Real Time Water Quality Report

Tata Steel Minerals Canada
Elross Lake Network

Deployment Period
2015-07-08 to 2015-08-05

Government of Newfoundland & Labrador
Department of Environment and Conservation
Water Resources Management Division
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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 July 8, 2015 to August 5, 2015, which was the second 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	2015-07-08	2015-08-05		2015-07-09	2015-08-04
Temperature	Excellent	Excellent		Excellent	Good
pH	Good	Good		Excellent	Excellent
Specific Conductivity	Excellent	Good		Excellent	Good
Dissolved Oxygen	Good	Good		Fair	Excellent
Turbidity	Excellent	Excellent		Good	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 Elross Creek on July 8, 2015 and at Goodream Creek on July 9, 2015. Continuous real-time monitoring continued at both sites without any significant operational issues until August 4, 2015 at Goodream Creek and August 5, 2015 at Elross 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 (ºC)
  (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 1.27 m at Elross Creek and from 1.79 m to 2.00 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 in stage height that are relatively short lived. (Climate data located in Appendix B).
- For both Elross and Goodream Creeks the deployment starts with a large spike in stage height which is related to significant rainfall for the Schefferville area over several days immediately preceding this deployment period (See inside red ovals).
- Over the course of the deployment period there are a series of three distinct spikes in stage height for both Elross and Goodream Creeks, which are related to significant rainfall levels on July 14th and 31st, as well as August 3rd (See inside orange ovals).
- During the deployment period stage height at Goodream Creek dipped down to a critically low level on July 30th and 31st (See inside green oval). This low flow condition 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 have a significant effect on water quality, impacting indicator parameters such as pH, dissolved oxygen, and specific conductivity, and tending to push them outside their normal range.

