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BASELINE DATA COLLECTION

Peace River Watershed Water Quality and Dinosaur Lake Limnology Sampling - 2008

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REPORT

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Executive Summary

In July of 2006, Golder Associates was awarded a contract from the British Columbia Hydro and Power Authority (BC Hydro) to complete sampling and analysis of water, river sediment, soil and vegetation in the Peace River watershed. The purpose of this work is to provide baseline data from the Peace River related to the proposed development of Site C. Field work began in November of 2006 and continued through to November of 2007. In the winter of 2007 - 2008, the study was extended to include a second year of sampling, but the scope of the project was changed from that of the 2007 study. In 2008, 18 Peace River and tributary sites were sampled for water quality and water temperature, and the scope for the study was expanded to include limnological studies at 3 sites in the Dinosaur Lake reservoir.

In addition to Dinosaur Lake limnology, 2008 water sampling extended from the Peace Canyon Dam (PCN) near Hudson's Hope BC downstream to the BC-Alberta Border at Clayhurst. Sampling in the Peace River occurred at five locations, including approximately 4 km downstream of the Peace Canyon Dam, upstream of the Halfway River, upstream of the proposed Site C dam site (upstream of the Moberly River), downstream of the proposed dam site and at Clayhurst. Tributaries sampled included Lynx, Farrell, Boudreau, and Cache creeks, as well as the Halfway, Moberly, Pine, Beaton and Kiskatinaw rivers. Sampling during the 2008 program included the following:

- Continuous water temperature monitoring using temperature data loggers (TDLs) at 11 Peace River and Peace tributary sites (including five sites which do not coincide with locations of water sampling sites);
- Surface water grab samples (water samples) for laboratory analysis at 13 Peace River and Peace tributary sites;
- In situ "spot" measurements of conductivity, pH, dissolved oxygen (DO), temperature, conductivity and turbidity supplemental to laboratory analysis from the 13 surface water grab sample sites. Total Gas Pressure (TGP) was also measured at the 5 Peace River sites; and
- Stream discharge measurements from four ungauged (by the Water Survey of Canada - WSC) tributaries upstream of the proposed Site C dam.

Sampling occurred six times during the 2008 sampling program. Additionally, Dinosaur Lake was sampled five times during 2008 and included the following sampling procedures at three locations (downstream, middle and upstream sites) within the reservoir:

- Continuous water temperature monitoring using TDLs positioned at depths of 1 m, 5 m and near the lake bottom; and
- In situ temperature, conductivity, pH, DO and TGP profiles at each of the three sites.

Results of the 2008 water sample analysis were compared to British Columbia Water Quality Guidelines (BCWQG) and Council of Canadian Ministers of Environment (CCME) guidelines for the protection of freshwater aquatic life.

There were a number of similarities between years in the data gathered from Peace River and Peace tributaries. As with the 2007 sample results, concentrations of total metals most often exceeded established criteria, whereas concentrations of dissolved metals, with some exceptions, were more often below detectable limits in 2008. Trends observed in 2008 were often consistent with those observed in 2007. Specifically, exceedences of total metals are linked to total suspended solids (TSS), as was particularly apparent for tributary sample sites during spring freshet conditions. In both years, Peace River water samples seldom exceeded BCWQ or CCME guidelines, except during periods when tributaries were in freshet. The upstream most Peace River sample location near the tailrace of the PCN dam (Peace 1) had the least number of observed exceedences during any sample period in 2007 and 2008, whereas the incidence and frequency of exceedence of total metals at other Peace River sites increased with distance downstream, reflecting inputs from tributaries. One dissimilarity between years was that there were instances of exceedences of total metals (cadmium) observed at Peace 1 in 2008, whereas no such exceedences were observed in 2007.

As in 2007, aluminum, antimony, arsenic, cadmium, copper, iron, manganese, selenium, silver, thallium, vanadium and zinc exceeded guidelines at both Peace River and tributary sites in 2008. Exceedences of aluminum, cadmium and iron exceeded guidelines most frequently and at the most sites, followed by copper, zinc and vanadium. There were more instances of exceedences and a wider range of dissolved metals exceeding guidelines in 2008 than was observed in 2007. Dissolved selenium, copper, aluminum, cadmium and manganese exceeded guidelines more frequently than other dissolved metals, but as in 2007, exceedences of selenium were almost exclusively within the Halfway River, whereas exceedences of other dissolved metals ranged across a number of sample sites. Unlike 2007, when mercury was never above detection limits (either the total or dissolved components), total mercury was detected at very low levels on one occasion in May 2008 at Peace 5.

Water temperatures were slightly warmer at Peace River sites in 2008 than in 2007, which was apparent from comparisons of both daily and monthly means of this parameter between the 2 years. A similar trend was not apparent at tributary sites.

Peaks in orthophosphate, dissolved organic carbon and nitrate were also closely associated with elevated TSS concentrations for each year, although the timing of peaks in these parameters varied with discharge between years. Peaks in discharge amongst Peace tributaries appeared about two weeks earlier in 2008 than in 2007, and these peaks were also smaller in 2008.

TGP measured in the Peace River seldom exceeded 103% of the atmospheric pressure at any of the sample sites. The highest measurements of TGP amongst Peace River sites were in June, when a level of 106% occurred at the left bank at Peace 2 and 104% at the right bank of Peace 3.

Dinosaur Lake, as might be expected of a run of the river type reservoir, showed very little stratification in most parameters measured, particularly temperature, oxygen and conductivity. The greatest variation in oxygen and temperature profiles occurred at the downstream most sampling station (Dino 1) in June, although these variations were minor. The difference in the Dino 1 DO profile was less than 0.5 mg/L between measurements taken at the surface and at depth. For temperature, the surface reading was approximately 1.4 ºC warmer (7.13 ºC) than at the bottom of the profile (5.65 ºC). For all other sampling periods, there was no distinguishable thermocline at any of the Dinosaur Lake sample locations. TDL data indicated the warmest water temperatures in Dinosaur Lake occurred in September, when the mean monthly temperature at the downstream most sample station (Dino 1) reached 12.1 ºC. Individual daily mean temperatures reached a high of 15.5 ºC at the surface TDL station of Dino 1 on July 5. The coolest monthly mean temperature (3.6 ºC) was observed in May at the upstream most sample site, nearest the WAC dam. Like the temperature profile data, variation in water temperatures recorded by TDLs at the three depths for each sample site was greatest at the downstream site. The TDL recordings for each depth at the upstream most sample site were almost indistinguishable from one another. TGP varied in profile measurements, particularly at the upstream most site (Dino 1), where it exceeded 110% of the atmospheric pressure during July at 5 and 6 m below the water surface. For other months, TGP never exceeded 107% of the atmospheric pressure at any of the Dinosaur Lake sites.

Disclaimer

This report was prepared for the exclusive use of BC Hydro, its assignees and representatives, and is intended to provide results of baseline data collection from the Peace River watershed. This report is not intended to identify or evaluate potential effects of contaminants that may occur at or near the Project area as a result of natural and/or anthropogenic activities, nor as a result of completion of the proposed project. The findings and conclusions documented in this baseline data report have been prepared for the specific application to this Project and have been developed in a manner consistent with the level of care normally exercised by environmental professionals currently practicing under similar conditions in the jurisdiction. Golder makes no other warranty, expressed or implied. Any use which a third party makes of this report or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Golder accepts no responsibility for damages, if any suffered by any third party as a result of decisions made or actions based on this report.

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1.0 INTRODUCTION

In July 2006, Golder Associates was awarded a contract from the British Columbia Hydro and Power Authority (BC Hydro) to complete sampling of water, river sediment, soil and vegetation in the Peace River watershed. The purpose of this work is to provide baseline data from the Peace River to aid predictive modeling should Site C be pursued. This baseline study represents a survey of existing conditions within the project study area and is not intended as an environmental effects assessment study of the proposed Site C project. Sampling was extended into 2008 for the collection of baseline water quality data in the Peace River and selected tributaries, and was also expanded to include collection of limnological data from Dinosaur Lake.

2.0 STUDY AREA

The study area for the project includes 18 sample sites in the Peace River and selected Peace tributaries, extending from the Peace Canyon Dam (PCN) located near Hudson's Hope, through to the confluence of the Alces River with the Peace River, near the BC – Alberta Border (Figure 1). Additionally three locations in Dinosaur Lake, a run of the river reservoir created by the PCN, were also sampled (Figure 2).

3.0 SCOPE OF WORK

Unlike 2007 studies (Golder 2009) which sampled water, vegetation, river sediment and soil, the 2008 study program only involved sampling water.

3.1 Baseline Water Quality Data

Baseline water quality data collection involved sampling at 21 locations in 2008, 18 of which are consistent with sites originally identified by Golder (2009), and three that are new sites established in Dinosaur Lake (Table 1). Water quality data collection for this project included the following three sampling procedures:

- General water quality (13 sites, only in the Peace River and selected tributaries);
- Continuous water temperature monitoring (11 sites in the Peace River and selected Peace tributaries and three sites in Dinosaur Lake); and
- Total gas pressure (TGP) (five sites in the Peace River and three sites in Dinosaur Lake).

Water quality sampling included laboratory analysis of water samples and completion of in situ measurements by calibrated meters.

The following parameters were tested for in water samples:

- Nutrients;
- Adsorbable Organic Halogens (AOX);
- Dissolved Organic Carbon;
- Total Nitrogen;
- Total Metals;
- Dissolved Metals;
- Sulphides;
- General Water Quality (pH, TSS, TDS, turbidity, etc.); and
- Chlorophyll *a*.

The following parameters were measured in situ by calibrated meters:

- pH;
- Dissolved Oxygen (DO);
- Temperature;
- Conductivity;
- TGP (Dinosaur Lake and Peace River sites only); and
- Turbidity (Peace River and Peace tributary sites only).

Sampling was conducted in 2008 during six different sample periods for the Peace River and selected tributaries and during five sample periods in Dinosaur Lake through 2008 as follows:

- winter - early March 2008 (Peace River and selected tributaries only);
- pre-freshet - early May 2008;
- mid-freshet - mid June 2008;
- end of freshet - early July 2008;
- late summer - mid August 2008; and
- fall - late October 2008.

Table 2 summarizes the month in which water samples were taken, including duplicate (replicate) water samples collected during each sample period. Details of sample locations are provided in Table 3. Although baseline water quality data collection required sampling over various seasons, some of the identified permanent sample sites were inaccessible during the winter, including Peace 3, Moberly 6, Halfway 8 and Farrell 11.

4.0 METHODS

Sample methods followed those employed in 2007, with specific procedures employed depending upon the type of water quality parameter measured, as described below.

4.1 Water Sampling

Water sampling was separated into three primary components as follows:

- In situ water quality sampling by calibrated meters;
- In situ water quality sampling by automated devices; and
- Laboratory analysis of water samples.

4.1.1 In Situ Sampling by Calibrated Meters

A YSI 650 and attached 600 series probe was used to take in situ readings of pH, DO, temperature and conductivity at 13 water quality sample sites in the Peace River and Peace tributaries (Figure 1) and all of the Dinosaur Lake limnology sites (Figure 2). A 60 m cable was used at the Dinosaur Lake sites. A Hanna HI 93703-11 turbidity meter was used for field measurements of turbidity. A Point 4 Systems Tracker TGP meter and attached probe on 25 m of cable was used to measure TGP in the Peace River, Peace tributaries, and Dinosaur Lake. Probes and meters were calibrated prior to each sampling session.

Sampling was completed in the Peace River from a jet boat proximate to the middle of the stream. Tributary sampling was completed by wading into the stream and placing probes in the current. Sampling in tributaries during winter conditions required cutting a hole in the ice through which probes were placed. In the mainstem Peace River, sampling was conducted by staying near the edge of the river, as boat access was not possible. Readings were taken in areas of flowing water, but restricted to near the surface of the water in the Peace River due to an inability to sample at depth because of water current.

Limnological sampling at Dinosaur Lake consisted of measurements with calibrated hand held meters at 1, 2, 3, 4, 5, 7, and 10 m below the water surface, and at 5 m intervals thereafter to the bottom of the lake to create a profile. Probes were weighted to the maximum extent possible to minimize deflection by current, although deflection could not be avoided during some surveys, particularly at the upstream most sample site (Dino 3) when the current was strong.

4.1.2 In Situ Sampling by Automated Devices

Temperature was recorded at 11 sites in the Peace River and selected tributaries (Figure 1) and at all three of the Dinosaur Lake limnology sites at ½ hour intervals (Figure 2). Two HOBO® Water Temp Pro v2 (± 0.2 °C) temperature data loggers (TDLs) were deployed at Peace River and selected tributary water temperature monitoring sites. A number of data loggers lost or damaged by the end of the 2007 sampling program were replaced by Golder in November 2007 prior to the onset of winter conditions. Temperature data loggers were placed proximate to each other, but anchored to individual weights and attached by cable to separate locations on shore. Redundant TDLs were employed should one logger fail, be lost or damaged, or experience any other unforeseen event.

At Dinosaur Lake, water temperature monitoring sites were established at three sites in the reservoir, including near the PCN dam (Dino 1), the middle of the lake (Dino 2) and approximately three km downstream of the WAC Bennett Dam (Dino 3). Each temperature monitoring station consisted of a scotch buoy anchored in place with cable to a 50 kg concrete weight. Cables were long enough to account for fluctuations in reservoir levels. A second lightly weighted cable, to which three TDLs were attached, was suspended from each scotch buoy. Two TDLs were positioned on this second cable at 1 m and 5 m depths below the water surface, and the third TDL was suspended within 3 m of the bottom of the reservoir. This system maintained a consistent depth for the upper two TDLs relative to the water surface as reservoir levels fluctuated, however, the distance between the bottom TDL and the bottom of the reservoir fluctuated depending upon the water level in the reservoir. Depths at each station varied, but on average, Dino 1 was approx. 13-15 m deep, Dino 2 was approximately 20-22 m deep and Dino 3 was approximately 33-35 m deep.

4.1.3 Surface Water Grab Samples

Water quality analysis of water samples collected over the course of this project, with the exception of AOX, was conducted by ALS Environmental Laboratories (ALS), following approved standard sampling procedures (Appendix A). Analysis of AOX was completed by Econotech Laboratories of New Westminster under contract to ALS Environmental. Analytical results were entered into Microsoft Access to facilitate data organization and statistical analysis.

Water samples were taken from 13 sites (Figure 1). The spring, summer, and fall sampling was completed from Peace River sites using a 7 m Kellehan inboard jetboat positioned near the middle of the stream. Water sampling of tributaries was completed by wading into the stream and retrieving water samples. Water sampling at Peace River sites during the winter, where possible, was completed from shore using an extendable pole holding a sampling vessel (see Golder 2009 for detailed methodology). In tributaries, a combination of axe and/or ice auger was used to create a hole in the ice to access flowing water.

Pre-cleaned and sterilized sample jars provided by ALS were rinsed three times prior to taking water samples. Samples were then carried back to the vehicle where they were fixed with appropriate preservatives and either put on ice in a cooler to keep them cool during the summer or in the truck to avoid freezing in the winter. Samples were dropped off at the Fort St. John office of ALS the following morning, where they were processed and shipped to ALS in Burnaby for final analysis.

4.1.3.1 *Quality Control and Quality Assurance of Surface Water Grab Samples*

Duplicate samples were collected at one site during each of the six field sample sessions; a travel blank was collected during one sample period in 2008.

Duplicate sampling involved taking a second sample of surface water from one of the 13 Peace River and/or Peace tributary water quality sites sampled during every field survey. Duplicate sample sites varied between sample periods and samples were labelled only with the name “duplicate” and the date.

