Real-Time Water Quality Deployment Report

Voisey's Bay Network

September 26 to November 4, 2012

Newfoundland Labrador

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

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Contents

General

- Department of Environment and Conservation staff monitors the real-time web pages regularly.
- This deployment report discusses water quality related events occurring at four stations in the Voisey's Bay Network; Upper Reid Brook, Tributary to Lower Reid Brook, Lower Reid Brook and Camp Pond Brook.
- On September 26, 2012, Vale Environment employees deployed real-time water quality monitoring instruments at the four real time stations in the Voisey's Bay network for a period of 40 days. Instruments were removed by Vale Environment employees for the winter season on November 4.

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: Ranking classifications for deployment and removal

	Rank				
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

- 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 Voisey's Bay Network stations deployed from September 26 to November 4, 2012 are summarized in Table 2.

Table 2: Comparison rankings for Voisey's Bay Network stations, September 26– November 4, 2012

Station Voisey's Bay	Date	Action	Comparison Ranking				
			Temperature	pH	Conductivity	Dissolved Oxygen	Turbidity
Upper Reid Brook (62884)	Sep 26, 2012	Deployment	Excellent	Good	Excellent	Excellent	Excellent
	Nov 4, 2012	Removal	Excellent	Good	Excellent	n/a†	n/a†
Tributary to L. Reid B. (62886)	Sep 26, 2012	Deployment	Excellent	Fair	Good	Excellent	Excellent
	Nov 4, 2012	Removal	Excellent	Good	Good	n/a†	n/a†
Lower Reid Brook (62887)	Sep 26, 2012	Deployment	Excellent	Fair	Good	Excellent	Excellent
	Nov 4, 2012	Removal	Excellent	Excellent	Excellent	n/a†	n/a†
Camp Pond Brook (62885)	Sep 26, 2012	Deployment	Excellent	Fair	Good	Excellent	Excellent
	Nov 4, 2012	Removal	Excellent	Excellent	Good	n/a†	n/a†

†Dissolved oxygen and turbidity sensors on QAQC instrument 62829 was not functioning on November 4, 2012

- At the station at Upper Reid Brook, all parameters ranked either 'good' or 'excellent' at deployment.

  At removal, temperature, pH, and specific conductivity ranked either 'good' or 'excellent'. Dissolved oxygen and turbidity were not ranked due to an error with the sensors on the QAQC instrument.

- At the station on the Tributary to Lower Reid Brook, temperature, specific conductivity, dissolved oxygen and turbidity ranked either 'good' or 'excellent' at deployment while pH ranked 'fair'. For pH, the field instrument read a value of 6.37 and the QAQC instrument read a value of 6.97. By the time the first transmission occurred, pH on the field instrument had increased to 6.83 which when compared to the QAQC instrument yields an 'excellent' ranking.

  At removal, temperature, pH, and specific conductivity ranked either 'good' or 'excellent'. Dissolved oxygen and turbidity were not ranked due to an error with the sensors on the QAQC instrument.

- At the station on Lower Reid Brook, temperature, specific conductivity, dissolved oxygen and turbidity ranked either 'good' or 'excellent' at deployment while pH ranked 'fair'. For pH, the field instrument read a value of 6.42 and the QAQC instrument read a value of 6.95. By the time the first transmission occurred, pH on the field instrument had increased to 6.83 which when compared to the QAQC instrument yields an 'excellent' ranking.

  At removal, temperature, pH, and specific conductivity ranked 'excellent'. Dissolved oxygen and turbidity were not ranked due to an error with the sensors on the QAQC instrument.

- At the station on Camp Pond Brook, temperature, specific conductivity, dissolved oxygen and turbidity ranked either 'good' or 'excellent' at deployment while pH ranked 'fair'. For pH, the field instrument read a value of 6.25 and the QAQC instrument read a value of 7.05. By the time the first transmission occurred, pH on the field instrument had increased to 6.75 which when compared to the QAQC instrument yields an 'good' ranking.

At removal, temperature, pH, and specific conductivity ranked either 'good' or 'excellent'. Dissolved oxygen and turbidity were not ranked due to an error with the sensors on the QAQC instrument.

Data Interpretation

- The following graphs and discussion illustrate significant water quality-related events from September 26 to November 4 in the Voisey's Bay Real Time Water Quality Monitoring Network.
- 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 QAQC protocol. Water Survey of Canada is responsible for QAQC of water quantity data. Corrected data can be obtained upon request.

Upper Reid Brook (Outlet from Reid Pond)

- Water temperature ranges from 4.27 °C to 9.32°C during the deployment period (Figure 1).
- Water temperature is decreasing throughout the first half deployment period. This trend is expected given the cooling ambient air temperatures in the fall season (Figure 2). After October 15, water temperature appears to level off between 4°C and 5.5°C indicating the fall turnover in Reid Pond.
- Water temperature fluctuates diurnally. Average water temperature is 6.21°C for the deployment period.

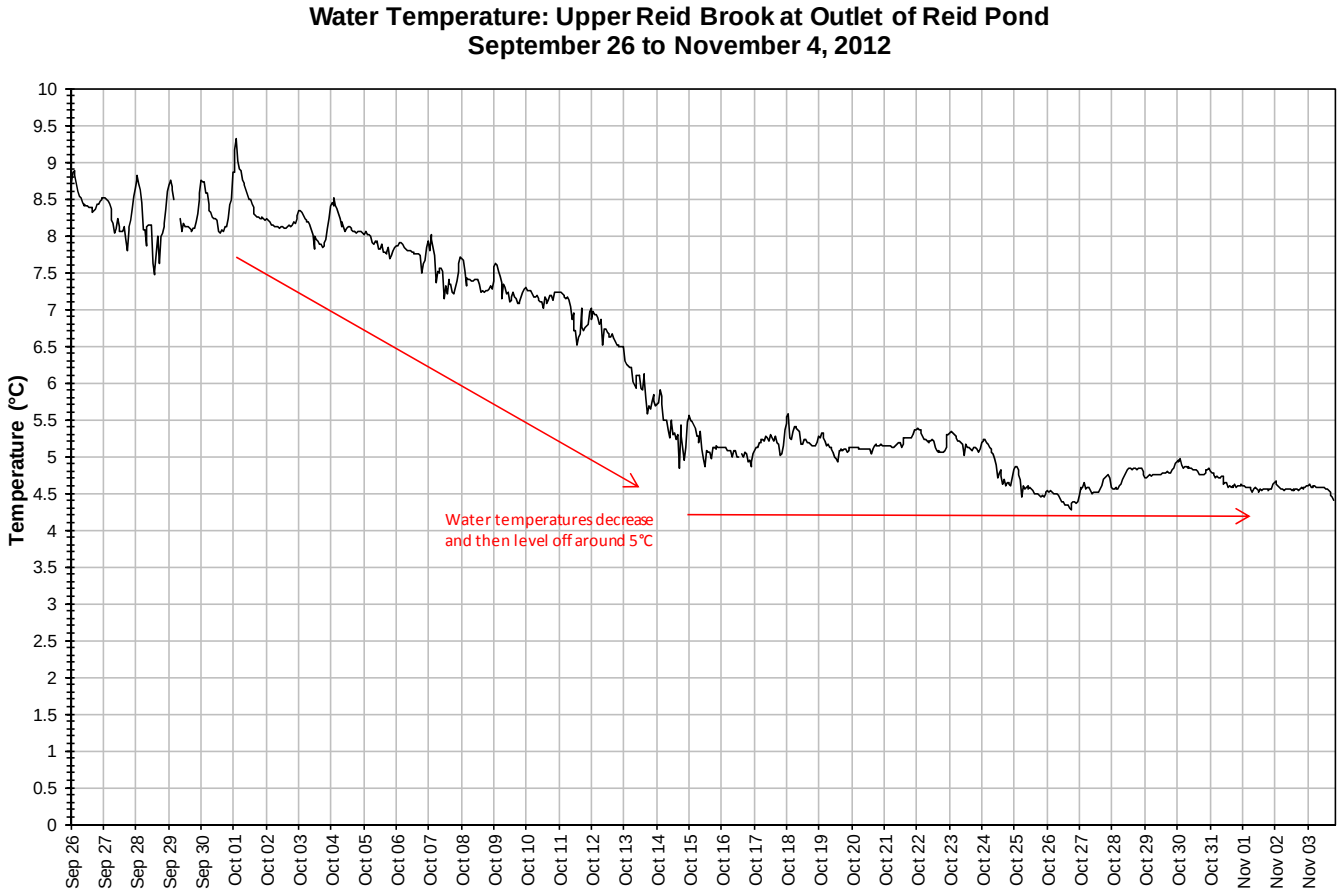

Figure 1: Water temperature at Upper Reid Brook

- Average daily air temperatures are fluctuating throughout the deployment period displaying a general decreasing trend while average daily water temperatures decrease consistently (Figure 2). Increases and decreases in air temperature are reflected in water temperatures. Air temperatures generally increase and decrease faster while water temperatures increase and decrease more slowly over time.

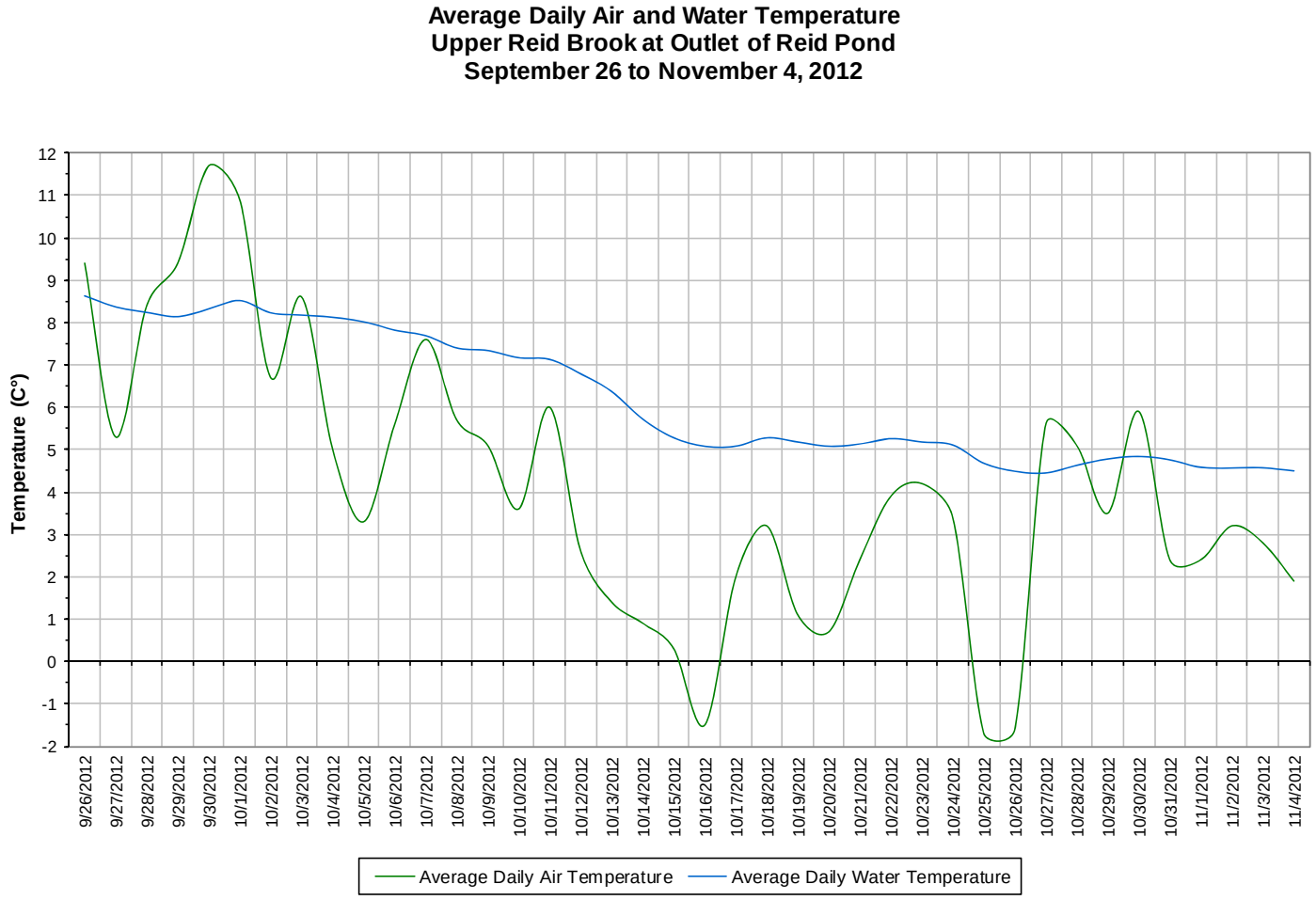

Figure 2: Average daily air and water temperatures at Upper Reid Brook

(weather data recorded at Nain)

- pH ranges between 6.84 and 6.98 pH units (Figure 3) and is very stable throughout the deployment period.
- There are small but notable decreases in pH on October 2 and 11. These events correspond with rainfall events on the same days. These events are highlighted in red on Figure 3. Decreases in pH during this time are also noticeable at all other stations in the network.
- All values are within the recommended range as suggested by the CCME Guidelines for the Protection of Aquatic Life (> 6.5 and <9.5 pH units). Guidelines are indicated in blue on Figure 3.

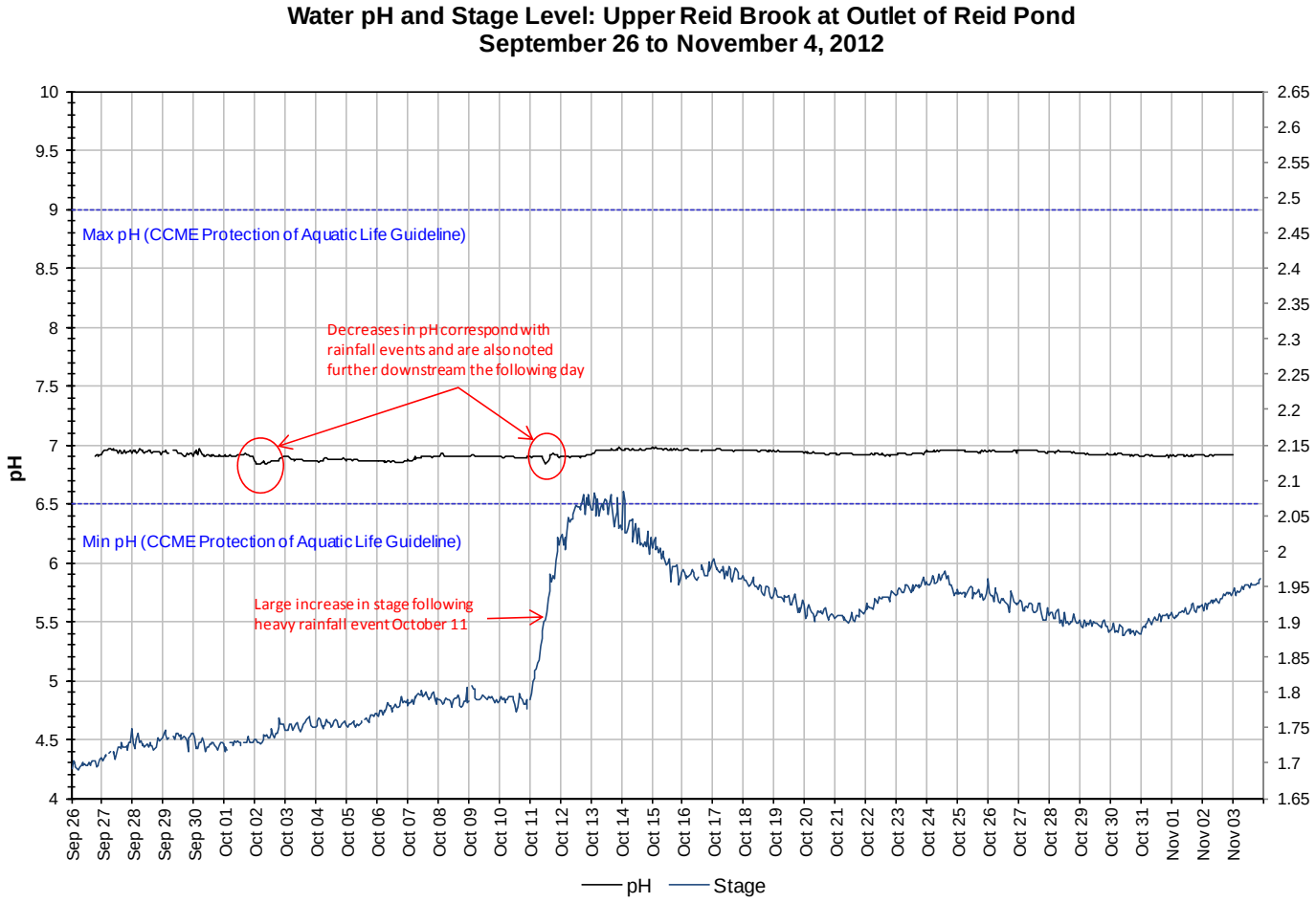

Figure 3: pH and stage level at Upper Reid Brook

- Specific conductivity values range from 8.8µS/cm to 9.4µS/cm during the deployment period (Figure 4).
- Specific conductivity remains very low and extremely stable throughout the deployment period with minimal fluctuation (±0.6µS/cm) regardless of the changing water level. This trend is expected as the flow from this station is directly from a stable lake environment.

