Real-Time Water Quality Annual Report

Flora Creek below TLH

June 13 to
October 23, 2017

Newfoundland Labrador

Government of Newfoundland & Labrador
Department of Municipal Affairs and Environment
Water Resources Management Division

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Acknowledgements

The Real-Time Water Quality Monitoring station (RTWQ) at Flora Creek was partially funded by Cliffs Natural Resources in 2017. During the 2017 deployment season, the mine was sold to Tacora Resources, Inc. The program is now a joint partnership between Tacora Resources, Environment and Climate Change Canada (EC), and the Newfoundland & Labrador Department of Municipal Affairs and Environment (MAE).

Various individuals from each sector have been diligently involved to ensure this program is a successful operation, they include, Renee Paterson (MAE), Patrick Ryan (Cliffs Natural Resources), Mike Twite (Tacora Resources, Inc.), and Howie Wills (EC). In addition to these managers, there have been a team of individuals who work together to ensure the day to day operation of this station is providing quality data. Maria Murphy (MAE) was responsible for this water quality station during 2017; responsibilities included deployment and removal of the instrument, maintenance and calibration of the instrument and preparation of monthly deployment reports. Brenda Greene (MAE) is acknowledged for her assistance during deployment and removal procedures in 2017.

EC staff are essential in the operation of the data logging/communication aspect of the network. Staff of the Meteorological Service of Canada Division – Water Survey of Canada, visit the station regularly to ensure that the data logging and data transmitting equipment is working properly. EC is also the lead on dealing with water stage and flow issues.

Introduction

- The real-time water quality monitoring station on Flora Creek was established during the summer of 2014, a partnership between the Newfoundland & Labrador Department of Municipal Affairs and Environment (MAE) and Cliffs Natural Resources. In 2017, the mine was sold and the partnership transferred to Tacora Resources and the Newfoundland & Labrador Department of Municipal Affairs and Environment.
- The official name of the station is Flora Creek below TLH, also referred to as the Flora Creek station.
- This station measures water quality parameters water temperature, pH, specific conductivity, dissolved oxygen and turbidity, as well as water quantity parameters stage and flow. Parameters are recorded on an hourly basis during the deployment period.

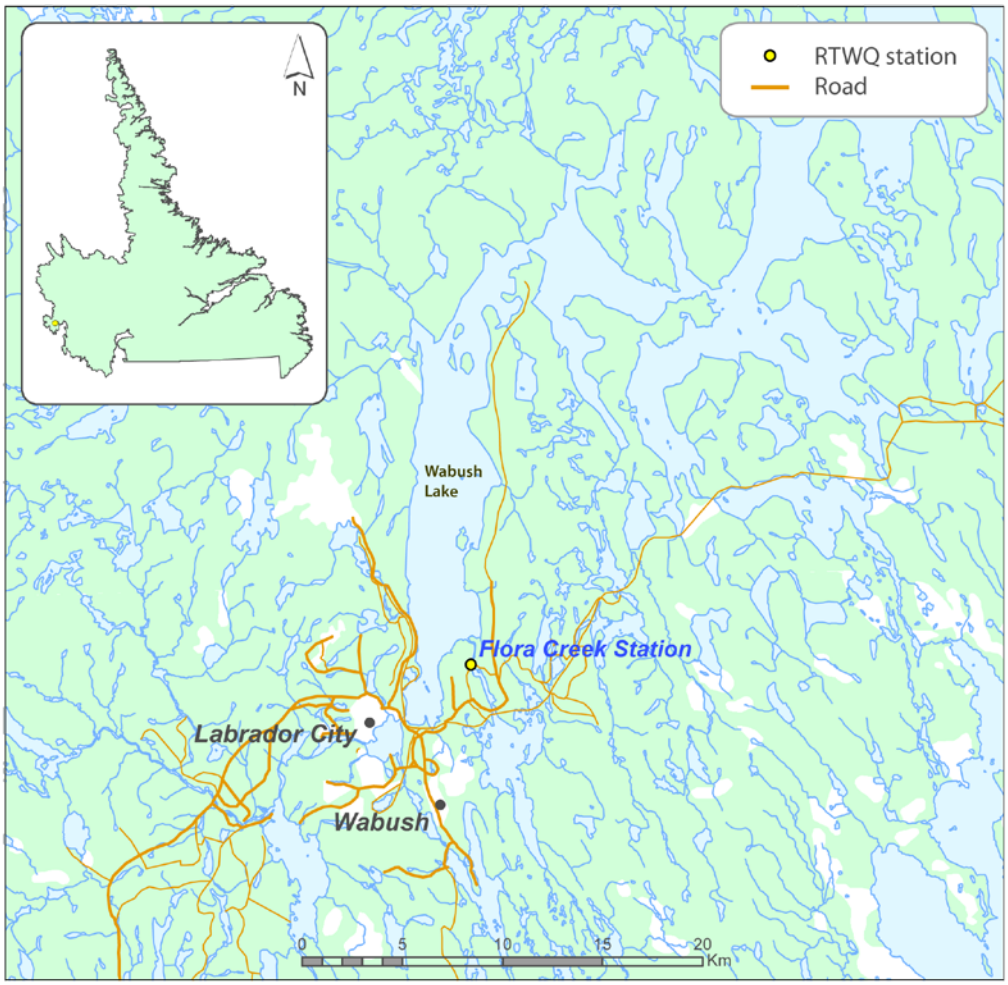

Figure 1: Map of Western Labrador area showing the RTWQ Flora Creek station.

- The purpose of this network is to monitor, process, and distribute water quality/quantity data to Tacora Resources, MAE and EC, for assessment and management of water resources, as well as to provide an early warning for any potential or emerging water issues. Therefore, mitigative measures can be implemented in a timely manner.
- MAE provides Tacora Resources with monthly and annual deployment reports.
- A RTWQ monitoring instrument has been deployed at this station each season since 2014, near a continuously evolving mine site. There are some small gaps in data on the graphs included in this report. Unless otherwise stated, these gaps indicate the time frame where the instrument was removed from the water for calibration and maintenance.
- The initial deployment for the 2017 season was on June 13th. The instrument was removed for the winter season on October 23rd. The following report depicts and discusses water quality events throughout this time period.

