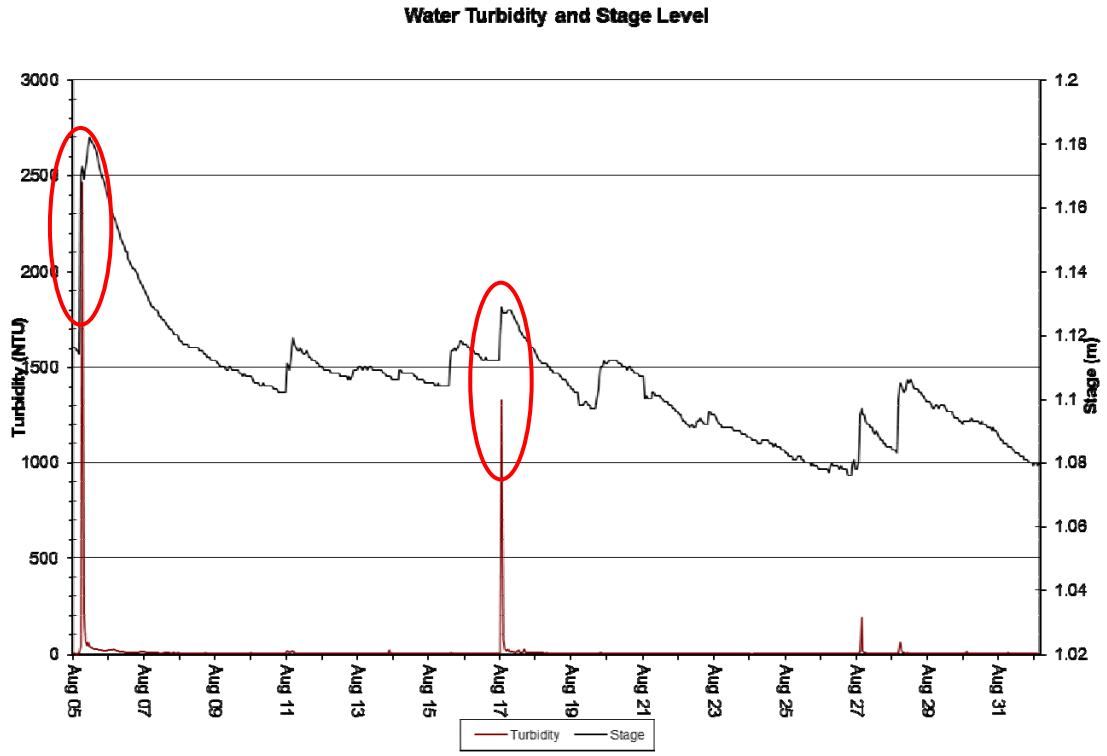

Figure 11: Turbidity (NTU) at Elross Creek – August 5, 2015 to September 1, 2015

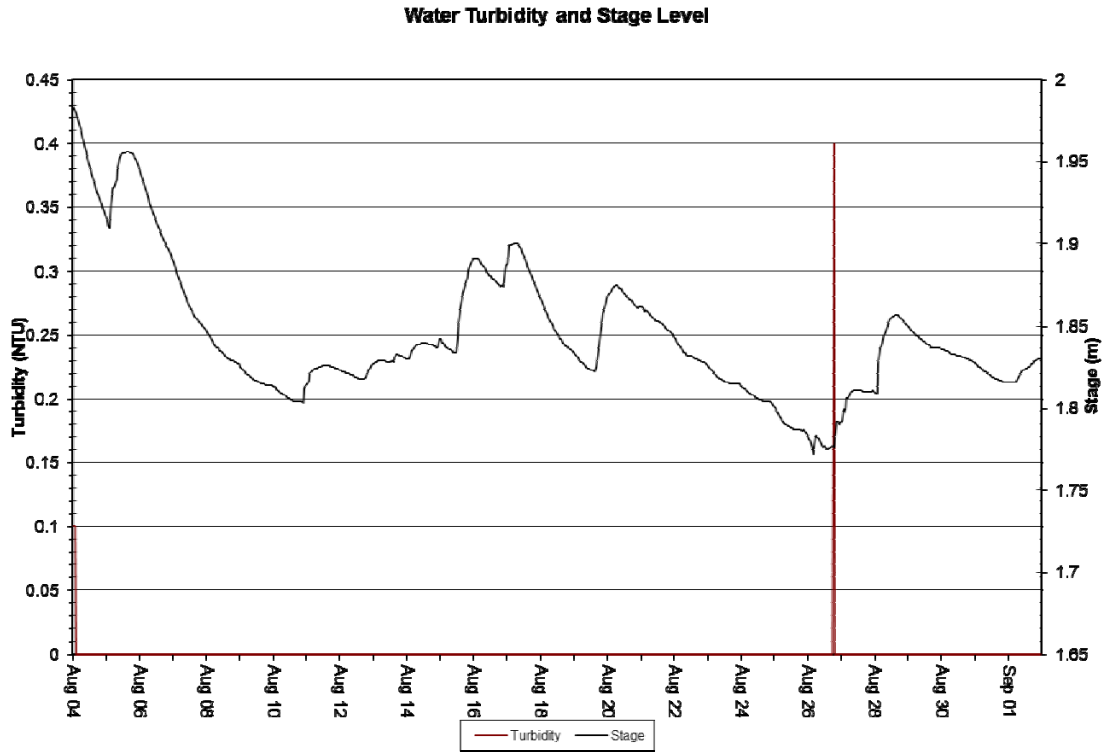

Figure 12: Turbidity (NTU) at Goodream Creek – August 4, 2015 to September 2, 2015