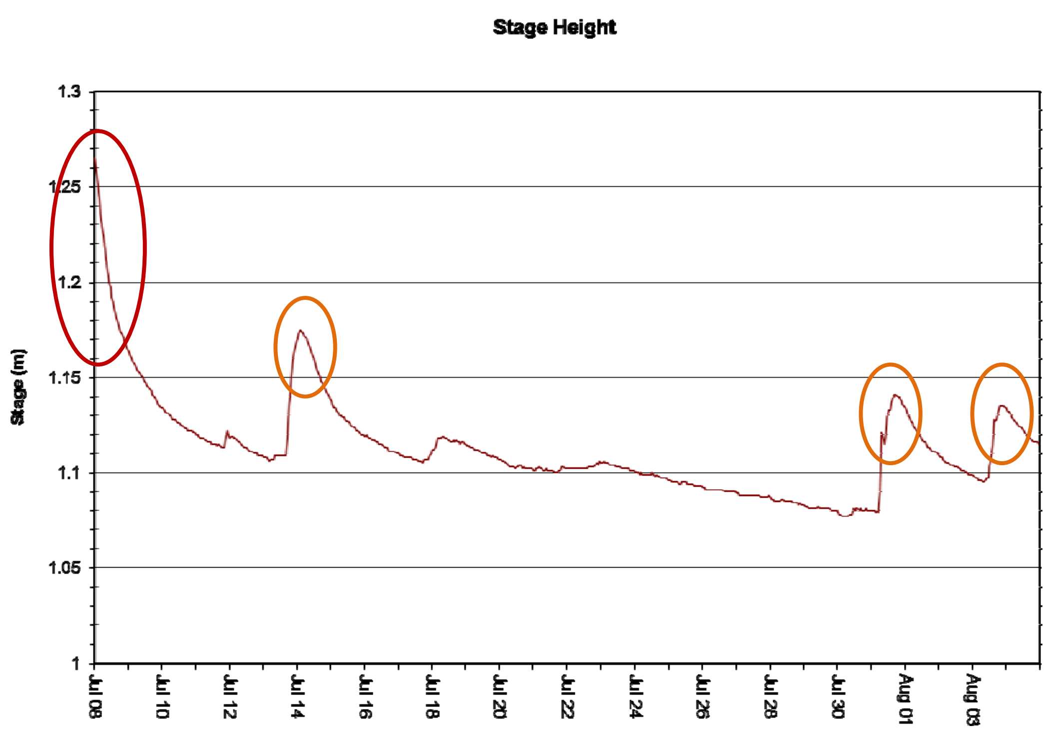

Figure 1: Stage Height (m) at Elross Creek –July 8, 2015 to August 5, 2015

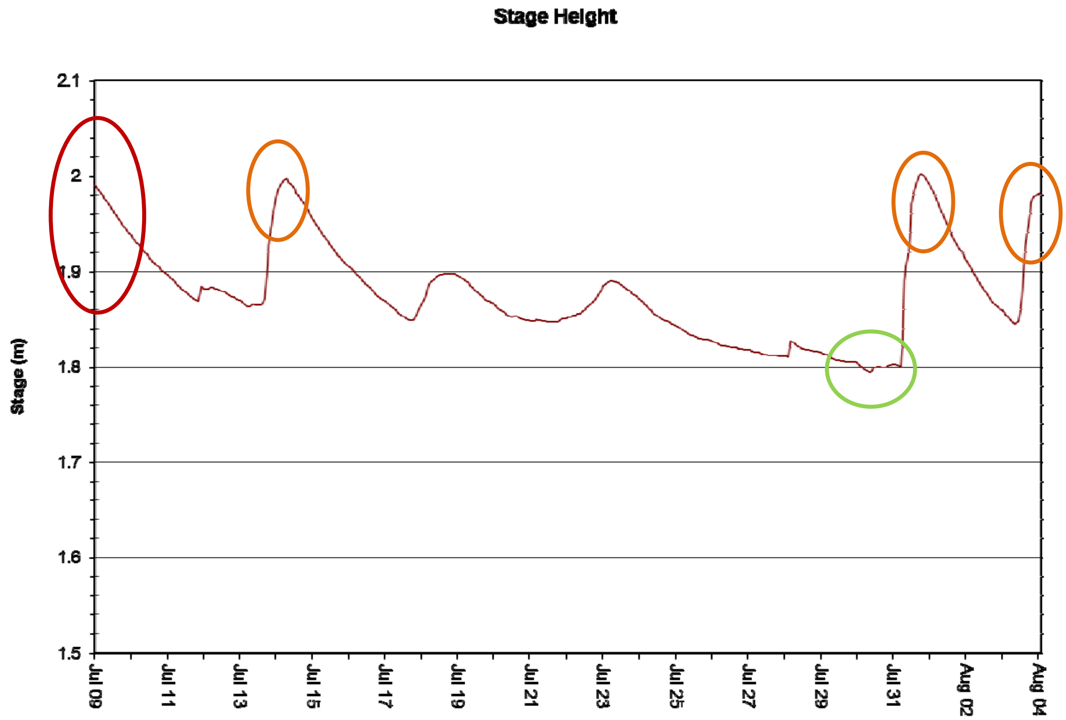

Figure 2: Stage Height (m) at Goodream Creek – July 9, 2015 to August 4, 2015

Temperature

- During the deployment periods covered by this report, water temperature ranged from 8.50˚C to 15.90˚C at Elross Creek and from 7.60˚C to 18.10˚C at Goodream Creek (Figures 3 & 4).
- For both Elross Creek and Goodream Creek there is a slight increasing temperature trend over the deployment period which is consistent with the early to mid-summer season.
- Both Goodream and Elross Creeks display noticeable diurnal temperature variations, typical of shallow water streams and ponds that are highly influenced by diurnal variations in ambient air temperatures.