Maintenance and Calibration

- To ensure accurate data collection, maintenance and calibration of the water quality instrumentation is performed routinely approximately every 45 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, MAE staff carefully calibrates each sensor attachment for pH, specific conductivity, dissolved oxygen and turbidity to ensure accurate data collection.
- Installation and removal dates for the 2017 season are summarized in the table below.

Table 1: Water quality instrument deployment start and end dates for 2017

Installation	Removal	Deployment duration (days)
June 13	July 18	35
July 20	September 12	54
September 13	October 23	40

Quality Assurance and Quality Control

- As part of the Quality Assurance and Quality Control protocol (QA/QC), an assessment of the reliability of data recorded by an instrument is made at the beginning and end of each deployment period. The procedure is based on the approach used by the United States Geological Survey.
- At deployment and removal, a QA/QC Sonde is temporarily deployed along side the Field Sonde. Values for temperature, pH, conductivity, dissolved oxygen and turbidity are compared between the two instruments**.** Based on the degree of difference between parameters recorded by the Field Sonde and QA/QC Sonde at deployment and at removal, a qualitative statement is made on the data quality (Table 2).

Table 2: Ranking classifications for deployment and removal

	Rank				
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

- It should be noted that the temperature sensor on any sonde is the most important. All other parameters can be broken down into three groups: temperature dependant, temperature compensated and temperature independent. Because the temperature sensor is not isolated from the rest of the sonde the entire sonde must be at the same temperature before the sensor will stabilize. The values may take some time to climb to the appropriate reading; if a reading is taken too soon it may not accurately portray the water body.
- Deployment and removal comparison rankings for the Flora Creek water quality station for the three deployment periods from June 13th to October 23rd, 2017, are summarized in Table 3.
- For additional information and explanations of rankings, please refer to the 2017 monthly deployment reports.

Table 3: QA/QC comparison rankings for Flora Creek June 13 – October 23, 2017

	Date		Instrument #	Temperature	pH	Specific Conductivity	Dissolved Oxygen	Turbidity
Flora Creek	13-Jun-17	Deployment	13G101500	Excellent	Poor	Excellent	Excellent	Excellent
	18-Jul-17	Removal	13G101500	Excellent	Good	Excellent	Good	Excellent
	20-Jul-17	Deployment	13G101500	Excellent	Good	Good	Fair	Excellent
	12-Sep-17	Removal	13G101500	Excellent	Excellent	Good	Fair	Excellent
	13-Sep-17	Deployment	13G101500	Excellent	Excellent	Excellent	Marginal	Excellent
	23-Oct-17	Removal	13G101500	Excellent	Poor	Good	Marginal	Fair

Data Interpretation

- The following graphs and discussion illustrate water quality-related events from June 13th, 2017 to October 23rd, 2017 at Flora Creek.
- With the exception of water quantity data (stage), all data used in the preparation of the graphs and subsequent discussion below adhere to this stringent QA/QC protocol. Water Survey of Canada is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

Flora Creek below TLH

- Water temperature ranged from 1.80 to 21.33°C during the 2017 deployment season. The median value was 13.51 °C (Figure 2).
- Water temperature increases at the beginning of the season and decreases during the later portion of the season; this is expected as ambient air temperature is warmer in the summer and cooler in the fall.

