Real-Time Water Quality Deployment Report

Voisey's Bay Network

July 21 to
August 30, 2011

Newfoundland Labrador

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

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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 July 21, 2011, ENVC and Vale Environment staff deployed real-time water quality monitoring instruments at the four real time stations in the Voisey's Bay network for a period of 39 days. Instruments were removed for cleaning and calibration by Vale Environment staff on August 30.

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 July 21 to August 30, 2011 are summarized in Table 2.

Table 2: Comparison rankings for Voisey's Bay Network stations, July 21– August 30, 2011

Station Voisey's Bay	Date	Action	Comparison Ranking				
			Temperature	pH	Conductivity	Dissolved Oxygen	Turbidity
Upper Reid Brook	Jul 21, 2011	Deployment	Good	Good	Excellent	Excellent	n/a*
	Aug 30, 2011	Removal	Excellent	Fair	Excellent	Poor	n/a†
Tributary to Lower Reid Brook	Jul 21, 2011	Deployment	Excellent	Marginal	Excellent	Good	Excellent
	Aug 30, 2011	Removal	Excellent	Fair	Good	Excellent	n/a†
Lower Reid Brook	Jul 21, 2011	Deployment	Good	Excellent	Good	Poor	Excellent
	Aug 30, 2011	Removal	Excellent	Fair	Good	Poor	n/a†
Camp Pond Brook	Jul 21, 2011	Deployment	Good	Good	Good	Good	Excellent
	Aug 30, 2011	Removal	Excellent	Good	Fair	Excellent	n/a†

* QAQC comparison rankings were not available at removal at the Upper Reid Brook station due to the absence of power in the field instrument.

† QAQC comparison readings were not available at deployment for turbidity at all four stations station due to the absence of a turbidity sensor on the QAQC instrument.

- At the station at Upper Reid Brook, temperature, pH, specific conductivity and dissolved oxygen all ranked either 'good' or 'excellent' at deployment. No turbidity comparison readings are available because the field sonde at this station is not equipped with a turbidity sensor.
- At removal, temperature and specific conductivity both ranked 'excellent' while pH ranked 'fair' and dissolved oxygen ranked 'poor'. For pH, the field instrument read a value or 7.45 and the QAQC instrument read a value of 8.04. For dissolved oxygen, the field instrument read 9.26mg/l while the QAQC instrument read a value of 10.47mg/l. Both of these disparities may in part be caused by the insufficient time for the instrument to stabilize or the difference between the positions of the field and QAQC instruments. No comparisons rankings for turbidity are available because the QAQC instrument was not equipped with a turbidity sensor.
- At the station on the Tributary to Lower Reid Brook, temperature, specific conductivity, dissolved oxygen and turbidity all ranked either 'good' or 'excellent' at deployment while pH ranked 'marginal'. The field instrument read a value of 5.80 and the QAQC instrument read a value of 6.70. This discrepancy is likely due to the time required for stabilization at deployment. Field notes indicate the 5.80 field instrument measurement was continuing to rise when values were recorded. The first transmission from the station following deployment (approximately 1 hour later) read a value of 6.63 which when compared to the QAQC value yields an 'excellent' ranking.
- At removal, temperature, specific conductivity and dissolved oxygen all ranked either 'good' or 'excellent' while pH ranked 'fair'. The field instrument read a value of 6.54 while the QAQC instrument read a value of 7.16. This disparity may in part be caused by the insufficient time for the instrument to stabilize or the

difference between the positions of the field and QAQC instruments. A similar situation at the Upper Reid Brook station happened on the same day where the pH sensor was reading high on the QAQC instrument. No comparisons rankings for turbidity are available because the QAQC instrument was not equipped with a turbidity sensor.

- At the station on Lower Reid Brook below the tributary, temperature, pH, specific conductivity, and turbidity all ranked either 'good' or 'excellent' at deployment while dissolved oxygen ranked 'poor'. The dissolved oxygen sensor failed to calibrate correctly on July 21 before deployment. The decision was made to deploy the instrument regardless of the sensor failure. A note on the online graph indicated to the public that values reported for dissolved oxygen content and percent saturation were inaccurate. Even though turbidity was ranked 'excellent' at deployment, it is clear from the data collected during the deployment period that the sensor electronics and functioning were affected by the dissolved oxygen sensor failure. Data collected for turbidity during this time is not accurate and has been removed from the data set.
- At removal, temperature and specific conductivity ranked 'excellent' and 'good' respectively while pH ranked 'fair'. The field instrument read a value of 6.80 while the QAQC instrument read a value of 7.50. This disparity may in part be caused by the insufficient time for the instrument to stabilize or the difference between the positions of the field and QAQC instruments. A similar situation at the Upper Reid Brook and Tributary to Lower Reid Brook stations happened on the same day where the pH sensor was reading high on the QAQC instrument. Dissolved oxygen continued to rank 'poor' however this was expected given that the sensor had failed to calibrate correctly at the time of deployment. Dissolved oxygen data for this deployment period is inaccurate and has been removed from the data set. Turbidity data was also compromised during this deployment period. No comparisons rankings for turbidity are available because the QAQC instrument was not equipped with a turbidity sensor.
- At the station on Camp Pond Brook, all parameters ranked either 'good' or excellent' at deployment.
- At removal, temperature, pH and dissolved oxygen all ranked either 'good' or 'excellent' while specific conductivity ranked 'fair'. The field instrument read a value of 40.9uS/cm while the QAQC instrument read a value of 29.5uS/cm, a difference 11.4uS/cm. Both the QAQC and field instrument for this station were calibrated to 100uS/cm on August 31 without any indication of sensor error supporting the idea that both instruments were functioning properly on the previous day during removal. This disparity may in part be caused by the insufficient time for the instrument to stabilize or the difference between the positions of the field and QAQC instruments. No comparisons rankings for turbidity are available because the QAQC instrument was not equipped with a turbidity sensor.

Data Interpretation

- The following graphs and discussion illustrate significant water quality-related events from July 21 to August 30 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 ranged from 9.39 ^{o}C to 19.34^{o}C during this deployment period (Figure 1).
- Water temperature is stable for the first two weeks before peaking mid deployment period to just under 20°C. Water temperature remains high (>16°C) for a period of 4 days before decreasing again and stabilizing for the remainder of the deployment period (around 13°C). The four days of warm water temperatures correspond with warm ambient air temperatures recorded in the region (Figure 2). Water temperature fluctuates diurnally.

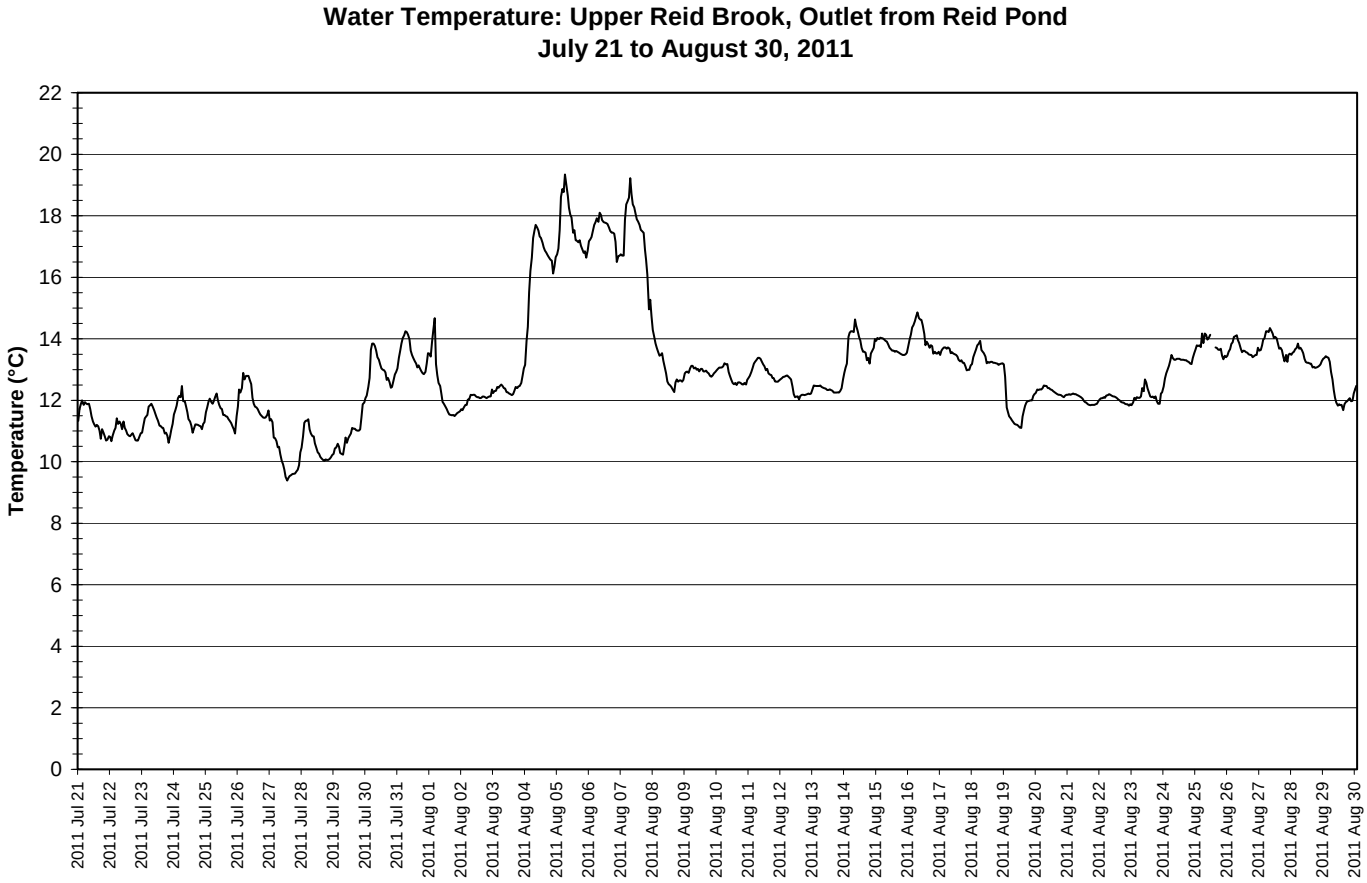

Figure 1: Water temperature at Upper Reid Brook

- Average daily air temperatures fluctuate at the beginning of the deployment period (Figure 2). Each time the air temperature increases for a period of time, the water temperature warms slightly. By mid deployment (mid summer), the water temperature surpasses the air temperature and peaks for the season. When compared seasonally, air temperatures generally increase and decrease faster while water temperatures increase and decrease more slowly.

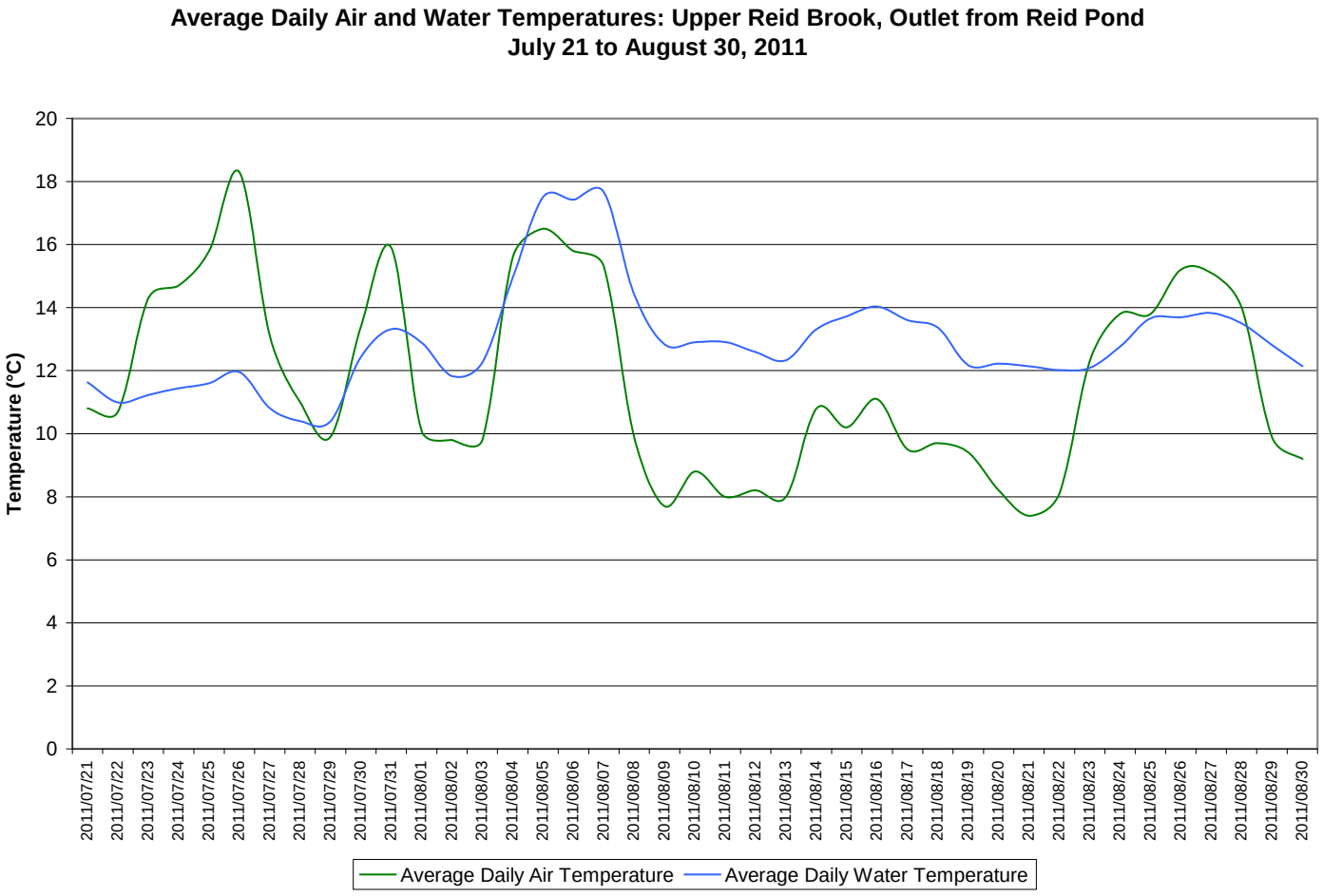

Figure 2: Average daily air and water temperatures at Upper Reid Brook

(weather data recorded at Nain)

- pH ranges between 6.50 and 7.81 pH units (Figure 3).
- All values are within the recommended range of the CCME Guideline for the Protection of Aquatic Life (between 6.5 and 9.0 pH units).
- Stage is included on Figure 3 to show the relationship between water level and pH. Stage level is decreasing in the first 2 weeks and then remains low for the remainder of the deployment period. After this decrease in water level, the deployed instrument appears to be more susceptible to changes in pH in the shallow water environment. pH fluctuates diurnally to a great extent in the last three weeks of the deployment period.