The travel blank consisted of unpreserved laboratory grade water that was treated as a normal sample and analyzed by the laboratory along with other water samples gathered during the sample period.

Results from duplicate and travel blank samples were examined for anomalies. In the case of duplicate samples, direct visual comparisons were made between results from the duplicate and original samples. These comparisons focussed upon large variations between specific sample parameters. For the travel blank the number of parameters which exceeded method detection limits was summarized to determine if this number exceeded 5% of the total of sampled parameters.

Laboratory results from water sample analysis were also compared against in situ results from calibrated meters for accuracy (including turbidity, pH and conductivity).

4.2 Stream Discharge

Discharge measurements were completed at Cache, Lynx, Farrell and Boudreau creeks during filed surveys as part of the background data collected in 2008. In addition to discharge measurements, water level measurements were taken from fixed objects (typically bridges over the stream) or in the case of Lynx Creek, from a staff gauge placed downstream of the highway crossing as part of another BC Hydro project. Rebar pins were placed in Cache and Boudreau creeks, the top of which was used as a reference point from which water level was measured.

Discharges were measured five times (excluding winter) over the duration of the study using a Marsh McBirney Flo-Mate Model 2000. Transects locations were consistent with those utilized in 2007 (Golder 2009). Flow measurements followed standard methods (RISC 1998a; Nielsen and Johnson 1983) ensuring no less than 10 water velocity and depth measurements were taken across the width of the transect. Widths of the cells were adjusted relevant to flow conditions to minimizes instances where flow through individual cells exceeded more than 10% of the discharge measured at the transect. Velocity measurements were taken at 60% of the total depth of the cell from the water surface when water depth was less than 0.76 m. For water depths equal to or greater than 0.76 m, the mean water velocity for each cell was estimated as the mean of measurements at two depths (i.e. 20% and 80% of the total depth of the cell from the water surface).

In addition to completion of discharge measurements, 2008 discharge data from established Water Survey of Canada (WSC) stations in the Peace River watershed were summarized for incorporation into this report (Table 4). It should be noted that WSC data had not yet been finalized at time of completion of this report and is subject to change.

4.3 Data Organization and Analysis

4.3.1 Water Temperature Data Loggers

Raw data recorded by TDLs were viewed to identify periods of anomalous data, typically associated with dewatering.

Where redundant data were available for a site (two TDLs functioned over the course of the project), a visual comparison between plots of mean daily temperatures facilitated selecting the most representative data set. In some situations, data from one temperature data logger at a site was used to replace anomalous data collected by the second logger to provide a more complete and accurate data set. For some tributaries where exposure of both temperature data loggers was suspected, data records were compared to those collected by another

BC Hydro consultant during a concurrent project to aid in verifying data. For the Halfway River, Golder's temperature data were supplemented with data courtesy of Mainstream Aquatics Ltd (2009).

Once datasets were viewed and purged of unrepresentative data, final daily mean, maximum and minimum temperatures were calculated.

Turbidity vs. TSS

Turbidity (NTU) and TSS (mg/L) data are commonly log-normally distributed (Gippel 1995; Packman et. al. 1999). In this study, the measured TSS and turbidity data from water samples taken in the Peace River mainstem and six tributary sites were assessed to determine the best-fit regression result. Regression models for measured data from results of laboratory analysis for TSS and turbidity were developed.

4.3.2 Stream Discharge

Measured Discharge for Non Gauged Tributaries

Discharge was calculated using standard methodology (RISC 1998a). Discharge was calculated by multiplying water velocity measured in a cell of water by the area (width and depth) of the cell, providing the discharge for the cell. The cumulative total discharges of all cells within a transect across a stream then provided an instantaneous discharge for that stream. These calculations are represented by the following equations:

$$q_i = (v_i + v_{i-1})/2 \times (b_i - b_{i-1}) \times (d_i + d_{i-1})/2 \qquad Eq\ (1)$$

Where: q = discharge
v = velocity
d = depth
b = measured distances from shore
i = section (cell)

Total discharge (Q) for the stream at the identified cross section is as follows:

$$Q = \sum_{I=1}^{n} q_i \qquad Eq\ (2)$$

5.0 RESULTS

5.1 Water Quality

5.1.1 In Situ Water Quality Sampling

Results of *in situ* water quality sampling by automated devices and calibrated meters are summarized in a series of appendices. Spot measurements (in situ measurements by calibrated meters) taken from the Peace River and Peace tributary sites are presented in Appendix B, and in situ water quality measurements at depth (profiles) from Dinosaur Lake are presented in Appendix C. Spot measurement data from the Peace River and Peace tributaries were compared against laboratory results for the same parameters.

5.1.1.1 Temperature

Peace River and Tributary Temperature Data Loggers

Daily mean, maximum and minimum water temperatures are provided in Appendix D, supplemented with an electronic copy provided separate from this document.

Temperature can influence various stages of life histories of common sports fish species including incubation, juvenile rearing, and adult migration and spawning. At present, guidelines for water temperature are outlined by RISC (1998b), indicating ± 1.0 °C as allowable change from natural levels for salmonids as follows:

- 18-19 °C maximum weekly average for adults and juveniles

- 8-10 °C maximum weekly average for spawning
- 13-15 °C maximum weekly average for embryo survival

Oliver and Fidler (2001) provide an extensive discussion regarding recommended water temperatures relevant to recommended guidelines pertaining to various species of sport fish, including a table listing optimum temperatures for these species based upon stages of life history. Data presented in Table 5 provides background information relative to some sports fish species which inhabit the Peace River watershed, but it is important to note that the Peace River starts out as a coldwater system at its head waters, and becomes warmer as it progresses downstream towards the Alberta border. As such, fish species composition varies accordingly within the Peace River mainstem; furthermore, some fish may demonstrate various adaptations and/or tolerances to seasonal site-specific temperature conditions in the Peace River mainstem and its tributaries. For example, based upon results from temperature monitoring for the duration of this study, cold water species such as bull trout and rainbow trout are unlikely to extensively utilize sections of the Kiskatinaw, Beaton and Moberly rivers, nor Farrell and Cache creeks during summer months when temperatures are warmest (Table 6).

Sample periods of November to October were analyzed for 2006-07 and 2007-08, to address consistency in the comparison of annual summary statistics in water temperatures between sample years. With the exception of Peace 5, maximum mean daily temperatures during the 2007-08 period of sampling in the Peace River never exceeded 18.0 °C in 2007-08, ranging from a low 13.3 °C at Peace 1 to a high of 15.9 °C at Peace 5 (Table 6a). Maximum daily water temperatures in Peace 5 peaked at 18.5 °C, when temperatures exceeded 18 °C three times during the period between June 30, July 2 and July 3 and instantaneous maximum temperature reached 20.4 °C.

The timing of peak water temperatures in the Peace River in 2008 was variable depending upon the sample location (Figure 3). At Peace 1, peak temperature occurred between August 28 and 31, whereas at Peace 2, peak temperatures were on August 2 to 3 and again on August 31. At Peace 3, water temperature peaked between June 29 and July 3, influenced by warmer water contributed to the Peace from the Halfway River (Figure 4). A slightly lower peak in water temperature at Peace 3 between August 2 and August 6 was similar to the peak observed at Peace 4 (August 2 to August 4), whereas Peace 5 water temperatures peaked between June 29 and July 4. The timing of 2007-08 peaks in water temperatures at Peace River sites was generally earlier than those observed in 2006-07.

As shown in Figures 3 and 4, and consistent between sample years, Peace River water temperatures fluctuated less than those observed in tributaries. The variation in maximum daily temperatures between sample years in the Peace River was less pronounced in the upstream most sample sites (Peace 1 and 2) than downstream sites (Peace 3 to 5). This temperature fluctuation became more pronounced with the downstream progression of Peace River sample sites (Figures 3 and 4). The increased fluctuation at downstream Peace River sites reflects inputs of tributary water between Peace 1 and Peace 5 and the influence of solar heating.

The annual mean of daily temperature at Peace 1 was 0.3 °C cooler in 2007-08 than in 2006-07; however, the maximum mean daily temperature was 0.7 °C warmer in 2007-08 than in 2006-07. Similarly, the annual mean of daily temperature at Peace 2 was 0.7 °C cooler in 2007-08 but the maximum daily temperature was 0.7 °C warmer in 2007-08. For the remaining Peace River sites, 2007-08 annual mean daily water temperatures were consistently warmer in 2007-08 than those in 2006-07, ranging between 0.8 °C warmer at Peace 5 to 2.4 °C warmer at Peace 3 (Table 6a). The same was true for the maximum daily temperatures recorded Peace 3, 4 and 5, which were between 1.2 °C warmer (Peace 4) and 2.7 °C (Peace 5) warmer in 2007-08 than 2006-07. Variations in the annual mean temperature between sample periods are influenced by the size of the data set. The number of sample days at Peace 4 and 5 were more similar to each other between years than at Peace 1, 2 and 3. The warmer trends in water temperatures in the Peace River in 2007-08 are more apparent from Figure 5 which shows daily mean water temperatures at all Peace River sites were warmer through the winter, spring and early summer 0f 2007-08 than those observed in 2006-07, although this difference became less apparent through the late summer and fall.

For tributary sites, only the Halfway River (17.8 °C) never exhibited a maximum of mean daily temperature above 18 °C in 2007-08, but even so, maximums of daily mean temperatures at all tributary sites exceeded those recorded at every Peace River sites (Table 6b). Not including the Halfway River, maximum mean daily temperatures at the remaining tributary sites ranged from a low of 21.4 °C in the Pine River to a high of 25.0 °C in the Kiskatinaw River. Instantaneous maximum daily temperatures ranged between 18.9 °C in the Halfway River to a high of 28.6 °C in the Beaton River. Unlike Peace mainstem sites, not only did mean daily temperatures at some tributary sites regularly exceeded 18 °C in 2007-08, they exceeded these temperatures for extended periods. For example, amongst the warmest tributaries (Farrell Creek, and the Beaton, Moberly and Kiskatinaw rivers), the number of days mean daily temperatures exceeded 18 °C ranged between 39 days in the Moberly River to 47 days in the Kiskatinaw River. This observation emphasizes the unsuitability of habitat in these tributaries for some cold water sports fish species during summer months.

Peak temperatures for the Halfway River in 2007-08 occurred from August 6 to 10 whereas in the Pine River, peak temperatures occurred from August 16 to 18 (Figure 4). In 2007-08, multiple peaks in mean daily temperatures were observed in Farrell Creek (July 3 - 5 and August 8 - 9) and in the Kistkatinaw River (July 3-4, August 9 and again on August 17) as well as in the Moberly River (August 8 - 9 and Aug 16 - 17). There was consistency in individual peaks in water temperatures observed among tributaries in 2008 (Figure 6). Peaks in temperature occurred at most tributary sites from late May to early June and again in July. Unlike the Peace River, there was no consistent trend in annual means of daily water temperatures or maximums of daily mean water temperatures in Peace River tributaries between sample years (Figure 6). Maximums of mean daily temperatures were variable between years. In the Moberly River, the maximum mean daily temperature was 1.8 °C warmer in 2007-08 than in 2006-07, whereas in the Halfway River, it was 1.7 °C lower in 2007-08 than it was in 2006-07. Similarly, the Kiskatinaw River and Farrell Creek exhibited maximums of mean daily water temperatures that were 1.1 °C and 1.5 °C cooler in 2007-08 than 2006-07, whereas the Beaton and Pine Rivers had maximums of mean water temperatures that were 0.9 °C and 2.6 °C warmer in 2007-08 than observed in 2006-07.

A summary of monthly mean, maximum and minimum water temperature data is provided in Appendix E. Not all monthly temperatures presented in Table 7 represent true means, since some data gaps exist in the daily water temperature record. These data gaps, associated with the timing of placement and removal of TDLs make direct comparisons of variations in mean monthly temperatures for all months between years problematic. Having said this, where data for direct comparisons are available, mean monthly temperatures in the Peace River through the late spring and early summer were up to 2.5 °C higher in 2008 compared to 2007 (e.g., June at Peace 2), but this difference decreased to 0.6 °C or less by September and October. In Peace River tributaries, mean monthly temperatures, like daily temperatures statistics, did not show a consistent trend among tributaries or sample years. The variation in mean monthly temperatures in tributaries never exceeded 1.0 °C between sample years. Monthly tributary temperatures were substantially warmer than those observed in the Peace River (Table 7). As in 2007, monthly temperatures in Farrell Creek and the Beatton and Kiskatinaw Rivers were warmer than other tributaries. The warmest monthly temperatures in 2008 occurred in July for all tributaries, ranging from a low of 15.3 °C in the Halfway River to a high of 19.9 °C in the Kiskatinaw River. As was the case in 2007, Peace River water temperatures in 2008 near the PCN dam were cooler in the summer months and warmer in the winter months than those recorded at downstream Peace River sites. In January 2008, the monthly mean water temperature at Peace 1 was 1.0 °C warmer than that observed at Peace 5, whereas in July, Peace 1 was 4.5 °C cooler than at Peace 5.

Recognizing mean monthly temperatures for all months in both years are not available, Figure 7 and Figure 8 provide an indication of the trend in differences in monthly water temperatures between sample years for the Peace River and sampled tributaries. These comparisons are consistent with trends shown by the mean daily temperatures. Specifically, water temperatures in the Peace River tended to be higher in 2008 than in 2007 through most of the year, although this difference was less apparent into the fall and early winter months; variation in monthly water temperatures between years for tributary sites was not as apparent. Mean monthly air temperatures recorded at Environment Canada’s Fort St. John weather office also indicate warmer ambient air temperatures in 2008 when compared to 2007 (Figure 9).

Dinosaur Lake Temperature Data Loggers

Temperatures recorded by TDLs positioned in Dinosaur Lake are presented in Appendix D, with the dataset extending from early May to late October 2008 except for Dino 2 where TDLs were lost (likely due to tampering) near the end of August.

This temperature record indicates variation between sample depths at each of the three sample locations increased with distance downstream of the WAC Bennett Dam (Figure 10). Means of daily, maximum and minimum temperatures recorded by TDLs at all three depths were virtually indistinguishable at Dino 3, whereas there was a difference of 7.1 °C between surface and bottom TDLs at Dino 1 on July 5 (Figure 10). Peaks in surface water temperatures observed in late May through to early June and again in late June through to early July are consistent between Dino 1 and Dino 2 but not apparent at Dino 3. Neither daily mean temperatures, nor daily maximum temperatures, exceeded 18 °C at any of the Dinosaur Lake sample stations (Table 8). Maximum daily surface temperatures peaked at 16.3 °C at Dino 1, 16.2 °C at Dino 2 and 14.3 °C at Dino 3 during early July. Maximum daily temperatures at TDLs positioned near the bottom of the reservoir ranged between a high of 14.3 °C at Dino 3 to 12.8 °C at Dino 1. Monthly mean temperatures for the 3 depths recorded at Dino 3 varied 0.2 °C or less, whereas this range increased to between 0.2 °C and 1.9 °C at Dino 1 (Table 9).

Mean monthly temperatures from Dinosaur Lake TDL data indicate the lowest mean temperature for the sample period occurred in May (3.6 °C) at Dino 3, whereas the highest mean monthly temperature occurred in September (12.1 °C) at Dino 1. Water temperatures were, on average, warmer near the surface than at the bottom for most months. Exceptions include May, when the mean monthly temperature for the bottom TDL at Dino 3 was warmer than that of TDLs nearer the surface

There was little temperature fluctuation between sample sites in monthly temperatures with respect to depth in the water column. The main difference was seen in June and July when it was 1.2 °C and 1.4 °C, respectively, otherwise, the range in monthly temperature fluctuations at all measurement depths was 0.9 °C or less for all of the TDL depths (Table 10). For TDLs positioned 5 m from the water surface and near the bottom of the reservoir, the range in monthly water temperature fluctuated 0.6 °C or less.