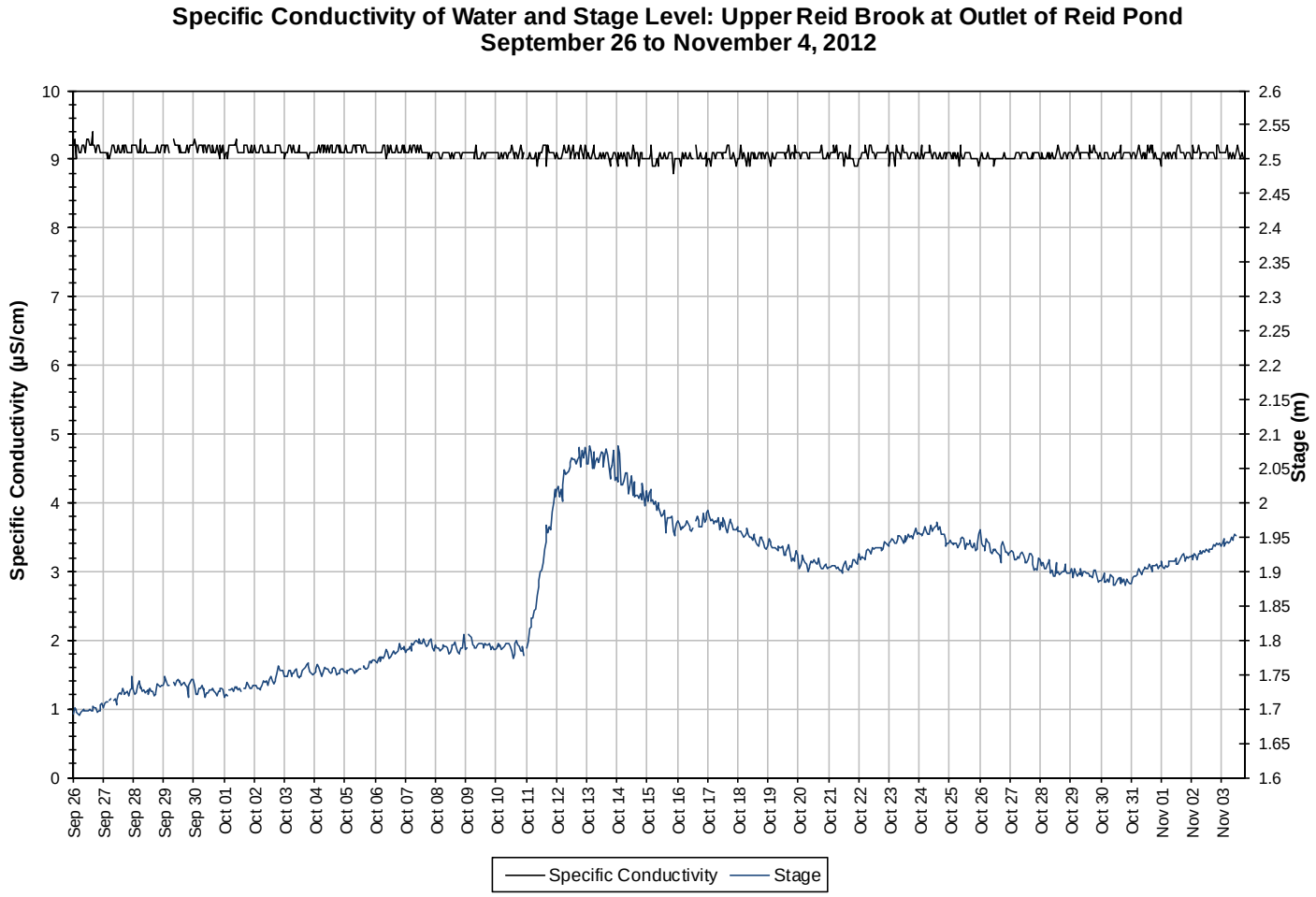

Figure 4: Specific conductivity and stage level at Upper Reid Brook

- Dissolved oxygen content ranges between 11.28mg/l and 12.31mg/l. The saturation of dissolved oxygen ranges from 92.7% to 100.1% (Figure 5).
- Dissolved oxygen content is stable and then increases from October 12 to 15. This increase follows a heavy rainfall event (~40mm) and corresponds to a period of rapidly decreasing air temperatures from ~23°C to ~1°C (Figure 2) and water temperature (Figure 1). Dissolved oxygen is generally stable for the remainder of the deployment period following these events. These events are indicated in red on Figure 5.
- All values are above both of the minimum CCME Guidelines for the Protection of Cold Water Biota at Other Life Stages (6.5mg/l) and Early Life Stages (9.5mg/l). The guidelines are indicated in blue on Figure 5. The average dissolved oxygen value was 11.76mg/l.

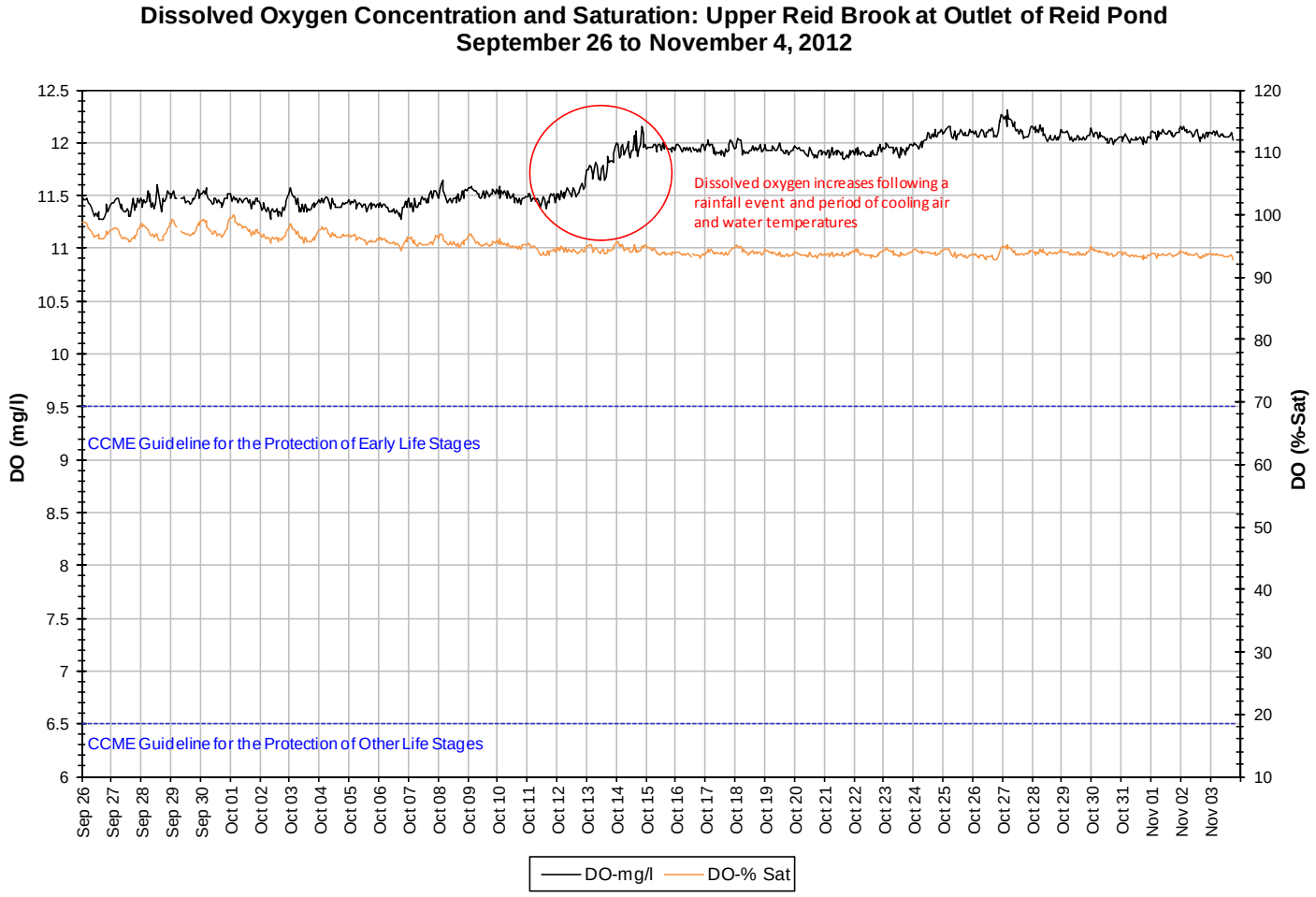

Figure 5: Dissolved oxygen and percent saturation at Upper Reid Brook

- Turbidity at this station remained at 0NTU for the entire deployment period except for one instance when turbidity reached 6.9NTU for a period of 1 hour (Figure 6). This trend is not unusual for this station as the water flowing from the lake is typically very clean, clear and cold.

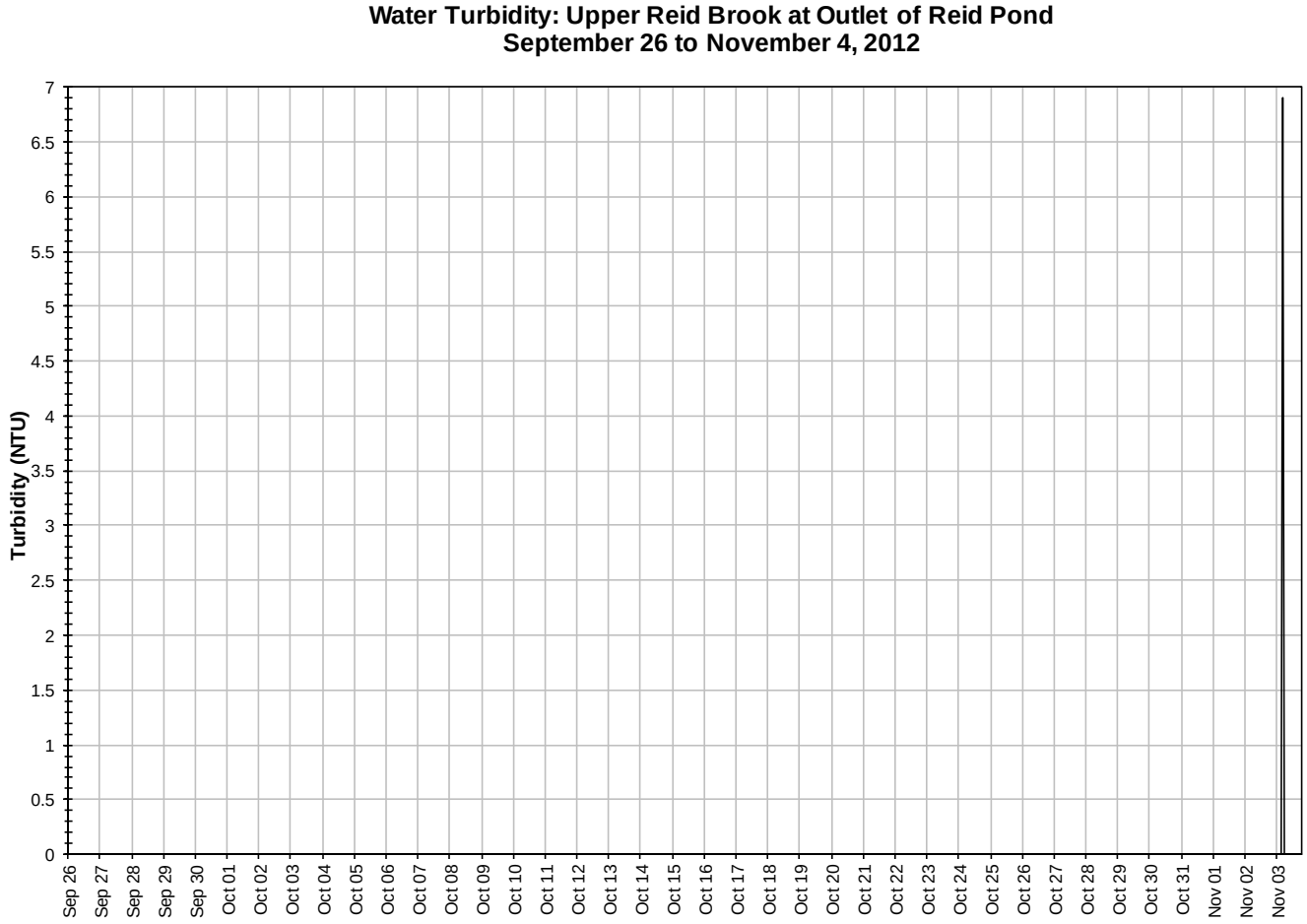

Figure 6: Turbidity at Upper Reid Brook

- Stage and precipitation are graphed below to show the relationship between rainfall and water level (Figure 7). Stage is generally increasing during the deployment period. Stage ranges from 1.69m to 2.08m, a difference of 0.39m.
- Precipitation events occur about 50% of the time and are generally low in magnitude with the exception of a significant event on October 11. Stage level increases following this event.

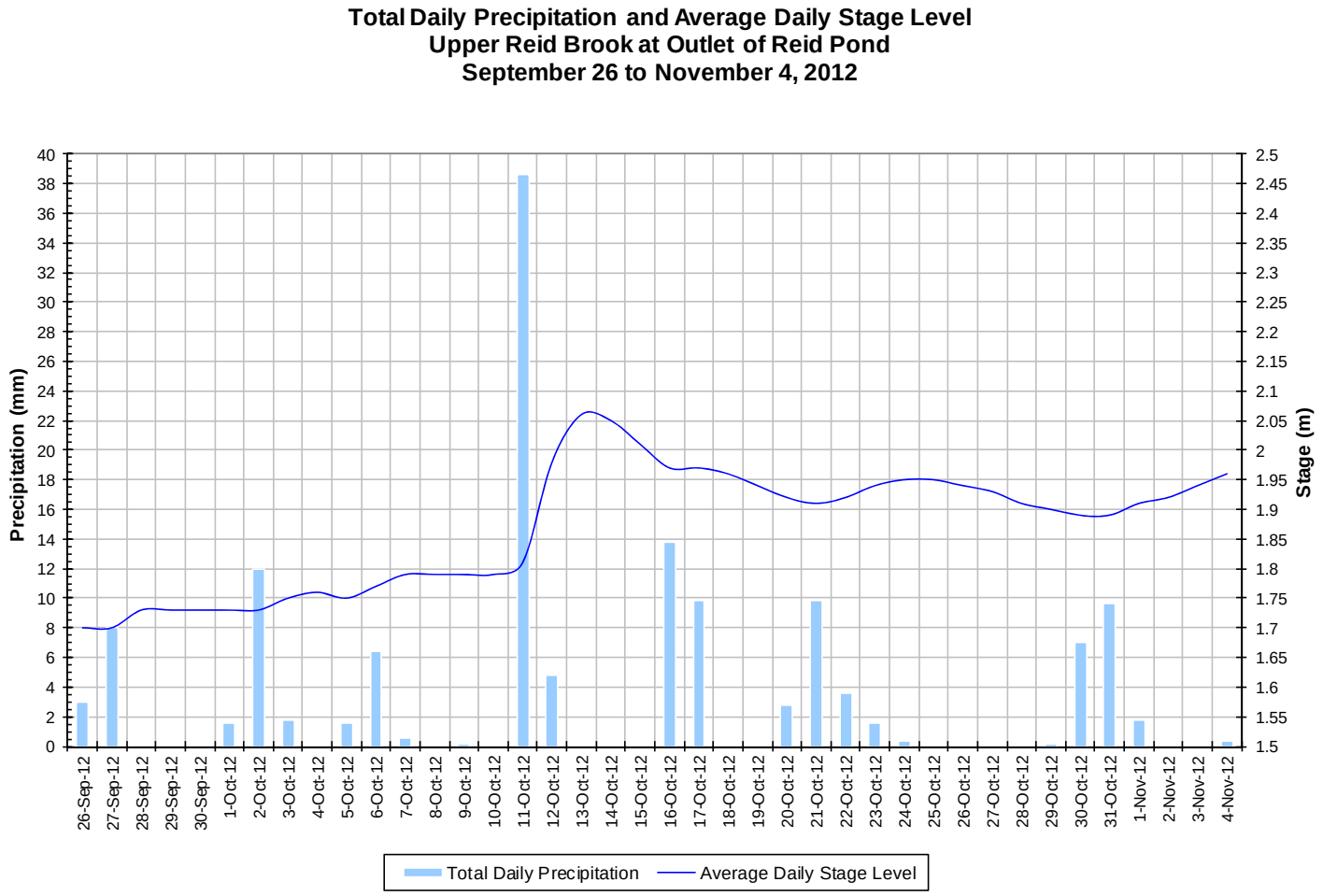

Figure 7: Daily precipitation and average daily stage level at Upper Reid Brook

(weather data recorded at Nain)

Tributary to Lower Reid Brook

- Water temperature ranges from 0.01 °C to 8.20°C during the deployment period (Figure 8).
- Water temperature is decreasing throughout the deployment period. This trend is expected given the cooling ambient air temperatures in the fall season (Figure 9)
- Water temperature fluctuates diurnally. Average water temperature is 3.59°C for the deployment period.
- There are sharp decreases in water temperature from October 11-15 and 23-26. These events correspond with periods of cold average daily air temperatures (Figure 9). These decreases are noticeable at other stations in the network and are highlighted in red on Figure 8.