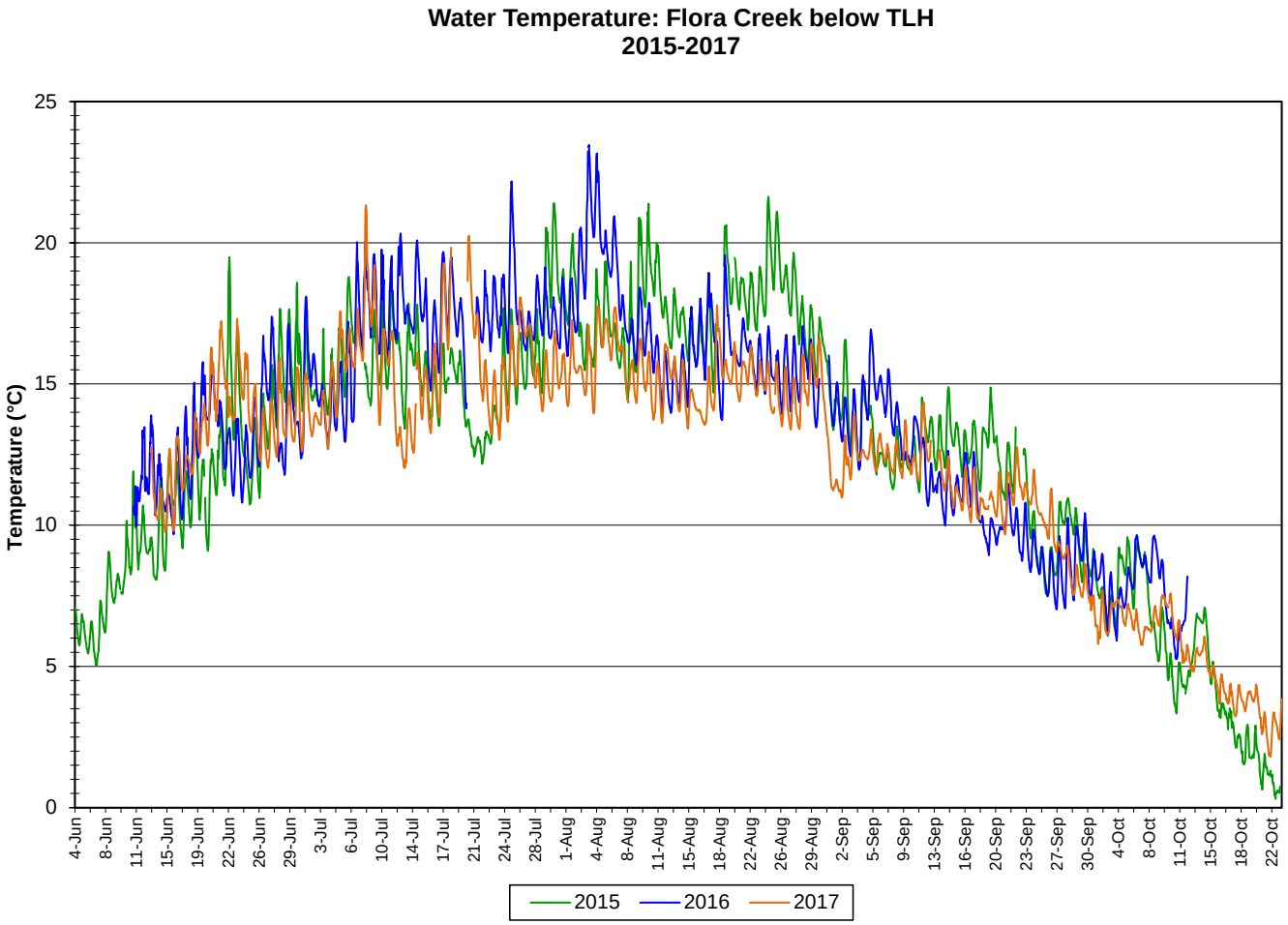

Figure 2: Water temperature (2015-2017) – Flora Creek below TLH

- Water temperature values show a typical seasonal trend; warm in the summer and decreasing into the fall season. Water temperature fluctuations correspond moderately well with the ambient air temperature recorded at Wabush Airport (Figure 3). Gaps on the graph are due to missing weather data.

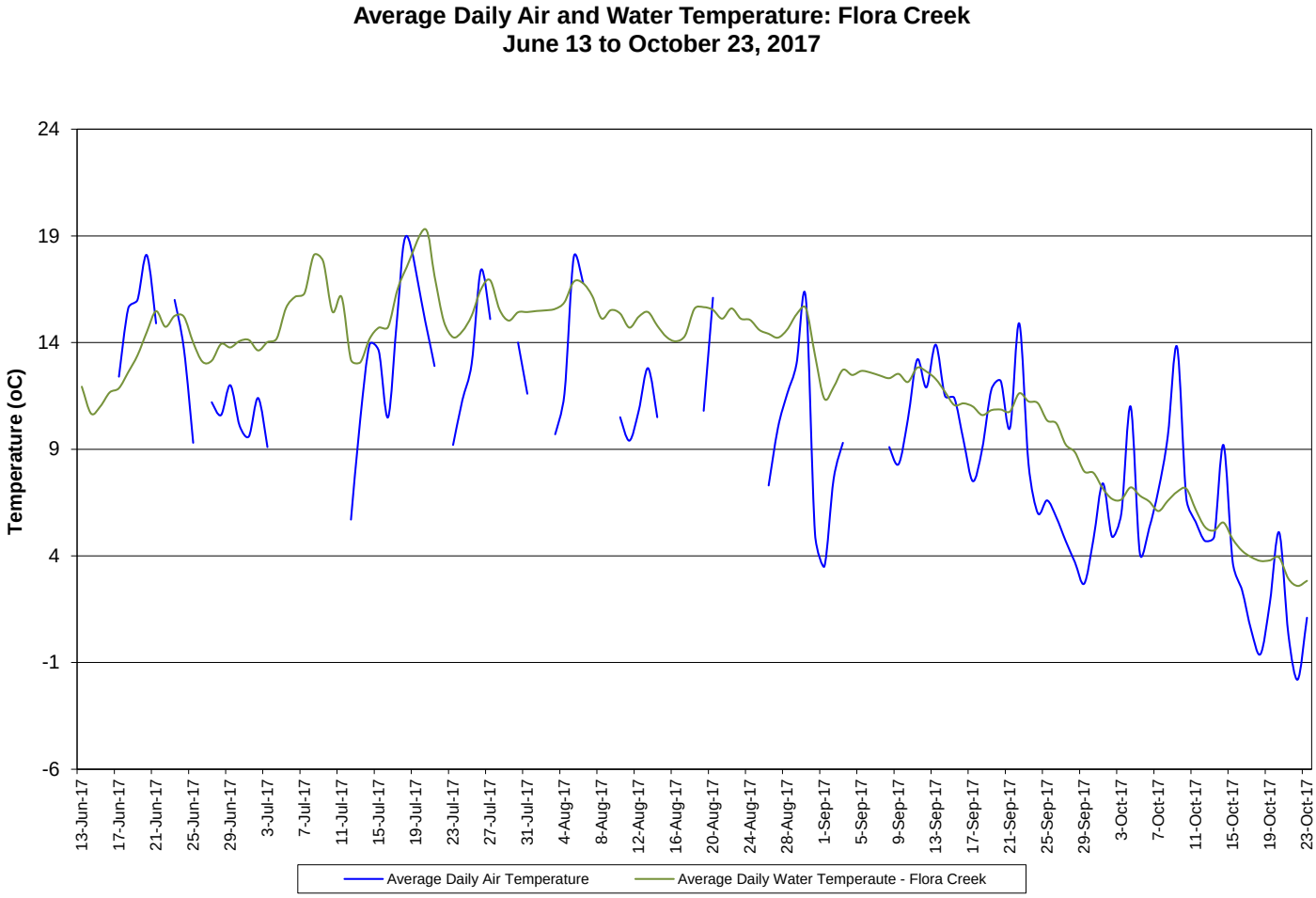

Figure 3: Average daily air and water temperatures (2017) – Flora Creek below TLH

(Weather data collected at Wabush Airport)

- pH ranges from 7.52 to 8.08 pH units at Flora Creek, throughout the 2017 deployment season(Figure 4). The median pH is 7.69.
- pH fluctuates daily. Peaks are observed during late afternoon and early evening.
- All values during the deployment are within the CCME Water Quality Guidelines for the Protection of Aquatic Life (between 6.5 and 9 pH units).
- pH increases slightly during the beginning of the season, then remains relatively stable until the end of the season.

