Real-Time Water Quality Deployment Report

Lower Churchill River Network

May 27 to June 25, 2015

Newfoundland Labrador

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

Contents

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Real Time Water Quality Monitoring

- Department of Environment and Conservation staff monitors the real-time water quality data on a regular basis.
- This deployment report discusses water quality related events occurring at four stations on the Lower Churchill River: below Grizzle Rapids, above and below Muskrat Falls and at English Point.
- There was no instrument deployed at the station on Lake Melville east of Little River. Instrument deployments at this station have been suspended until a buoy system can be established at this site.
- On May 27, 2015, real-time water quality monitoring instruments were deployed at two of the Lower Churchill River Stations for a period of 27 & 28 days. The station below Lower Muskrat Falls was not deployed due to continued issues with sand at the site which could damage the instrument. The station below Grizzle Rapids was not deployed as the station was inaccessible due to spring ice.

Quality Assurance and Quality Control

- As part of the Quality Assurance and Quality Control protocol (QAQC), an assessment of the reliability of data recorded by an instrument is made at the beginning and end of the deployment period. The procedure is based on the approach used by the United States Geological Survey.
  - ► At deployment and removal, a QAQC Instrument is temporarily deployed along side the Field Instrument. 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 Instrument and QAQC Instrument at deployment and at removal, a qualitative statement is made on the data quality (Table 1).

Table 1: Instrument Performance 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 > 35µS/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 instrument 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

instrument the entire instrument 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 Lower Churchill River stations deployed from May 27 to June 24, 2015 are summarized in Table 2.

Table 2: Comparison rankings for Lower Churchill River stations, May 27 to June 25, 2015

Churchill River Station and Instrument Number	Date	Action	Comparison Ranking				
			Temperature	pH	Conductivity	Dissolved Oxygen	Turbidity
Below Grizzle Rapids	Not deployed	Deployment	N/A	N/A	N/A	N/A	N/A
	Not deployed	Removal	N/A	N/A	N/A	N/A	N/A
Above upper Muskrat Falls (45708)	May 27, 2015	Deployment	Good	Excellent	Excellent	Excellent	Good
	June 24, 2015	Removal	N/A	N/A	N/A	N/A	N/A
Below Muskrat Falls	Not deployed	Deployment	N/A	N/A	N/A	N/A	N/A
	Not deployed	Removal	N/A	N/A	N/A	N/A	N/A
At English Point (45042)	May 27, 2015	Deployment	Fair	Good	Excellent	Good	Poor
	June 25, 2015	Removal	Good	Good	Excellent	Good	Poor

- At the station above Muskrat Falls, pH, specific conductivity and dissolved oxygen all rank 'excellent' while temperature and turbidity rank 'good' at deployment.

  At removal the instrument was out of the water due to the rapid drop in spring water levels, making rankings impossible.

- At the station at English Point, temperature ranked 'fair' while pH and dissolved oxygen ranked 'good', specific conductivity ranked 'excellent' and turbidity ranked 'poor' at deployment. The field turbidity value was 52.0NTU and the QA/QC value was 20.1NTU, while the grab sample value was 7.3NTU. This discrepancy is likely due to sediment being suspended and disturbed around the QA/QC and field sonde as the value was being recorded.

- At removal, temperature, pH, and dissolved oxygen ranked 'good' specific conductivity and dissolved oxygen ranked 'excellent' while turbidity ranked 'poor' upon removal. The field turbidity value was 47.8NTU and the QA/QC value was 16.21NTU. This discrepancy is likely due to sediment being suspended and disturbed around the QA/QC and field sonde as the value was being recorded.

Data Interpretation

- The following graphs and discussion illustrate water quality related events occurring from May 27 to June 25, 2015 on the Lower Churchill River Network.
- With the exception of water quantity data (stage & flow), all data used in the preparation of the graphs and subsequent discussion below adhere to this stringent QAQC protocol. Water Survey of Canada is responsible for QAQC of water quantity data. Corrected data can be obtained upon request.
- The below Grizzle Rapids station was inaccessible due to spring ice.
- The below Muskrat Falls station is experiencing issues with the sediment in the area. The sonde has been repeatedly buried in sand during deployment. To prevent damage to the sonde, this station was not deployed during this period. The instrument will be redeployed should conditions improve in the 2015 field season.

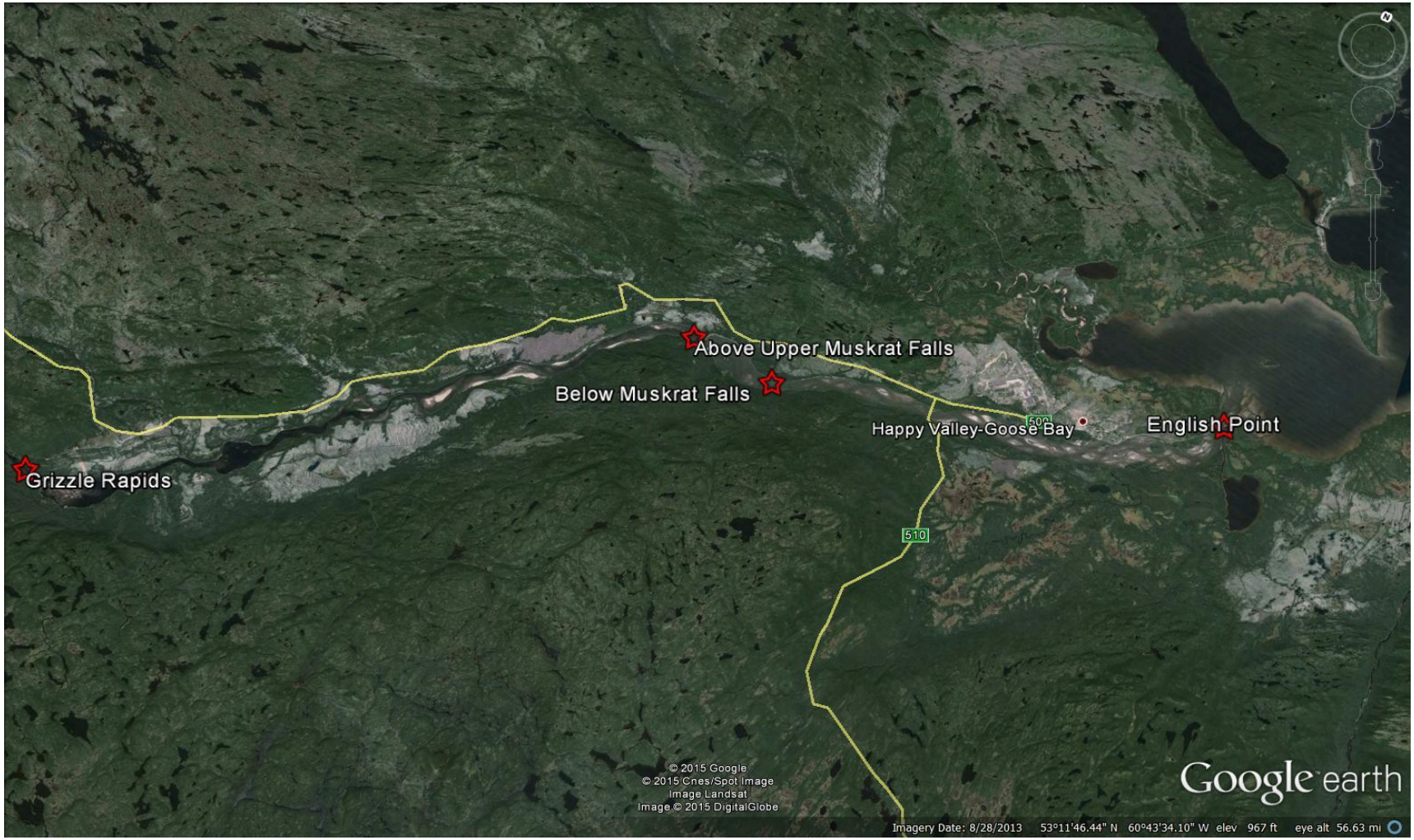

Figure 1: Lower Churchill Network- Station Locations

Churchill River below Grizzle Rapids

- The sonde located at this station was inaccessible on May 27th due to remaining winter ice. It will be deployed in June 2015.
- Stage and precipitation (Muskrat Falls Weather Station) are graphed below to show the relationship between rainfall and water level (Figure 2). Stage decreases during the deployment period. Precipitation occurs on 21 of the days in the deployment period and amounts are generally low, with the exception of the largest event on May 30th with 22.35mm of rain. Stage ranges between 34.52m and 33.45m, and a decrease of 1.07m in stage occurred over this period.
- Water Survey of Canada (Environment Canada) is responsible for QAQC of water quantity data (stage and flow). Corrected data can be obtained upon request.

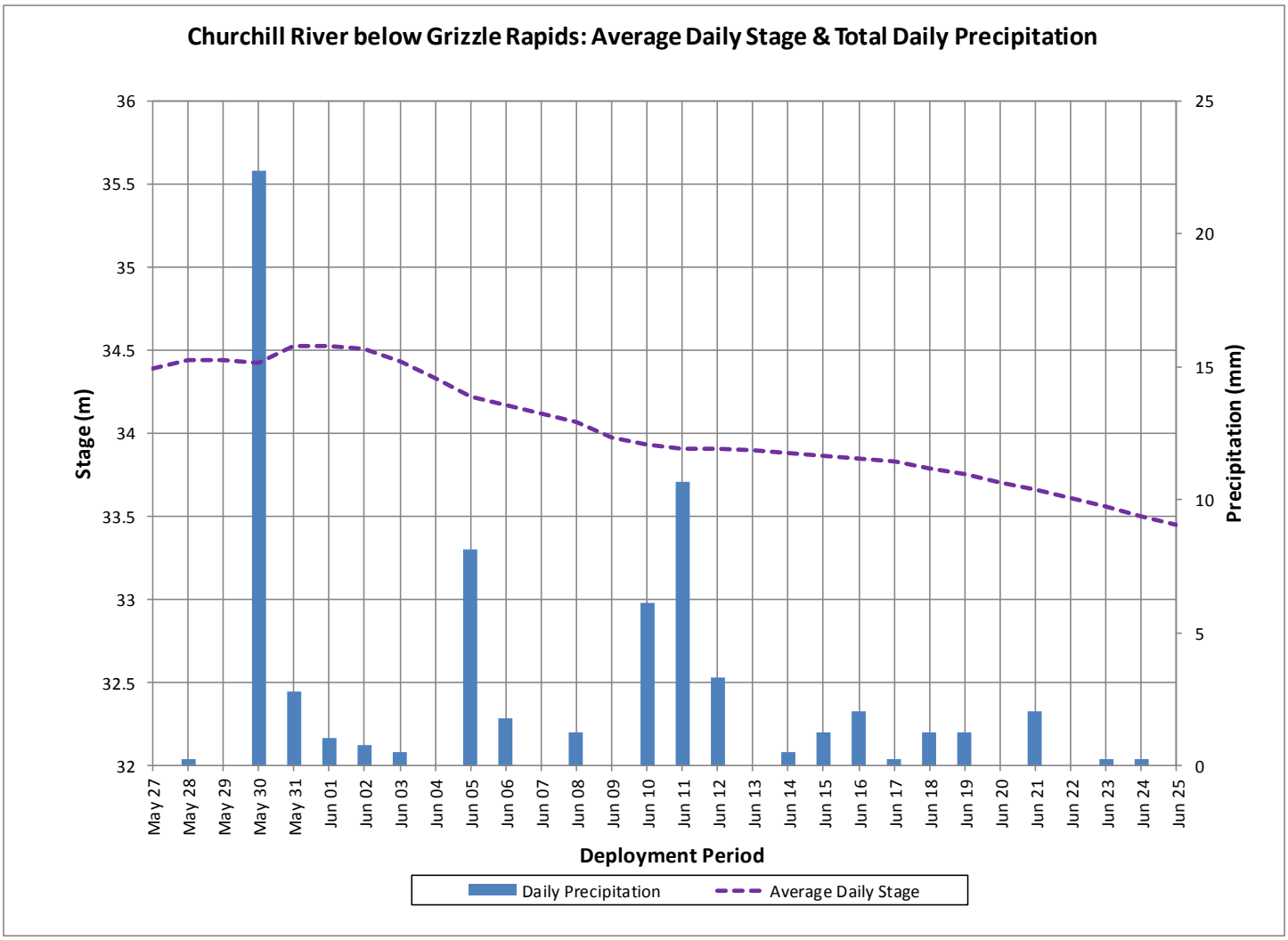

Figure 2: Average Stage & Total Daily Precipitation (Muskrat Falls Weather Station) at Churchill Falls below Grizzle Rapids Station

Figure 3: May 2015 – Grizzle Rapids ice build-up, inaccessible

Churchill River above upper Muskrat Falls

- Water temperature ranges from 2.83°C to 6.97°C with a median value of 4.79°C (Figure 4).
- Water temperature is gradually increasing throughout the deployment period. This trend is expected as air temperatures warms in the spring and summer months.
- The instrument was found out of the water upon removal; the data collected during this time is not reflective of the aquatic environment.