Water pH and Stage Level: Upper Reid Brook, Outlet from Reid Pond
July 21 to August 30, 2011

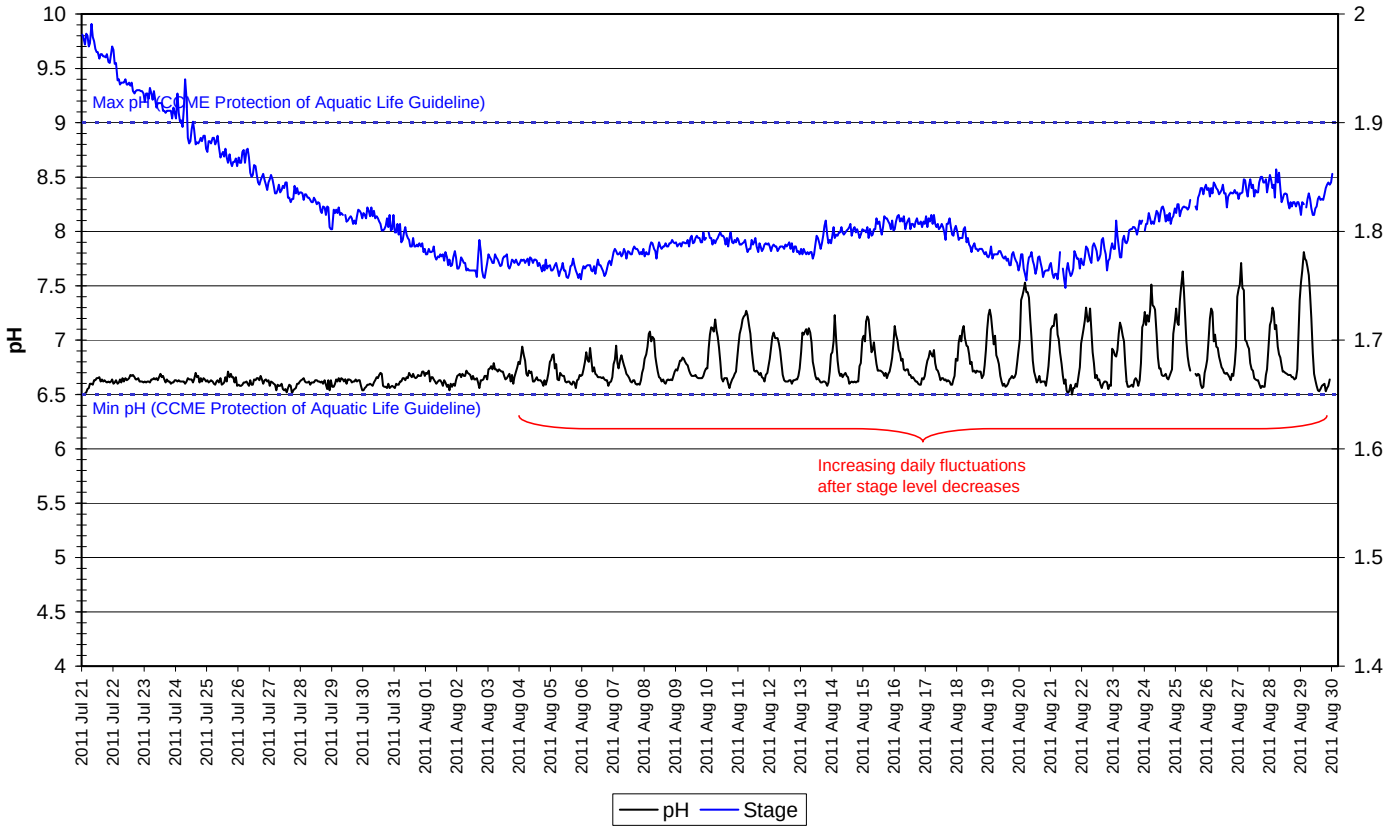

Figure 3: pH and stage level at Upper Reid Brook

- Specific conductivity ranges from 9.5µS/cm to 11.0µS/cm during the deployment period, averaging 10.1µS/cm (Figure 4).
- Specific conductance remains very low and stable throughout the deployment period with minimal fluctuation regardless of the changing water level. This trend is expected as the flow from this station is directly from a stable lake environment.

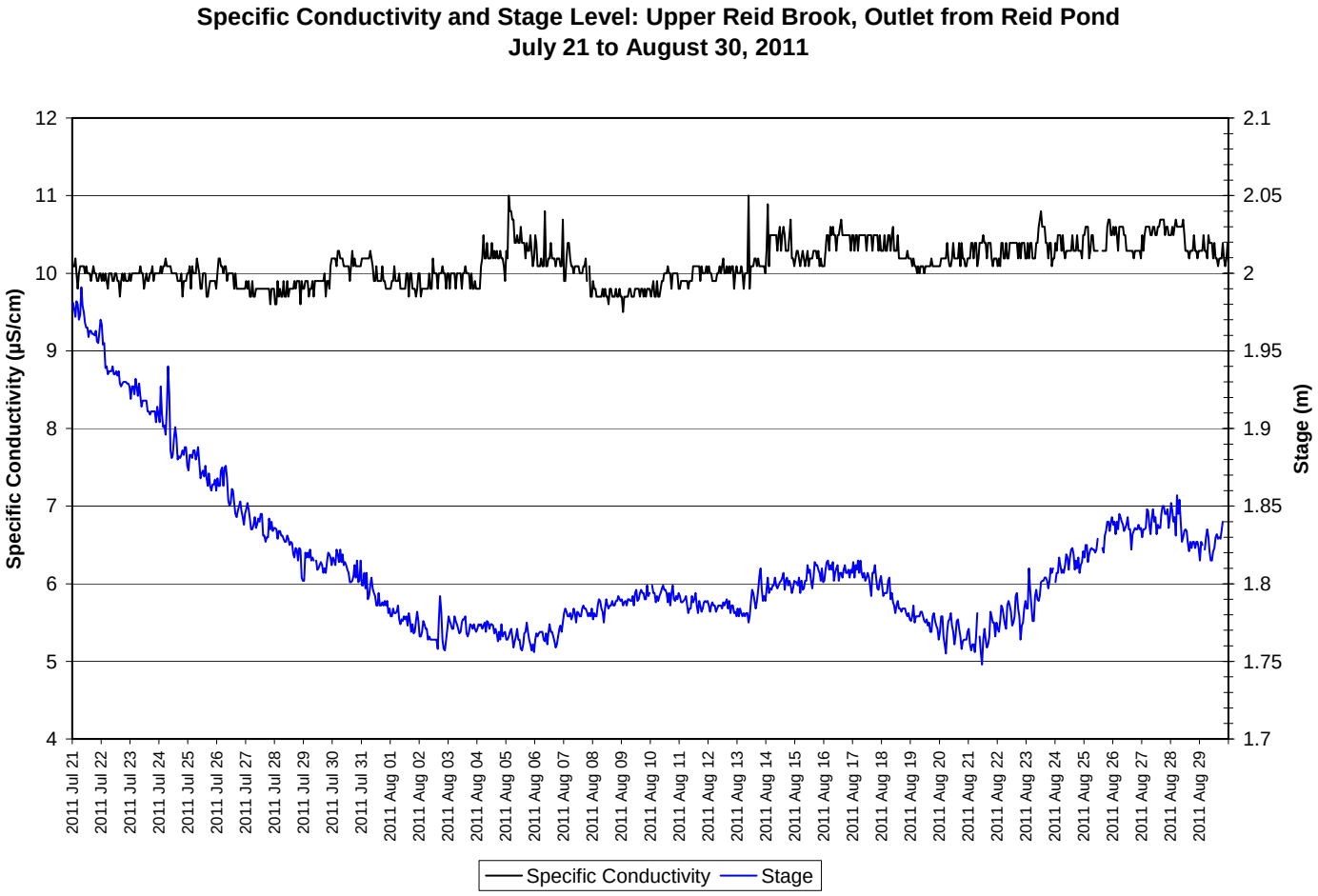

Figure 4: Specific conductivity and stage level at Upper Reid Brook

- Dissolved oxygen content ranged between 7.40mg/L and 11.39mg/L. The saturation of dissolved oxygen ranged from 76.8% to 104.2% (Figure 5).
- All values were above the minimum CCME Guideline for the Protection of Other Life Stage Cold Water Biota of 6.5 mg/l. After the first week of the deployment period, values decrease to below the minimum CCME Guideline for the Protection of Early Life Stage Cold Water Biota value of 9.5 mg/l for the remainder of the deployment period. The guidelines are indicated in blue on Figure 5.
- Dissolved oxygen content and percent saturation are low at this station for this time of year however values have fluctuated considerably in previous years. Values at the station at Camp Pond Brook are also low during this deployment period. Sensor performance may be lessening as the instruments age.

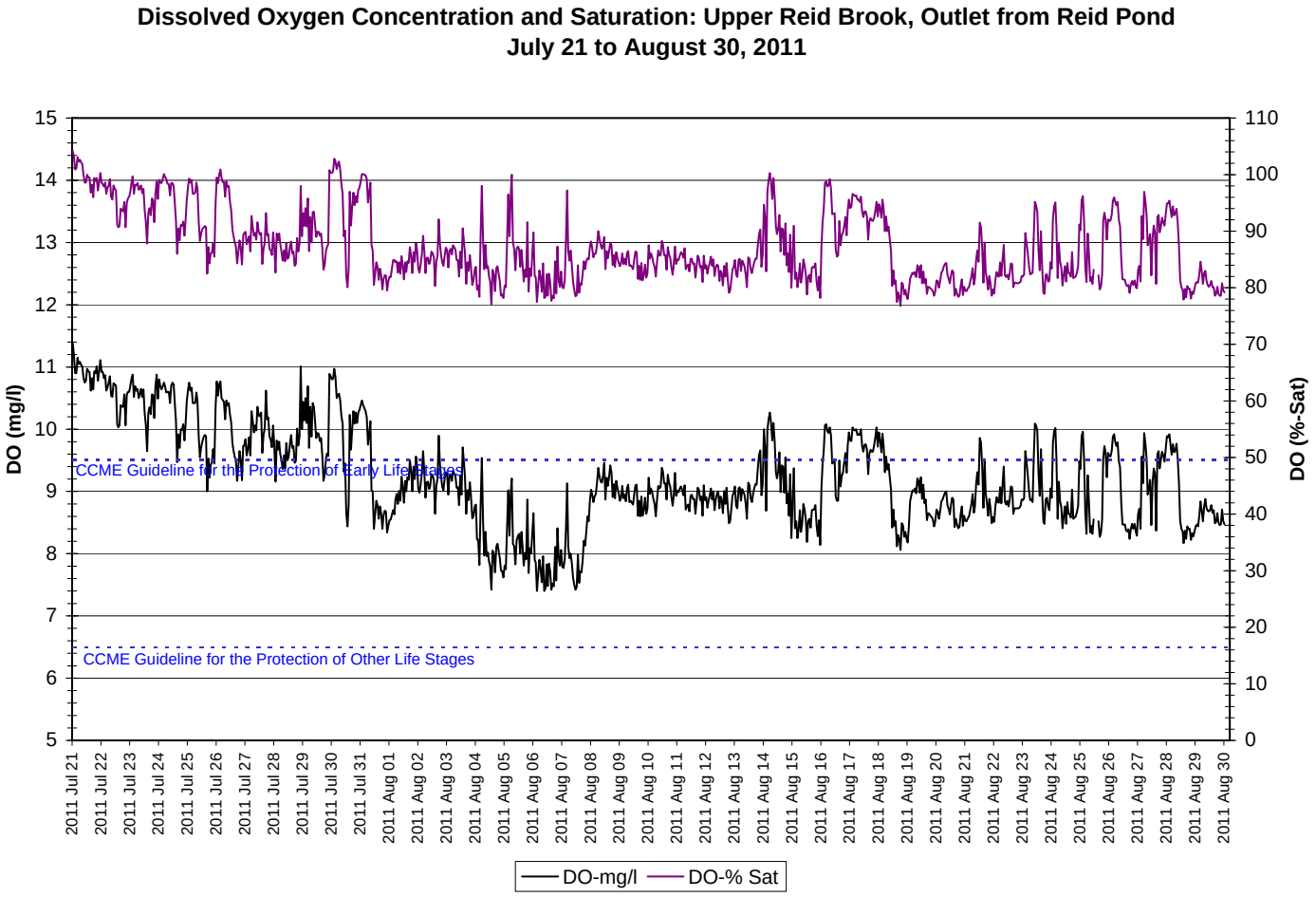

Figure 5: Dissolved oxygen and percent saturation at Upper Reid Brook

- The instrument deployed at Upper Reid Brook is a replacement instrument provided by the Department of Environment and Conservation. The Minisonde 4a, Special Edition, features a temperature, specific conductivity, Clark cell dissolved oxygen and pH sensors. This instrument is not equipped with a turbidity sensor therefore no turbidity data is available for discussion at this station.

- Stage and precipitation are graphed below to show the relationship between rainfall and water level (Figure 6). Stage is generally decreasing throughout the first two weeks of deployment period. Stage level remains stable for a period of two and a half weeks before increasing slightly just before removal. Precipitation events are frequent and vary in magnitude throughout the deployment period.