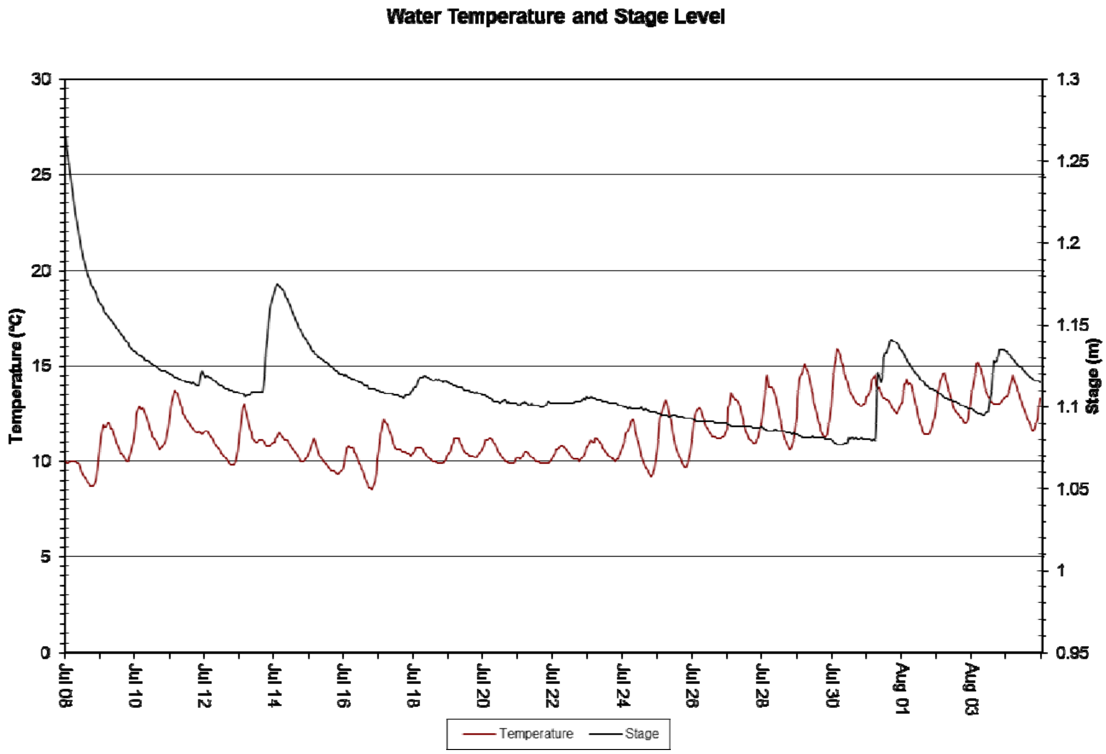

Figure 3: **Temperature (ºC) - Elross Creek – July 8, 2015 to August 5, 2015**

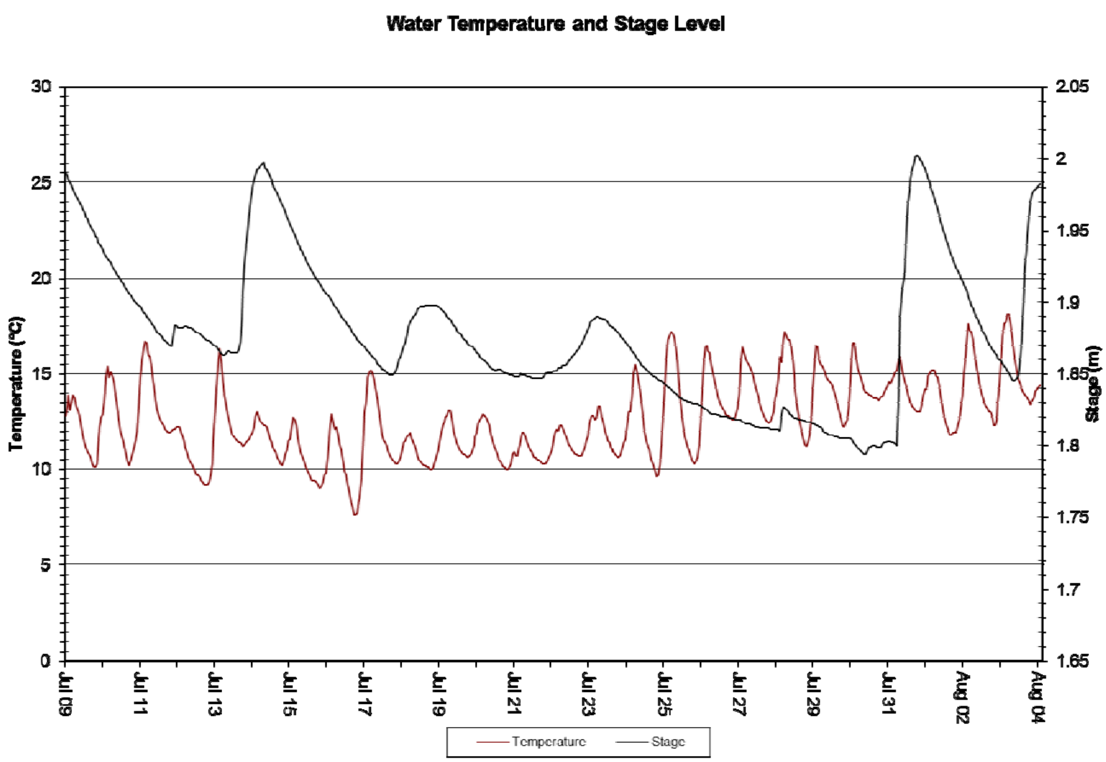

Figure 4: **Temperature (ºC) - Goodream Creek - July 9, 2015 to August 4, 2015**

pH

- During the deployment periods covered by this report, pH values ranged from 5.77 units to 6.56 units at Elross Creek, and from 5.50 units to 6.22 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.
- Rapid changes in flow related to heavy precipitation tend to have an impact on pH at both Elross and Goodream Creeks. For example, a spike in flow (as indicated by stage height) around July 14th, appears to cause a noticeable dip in pH at both sites (See inside orange ovals). This dip is more pronounced at Goodream Creek.
- At Goodream Creek it appears that pH was affected by low flow conditions (see inside green oval) from about July 27th to August 1st. During the low flow conditions it appears that pH is more variable than normal.
- At both Elross Creek and Goodream Creeks pH is below the minimum pH 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). 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.