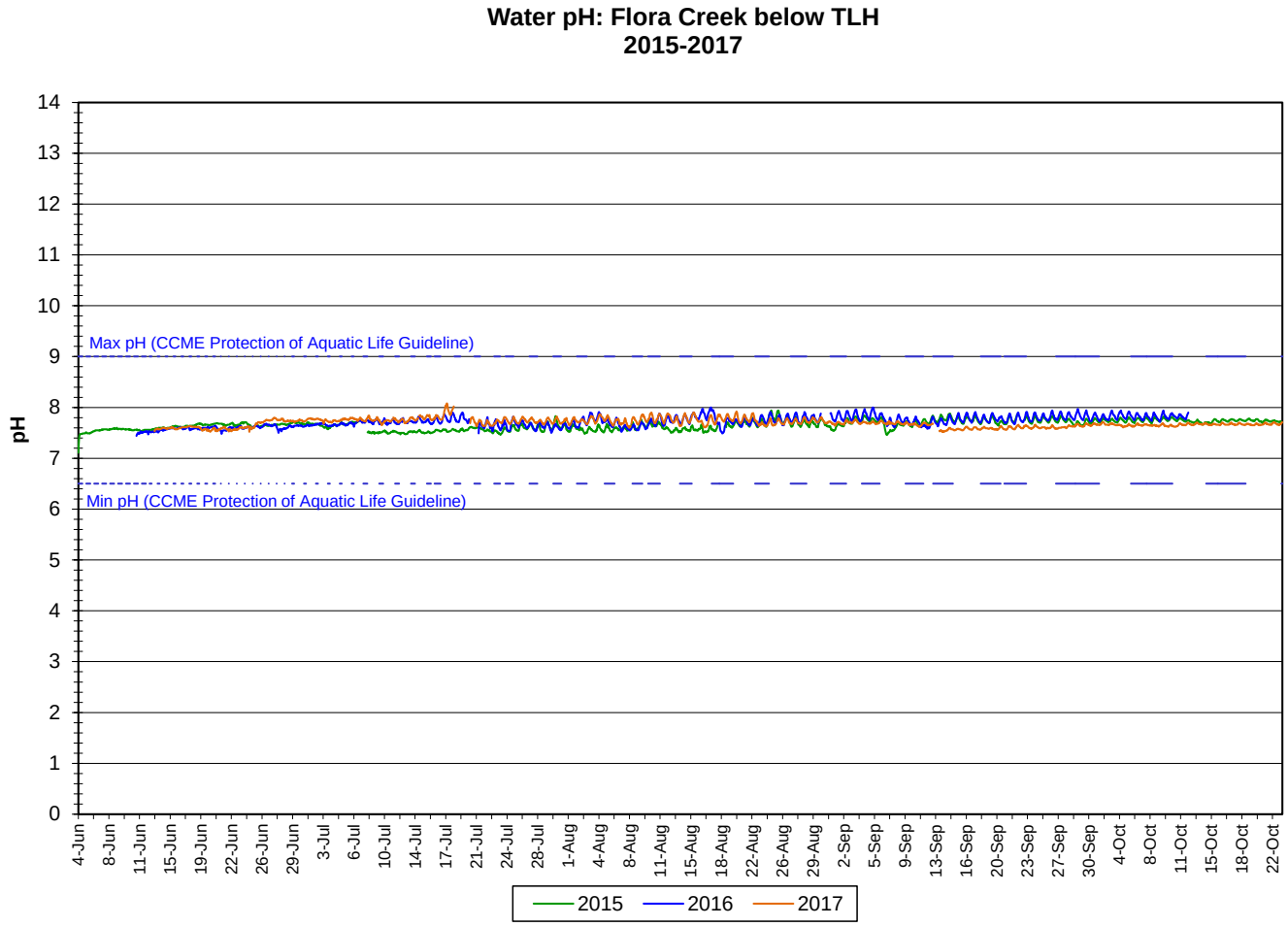

Figure 4: pH (2015-2017) – Flora Creek below TLH

- Throughout the 2017 deployment season, specific conductivity ranged from 60.9 to 69.5 µs/cm at Flora Creek (Figure 5).
- Small decreases during the second and third deployment period can be attributed to high precipitation events.
- In 2015, the conductivity sensor on this instrument required a substantial amount of time to stabilize, as evident on the graph below. After the 2015 field season, the conductivity sensor was replaced as part of an upgrade program, correcting this issue.
- Conductivity increases during the first two deployment periods, decreasing after the second deployment period before increasing slightly for the remainder of the season.
- With the exception of water quantity data (stage), all data used in the preparation of the graphs and subsequent discussion below adhere to this stringent QA/QC protocol. Water Survey of Canada is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