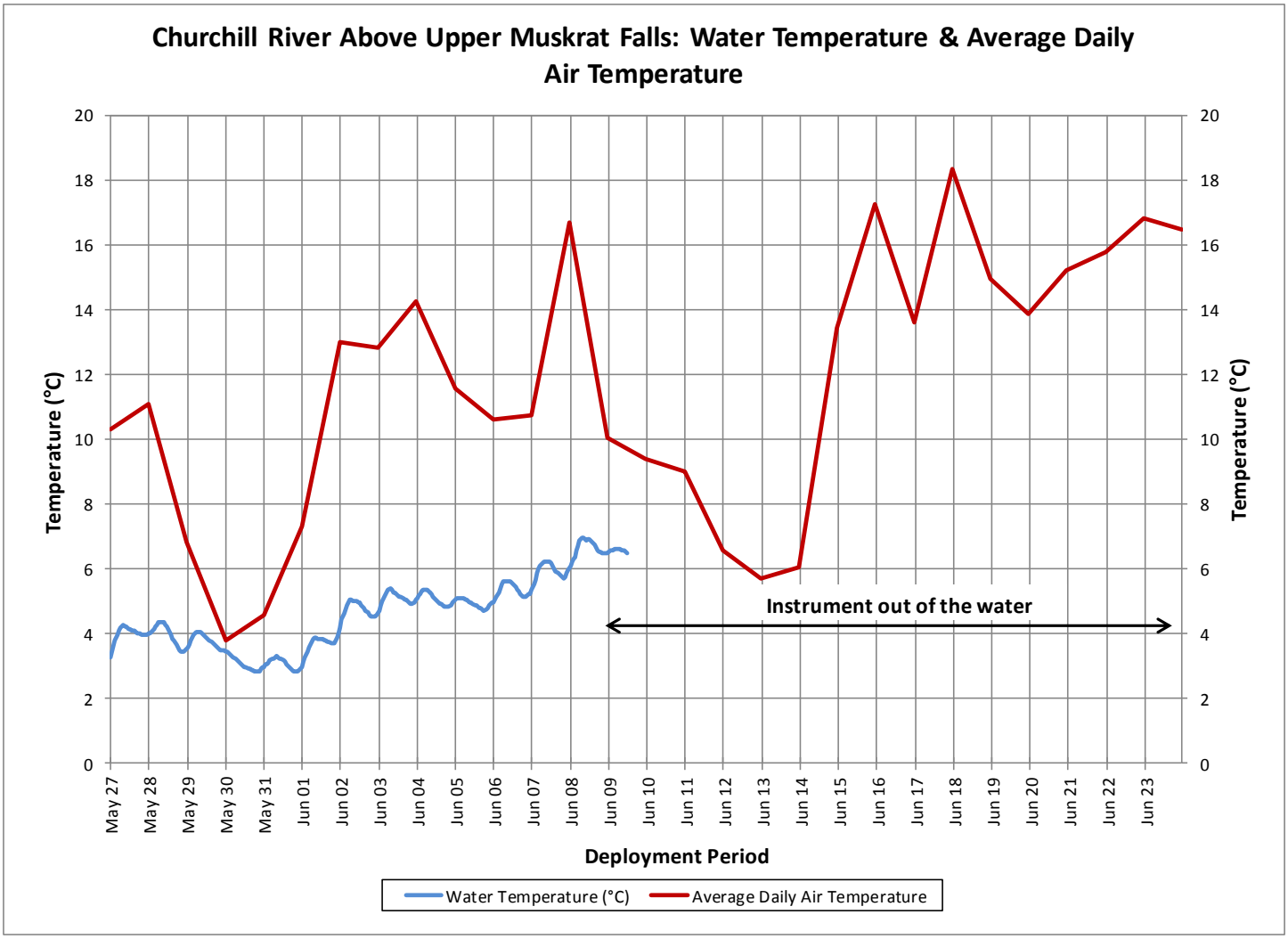

Figure 4: Water temperature and daily average air temperature (Muskrat Falls Weather Station) at Churchill River above upper Muskrat Falls Station

- pH ranges between 6.60 and 6.78 pH units with a median value of 6.63 (Figure 5).
- pH values are relatively stable and fall within the CCME Protection of Aquatic Life Guidelines .
- The instrument was found out of the water upon removal; the data collecte4d during this time is not reflective of the aquatic environment.

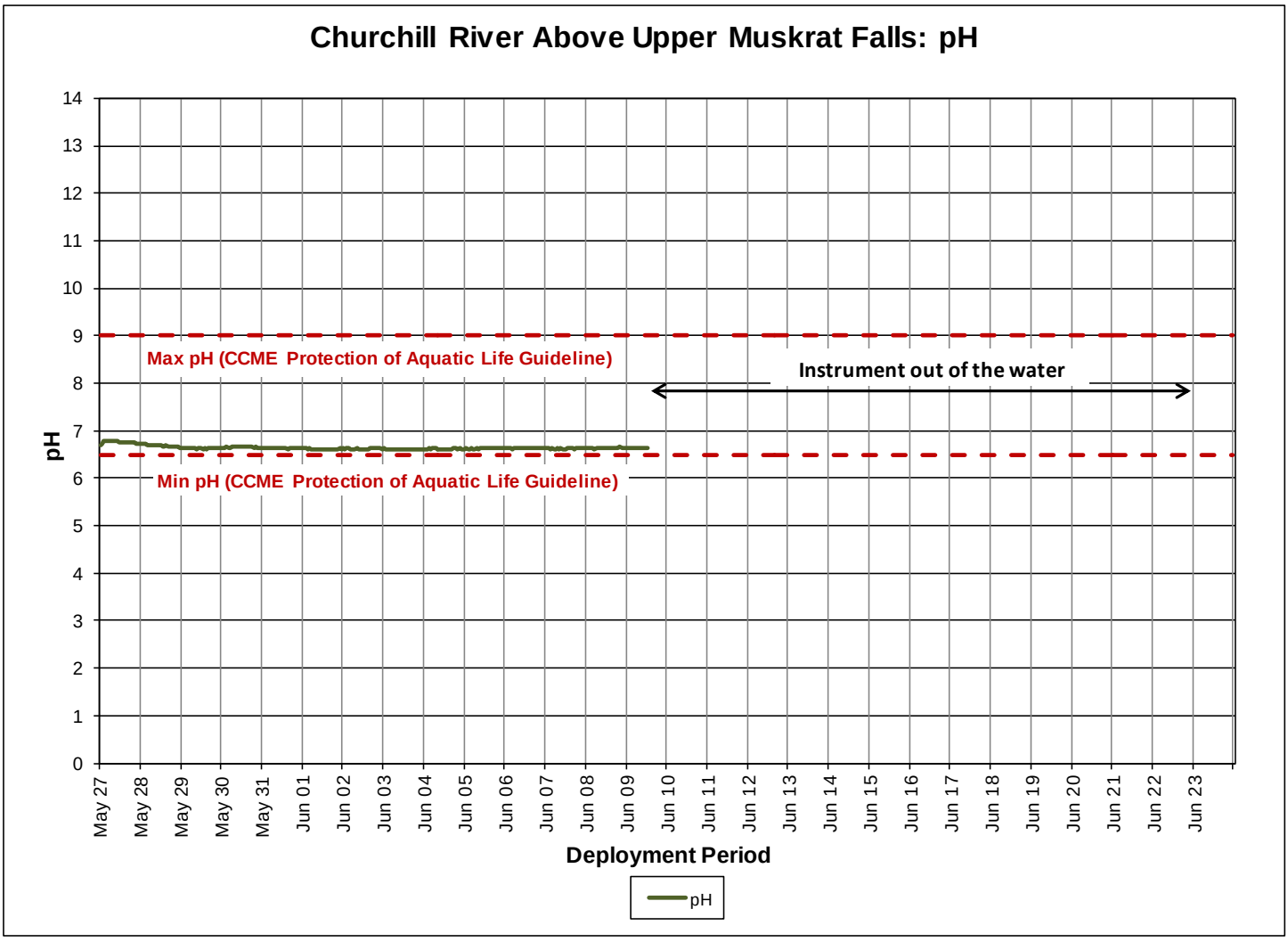

Figure 5: pH values at Churchill River above upper Muskrat Falls Station

- Specific conductivity ranges from 8.3µS/cm to 10.2µS/cm with a median of 9.1µS/cm. (Figure 6).
- TDS (total dissolved solids) ranges from 0.0053 g/L to 0.0065 g/L with a median of 0.0058 g/L (Figure 6).
- Specific conductivity and TDS have a direct relationship but are two separate parameters. Specific conductivity is the ability of the water to conduct electricity. Therefore the value of TDS can be estimated by the conductivity of the water.
- The relationship between conductivity and stage are inversed. When stage level rises, the specific conductance levels drops in response as the increased amount of water in the river system dilutes the solids that are present.
- The instrument was found out of the water upon removal; the data collected during this time is not reflective of the aquatic environment.

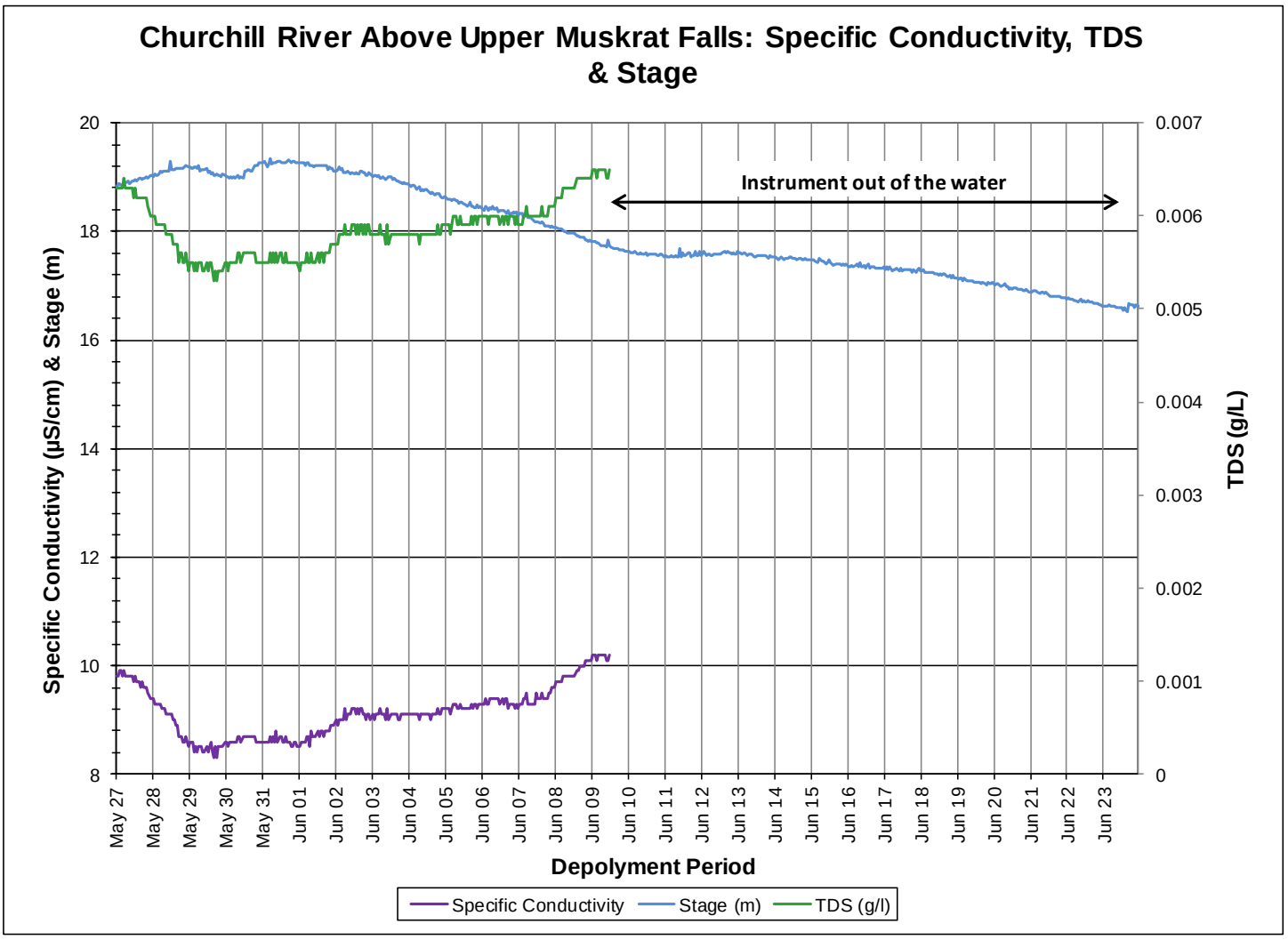

Figure 6: Specific Conductivity & TDS at Churchill River above upper Muskrat Falls Station

- Dissolved oxygen content ranges between 11.50mg/l and 12.77mg/l with a median value of 12.29mg/l. The saturation of dissolved oxygen ranges from 93.4% to 97.7% with a median value of 95.3% (Figure 7).
- There is an evident relationship between water temperature and dissolved oxygen. Over the deployment period the dissolved oxygen levels are slowly falling as temperatures rise into the spring and summer season. Generally there is more dissolved oxygen present in a waterbody during the cooler temperatures.
- The dissolved oxygen levels remained above the CCME Guidelines for the Protection of Early Life Stages and Other Life Stages.
- The instrument was found out of the water upon removal; the data collected during this time is not reflective of the aquatic environment.