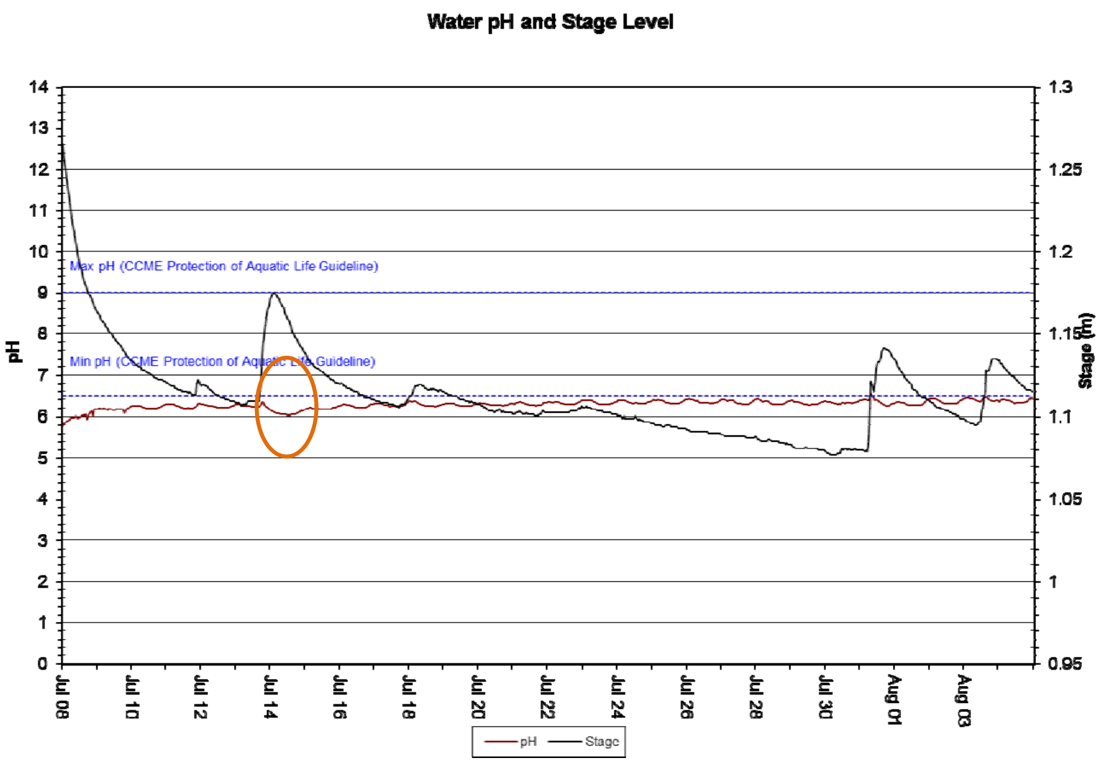

Figure 5: pH at Elross Creek – July 8, 2015 to August 5, 2015

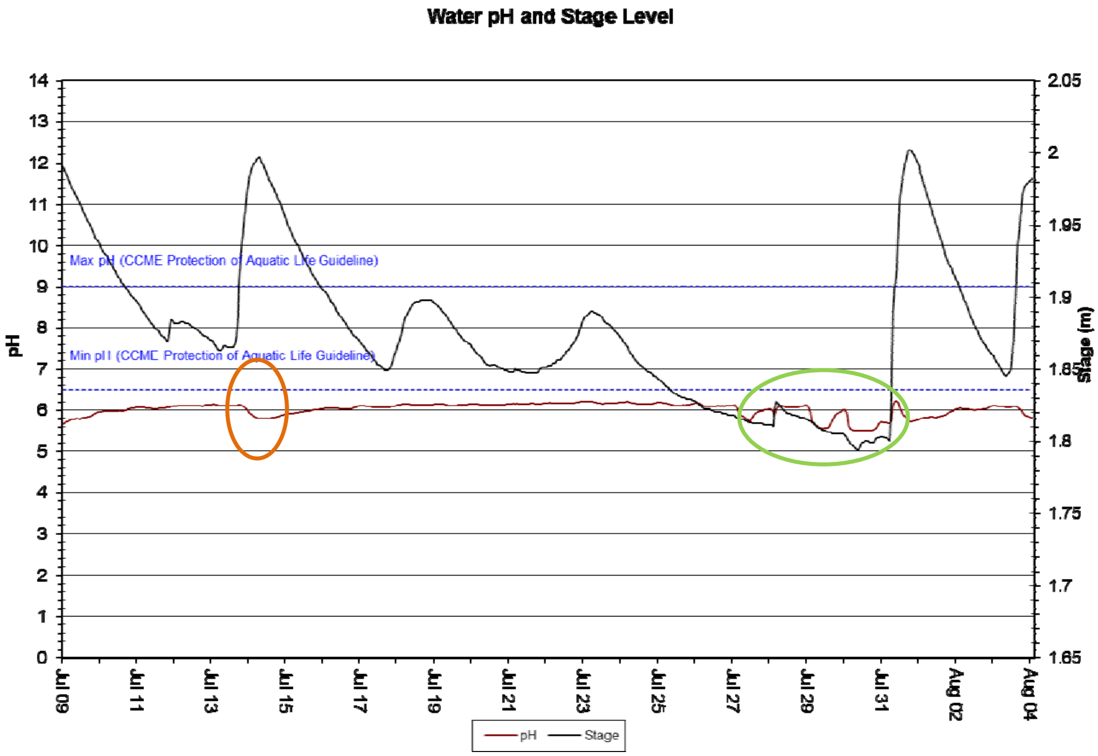

Figure 6: **pH at Goodream Creek – July 9, 2015 to August 4, 2015**

Specific Conductivity

- During the deployment periods covered by this report, specific conductivity ranged from 5.8 µs/cm to 11.9 µs/cm at Elross Creek and 2.9 µs/cm to 6.1 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. In addition, the gentle increasing temperature trend over the deployment period is clearly impacting the specific conductivity trend over the same timeframe, with a comparable increasing trend.
- Rapid increases in flow due to significant precipitation events can impact specific conductivity and depending on the general water quality can cause noticeable increases. This is the case at Elross Creek where a series of spikes in stage height correspond very well with spikes in specific conductivity (See inside red ovals).
- At Goodream Creek, where the general water quality is different, it appears that specific conductivity does not tend to increase with rapid increases in flow, but appears to be highest during low flow conditions. During this deployment period specific conductivity at Goodream Creek was highest during a period of extreme low flow conditions from about July 27th to July 31st. During this low flow period diurnal variations were also notably larger (see inside green oval).

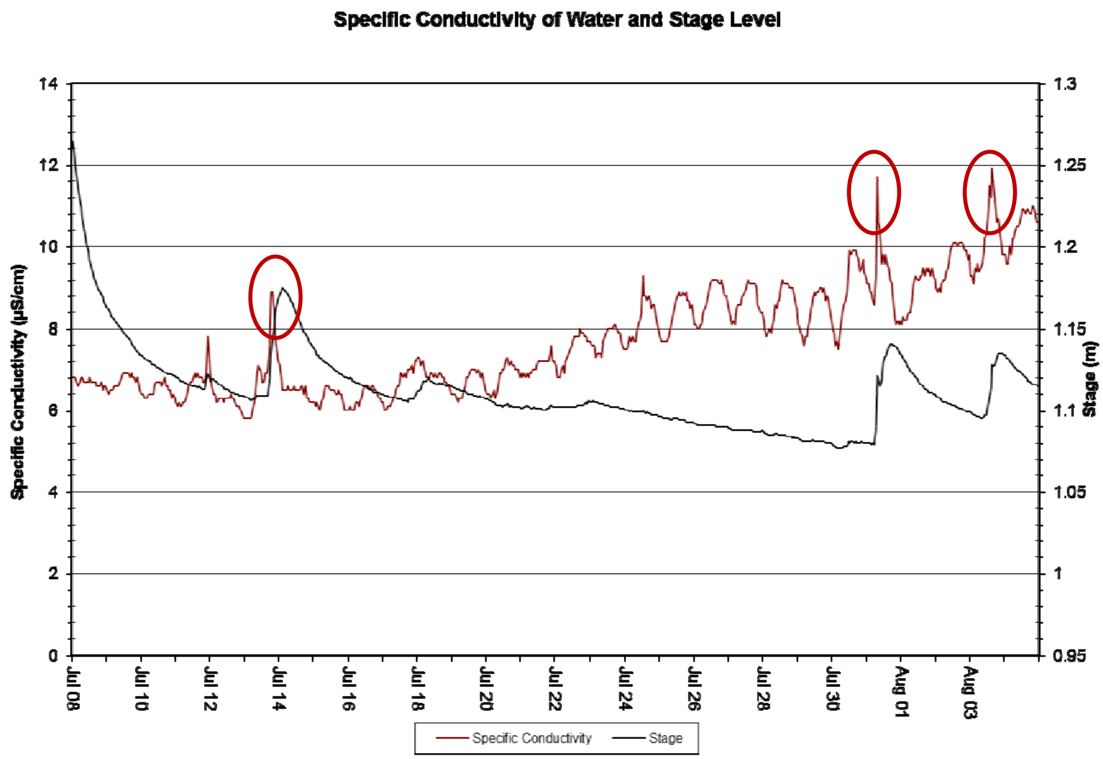

Figure 7: Specific conductivity (us/cm) - Elross Creek – July 8, 2015 to August 5, 2015