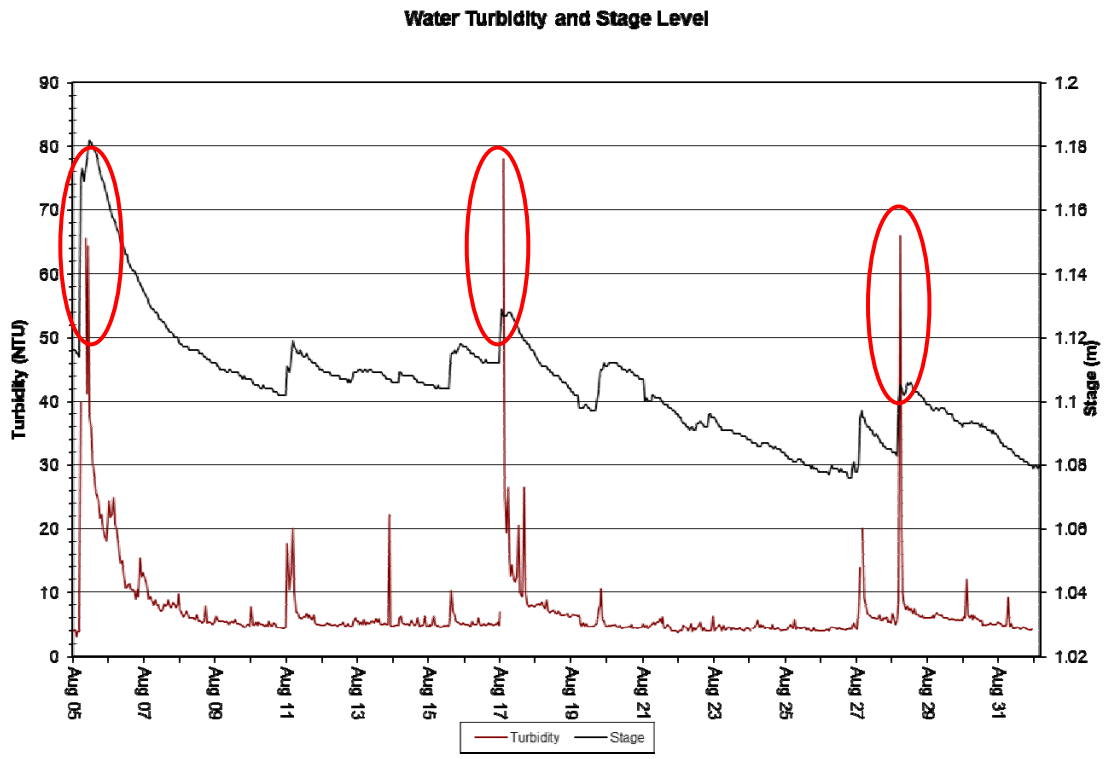

Figure 13: Turbidity (NTU<100)) at Elross Creek – August 5, 2015 to September 1, 2015

Conclusions

- This monthly deployment report, presents water quality and water quantity data recorded at the Elross Creek and Goodream Creek stations from August 4, 2015 to September 2, 2015.
- Field instruments for both stations performed well over the deployment period with no significant maintenance issues.
- Variations in water quality/quantity values recorded at each station are summarized below:
    - For both Elross Creek and Goodream Creek the stage height is typical for the summer season, when hydrological conditions are affected by rainfall events which cause spikes in flow that are relatively short lived. At Goodream Creek there was a brief period of extreme low flow which impacted general water quality.
    - For both Elross and Goodream Creeks the temperature is relatively stable for the first three weeks of the deployment and then begins to decrease over the last week of the deployment as the summer season came to an end.
    - During the deployment periods covered by this report, pH values ranged from 6.23 units to 6.81 units at Elross Creek, and from 5.44 units to 6.46 units at Goodream Creek.

- During the deployment periods covered by this report, specific conductivity ranged from 9.8 µs/cm to 15.2 µs/cm at Elross and 3.8 µs/cm to 8.4 µs/cm at Goodream Creek
- During the deployment periods covered by this report, dissolved oxygen (DO) values ranged from 8.15 mg/l (82.4% saturation) to 9.99 mg/l (94.2% saturation) at Elross Creek. At Goodream Creek DO values were significantly impacted by low flow conditions and ranged from 1.25 mg/l (12.9% saturation) to 10.47 mg/l (100.8% saturation).
- During the deployment periods covered by this report, turbidity values ranged from 3.1 NTU to 2462.0 NTU at Elross Creek and from 0.0 NTU to 0.4 NTU at Goodream Creek.

References