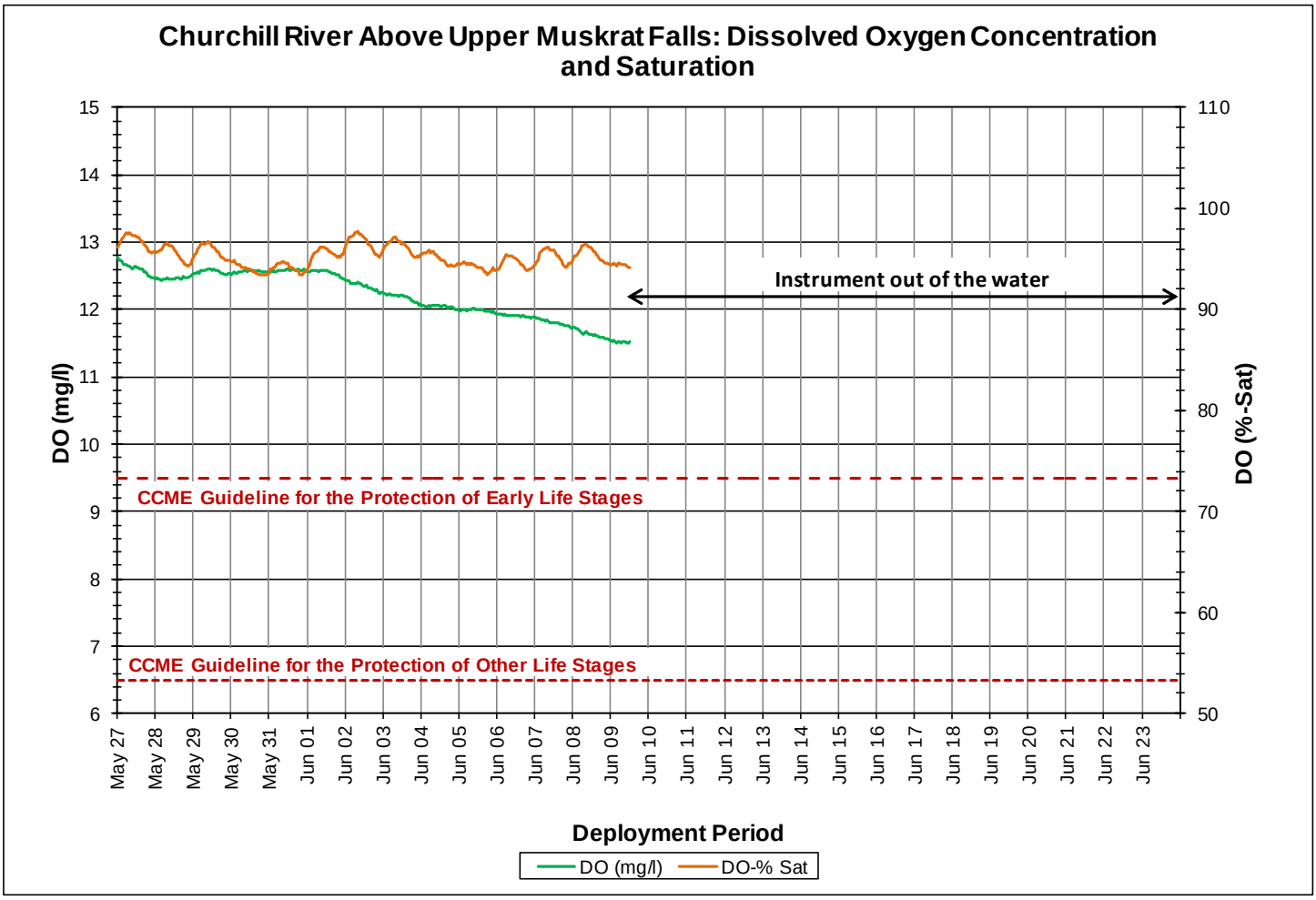

Figure 7: Dissolved Oxygen at Churchill River above upper Muskrat Falls Station

- Chlorophyll ranges between 5.2ug/L and 6.9 ug/L with a median value of 6.3 ug/L (Figure 8).
- Chlorophyll is found within living cells of photosynthetic organisms like phytoplankton and cyanobacteria. The amount of chlorophyll found in water can be used to understand the general biological health of an ecosystem. Chlorophyll can also be used to identify algal bloom events and is an indicator of nutrient loading in ecosystems.
- The chlorophyll values remained steady during the deployment period. Chlorophyll values at the station above Upper Muskrat Falls indicate a Mesotrophic aquatic ecosystem (2.6. ug/L to 7.3 ug/L). Mesotrophic water ecosystems have moderate productivity and are commonly clear with medium levels of nutrients, and some macrophyte (submergent, emergent, and floating) coverage.
- The instrument was found out of the water upon removal; the data collected during this time is not reflective of the aquatic environment.

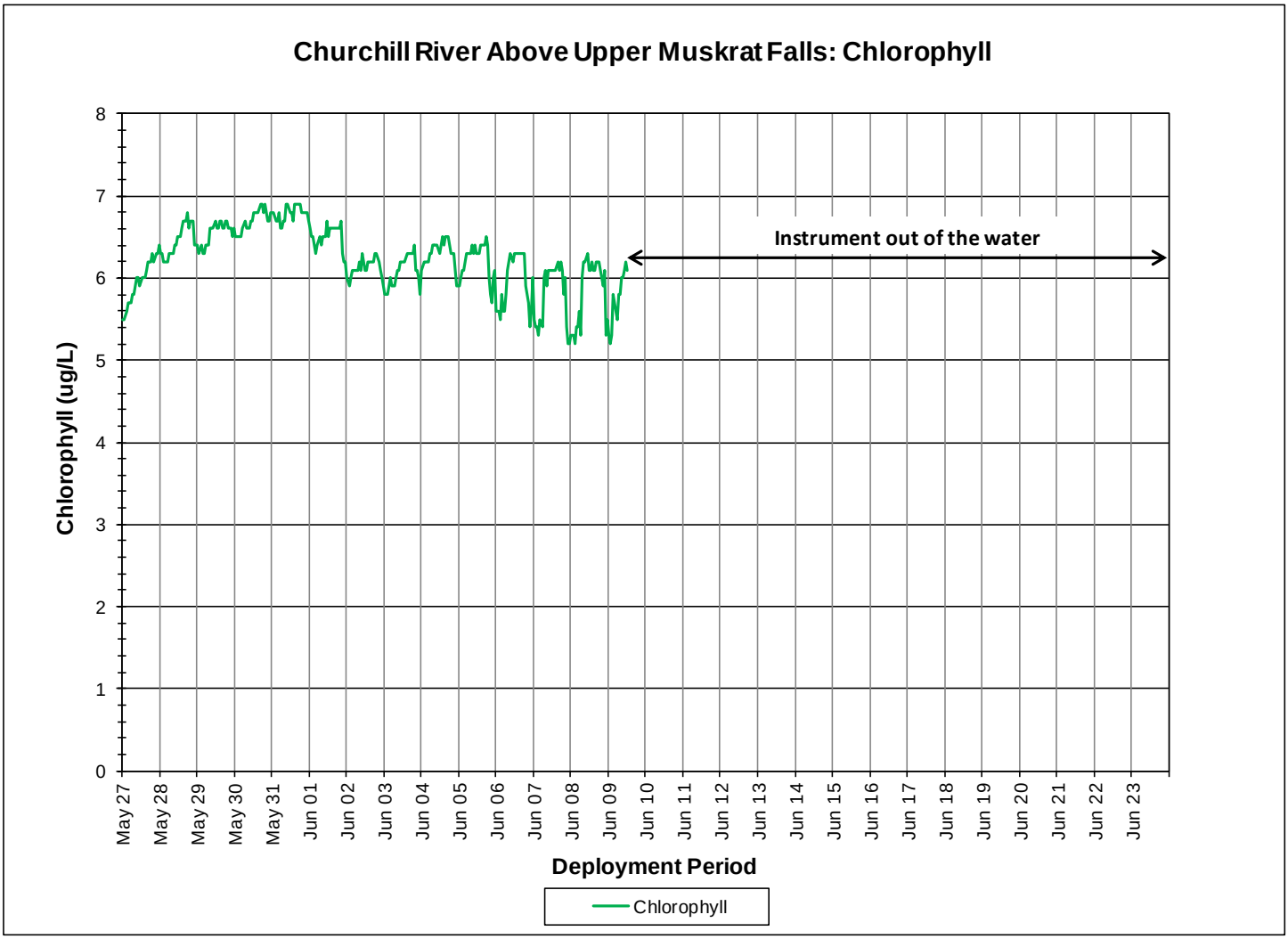

Figure 8: Chlorophyll at Churchill River above upper Muskrat Falls Station

- Turbidity ranges between 10.9NTU and 31.7NTU with a median value of 15.7NTU (Figure 9).
- The turbidity sensor on this instrument can read values between 0NTU and 3000NTU. However a reading of 3000 NTU is always identified as an error reading and should not be used as a valid reading or included in any statistical analysis.
- The majority of turbidity events in the deployment period correlate with increases in stage and larger precipitation events. Precipitation can increase the presence of suspended material in water.
- The instrument was found out of the water upon removal; the data collected during this time is not reflective of the aquatic environment

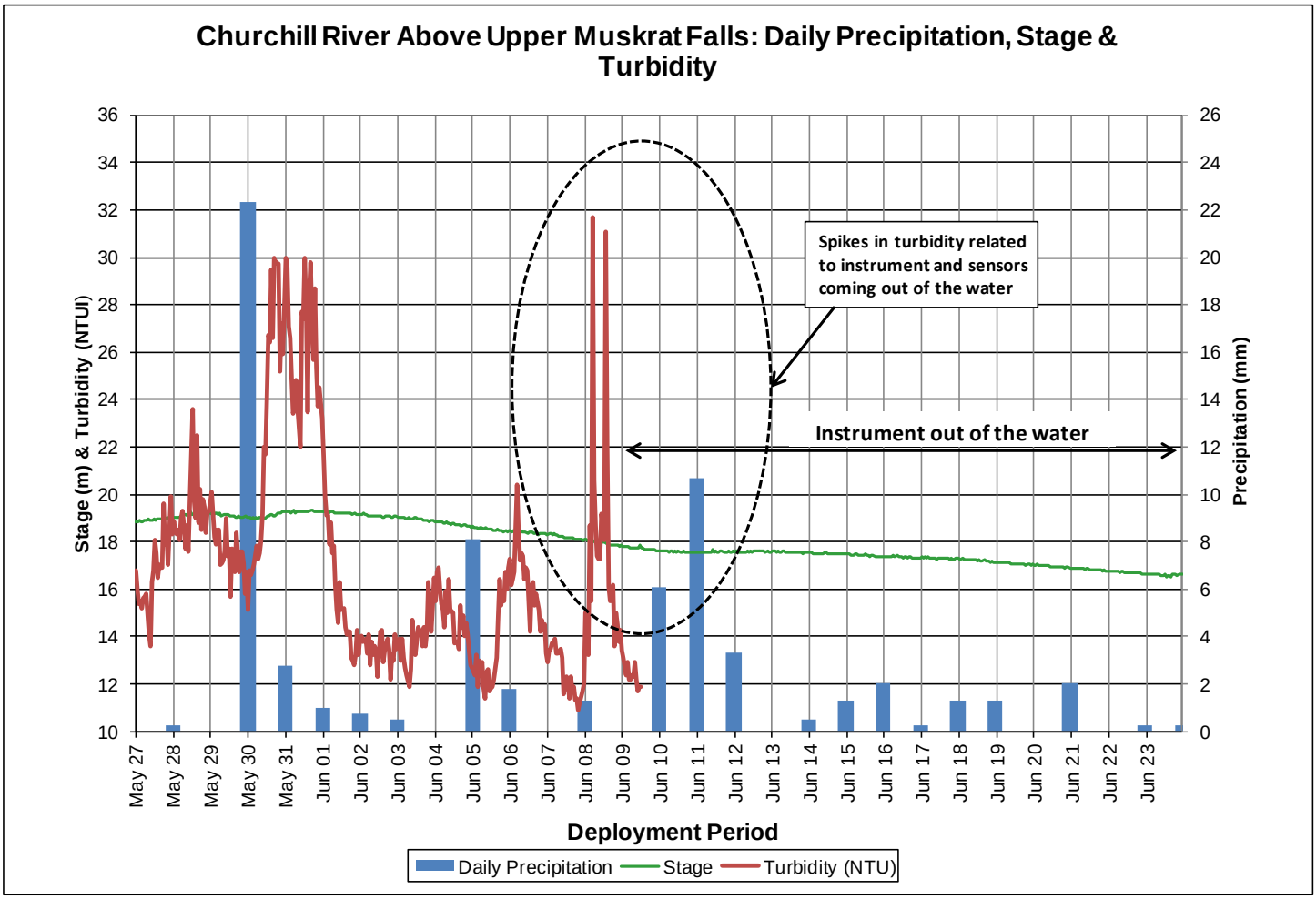

Figure 9: Daily Precipitation, Stage & Turbidity at Churchill River above upper Muskrat Falls Station