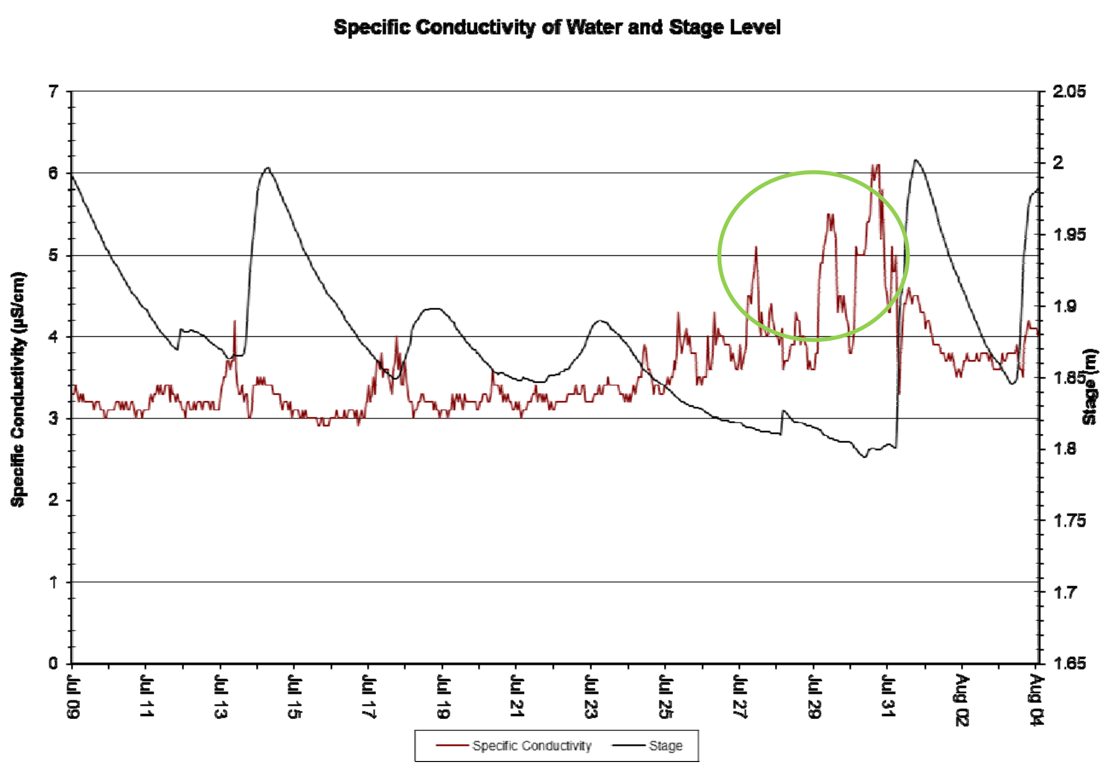

Figure 8: Specific conductivity (us/cm) - Goodream Creek – July 9, 2015 to August 4, 2015

Dissolved Oxygen

- During the deployment periods covered by this report, dissolved oxygen (DO) values ranged from 8.39 mg/l (82.0% saturation) to 10.36 mg/l (94.3% saturation) at Elross Creek (Figure 9). At Goodream Creek DO values were significantly impacted by low flow conditions and ranged from 1.05 mg/l (10.2% saturation) to 10.29 mg/l (91.6% saturation) (Figure 10).
- DO was relatively stable over the deployment period for Elross Creek, with a gentle declining trend which is related to the gentle increasing temperature trend over the same period. At Goodream Creek this general decreasing DO trend is noticeable, however the impacts of low flow conditions are far more significant. At both sites there are obvious diurnal trends in DO which are related to diurnal temperature trends.
- At Goodream Creek DO there is a period from approximately July 27th to August 1st when low flow conditions had a significant impact on DO values (see inside green oval). In general this is due to the fact that reduced flows lead to reduced turbulent flow which is the most significant pathway for the input of oxygen into water.
- The DO values at Elross Creek were at, or slightly below, 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.