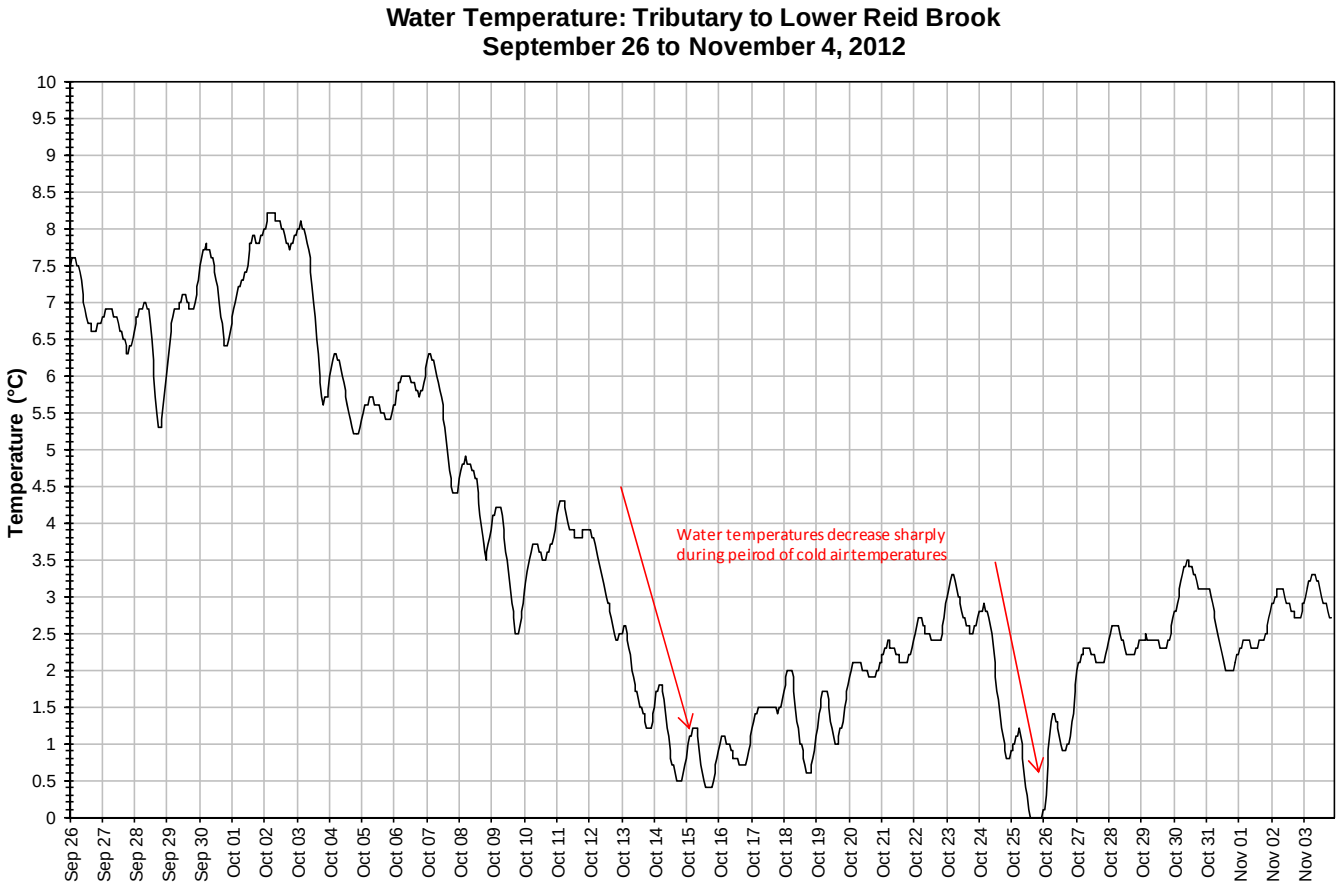

Figure 8: Water temperature at Tributary to Lower Reid Brook

- Average daily air and water temperatures fluctuate daily but show a general decreasing trend throughout the deployment period (Figure 9). Increases and decreases in air temperature are reflected in water temperatures. Air temperatures generally increase and decrease faster while water temperatures increase and decrease more slowly over time.

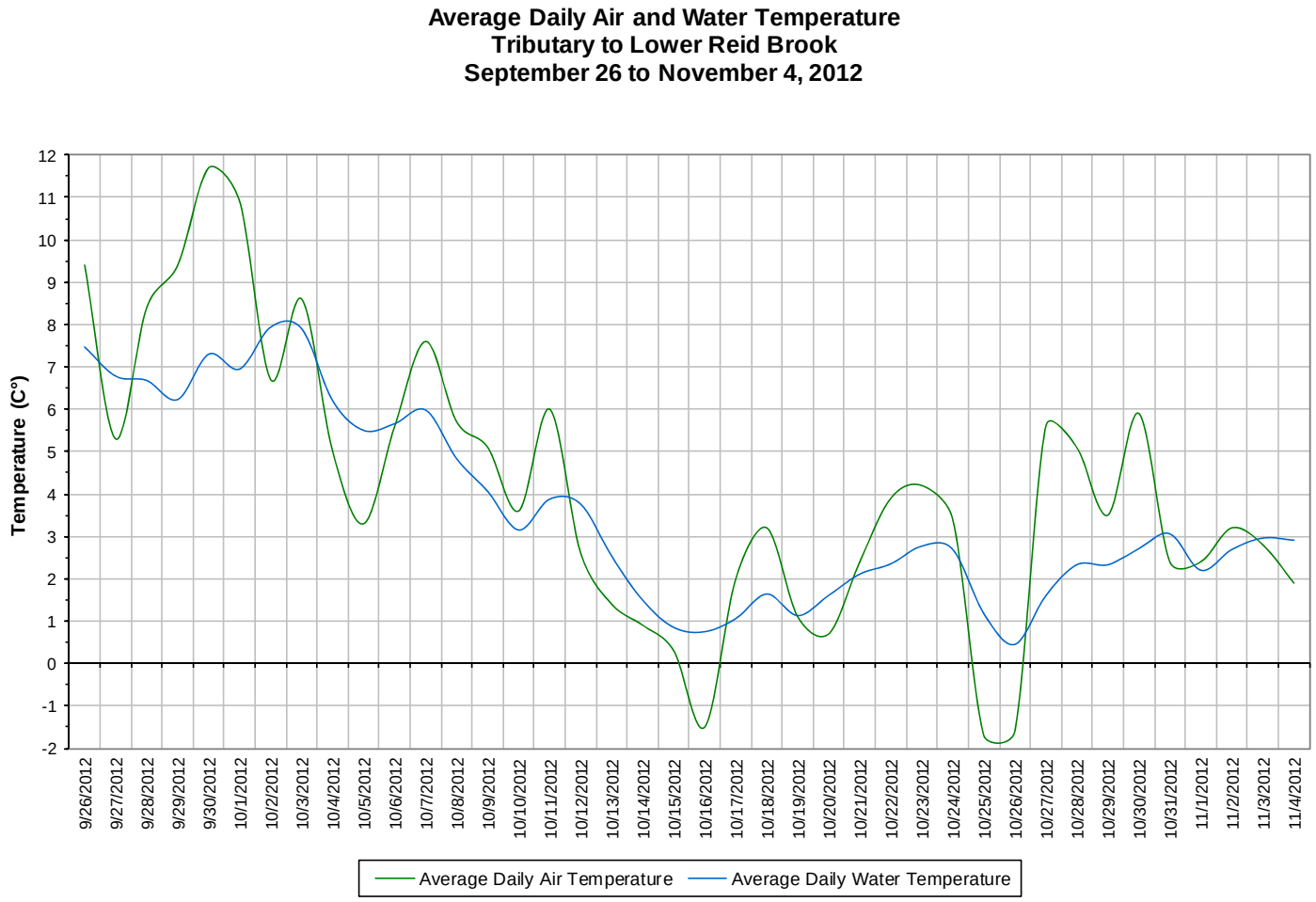

Figure 9: Average daily air and water temperatures at Tributary to Lower Reid Brook (weather data recorded at Nain)

- pH ranges between 6.12 and 6.97 pH units (Figure 10).
- Stage is included on Figure 10 to show the relationship between water level and pH. Stage increases significantly on September 27, October 2, 6, 11, 16, 21, & 31 causing pH to decrease sharply each time. These increases in stage level correspond with rainfall events. Oddly, the increase in stage on October 26 does not cause a decrease in pH and the reason for this is unknown. Events are highlighted in red on Figure 10.
- Most values are within the recommended range for pH as suggested by the CCME Guidelines for the Protection of Aquatic Life (>6.5 and <9.0 pH units). During the stage increase and pH decrease on October 11 (the most substantial rainfall event of nearly 40mm) pH values drop below the minimum CCME Guideline but increase again the days following. Guidelines are indicated in blue on Figure 10.

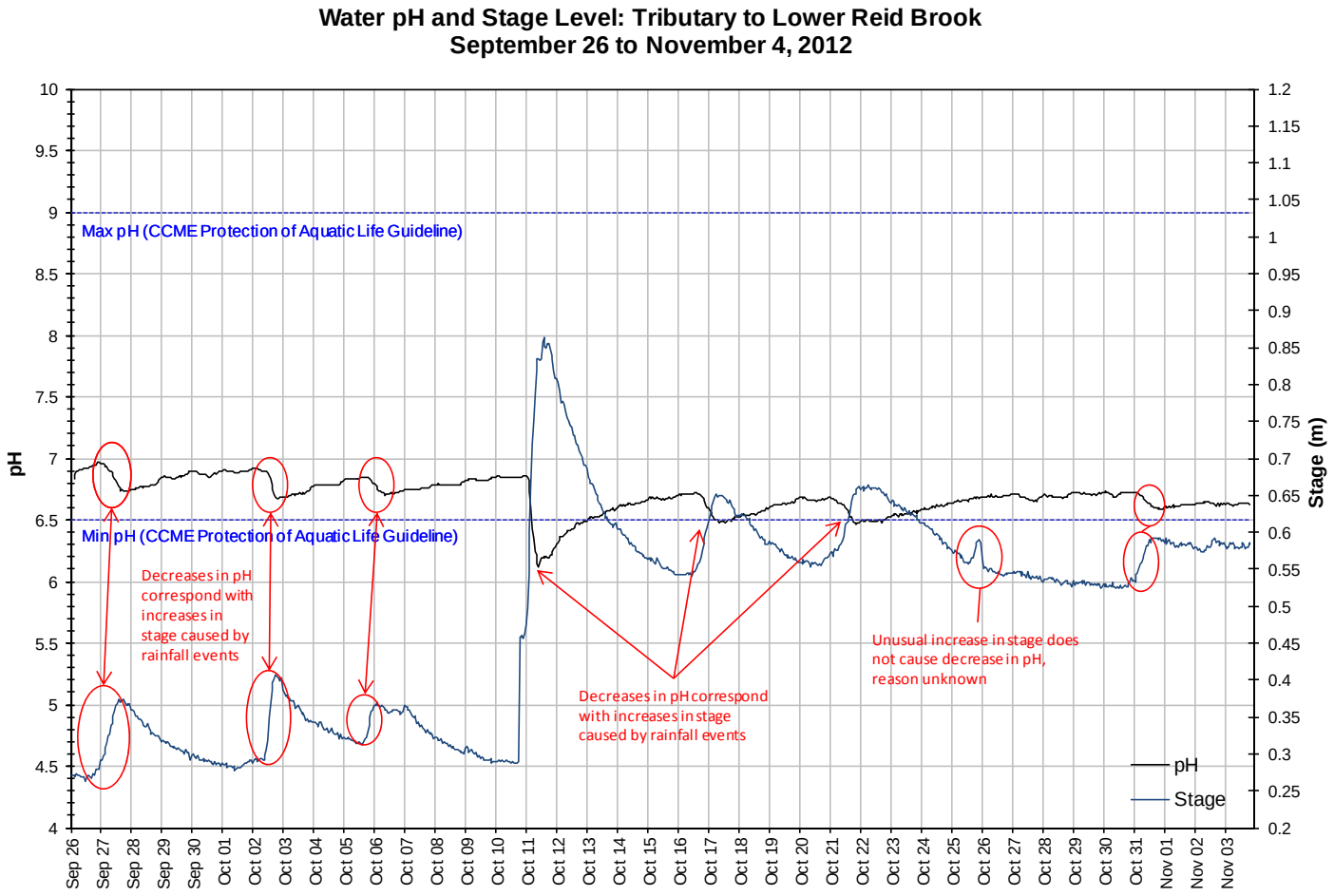

Figure 10: pH and stage level at Tributary to Lower Reid Brook

- Specific conductivity ranges between 22.7µS/cm and 40.3µS/cm and fluctuates throughout the deployment period (Figure 11).
- Stage is included in Figure 11 to illustrate the inverse relationship between conductivity and water level. Stage increases and decreases sharply throughout the deployment period, corresponding with numerous precipitation events. Specific conductivity changes with the varying water level. As stage increases, specific conductivity generally decreases due to the dilution of dissolved solids in the water column. Inversely, as stage decreases, specific conductivity increases as the concentration of dissolved solids increases.
- This trend is exceptionally clear with the values collected from this station during the deployment period. The specific conductivity values almost appear to mirror changes in stage. This pattern is also clearly apparent at the station nearby on Lower Reid Brook. This trend is highlighted in red on Figure 11.