- Stage and precipitation (Muskrat Falls Weather Station) are graphed below to show the relationship between rainfall and water level (Figure 10).
- Stage is decreasing throughout the deployment period.
- Precipitation events led to temporary increases in stage. Precipitation occurs on 21 of the days in the deployment period and amounts are generally low, with the exception of the largest event on May 30 with 22.35mm
- Stage ranges between 19.34m to 16.52m resulting in a drop in stage of 2.82m over the course of the deployment period. This drop in water level shows why the field instrument deployed was likely found out of the water at the time of removal. Dramatic decreases in stage at this time of year are common after the spring melt.
- Water Survey of Canada (Environment Canada) is responsible for QAQC of water quantity data (stage and flow). Corrected data can be obtained upon request

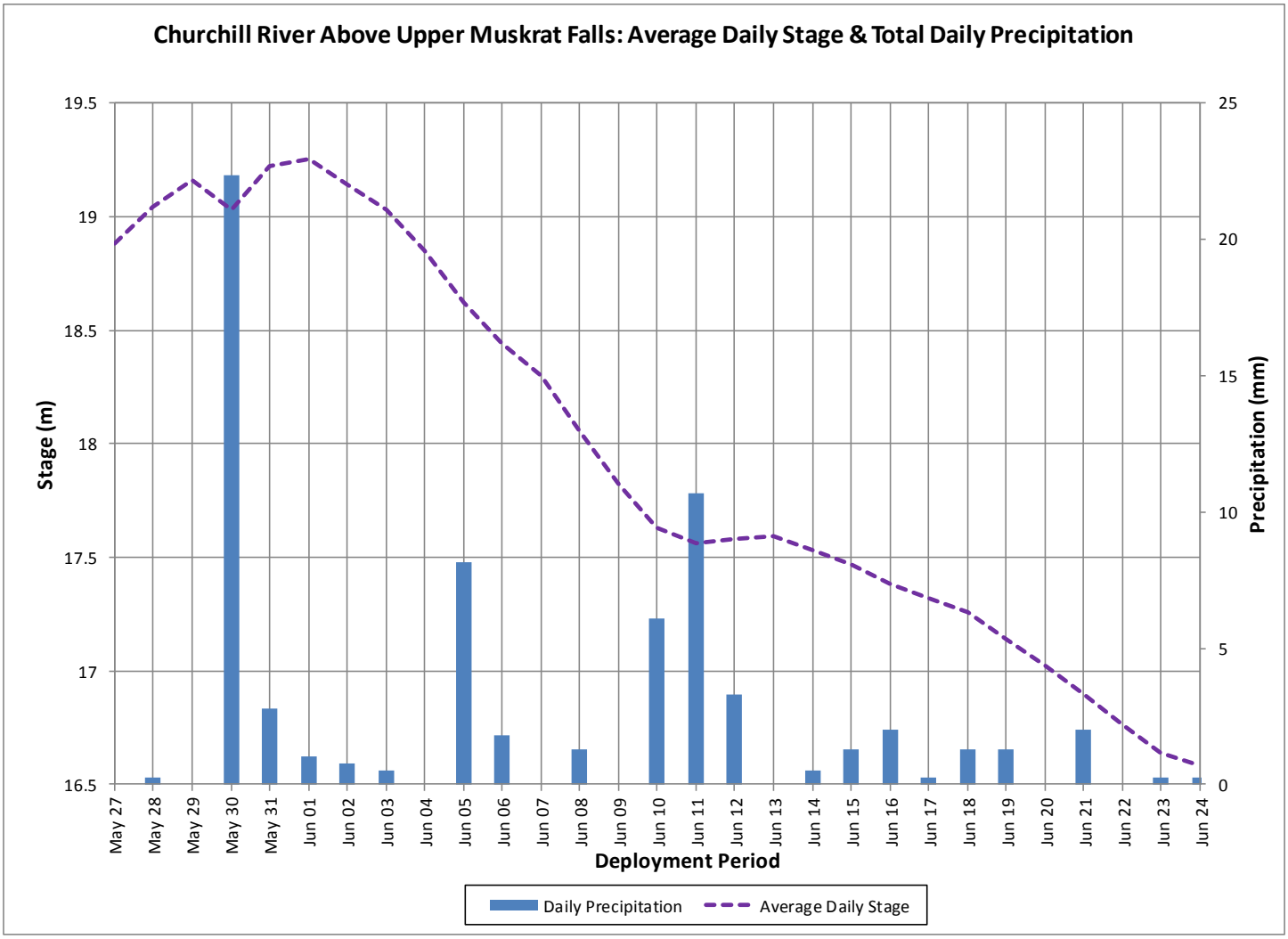

Figure 10: Total Daily Precipitation (Muskrat Falls Weather Station) and Average Daily Stage at Churchill River above upper Muskrat Falls Station

- Stage and flow decrease throughout the deployment period. This is common during this time of the year after the spring melt.
- Stage ranges from 19.34m to 16.52m with a drop of 2.82m (Figure 11).
- Flow ranges from 3681.96m^3/s to 1605.02m^3/s, a lower stage results in less flow through the river.
- Water Survey of Canada (Environment Canada) is responsible for QAQC of water quantity data (stage and flow). Corrected data can be obtained upon request

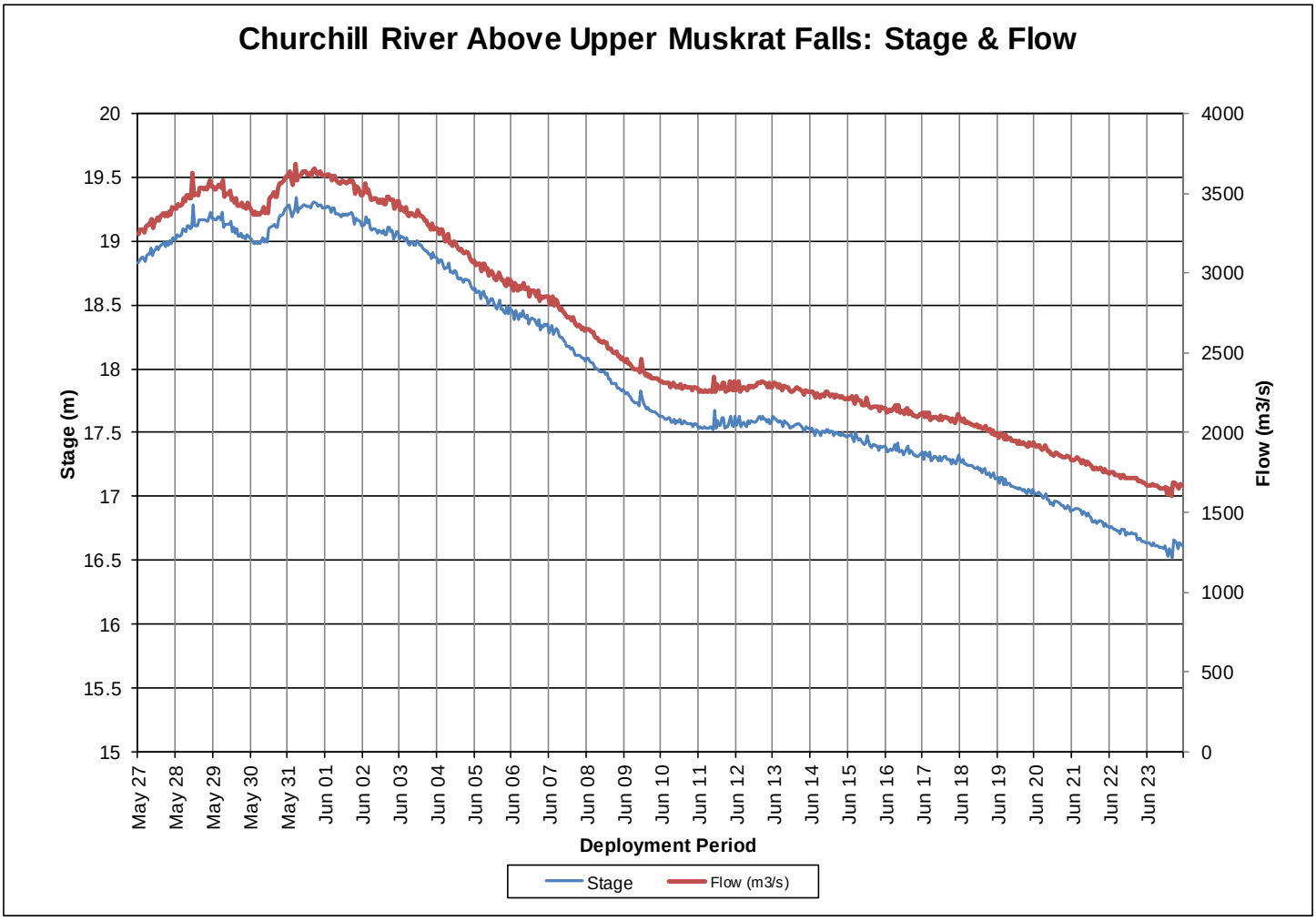

Figure 11: Stage & Flow at Churchill River above upper Muskrat Falls Station

Churchill River below Muskrat Falls

- The sonde located at this station has been repeatedly buried in sand during 2014. The decision to not redeploy the sonde until sand conditions in the area improve was made in August, 2014. The station will be redeployed in the 2015 field season if conditions have improved enough to permit deployment.
- Stage and precipitation (Muskrat Falls Weather Station) are graphed below to show the relationship between rainfall and water level. Stage decreases during the deployment period. Precipitation occurs on 21 of the days in the deployment period and amounts are generally low, with the exception of the largest event on May 30th with 22.35mm of rain. Stage ranges between 4.50 and 2.72, and a decrease of 1.78m in stage occurred over this period (Figure 12).
- Water Survey of Canada (Environment Canada) is responsible for QAQC of water quantity data (stage and flow). Corrected data can be obtained upon request

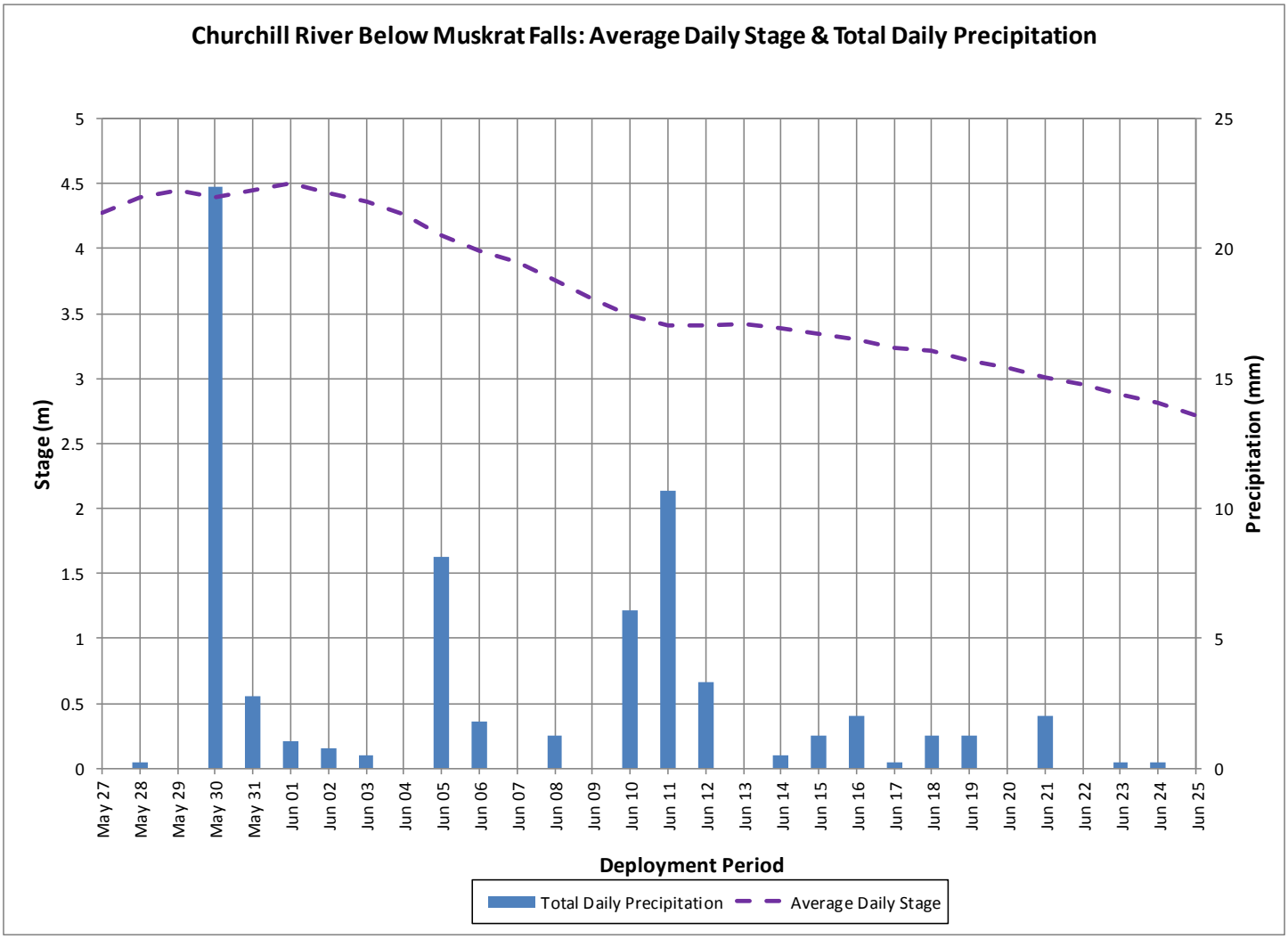

Figure 12: Total Daily Precipitation (Muskrat Falls Weather Station) & Average Daily Stage at Churchill River below Muskrat Falls Station