Daily Precipitation and Average Daily Stage Level: Upper Reid Brook, Outlet from Reid Pond
July 21 to August 30, 2011

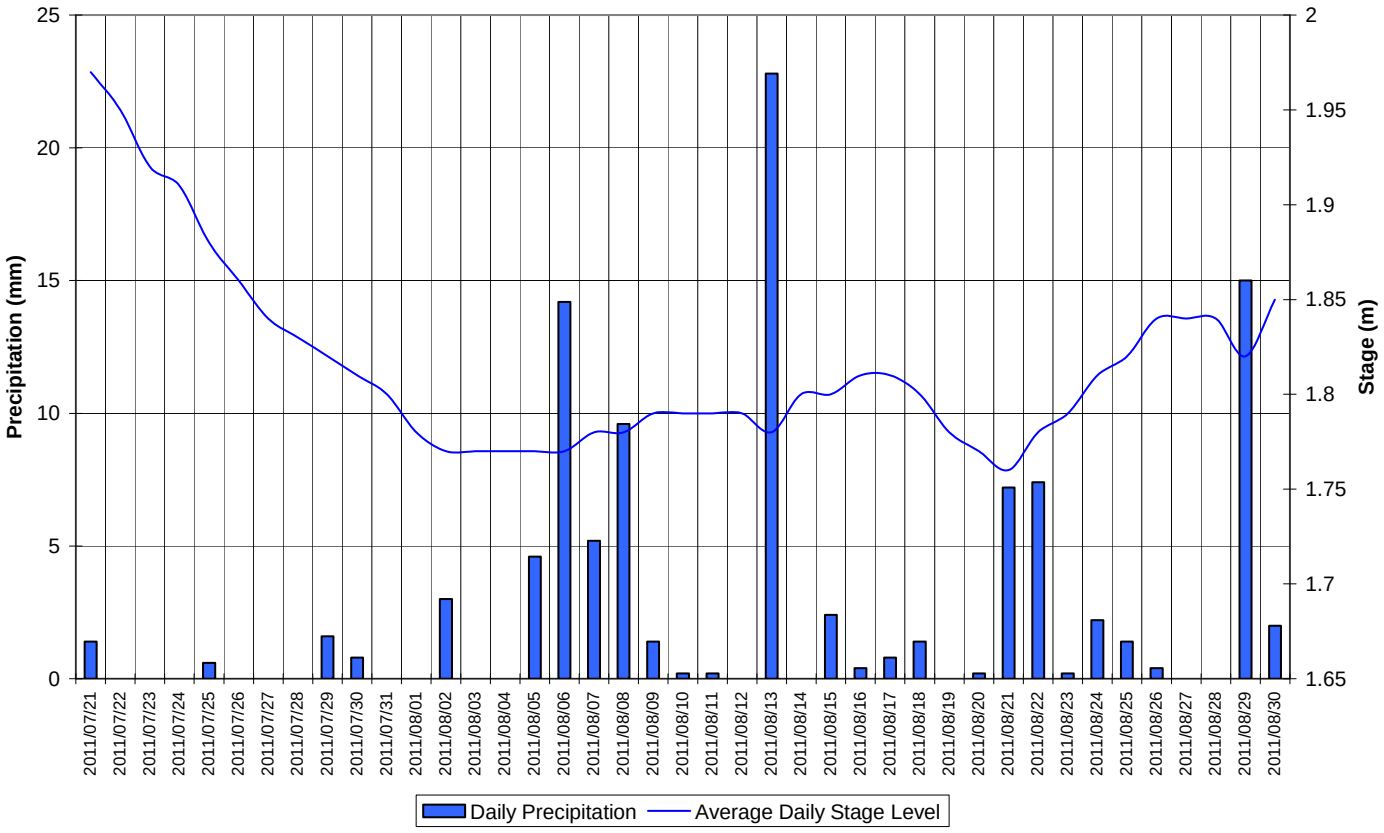

Figure 6: Daily precipitation and average daily stage level at Upper Reid Brook

(weather data recorded at Nain)

Tributary to Lower Reid Brook

- Water temperature ranges from 8.60 °C to 15.40°C during this deployment period (Figure 7).
- Water temperature is generally increasing throughout the beginning of the deployment period. Water temperature peaks for the season at 15.40°C on August 5 and decreases throughout the remainder of the deployment period. This trend is expected given the warm ambient air temperature in the summer season (Figure 8). Water temperature fluctuates diurnally.

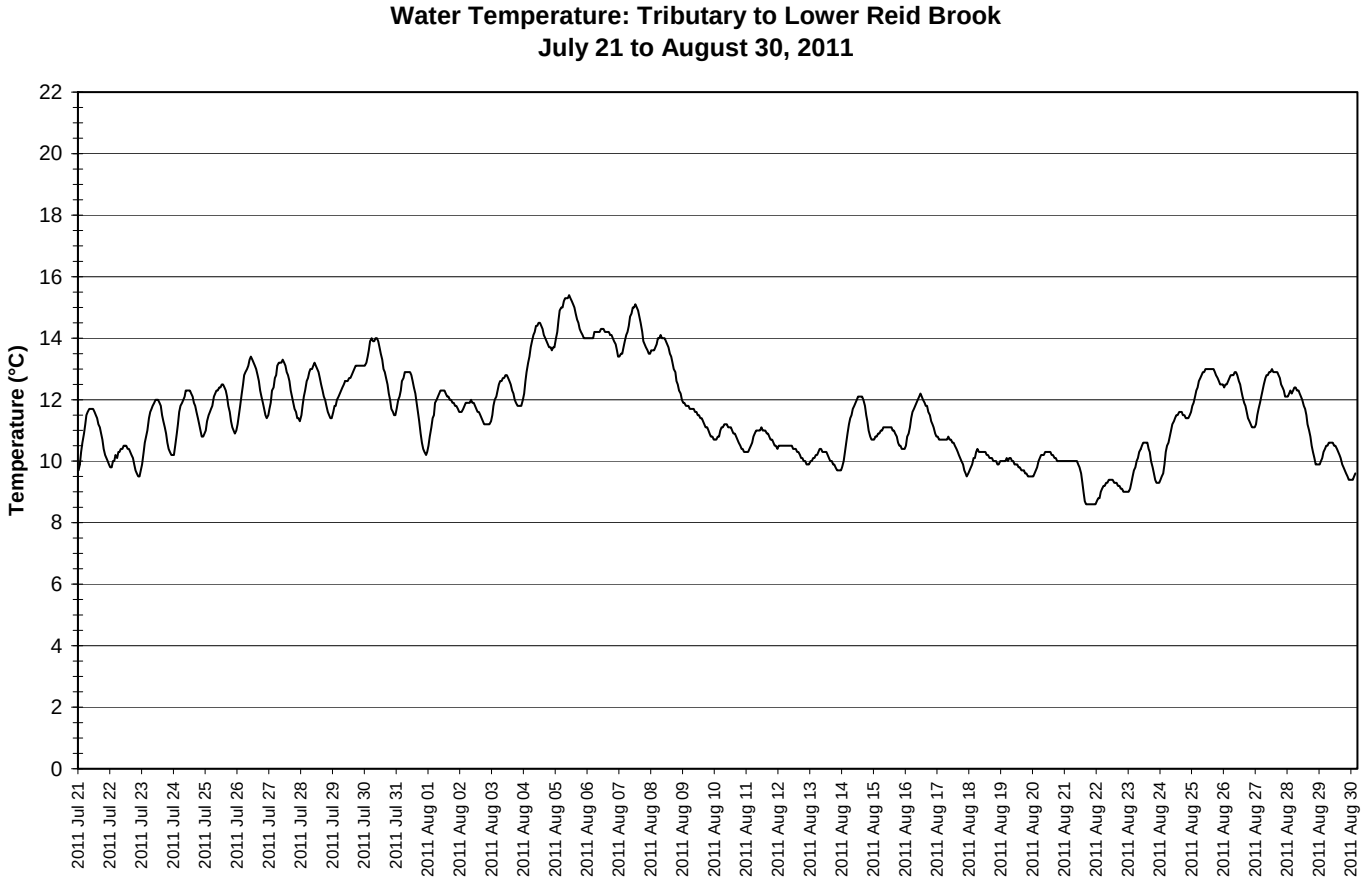

Figure 7: Water temperature at Tributary to Lower Reid Brook

- Average daily air temperatures fluctuate at the beginning of the deployment period (Figure 8). Each time the air temperature increases for a period of time, the water temperature warms slightly. By mid deployment (mid summer), the water temperature surpasses the air temperature. When compared seasonally, air temperatures generally increase and decrease faster while water temperatures increase and decrease more slowly.

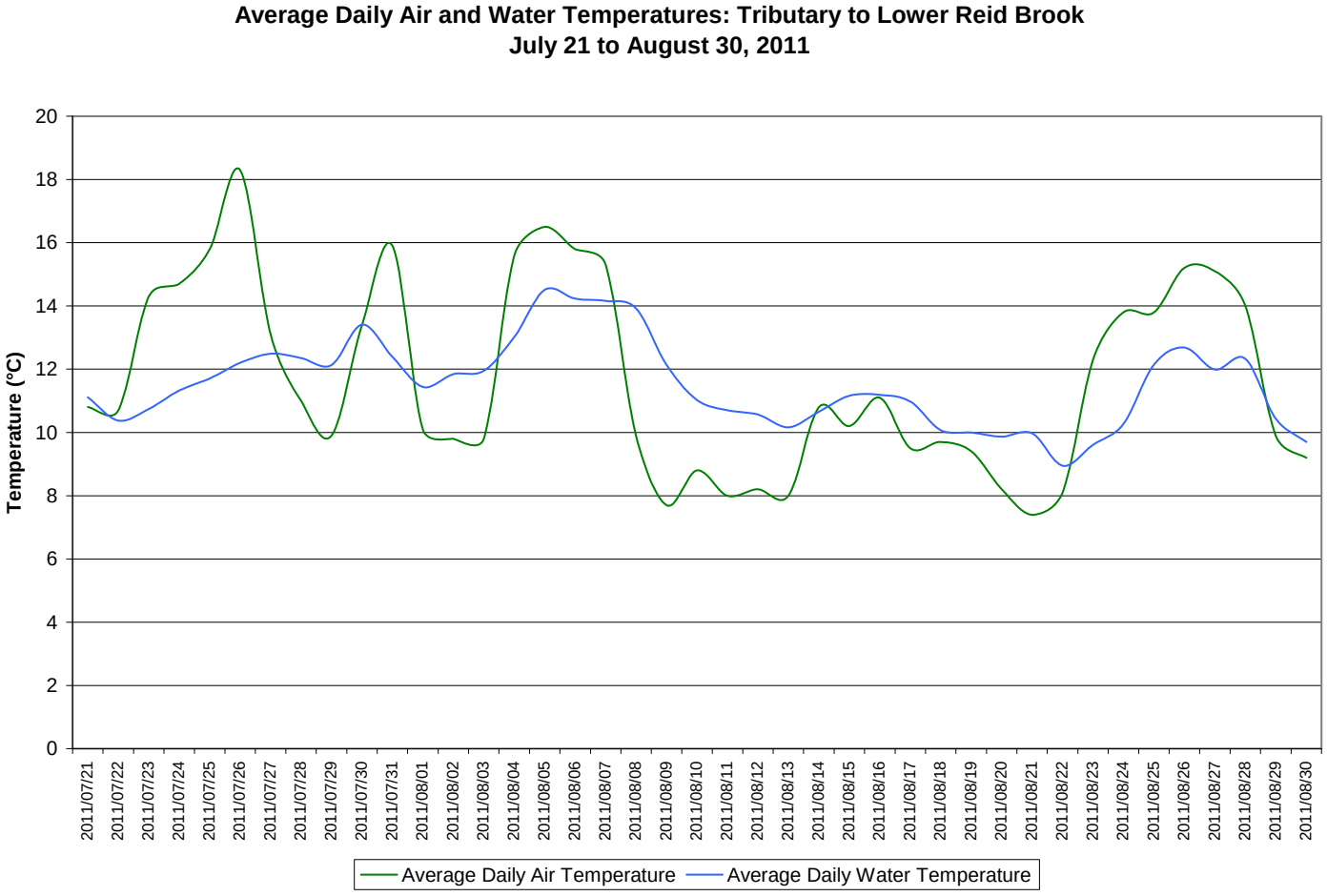

Figure 8: Average daily air and water temperatures at Tributary to Lower Reid Brook

(weather data recorded at Nain)

- pH ranges between 6.60 and 7.13 pH units (Figure 9). pH values decrease throughout the deployment period, averaging 6.91 pH units.
- All 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 9).
- Stage is included on Figure 9 to show the relationship between water level and pH. pH decreases significantly on two different occasions. On August 6-7, pH decreases from a high of 7.13 to 6.77 in just over 2 days. This decrease corresponds with the rapidly decreasing specific conductivity (Figure 10) and a rainfall event recorded in the region with an increase in stage (Appendix 1). On August 21-22, pH drops from a high of 6.98 to a low of 6.60 in a matter of only 10 hours. This event also corresponds with decreasing specific conductivity (Figure 10), and a rainfall event with an increase in stage lasting several days (Appendix 1).

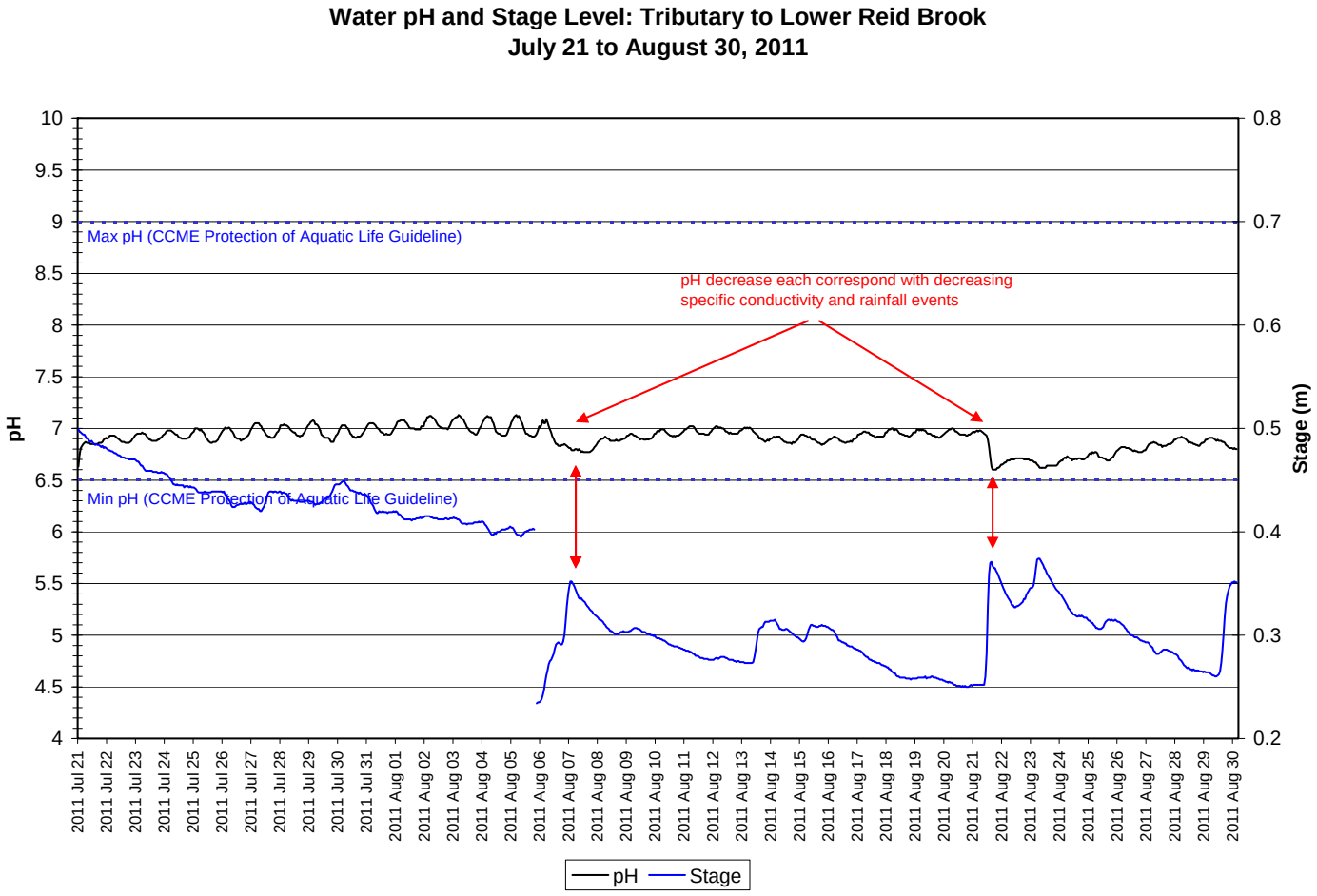

Figure 9: pH and stage level at Tributary to Lower Reid Brook

- Specific conductivity ranges between 27.1µS/cm and 36.4µS/cm and is fluctuating significantly throughout the deployment period (Figure 10).
- Stage is included in Figure 10 to illustrate the inverse relationship between conductivity and water level. Raw uncorrected stage data for this deployment period is depicted below. There is a jump in stage level from 0.404m to 0.234m on August 6. Corrected hydrometric data is available upon request from Environment Canada.
- Generally, stage is fluctuating throughout the deployment period with many increases and decreases. As stage increases, specific conductivity generally decreases (indicated by red arrows on Figure 10). During these events, trends in pH are also affected (Figure 9). As stage decreases, specific conductivity usually increases as the concentration of dissolved solids increases. Inversely, as stage increases, specific conductivity generally decreases due to the dilution of dissolved solids in the water column.