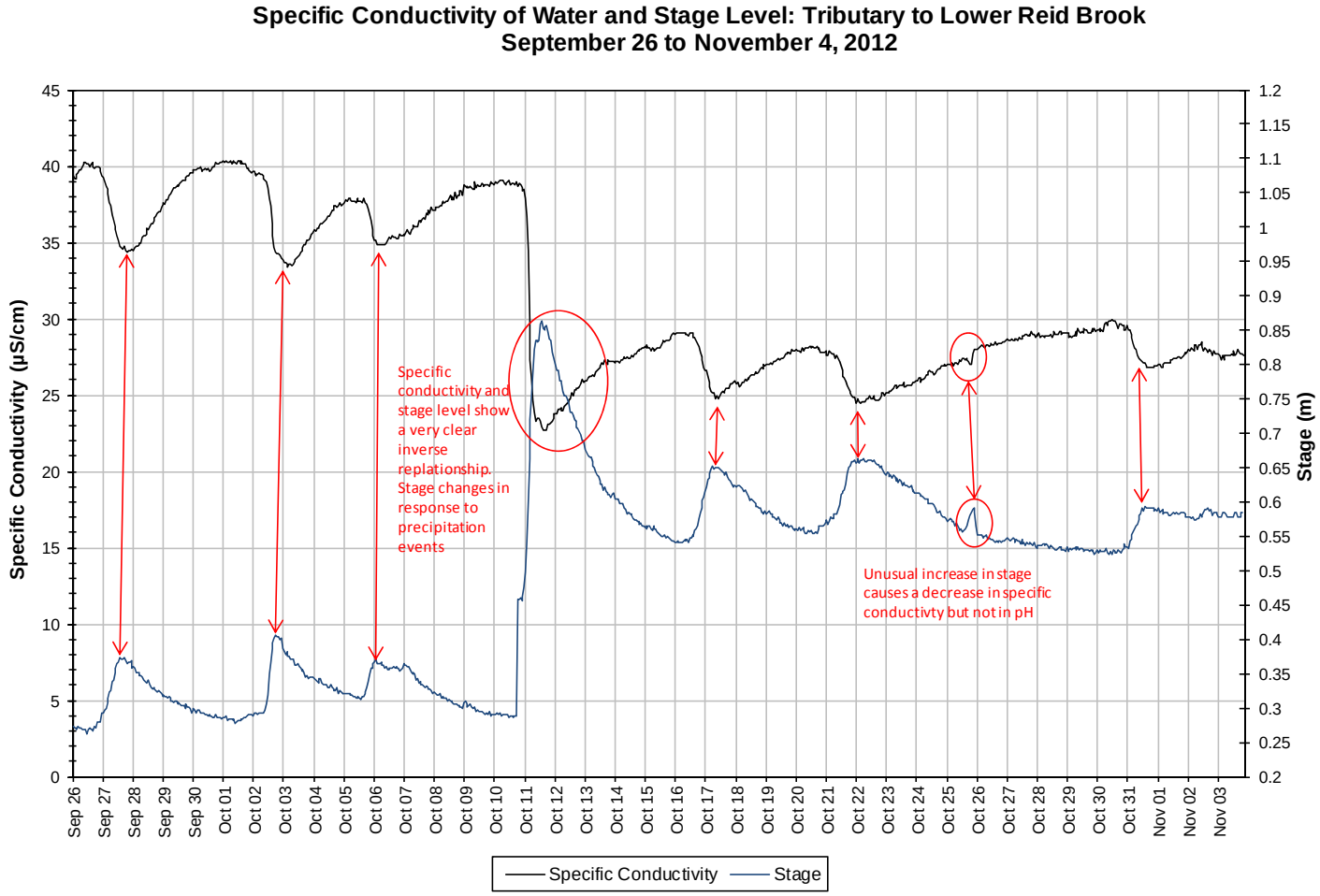

Figure 11: Specific conductivity and stage level at Tributary to Lower Reid Brook

- Dissolved oxygen content ranges between 11.29mg/l and 14.30mg/l. The saturation of dissolved oxygen ranges from 92.1% to 99.1% (Figure 12).
- Dissolved oxygen content is generally increasing throughout the deployment period but also has many short term decreases. These decreases in dissolved oxygen correspond with unusually warm air temperatures which temporarily increase the water temperature (Figure 9). The decrease in dissolved oxygen on October 11 corresponds with warm air temperatures and a significant rainfall event. These events are highlighted in red on Figure 19.
- All values are above both the minimum CCME Guideline for the Protection of Cold Water Biota at Other Life Stages (6.5mg/l) and Early Life Stages (9.5mg/l). The guidelines are indicated in blue on Figure 12. Average dissolved oxygen value was 12.81mg/l.

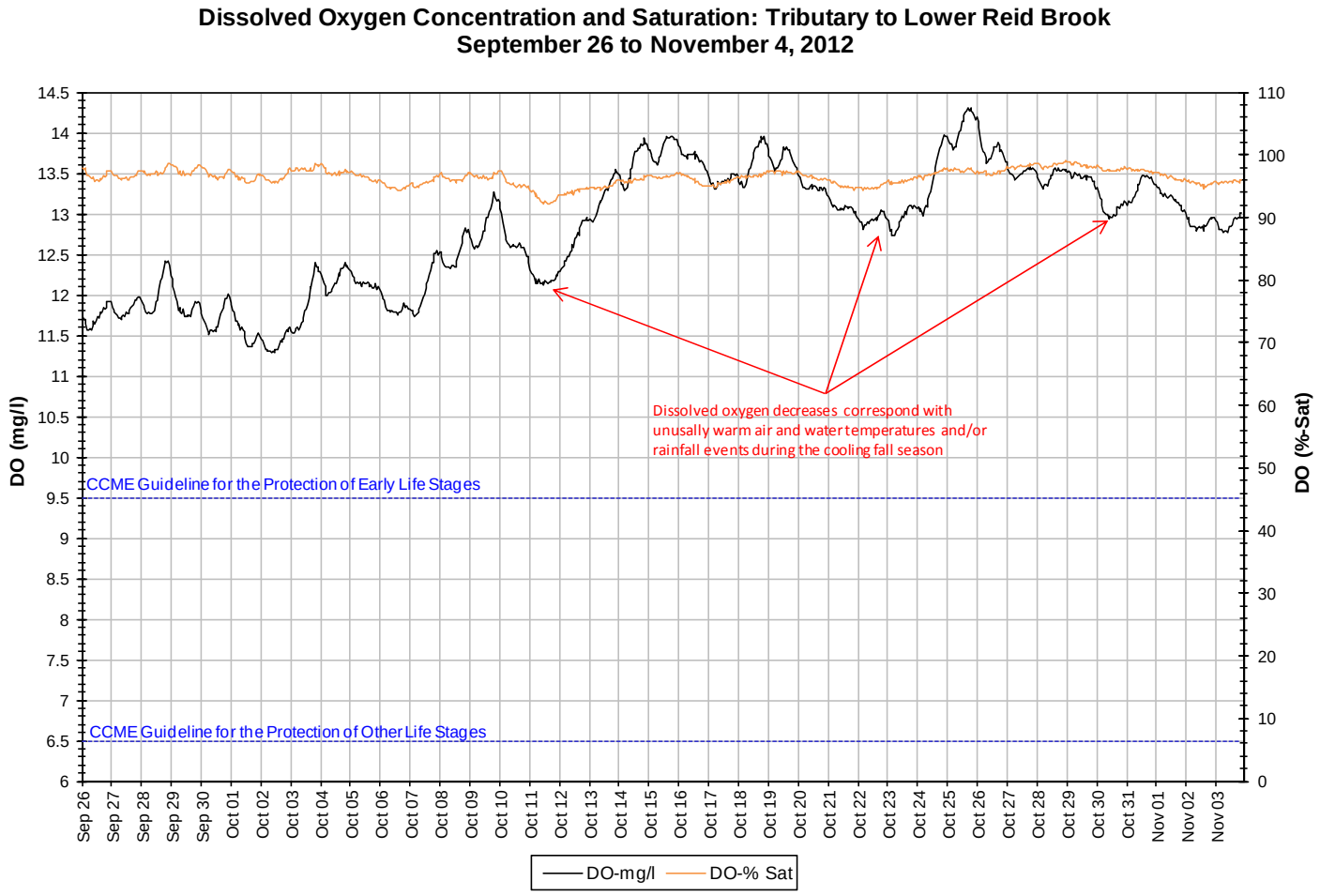

Figure 12: Dissolved oxygen and percent saturation at Tributary to Lower Reid Brook

- Turbidity ranges between 0 and 48.1NTU throughout the deployment period (Figure 13). A median value of 0NTU indicates there is no natural background turbidity value for this deployment period.
- Short-lived turbidity increases are common at this station. Stage is graphed on Figure 13 as the increases in turbidity most times correspond with increases in stage caused by a rainfall event. There are a number of rainfall events during the deployment period on September 27, October 2, 6, 11, 16-17, 21 & 31. These events along with corresponding turbidity and stage increases are indicated in red while turbidity increases with no corresponding precipitation events are highlighted in green on Figure 13.

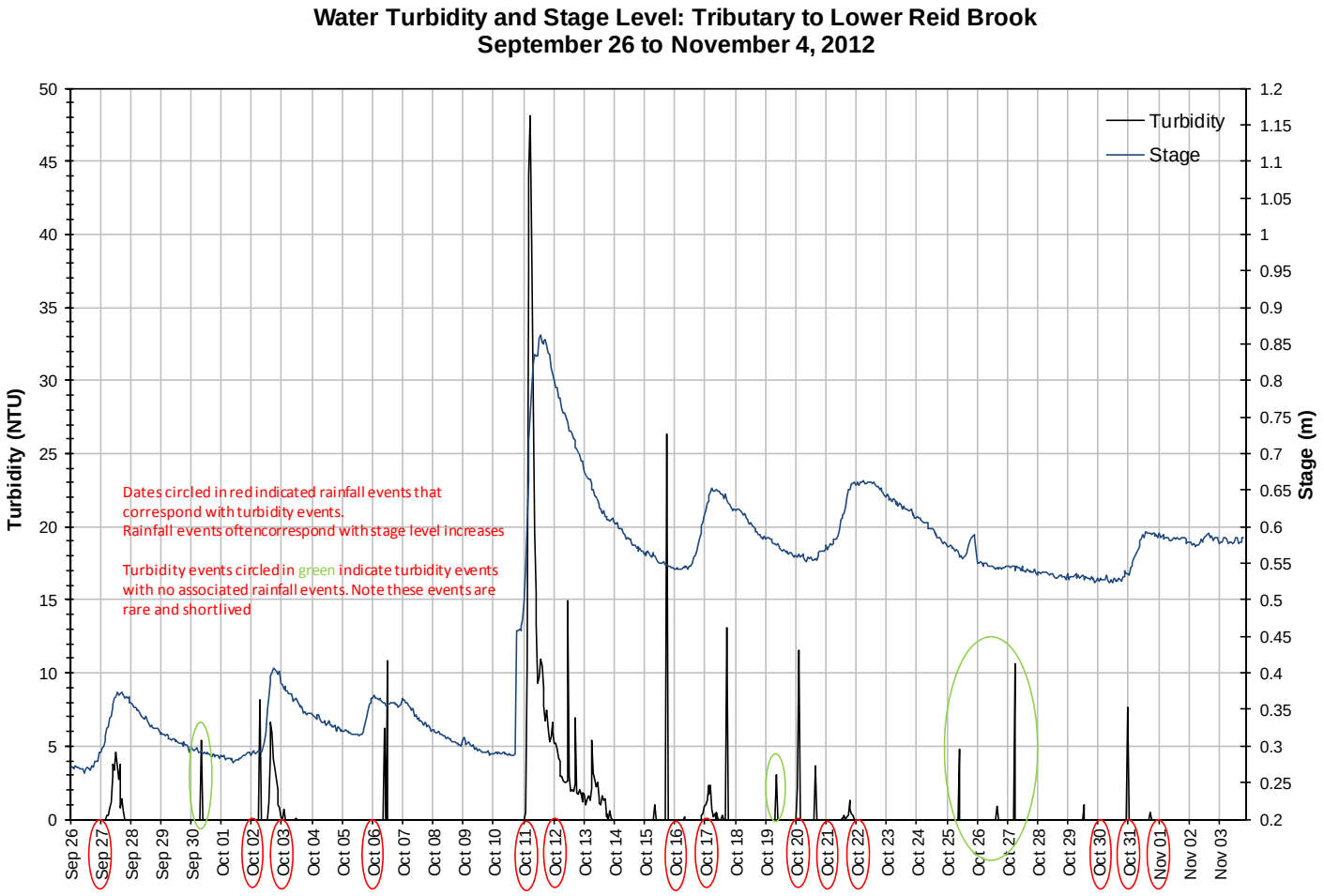

Figure 13: Turbidity and stage level at Tributary to Lower Reid Brook

- Stage and precipitation are graphed below to show the relationship between rainfall and water level (Figure 14). Stage is generally stable for the first two weeks of the deployment period before increasing October 11-12 following a heavy rainfall event on October 11. Stage stabilizes and remains higher than at the beginning of the deployment period from October 15 onwards. Stage ranges from 0.26m to 0.86m, a difference of 0.60m.
- Precipitation events occur about 50% of the time and are generally low in magnitude with the exception of the significant event on October 11.

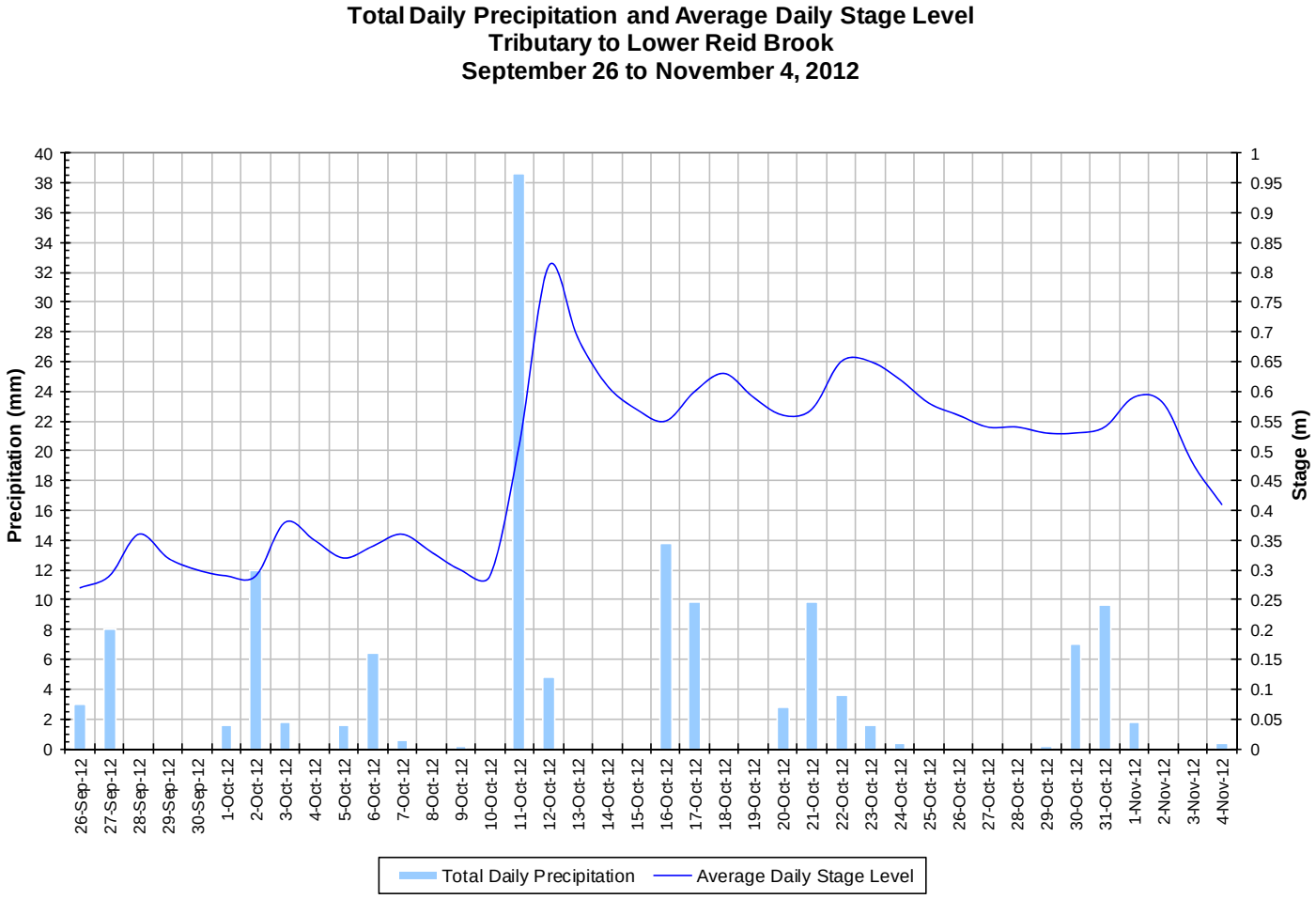

Figure 14: Daily precipitation and average daily stage at Tributary to Lower Reid Brook

(weather data recorded at Nain)

Lower Reid Brook

- Data transmission was sporadic at this station during the deployment period. Many times data values are missing for a period a three to six hours. For the purposes of the deployment report, transmitted data was used because the gaps are not long enough to miss any significant patterns. Log file data will be incorporated into the final dataset provided to Vale Voisey's Bay, Environment Department.
- Water temperature ranges from 0.04 ^{o}C to 8.45^{o}C during the deployment period (Figure 15).
- Water temperature is decreasing throughout the deployment period. This trend is expected given the cooling ambient air temperatures in the fall season (Figure 16).
- Water temperature fluctuates diurnally. Average water temperature is 3.76°C for the deployment period.
- There are sharp decreases in water temperature on October 11-15 & 23-26, both of which correspond with periods of cold air temperatures (Figure 16). These decreases in water temperatures are also noticeable at other stations in the network.