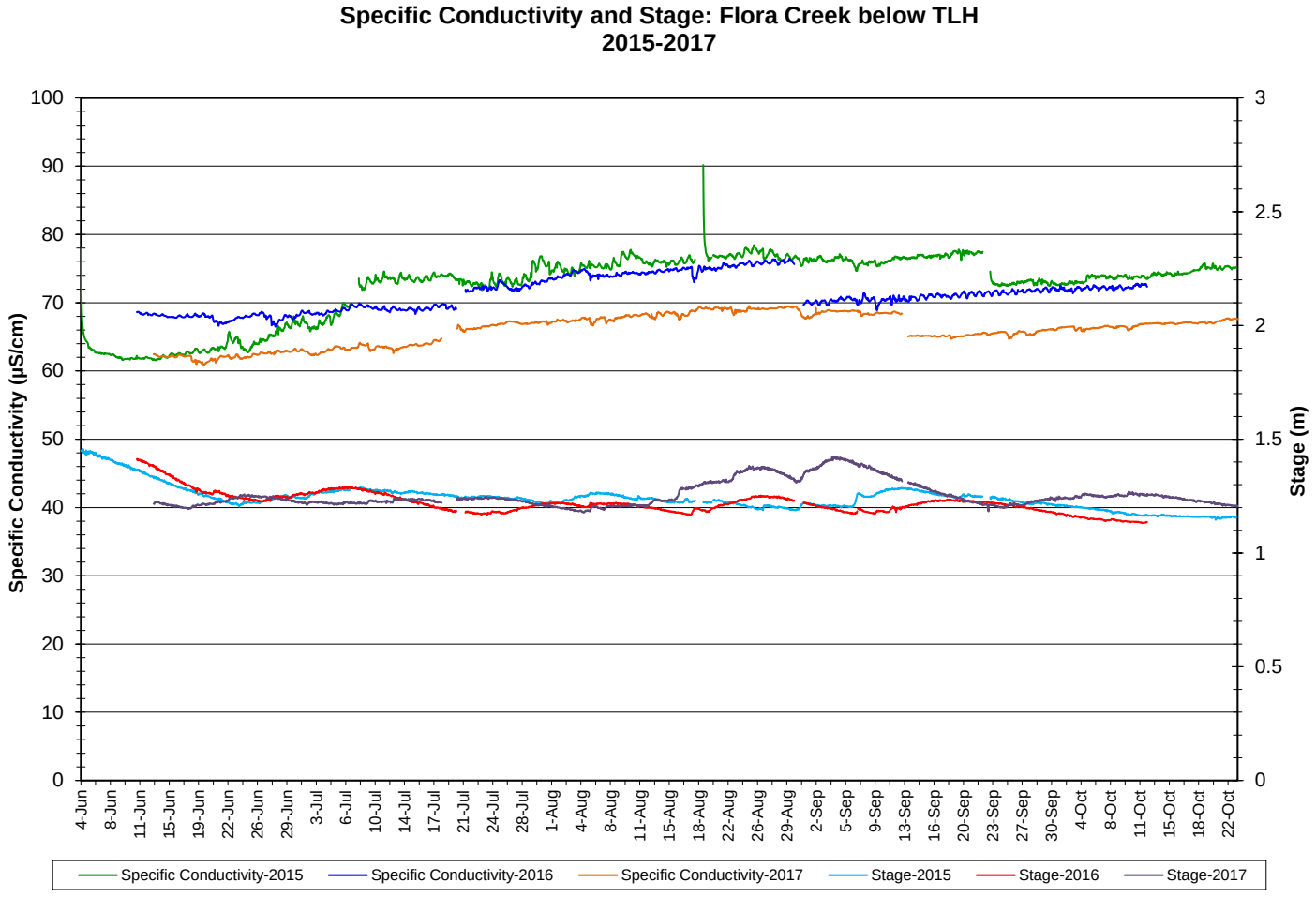

Figure 5: Specific conductivity (2015-2017) – Flora Creek below TLH

- The saturation of dissolved oxygen ranged from 90.0 to 109.1%, while the dissolved oxygen content ranged from 9.03 to 13.70 mg/l, with a median value of 10.10 mg/l (Figure 6).
- Dissolved oxygen fluctuated daily with decreases observed at night.
- Dissolved oxygen decreases during the summer months when water temperature is warmest. It then increases during the last deployment period of the season, when water temperatures cool into the fall.
- All values were above the CCME Water Quality Guideline for the Protection of Aquatic Life for Cold Water Biota at Other Life Stages of 6.5 mg/l. Most values recorded were above the minimum CCME Water Quality Guideline for the Protection of Aquatic Life for Cold Water Biota at Early Life Stages of 9.5 mg/l. The guidelines are indicated in blue on Figure 5.