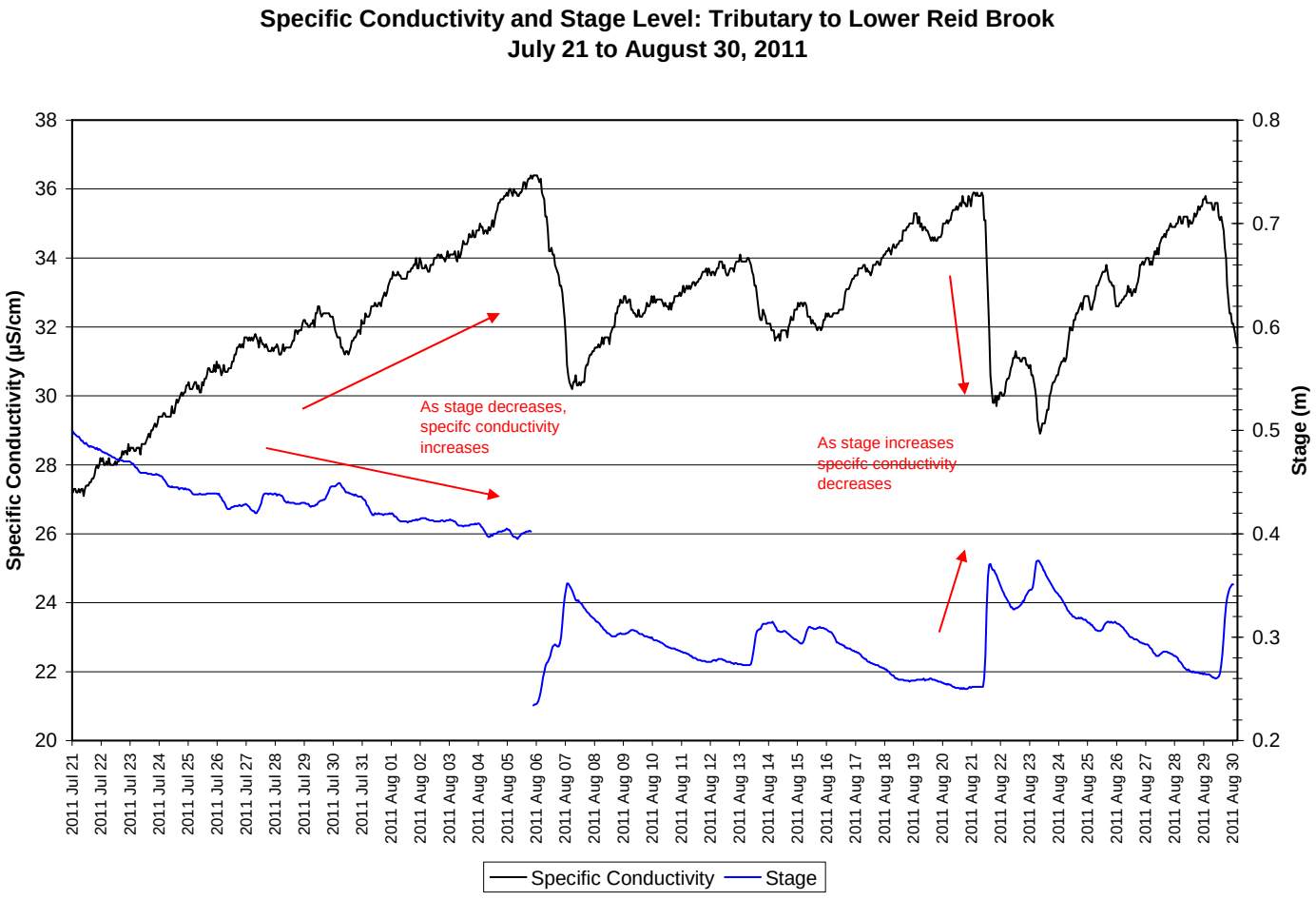

Figure 10: Specific conductivity and stage level at Tributary to Lower Reid Brook

- Dissolved oxygen content ranged between 9.44mg/L and 11.13mg/L. The saturation of dissolved oxygen ranged from 92.6% to 101.5% (Figure 11).
- All values were above the minimum CCME Guideline for the Protection of Other Life Stage Cold Water Biota of 6.5 mg/l. The dissolved oxygen values fell below the minimum CCME Guideline for the Protection of Early Life Stage Cold Water Biota value of 9.5 mg/l for a total of five hours on August 5-6 during a rainfall event and period of warm ambient air and water temperatures (Figure 8). The guidelines are indicated in blue on Figure 11.
- Dissolved oxygen remains relatively stable for the entire deployment period, fluctuating slightly in response to changing water temperatures. Dissolved oxygen fluctuates diurnally.

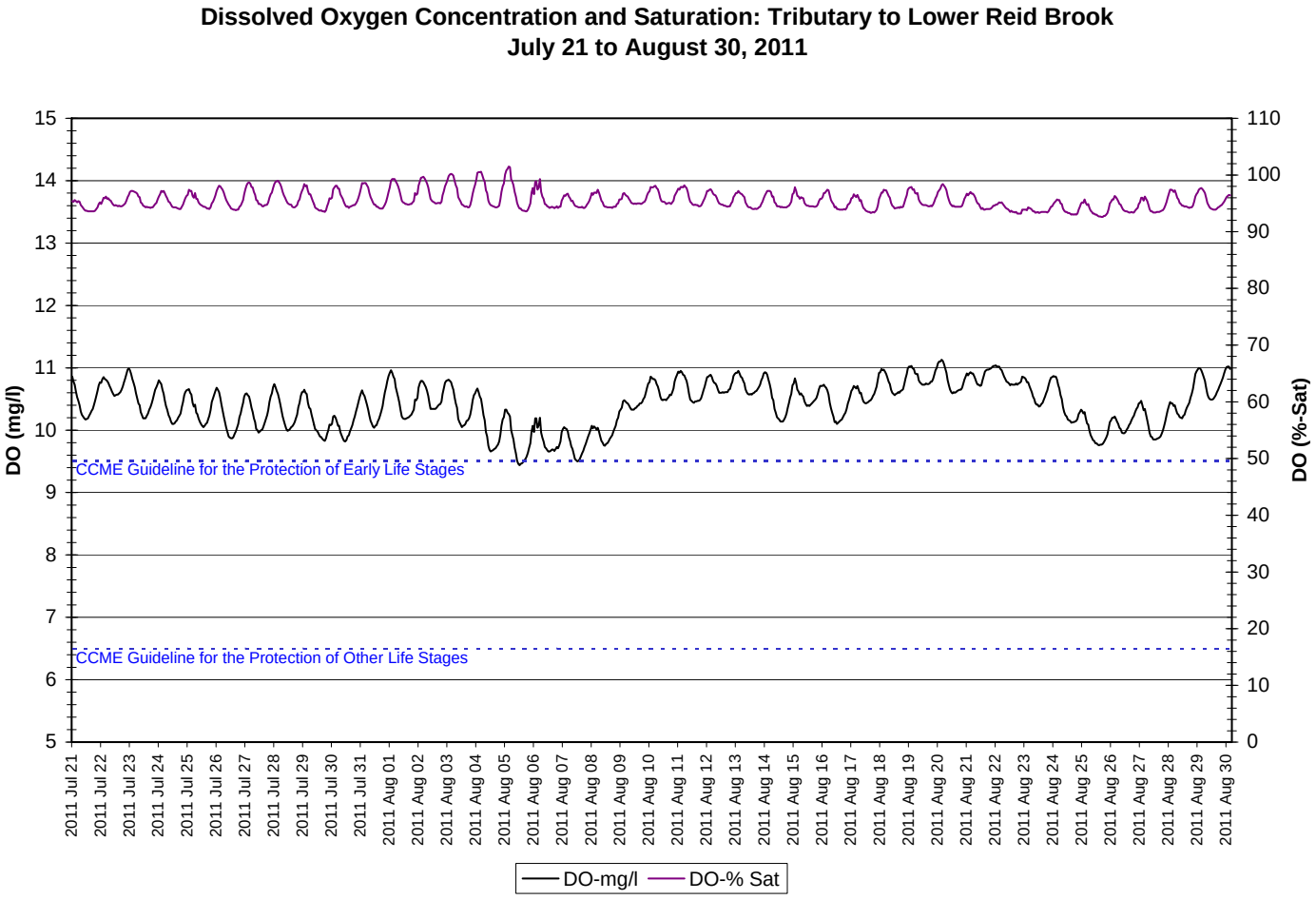

Figure 11: Dissolved oxygen and percent saturation at Tributary to Lower Reid Brook

- Turbidity remains at 0NTU for the entire deployment period (Figure 12).
- The turbidity sensor on the Tributary to Lower Reid Brook instrument (s/n 44175) was not functioning at full capacity during the deployment period. The wiper on the instrument no longer roates to clean the turbidity window prior to the taking reading. The sensor still reads turbidity values and calibrated correctly to 0NTU and 100NTU in the laboratory on July 21 prior to deployment.
- During cleaning and calibration on August 31 after removal, the turbidity sensor was unresponsive and did not recalibrate indicating that the sensor no longer worked. Data collected during this deployment period is invalid and will be removed from the data set for future use. Historically, turbidity at this station fluctuates between 0 and 15NTU.

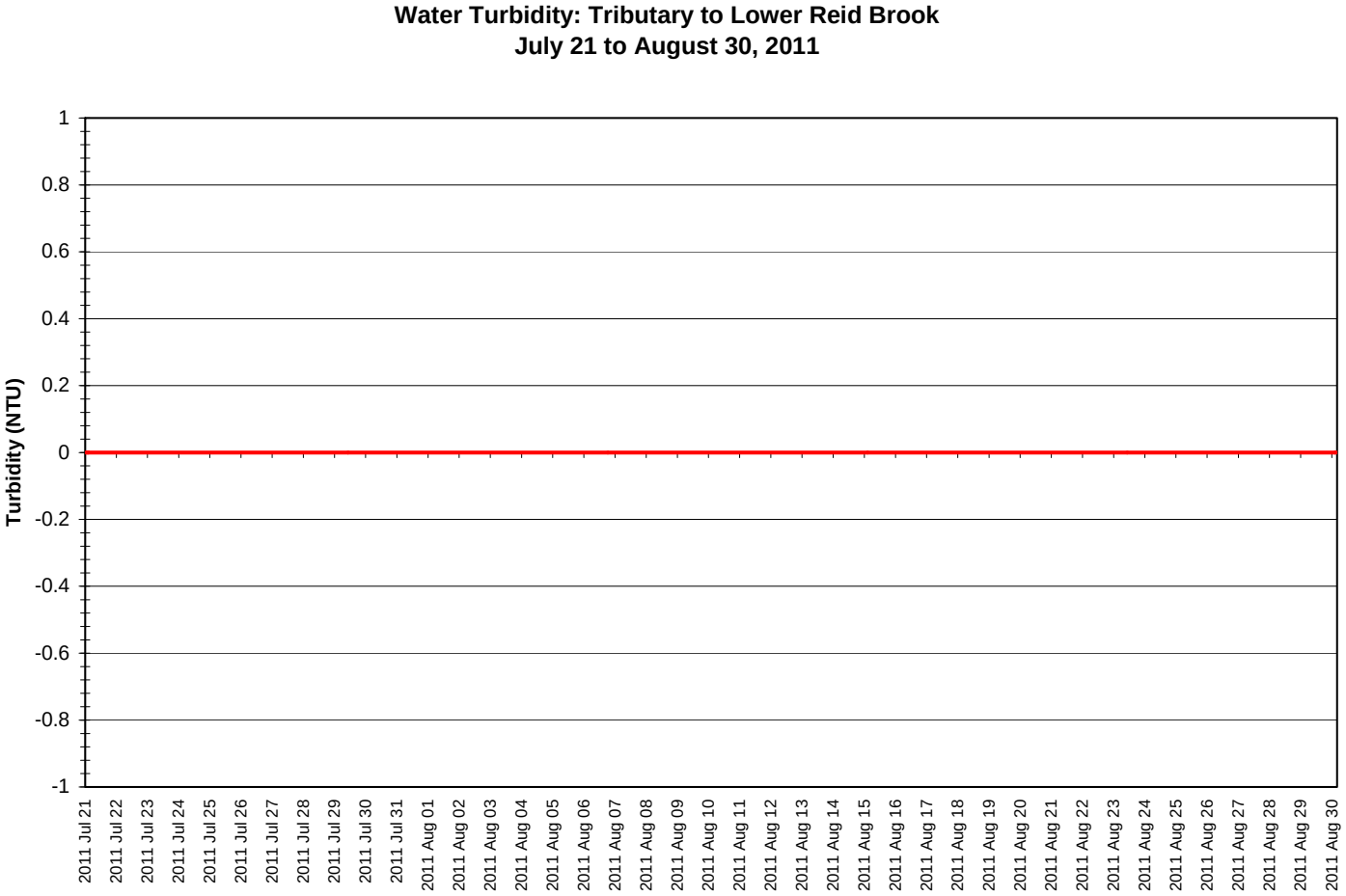

Figure 12: Turbidity and stage level at Tributary to Lower Reid Brook

- Stage and precipitation are graphed below to show the relationship between rainfall and water level (Figure 13). Stage is generally decreasing throughout the deployment period with occasionally small increases. Precipitation events are frequent and vary in magnitude throughout the deployment period.