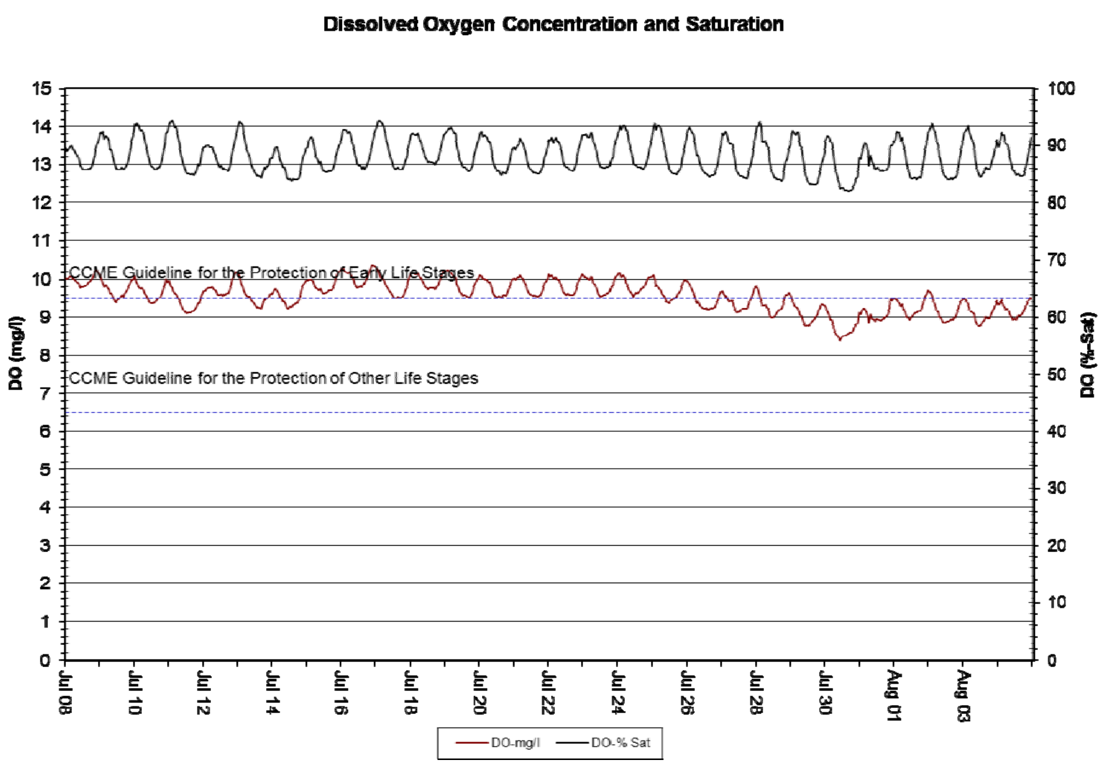

Figure 9: DO (mg/l & % saturation) at Elross Creek – July 8, 2015 to August 5, 2015

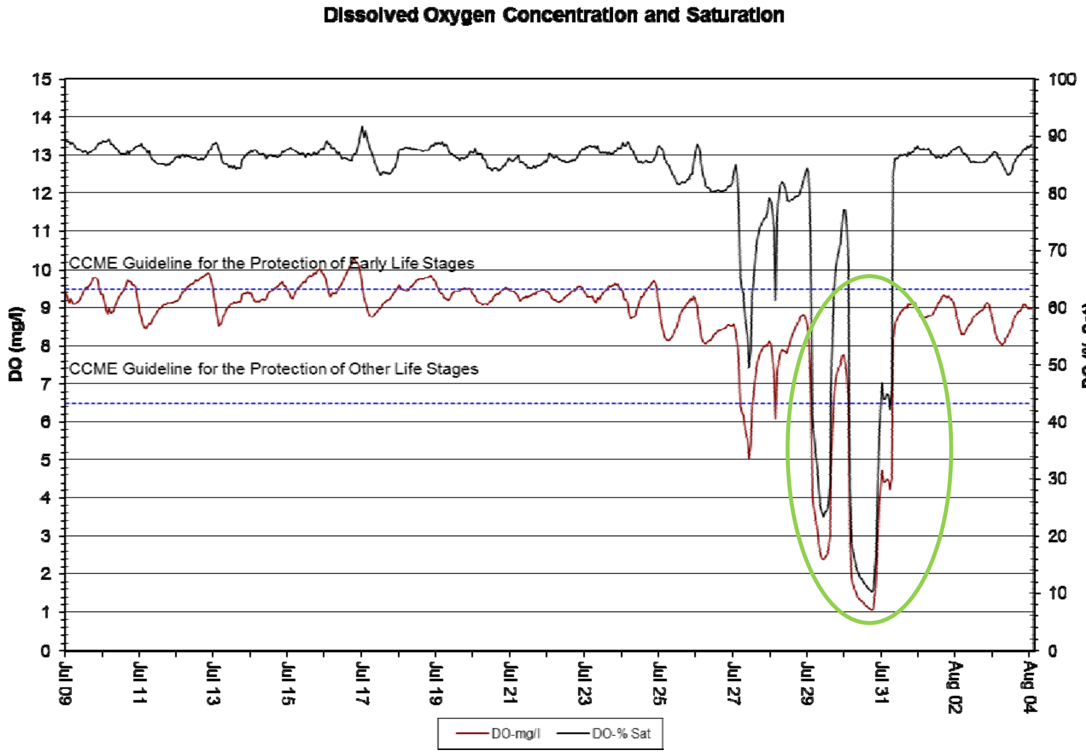

Figure 10: **DO (mg/l & % saturation) at Goodream Creek – July 9, 2015 to August 4, 2015**

Turbidity

- During the deployment periods covered by this report, turbidity values ranged from 1.4 NTU to 583.0 NTU at Elross Creek (Figure 11) and from 0.0 NTU to 6.0 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 6 datum from the July 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. Given the relatively high background turbidity levels at Elross, and the tendency of turbidity readings to fluctuate and be highly variable in the short term, it is often difficult to achieve excellent comparisons between the field and QA/QC sonde at the time of deployment.