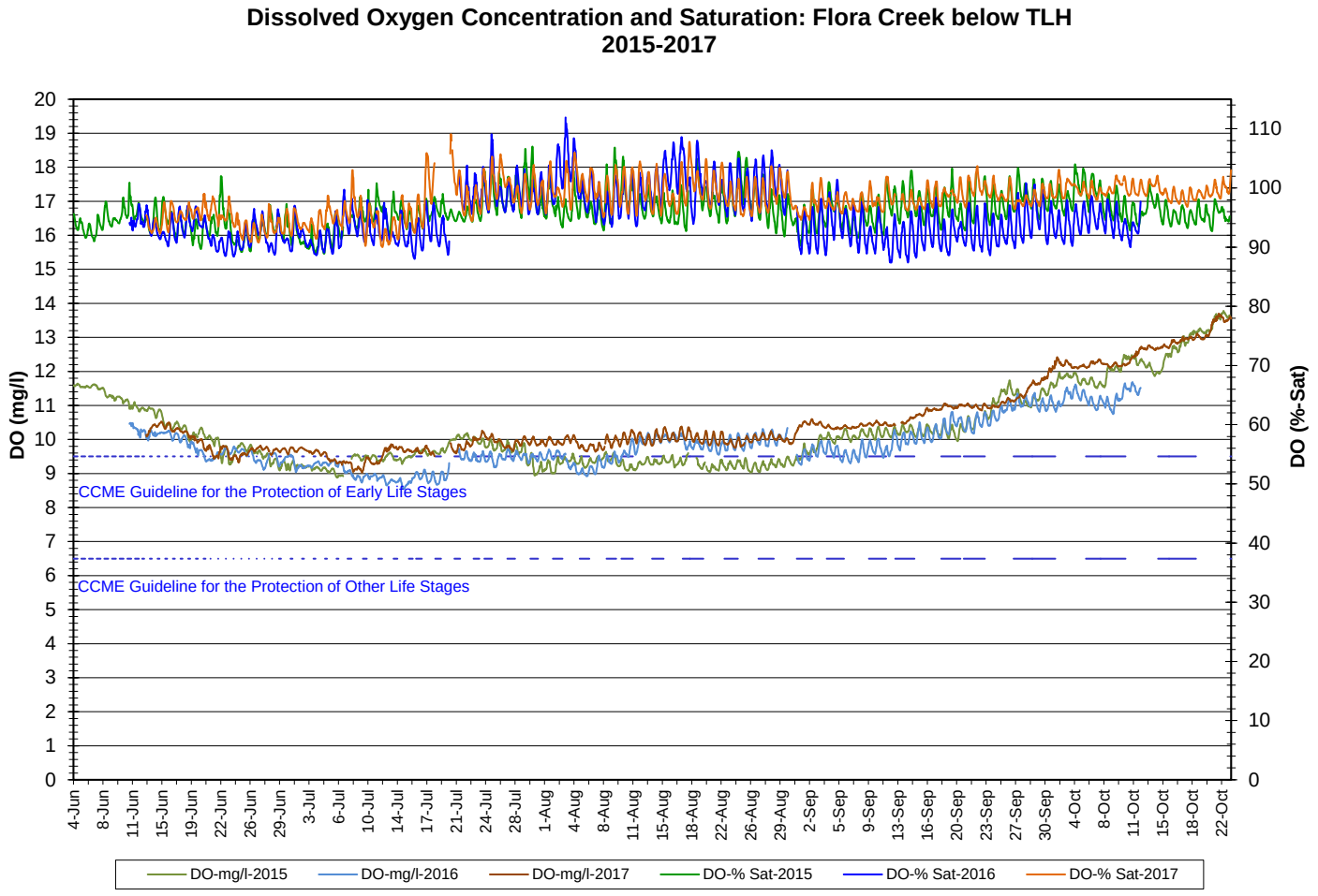

Figure 6: Dissolved oxygen and percent saturation (2015-2017) – Flora Creek below TLH

- At the Flora Creek station, turbidity values range from 9.6 to 572.4 NTU with a median value of 48.0 NTU (Figure 7). This station was somewhat turbid for the entire season.
- Turbidity at the beginning of the season was very high and decreased over time; this was due to the late winter melt/freshet. This is a typical trend noticed each year since the instrument was deployed in 2014.
- After the significant decrease in the beginning of the season, turbidity readings above 100NTU occur occasionally and for small periods of time.

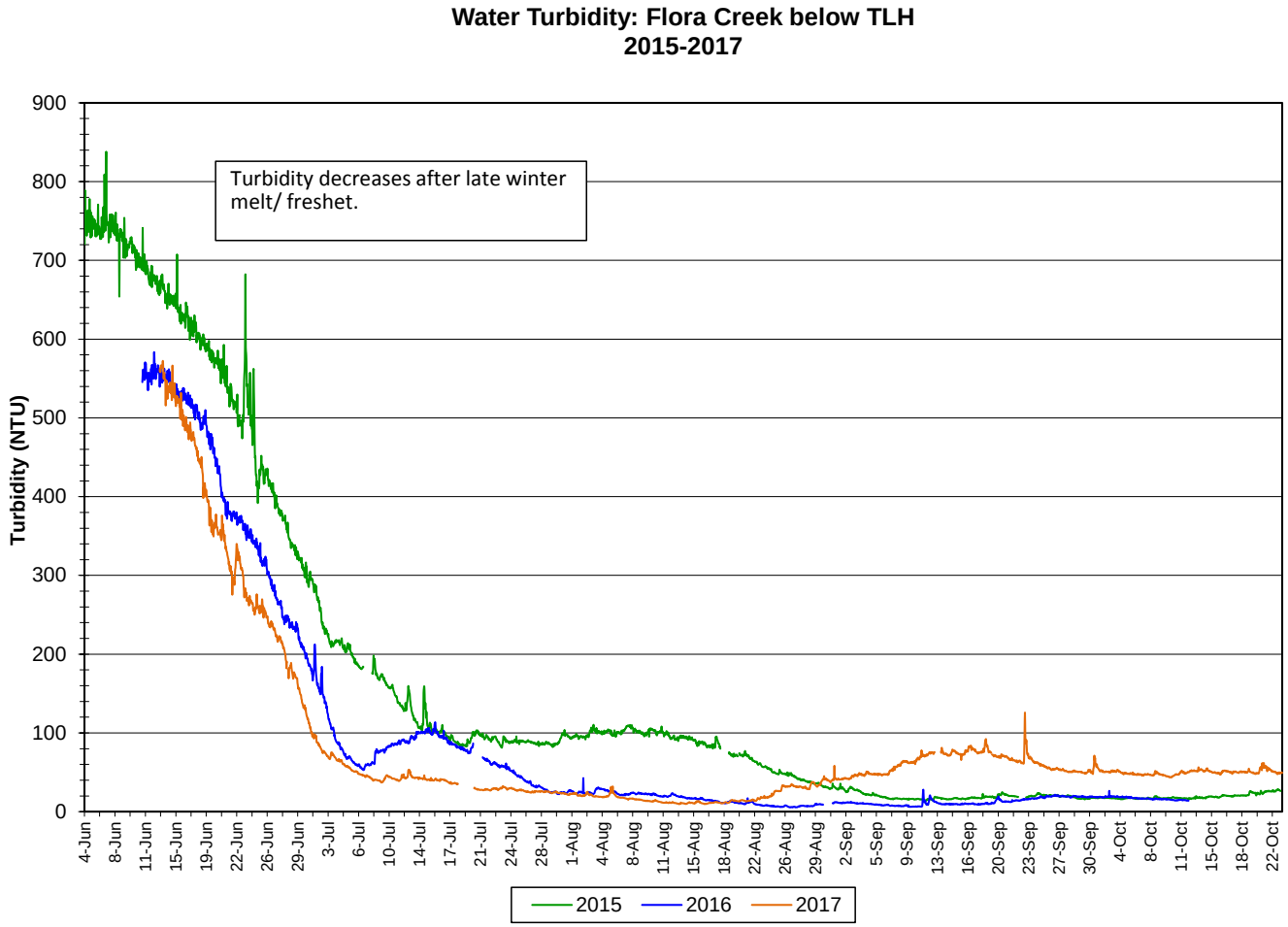

Figure 7: Turbidity at Flora Creek below TLH (2015-2017)