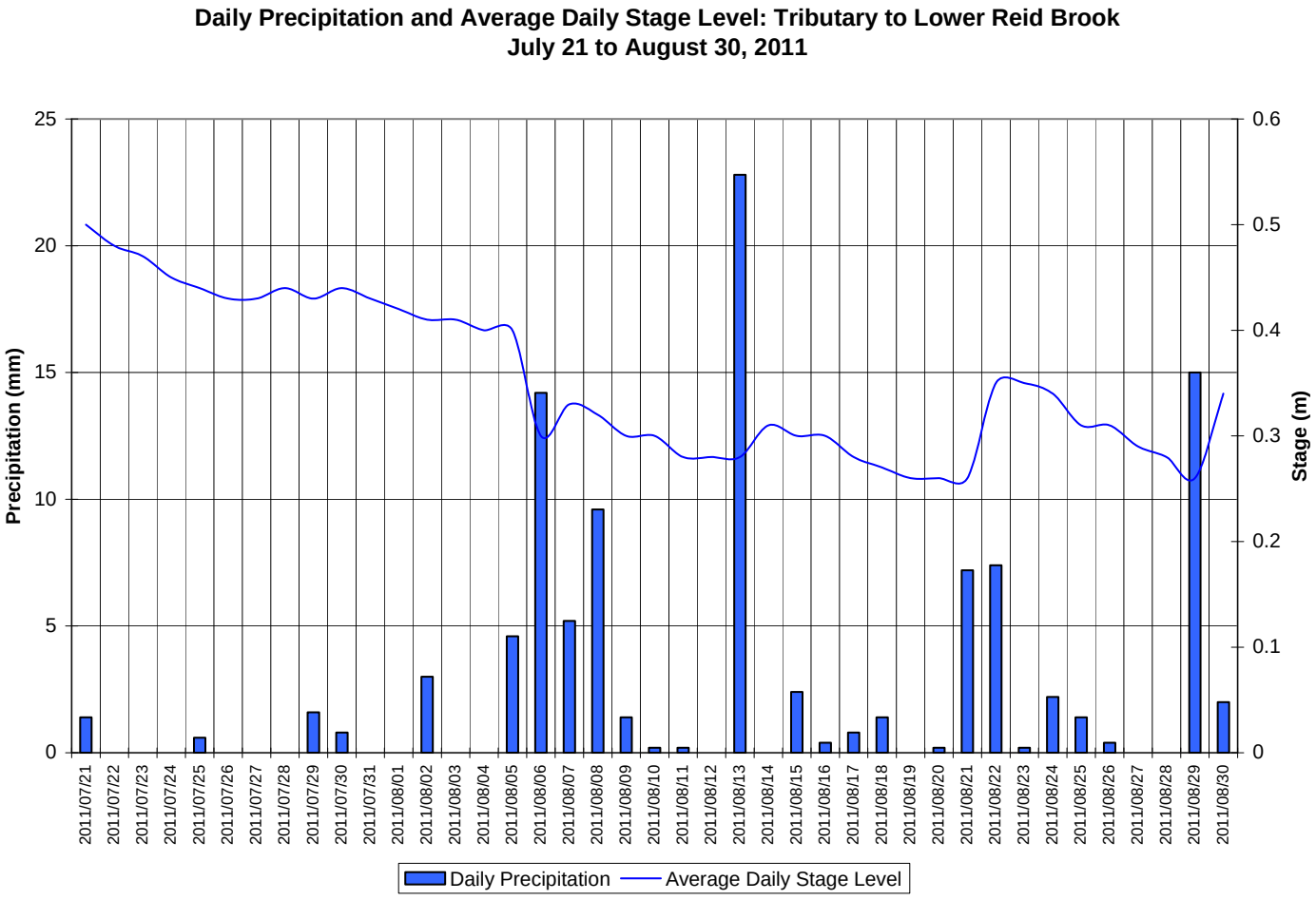

Figure 13: Average Daily Stage and Daily Precipitation at Tributary to Lower Reid Brook

Lower Reid Brook

- Water temperature ranges from 8.42 °C to 19.59°C during this deployment period (Figure 15).
- Water temperature is increasing throughout the beginning of the deployment period fluctuating considerably during the day and night. Water temperature decreases slightly after the first week of August and remains generally stable for the remainder of the deployment period. This trend is expected given the warm ambient air temperature peaking in late July before cooling slightly late in the summer season (Figure 16).

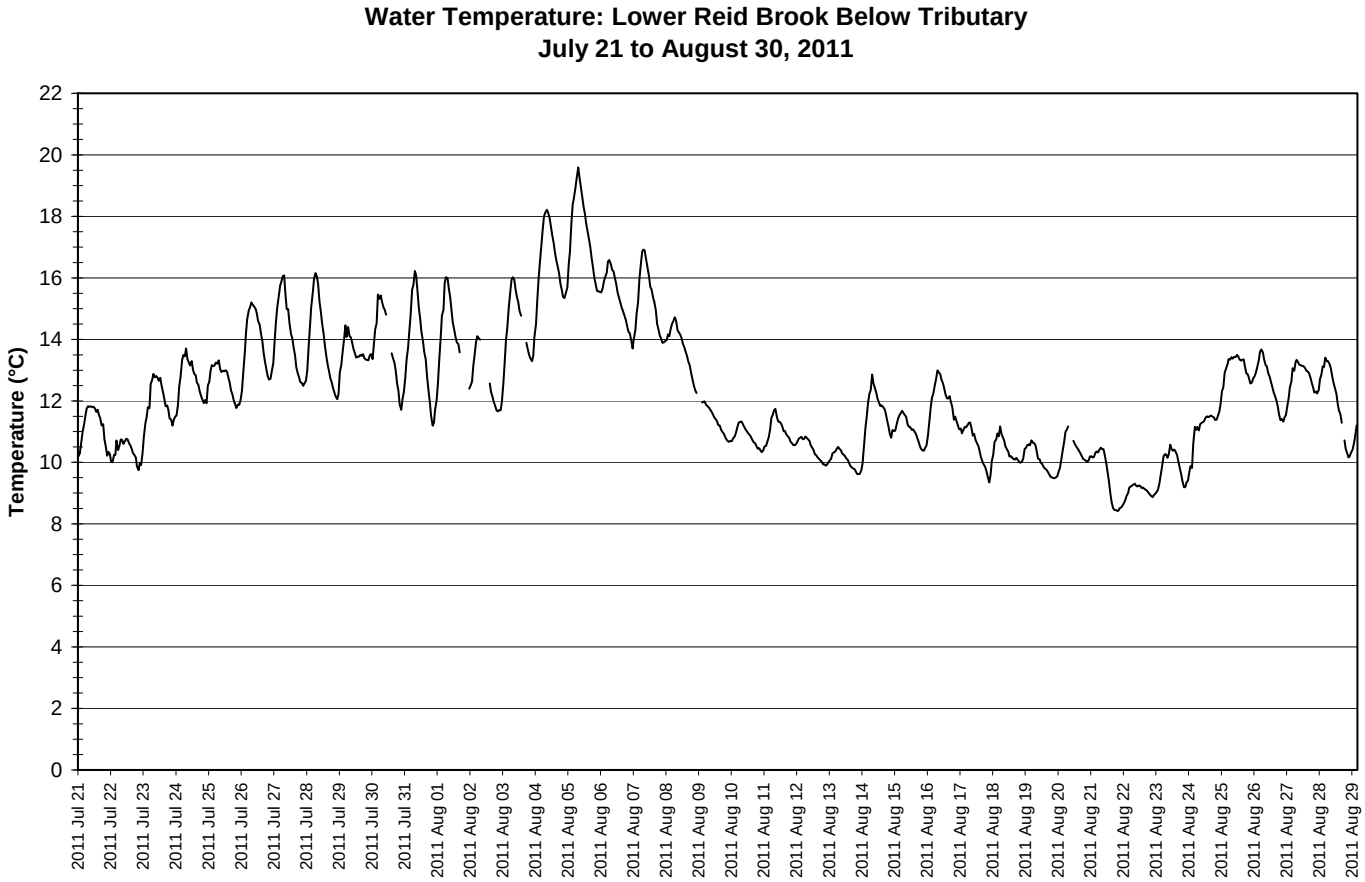

Figure 15: Water temperature at Lower Reid Brook

- Average daily air temperatures fluctuate at the beginning of the deployment period (Figure 16). Each time the air temperature increases for a period of time, the water temperature warms slightly. By mid deployment (mid summer), the water temperature surpasses the air temperature. When compared seasonally, air temperatures generally increase and decrease faster while water temperatures increase and decrease more slowly.

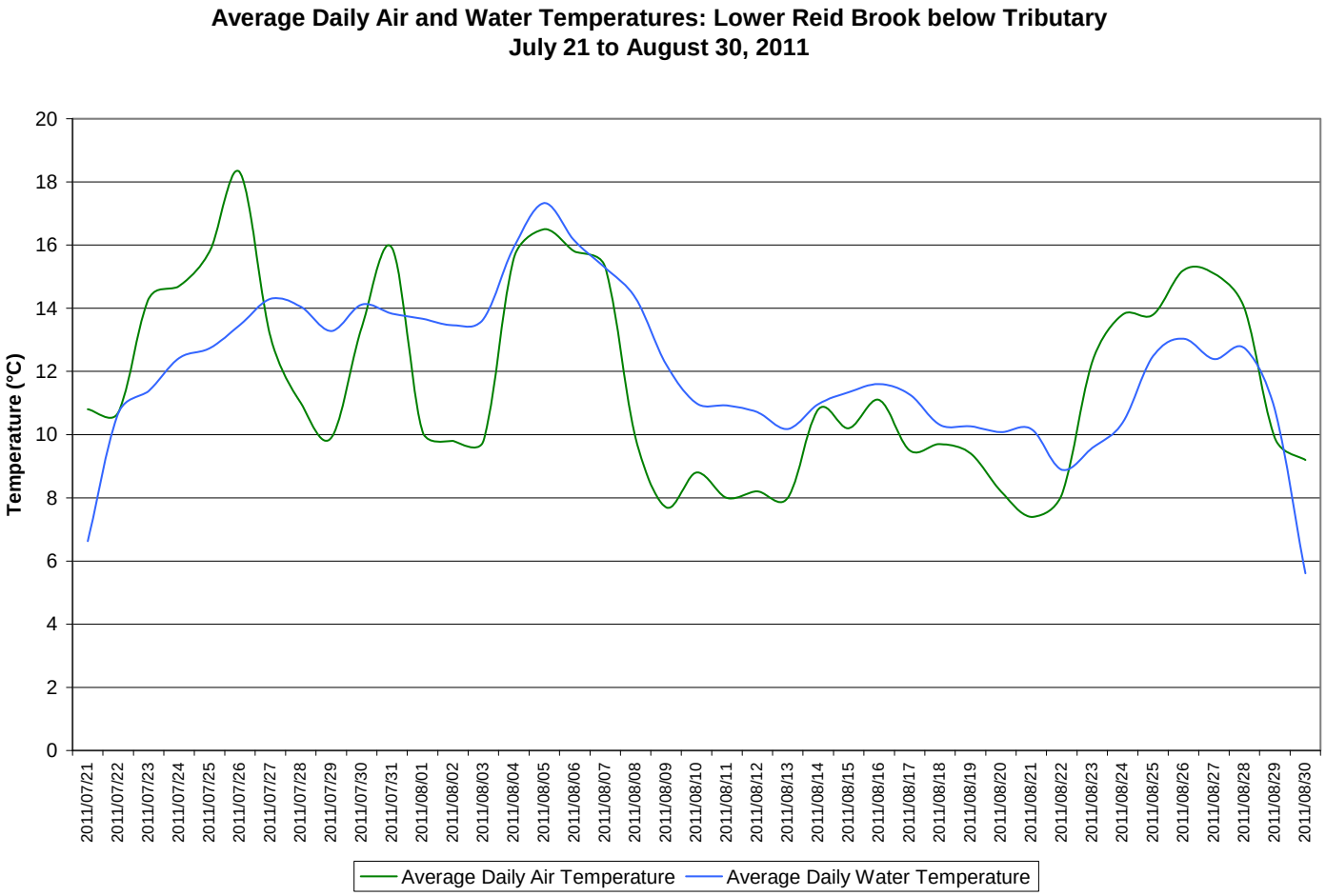

Figure 16: Average daily air and water temperatures at Lower Reid Brook

(weather data recorded at Nain)

- pH ranges between 6.55 and 7.11 pH units (Figure 17). pH values fluctuate daily throughout the deployment period.
- All 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).
- Stage is included on Figure 17 to show the relationship between water level and pH. As stage levels increase quickly, the regular fluctuations experienced daily in pH values are disrupted. This is noticeable on August 7 and August 22-24 when stage levels increases significantly very quickly, resulting in a decrease in pH (indicated by red arrows on Figure 17).

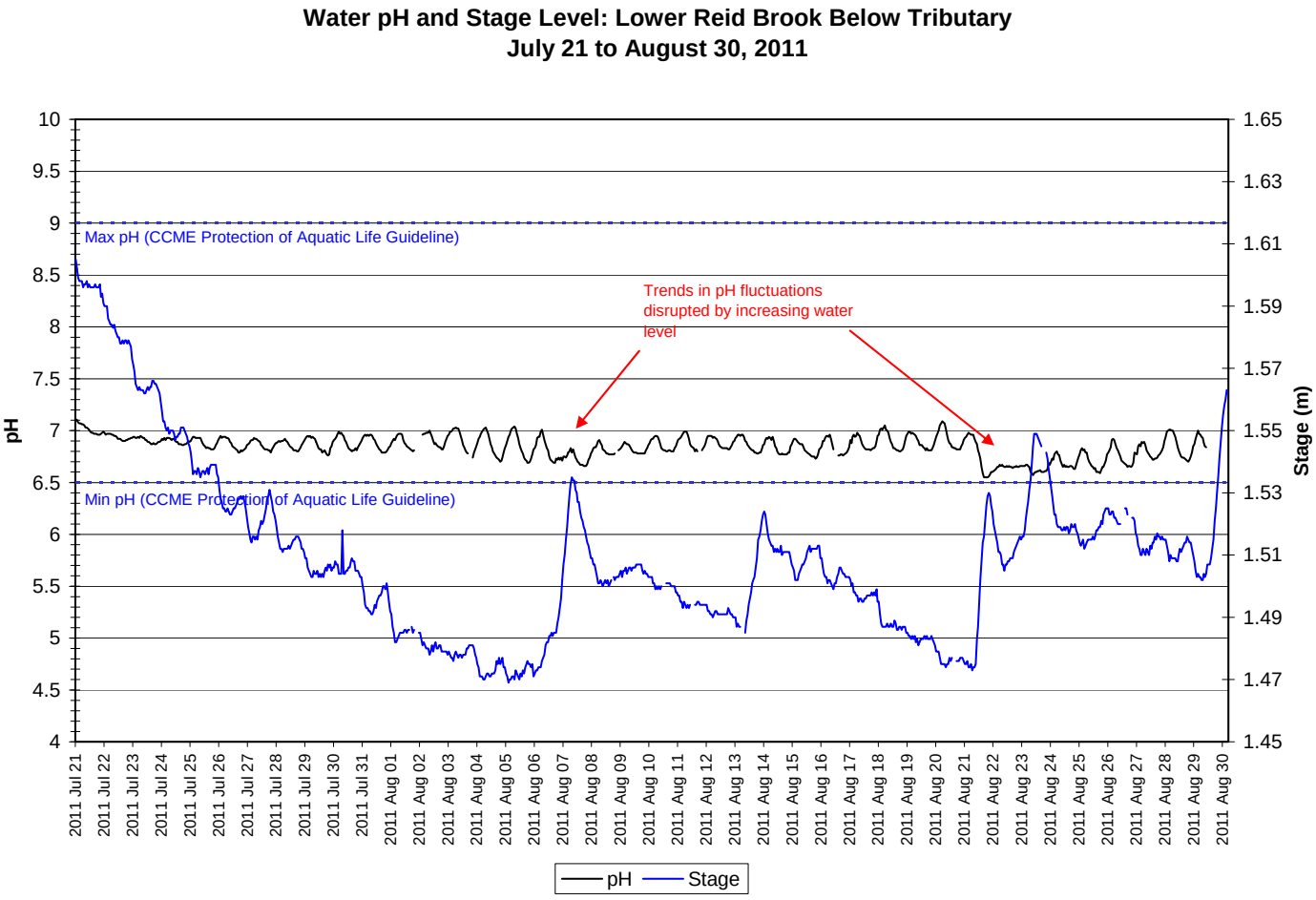

Figure 17: pH and stage level at Lower Reid Brook

- Specific conductivity ranges between 25.0 and 35.0µS/cm and is generally increasing throughout the deployment period (Figure 18). Due to a programming error at this station, specific conductivity is only recorded to zero decimal places.
- Stage is included in Figure 18 to illustrate the inverse relationship between conductivity and water level. Stage is generally decreasing throughout the first two weeks of the deployment period while specific conductivity is increasing (indicated by red arrows on Figure 18). Stage fluctuates for the remainder of the deployment period with quick increases followed by up to one week of decreasing water levels. As stage decreases, specific conductivity usually increases as the concentration of dissolved solids increases. Inversely, as stage increases, specific conductivity generally decreases due to the dilution of dissolved solids in the water column.