(a) November 2014 – sand has buried conduit

(b) November 2014 – Helicopter landed on sand bank east of the station

(c) May 2015 – sand along the river bank still an issue

(d) May 2015 – sand along the river bank still an issue

(e) May 2015 – hut has been shifted due to ice and sand movement

(f) May 2015- helicopter landing pad has been shifted off its base

Figure 13: Photos of Churchill River below Muskrat Falls Station

Churchill River at English Point

- Water temperature ranges from 2.20°C to 17.40°C with a median value of 6.95°C (Figure 14).
- Water temperature is steadily increasing throughout this deployment period. This trend is expected as ambient air temperatures warms into the summer months. Water temperature fluctuates diurnally.

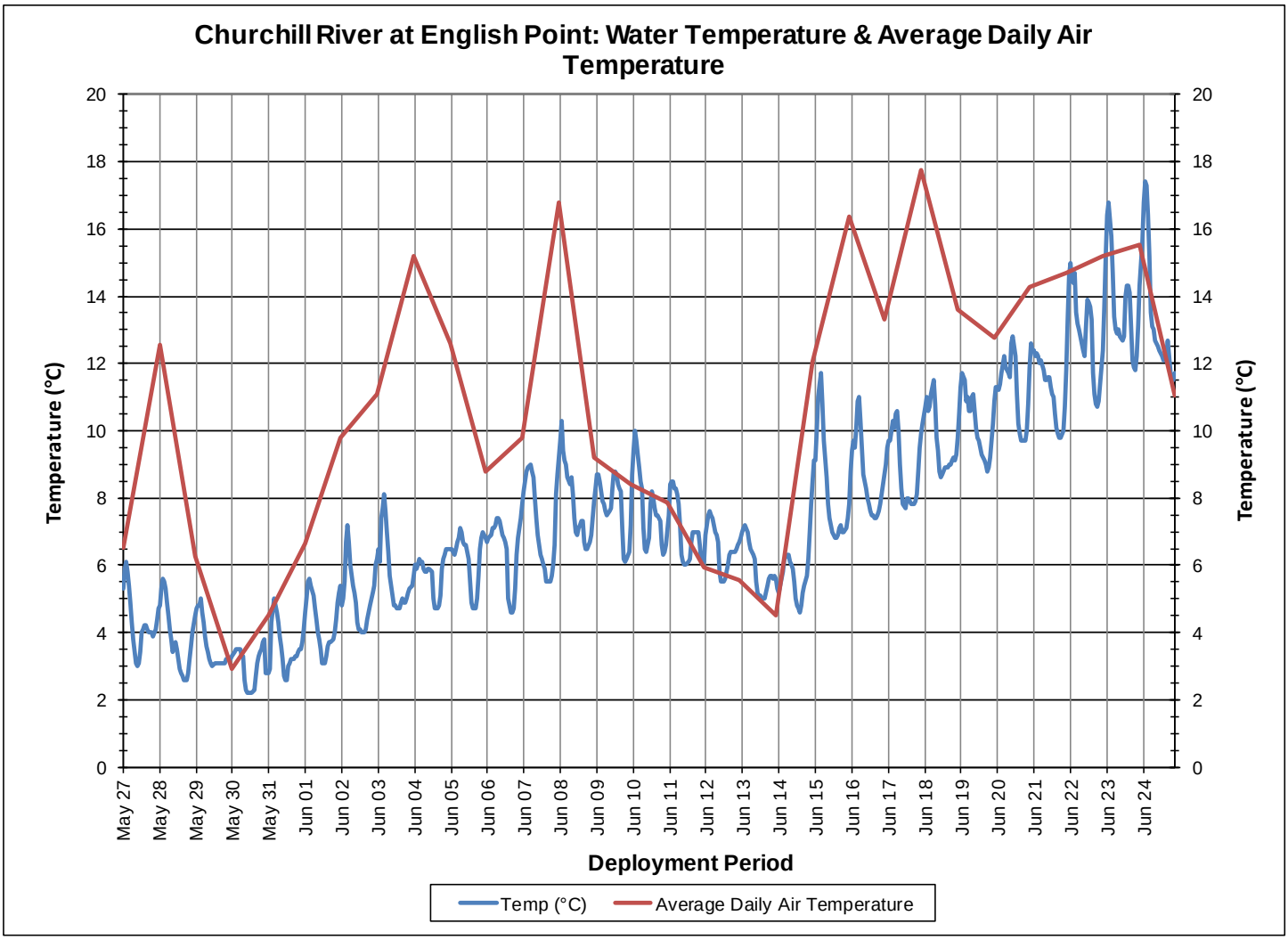

Figure 14: Water Temperature & Average Daily Air Temperature (Mud Lake Weather Station) at Churchill River at English Point Station

- pH ranges between 6.09 and 6.80 pH units with a median value of 6.42 (Figure 15)
- All pH values recorded during this deployment period hovered around the Min pH CCME protection of Aquatic Life Guidelines of 6.5.
- During deployment the QA/QC ranking for the pH sensor was 'good' with a field value of 6.07 compared to the QA/QC sonde's 6.38, and the grab sample's 7.11. The pH was slow to acclimate, rising slowly to 6.80 but never reaching the value of the grab sample.
- Upon removal the QA/QC ranking for the pH sensor was 'good' with a field value of 6.63 compared to the QA/QC sonde's 6.85, and the grab sample's 6.99.

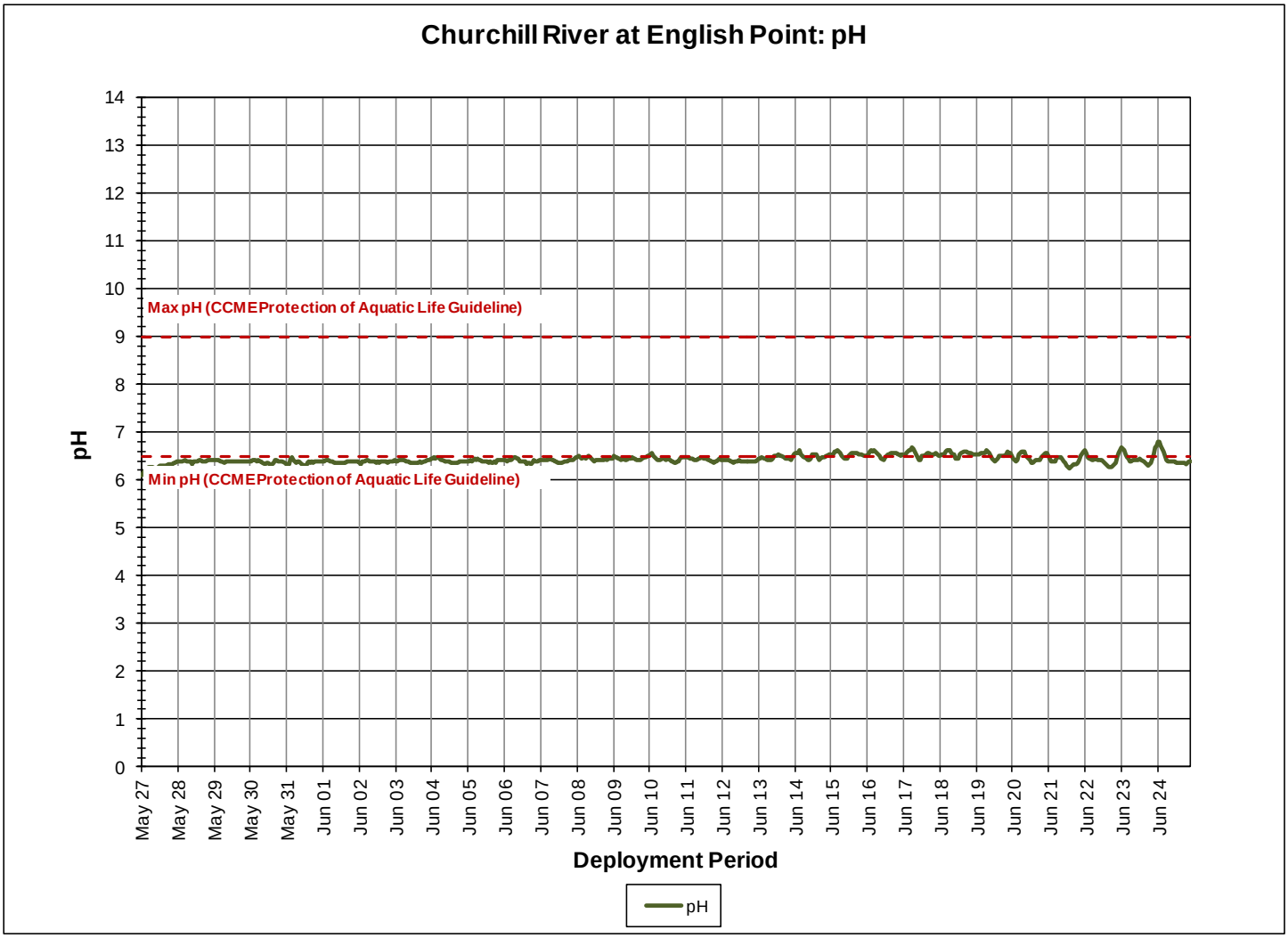

Figure 15: pH at Churchill River at English Point Station

- Specific conductance ranges between 10.3µS/cm and 53.5µs/cm during the deployment period, with a median of 29.2µS/cm (Figure 16).
- TDS ranges between 0.0342 g/mL to 0.0066 g/mL during the deployment period, with a median of 0.0180 g/mL (Figure 116).
- Specific conductivity fluctuates considerably at this location due to the tidal influences of the Atlantic Ocean. As the tide comes in, the specific conductivity increases as the dissolved solids and salinity increase, and vice versa as the tide goes out. This increase and decrease in specific conductivity and stage occurs twice daily. This pattern is generally consistent throughout the deployment period (Figure 17).