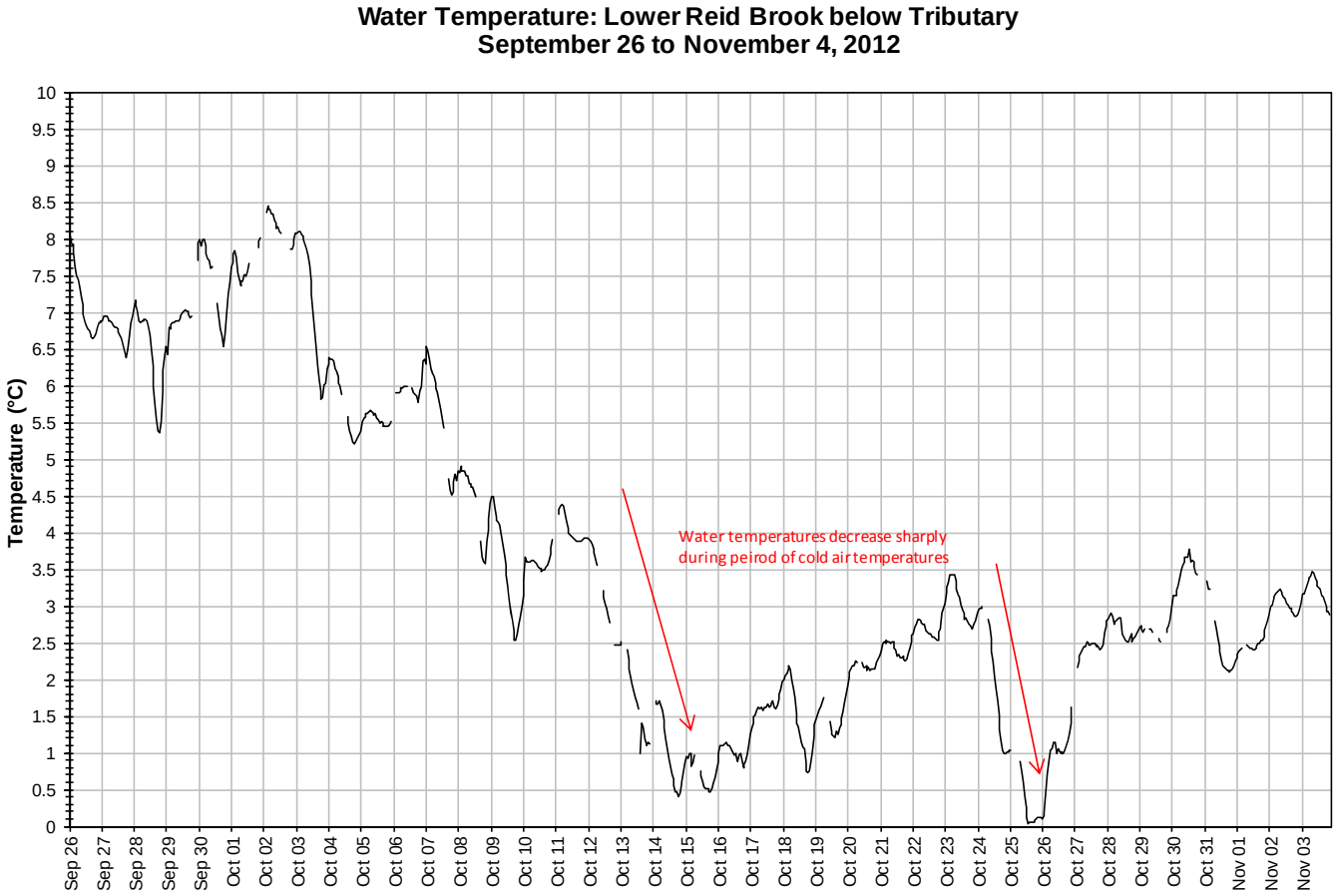

Figure 15: Water temperature at Lower Reid Brook

- Average daily air and water temperatures are generally decreasing throughout the deployment period (Figure 16). Increases and decreases in air temperature are reflected in water temperatures. Air temperatures generally increase and decrease faster while water temperatures increase and decrease more slowly over time.

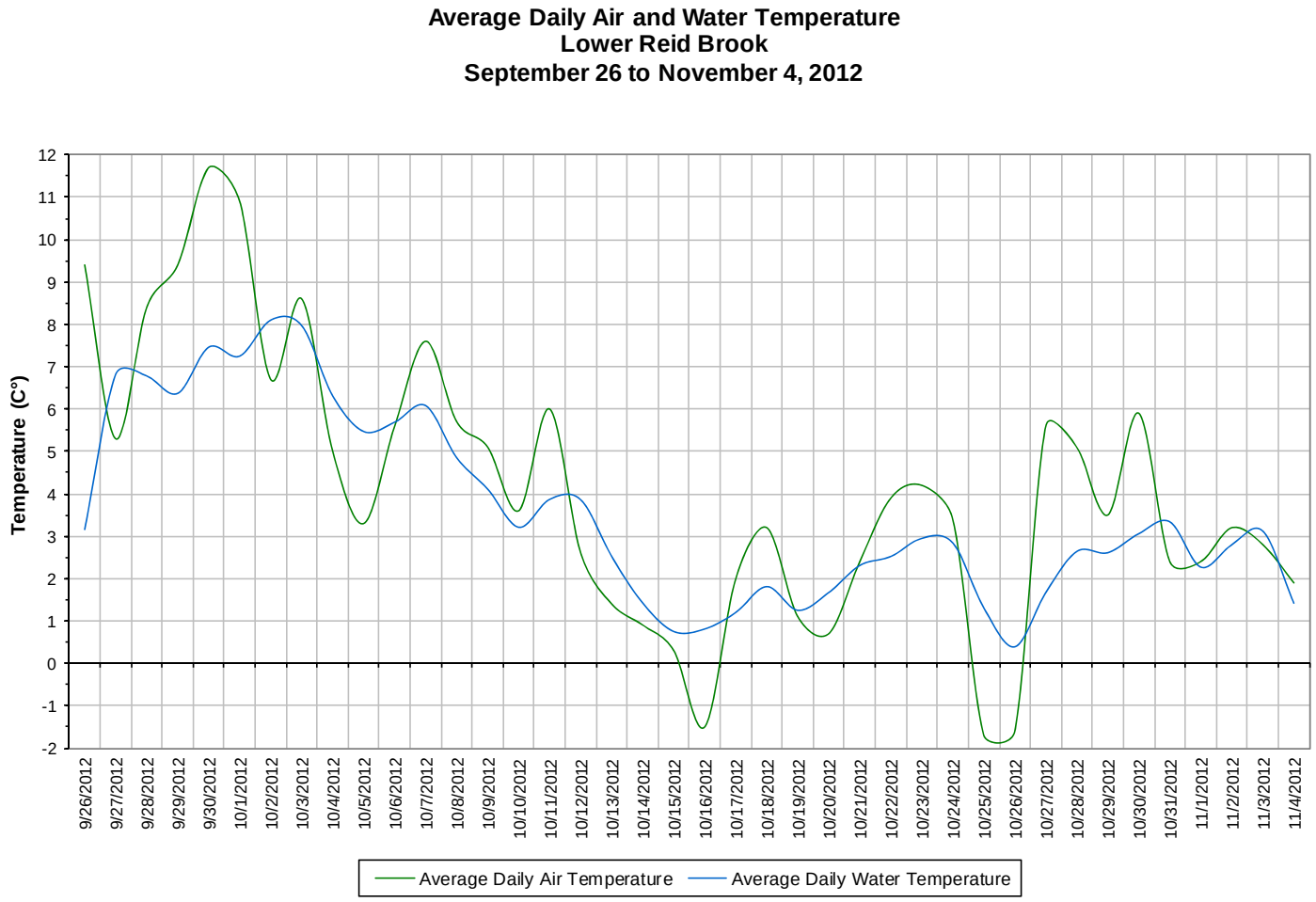

Figure 16: Average daily air and water temperatures at Lower Reid Brook

(weather data recorded at Nain)

- pH ranges between 6.21 and 7.01 pH units (Figure 17).
- Stage is included on Figure 17 to show the relationship between water level and pH. Stage increases on September 27, October 2, 6, 11, 16, 21, & 31 causing pH to decrease sharply each time. These increases in stage level correspond with rainfall events. Oddly, the increase in stage on October 26 does not cause a decrease in pH. These trends are very similar to the nearby station on the Tributary to Lower Reid Brook (Figure 10).
- Most values are within the recommended range for pH as suggested by the CCME Guidelines for the Protection of Aquatic Life (indicated in blue on Figure 17). During the stage increase and pH decrease on October 11 (the most substantial rainfall event of nearly 40mm) pH values drop below the minimum CCME Guideline but increase again the days following.

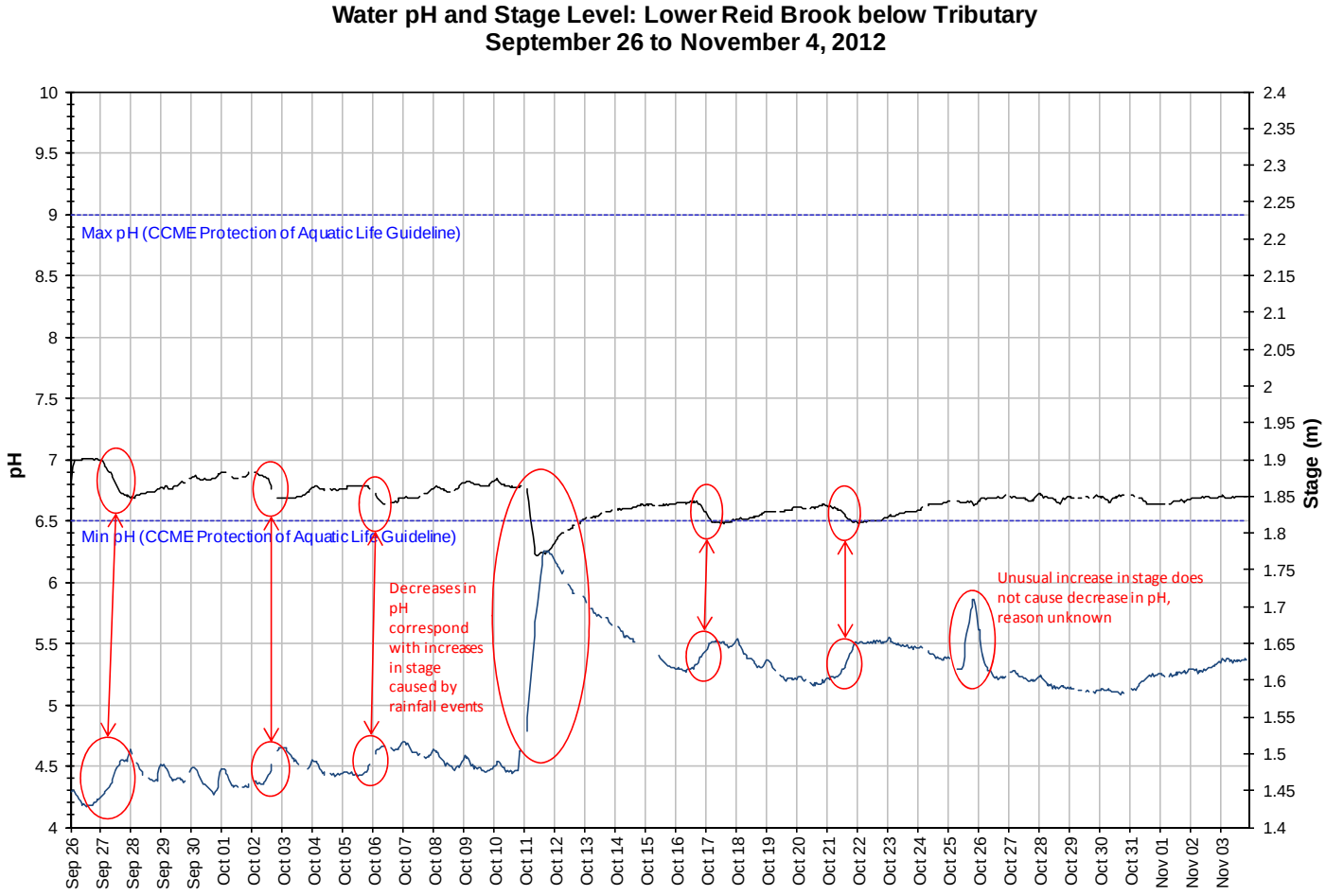

Figure 17: pH and stage level at Lower Reid Brook

- Specific conductivity ranges between 22.4µS/cm and 39.7µS/cm (Figure 18).
- Stage is included in Figure 18 to illustrate the inverse relationship between conductivity and water level. Stage increases and decreases sharply throughout the deployment period. Specific conductivity changes with the varying water level. As stage increases, specific conductivity generally decreases due to the dilution of dissolved solids in the water column. Inversely, as stage decreases, specific conductivity increases as the concentration of dissolved solids increases.
- This trend is exceptionally clear with the values collected from this station during the deployment period. The specific conductivity values almost appear to mirror changes in stage. This trend is highlighted in red on Figure 18. This pattern is also clearly apparent at the station nearby on Tributary to Lower Reid Brook (Figure 11).

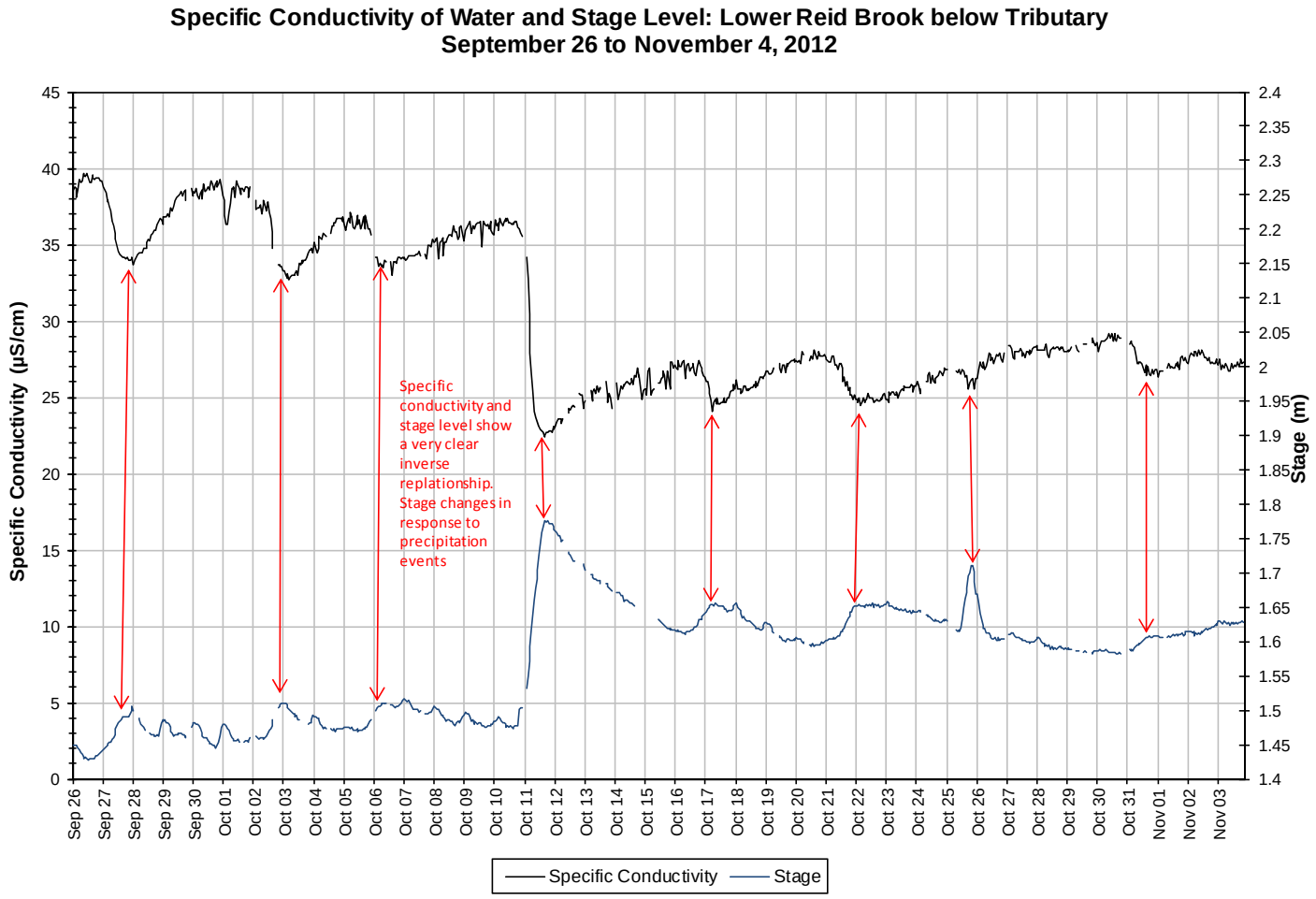

Figure 18: Specific conductivity and stage level at Lower Reid Brook

- Dissolved oxygen content ranges between 11.45mg/l and 14.50mg/l. The saturation of dissolved oxygen ranges from 94.2% to 101.8% (Figure 19).
- Dissolved oxygen content is generally increasing throughout the deployment period but also has many short term decreases. These decreases in dissolved oxygen correspond with unusually warm air temperatures which temporarily increase the water temperature (Figure 15). The decrease in dissolved oxygen on October 11 corresponds with warm air temperatures and a significant rainfall event. These events are highlighted in red on Figure 19.
- All values are above both the minimum CCME Guideline for the Protection of Cold Water Biota at Other Life Stages (6.5mg/l) and Early Life Stages (9.5 mg/l). The guidelines are indicated in blue on Figure 19. Average dissolved oxygen content is 12.98mg/l for the deployment period.