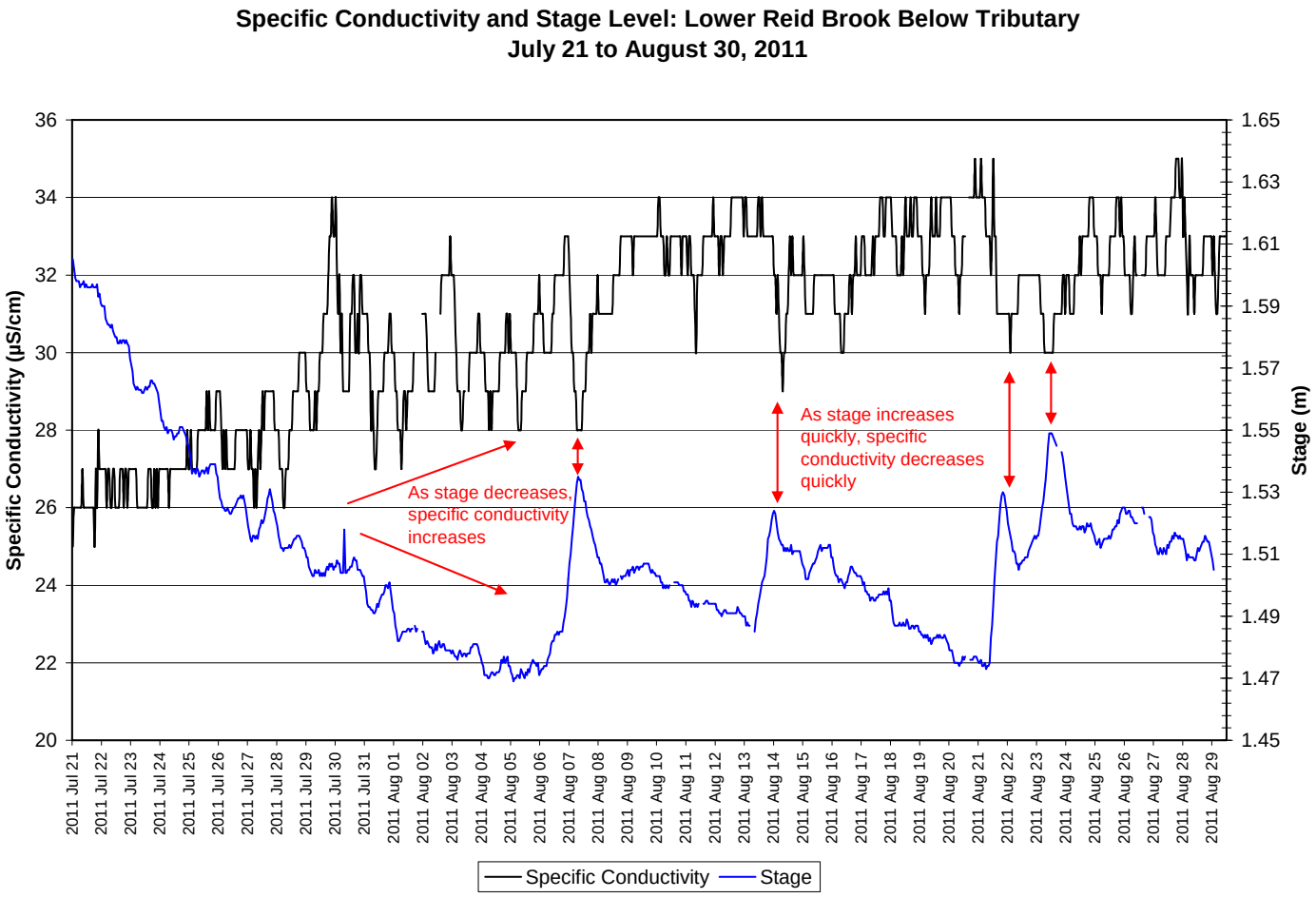

Figure 18: Specific conductivity and stage level at Lower Reid Brook

- The dissolved oxygen sensor failed to calibrate on July 21. The decision was made to return the instrument to the water with the broken sensor and note on the graph on the RTWQ webpage that the data was inaccurate. No dissolved oxygen or percent saturation data is available for this deployment period.

- The turbidity sensor electronics are closely related to the functioning of the dissolved oxygen sensor. In many cases when the dissolved oxygen sensor fails, the turbidity sensor will also not work properly, compromising data collected by both sensors. Such is the case for this deployment period. Turbidity values are inaccurate for this time period. In previous deployment periods, turbidity values had been inaccurate due to the accumulation of sand and debris in the sensor casing. This problem had since been rectified with a stand engineered by Vale Environment staff which prevented the instrument from being buried in the riverbed during deployment.

- Stage and precipitation are graphed below to show the relationship between rainfall and water level (Figure 19). Stage is generally decreasing throughout the beginning of the deployment period before remaining relatively stable throughout the latter half. Precipitation events are frequent and vary in magnitude throughout the deployment period.

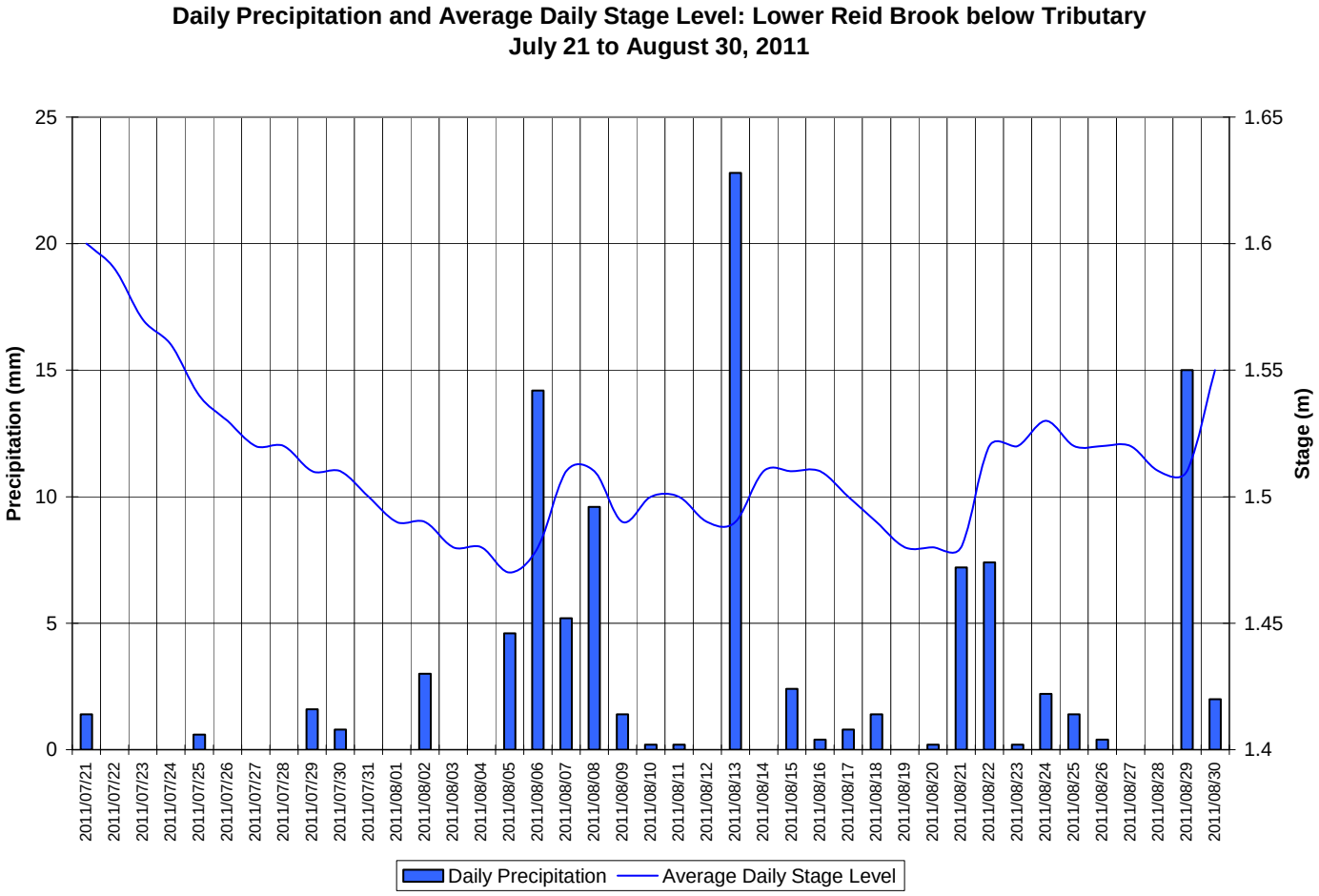

Figure 19: Daily precipitation and average daily stage level at Lower Reid Brook

(weather data recorded at Nain)

Camp Pond Brook

- Water temperature ranges from 10.70 °C to 22.60°C during this deployment period (Figure 20).
- Water temperature is increasing throughout the first two weeks of the deployment period. After August 4, the water temperature begins to decrease for the remainder of the deployment period. This trend is expected given warm ambient air temperatures in the summer season in July and early August (Figure 21). Air temperatures begin to cool within the first weeks of August. Water temperature fluctuates diurnally.

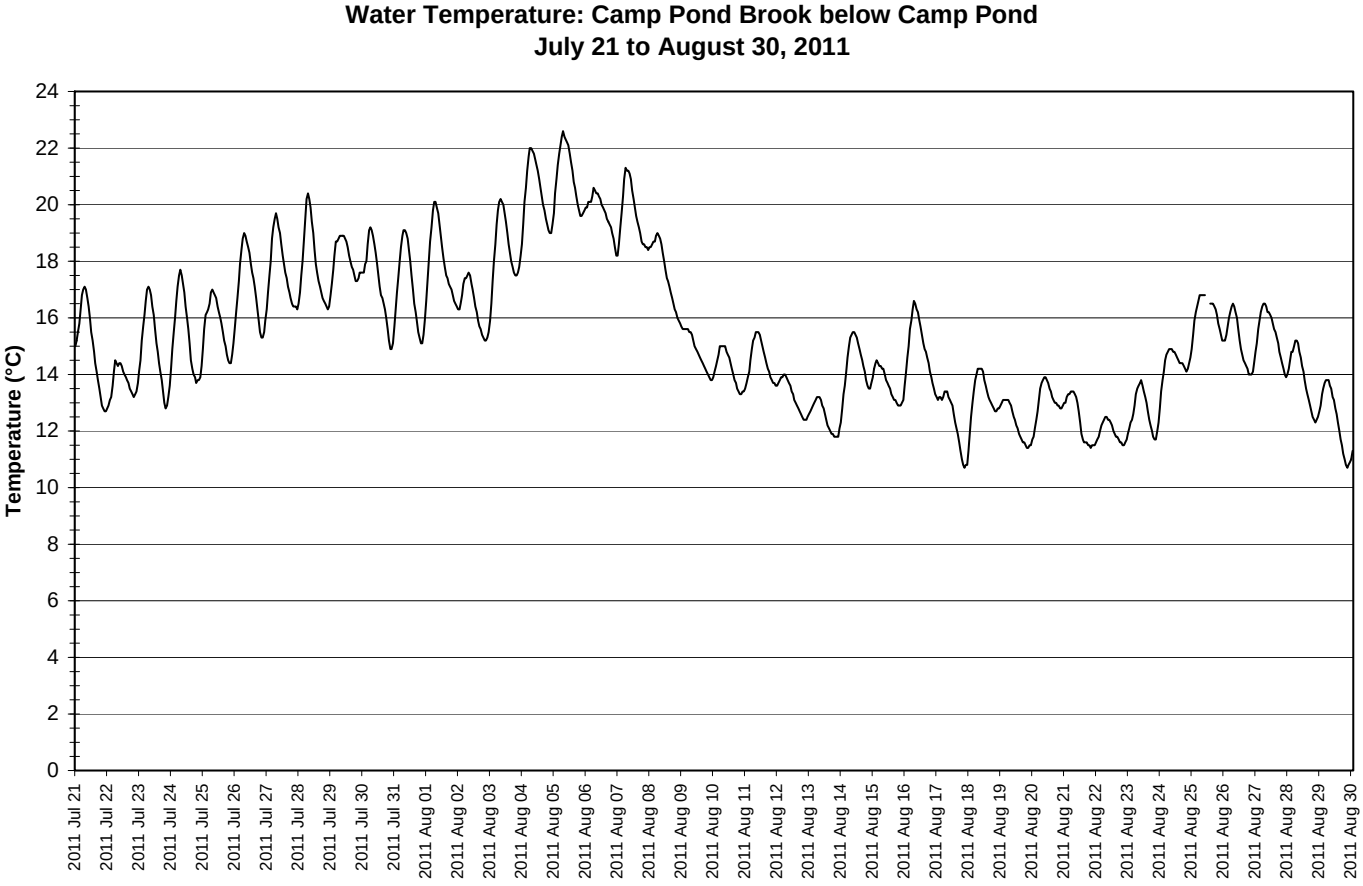

Figure 20: Water temperature at Camp Pond Brook

- Average daily air temperatures fluctuate at the beginning of the deployment period (Figure 21). Each time the air temperature increases for a period of time, the water temperature warms slightly. At the beginning of the deployment period, the water temperature is already greater than the average daily air temperature. When compared seasonally, air temperatures generally increase and decrease faster while water temperatures increase and decrease more slowly.