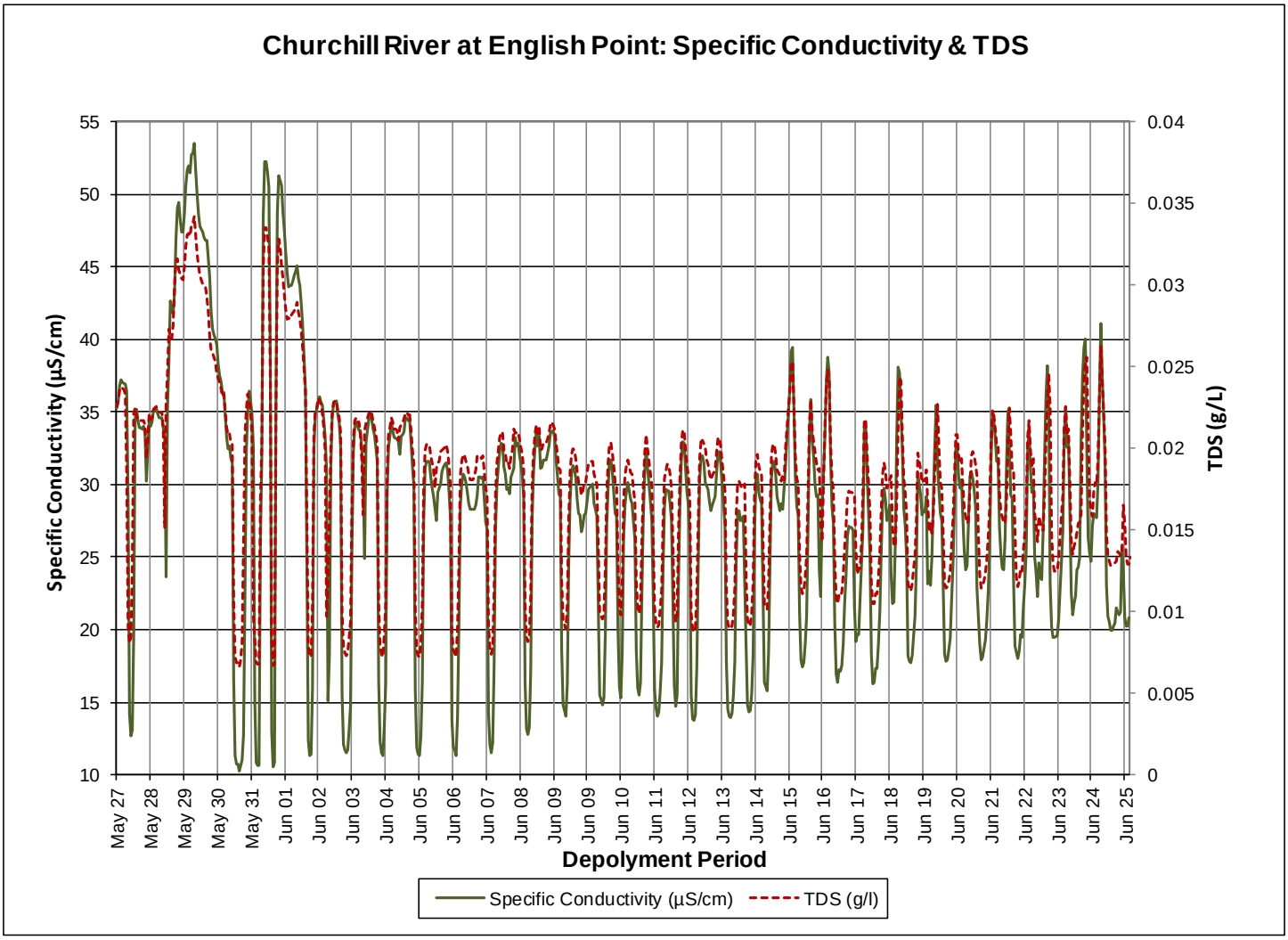

Figure 16: Specific Conductivity & TDS at Churchill River at English Point Station

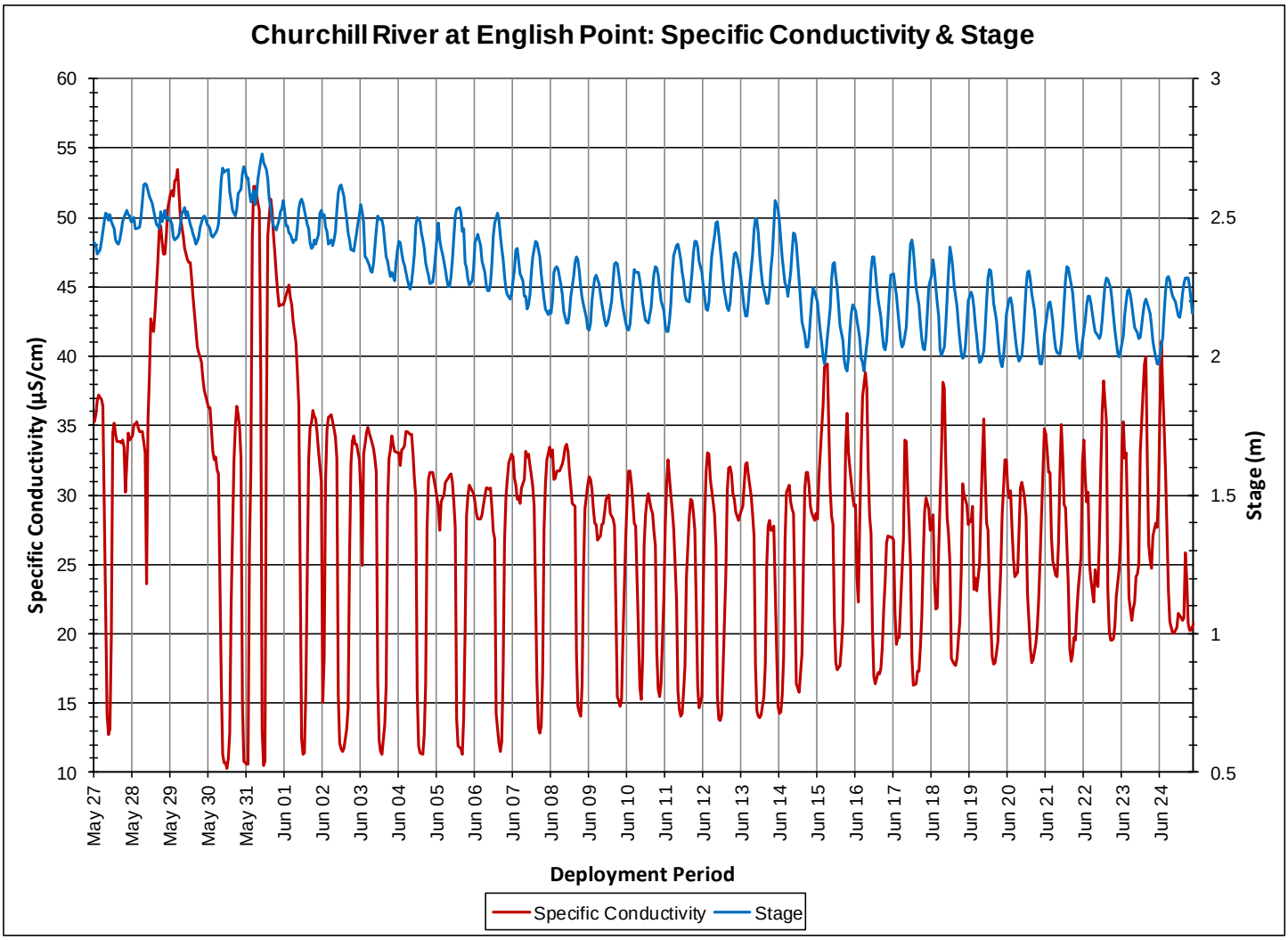

Figure 17: Specific Conductivity and Stage at Churchill River at English Point Station

- Dissolved oxygen content ranges between 9.31mg/l and 13.43mg/l during the deployment period. The saturation of dissolved oxygen ranges from 73.8% to 112.5% (Figure 18).
- Almost all values were above both the minimum CCME Guidelines for the Protection of Other Life Stages of 6.5mg/l and at Early Life Stages of 9.5mg/l. The guidelines are indicated in red on Figure 18.
- Briefly on June 24th the dissolved oxygen reaches below 9.5mg/L.

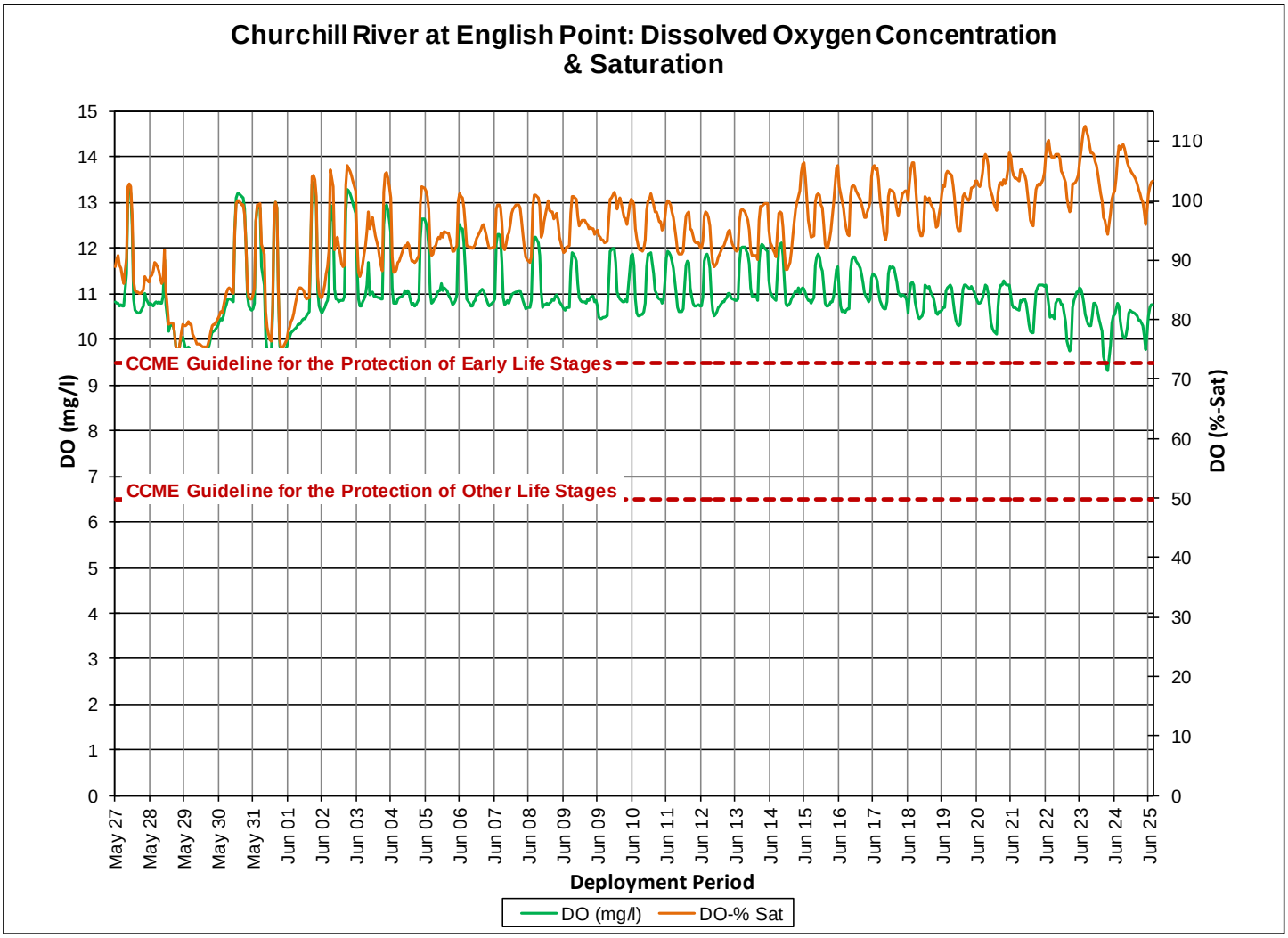

Figure 18: Dissolved Oxygen at Churchill River at English Point Station

- Turbidity ranges from 10.6NTU to 359.5NTU during the deployment period, with a median value of 33.4NTU (Figure 19).
- The majority of turbidity events in the deployment period correlate with increases in stage and larger precipitation events. Precipitation can increase the presence of suspended material in water (Figure 19)
- Stage fluctuates considerably at this location due to the tidal influences of the Atlantic Ocean. As the tide comes in, the stage level increases causing tide related turbidity events, and vice versa as the tide goes out. This pattern is generally consistent throughout the deployment period (Figure 20).
- Water Survey of Canada (Environment Canada) is responsible for QAQC of water quantity data (stage and flow). Corrected data can be obtained upon request