In general, there was little variation in the combined mean water temperature (derived from all three TDLs recordings at one site) among sites (Figure 11). A small delay of approximately four days is apparent between various peaks in water temperatures derived from the Dino 3 TDLs compared to those from Dino 1. This likely approximates the transit time for water moving through the reservoir.

5.1.1.2 Dinosaur Lake Limnology

A summary of mean *in situ* water quality measurements taken with calibrated meters in Dinosaur Lake is provided in Table 11. Specifics of each profile are discussed individually below.

Temperature

In situ profiles of water temperature taken with the YSI temperature probe confirm observations from TDLs, specifically, surface water temperatures were consistently warmer for all sites and the warmest water temperatures were observed through the later part of the sampling regime (August and September). There was little evidence of stratification at any of the sites and there was no distinguishable metalimnion (the thermal discontinuity between the hypolimnion and the epilimnion), let alone an obvious hypolimnion or epilimnion at any of the temperature profile stations (Figure 12). Thermal stratification was almost nonexistent at any of the sample sites, indicative of the high through flow volume of water associated with a run of the river type reservoir (Wetzel 1983). The only sign of thermal stratification was at Dino 1, which showed a slight gradient in the thermocline where water temperatures at the deeper extent of the profile were almost 1.5 °C cooler than those observed 1 m below the surface for the month of June. June profiles typically showed the greatest variation in temperature gradient between the warmest (surface) and coldest (bottom) temperature for all of the sample sites, but this variation was only about 0.5 °C at Dino 2 and Dino 3; otherwise, the variation was often less than 0.5 °C for all sites.

In 2008, the combined mean monthly temperature of all three TDLs at Dino 1 was always within 0.2 °C of the mean monthly temperatures record at Peace 1 (Table 12).

Dissolved Oxygen

DO profiles were taken in May, June, July, August and October, however, the profile taken at Dino 1 during October was discarded after a comparison to readings taken at Dino 2 and Dino 3 suggested the meter was malfunctioning at Dino 1 (Appendix C).

Depth profiles of DO indicated water was well oxygenated throughout the water column (Figure 13). Like temperature, DO profiles indicated little stratification at the 3 sample locations, with levels seldom varying more than 0.2 mg/L among all sample depths for any one measurement period. The largest observed variation in DO readings was at Dino 1, which showed a 0.44 mg/L variation between maximum and minimum readings taken during June. On average, DO levels were higher earlier in the year (peaking in June) and dropped through July and August (Table 11), which corresponds with the reduced solubility of oxygen in water at the higher water temperatures.

pH

Unlike most other depth profiles of in situ measured parameters, the greatest variation in pH was noted at Dino 3, the upstream most sample location. Dino 3 not only showed the greatest variation in pH related to changes in depth, it also showed the greatest variation in pH between sample periods (Figure 14). Dino 1 and Dino 2 showed very small variation in pH for all depths. As observed for all Peace River sample locations, water conditions are slightly basic in Dinosaur Lake and pH stayed between 8 and 8.5 over the course of sampling at these two sample locations. Dino 1, however, showed a much wider range in measured pH, particularly nearer the water surface, where it ranged from a low of 7.1 in July to a high of 8.9 in August (Table 11).

Conductivity

Conductivity profiles showed little variation in measurements taken at the surface compared to those taken at depth although this parameter varied considerably between sample months (Figure 15). Conductivity did not vary substantially between sites for each month, but like other in situ measurements, conductivity tended to decrease as the season progressed, from the highest levels observed in May and June to the lowest levels observed in August (Table 11). Conductivity profiles were not available for October due to equipment malfunction.

5.1.1.3 Total Gas Pressure

TGP is relevant to fish health since it can result in gas bubble disease/trauma resulting from supersaturation of gases in solution (Point 4 Systems 2005, Antcliffe and Finster 1999, BCMoE 1997). Dissolved gas supersaturation is a condition that occurs when partial pressures of atmospheric gases in solution exceed their respective partial pressures in the atmosphere (CCME 2003a). TGP measures primarily nitrogen and oxygen in solution although other gases such as argon and CO_2 contribute a minor amount to TGP. Guidelines for TGP are presented by both the CCME and the BCMoE are ΔP, which is the difference between the TGP in the water column minus the atmospheric pressure. The guideline for this difference, known as excess gas pressure, can only be 24 to 76 mm Hg at depths of 0 to 1 m, which at sea level conditions, corresponds to a range in TGP of approximately 103% to 110% saturation (BCMoE 1997). For depths greater than 1m, TGP should be ≤ 110% saturation.

Peace River

Because of the current at Peace River sampling sites, all measurements were taken within 1m of the water surface; typically the probe was held in place approximately 0.3 m below the water surface. Results from 2008 indicate surface measurements of TGP often reached, but seldom exceeded 103% at all sites (Figure 16). A single TGP reading of 106% was observed at Peace 2 and 104% at Peace 3 during the June sampling period. There was also variability noted in TGP levels from one side of the river to the other (Table 11). This variability may be attributed to small changes in temperature or variable mixing of water between either bank of the Peace

River. Only the left bank was sampled for TGP at Peace 2 as this area was accessed by foot during sample sessions and the right bank was inaccessible except by boat.

Dinosaur Lake

TGP measurements at Dinosaur Lake showed the greatest variation nearest the WAC Bennett Dam at Dino 3. TGP measurements at Dino 3 were generally highest at the 5 and 10 m depth, ranging between 103 and 111% of the atmospheric pressure (Figure 17). With the exception of the June sampling period, when only one surface reading of TGP was taken, there generally was a decrease in TGP with downstream progression of the sample stations in the reservoir, likely due to dissipation of supersaturated dissolved gas as the water progressed downstream. There also tended to be a slight increase in TGP with depth.

5.1.1.4 *Turbidity and TSS*

Similar to what was observed in 2007, peak readings of turbidity were generally associated with peaks in discharge at tributary sites but not at Peace River sites. The relationship between discharge and turbidity is most evident for the Halfway and Moberly rivers where a complete discharge curve is available for these streams from the WSC (Figure 18). Peak turbidity observations are sensitive to the timing of water sampling relative to the discharge curve. Turbidity readings taken during the descending portion of the discharge curve or away from peak discharges rapidly decreased in both the Moberly and Halfway Rivers, and were often an order of magnitude less than those observed proximate to peak discharge. This observation is even more apparent in the small tributaries although the discharge record is less continuous. Observed peaks in turbidity in small tributaries were commonly observed with higher discharge although concurrent discharge measurements were not always available for each water sample date (Figure 19).

The relationship between discharge and turbidity is less clear at Peace River sites. This is primarily because peak discharge in the Peace River upstream of the Pine River is typified by releases of water related to electrical generation during the winter as a function of operation of the WAC Bennett and PCN dams (Figure 20). WSC data from 2008 indicate brief surges in discharge in the spring, summer and fall from the Halfway, Moberly, Pine, Beaton and Kiskatinaw Rivers. As discussed above, such surges in discharge are associated with increased turbidity which is measurable in the Peace River during what is (relative to the winter) a period of reduced flow in the Peace River hydrograph. With the downstream progression of sample sites (particularly noticeable at Peace 5), the influence of tributary inputs also becomes more apparent on the Peace River hydrograph measured at Clayhurst. Otherwise, at upstream locations, in situ spot readings of turbidity from the Peace River appear to reflect the timing of contributions of TSS from tributaries, based upon WSC data as opposed to periods of peak discharge or even localized peaks in discharge in the Peace River hydrograph.

5.1.1.5 *Total Suspended Solids Compared to Turbidity*

A log-linear relationship was developed to predict TSS from turbidity, based upon laboratory results from water sample analysis (Figure 21).

A log-linear model showed strong positive correlation between TSS and turbidity, described by Equation 1.

$$\ln(TSS) = 0.9407\ln(NTU) + 0.3998 \quad (r^2 = 0.9122) \qquad \text{Eq (3)}$$

Where: TSS = Total Suspended Solids (mg/L)

NTU = Turbidity (NTU)

This log linear relationship was not quite as strong as that developed for 2007 data, although the regression equation still accounts for over 90% of the variability (r^2 =0.9122).

5.1.2 Water Quality from Surface Water Grab Samples

Ranges (maximum and minimum) of water quality analyses results for all parameters sampled during the 2008 monitoring period are provided in Table13 and Table 14. Individual results from each sample site for each sample parameter are presented chronologically in Appendix F. An electronic Microsoft Access database of this information has been provided separate of this text.

Exceedences of CCME and/or BCWQ guidelines for fresh water aquatic life (Appendix G) were observed in 2008 water samples in both Peace River and tributary sites for the following parameters:

- Fluoride;
- Aluminum;
- Arsenic;
- Iron;
- Cadmium;
- Copper;
- Silver;
- Selenium;
- Vanadium; and
- Zinc.

The above list of parameters is consistent with that observed from 2007 results.

5.1.2.1 Metals

Metal analysis within water samples is discussed as both a total and a dissolved form in this report. Total metals represent the concentration of a specific metal in all forms, associated with both particulate matter (TSS) and in solution (dissolved). Dissolved metals represent a subset of total metals, which because it is dissolved in the water, is more mobile and typically more readily available to aquatic organisms.

As in 2007, total metal exceeded CCME and BCWQ guidelines more frequently than dissolved metals. Of 286 identified exceedences of metals as per CCME and BCWQ guidelines amongst all water samples taken in 2008, only 42 represented dissolved metals, with the remaining exceedences being total metals. In 2009, dissolved metals exceeded guidelines only 29 times out of a total of 263 identified exceedences of all water samples taken.

Exceedences of total aluminum, iron and cadmium were most frequently observed in 2008 water samples, followed by copper, zinc, and vanadium (Table 15). Mercury never exceeded guidelines for any water samples and only slightly exceeded the MDL (0.00005 mg/L) in both the original and duplicate samples taken at Peace 5 during May of 2008 when concentrations of mercury were at 0.00012 and 0.00013 mg/L.

A number of other metals, primarily in dissolved form, never exceeded MDL in the water samples taken from the Peace River during 2008. These include antimony (dissolved), beryllium (dissolved), bismuth (both), boron (both), phosphorous (dissolved), selenium (both), silver (dissolved), thallium (dissolved), tin (both) and titanium (dissolved). Of these metals where the total metal component did exceed MDL, all with the exceptions of silver and titanium, only did so at Peace 5. Dissolved cadmium only exceeded MDL on one occasion at Peace 1.

Unlike Peace River samples, only beryllium (dissolved), bismuth (both) and tin (dissolved) were never detected, and in the case of beryllium, the total component only exceeded MDL at the Moberly 7 and Halfway 8 sites on one occasion. On average, dissolved metals were only detectable 44% of the time in the 2006-07 and 2008 sample periods, although only about 1/3 (35%) of the water samples taken in the Peace River had dissolved metals detected in them compared to 53% for tributary sites (Table 16).

The tendency for more observations of dissolved metals above MDL in 2008 discussed above highlights another trend which was consistent between years. Exceedences of dissolved and total metals in 2008 water samples when compared to BCWQ and/or CCME guidelines were highest in Peace tributary sites. Expressed as an average per sample taken, there were over twice as many individual total metals exceeding guidelines in Peace tributary water samples as in Peace River water samples (1.56 compared to 0.71) in 2008 (Table 17). On average, the frequency at which total metals exceeded guidelines per sample was also twice as high in tributary water samples as in Peace River samples (3.96 compared to. 1.94). A similar relationship was observed for the average number per sample of individual dissolved metal exceedences and the frequency at which dissolved metals were observed to exceed guidelines in water samples for the tributary and Peace River sites There were on average, four times as many individual types of dissolved metals found to exceed guidelines in water samples at tributary sites as in Peace River sites (0.58 compared to 0.15), and the mean frequency of these exceedences was almost four times greater at Peace tributary sites than at Peace River sites (0.76 compared to 0.21). The relationship between the frequency and number of individual dissolved metals exceeding guidelines in Peace tributary and Peace River sites is similar between years, but there were variations in the number and frequency of these observations. The average frequency per sample at which exceedences of dissolved metals for all sites combined was similar between years (0.4 in 2007 compared to 0.52 in 2008). There was however, almost a two fold increase in the average number of individual dissolved metals per sample observed to exceed guidelines between years (0.22 in 2007 compared to 0.35 in 2008) for all the sites combined.

The trend of an increasing number of total metals exceeding CCME and BCWQ guidelines in Peace River water samples with the downstream progression of sample sites was consistent between years. This same trend also applied to the frequency at which these exceedences occurred (Figure 22). Unlike 2007, when no total or dissolved metals at Peace 1 were found to exceed guidelines, cadmium (dissolved and total) exceeded guidelines on one occasion in 2008. Overall, the frequency of occurrence for exceedences of total metals at Peace 5 was the highest of all the Peace River sites; however, compared to 2007 exceedences occurred less frequently than in 2008.

As indicated earlier, on average there were more instances of individual dissolved metals exceeding guidelines in 2008 than observed for 2007. In 2007, selenium and aluminum were the most commonly observed dissolved metals to exceed CCME and/or BCWQ guidelines. In 2008, aluminum, cadmium, copper, iron, manganese and selenium exceeded guidelines a similar number of times, but as in 2007, exceedences of dissolved selenium were primarily confined to the Halfway River. Selenium consistently exceeded CCME guidelines at both Halfway 8 and Halfway 9. Exceedences of the other dissolved metals were spread amongst a number of sample sites but on a less consistent basis. For example while dissolved selenium exceeded guidelines in four of five water samples taken at Halfway 8 and four of six samples taken from Halfway 9, Boudreau 13 was the only other sample site where multiple exceedences of dissolved metals were observed over the course of the 2008 study period. Exceedences of other dissolved metals were generally confined to one water sample period but spread through a number of sample sites.

Typically, as in 2007, exceedences of dissolved and/or total metals observed in 2008 were associated with high levels of TSS transported by tributaries during freshet (Figure 23). Plots of this relationship for a range of metals found to exceed CCME and/or BCWQ guidelines for all sample sites are presented in Appendix H. Jang (1996) suggested long term records of water sample analysis from the Clayhurst sampling station on the Peace River (upstream of the Alces River) indicated that in cases where total metal exceedences are linked to TSS, dissolved metal components are likely more reflective of natural background levels and should be used for direct comparisons to available water quality guidelines.

In the case of dissolved metals, most observed exceedences of guidelines in 2008 were from tributary water samples. Water samples from Boudreau 13 exhibited the largest mean number of individual dissolved metals per sample and the highest mean frequency of dissolved metals per sample exceeding guidelines in 2007. Unlike 2007, both Halfway River sample sites showed the highest average frequency of exceedence of individual dissolved metals per water sample in 2008 (Figure 24). Water samples from Boudreau 13 had the highest mean number of exceedences of dissolved metals per sample in both 2007 and 2008 which is somewhat inconsistent with general expectations regarding systems with wetland head water sources such as the Boudreau Lakes. Typically, wetlands act as natural biological filter for nutrients and metals in receiving waters, which is considered a primary reason for present efforts to protect and maintain such ecosystems (Pers. Comm. B. Harrison. May 26, 2009, Ducks Unlimited, Canada).