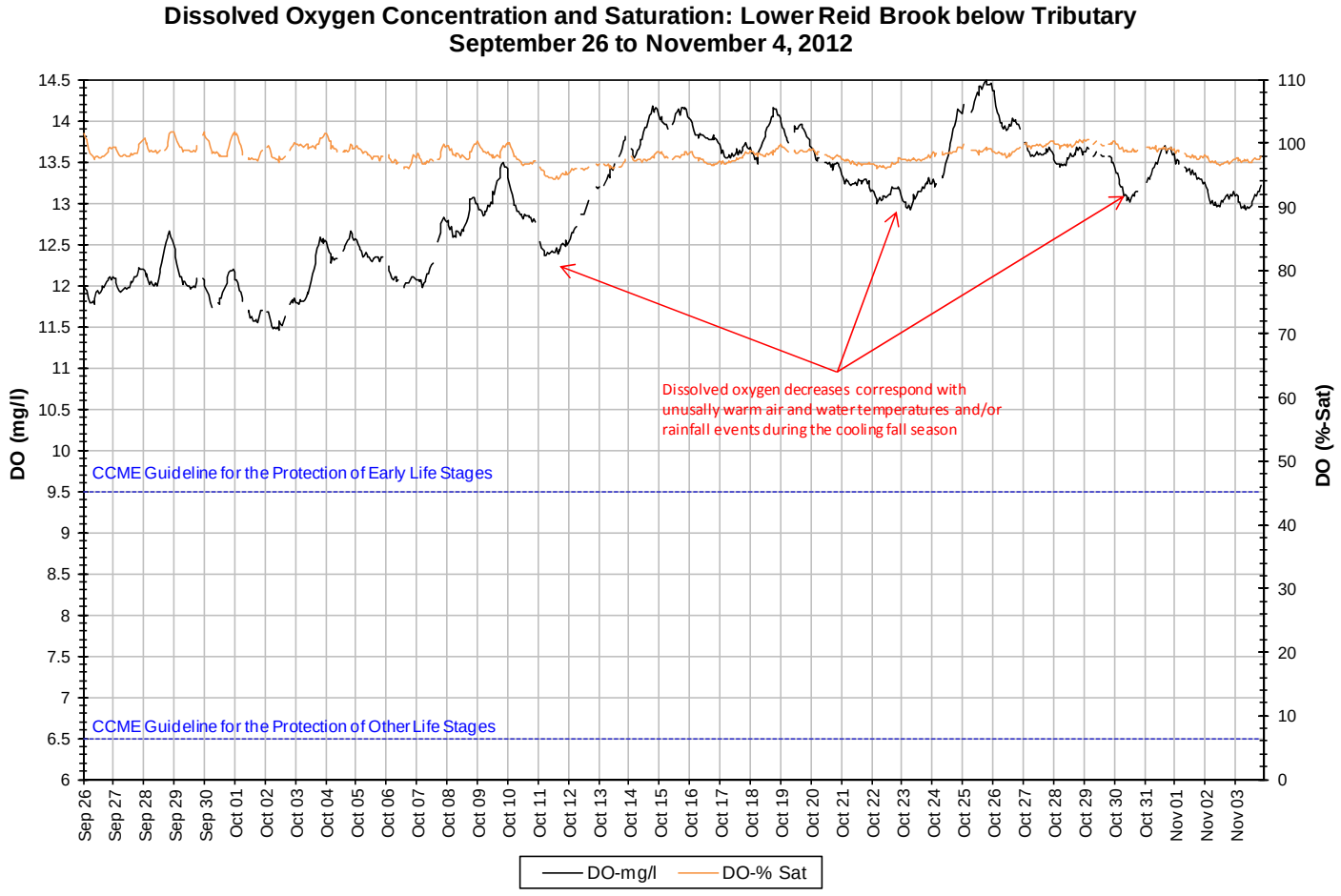

Figure 19: Dissolved oxygen and percent saturation at Lower Reid Brook

- Turbidity ranges between 0 and 33.3NTU throughout the deployment period (Figure 20). A median value of 0.0 indicates there is no natural background turbidity data for this deployment period.
- Turbidity remains 0NTU for much of the deployment period with one event. From October 11-12, turbidity is >0NTU following a heavy rainfall event where nearly 40mm of precipitation was recorded in the area.
- Stage is included on Figure 20 to show the relationship between turbidity and stage level. Stage level increases sharply on October 11 in response to the precipitation event. Turbidity levels return to baseline values (0NTU) on October 13. No other precipitation events occurring throughout the deployment period appear to cause increases in turbidity.

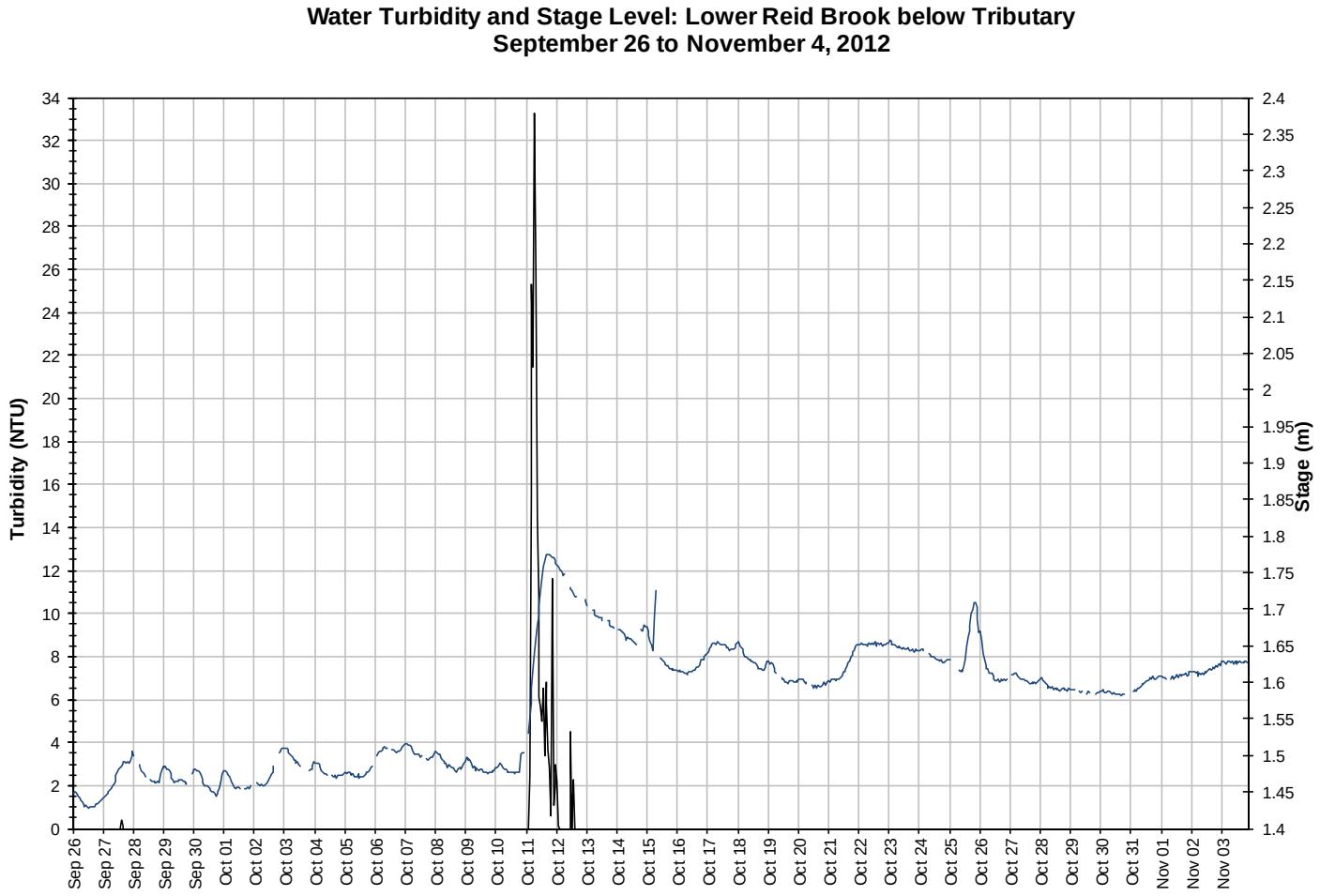

Figure 20: Turbidity and stage level at Lower Reid Brook

- Stage and precipitation are graphed below to show the relationship between rainfall and water level (Figure 21). Stage is generally stable for the first two weeks of the deployment period before increasing October 11-12 following a heavy rainfall event on October 11. Stage stabilizes and remains higher than at the beginning of the deployment period from October 15 onwards. Stage ranges from 1.43 to 1.78m, a difference of 0.35m.
- Precipitation events occur about 50% of the time and are generally low in magnitude with the exception of the significant event on October 11.

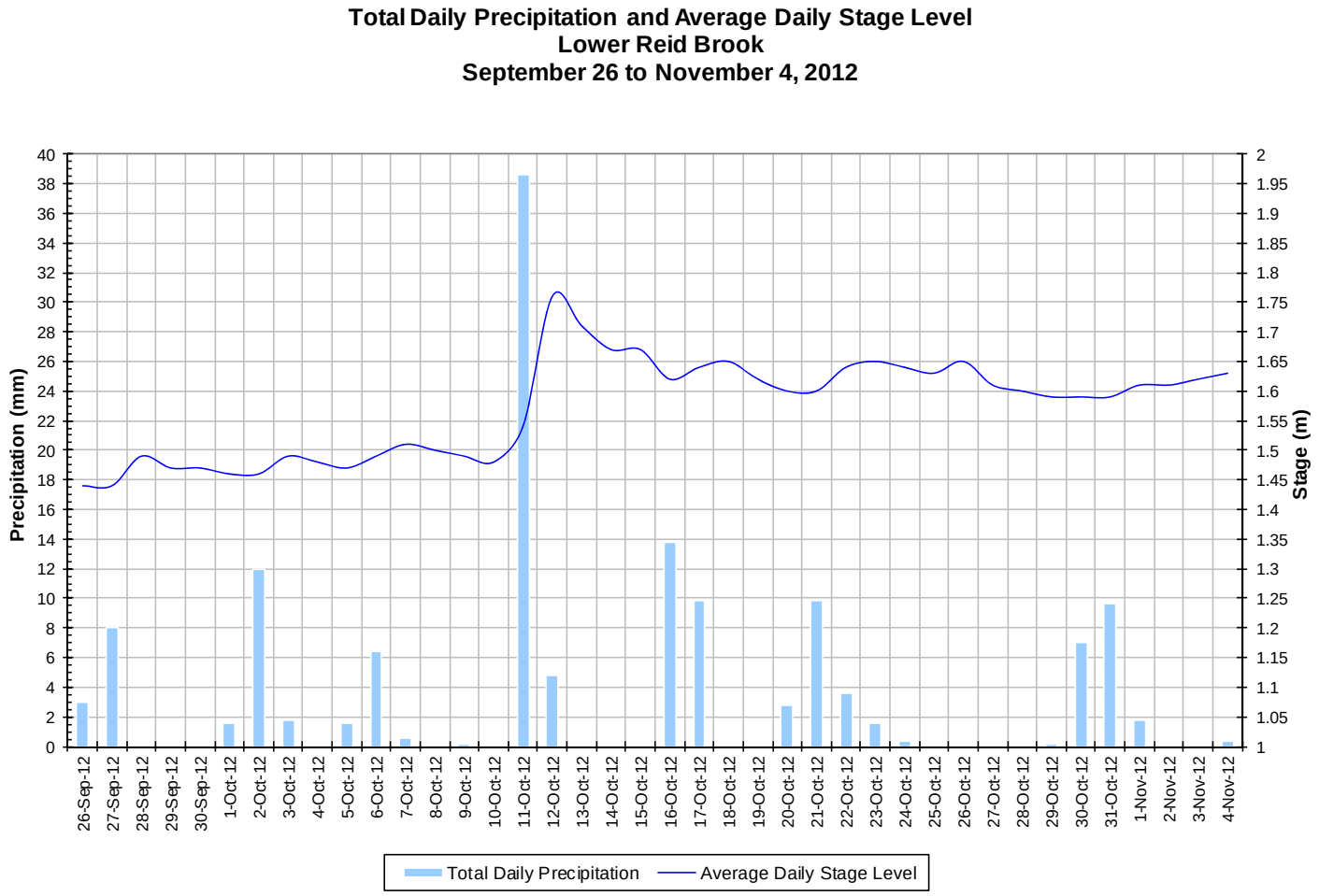

Figure 21: Daily precipitation and average daily stage level at Lower Reid Brook

(weather data recorded at Nain)

Camp Pond Brook

- A transmission error at this station caused data transfer to cease on September 13. Transmission resumed on October 11. Data from the instruments internal log file is used to supplement transmitted data for Figures 22-27 and for discussions. Stage data and daily averages are only available after October 11.

- Water temperature ranges from 0.01 ^{o}C to 10.71^{o}C during the deployment period (Figure 22).
- Water temperature is decreasing throughout the deployment period. This trend is expected given the cooling ambient air temperatures in the fall season (Figure 23).
- Water temperature fluctuates diurnally. Average water temperature is 4.07°C for the deployment period.
- There are sharp decreases in water temperature on October 11-15 and 23-26. These decreases correspond with cold average daily air temperatures recorded in the area. These decreases are also noticeable at other stations in the network.

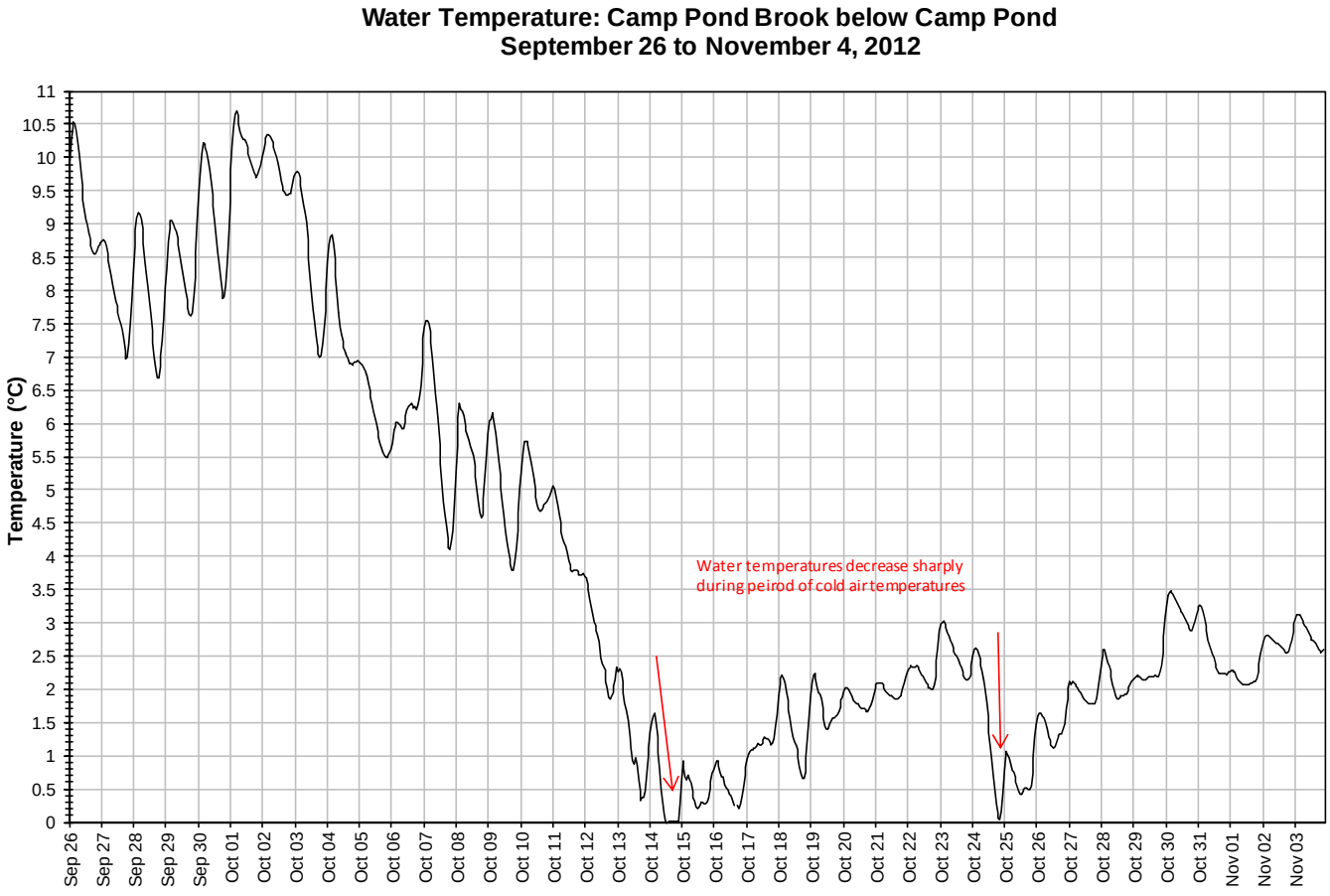

Figure 22: Water temperature at Camp Pond Brook

- Average daily air and water temperatures are decreasing throughout the deployment period (Figure 23). Average daily water temperatures are unavailable for the time when the station was not transmitting (September 13 to October 11). Fluctuations in average daily air temperatures are reflected by slight changes in water temperature. Air temperatures generally increase and decrease faster while water temperatures increase and decrease more slowly over time.