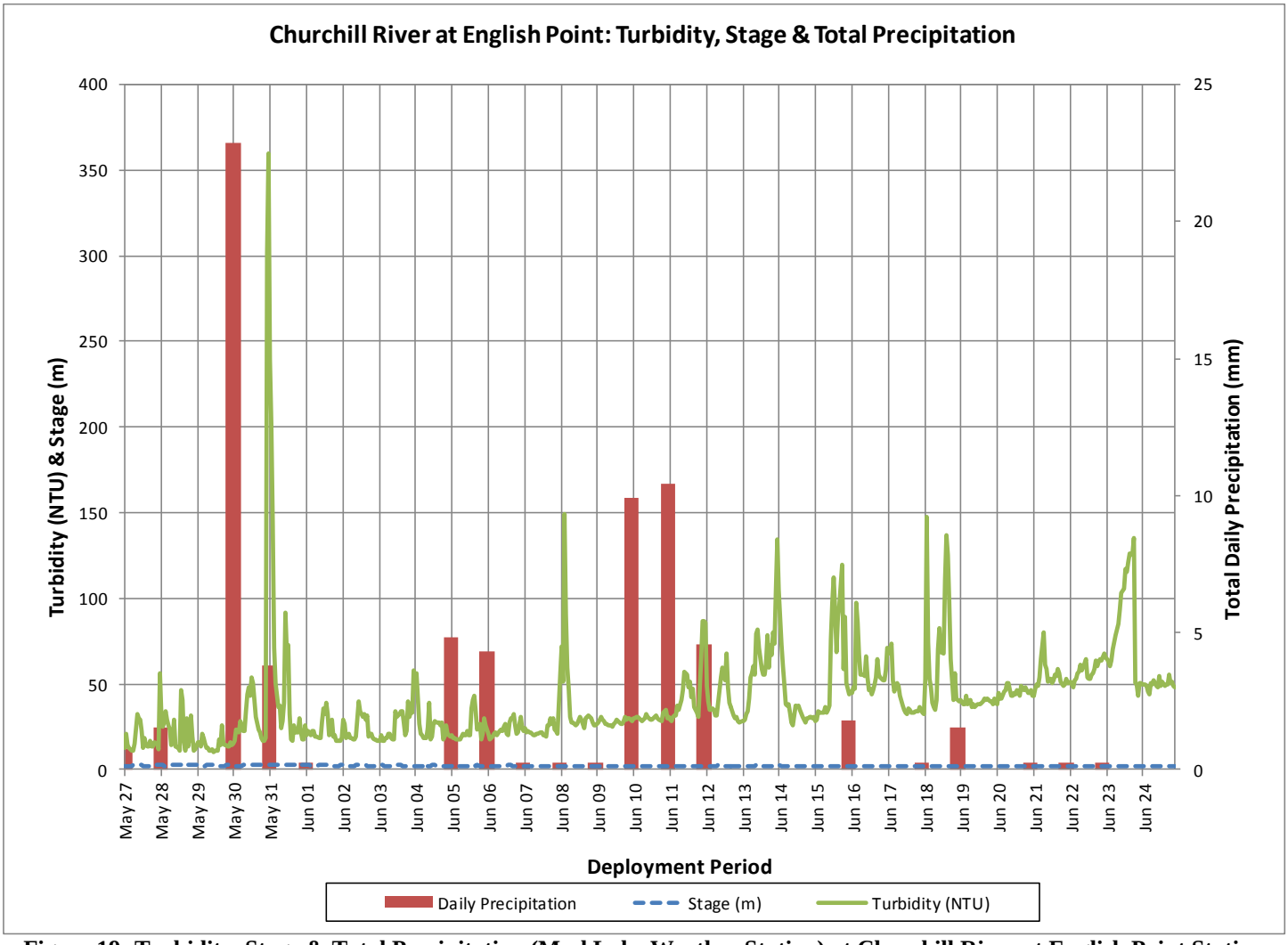

Figure 19: Turbidity, Stage & Total Precipitation (Mud Lake Weather Station) at Churchill River at English Point Station

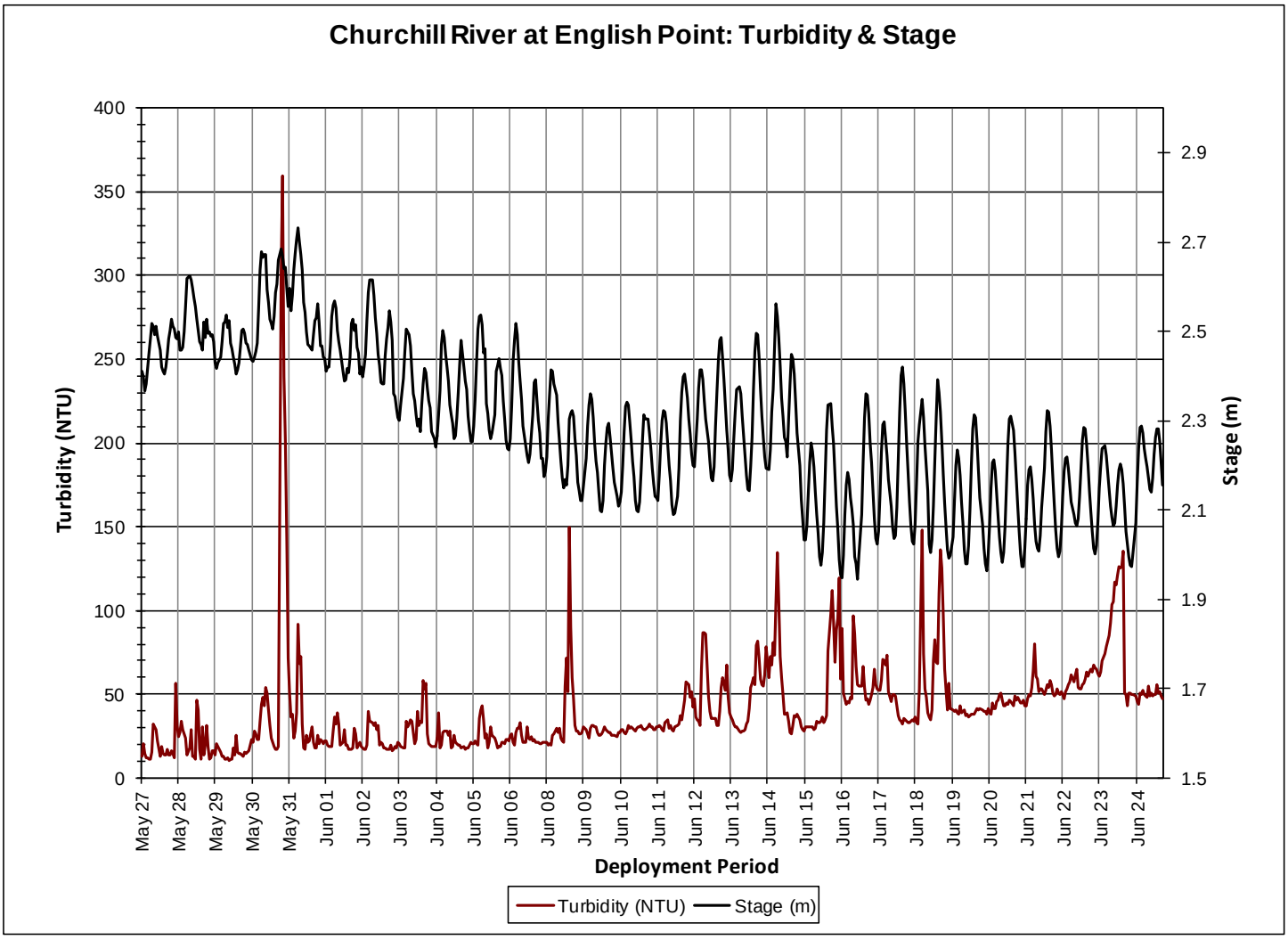

Figure 20: Turbidity & Stage at Churchill River at English Point Station

- Stage and precipitation (from Mud Lake Weather Station) are graphed below to show the relationship between rainfall and water level (Figure 21).

- Stage is fluctuating throughout the deployment period, but peaks after precipitation events. Precipitation occurs on 19 days during the deployment period and amounts are small in magnitude, with the exception of the largest event on May 30th with 22.86mm of rain. Stage ranges between 1.95m and 2.73m.

- Water Survey of Canada (Environment Canada) is responsible for QAQC of water quantity data (stage and flow). Corrected data can be obtained upon request

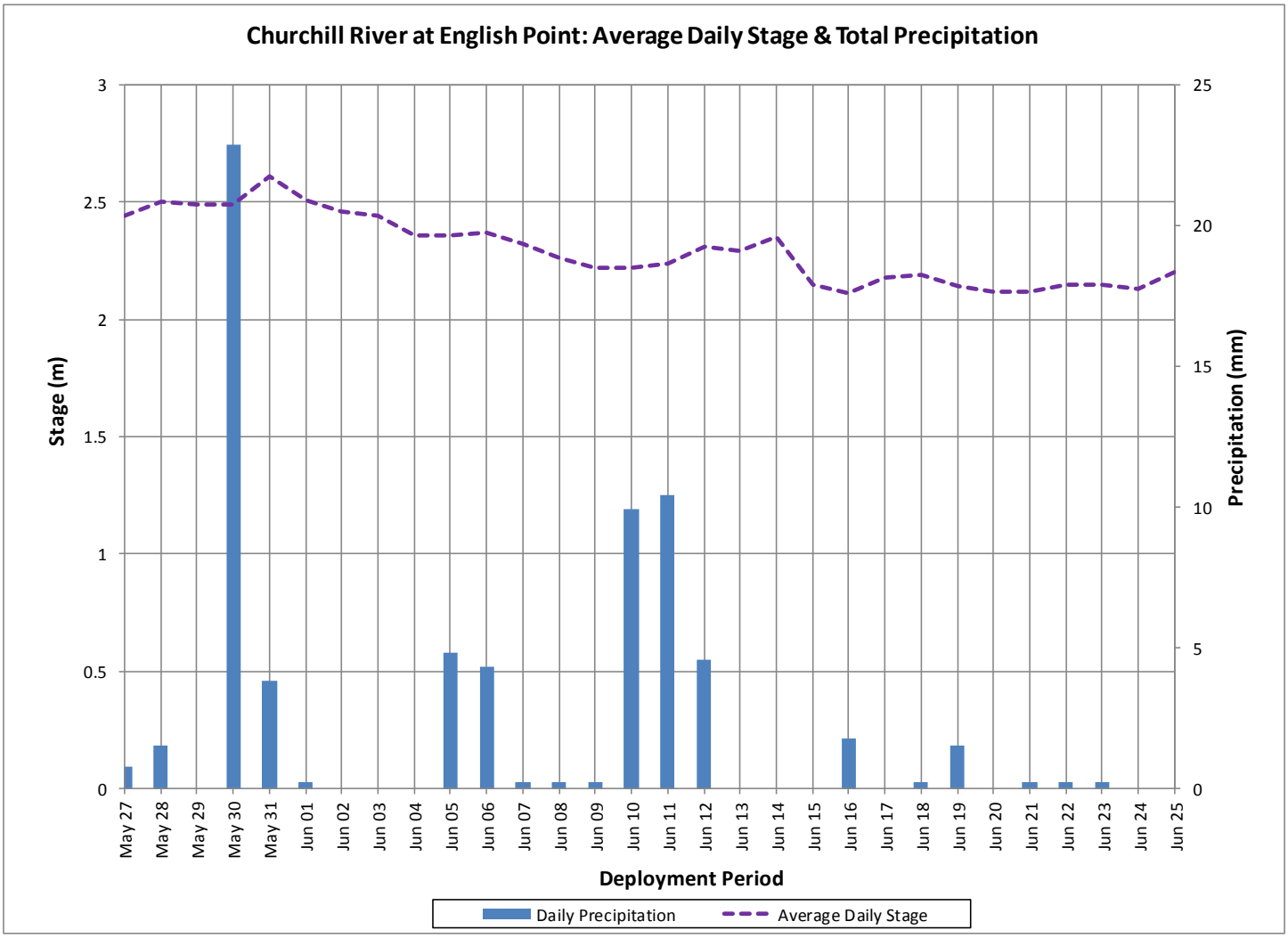

Figure 21: Total Daily Precipitation & Stage at Churchill River at English Point Station

Conclusions

- Instruments at two water quality monitoring stations on the Lower Churchill River were deployed from May 27 to June 25, 2015. The below Grizzle Rapids station and below Lower Muskrat Falls station were not deployed.
- Stage levels are generally decreasing at all stations throughout the deployment as the spring melt ends and we head into the summer months. Water level changes at the each of the stations ranged between 0.78m and 2.82m.
- Water temperature was increasing at all stations throughout the deployment period due to the increasing ambient air temperatures in the region as summer approaches. Water temperature typically ranged between 2.20°C and 17.40°C.
- pH is generally neutral and stable at stations along the Lower Churchill River ranging between 6.09 and 6.80 pH units. The majority of pH values at all stations were within the recommended CCME Guidelines for the Protection of Aquatic Life. Values dropped below the minimum guideline during the deployment period at English Point, but this is likely due to sensor acclimatization.
- Specific conductivity was relatively stable at the station above upper Muskrat Falls regardless of the fluctuating stage levels. All stations showed little variation in values except at English Point, which is influenced by the tides in Lake Melville. Specific conductivity ranged between 8.3µS/cm and 10.2µS/cm at station above upper Muskrat Falls. Specific conductivity values at the station at English Point ranged higher at 10.3µS/cm to 53.5µS/cm.
- Dissolved oxygen was relatively stable throughout the deployment period at above upper Muskrat Falls. Since the instrument was not in the water for the entire deployment we cannot see the effect of increased water temperature on the dissolved oxygen at this location. Dissolved oxygen was decreasing at English Point with the increase of ambient air and water temperatures. Values ranged between 9.31mg/l and 13.43mg/l.
- Turbidity data at above upper Muskrat Falls experienced several turbidity events related to precipitation events. In addition, due to the spring melt and changing of stage the instrument was likely exposed to mixing sediment. A median value of 15.7NTU was recorded during the deployment period. English Point experienced a median value of 33.4NTU during the deployment period. There is known consistent background turbidity at this station due to the substrate at the location, tidal wave action, and precipitation events.