Canadian Council of Ministers of the Environment. 2007. Canadian water quality guidelines for the protection of aquatic life: Summary table. Updated December, 2007. In: Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg. (Website: http://ceqg-rcqe.ccme.ca/download/en/222/)

APPENDIX A
Quality Assurance / Quality Control Procedures

As part of the Quality Assurance / Quality Control (QA/QC) protocol, the performance of a station's water quality instrument (i.e., Field Sonde) is rated at the beginning and end of its deployment period. The procedure is based on the approach used by the United States Geological Survey (Wagner *et al.* 2006)[1].

At the beginning of the deployment period, a fully cleaned and calibrated QA/QC water quality instrument (i.e., QA/QC Sonde) is placed *in-situ* with the fully cleaned and calibrated Field Sonde. After Sonde readings have stabilized, which may take up to five minutes in some cases, water quality parameters, as measured by both Sondes, are recorded to a field sheet. Field Sonde performance for all parameters is rated based on differences recorded by the Field Sonde and QA/QC Sonde. If the readings from both Sondes are in close agreement, the QA/QC Sonde can be removed from the water. If the readings are not in close agreement, there will be attempts to reconcile the problem on site (e.g., removing air bubbles from sensors, etc.). If no fix is made, the Field Sonde may be removed for recalibration.

At the end of the deployment period, a fully cleaned and calibrated QA/QC Sonde is once again deployed *in-situ* with the Field Sonde, which has already been deployment for 30-40 days. After Sonde readings have stabilized, water quality parameters, as measured by both Sondes, are recorded to a field sheet. Field Sonde performance for all parameters is rated based on differences recorded by the Field Sonde and QA/QC Sonde.

Performance ratings are based on differences listed in the table below.