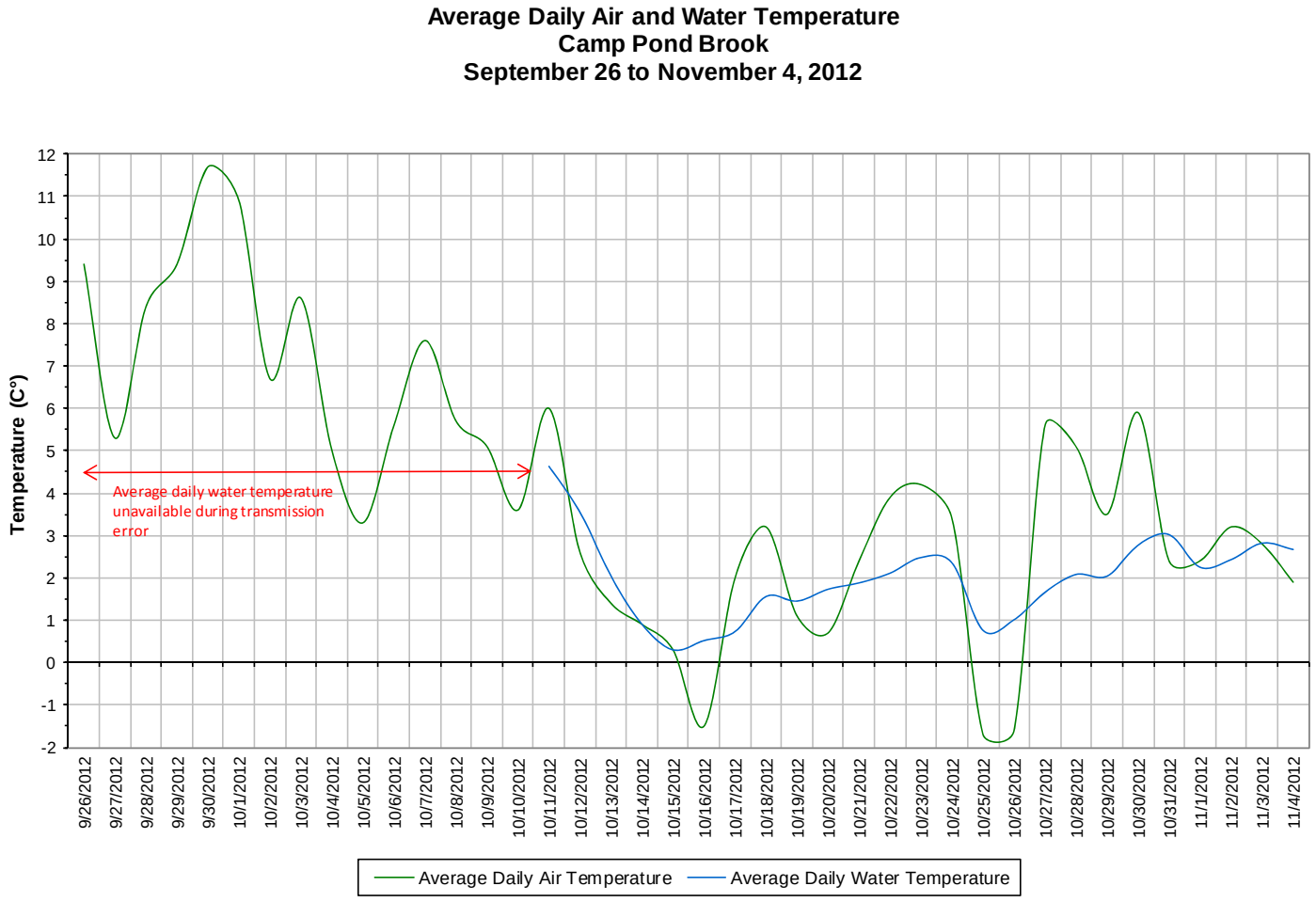

Figure 23: Average daily air and water temperatures at Camp Pond Brook

(weather data recorded at Nain)

- pH ranges between 6.75 and 7.24 pH units (Figure 24).
- pH values are generally stable with daily fluctuations during the deployment period. There is a notable decrease in pH on October 11 following a heavy rainfall event of nearly 40mm (Appendix 1). Although stage data is largely unavailable for this time period, stage level does appear to be increasing when the station resumes transmitting on October 11 when the decrease in pH occurs. Strangely, an increase in stage on October 15 does not cause a decrease in pH and the reason for this is unknown. These events are indicated in red on Figure 24.
- All values are within the recommended range for pH as suggested by the CCME Guidelines for the Protection of Aquatic Life (>6.5 and <9.0 pH units). Guidelines are indicated in blue on Figure 24.

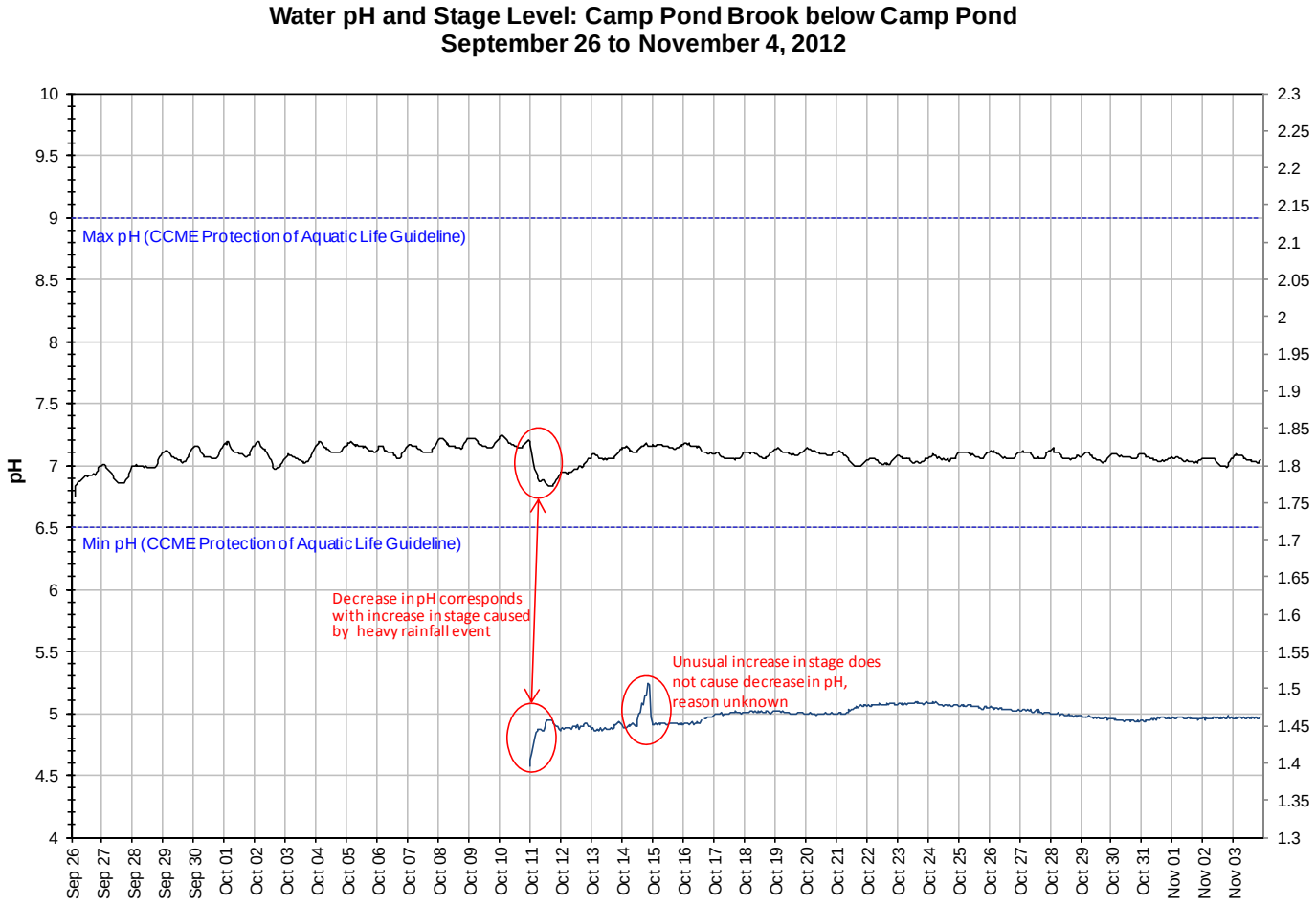

Figure 24: pH and stage level at Camp Pond Brook

- Specific conductivity ranges from 32.1µS/cm to 59.2µS/cm, fluctuating during the deployment period (Figure 25).
- Available stage data is included in Figure 25 to illustrate the inverse relationship between conductivity and water level. Stage data is very stable for the latter half of the deployment period. Typically, stage level increase causes decreases in the specific conductivity of the water by diluting the concentrations of dissolved solids present in the water column. However, at this station, historic trends show an increase in specific conductivity when stage increases.
- It can be assumed that stage increased during the significant rainfall event on October 11 which corresponds with the increase in specific conductivity. There were also moderate rainfall events on September 27 and October 2, 6, 16-17, 21, 31. Each of these events corresponds with an increase in specific conductivity however not necessarily in stage level. These events are highlighted in red on Figure 25 while events not corresponding to precipitation events are highlighted in green.

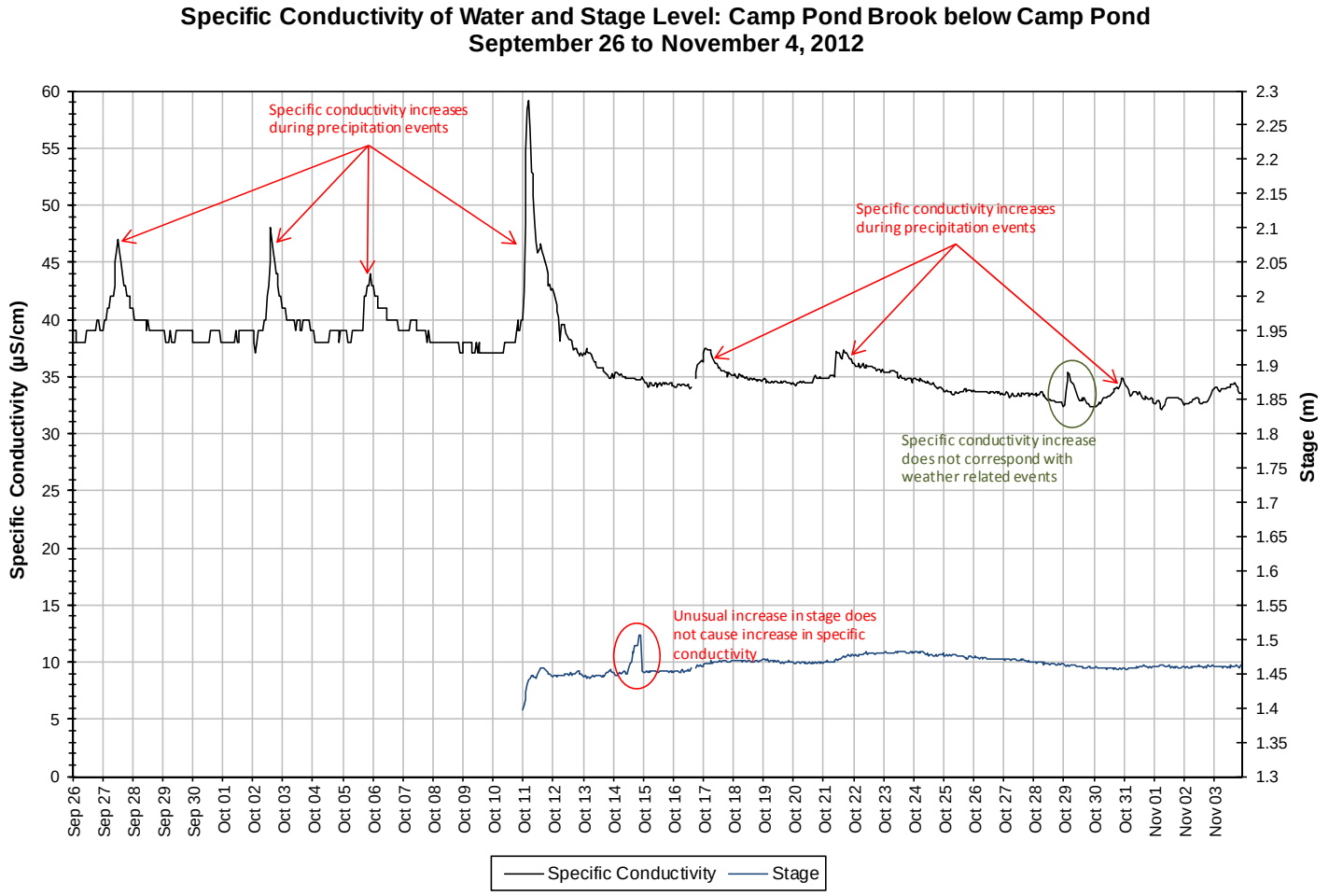

Figure 25: Specific conductivity and stage level at Camp Pond Brook

- Dissolved oxygen content ranges between 10.65mg/l and 14.01mg/l. The saturation of dissolved oxygen ranges from 89.3% to 101.0% (Figure 26).
- Dissolved oxygen content is generally increasing throughout the deployment period but also has many short term decreases. These decreases in dissolved oxygen correspond with unusually warm air temperatures which temporarily increase the water temperature (Figure 23). The decrease in dissolved oxygen on October 11 corresponds with warm air temperatures and a significant rainfall event. These events are highlighted in red on Figure 26.
- All values are above both the minimum CCME Guideline for the Protection of Cold Water Biota at Other Life Stages (6.5mg/l) and Early Life Stages (9.5mg/l). Guidelines are indicated in blue on Figure 26. Average dissolved oxygen content is 12.63mg/l.