5.1.2.2 Anions

Of the anions analysed from water samples taken in 2008, including bromide, chloride, fluoride, sulphate and sulphide, only fluoride and sulphate levels were observed to exceed BCWQ and or CCME guidelines (Table 12). This observation is similar to results obtained in the 2007 sampling period. Unlike 2007, exceedences of guidelines for these parameters in 2008 water samples were spread over a larger number of sample sites, and while most exceedences were confined to tributary sites, more observations of exceedences of fluoride and sulphate were noted in Peace River water samples in 2008. However, only Lynx 10 and Boudreau 13 water samples consistently exceeded guidelines for fluoride and only Boudreau 13 consistently exceeded guidelines for sulphate. As seen in 2007, exceedences of fluoride (Figure 25) and sulphate (Figure 26) concentrations were associated with low flow periods, not peaks in suspended sediment load.

5.1.2.3 Adsorbable Organic Halogens (AOX)

AOX represents a broad range of organohalides, which collectively have no identified guideline concentration within CCME and/or BCWQ guidelines; individually, concentrations of specific molecules within this broad category have CCME and/or BCWG guideline concentrations. Organohalides include a wide variety of individual molecules associated with halogens, such as bromine, fluorine, chlorine and iodine, representing a number of industrial chemicals in which one or more carbon atoms are linked by covalent bonds with one or more halogen atoms. These molecules are most commonly associated with chemicals such as plastics, pesticides, refrigerants and PCBs. Anthropogenic sources include industrial outfalls (pulp mills) but can also be associated with agricultural activities (BC MoE 2008).

Generally, levels of AOX were lower in 2008 than those observed in 2007 (Figure 27). Water samples from Cache, Lynx and Farrell creeks still had some of the highest AOX concentrations in 2008, but the magnitude and timing of these peaks were different in 2008. In 2007, there appeared to be a general trend towards higher levels of AOX in water samples in the summer months, whereas the same trend was not observed in 2008. Conspicuously large peaks in AOX (> 60 µg/L) in water samples taken from these three streams in July 2007 were not apparent in 2008; rather, smaller peaks (~ 20 µg/L) were observed in the winter (February) of 2008. AOX was below detectable limits in the winter sample period for these tributaries (early March) of 2007. An observed peak in AOX in water samples taken from most Peace tributary sites during May was consistent between years, suggesting an association with run-off during spring freshet. Generally, there were fewer observations of AOX above MDL in both tributary and Peace River sites in 2008 compared to 2007. Only 48% of all samples were above MDL in 2008, whereas 74% of the samples had AOX concentrations above MDL in 2007 (Table 18). There were however, exceptions for individual sites. Farrell Creek water samples exceeded the MDL for AOX more frequently in 2008 than 2007 whereas the number of observations of AOX above MDL at Moberly 6 was similar between years.

5.1.2.4 Nutrients and Other Organic Compounds

A number of organic and nutrient parameters were sampled during the course of water sampling for the 2007 and 2008 monitoring program, the ranges in concentration of which are summarized in Tables 12 and 13. A complete listing of individual survey results for these parameters is provided in Appendix F. A summary of results from some the key parameters in this group are presented below.

Chlorophyll a

Chlorophyll *a* is an index of primary productivity (RISC 1998b). Analysis for planktonic chlorophyll *a* was completed at sample sites on the Peace River and its tributaries. For comparative purposes, results identifying orthophosphate concentration are presented together with chlorophyll *a* (Figures 28-30).

Chlorophyll *a* concentrations ranged from a low of 0.254 µg/L at Peace 1 to a high of 81 µg/L at Boudreau 13 in 2008. Peace River chlorophyll *a* never exceeded 1.44 µg/L (observed in October 2008 at Peace 4) whereas concentrations of chlorophyll *a* were generally higher at tributary sites, ranging between a low of 0.606 µg/L at Halfway 9 in July to 9.24 µg/L at Moberly 7 in June (excluding the peak concentration observed at Bourdreau 13). The peak concentration of chlorophyll *a* of 81 µg/L at Boudreau Creek in October suggests potential contamination of this sample, however, Shaw et al (1990) observed planktonic concentrations of chlorophyll *a* as high as 19.5 µg/L in the Wolverine River and 15.7 µg/L in the Peace River at Dunvegan (this latter value was coincident with a high concentration of suspended solids). Shaw et al (1999) noted the highest concentrations of Chlorophyll a in the Peace River between August and September, ranging from just over 2.0 µg/L at the BC – Alberta border to 1.8 µg/L upstream of the Whitemud River.

The timing of peak chlorophyll *a* production in the water column is linked to a combination of available light and nutrient levels. Generally, in both 2007 and 2008, chlorophyll *a* production in Peace River sites and the small tributary sites tended to be higher later into the summer, although some of the highest concentrations of chlorophyll *a* were noted in November 2006 (Peace 4 and Peace 5) and October 2008 (Peace 1, Peace 3, Peace 5, Lynx 10 and Farrell 11) (Figures 28 and 30). In large tributaries, peak chlorophyll *a* levels in 2008 occurred in May and June at Moberly 6 and 7 but in June and July at Halfway 8 and 9 (Figure 29). Increasing water clarity in these streams combined with high water temperatures appears to contribute to higher photosynthetic activity during the summer. However, high water clarity in the fall may also explain consistent observations of high fall chlorophyll *a* levels at every Peace River and some tributary sites, despite cooling water temperatures observed during this time of year.

Orthophosphate

Phosphate is an essential element that often limits plant growth in fresh water, but seldom naturally occurs in concentrations greater than 0.01 mg/L. It is typically reported as total phosphate (organic and inorganic forms), total dissolved phosphate (non particulate) and orthophosphate (inorganic oxidized form). Ranges of each form of phosphate from the 2008 water sampling are presented in Tables 12 and 13. Since orthophosphate is most readily available to plants (RISC 1998b), this form is discussed here.

Surges in orthophosphate concentrations sometimes preceded increases in chlorophyll *a* levels in 2008 water sample results as observed in May 2008 at Peace 3, 4 and 5 (Figure 28) as well as in large tributary sites (Figure 30), but this observation was not consistent with small tributary sites (Figure 29). Common to both 2007 and 2008 were surges of orthophosphate during spring (April and or May) although this was not always consistent between sites. Like other sampled parameters, increases in orthophosphate are likely linked to surface run-off during spring freshet. Freshet occurs earlier in small tributaries than in large tributaries, and each peak influences Peace River orthophosphate levels. Peaks in orthophosphate were generally higher in 2007 than those observed in 2008 at Peace River and small tributary sites but lower in 2007 when compared to 2008 at large tributary sites.

Dissolved Organic Carbon

Dissolved organic carbon (DOC) is that part of the total organic carbon (TOC) component that can be filtered through a 7 µm filter. DOC is an essential component of the carbon cycle and energy balance in streams as it is a nutrient contributing to primary productivity. DOC can react with trace metals to form complexes which can influence the metal’s mobility and transport within aquatic systems. High levels of DOC can also coincide with decreased dissolved oxygen levels in aquatic systems and can alter acid-base chemistry in low alkalinity streams. DOC can also affect water colour and thereby attenuate light penetration into a stream. There are multiple natural and anthropogenic sources of DOC, including, but not limited to the following:

- leaf drop from forest canopy, forest floor, soil organics, plant roots etc. contributed via surface run-off;
- atmospheric inputs from industrial sources;
- aquatic sediments, detritus and organisms; and
- agricultural, industrial and municipal (such as sewage) outfalls.

Ranges of DOC found during the course of the 2008 water sampling are reported along with other organic parameters in Tables 13 and 14.

In general, trends in DOC, like metals, closely followed TSS for most, but not all sites (Figure 31). Exceptions include Peace 1 and Peace 3. The highest concentration of DOC was noted at Boudreau 13, which is consistent with the wetland source of this drainage. Farrell 11 also exhibited high levels of DOC compared to other sample locations.

Nitrogen

Nitrogen is an essential plant nutrient and exists in various forms in freshwater aquatic systems. Nitrogen can be introduced into aquatic systems from natural sources, such as igneous rocks, mineralization of native soils, as well as by oxidation of organic debris, such as vegetation and animal matter (CCME 2003b). Nitrogen can also be introduced into freshwater in liquid or dry form through deposition from the atmosphere (often via anthropogenic sources) and/or point sources such as municipal and industrial wastewaters, and mining (explosives). Nitrogen can also be introduced from non-point sources, such as agriculture, urban run-off, and vehicle exhaust (CCME 2003b, RISC 1998b). The form of nitrogen in fresh water depends upon availability of oxygen. When dissolved oxygen is high, nitrification (oxidation of NH_4 and NO_2 to NO_3) is promoted by autotrophic bacteria whereas in oxygen deficient waters, denitrification ($N0_3$ to NO_2 and then gaseous N_2) via autotrophic and heterotrophic bacteria occurs (CCME 2003b). Sample analyses for this nutrient typically include ammonia, nitrite, nitrate, total Kjeldahl nitrogen and total nitrogen (CCME 2003b):

Nitrate ($N0_3$) is the most oxidized and stable form of nitrogen and can lead to algal blooms and eutrophication although it is generally accepted that phosphorus, not nitrogen, most often limits primary productivity in fresh water systems (CCME 2003, RISC 1998b). Since nitrate is the most stable form of nitrogen and generally accounts for two thirds to four fifths of total available nitrogen in surface waters, results of nitrate concentrations found in water samples in 2007 and 2008 are discussed in this text. Results of other forms of nitrogen are presented in Tables 10 and 11.

Similar to other parameters, nitrate concentrations tended to fluctuate with TSS during the spring (April and/or May) at most tributary sample locations but exceptions include Boudreau 13 and many of the Peace River sites (Figure 32). Additionally, a pattern of increasing nitrate with increasing TSS was not consistent at all sites between years. For example, Moberly 6 and Moberly 7 showed decreasing nitrate concentrations during peak TSS in 2007, but in 2008, a peak in nitrate was closely associated with the peak in TSS at Moberly 7. The highest peak in TSS in Lynx Creek was associated with very low nitrate levels.

Nitrate rarely exceeds four mg/L in nature (CCME 2003b). The highest nitrate concentrations were observed amongst tributary sites, particularly in Farrell Creek, where nitrate peaked at 0.469 mg/L in May (Table 14). Other small tributaries such as such as Lynx 10 and Cache 12 also had relatively high levels of nitrate in 2008 (0.156 and 0.147 mg/L) although these levels were a third of those observed at t Farrell 11. Most tributary sites had solitary peaks in nitrate associated with TSS; otherwise, nitrate levels were generally low and/or undetectable at the tributary sites. An exception was at Lynx Creek, where nitrate was detected in all but 1 sample period (August 2008). The high peaks in nitrates in these small streams may be attributed to agricultural activities and associated runoff during spring melt.

Nitrate concentrations were generally higher and fluctuated less over the duration of sampling at Peace River sites when compared to tributary sites. Peak levels of nitrates at Peace River sites were however lower than those in tributary sites, never exceeding 0.0724 mg/L (Peace 4). The magnitude of these peaks were very similar to each amongst the Peace River sites, ranging between 0.706 and 0.724 mg/L for all sites except Peace 5 where the peak concentration was 0.548 mg/L (Table 13).

5.1.2.5 *Surface Water Grab Sample Quality Control/Quality Assurance*

Most of the duplicate samples (three) were taken from Peace 1, although a single set of duplicate samples was also taken from Peace 3, Peace 5 and Moberly 6 (Table 2, Section 5.1.1). Only one travel blank was submitted to ALS from the 2008 sample period. There were only minor variations observed from results of analysis of the travel blank and duplicate samples from the 2008 monitoring program. Individual results associated with each sample session are presented along with results from specific sample sites in Appendix F.

Visual comparisons of duplicate samples indicate only one instance, specifically for chlorophyll *a* at Peace 5, where a variance of more than 100% between the duplicate set of samples was observed in 2008 results (Table 19). Analysis results for dissolved aluminum at Peace 1 in June and total phosphate at Peace 3 in July of 2008 were the next largest variations between duplicate sample results, but this variation was less than 100%.

The variation between samples for chlorophyll *a* in the Peace 5 duplicate set is not unusual, as this parameter tended to show exceedences in MDLs for travel blanks taken in 2007 as was again the case for the single travel blank taken during 2008. Slight hits of chlorophyll *a* in travel blanks may be attributed to blanks being prepared weeks or even months prior to analysis depending upon when sample bottles are requested from the lab. Such blanks may be unrepresentative of chlorophyll *a* levels since they are unpreserved, not refrigerated, and may be exposed to light, all of which increase the potential for algal growth (A. Springer, ALS, pers. comm.). Because samples are unpreserved, variable exposure to light may also create variation in analysis results of this parameter in duplicate samples.

Results from blanks are expected to be below MDLs about 95% of the time, assuming they are returned unopened and no contamination occurred during transport of the blanks. The single travel blank taken this year only had one exceedence of MDL, which was for Chlorophyll *a,* which for reasons explained above, is not a good indicator of problems between original and duplicate samples. Regardless, this single exceedence accounted for only 3% of the total number of parameters sampled (Table 20).

5.2 Stream Discharge

Discharge measurements were taken at Lynx, Farrell, Cache and Boudreau creeks during the 2008 field surveys (Appendix I). Additionally, WSC discharge records from Peace River and relevant tributary stations are presented in Appendix J. Flow measurements at Boudreau Creek and Cache Creek were hampered by site specific conditions. Flows in Boudreau Creek were so low that the flow meter could only measure water velocity during the May sample period. Bridge replacement at Cache Creek prevented access to the water velocity measurement transect in May and July and there was no measureable flow during the August sample period.

Peak discharge for the four small Peace tributaries cannot be confirmed from discharge measurements recorded during 2008. Highest flows were measured in early May in Lynx and Boudreau creeks, but it cannot be assumed these measurements are representative of the period of peak flow (Figure 33). Turbidity measurements from 2008 (Figure 17, Section 5.1.1.4 indicated the highest turbidity was observed during the early May 2008 sample period in these streams, when discharge measurements could not be measured in either Cache or Farrell creeks. Farrell Creek was too high to wade in May and heavy machinery was working at Cache Creek. WSC data indicates freshet occurred in larger tributaries between one to two weeks earlier in 2008 when compared to 2007 (Figure 34). Golder (2009) observed highest flows in Cache Creek during the April 2007 field survey. Despite indications that measurements taken in the small tributaries did not capture peak discharge, flows appeared to be lower in 2008 than in 2007 for the small tributaries except Boudreau Creek (Table 21). This conclusion is consistent with observations from WSC data for the larger streams.

6.0 DISCUSSION

Results from two years of water quality analysis in the Peace River and associated tributaries show some consistencies in the findings between years. Variations related to the timing and magnitude of spring freshet of Peace tributaries had a measureable influence upon Peace River water quality in both 2007 and 2008. Aside from periods of high water associated with freshet, tributary inputs into the Peace River are small relative to mean annual discharge (MAD), particularly when considering differences between winter flows in the Peace mainstem compared to tributary inputs (Golder 2009). During spring freshet however, the combined inflow of tributary water surges relative to Peace River discharge released from the upstream dams. During these times, total metal content observed in water samples from the Peace River and particularly from tributary sample locations begins to exceed CCME and BCWQ guidelines for fresh water aquatic life. When exceedences of dissolved metals were observed, they followed a similar trend demonstrated by the total metal component; otherwise dissolved metal concentrations were generally below MDL.

Elevated levels of total metals were associated with TSS load in both Peace River and tributary sample sites in 2007 and 2008; consequently, changes in the timing and magnitude of freshet in tributaries affects sediment load and metal concentrations in the Peace River. TSS in the Peace River appears to be primarily a function of tributary inputs, particularly from the Moberly, Halfway, Pine, Beaton and Kiskatinaw rivers.