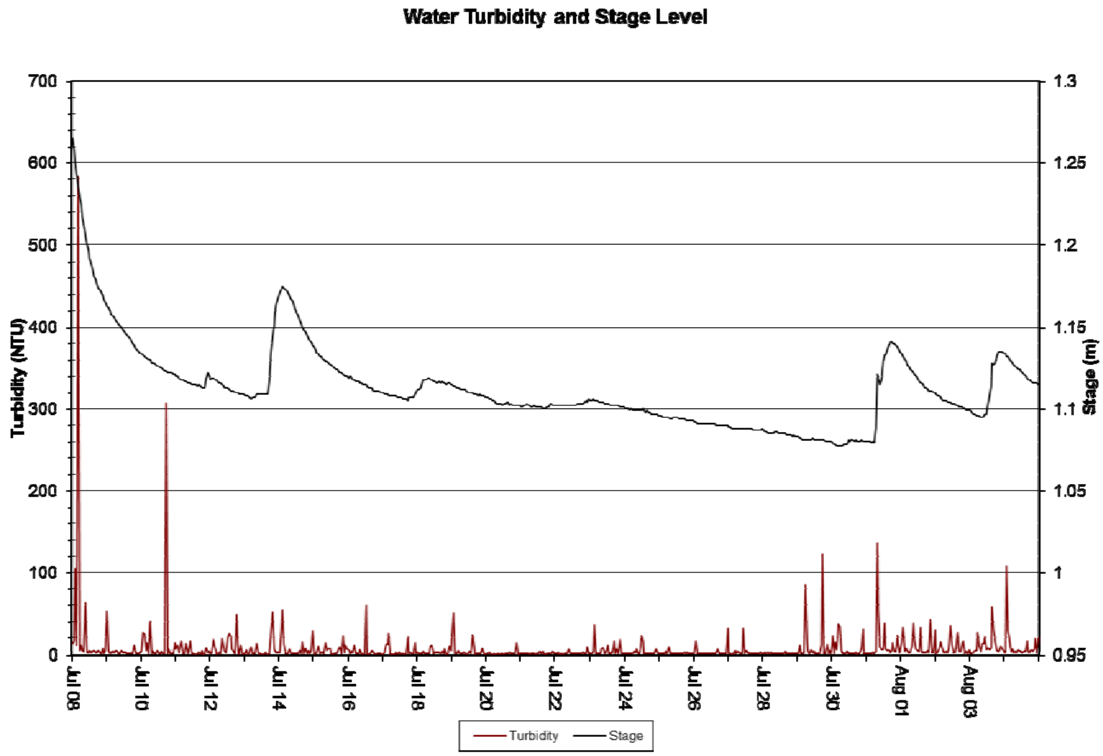

Figure 11: Turbidity (NTU) at Elross Creek – July 8, 2015 to August 5, 2015

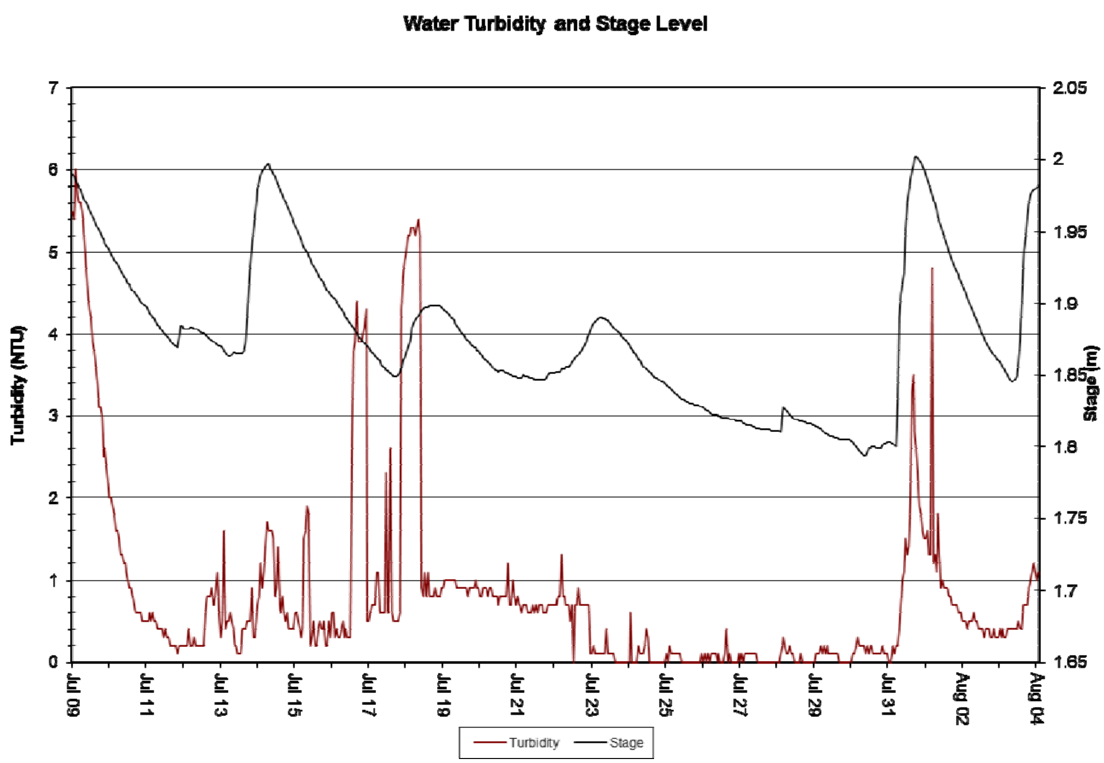

Figure 12: Turbidity (NTU) at Goodream Creek – July 9, 2015 to August 4, 2015

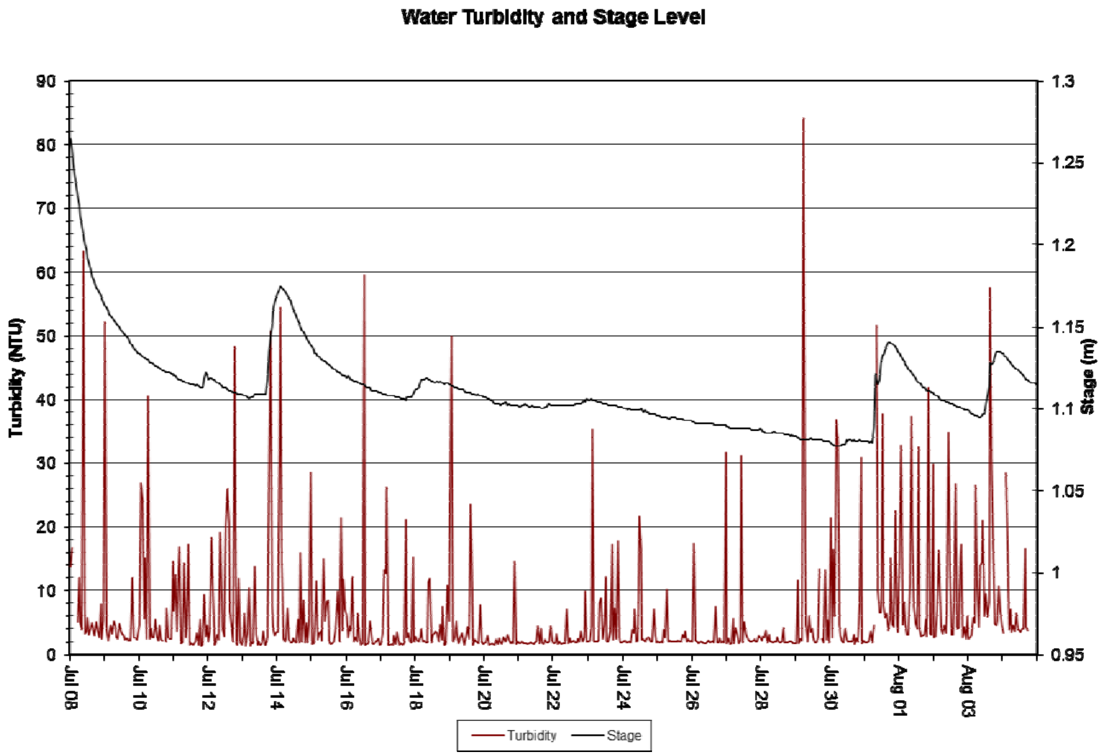

Figure 13: Turbidity (NTU<100)) at Elross Creek – July 8, 2015 to August 5, 2015

Conclusions

- This monthly deployment report, presents water quality and water quantity data recorded at the Elross Creek and Goodream Creek stations from July 8, 2015 to August 5, 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:
  - Stage height for both Elross Creek and Goodream Creek was typical for the time of this deployment period, when the hydrology of the area is dominated by summer rainfall events which cause sharp spikes in stream flow.
  - For both Elross Creek and Goodream Creek temperature shows a gentle increasing trend which is typical of the season and the transition from early to mid-summer.
  - During the deployment periods covered by this report, pH values ranged from 5.77 units to 6.56 units at Elross Creek, and from 5.50 units to 6.22 units at Goodream Creek.
  - During the deployment periods covered by this report, specific conductivity ranged from 5.8 µs/cm to 11.9 µs/cm at Elross Creek, and 2.9 µs/cm to 6.1 µs/cm at Goodream Creek.