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- Volunteers Contributing to Our Understanding of Water Quality. Trophic State Equations
  - Online: http://www.secchidipin.org/index.php/monitoring-methods/trophic-state-equations/

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 newly calibrated QA/QC water quality instrument (i.e., QA/QC Sonde) is temporarily deployed *in-situ* and along side the newly calibrated Field Sonde. A grab sample is also taken from the water body at this time and sent away to a laboratory for analysis. Field Sonde performance ratings for *temperature (^oC)* and *Dissolved Oxygen (% saturation)* are based on differences recorded by the Field Sonde and QA/QC Sonde. Field Sonde performance ratings for *specific conductivity (µS/cm), pH (unit)* and *turbidity (NTU)* are based on differences between Field Sonde readings and grab sample results.
- At the end of the deployment period, water quality parameters are recorded by the Field Sonde before and after a thorough cleaning of its probes. Error caused by *bio-fouling* (E_f) is assessed by comparing these readings with readings made by a newly calibrated QA/QC Sonde, which is temporarily deployed *in-situ* and along side the Field Sonde. An assessment of *instrument drift error* (E_d) is made during laboratory calibration of the Field Sonde, and the two error values are added to give an estimate of total error ($E_t = E_f + E_d$). If E_t exceeds a predetermined data correction criterion, a correction factor is applied to the dataset based on linear interpolation of E_t. The Field Sonde performance is also rated at the end of the deployment period, based on the E_t value.
- Performance ratings are based on differences listed in the table below.

	Rating				
Parameter	**Excellent**	**Good**	**Fair**	**Marginal**	**Poor**
Temperature (^oC)	≤ ±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*

APPENDIX B

Water Parameter Description

- ***Dissolved Oxygen*** - The amount of Dissolved Oxygen (DO) (mg/l or % saturation) in the water is vital to aquatic organisms for their survival. The concentration of DO is affected by such things as water temperature, water depth and flow (e.g., aeration by rapids, riffles etc.), consumption by aerobic organisms, consumption by inorganic chemical reactions, consumption by plants during darkness, and production by plants during the daylight (Allan 2010).
- ***Flow*** – Flow (m3/s) is a measure of how quickly a volume of water is displaced in streams, rivers, and other channels.
- ***pH*** - pH is the measure of hydrogen ion activity and affects: (i) the availability of nutrients to aquatic life; (ii) the concentration of biochemical substances dissolved in water; (iii) the efficiency of hemoglobin in the blood of vertebrates; and (iv) the toxicity of pollutants. Changes in pH can be attributed to industrial effluence, saline inflows or aquatic organisms involved in the photosynthetic cycling of CO_2 (Allan 2010).
- ***Specific conductivity*** - Specific conductivity (μS/cm) is a measure of water's ability to conduct electricity, with values normalized to a water temperature of 25ºC. Specific conductance indicates the concentration of dissolved solids (such as salts) in the water, which can affect the growth and reproduction of aquatic life. Specific conductivity is affected by rainfall events, the composition of inflowing tributaries and their associated geology, saline inflow (e.g., road salt), agricultural run-off and industrial inputs (Allan 2010; Swanson and Baldwin 1965).
- ***Stage*** – Stage (m) is the elevation of the water surface and is often used as a surrogate for the more difficult to measure flow.
- ***Temperature*** - Essential to the measurement of most water quality parameters, temperature (oC) controls most processes and dynamics of limnology. Water temperature is influenced by such things as ambient air temperature, solar radiation, meteorological events, industrial effluence, wastewater, inflowing tributaries, as well as water body size and depth (Allan 2010; Hach 2006).
- ***Total Dissolved Solids*** - Total Dissolved Solids (TDS) (g/l) is a measure of alkaline salts dissolved in water or in fine suspension and can affect the growth and reproduction of aquatic life. It is affected by rainfall events, the composition of inflowing tributaries and their associated geology, saline inflow (e.g., road salt), agricultural run-off and industrial inputs (Allan 2010; Swanson and Baldwin 1965).

Turbidity - Turbidity (NTU) is a measure of the translucence of water and indicates the amount of suspended material in the water. Turbidity is caused by any substance that makes water cloudy (e.g., soil erosion, micro-organisms, vegetation, chemicals, etc.) and can correspond to precipitation events, high stage, and floating debris near the sensor (Allan 2010; Hach 2006; Swanson and Baldwin 1965).

APPENDIX C

Grab Sample Results

REPORT OF ANALYSIS

Lab Report Number: 1509223

Cient:	Department of Environment	**COC Number:**	3368
Attention:	Ms. Melissa McComiskey	**Date Reported:**	2015-06-15
Client Project:	Grands Falls - Windsor	**Date Submitted:**	2015-05-30
Purchase Order:	214004545	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date
1177559	WS-S-0000 CR at Upper MF	2015-6300-00-SI-SP	2015-05-27

Sample comment:

All DOC, TOC and Solids analysed at Edmonton facility. All TKN analysed at Paointe Claire facility.

Report comment:

ANALYTE	UNIT	MRL	RESULT
Alkalinity as CaCO3	mg/L	5	<5
Bromide	mg/L	0.25	<0.25
Chloride	mg/L	1	<1
Colour	TCU	2	49
Conductivity	uS/cm	5	15
Dissolved Organic Carbon	mg/L	0.5	5.0
Fluoride	mg/L	0.10	<0.10
Hardness as CaCO3	mg/L	1	5
N-NH3 (Ammonia)	mg/L	0.02	0.13
N-NO2 (Nitrite)	mg/L	0.10	<0.10
N-NO3 (Nitrate)	mg/L	0.10	<0.10
pH		1.00	6.71
Sulphate	mg/L	1	<1
Total Dissolved Solids (COND - CALC)	mg/L	1	10
Total Kjeldahl Nitrogen	mg/L	0.8	<0.8
Total Organic Carbon	mg/L	0.5	5.6
Total Phosphorus	mg/L	0.01	0.03
Turbidity	NTU	0.1	3.4
Aluminum	mg/L	0.01	0.42
Antimony	mg/L	0.0005	<0.0005
Arsenic	mg/L	0.001	<0.001
Barium	mg/L	0.01	<0.01
Boron	mg/L	0.01	<0.01
Calcium	mg/L	1	2
Cadmium	mg/L	0.0001	<0.0001
Chromium	mg/L	0.001	<0.001

Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

APPROVAL: Nadine Pinsonneault

Exova - 146 Colonnade Road, Unit 8, Ottawa, ON, K2E 7Y1 Tel: 613-727-5692 Fax: 613-727-5222

REPORT OF ANALYSIS

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Client Project:	Grands Falls - Windsor	**Date Submitted:**	2015-05-30
Purchase Order:	214004545	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1177559	WS-S-0000 CR at Upper MF	2015-6300-00-SI-SP	2015-05-27	Copper	mg/L	0.001	0.001
				Iron	mg/L	0.03	0.47
				Lead	mg/L	0.001	<0.001
				Magnesium	mg/L	1	<1
				Manganese	mg/L	0.01	0.02
				Mercury	mg/L	0.0001	<0.0001
				Nickel	mg/L	0.005	<0.005
				Potassium	mg/L	1	<1
				Selenium	mg/L	0.001	<0.001
				Sodium	mg/L	2	<2
				Strontium	mg/L	0.001	0.010
				Uranium	mg/L	0.001	<0.001
				Zinc	mg/L	0.01	<0.01
				Total Suspended Solids	mg/L	1	35

Sample comment:

All DOC, TOC and Solids analysed at Edmonton facility. All TKN analysed at Paointe Claire facility.

Report comment:

Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

APPROVAL:

Nadine Pinsonneault

Exova

REPORT OF ANALYSIS

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Attention:	Ms. Melissa McComiskey	**Date Reported:**	2015-06-15
Client Project:	Grands Falls - Windsor	**Date Submitted:**	2015-05-30
Purchase Order:	214004545	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1177560	WS-S-0000 CR Below MF	2015-6301-00-SI-SP	2015-05-27	Alkalinity as CaCO3	mg/L	5	6
				Bromide	mg/L	0.25	<0.25
				Chloride	mg/L	1	2
				Colour	TCU	2	52
				Conductivity	uS/cm	5	16
				Dissolved Organic Carbon	mg/L	0.5	6.6
				Fluoride	mg/L	0.10	<0.10
				Hardness as CaCO3	mg/L	1	5
				N-NH3 (Ammonia)	mg/L	0.02	0.16
				N-NO2 (Nitrite)	mg/L	0.10	<0.10
				N-NO3 (Nitrate)	mg/L	0.10	<0.10
				pH		1.00	6.82
				Sulphate	mg/L	1	<1
				Total Dissolved Solids (COND - CALC)	mg/L	1	10
				Total Kjeldahl Nitrogen	mg/L	0.8	<0.8
				Total Organic Carbon	mg/L	0.5	6.1
				Total Phosphorus	mg/L	0.01	0.04
				Turbidity	NTU	0.1	4.6
				Aluminum	mg/L	0.01	0.68
				Antimony	mg/L	0.0005	<0.0005
				Arsenic	mg/L	0.001	<0.001
				Barium	mg/L	0.01	0.01
				Boron	mg/L	0.01	<0.01
				Calcium	mg/L	1	2
				Cadmium	mg/L	0.0001	<0.0001
				Chromium	mg/L	0.001	0.001

Sample comment:

Report comment:

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Purchase Order:	214004545	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1177560	WS-S-0000	2015-6301-00-SI-SP	2015-05-27	Copper	mg/L	0.001	0.001
	CR Below MF			Iron	mg/L	0.03	0.68
				Lead	mg/L	0.001	<0.001
Sample comment:				Magnesium	mg/L	1	<1
				Manganese	mg/L	0.01	0.02
				Mercury	mg/L	0.0001	<0.0001
Report comment:				Nickel	mg/L	0.005	<0.005
				Potassium	mg/L	1	<1
				Selenium	mg/L	0.001	<0.001
				Sodium	mg/L	2	<2
				Strontium	mg/L	0.001	0.010
				Uranium	mg/L	0.001	<0.001
				Zinc	mg/L	0.01	<0.01
				Total Suspended Solids	mg/L	1	36

Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

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Exova

REPORT OF ANALYSIS

Lab Report Number: 1509223

Cient:	Department of Environment	**COC Number:**	3368
Attention:	Ms. Melissa McComiskey	**Date Reported:**	2015-06-15
Client Project:	Grands Falls - Windsor	**Date Submitted:**	2015-05-30
Purchase Order:	214004545	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1177562	WS-S-0000 English Point	2015-6303-00-SI-SP	2015-05-27	Alkalinity as CaCO3	mg/L	5	14
				Bromide	mg/L	0.25	<0.25
				Chloride	mg/L	1	4
Sample comment:				Colour	TCU	2	74
				Conductivity	uS/cm	5	43
				Dissolved Organic Carbon	mg/L	0.5	7.5
Report comment:				Fluoride	mg/L	0.10	<0.10
				Hardness as CaCO3	mg/L	1	9
				N-NH3 (Ammonia)	mg/L	0.02	0.16
				N-NO2 (Nitrite)	mg/L	0.10	<0.10
				N-NO3 (Nitrate)	mg/L	0.10	<0.10
				pH		1.00	7.11
				Sulphate	mg/L	1	1
				Total Dissolved Solids (COND - CALC)	mg/L	1	28
				Total Kjeldahl Nitrogen	mg/L	0.8	<0.8
				Total Organic Carbon	mg/L	0.5	7.2
				Total Phosphorus	mg/L	0.01	0.03
				Turbidity	NTU	0.1	7.3
				Aluminum	mg/L	0.01	0.59
				Antimony	mg/L	0.0005	<0.0005
				Arsenic	mg/L	0.001	<0.001
				Barium	mg/L	0.01	0.01
				Boron	mg/L	0.01	<0.01
				Calcium	mg/L	1	2
				Cadmium	mg/L	0.0001	<0.0001
				Chromium	mg/L	0.001	0.001

Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

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Purchase Order:	214004545	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1177562	WS-S-0000 English Point	2015-6303-00-SI-SP	2015-05-27	Copper	mg/L	0.001	0.001
				Iron	mg/L	0.03	0.97
				Lead	mg/L	0.001	<0.001
Sample comment:				Magnesium	mg/L	1	1
				Manganese	mg/L	0.01	0.03
				Mercury	mg/L	0.0001	<0.0001
Report comment:				Nickel	mg/L	0.005	<0.005
				Potassium	mg/L	1	<1
				Selenium	mg/L	0.001	<0.001
				Sodium	mg/L	2	4
				Strontium	mg/L	0.001	0.017
				Uranium	mg/L	0.001	<0.001
				Zinc	mg/L	0.01	<0.01
				Total Suspended Solids	mg/L	1	17

Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

APPROVAL: Nadine Pinsonneault