- Stage and precipitation are graphed below to show the relationship between rainfall and water level at Flora Creek (Figure 8).
- Stage increases during the second deployment period before decreasing into September, stage is relatively stable for the remainder of the deployment season with fluctuating precipitation levels.
- With the exception of water quantity data (stage), all data used in the preparation of the graphs and subsequent discussion below adhere to this stringent QA/QC protocol. Water Survey of Canada is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

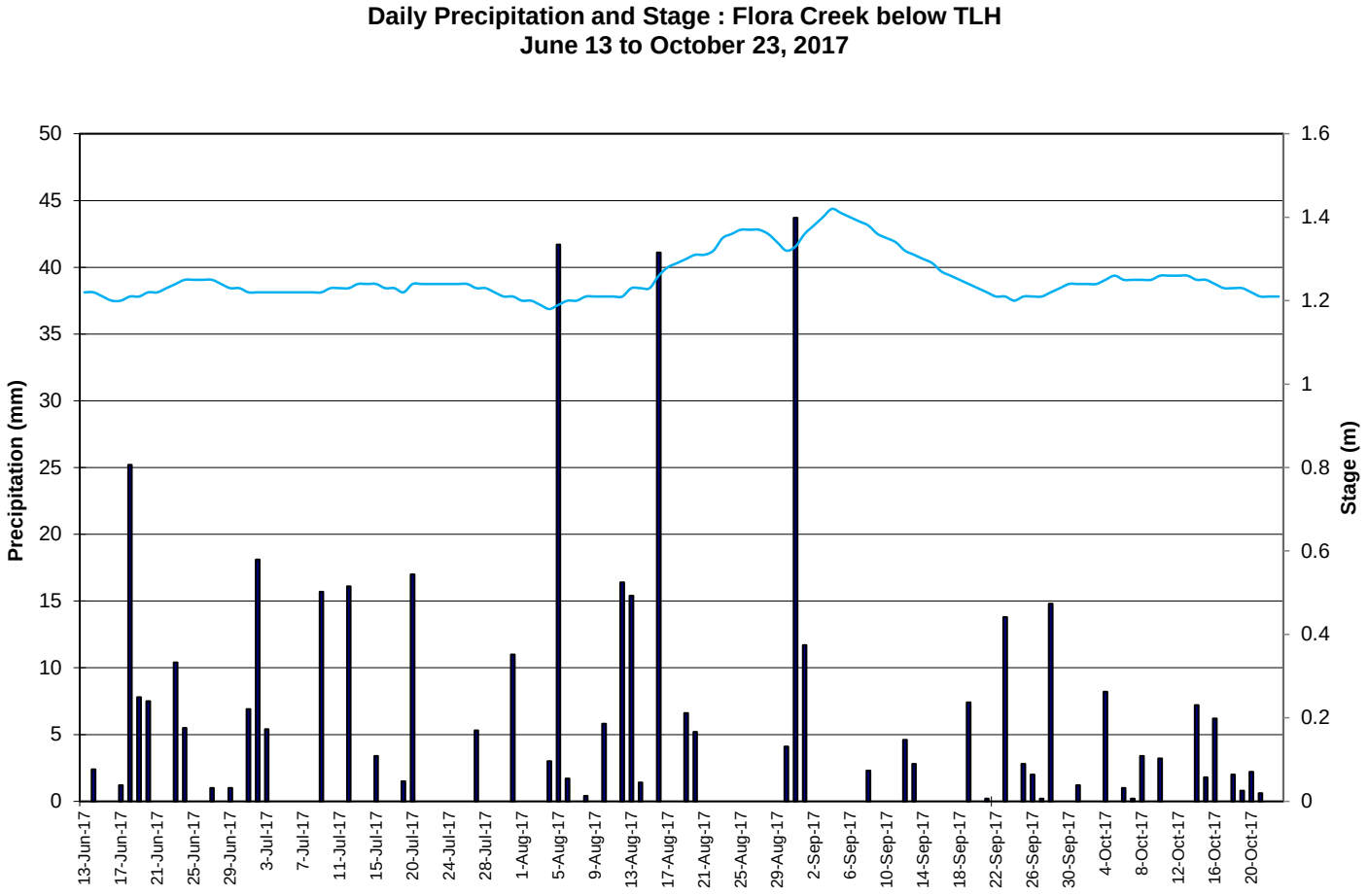

Figure 8: Stage and precipitation (2017) - Flora Creek below TLH

(Weather data collected at Wabush Airport)

Conclusions

- The instrument at the water quality monitoring station on Flora Creek was deployed on June 13th, 2017 and removed on October 23rd, 2017 for the winter season.
- Deployment periods ranged from 35-54 days.
- In most cases, weather related events or increases/decreases in water level explain the data fluctuations.
- Most values recorded were within ranges as suggested by the CCME Water Quality Guidelines for the Protection of Aquatic Life.
- The instrument performed well for the 2017 season with no issues.
- Water temperature followed the seasonal trend of increasing during the summer and decreasing into the fall. Water temperature corresponded with air temperature.
- All pH values were within the acceptable range of the CCME Water Quality Guidelines for Protection of Aquatic Life.
- Specific conductivity increased during the first two deployment periods, decreasing after the second deployment period, and then increasing slightly for the remainder of the season. There is no longer a waiting period for the conductivity sensor to stabilize as this sensor was replaced before the 2016 season.
- In some cases, dissolved oxygen values were below the minimum CCME Water Quality Guideline for the Protection of Aquatic Life for Cold Water Biota at Early Life Stages of 9.5 mg/l. All values were above the CCME Water Quality Guideline for the Protection of Aquatic Life for Cold water Biota at Other Life Stages of 6.5 mg/l.
- This station tends to have high turbidity values. As usual, a decrease was noted after the late winter melt/freshet.