- The DO values at Elross Creek were at, or slightly below, 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 CCME (2007). The same is true at Goodream Creek, with the exception of a period of extreme low flow from approximately July 27th to August 1st .
- During the deployment periods covered by this report, turbidity values ranged from 1.4 NTU to 583.0 NTU at Elross Creek, and from 0.0 NTU to 6.0 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 (°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 (July 8, 2015 to August 5, 2015)

Date/Time	Max Temp (°C)	Min Temp (°C)	Mean Temp (°C)	Heat Deg Days (°C)	Cool Deg Days (°C)	Total Precip (mm)
7/8/2015	14.4	7.2	10.8	7.2	0	15
7/9/2015	21.7	8.7	15.2	2.8	0	0.3
7/10/2015	18	7.9	13	5	0	0
7/11/2015	18.5	7.2	12.9	5.1	0	0
7/12/2015	13.3	6.6	10	8	0	4
7/13/2015	17.1	6.3	11.7	6.3	0	2.2
7/14/2015	18.2	8.7	13.5	4.5	0	22.8
7/15/2015	12.8	6.4	9.6	8.4	0	2
7/16/2015	11.6	6.1	8.9	9.1	0	0
7/17/2015	19	3.7	11.4	6.6	0	0
7/18/2015	11.6	9.3	10.5	7.5	0	8.8
7/19/2015	14.1	8.9	11.5	6.5	0	0.4
7/20/2015	14.4	9	11.7	6.3	0	0.6
7/21/2015	11.6	9.2	10.4	7.6	0	1.7
7/22/2015	12.9	10.1	11.5	6.5	0	4.7
7/23/2015	16.9	10	13.5	4.5	0	1.7
7/24/2015	17.7	8.8	13.3	4.7	0	0
7/25/2015	21.4	8.2	14.8	3.2	0	0
7/26/2015	21.4	9.2	15.3	2.7	0	0
7/27/2015	21.5	12.6	17.1	0.9	0	1.3
7/28/2015	22.5	9.8	16.2	1.8	0	0
7/29/2015	24.3	8.9	16.6	1.4	0	0.2
7/30/2015	27.4	13.1	20.3	0	2.3	1.5
7/31/2015	21.2	13.6	17.4	0.6	0	25.4
8/1/2015	19.8	9.1	14.5	3.5	0	2.3
8/2/2015	20.2	9.4	14.8	3.2	0	0
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