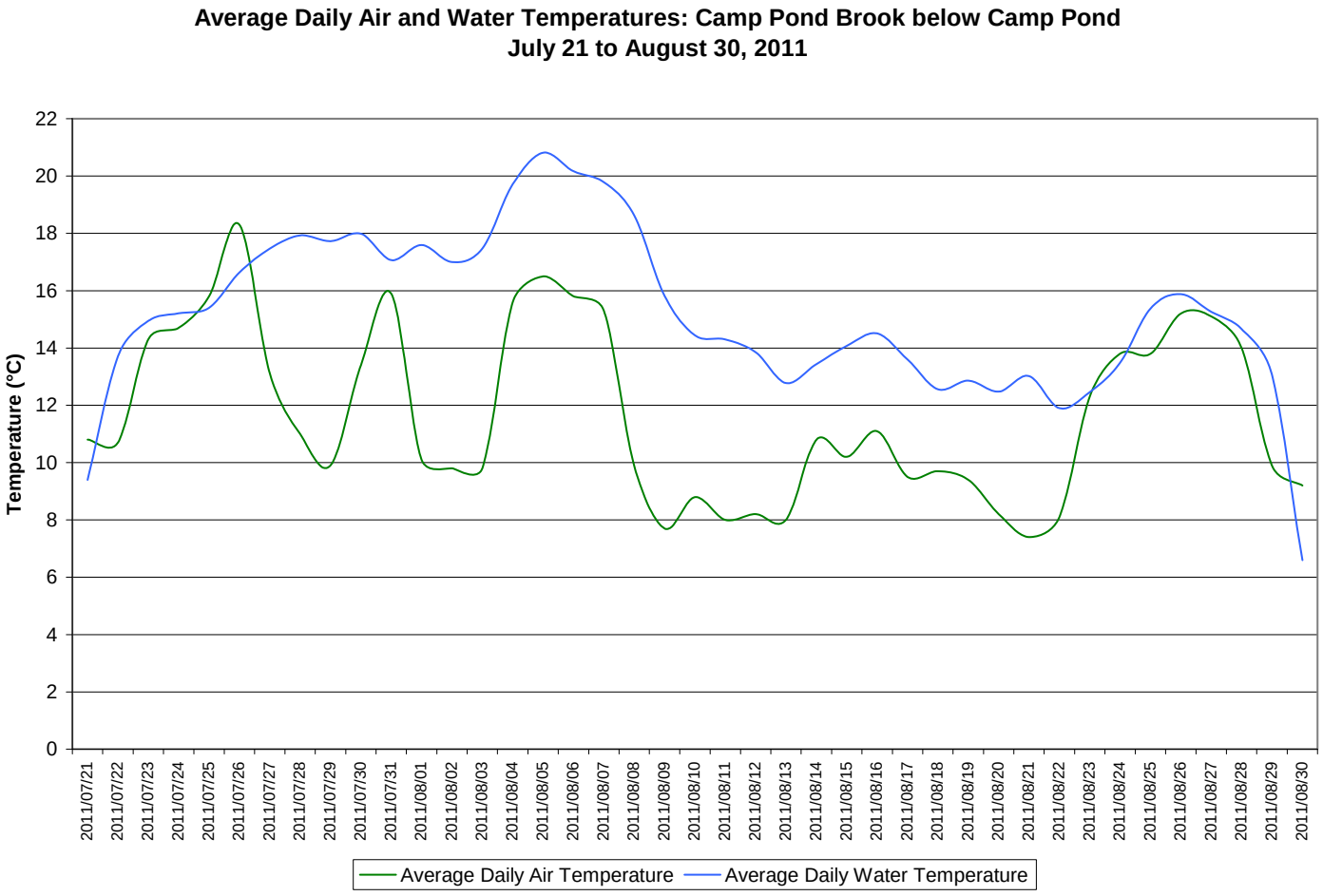

Figure 21: Average daily air and water temperatures at Camp Pond Brook (weather data recorded at Nain)

- pH ranges between 6.65 and 7.17 pH units (Figure 22). pH values fluctuate diurnally.
- All values during the deployment are within the recommended range as suggested by the CCME Guidelines for the Protection of Aquatic Life (indicated in blue on Figure 22).
- Stage is included on Figure 22 to show the relationship between water level and pH. As stage level is decreasing steadily at the beginning of the deployment period, pH values fluctuate considerably through a 24 hour period (indicated by red arrows on Figure 22). Later in the deployment period when stage level is more stable and not decreasing, the daily fluctuations in pH are not as great.

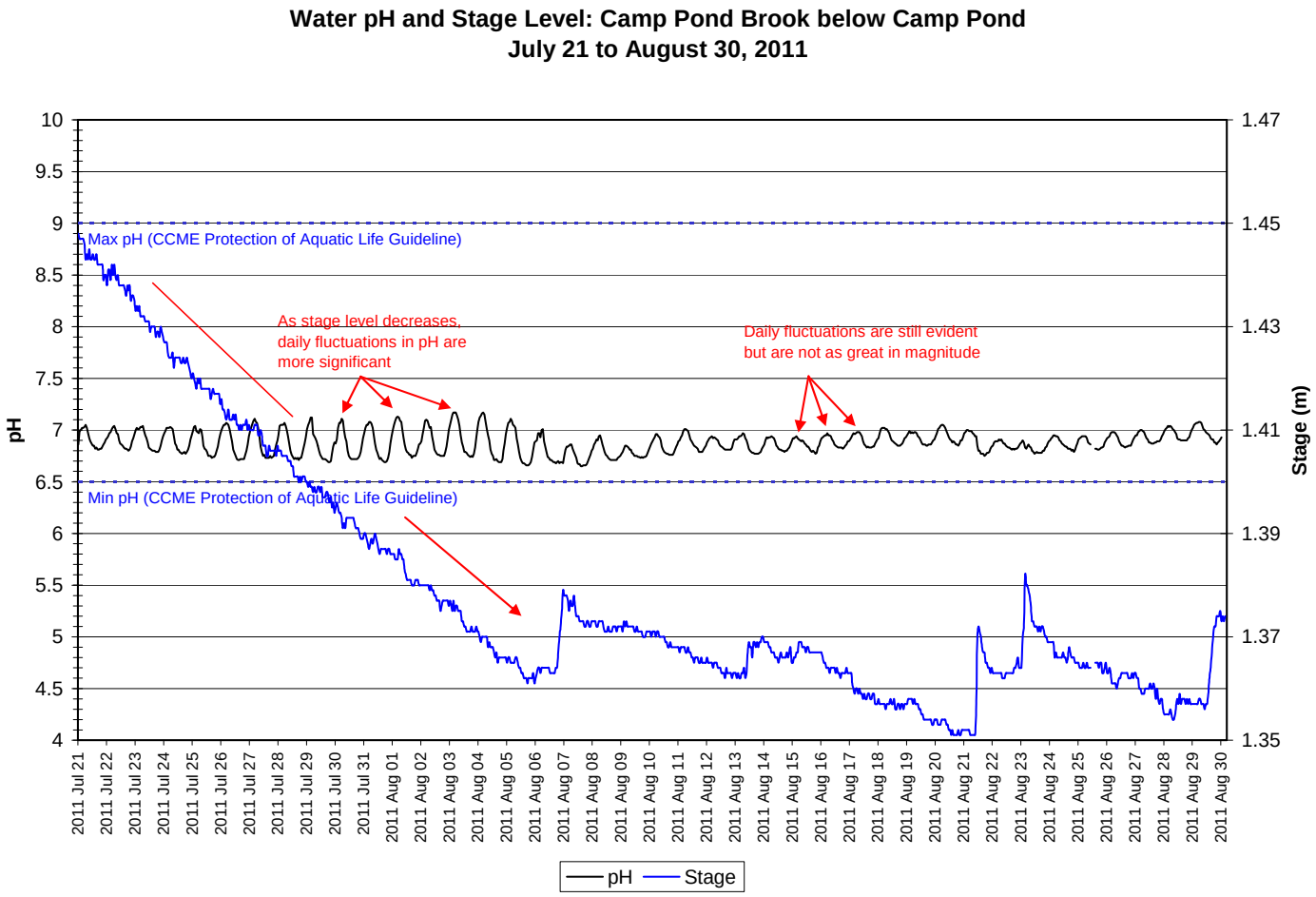

Figure 22: pH and stage level at Camp Pond Brook

- Specific conductivity ranged from 25.3µS/cm to 55.9µS/cm during the deployment period (Figure 23). Specific conductance is generally increasing throughout the deployment period.
- Stage is included in Figure 23 to illustrate the inverse relationship between conductivity and water level. Stage is decreasing consistently throughout the first two weeks of the deployment period. As stage decreases, specific conductivity increases (indicated by red arrows on Figure 23 As the water level drops, the concentration of total dissolved solids in the water column is increased, hence increasing the specific conductivity.
- On several occasions in the latter half of the deployment period, stage levels increase rapidly over a number of hours (during an intense rainfall event) followed by a period of decreasing water levels over the next number of days. Precipitation input and stage level increase typically decrease the specific conductivity of the water by diluting the concentrations of dissolved solids present in the water column, however, in these instances, there is an increase in specific conductivity following the increase in stage.

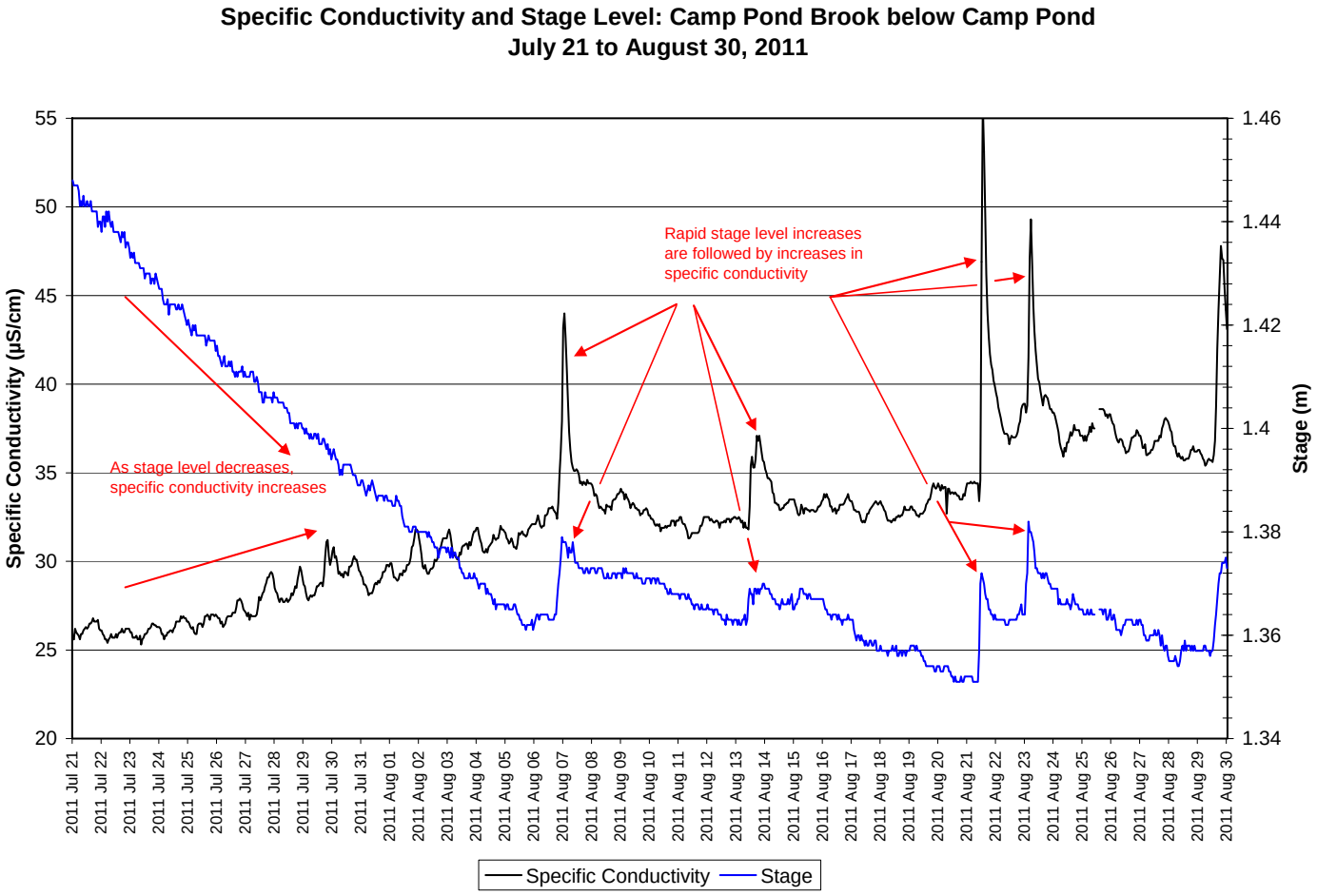

Figure 23: Specific conductivity and stage level at Camp Pond Brook

- Dissolved oxygen content ranged between 6.46mg/L and 12.14mg/L. The saturation of dissolved oxygen ranged from 70.9% to 119.6% (Figure 27).
- In several instances, DO and percent saturation dropped significantly to values as low as 20.0% and 3.00mg/L respectively. These outlying values are not included in the range and have been removed from the data set. The reason for the sporadic sensor readings is unknown at this time. The sensor will be examined carefully during the next calibration and will likely need to be replaced prior to the 2012 deployment season.
- All values were above the minimum CCME Guideline for the Protection of Other Life Stage Cold Water Biota of 6.5 mg/l while most of the values were below the minimum CCME Guideline for the Protection of Early Life Stage Cold Water Biota value of 9.5 mg/l.