Tributaries also showed the widest range in the types of metals exceeding guidelines when expressed as a mean of the total number of samples taken from sites surveyed in both 2007 and 2008. Consequently, an increasing frequency in exceedences of metal content and also the types of metals found to exceed CCME and BCWQ guidelines at Peace River sample sites increased with distance downstream from the PCN dam. This observation was consistent between sample years, and reflects the cumulative influence of an increasing number of tributaries entering the Peace River as it flows towards the Alberta border.

There was little variation in the list of metals found to exceed CCME and/or BCWQ guidelines between years, nor the sample locations where such exceedences were observed. Aluminum and iron exceeded guidelines more often than other dissolved metals, and amongst the widest range of sample sites both in 2007 and 2008, followed by such metals as cadmium, copper, zinc and vanadium. Selenium concentrations in the Halfway River, both in total and dissolved form, consistently exceeded guidelines for almost every water sample period for both years. Peace 1 was almost completely devoid of metals (either dissolved or total components) that exceeded guidelines in both years, whereas Peace 5 frequently exceeded guidelines for specific metals, such as aluminum, iron and cadmium. Mercury was below detection limits at all sample sites on every sample occasion for both years except in duplicate samples taken in May of 2008 at Peace 5.

Freshet in the larger Peace River tributaries occurred earlier and was smaller in magnitude in 2008 than in 2007 (WSC 2009). These differences in timing and magnitude of the freshet conditions did not influence the mean number per sample, or mean frequency per sample at which total metals exceeded CCME and BCWQ guidelines between years for either Peace tributary or Peace River sample sites. However, the mean number of dissolved metals found to exceed guidelines in 2008 amongst all sites was almost twice that observed in 2007. Some of this variation is likely attributed to a number of individual observations of dissolved metals, such as cadmium, copper and iron. These 3 dissolved metals often only exceeded guidelines on one occasion at individual sample sites over the course of water sampling in 2008 where similar exceedences, particularly amongst tributaries, were not observed in 2007.

Like metal concentrations in water samples, peaks in nutrients, such as orthophosphate, DOC and nitrates, followed similar trends between years in that they were often associated with surges in TSS observed at sample sites. In Peace River sites, two distinct and two extended peaks in these nutrients are evident, and likely reflect the differential timing in freshet between large and small tributaries entering the Peace River. In 2007, small Peace tributaries, particularly those entering the north side of the Peace River, were found to be free of ice and therefore enter freshet earlier than large tributaries. The earlier timing of freshet and ice-off in small tributaries could not be directly verified from discharge measurements in 2008, however other results, such as TSS levels and observations of peaks in water quality parameters such as metals and nutrients, suggest a similar trend occurred in 2008.

Levels of chlorophyll *a* in water samples at all sample sites typically did not show an immediate response to increased levels of nutrients, and often increased levels of chlorophyll *a* were observed in water samples collected in the month following peak levels of orthophosphate. There was a general trend towards increasing chlorophyll *a* in both 2007 and 2008 towards the summer months in both the Peace River and in Peace tributaries, as water temperatures rose. However, some of the highest levels of chlorophyll *a* at a number of sample sites were observed during the fall, which suggests increased water clarity during the fall in all streams as stream flow subsides is also influencing primary productivity.

Water temperature data collected via TDLs indicate water temperatures in the Peace River were warmer in 2008 than 2007. Monthly mean temperatures in the Peace River were almost 2.5 ºC warmer during the early spring in 2008 when compared to 2007. These monthly variations in temperature between years became less apparent as water levels subsided. This trend was similar to that of ambient air temperatures recorded at the Fort St. John weather office. A similar trend was not observed in mean daily or mean monthly water temperatures among sampled tributaries entering the Peace River.

In Dinosaur Lake, TDLs placed at 1 m below the surface, 5 m below the surface and near the lake bottom indicated virtually no variation in mean daily temperatures records at the upstream most site (Dino 3 located nearest the WAC Bennett Dam). For downstream sites, the warmest mean daily water temperatures were recorded by the TDLs located at the surface, and that variation between the mean daily surface temperatures and those at the bottom of the reservoir was greatest at the downstream most sample location (Dino 1). The largest variation among mean daily surface and bottom water temperature was observed at Dino 1 in July (1.6 ºC). Mean monthly temperatures for all depths were warmest in September. Temperature profile data indicated there was little stratification in temperature at any of the Dinosaur Lake sites, with the greatest variation observed at the downstream most sample station. Similarly, the greatest variation in DO measurements for all profiles at Dino 1 was less than 0.5 mg/L, with the highest variation occurring in June. This is not unexpected given the large volumes of water flowing through Dinosaur Lake.

Unlike temperature and DO, pH varied the most at Dino 3, nearest the WAC Bennett Dam. Conductivity showed the least amount of variation of all parameters at all three measuring stations. TGP seldom exceeded 105% of the atmospheric pressure except at Dino 3, which showed the greatest variation in TGP and tended to reach maximum levels (111% saturation) at mid depth readings. Again, this is not unexpected given the close proximity of Dino 3 to the WAC Bennett Dam.

7.0 CLOSURE

We trust the information presented in this report meets your current requirements. Should you have any questions or concerns, please do not hesitate to contact Golder.

GOLDER ASSOCIATES LTD.

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8.0 REFERENCES

Antcliffe, B.L., and A. von Finster. 1999. Dissolved gas supersaturation monitoring at three hydroelectric generating facilities in the Yukon, Canada, in August of 1997 and 1998. Can. Tech. Rep. Fish. Aquat. Sci. 2275.

BC Ministry of Environment (BCMoE). 2008. Ambient water quality guidelines for chlorophenols. Environmental Protection Division, Province of British Columbia. http://www.env.gov.bc.ca/wat/wq/BCguidelines/chlorophenols/index.htm

BC Ministry of Environment (BCMoE). 1997. Water quality criteria for total gas pressure. Overview report. Environmental Management Act. Section 2 (e).

Canadian Council of Ministers (CCME). 2003a. Canadian water quality guidelines for the protection of aquatic life – dissolved gas supersaturation. In Canadian environmental quality guidelines, Canadian Council of Ministers of the Environment, Winnipeg.

Canadian Council of Ministers (CCME). 2003b. Canadian water quality guidelines for the protection of aquatic life – nitrate ion. In Canadian environmental quality guidelines, Canadian Council of Ministers of the Environment, Winnipeg.

Gippel, C. J. 1995. Potential of turbidity monitoring for measuring the transport of suspended solids in streams, Hydrological Processes, Vol. 9: 83-97.

Jang, L. 1996. State of water quality of Peace River above Alces River 1984-1995. BC Water Quality Br. Environ. Protection Unit. British Columbia Ministry of Environment. Victoria, BC.

Mainstream Aquatics Ltd. 2009. Site C fisheries studies – juvenile fish use and habitat inventory of Peace River tributaries in summer 2008. Prep. for B.C. Hydro. Report No. 08008CF: 78 p. + appendices.

Nielsen, L. A., and D.L. Johnson. 1983.Fisheries techniques. American Fisheries Society, Backsburg. Virginia, USA.

Oliver, G. G., and L. E. Fidler, 2001. Towards a water quality guideline for temperature in the Province of British Columbia. Prep. for the Ministry of Environment, Lands and Parks, Water Management Branch, Water Quality Section, Victoria, B.C. Prep. by Aspen Applied Sciences Ltd. P.O. Box 517, Cranbrook, BC V1C 4J1

Packman, J. J., K.J. Comings, and D.B.Booth. 1999. Using turbidity to determine total suspended solids in urbanizing streams in the Puget lowlands, in confronting uncertainty. Pages 158-165 In Managing change in water resources and the environment. CWRA Annual Meeting, Vancouver, BC, 27-29 October 1999,.

Point 4 Systems Inc. 2005. Total gas pressure information sheet. Point 4 Systems Inc., Port Moody, BC

Resource Inventory Committee (RISC). 1998a. Manual of standard operating procedures for hydrometric surveys in British Columbia Ver. 1.1. Resource Inventory Standards Committee, BC Ministry of Environment, Lands and Parks.

Resource Inventory Committee (RISC). 1998b. Guidelines for interpreting water quality data. Ver. 1.0. Resource Inventory Standards Committee, BC Ministry of Environment, Lands and Parks.

Shaw, R.D, L.R. Noton and G.W. Guenther. 1990. Water quality of the Peace River in Alberta. Prepared by the Hydrology Branch, Technical Services Division, Water Services Div., Water Resources Management Services, Alberta Environment.

Water Survey of Canada (WSC). 2008. National water quantity survey program. Data & Prod. Serv. http://www.wsc.ec.gc.ca/products/main_e.cfm?cname=products_e.c

Wetzel, R.G. 1983. Limnology. 2nd edition. IBN 0-03-057913. Orlando, Florida. United States. 767 p.

Table 1: **Peace River and tributary sample site locations in 2008 and associated sampling.**

Site Name	Location	Mainstem	Tributary	Sample		
				Water Quality	Temperature Data Logger	Total Gas Pressure
Peace River and Tributaries						
Peace 1	~ 4 km downstream of PCN (**Sites 1 & 15 combined)**	✓		✓	✓	✓
Peace 2	500 m upstream of Halfway River	✓		✓	✓	✓
Peace 3	~ 2 km downstream of proposed Site C	✓		✓	✓	✓
Peace 4	Proximate to WSC Stn 07FA004 upstream of the Pine R. but downstream of the Moberly and the proposed Site C	✓		✓	✓	✓
Peace 5	U/S of Alces River ~ at WSC station	✓		✓	✓	✓
Moberly 6	Upper Moberly River ~ at WSC Stn 07FB008		✓	✓	✓	
Moberly 7	Lower Moberly River upstream of reservoir high-water mark		✓	✓		
Halfway 8	Halfway R. ~ 26 km upstream of confluence with the Peace R.		✓	✓		
Halfway 9	Halfway R. ~ 1.5 km upstream of confluence with the Peace R.		✓	✓	✓	
Lynx 10	Lynx Ck. at Ree Simpson (~2.5 km upstream)		✓	✓		
Farrell 11	Farrell Ck. 2.5 km upstream - Ardell property		✓	✓		
Farrell 11a	Farrell Ck. at highway bridge				✓	
Cache 12	Cache Ck. at Hwy 29 Bridge (~ 1 km upstream)		✓	✓		
Boudreau 13	Boudreau Ck downstream of lakes ~ 4 km upstream of confluence with Peace R.		✓	✓		
Peace 14	~ 10 km downstream of Taylor between Pine & Beatton rivers	discontinued - past turbidity sonde site only				
Pine 16	Pine R. ~ 400 m upstream of confluence with Peace R.		✓		✓	
Beatton 17	Beatton R. ~ 500 m upstream of confluence with Peace R.		✓		✓	
Kiskatinaw 18	Kiskatinaw R. ~ 400 m upstream of confluence with Peace R.		✓		✓	
Dinosaur Lake						
Dino 1	Dinosaur Lake - downstream end of lake proximate to PCN Dam	✓			✓	✓
Dino 2	Dinosaur Lake - middle of lake - Johnson Creek Arm.	✓			✓	✓
Dino 3	Dinosaur Lake - proximate to boat launch.	✓			✓	✓

Table 2: Months in which sampling was completed at sites in 2008.

Site Name	Feb	May	June	July	August	October
Peace 1	✓	✓	✓x2	✓	✓x2	✓x2
Peace 2	✓	✓	✓	✓	✓	✓
Peace 3		✓	✓	✓x2	✓	✓
Peace 4	✓	✓	✓	✓	✓	✓
Peace 5	✓	✓x2	✓	✓	✓	✓
Moberly 6	✓x2	✓	✓	✓	✓	✓
Moberly 7		✓	✓	✓	✓	✓
Halfway 8		✓	✓	✓	✓	✓
Halfway 9	✓	✓	✓	✓	✓	✓
Lynx 10	✓	✓	✓	✓	✓	✓
Farrell 11		✓	✓	✓	✓	✓
Cache 12	✓	✓	✓	✓	✓	✓
Boudreau 13		✓	✓	✓	✓	✓
Blank		✓				
Dino 1		✓	✓	✓	✓	✓
Dino 2		✓	✓	✓	✓	✓
Dino 3		✓	✓	✓	✓	✓

Note x2 indicates duplicate sample taken at site

Table3: **Summer and winter sample site locations in the Peace River watershed in 2008.**

Site	UTM Co-ordinates (NAD 83)		Comments/ Winter Access Considerations
	Summer (permanent)	Winter (temporary)	
Peace 1	10 V 566116 6207817	10 V 568043 6209727	Winter location at Hudson Hope Boat Launch.
Peace 2	10 V 595751 6230589	Same	Steep bank may prevent winter access depending upon snow conditions
Peace 3	10 V 627026 6232489	Not accessible	Inaccessible in winter unless boat launch is open.
Peace 4	10 V 636567 6230311	same	By snowshoe via shoreline via Old Fort Road in Fort St. John. Sample via sampling pole.
Peace 5	10 V 682612 6224002	Same	By snowshoe off of Peace Bridge crossing at confluence with Alces. Sample via sampling pole.
Moberly 6	10 V 603451 6217878	Same	By snowshoe and through ice.
Moberly 7	10 V 622802 6228018	Not accessible	Not accessible in winter except possibly via helicopter.
Halfway 8	10 V 584737 6245558	Same if accessible	Winter sampling may be possibly by snowmobile depending upon snow depth and road access.
Halfway 9	10 V 596340 6231876	Same	Winter sampling via snowshoe and through ice at bridge crossing
Lynx 10	10 V 569463 6214794	Same	Ice free during winter sample in 2008
Farrell 11	10 V 579378 6222295	10 V 578754 6220358	Winter sample location upstream of Hwy. 29 bridge crossing through ice.
Cache 12	10 V 609153 6237617	Same	Through ice.
Boudreau 13	10 V 604043 6230478	Not accessible	May be possible to access top of bank via long snowmobile trip assuming PDR ploughed, but access down bank tentative. Unlikely enough water in stream in winter to sample.
Peace 14	10 V 656193 6222020	Not accessible	Discontinued in 2007 - turbidity sonde location only.
Pine 16	10 V 642224 6223870	Not accessible	Temperature data logger station – no other water sampling required here.
Beatton 17	10 V 663139 6221104	Not accessible	Temperature data logger station – no other water sampling required here.
Kiskatinaw 18	10 V 676546 6219352	Not Accessible	Temperature data logger station – no other water sampling required here.
Dino 1	10 U 561092 6202966	unknown	String of three temperature data loggers and water quality profiles at each site. Winter access unlikely unless campground road kept open and no shore ice present at boat ramp.
Dino 2	10 U 553962 6201124	unknown	
Dino 3	10 U 548341 6205435	unknown	

Table 4: WSC hydrometric stations in the Peace Rive watershed study area.