Path Forward

- The field instrument will undergo proficiency testing and evaluation during the winter of 2017-2018. MAE will inform Tacora Resources of any instrument performance issues.
- MAE staff will deploy real time water quality instruments in spring 2018, when ice conditions allow and perform regular site visits throughout the 2018 deployment season for calibration and maintenance of the instruments.
- If necessary, deployment techniques will be evaluated and modified, ensuring secure and suitable conditions for RTWQ monitoring.
- MAE will continue to work on its Automatic Data Retrieval System, to incorporate new capabilities in data management and data display.
- Open communication lines will continue to be maintained between MAE, EC and Tacora Resources in order to respond to emerging issues on a proactive basis. Tacora Resources will receive monthly deployment reports and an annual report, summarizing the events of the deployment season.
- A discussion will be held between MAE and the industry partner regarding high turbidity values during the spring runoff, and potential mitigative measures that can be taken to reduce these values.

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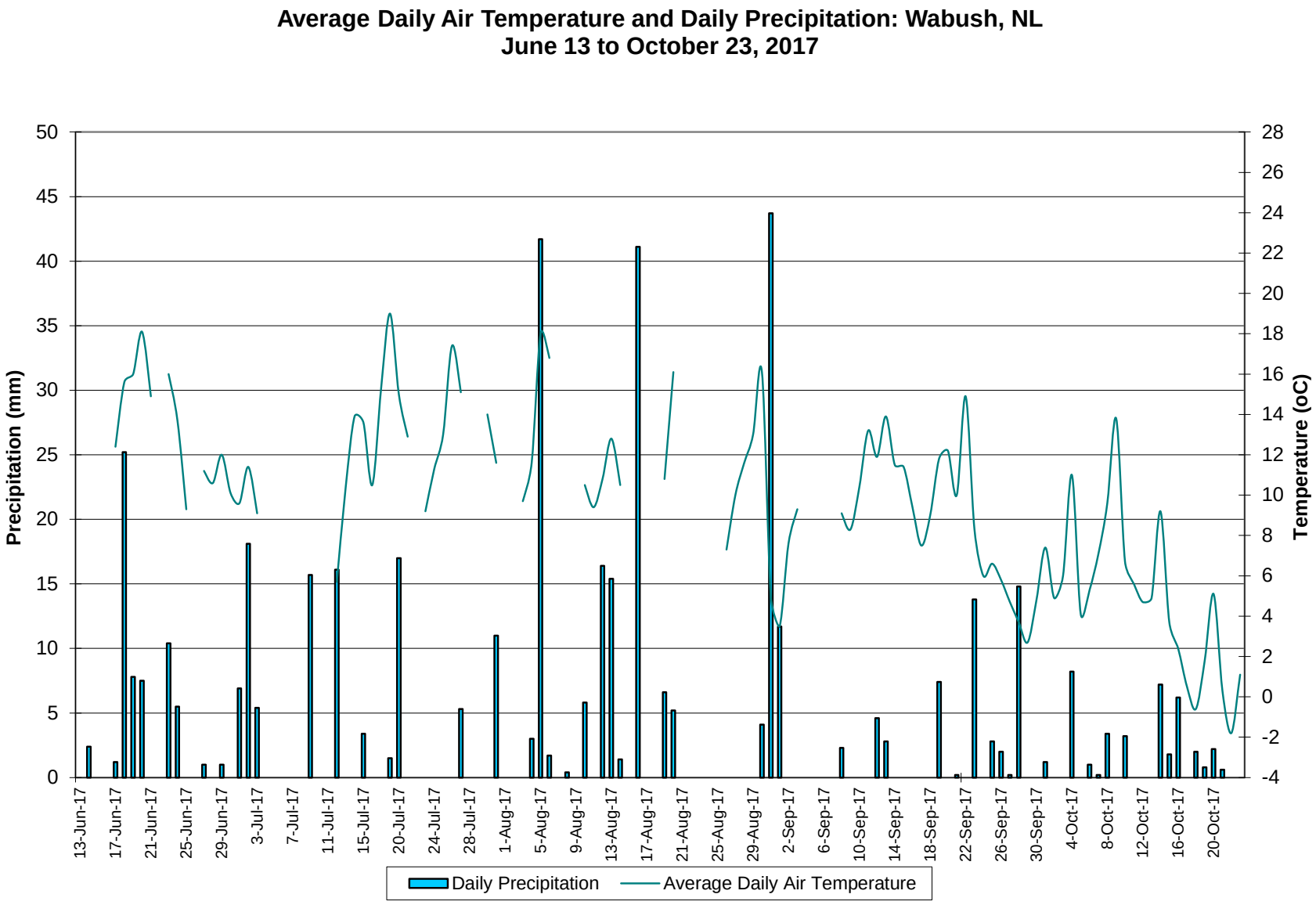
Appendix 1


Average Daily Air Temperature and Daily Precipitation: Wabush, NL
June 13 to October 23, 2017
Precipitation (mm)
Temperature (oC)
0
5
10
15
20
25
30
35
40
45
50
-4
-2
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
13-Jun-17
17-Jun-17
21-Jun-17
25-Jun-17
29-Jun-17
3-Jul-17
7-Jul-17
11-Jul-17
15-Jul-17
20-Jul-17
24-Jul-17
28-Jul-17
1-Aug-17
5-Aug-17
9-Aug-17
13-Aug-17
17-Aug-17
21-Aug-17
25-Aug-17
29-Aug-17
2-Sep-17
6-Sep-17
10-Sep-17
14-Sep-17
18-Sep-17
22-Sep-17
26-Sep-17
30-Sep-17
4-Oct-17
8-Oct-17
12-Oct-17
16-Oct-17
20-Oct-17
Daily Precipitation
Average Daily Air Temperature