	Rating				
Parameter	**Excellent**	**Good**	**Fair**	**Marginal**	**Poor**
Temperature (^{o}C)	≤ ±0.2	> ±0.2 to 0.5	> ±0.5 to 0.8	> ±0.8 to 1	> ±1
pH (unit)	≤ ±0.2	> ±0.2 to 0.5	> ±0.5 to 0.8	> ±0.8 to 1	> ±1
Sp. Conductance (µS/cm)	≤ ±3	> ±3 to 10	> ±10 to 15	> ±15 to 20	> ±20
Sp. Conductance > 35 µS/cm (%)	≤ ±3	> ±3 to 10	> ±10 to 15	> ±15 to 20	> ±20
Dissolved Oxygen (mg/l) (% Sat)	≤ ±0.3	> ±0.3 to 0.5	> ±0.5 to 0.8	> ±0.8 to 1	> ±1
Turbidity <40 NTU (NTU)	≤ ±2	> ±2 to 5	> ±5 to 8	> ±8 to 10	> ±10
Turbidity > 40 NTU (%)	≤ ±5	> ±5 to 10	> ±10 to 15	> ±15 to 20	> ±20

[1] Wagner, R.J., Boulger, R.W., Jr., Oblinger, C.J., and Smith, B.A., 2006, Guidelines and standard procedures for continuous water-quality monitors—Station operation, record computation, and data reporting: U.S. Geological Survey Techniques and Methods 1–D3, 51 p. + 8 attachments; accessed April 10, 2006, at *http://pubs.water.usgs.gov/tm1d3*

APENDIX B

Environment Canada Weather Data – Schefferville (August 5, 2015 to September 1, 2015)

Date/Time	Max Temp (°C)	Min Temp (°C)	Mean Temp (°C)	Heat Deg Days (°C)	Cool Deg Days (°C)	Total Precip (mm)
8/3/2015	20.8	11.6	16.2	1.8	0	16.5
8/4/2015	21.8	12.1	17	1	0	2.4
8/5/2015	21.2	10.7	16	2	0	15
8/6/2015	14.3	8.9	11.6	6.4	0	0.2
8/7/2015	15.6	6.2	10.9	7.1	0	0
8/8/2015	21.4	5.7	13.6	4.4	0	0
8/9/2015	23.2	7.1	15.2	2.8	0	0
8/10/2015	24.4	9.2	16.8	1.2	0	0
8/11/2015	18.1	10	14.1	3.9	0	10.9
8/12/2015	12.4	7.9	10.2	7.8	0	0
8/13/2015	16.8	10.7	13.8	4.2	0	3.4
8/14/2015	18.4	12.6	15.5	2.5	0	1.3
8/15/2015	17.3	12.1	14.7	3.3	0	2.2
8/16/2015	18.2	11.7	15	3	0	4.2
8/17/2015	23.4	7	15.2	2.8	0	0.2
8/18/2015	17.8	6.5	12.2	5.8	0	0
8/19/2015	20.6	5.8	13.2	4.8	0	0
8/20/2015	23.5	11.5	17.5	0.5	0	12.7
8/21/2015	22.4	12.9	17.7	0.3	0	0
8/22/2015	19.3	10.9	15.1	2.9	0	3.7
8/23/2015	22.2	11.9	17.1	0.9	0	0
8/24/2015	24.9	12.5	18.7	0	0.7	0
8/25/2015	25.2	13.6	19.4	0	1.4	0
8/26/2015	21.2	13.8	17.5	0.5	0	4.9
8/27/2015	19	8.6	13.8	4.2	0	3.3
8/28/2015	17.9	6.8	12.4	5.6	0	1.5
8/29/2015	12.7	5.5	9.1	8.9	0	0
8/30/2015	14.1	6.6	10.4	7.6	0	1.6
8/31/2015	11.1	1.6	6.4	11.6	0	0
9/1/2015	9.4	1.1	5.3	12.7	0	1.6
9/2/2015	13.8	1.8	7.8	10.2	0	0.3