River	Station #	Period of Record	Mainstem/ Tributaries	Drainage Area (km^2)	*MAD (m^3/s)
WSC Stations referenced in 2008 report					
Peace R. at Hudson Hope	07EF001	1917 to 1922; 1949-present	Mainstem	69,900	1,160
Peace R. above Pine River	**07FA004**	1979 to present	Mainstem	83,900	1,290
Peace R. above Alces River	**07FD010**	1974 to present	Mainstem	118,000	1620
Halfway R. near Farrell (upper)	**07FA006**	1981 to present	Halfway R.	9,350	78.3
Moberly R. near Fort St. John	**07FB008**	1980 to present	Moberly R.	1,520	12.0
Pine R. at East Pine	**07FB001**	1961 to present	Pine R.	12,100	199.0
Beatton R. near Fort St. John	**07FC001**	1917 to present	Beatton R.	15,600	58.4
Kiskatinaw R. near Farmington	**07FD001**	1971 to present	Kiskatinaw R.	3,570	9.95
Other WSC Stations in the study area but not referenced					
Peace R. near Taylor	07FD002	1944 to 1959	Mainstem	97,100	1,440
Cypress Ck. near mouth	**07FA007**	1988 to present	Halfway R.	N/A	N/A
Graham R. above Colt Creek	**07FA005**	1981 to present	Halfway R.	2,200	25.1
Halfway R. above Graham R.	07FA003	1977 to 1996	Halfway R.	3,780	35.5
Halfway R. near Farrell (lower)	07FA001	1917 to 1983	Halfway R.	9,400	80.6
Quality Ck near the mouth	**07FB005**	1978 to present	Pine R.	29.5	0.195
Dickebusch Ck. near the mouth	**07FB004**	1978 to present	Pine R.	85.5	0.597
Pine R. above Mountain Creek	**07FB010**	1985 to 1989	Pine R.	677	29.7
Flatbed Ck at km.110 heritage	**07FB009**	1982 to present	Pine R.	697	4.3
Sukunka R. above Chamberlain	**07FB007**	1977 to present	Pine R.	927	23.7
Murray R. above Wolverine R.	**07FB006**	1977 to present	Pine R.	2,410	56.1
Sukunka R. near the mouth	**07FB003**	1977 to present	Pine R.	2,510	54.1
Murray R. near the mouth	**07FN002**	1977 to present	Pine R.	5,620	83.6

*MAD=Mean Annual Discharge

Station names in **shaded white** indicate instantaneous sediment concentration or residue concentration data is available

(Source: http://scitech.pyr.ec.gc.ca/climhydro/mainContent/main_e.asp?province=bc)

Table 5: Optimum temperature ranges of specific life history stages of salmonids and other coldwater sport fish species inhabiting the Peace River watershed. (1)

Species		Incubation	Rearing	Spawning
Rainbow Trout		*10.0-12.0*	*16.0-18.0*	*10.0-15.5*
Char	*Brook trout*	*1.5-9.0*	*12.0-18.0*	*7.1-12.8*
	Bull trout	*2.0-6.0*	*6.0-14.0*	*5.0-9.0*
	Lake trout	*5.0*	*6.0-17.0*	*10.0*
Artic Grayling		*7.0-11.0*	*10.0-12.0*	*4.0-9.0*
Whitefish	Lake whitefish	4.0-6.0	12.0-16.0	<8.0
	Mountain whitefish	*<6.0*	*9.0-12.0*	*<6.0*
Northern Pike		*n/a*	*n/a*	*n/a*
Burbot		*4.0-7.0*	*15.6-18.3*	*0.6-1.7*

(1) adapted From Oliver and Fidler, 2001.

Table 6: **Summary of mean daily temperature statistics (º C) from temperature data loggers placed in the Peace River and selected from November 2006 to October 2008. Annual statistics for individual years represent the period November to October.**

6a: Peace River

Year	Parameter	Peace 1			Peace 2			Peace 3			Peace 4			Peace 5		
		mean	max	min	mean	max	min	mean	max	min	mean	max	min	mean	max	min
2006-07	Range of Daily Means	6.3	12.4	0.3	7.0	12.8	0.0	4.1	12.5	-0.1	5.5	13.2	0.0	6.1	16.5	-0.1
	Instantaneous Maximum	12.6			14.5			13.4			13.7			17.7		
	Instantaneous Minimum	-0.1			-0.3			-0.1			-0.1			-0.1		
	Days Daily Mean ≥ 18.0 ºC	0			0			0			0			0		
	n (days)	242			240			282			361			336		
2007-08	Range of Daily Means	6.0	13.0	0.6	6.3	13.5	0.0	6.5	14.6	0.0	6.4	14.9	-0.1	6.9	18.5	-0.1
	Instantaneous Maximum	13.3			14.5			15.9			15.9			20.4		
	Instantaneous Minimum	0.5			-0.1			0.0			-0.1			-0.2		
	Days Daily Mean ≥ 18.0 ºC	0			0			0			0			3		
	n (days)	363			366			351			351			365		
Pooled	**Range of Daily Means**	**6.1**	**13.3**	**-0.1**	**6.1**	**14.5**	**-0.3**	**6.1**	**13.4**	**-0.1**	**6.1**	**13.7**	**-0.1**	**6.1**	**17.7**	**-0.1**
	Instantaneous Maximum	**13.3**			**14.5**			**15.9**			**15.9**			**20.4**		
	Instantaneous Minimum	**-0.1**			**-0.3**			**-0.1**			**-0.1**			**-0.2**		
	Days Daily Mean ≥ 18.0 ºC	**0**			**0**			**0**			**0**			**3**		
	n (days)	**605**			**606**			**633**			**712**			**701**		

6a: Peace River tributaries

Year	Parameter	Moberly 6			Halfway 9			Farrell 11			Pine 16			Beaton 17			Kiskatinaw 18		
		mean	max	min	mean	max	min	mean	max	min	mean	max	min	mean	max	min	mean	max	min
2006-07	Range of Daily Means	9.5	20.9	-0.1	8.3	19.5	-0.1	10.2	24.4	-0.2	5.1	18.8	-0.3	13.0	23.3	1.3	6.8	25.0	-0.1
	Instantaneous Maximum	21.3			20.5			29.6			20.6			25.0			28.2		
	Instantaneous Minimum	-0.2			-0.1			-0.2			-0.4			0.5			-0.1		
	Days Daily Mean ≥ 18.0 ºC	24			6			40			6			34			54		
	n (days)	242			241			238			344			62			362		
2007-08	Range of Daily Means	6.4	22.7	-0.1	10.6	17.8	-0.1	6.6	22.9	-0.1	5.1	21.4	-0.1	6.6	24.2	-0.2	7.1	23.9	-0.1
	Instantaneous Maximum	25.3			18.9			27.3			23.4			28.6			27.1		
	Instantaneous Minimum	-0.1			-0.1			-0.1			-0.1			-0.3			-0.1		
	Days Daily Mean ≥ 18.0 ºC	39			0			44			11			40			47		
	n (days)	364			171			359			325			340			365		
Pooled	**Range of Daily Means**	**7.6**	**8.3**	**7.1**	**9.3**	**10.1**	**8.5**	**8.0**	**9.9**	**6.5**	**5.1**	**5.6**	**4.7**	**8.6**	**9.6**	**7.8**	**8.6**	**9.6**	**7.8**
	Instantaneous Maximum	**25.3**			**20.5**			**29.6**			**23.4**			**28.6**			**28.2**		
	Instantaneous Minimum	**-0.2**			**-0.1**			**-0.2**			**-0.4**			**-0.3**			**-0.1**		
	Days Daily Mean ≥ 18.0 ºC	**63**			**6**			**84**			**17**			**74**			**101**		
	n (days)	**606**			**412**			**597**			**669**			**402**			**727**		

Table 7a: **Monthly water temperatures from Peace River continuous temperature monitoring sites between November 2006 and October 2008.**

Month	Peace 1				Peace 2				Peace 3				Peace 4				Peace 5			
	2006-07		2008		2006-07		2008		2006-07		2008		2006-07		2008		2006-07		2008	
	ºC	n	ºC	n	ºC	n	ºC	n	ºC	n	ºC	n	ºC	n	ºC	n	ºC	n	ºC	n
Nov									**3.3**	**27.4**			**3.3**	**27.5**			**1.9**	**26.0**		
Dec									1.8	31.0			1.8	31.0			1.1	31.0		
Jan			1.0	31.0			0.5	31.0	0.4	31.0	0.4	31.0	0.4	31.0	0.2	31	0.1	31.0	**0.0**	**29.8**
Feb			1.3	29.0			1.0	29.0	0.0	28.0	0.9	29.0	0.0	28.0	0.7	29.0	-0.1	28.0	0.5	28.8
Mar	**0.6**	**23.1**	1.7	31.0	**0.6**	**21.9**	1.7	31.0	0.5	30.6	1.7	31.0	0.5	31.0	1.6	31.0	0.0	30.8	1.6	30.9
Apr	**1.4**	**29.2**	2.3	30.0	**2.0**	**22.7**	2.7	30.0	**1.7**	**24.4**	2.7	30.0	**1.7**	**28.6**	2.7	30.0	3.1	30.0	2.9	30.0
May	2.8	31.0	4.0	30.9	3.8	31.0	5.3	31.0	5.2	31.0	**6.4**	**29.8**	**4.9**	**29.0**	5.7	22.3	6.9	31.0	7.5	31.0
Jun	5.7	30.0	7.5	30.0	7.2	30.0	9.7	30.0	8.8	30.0	11.1	29.9	**9.3**	**26.8**	**11.8**	**19.6**	11.1	30.0	13.4	30.0
Jul	9.3	31.0	10.3	31.0	**10.5**	**26.0**	11.4	31.0	10.8	31.0	12.3	31.0	11.6	31.0	12.7	31.0	14.0	31.0	14.8	30.9
Aug	9.3	31.0	11.5	31.0	**10.3**	**29.3**	12.0	31.0	**10.7**	**14.4**	12.4	31.0	10.7	31.0	12.8	31.0	**12.1**	**25.2**	14.0	30.7
Sep	11.3	30.0	11.7	30.0	11.4	30.0	11.9	30.0			12.1	30.0	11.4	30.0	12.0	30.0	11.6	30.0	12.4	30.0
Oct	9.8	31.0	**10.6**	**27.7**	9.5	31.0	10.1	30.5				29.4	9.1	31.0	9.7	29.5	8.4	31.0	**9.1**	**29.7**
Nov	7.4	30.0			6.4	30.0			**5.2**	**15.4**			5.8	30.0			4.9	30.0		
Dec	3.0	31.0			2.5	31.0			2.3	31.0			2.0	31.0			1.1	31.0		

Table 7b: **Monthly water temperatures from Peace tributary continuous temperature monitoring sites between November 2006 and October 2008.**

Month	Moberly 6				Halfway 9				Farrell 11				Pine 16				Beaton 17				Kiskatinaw 18			
	2006-07		2008		2006-07		2008		2006-07		2008		2006-07		2008		2006-07		2008		2006-07		2008	
	ºC	n	ºC	n	ºC	n	ºC	n	ºC	n	ºC	n	ºC	n	ºC	n	ºC	n	ºC	n	ºC	n	ºC	n
Nov													**-0.1**	**27.5**							**-0.1**	**26.4**		
Dec													-0.1	31.0							-0.1	31.0		
Jan			-0.1	31.0							0.0	31.0	-0.1	31.0	0.4	31.0			-0.1	31.0	-0.1	31.0	-0.1	31.0
Feb			-0.1	29.0							0.0	29.0	-0.2	28.0	0.1	29.0			-0.3	29.0	-0.1	28.0	-0.1	29.0
Mar	**-0.1**	**28.4**	-0.1	31.0	**-0.1**	**26.5**			**-0.1**	**27.4**	0.0	31.0	-0.2	31.0	0.2	31.0			-0.2	31.0	-0.1	31.0	-0.1	31.0
Apr	**0.0**	**9.0**	0.1	30.0	1.8	29.5			**2.3**	**25.4**	**0.6**	**26.5**	1.4	30.0	0.3	30.0			0.1	30.0	-0.1	29.5	1.3	30.0
May	**8.8**	**29.1**	8.9	31.0	8.8	31.0	**9.3**	**10.3**	**9.6**	**23.4**	**9.5**	**25.8**	7.1	31.0	6.9	31.0	**11.3**	**15.4**	8.5	31.0	8.6	31.0	11.2	31.0
Jun	13.5	29.9	**14.8**	**17.0**	10.9	30.0	11.2	30.0	**17.7**	**24.2**	16.6	30.0	9.3	30.0	11.1	30.0	17.8	30.0	**15.7**	**27.7**	18.5	30.0	17.2	30.0
Jul	18.2	31.0	**18.4**	**20.3**	16.1	31.0	15.3	31.0	20.0	31.0	19.3	31.0	15.2	31.0	**17.1**	**25.2**	**20.2**	**24.4**	**19.6**	**22.3**	20.8	31.0	19.9	31.0
Aug	16.1	31.0	17.8	31.0	15.0	31.0	14.0	31.0	16.3	31.0	17.5	31.0	**16.2**	**20.6**	**16.5**	**21.7**	**17.0**	**16.5**	18.4	30.9	16.7	31.0	18.3	31.0
Sep	11.9	30.0	12.1	30.0	10.0	30.0	10.9	30.0	10.9	30.0	11.9	30.0	**11.0**	**19.0**	**11.4**	**2.0**	11.1	30.0	13.1	30.0	11.2	30.0	12.3	30.0
Oct	5.4	31.0	**4.2**	**28.7**	3.7	31.0	4.5	30.5	3.8	31.0	4.0	30.4	5.3	31.0	**6.0**	**26.3**	4.9	31.0	**8.7**	**13.4**	4.1	31.0	**4.5**	**29.5**
Nov	0.4	30.0			0.3	5.4			0.0	26.7			0.4	30.0			0.2	30.0			0.0	30.0		
Dec	-0.1	31.0							0.0	31.0			0.0	31.0			0.2	31.0			-0.1	31.0		

Shaded white text indicates data set for month is incomplete

Table 8: **Summary of mean daily temperature statistics (º C) from temperature data loggers placed in Dinosaur Lake from May to October 2008.**

Year	Parameter	Surace (-1m)			Middle (-5m)			Bottom		
		mean	max	min	mean	max	min	mean	max	min
Dino 1	Range of Daily Means	10.0	15.5	3.3	9.5	13.1	3.2	8.9	12.6	3.2
	Instantaneous Maximum	16.3			13.8			12.8		
	Instantaneous Minimum	3.2			3.1			3.1		
	Days Daily Mean ≥ 18.0 ºC	0			0			0		
	n (days)	173.5								
Dino 2	Range of Daily Means	8.7	13.6	3.1	8.3	13.0	3.1	8.0	12.8	3.0
	Instantaneous Maximum	16.2			13.6			13.4		
	Instantaneous Minimum	3.1			3.0			2.9		
	Days Daily Mean ≥ 18.0 ºC	0			0			0		
	n (days)	110.5								
Dino 3	**Range of Daily Means**	9.2	13.4	2.8	9.2	13.4	2.9	9.3	13.4	2.9
	Instantaneous Maximum	14.3			14.3			14.3		
	Instantaneous Minimum	2.7			2.8			2.8		
	Days Daily Mean ≥ 18.0 ºC	0			0			0		
	n (days)	173.4								

Table 9: **Monthly mean water temperatures recorded by temperature data loggers at the three monitoring stations in Dinosaur Lake, 2008.**

	Dino 1 (downstream)						**Dino 2 (middle)**						**Dino 3 (upstream)**					
Month	**Bottom**		**-5 m**		**-1 m**		**Bottom**		**-5 m**		**-1 m**		**Bottom**		**-5 m**		**-1 m**	
	ºC	n	ºC	n	ºC	n	ºC	n	ºC	n	ºC	n	ºC	n	ºC	n	ºC	n
May	**3.8**	***24.0***	**4.0**	***23.0***	**4.3**	***24.0***	**3.8**	***24.0***	**3.9**	***24.0***	**4.1**	***24.0***	3.7	***24.0***	**3.6**	***24.0***	**3.6**	***24.0***
Jun	6.3	*30.0*	7.4	*30.0*	8.2	*30.0*	6.9	*30.0*	7.3	*30.0*	7.8	*30.0*	7.1	*30.0*	7.1	*30.0*	7.0	*30.0*
Jul	9.8	*31.0*	10.4	*31.0*	11.4	*31.0*	10.0	*31.0*	10.3	*31.0*	11.0	*31.0*	10.1	*31.0*	10.0	*31.0*	10.0	*31.0*
Aug	10.8	*31.0*	11.6	*31.0*	12.0	*31.0*	**10.9**	***25.5***	**11.2**	***25.5***	**11.3**	***25.5***	11.2	*31.0*	11.2	*31.0*	11.1	*31.0*
Sep	11.3	*30.0*	11.8	*30.0*	12.1	*30.0*							11.7	*30.0*	11.7	*30.0*	11.6	*30.0*
Oct	**10.5**	***27.6***	**10.7**	***27.6***	**10.5**	***27.6***							**10.8**	***27.5***	**10.7**	***27.5***	**10.7**	***27.5***

n = number of days for which temperature data are available

Bold = months for which a full set of temperature data are unavailable, hence presented monthly temperature data are not a true mean.