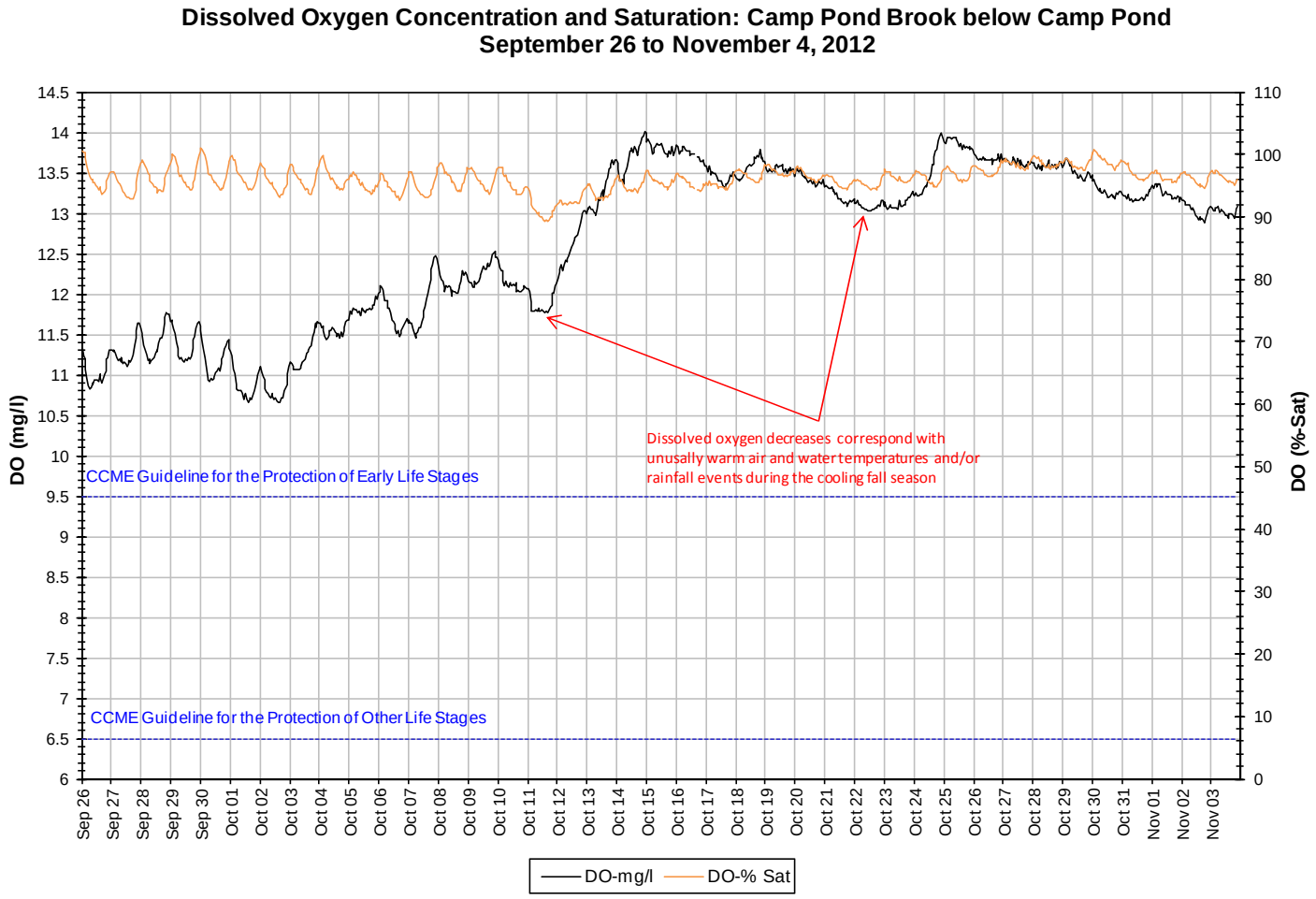

Figure 26: Dissolved oxygen and percent saturation at Camp Pond Brook

- Turbidity generally ranges between 0.0NTU to 92.8NTU (Figure 27). A median value of 33.7NTU indicates there is a natural background turbidity value at this station for this deployment period.
- This high median value is exceptionally unusual for this station and data should be considered with caution. Upon retrieval, some biofouling was reported on the sensors however this is a significant increase in background turbidity values. Typically, this station reports numerous turbidity events however they are normally short lived and correspond well with rainfall events.
- Turbidity patterns for this deployment period are not typical of this station or any station in the network. Normally during a turbidity event, an increase occurs relatively quickly followed by a period of recovery when turbidity decreases to baseline levels (in this case 0NTU) over a number of hours or days depending on the magnitude of the increase and stage level. It is unknown what caused these turbidity values at this station for this deployment period.

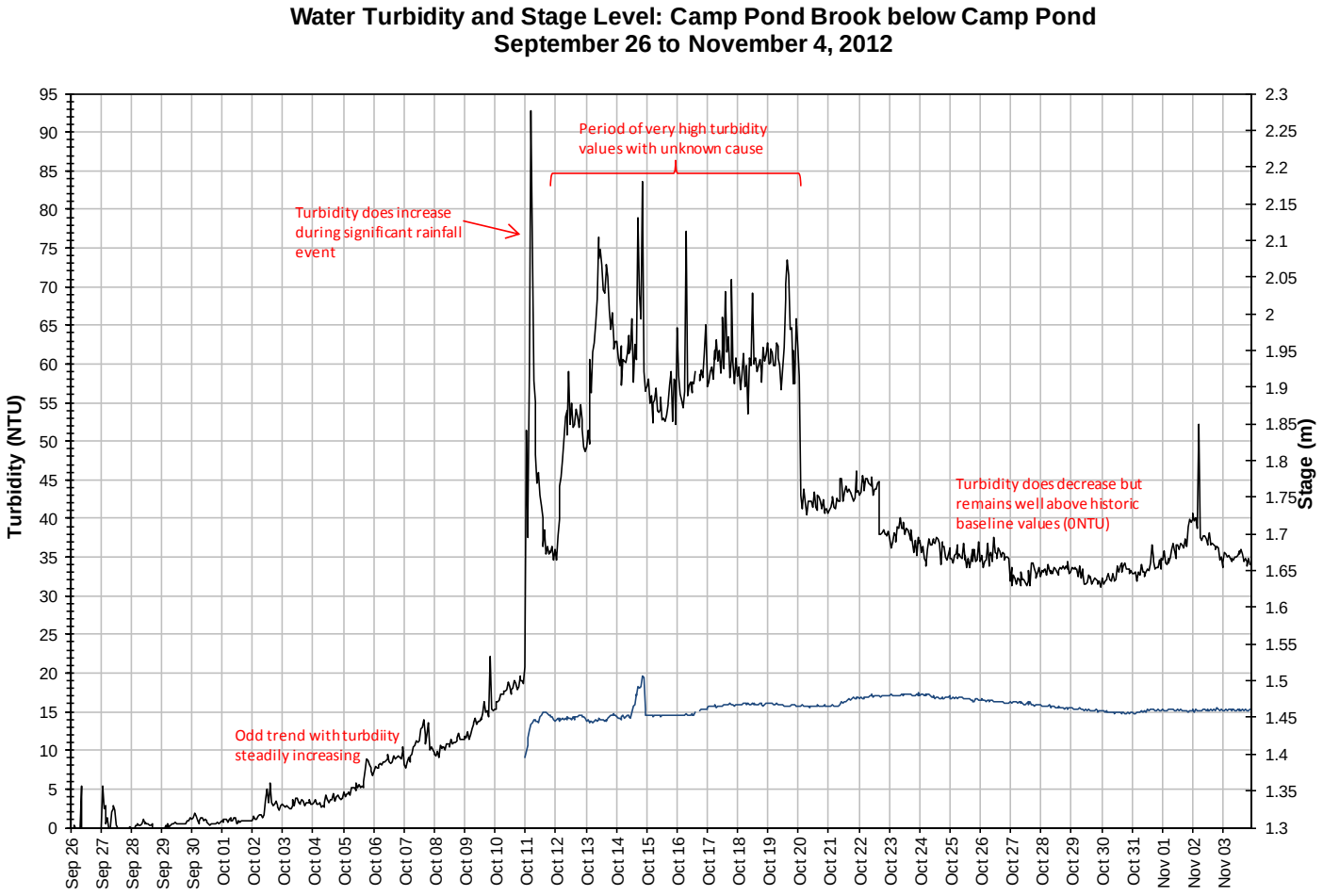

Figure 27: Turbidity and stage level at Camp Pond Brook

- Stage and precipitation are graphed below to show the relationship between rainfall and water level (Figure 28). Stage data is only available for the latter half of the deployment period due to the transmission error from September 13 to October 11. Stage is generally stable for this part of the deployment period. Available stage level values range from 1.40 to 1.51m, a difference of 0.11m.
- Precipitation events occur about 50% of the time and are generally low in magnitude with the exception of the significant event on October 11.

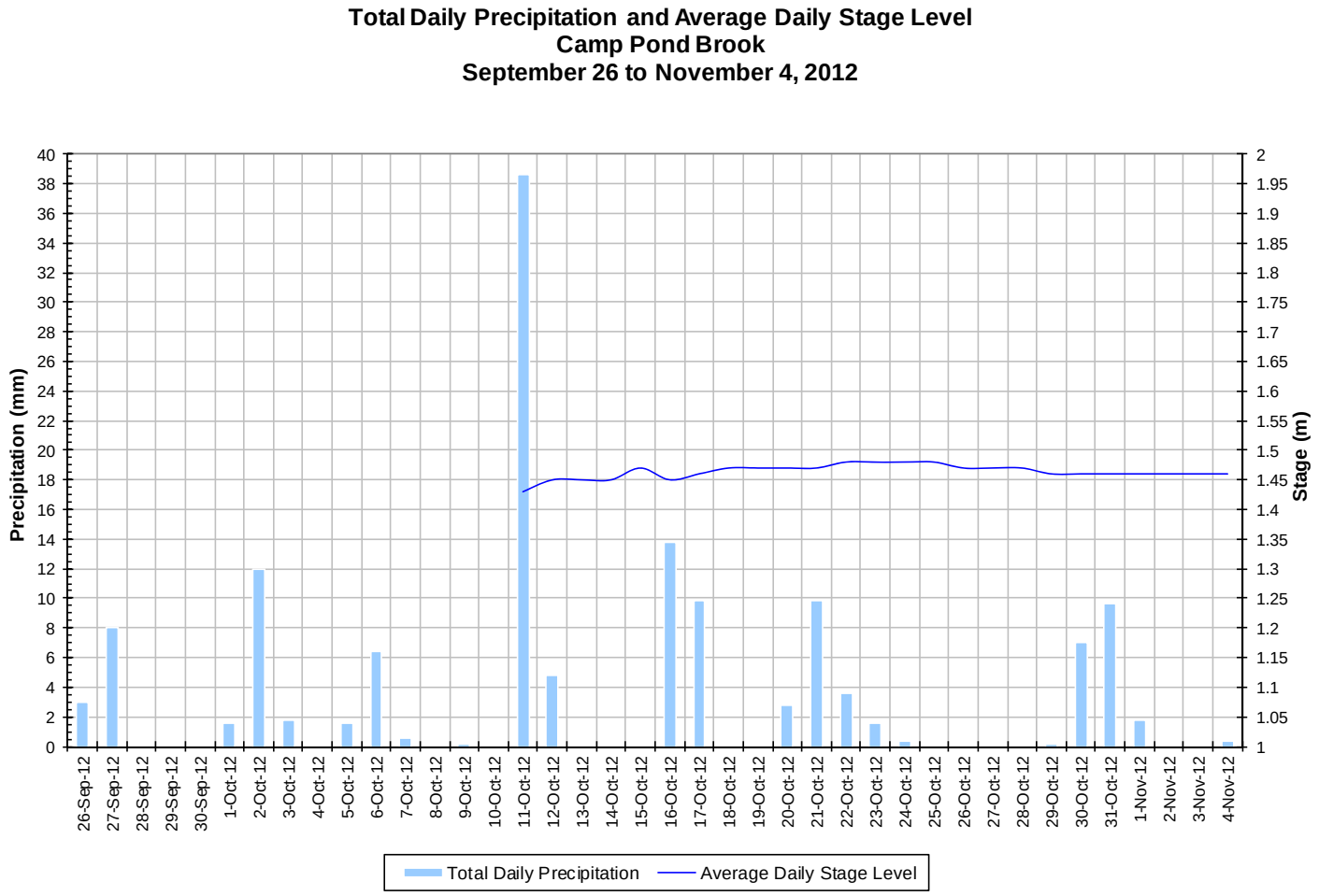

Figure 28: Daily precipitation and average daily stage level at Camp Pond Brook

(weather data recorded at Nain)

Conclusions

- Instruments at water quality monitoring stations in the Voisey's Bay Network were deployed from September 26 to November 4, 2012.

Summary by Station

- At Upper Reid Brook, water temperature decreased for the first half of the deployment period and then levelled out midway through October. pH was neutral and stable with the exception of 2 decreases that corresponded with precipitation events. Specific conductivity was low and very stable which is normal for this station. Dissolved oxygen generally increased however showed some periods of decreasing when air and water temperatures were exceptionally warm. Turbidity remained mostly at 0NTU. Stage levels increased mid-way through the deployment period.
- At Tributary to Lower Reid Brook, temperature generally decreased in response to cold air temperatures while dissolved oxygen showed a clear inverse relationship to water temperature and increased. pH and specific conductivity fluctuated significantly and quickly in response to changing water levels displaying an inverse relationship with stage levels. Turbidity events were frequent and typically correspond with precipitation events. Events at this station closely resemble the events captured at the station nearby on Lower Reid Brook.
- At Lower Reid Brook, temperature also generally decreased in response to cold air temperatures while dissolved oxygen showed a clear inverse relationship to water temperature and increased. pH and specific conductivity changed significantly quickly in response to changing water levels displaying an inverse relationship to stage level. There was one main turbidity event recorded on October 11 which corresponded with a heavy rainfall event and stage increase. Events at this station closely resemble the events captured at the station nearby on Tributary to Lower Reid Brook.
- At Camp Pond Brook, temperature also generally decreased in response to cold air temperatures while dissolved oxygen showed a clear inverse relationship to water temperature and increased. pH was generally stable, fluctuating diurnally except for a notable decrease on October 11 following a large rainfall event. Specific conductivity did not portray a typical inverse relationship with stage level increases caused by precipitation events. Instead of seeing specific conductivity decrease during or shortly after rainfall events, specific conductivity increased. This atypical pattern has been seen at this station in the past. Turbidity data had a median value of 33NTU and is likely the cause of an instrument error. Turbidity values were consistently increasing or way above average throughout the deployment period. Stage data is missing for the first half of the deployment period due to a transmission error. Stage levels in the latter half of the month are relatively stable.

Summary by Parameter

- Temperature averaged between 4.07°C (Camp Pond Brook) and 6.21°C (Upper Reid Brook) at the 4 stations in the Voisey's Bay Network. Temperature decreased at all stations throughout the deployment period in response to cold air temperatures. Water temperature is most stable at the Upper Reid Brook station because of the lake environment from which the water flows. At Upper Reid Brook, water temperatures levelled off at ~5°C indicating the fall turnover.

- pH values averaged between 6.67 (Lower Reid Brook) and 7.08 (Camp Pond Brook) pH units across the network. At Lower Reid Brook and Tributary to Lower Reid Brook, pH values increased and decreased inversely to changing water level. Values collected at these stations decreased below the CCME Guideline for the Protection of Aquatic Life. At Upper Reid Brook and Camp Pond Brook, pH values were less variable but a couple of decreases were noted during the largest rainfall event of nearly 40mm on October 11. All values recorded at these two stations were within the recommended range as stated by the CCME Guideline for the Protection of Aquatic Life.
- At Tributary to Lower Reid Brook, Lower Reid Brook and Camp Pond Brook stations, specific conductivity averaged between 30.7µS/cm (Lower Reid Brook) and 36.7µS/cm (Camp Pond Brook). Values at Upper Reid Brook were considerably lower averaging 9.1µS/cm. These lower values are expected from this pristine station at the outflow from Reid Pond. Values at this station tend not to fluctuate a lot even with changing stage levels. At Tributary to Lower Reid and Lower Reid Brook Stations, specific conductivity displayed a clear inverse relationship with stage level, with values decreasing when stage level increased. At Camp Pond Brook, specific conductivity increased sharply during precipitation events which is a trend normally seen at this station.
- Dissolved oxygen levels averaged between 11.76mg/l (Upper Reid Brook) and 12.98mg/l (Lower Reid Brook). All values recorded at these stations were above both the minimum CCME Guideline for the Protection of Aquatic Life at Other Life Stages (6.5mg/l) and Early Life Stages (9.5mg/l). Dissolved oxygen content fluctuated diurnally and in response to changing water temperatures at all stations throughout the deployment period. Dissolved oxygen content at Upper Reid Brook is more stable due to the lake from which the water flows.
- Median turbidity values are 0NTU at stations at Upper Reid Brook, Tributary to Lower Reid Brook and Lower Reid Brook indicating there is generally no background turbidity in these streams. The median turbidity level at Camp Pond Brook was 33NTU which is extremely high and trends suggest this data is subject to error. Turbidity events were rare at stations on Upper Reid Brook and Lower Reid Brook. At the Tributary to Lower Reid station, turbidity events were more frequent but almost always corresponded well with precipitation events.
- Stage generally increased throughout the deployment period, most notably on October 11 following a large rainfall event. Stage remained higher at most stations following this increase. Stage data is missing for the first half of the deployment period at Camp Pond Brook due to a transmission error from September 13 to October 11. Stage is very stable at this station in the latter half of the deployment period. Total stage fluctuation ranged anywhere from 60cm (Tributary) to just 11cm (Camp Pond Brook) over the deployment period. Precipitation events were frequent but low in magnitude except for the heavy rainfall recorded on October 11.

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Appendix 1: Weather Data – Environment Canada Historical Climate Database