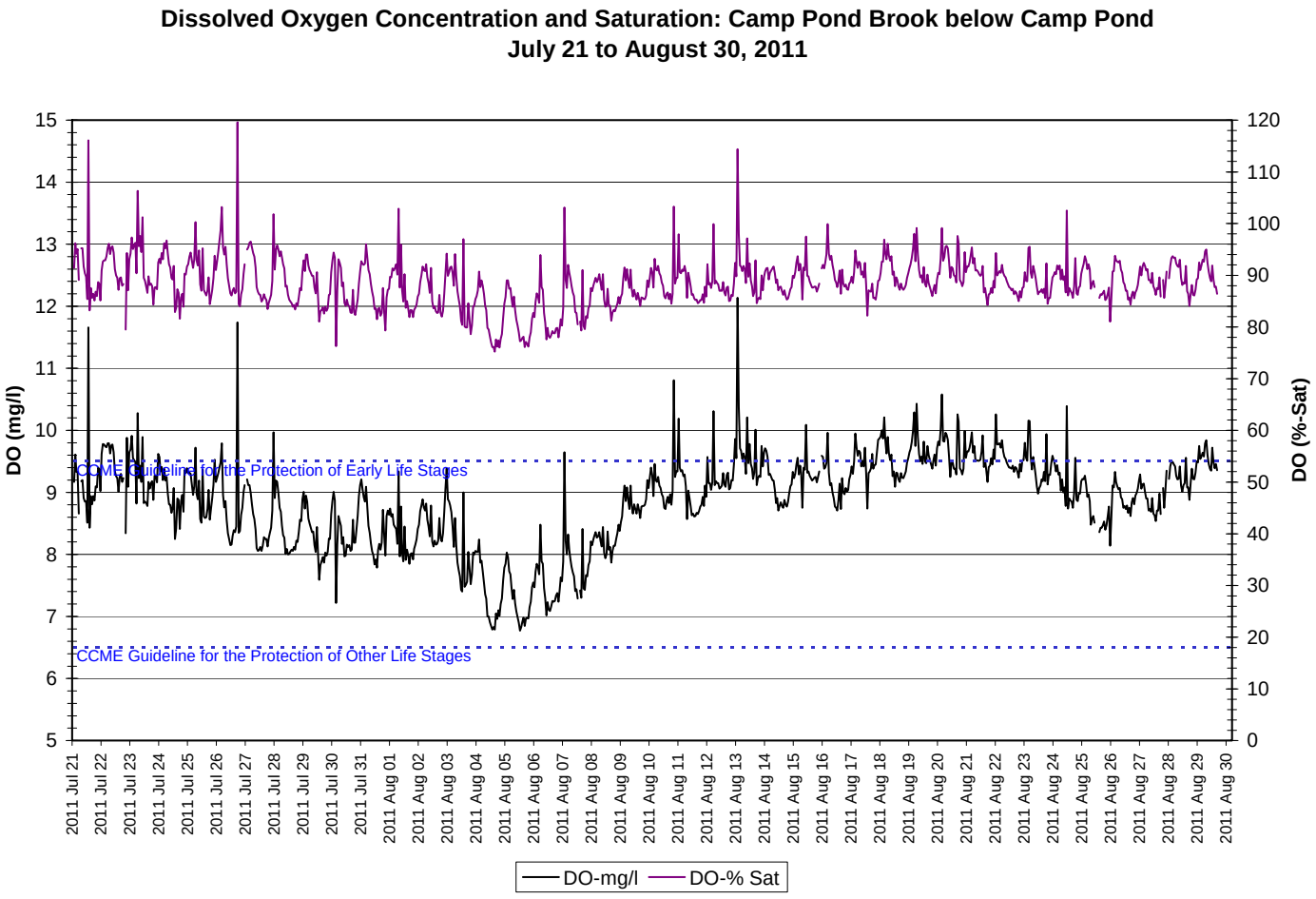

Figure 24: Dissolved oxygen and percent saturation at Camp Pond Brook

- A range of 0.6 to 44.6NTU was recorded for turbidity for this deployment period (Figure 28). A median value of 1.8 NTU indicates there is a consistent natural background turbidity value at this station.
- This trend is typical for turbidity at this station. There are a couple of instances when turbidity spikes to greater than the background level (>5NTU) however these events are short lived (1-2 hours) and not of significant magnitude (<45NTU)

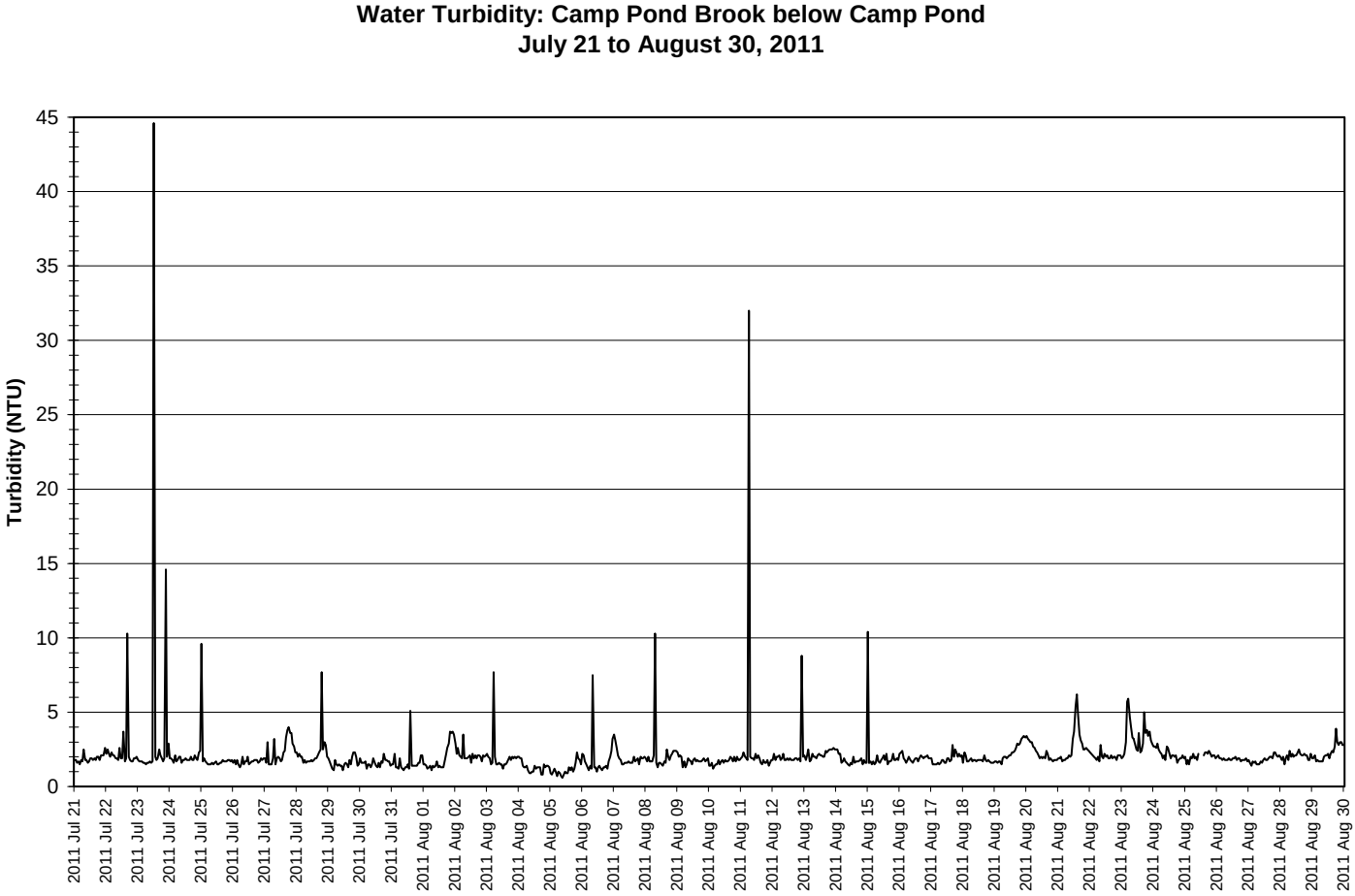

Figure 25: Turbidity at Camp Pond Brook

- Stage and precipitation are graphed below to show the relationship between rainfall and water level (Figure 29). Stage is generally decreasing throughout the first two weeks of deployment period. Stage level remains stable for a period of two and a half weeks before increasing slightly just before removal. Precipitation events are frequent and vary in magnitude throughout the deployment period.

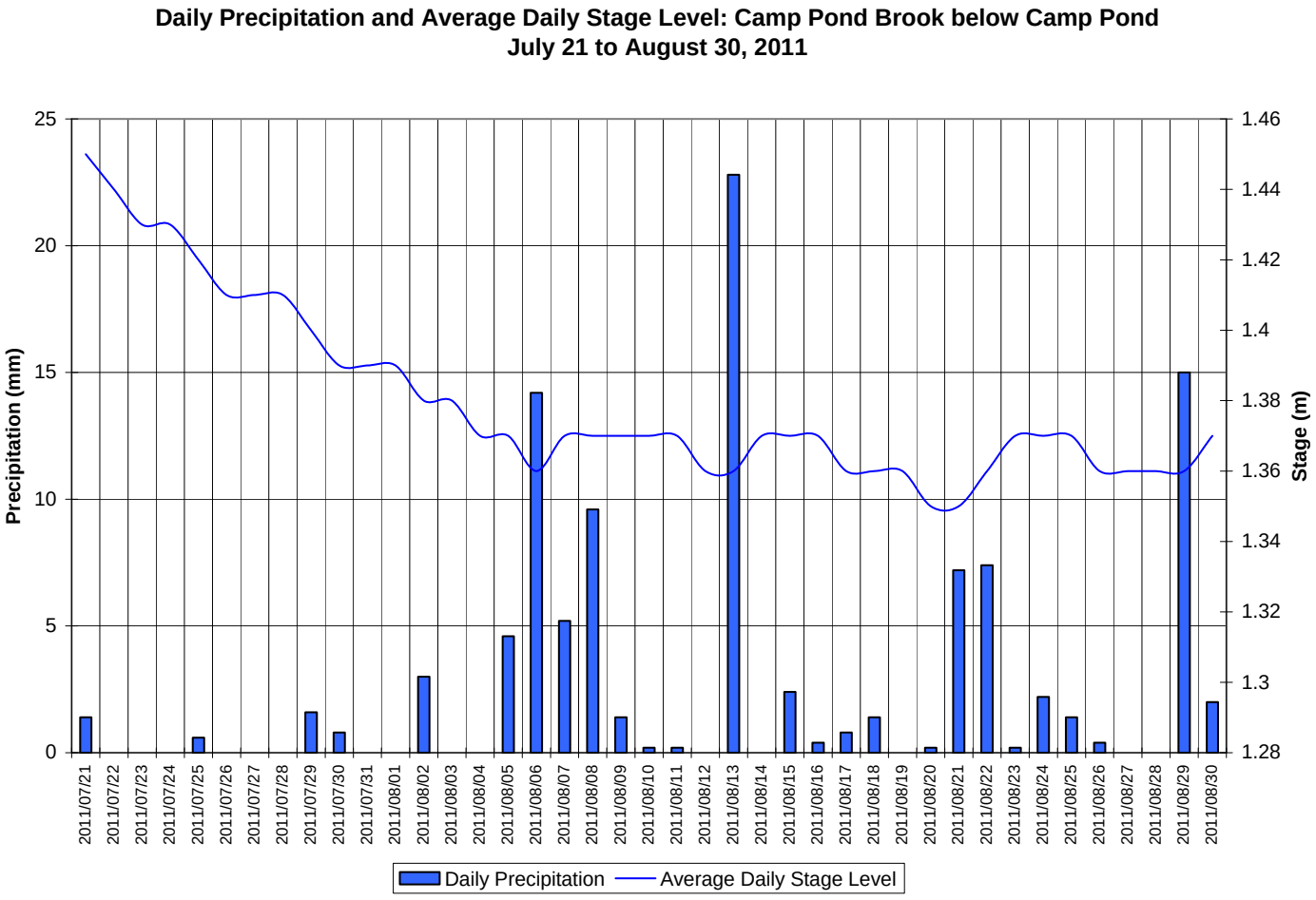

Figure 26: Daily precipitation and average daily stage level at Camp Pond Brook

(weather data recorded at Nain)

Conclusions

- Instruments at water quality monitoring stations in the Voisey's Bay Network were deployed from July 21 to August 30, 2011.

Summary by Station

- At Upper Reid Brook, a replacement instrument loaned to Vale by ENVC was deployed on July 21. This instrument features no turbidity sensor or battery pack therefore there is no turbidity data or option for a back up log file. Temperature peaked for the season in early August. Daily fluctuations in pH increased in magnitude as the stage dropped throughout the deployment period. Specific conductivity values were stable throughout. Dissolved oxygen and percent saturation values were low and variable with significant fluctuations daily.
- At Tributary to Lower Reid Brook, the turbidity wiper and cleaning brush is not working. It was believed that the turbidity sensor still functioned properly because the sensor would calibrate successfully in the laboratory. When the instrument was removed and calibrated at the end of August, the turbidity sensor was unresponsive. Turbidity data collected during this time is invalid and has been removed from the data set for future use. Other parameters were satisfactory; temperature peaked in early August, pH was stable and changed only when water levels increased or decreased sharply, specific conductivity showed a clear inverse relationship with stage level as well and dissolved oxygen and percent saturation values remained normal for the season and fluctuated inversely to water temperature.
- At Lower Reid Brook, temperature also peaked in early August. The trend in pH values was disrupted by sharp changes in water level during and after rainfall events. Specific conductivity showed a clear inverse relationship with changes in water level. The dissolved oxygen sensor is not working on this instrument therefore there is no data for this parameter or for percent saturation. The turbidity sensor electronics were also affected by the damaged dissolved oxygen sensor and data collected during the deployment period is inaccurate and has been removed from the data set.
- At Camp Pond Brook, water temperature reached a seasonal maximum in early August. pH values fluctuated diurnally and were variable with changing stage levels. Specific conductivity did not portray a typical inverse relationship with stage level. Instead of seeing specific conductivity decrease with increasing stage, specific conductivity increased on a number of occasions. Dissolved oxygen values throughout the deployment period were low, however the comparison rankings at the beginning and the end of the deployment period were 'good' and 'excellent' respectively, Turbidity averaged around 2NTU, which is typical for this station.

Summary by Parameter

- Temperature ranged from 8°C to 20°C at stations on Upper Reid Brook, Tributary to Lower Reid Brook and Lower Reid Brook. At Camp Pond Brook, water temperatures were on average the warmest across the network for this deployment period, ranging between 11°C and 22°C. Temperature peaked for the season at all stations in early August before beginning to decrease again late in the summer season. All station experienced diurnal fluctuations in water temperature.
- pH values ranged from 6.5 to 7.81 pH units across the network. All values recorded were within the recommended range as stated by the CCME Guideline for the Protection of Aquatic Life. At all stations,

changes in stage level affected the daily fluctuations in pH. As stage decreased, the daily fluctuations in pH increased.

- At Tributary to Lower Reid Brook, Lower Reid Brook and Camp Pond Brook stations, specific conductivity averaged between 30µS/cm and 33µS/cm. Values at Upper Reid Brook were considerably lower ranging between 9µS/cm and 11µS/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 Stations, specific conductivity displayed a clear inverse relationship with stage level, with values increasing when stage level decreased. At Camp Pond Brook, an atypical trend was found when specific conductivity would increase sharply when stage levels increased.
- Dissolved oxygen levels tended to be low at the stations on Upper Reid Brook and Camp Pond Brook, averaging around 9.0mg/l while values averaged 10.4mg/l at Tributary to Lower Reid. Dissolved oxygen values are unavailable for the station at Lower Reid Brook due to sensor failure. Values recorded at the three stations were all above the CCME Guideline for the Protection of Aquatic Life at Other Life Stages. Most values recorded at stations on Upper Reid Brook and Camp Pond Brook were just below the CCME Guideline for the Protection of Aquatic Life at Early Life Stages of 9.5mg/l. At Camp Pond Brook, all values were above 9.5mg/l. Dissolved oxygen trends displayed a clear inverse relationship with water temperature and fluctuated diurnally.
- Turbidity values recorded at Camp Pond Brook were typical of this station, averaging around 2NTU. The Turbidity sensor at Tributary to Lower Reid Brook likely failed some time during the deployment as it would not calibrate correctly upon retrieval and reported 0NTU for the entire deployment period. The turbidity sensor at Lower Reid Brook failed in conjunction with the dissolved oxygen sensor and the data has been removed from the data set. There is no turbidity sensor on the instrument at Upper Reid Brook.
- Stage tended to decrease for the first 2 weeks of the deployment period across all 4 stations. In the latter half of the deployment period, several sharp increases and recovery periods were noted. Precipitation events recorded in the area were frequent throughout the month and varied in magnitude.

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Appendix 1

Daily Precipitation and Average Daily Air Temperature: Nain, NL
July 21 to August 30, 2011