Table 10: **Ranges in temperatures recorded by temperature data loggers at each depth from sample sites in Dinosaur Lake in 2008.**

Month	Bottom		-5m		-1m	
	Range (ºC)	Variation (ºC)	Range (ºC)	Variation (ºC)	Range (ºC)	Variation (ºC)
May	3.7 - 3.8	0.1	3.7 - 4.0	0.3	3.6 - 4.3	0.7
Jun	6.3 - 7.1	0.8	6.9 - 7.4	0.5	7.0 - 8.2	1.2
Jul	9.8 - 10.1	0.2	10.0 - 10.4	0.4	10.0 - 11.4	1.4
Aug	10.8 - 11.2	0.3	11.2 - 11.6	0.4	11.1 - 12.0	0.9
Sep (1)	11.3 - 11.7	0.4	11.7 - 11.8	0.1	11.6 -12.1	0.5
Oct (1)	10.5 - 10.8	0.3	10.7	0.0	10.5 - 10.7	0.2
Mean		**0.4**		**0.3**		**0.8**

(1) Site 2 data not available for comparison of ranges for September and October

Table 11: A summary of the mean, maximum and minimum in-situ profile measurements taken for dissolved oxygen, water temperature, conductivity, pH and TGP in Dinosaur Lake during 2008.

Parameter		Dino 3 (upstream)					Dino 2 (middle)					Dino 1 (downstream)				
		May	June (1)	July	Aug.	Oct.	May	June (1)	July	Aug.	Oct.	May	June (1)	July	Aug.	Oct.
Dissolved Oxygen (mg/L)	**Mean**	12.5	12.6	11.9	11.2	*10.6*	12.3	12.6	11.8	11.3	*10.1*	12.3	12.7	12.1	11.8	*n/a*
	Max	12.5	12.7	12.0	11.3	*11.4*	12.4	12.8	11.8	11.5	*10.6*	12.4	13.0	12.2	11.9	*n/a*
	Min	12.4	12.7	11.8	11.2	*10.3*	12.2	12.5	11.8	11.3	*9.8*	12.1	12.6	12.1	11.6	*n/a*
Water Temperature (°C)	**Mean**	3.1	6.7	10.0	13.0	9.3	3.1	6.8	10.1	12.1	9.3	3.3	6.4	8.3	9.8	9.3
	Max	3.2	6.8	10.0	13.1	9.3	3.2	7.1	10.3	12.3	9.3	3.3	7.1	8.5	10.1	9.3
	Min	3.1	6.8	10.0	12.9	9.3	3.1	6.6	9.9	11.9	9.3	3.2	5.6	8.1	9.6	9.3
Conductivity (µS/cm)	**Mean**	181	182	177	163	*n/a*	180	182	177	164	*n/a*	181	182	179	170	*n/a*
	Max	181	182	177	163	*n/a*	181	182	178	165	*n/a*	181	182	179	171	*n/a*
	Min	181	181	177	162	*n/a*	179	182	177	164	*n/a*	180	182	178	170	*n/a*
pH	**Mean**	8.3	7.7	7.5	8.4	8.0	8.1	8.0	8.0	8.3	8.1	8.0	8.0	8.1	8.2	8.2
	Max	8.5	7.8	7.8	8.9	8.0	8.2	8.0	8.0	8.3	8.1	8.1	8.0	8.1	8.3	8.2
	Min	8.1	7.5	7.1	8.3	8.0	8.0	7.9	7.9	8.2	8.1	7.9	7.7	8.0	8.2	8.2
TGP (%)	**Mean**	n/a	104	108	105	101	n/a	104	104	103	97	n/a	106	104	102	97
	Max	n/a	104	111	107	105	n/a	104	106	104	98	n/a	106	106	105	98
	Min	n/a	104	104	103	97	n/a	104	102	101	97	n/a	106	104	100	97

(1) TGP reading in June only taken at 1 m depth.

Table 12: Monthly water temperatures at Dino 1 compared to those at Peace 1 in 2008.

	Dino 1 (downstream)							
Month	**Bottom**		**-5m**		**-1m**		**Mean**	**Peace 1**
	ºC	n	ºC	n	ºC	n		
May	**3.8**	**24.0**	**4.0**	**23.0**	**4.3**	**24.0**	**4.0**	4
Jun	6.3	30.0	7.4	30.0	8.2	30.0	7.3	7.5
Jul	9.8	31.0	10.4	31.0	11.4	31.0	10.5	10.3
Aug	10.8	31.0	11.6	31.0	12.0	31.0	11.5	11.5
Sep	11.3	30.0	11.8	30.0	12.1	30.0	11.7	11.7
Oct	**10.5**	**27.6**	**10.7**	**27.6**	**10.5**	**27.6**	**10.7**	**10.6**

n = number of days for which temperature data are available

Bold = months for which a full set of temperature data are unavailable, hence presented monthly temperature data are not a true mean.

Table 13: **Water quality analysis results summary showing maximum and minimum values and the number of samples within the data set below method detection limits (MDLs) from sample sites in the Peace River, 2008.**

Parameter	Peace 1				Peace 2				Peace 3				Peace 4				Peace 5				MDL (1)
	Max	Min	No. < D.L.	n	Max	Min	No. < D.L.	n	Max	Min	No. < D.L.	n	Max	Min	No. < D.L.	n	Max	Min	No. < D.L.	n	
Physical Tests (mg/L except as noted)																					
Colour (CU)	7.4	5.1		9	13.3	5.3		6	26.5	<5.0	1	6	32.9	<5.0	2	6	114	5.2		7	5.0
Conductivity (µS/cm)	193	158		9	193	167		6	220	165		6	232	166		6	209	138		7	2.0
Hardness	97.8	82.9		9	99.4	85.6		6	119	89.4		6	126	88.1		6	112	63.3		7	0.5
pH (pH units)	8.15	7.92		9	8.21	7.9		6	8.25	8.01		6	8.26	8.01		6	8.3	7.86		7	0.01
Salinity (g/L)	<1.0	<1.0	9	9	<1.0	<1.0	6	6	<1.0	<1.0	6	6	<1.0	<1.0	6	6	<1.0	<1.0	7	7	1.0
TDS	107	94		9	127	97		6	126	101		6	128	101		6	156	104		7	10
TSS	5.2	<3.0	4	9	62	4.2		6	162	6.2		6	189	4.7		6	1640	7.5		7	3.0
Turbidity (NTU)	8.34	1.09		9	82.1	2.37		6	123	4.38		6	155	3.36		6	1110	7.03		7	0.1
Anions and Nutrients (mg/L except as noted)																					
AOX (µg/L)	11	<4.0	5	9	<4.0	<4.0	5	6	12	<4.0	4	6	10	<4.0	4	6	6.3	4	4	7	4.0
Alkalinity	85	76		9	85.8	79.5		6	98.8	78.4		6	103	79.4		6	96	50.7		7	2.0
Ammonia	0.05	<0.02	8	9	0.032	<0.02	4	6	0.043	<0.02	4	6	0.041	<0.02	4	6	0.069	<0.02	3	7	0.02
Acidity	4.9	<1.0	1	9	2.5	<1.0	3	6	5.2	<1.0	2	6	5.3	<1.0	2	6	6.6	<1.0	3	7	1.0
Bromide	<0.05	<0.05	9	9	<0.05	<0.05	6	6	<0.05	<0.05	6	6	<0.05	<0.05	6	6	<0.05	<0.05	7	7	0.05
Chloride	<0.5	<0.5	9	9	<0.5	<0.5	6	6	<0.5	<0.5	6	6	<0.5	<0.5	6	6	<0.5	<0.5	7	7	0.5
Fluoride	0.039	0.028		9	0.044	0.03		6	0.046	0.035		6	0.048	0.035		6	0.06	0.036		7	0.02
Sulphate	13.9	9.86		9	13.8	10.4		6	16	10.8		6	17.6	10.6		6	17.7	11.4		7	0.5
Sulphide	<0.02	<0.02	9	9	<0.02	<0.02	6	6	0.037	<0.02	4	6	0.04	<0.02	5	6	0.031	<0.02	4	7	0.02
Nitrate & Nitrite (as N)	0.0721	0.0522		9	0.0706	0.0284		6	0.0715	0.0337		6	0.0724	0.0331		6	0.0548	0.036		7	0.005
Nitrate (as N)	0.0721	0.0522		9	0.0706	0.0284		6	0.0715	0.0337		6	0.0724	0.0331		6	0.0548	0.036		7	0.005
Nitrite (as N)	<0.001	<0.001	9	9	0.001	<0.001	5	6	<0.001	<0.001	6	6	<0.001	<0.001	6	6	<0.001	<0.001	7	7	0.001
Tot. Kjeldahl Nitrogen	0.157	0.055		9	0.316	0.096		6	0.577	0.113		6	0.451	0.079		6	2.53	0.101		7	0.05
Total Nitrogen	0.219	0.121		9	0.387	0.133		6	0.649	0.172		6	0.523	0.131		6	2.56	0.142		7	0.05
Ortho Phosphate	<0.001	<0.001	9	9	0.0016	<0.001	5	6	0.0058	<0.001	4	6	0.0055	<0.001	4	6	0.0156	<0.001	2	7	0.001
Tot. Diss.Phos.	0.0034	<0.002	7	9	0.004	<0.002	3	6	0.0097	<0.002	1	6	0.0126	<0.002	4	6	0.0426	<0.002	2	7	0.002
Total Phosphate	0.012	<0.002	1	9	0.088	0.0073		6	0.158	0.012		6	0.195	0.0069		6	1.27	0.0113		7	0.002
Metals (mg/L except as noted)																					
Aluminum-D	0.0084	0.0039		9	0.0209	0.0034		6	0.0411	0.0067		6	0.0337	0.0054		6	0.17	0.0081		7	0.001
Aluminum-T	0.162	0.017		9	0.967	0.0397		6	3.06	0.111		6	3.41	0.0129		6	16.8	0.067		7	0.001
Antimony-D	<0.0001	<0.0001	9	9	<0.0001	<0.0001	6	6	<0.0001	<0.0001	6	6	<0.0001	<0.0001	6	6	<0.0001	<0.0001	7	7	0.0001
Antimony-T	<0.0001	<0.0001	9	9	0.00011	<0.0001	5	6	0.00018	<0.0001	2	6	0.00019	<0.0001	5	6	0.00046	<0.0001	3	7	0.0001
Arsenic-D	0.0002	0.00015		9	0.00031	0.00018		6	0.00028	0.00015		6	0.00027	0.00016		6	0.00061	0.00015		7	0.0001
Arsenic-T	0.00026	0.00016		9	0.00065	0.00021		6	0.00148	0.00023		6	0.00169	0.0002		6	0.0125	0.00019		7	0.0001
Barium-D	0.0311	0.026		9	0.0334	0.0276		6	0.0452	0.0289		6	0.0467	0.0287		6	0.0527	0.0293		7	0.00005
Barium-T	0.0357	0.0275		9	0.0584	0.0283		6	0.11	0.0321		6	0.127	0.0316		6	0.69	0.034		7	0.00005
Beryllium-D	<0.0005	<0.0005	9	9	<0.0005	<0.0005	6	6	<0.0005	<0.0005	6	6	<0.0005	<0.0005	6	6	<0.0005	<0.0005	7	7	0.0005
Beryllium-T	<0.0005	<0.0005	9	9	<0.0005	<0.0005	6	6	<0.0005	<0.0005	6	6	<0.0005	<0.0005	6	6	0.0011	<0.0005	5	7	0.0005
Bismuth-D	<0.0005	<0.0005	9	9	<0.0005	<0.0005	6	6	<0.0005	<0.0005	6	6	<0.0005	<0.0005	6	6	<0.0005	<0.0005	7	7	0.0005
Bismuth-T	<0.0005	<0.0005	9	9	<0.0005	<0.0005	6	6	<0.0005	<0.0005	6	6	<0.0005	<0.0005	6	6	<0.0005	<0.0005	7	7	0.0005
Boron-D	<0.01	<0.01	9	9	<0.01	<0.01	6	6	<0.01	<0.01	6	6	<0.01	<0.01	6	6	<0.01	<0.01	7	7	0.01
Boron-T	<0.01	<0.01	9	9	<0.01	<0.01	6	6	<0.01	<0.01	6	6	0.01	<0.01	5	6	0.031	<0.01	5	7	0.01
Cadmium-D	0.000076	<0.00005	8	9	<0.00005	<0.00005	6	6	<0.00005	<0.00005	6	6	<0.00005	<0.00005	6	6	<0.00005	<0.00005	7	7	0.00005
Cadmium-T	0.000217	<0.00005	7	9	0.000103	<0.00005	4	6	0.000174	<0.00005	2	6	0.000212	<0.00005	3	6	0.00095	<0.00005	3	7	0.00005
Calcium-D	29	24.4		9	29.5	25.3		6	34.4	26.2		6	36.3	25.7		6	32.7	18.2		7	0.05
Calcium-T	29.2	24.2		9	31	25		6	34.7	25.5		6	36.6	24.1		6	33.9	25.9		7	0.05
Chromium-D	<0.0005	<0.0005	9	9	<0.0005	<0.0005	6	6	<0.0005	<0.0005	6	6	0.00074	<0.0005	5	6	<0.0005	<0.0005	7	7	0.0005
Chromium-T	<0.0005	<0.0005	9	9	0.00185	<0.0005	3	6	0.00493	<0.0005	2	6	0.00603	<0.0005	3	6	0.0271	<0.0005	2	7	0.0005
Cobalt-D	<0.0001	<0.0001	9	9	<0.0001	<0.0001	6	6	0.00016	<0.0001	5	6	0.00012	<0.0001	5	6	0.00048	<0.0001	5	7	0.0001
Cobalt-T	<0.0001	<0.0001	9	9	0.00052	<0.0001	3	6	0.00156	<0.0001	2	6	0.00183	<0.0001	3	6	0.0144	<0.0001	2	7	0.0001
Copper-D	n/a	0.00058		9	0.00117	0.00063		6	0.00124	0.00059		6	0.00138	0.00059		6	0.00349	0.00062		7	0.0001
Copper-T	0.00133	0.00062		9	0.00241	<0.0001 (1)	1	6	0.00496	<0.0001 (1)	1	6	0.00584	<0.0001 (1)	1	6	0.0354	0.00073		7	<0.0001 (1)
Iron-D	<0.03	<0.03	9	9	0.042	<0.03	5	6	0.066	<0.03	5	6	0.077	<0.03	4	6	0.582	<0.03	3	7	0.03
Iron-T	0.219	<0.03	2	9	1.12	0.067		6	3.85	0.14		6	4.93	0.038		6	34.8	0.107		7	0.03
Lead-D	<0.00005	<0.00005	9	9	0.000089	<0.00005	5	6	<0.00005	<0.00005	6	6	<0.00005	<0.00005	6	6	0.00029	<0.00005	5	7	0.00005
Lead-T	0.000185	<0.00005	4	9	0.000703	0.000054		6	0.00197	0.000096		6	0.00242	<0.00005	1	6	0.0182	0.000084		7	0.00005
Lithium-D	<0.005	<0.005	9	9	<0.005	<0.005	6	6	<0.005	<0.005	6	6	<0.005	<0.005	6	6	<0.005	<0.005	7	7	0.005
Lithium-T	<0.005	<0.005	9	9	<0.005	<0.005	6	6	<0.005	<0.005	6	6	<0.005	<0.005	6	6	0.025	<0.005	5	7	0.005
Magnesium-D	6.39	5.29		9	6.45	5.44		6	8.12	5.76		6	8.62	5.79		6	7.5	4.34		7	0.1
Magnesium-T	6.64	5.31		9	6.58	5.53		6	8.4	5.53		6	8.74	5.63		6	9.82	6.23		7	0.1

Table 13: Water quality analysis results summary showing maximum and minimum values and the number of samples within the data set below method detection limits (MDLs) from sample sites in the Peace River, 2008.

Parameter	Peace 1				Peace 2				Peace 3				Peace 4				Peace 5				MDL (1)
	Max	Min	No. < D.L.	n	Max	Min	No. < D.L.	n	Max	Min	No. < D.L.	n	Max	Min	No. < D.L.	n	Max	Min	No. < D.L.	n	
Manganese-D	0.000855	0.000548		9	0.00441	0.000375		6	0.0107	0.000891		6	0.00914	0.000306		6	0.0376	0.000671		7	0.00005
Manganese-T	0.00585	0.00154		9	0.0269	0.0035		6	0.0507	0.00448		6	0.0599	0.00254		6	0.489	0.0052		7	0.00005
Mercury-D	<0.00005	<0.00005	9	9	<0.00005	<0.00005	6	6	<0.00005	<0.00005	6	6	<0.00005	<0.00005	6	6	<0.00005	<0.00005	7	7	0.00005
Mercury-T	<0.00005	<0.00005	9	9	<0.00005	<0.00005	6	6	<0.00005	<0.00005	6	6	<0.00005	<0.00005	6	6	0.00013	<0.00005	5	7	0.00005
Molybdenum-D	0.000723	0.000638		9	0.000737	0.000681		6	0.00119	0.0007		6	0.00141	0.000732		6	0.00097	0.00052		7	0.00005
Molybdenum-T	0.000793	0.000617		9	0.000807	0.000645		6	0.00116	0.000791		6	0.00132	0.000793		6	0.00181	0.000698		7	0.00005
Nickel-D	0.00105	<0.0005	2	9	0.00106	<0.0005	2	6	0.00158	<0.0005	1	6	0.00193	<0.0005	2	6	0.0039	<0.0005	1	7	0.0005
Nickel-T	0.00126	<0.0005	1	9	0.00252	<0.0005	1	6	0.00609	0.00075		6	0.00711	0.00064		6	0.0432	0.00055		7	0.0005
Phosphorus-D	<0.3	<0.3	9	9	<0.3	<0.3	6	6	<0.3	<0.3	6	6	<0.3	<0.3	6	6	<0.3	<0.3	7	7	0.3
Phosphorus-T	<0.3	<0.3	9	9	<0.3	<0.3	6	6	<0.3	<0.3	6	6	<0.3	<0.3	6	6	1.1	<0.3	5	7	0.3
Potassium-D	<2.0	<2.0	9	9	<2.0	<2.0	6	6	<2.0	<2.0	6	6	<2.0	<2.0	6	6	<2.0	<2.0	7	7	2.0
Potassium-T	<2.0	<2.0	9	9	<2.0	<2.0	6	6	<2.0	<2.0	6	6	2.2	<2.0	5	6	6	<2.0	5	7	2.0
Selenium-D	<0.001	<0.001	9	9	<0.001	<0.001	6	6	<0.001	<0.001	6	6	<0.001	<0.001	6	6	<0.001	<0.001	7	7	0.001
Selenium-T	<0.001	<0.001	9	9	<0.001	<0.001	6	6	<0.001	<0.001	6	6	<0.001	<0.001	6	6	<0.001	<0.001	7	7	0.001
Silicon-D	2.08	1.92		9	2	1.85		6	2.14	1.9		6	2.17	1.89		6	2.3	1.73		7	0.05
Silicon-T	2.26	1.97		9	4.03	2.03		6	8.9	2.08		6	10.6	1.97		6	29.6	2.11		7	0.05
Silver-D	<0.00001	<0.00001	9	9	<0.00001	<0.00001	6	6	<0.00001	<0.00001	6	6	<0.00001	<0.00001	6	6	<0.00001	<0.00001	7	7	0.00001
Silver-T	<0.00001	<0.00001	9	9	0.000015	<0.00001	5	6	0.000044	<0.00001	3	6	0.00005	<0.00001	4	6	0.000321	<0.00001	4	7	0.00001
Sodium-D	<2.0	<2.0	9	9	<2.0	<2.0	6	6	<2.0	<2.0	6	6	<2.0	<2.0	6	6	2.9	<2.0	4	7	2.0
Sodium-T	2.6	<2.0	8	9	<2.0	<2.0	6	6	<2.0	<2.0	6	6	<2.0	<2.0	6	6	3.2	<2.0	4	7	2.0
Strontium-D	0.104	0.0697		9	0.104	0.0746		6	0.122	0.0753		6	0.135	0.0761		6	0.106	0.0619		7	0.0001
Strontium-T	0.112	0.0769		9	0.104	0.0784		6	0.12	0.079		6	0.136	0.079		6	0.139	0.0794		7	0.0001
Thallium-D	<0.0001	<0.0001	9	9	<0.0001	<0.0001	6	6	<0.0001	<0.0001	6	6	<0.0001	<0.0001	6	6	<0.0001	<0.0001	7	7	0.0001
Thallium-T	<0.0001	<0.0001	9	9	<0.0001	<0.0001	6	6	<0.0001	<0.0001	6	6	<0.0001	<0.0001	6	6	0.00041	<0.0001	5	7	0.0001
Tin-D	<0.0001	<0.0001	9	9	<0.0001	<0.0001	6	6	<0.0001	<0.0001	6	6	<0.0001	<0.0001	6	6	<0.0001	<0.0001	7	7	0.0001
Tin-T	<0.0001	<0.0001	9	9	<0.0001	<0.0001	6	6	<0.0001	<0.0001	6	6	<0.0001	<0.0001	6	6	<0.0001	<0.0001	7	7	0.0001
Titanium-D	<0.01	<0.01	9	9	<0.01	<0.01	6	6	<0.01	<0.01	6	6	<0.01	<0.01	6	6	0.011	<0.01	6	7	0.01
Titanium-T	<0.01	<0.01	9	9	0.033	<0.01	3	6	0.104	<0.01	1	6	0.118	<0.01	2	6	0.223	<0.01	3	7	0.01
Uranium-D	0.00047	0.000338		9	0.000472	0.000375		6	0.000486	0.000358		6	0.000505	0.000325		6	0.000465	0.000355		7	0.00001
Uranium-T	0.00048	0.000387		9	0.00054	0.000406		6	0.000683	0.000414		6	0.000692	0.0004		6	0.00216	0.000366		7	0.00001
Vanadium-D	<0.001	<0.001	9	9	<0.001	<0.001	6	6	<0.001	<0.001	6	6	<0.001	<0.001	6	6	<0.001	<0.001	7	7	0.001
Vanadium-T	<0.001	<0.001	9	9	0.0044	<0.001	3	6	0.012	<0.001	2	6	0.0136	<0.001	3	6	0.0548	<0.001	2	7	0.001
Zinc-D	0.0094	<0.001	4	9	0.0051	<0.001	1	6	0.0024	<0.001	1	6	0.0031	<0.001	5	6	0.0023	<0.001	4	7	0.001
Zinc-T	0.0034	<0.001	5	9	0.0102	<0.001	2	6	0.0193	<0.001	2	6	0.0226	<0.001	3	6	0.14	<0.001	2	7	0.001
Organic Parameters (mg/L except as noted)																					
Chlorophyll *a* (µg/L)	0.892	0.23		9	1.39	0.349		6	1.3	0.799		6	1.44	0.444		6	1.19	0.0929		7	0.0006
Diss. Organic Carbon	2.91	2.17		9	3.38	2.47		6	6.4	2.43		6	5.2	2.17		6	18.5	2.21		7	0.5
Tot. Inorg. Carbon	16.7	13.7		9	17.3	13.6		6	18.8	14.1		6	20.7	14.7		6	19.5	6.7		7	0.5
Total Organic Carbon	3.26	2.39		9	4.5	2.57		6	11.2	2.75		6	7.75	2.41		6	35.1	2.53		7	0.5

Notes: Min. >MDL = Minimum value within sample set for site above detection limit (MDL).

No.< MDL=No. of samples in a sample set for a site below the MDL (if No.< MDL=6 when n=8, 6 of 8 samples were below the MDL & presented data is from two samples).

(1) Total copper MDLs at Peace 2 = 00.0013 mg/L in August and 0.011 mg/L at Peace 3 and 4 in October due to contamination issues during laboratory analysis.

Table 14: **Water quality analysis results summary showing maximum and minimum values and the number of samples within the data set below method detection limits (MDLs) from sample sites in the Peace River tributaries, 2008.**

Parameter	Moberly 6				Moberly 7				Halfway 8				Halfway 9				Lynx 10				Farrell 11				Cache 12				Boudreau 13				MDL
	Max	Min	No. < D.L.	n	Max	Min	No. < D.L.	n	Max	Min	No. < D.L.	n	Max	Min	No. < D.L.	n	Max	Min	No. < D.L.	n	Max	Min	No. < D.L.	n	Max	Min	No. < D.L.	n	Max	Min	No. < D.L.	n	
Physical Tests (mg/L except as noted)																																	
Colour (CU)	53.9	10.3		7	41.4	5.9		5	133	<5.0	1	5	137	<5.0	2	6	78.3	<5.0	2	6	133	7.4		5	164	<5.0	1	6	157	10.4		5	5.0
Conductivity (µS/cm)	238	174		7	896	195		5	542	214		5	481	200		6	891	319		6	574	188		5	2460	183		6	949	239		5	2.0
Hardness	128	87.8		7	148	95.3		5	298	111		5	259	105		6	509	172		6	310	90.2		5	756	106		6	528	120		5	0.5
pH (pH units)	8.37	7.56		7	8.39	8.06		5	8.49	7.93		5	8.37	7.9		6	8.36	8.09		6	8.49	7.99		5	8.19	7.74		6	8.2	7.96		5	0.01
Salinity (g/L)	<1.0	<1.0	7	7	<1.0	<1.0	5	5	<1.0	<1.0	5	5	<1.0	<1.0	6	6	<1.0	<1.0	6	6	<1.0	<1.0	5	5	1.2	<1.0	5	6	<1.0	<1.0	5	5	1.0
TDS	161	111		7	637	124		5	348	169		5	282	174		6	522	209		6	357	181		5	2420	125		6	676	209		5	10
TSS	710	<3.0	2	7	407	<3.0	1	5	702	<3.0	1	5	497	<3.0	1	5	1950	14.5		6	1520	<3.0	1	5	1620	3		6	409	11.3		5	3.0
Turbidity (NTU)	772	1.5		7	229	2.9		5	540	4.02		5	596	3.45		6	740	17.2		6	760	3.35		5	1300	7.48		6	309	11.2		5	0.1
Anions and Nutrients (mg/L except as noted)																																	
AOX (µg/L)	10	<4.0	2	7	9.9	<4.0	3	5	12	<4.0	3	5	15	<4.0	4	6	9.3	<4.0	2	6	15	5		5	21	<4.0	3	6	10	<4.0	2	5	4.0
Alkalinity	122	80.1		7	237	102		5	286	86.5		5	213	81.6		6	458	162		6	273	83		5	350	87.9		6	305	103		5	2.0
Ammonia	0.048	<0.02	5	7	0.034	<0.02	3	5	0.065	<0.02	3	5	0.054	<0.02	4	6	0.056	<0.02	4	6	0.055	<0.02	1	5	0.112	<0.02	1	6	0.11	<0.02	1	5	0.02
Acidity	5.3	<1.0	3	7	2	<1.0	3	5	2.5	<1.0	4	5	2.6	<1.0	4	6	3.3	<1.0	3	6	2.3	<1.0	4	5	14.4	<1.0	1	6	7.5	2.5		5	1.0
Bromide	<0.05	<0.05	7	7	<0.05	<0.05	5	5	<0.05	<0.05	5	5	<0.05	<0.05	6	6	<0.05	<0.05	6	6	<0.05	<0.05	5	5	<0.05	<0.05	6	6	<0.05	<0.05	5	5	0.05
Chloride	0.77	<0.5	6	7	4.99	<0.5	3	5	0.65	<0.5	4	5	0.75	<0.5	4	6	0.88	<0.5	1	6	1.8	<0.5	1	5	279	<0.5	1	6	0.66	<0.5	2	5	0.5
Fluoride	0.071	0.056		7	0.309	0.06		5	0.194	0.081		5	0.095	0.083		6	0.256	0.09		6	0.161	0.087		5	0.437	0.065		6	0.356	0.058		5	0.02
Sulphate	8.87	5.93		7	245	7.5		5	46.5	23.8		5	50.7	22.6		6	87.8	20.5		6	66.1	15.7		5	567	6.8		6	251	20.9		5	0.5
Sulphide	0.026	<0.02	6	7	0.031	<0.02	3	5	0.027	<0.02	4	5	0.028	<0.02	3	6	0.027	<0.02	4	6	0.031	<0.02	2	5	0.025	<0.02	4	6	0.028	<0.02	3	5	0.02
Nitrate & Nitrite (as N)	0.117	<0.005	4	7	0.124	<0.005	4	5	0.0938	<0.005	3	5	0.09	<0.005	3	6	0.159	<0.005	1	6	0.473	<0.005	4	5	0.197	<0.005	3	6	0.0533	0.025		5	0.005
Nitrate (as N)	0.115	<0.005	4	7	0.122	<0.005	4	5	0.0925	<0.005	3	5	0.09	<0.005	3	6	0.156	<0.005	1	6	0.469	<0.005	4	5	0.147	<0.005	3	6	0.0513	0.0222		5	0.005
Nitrite (as N)	0.0021	<0.001	6	7	0.0017	<0.001	3	5	0.0013	<0.001	4	5	0.0014	<0.001	5	6	0.0031	<0.001	5	6	0.0039	<0.001	4	5	0.0492	<0.001	4	6	0.0065	0.0019		5	0.001
Tot. Kjeldahl Nitrogen	2.33	0.169		7	1.31	0.158		5	0.84	0.077		5	1.95	0.065		6	2.1	0.165		6	2.45	0.203		5	1.48	0.277		6	2.23	0.268		5	0.05
Total Nitrogen	2.45	0.169		7	1.43	0.158		5	0.934	0.077		5	2.04	0.065		6	2.26	0.165		6	2.93	0.203		5	1.51	0.277		6	2.27	0.293		5	0.05
Ortho Phosphate	0.0122	<0.001	3	7	0.0078	<0.001	3	2	0.0165	0.0013		5	0.0157	0.0013		6	0.0199	<0.001	1	6	0.0204	<0.001	1	5	0.0243	<0.001	3	6	0.0158	<0.001	2	5	0.001
Tot. Diss. Phos.	0.0269	<0.002	1	7	0.017	0.0021		5	0.0474	<0.002	1	5	0.0511	<0.002	1	6	0.0389	0.0042		6	0.0512	<0.002	2	5	0.0722	<0.002	1	6	0.06	0.0035		5	0.002
Total Phosphate	0.84	0.0046		7	0.33	0.0082		5	0.87	0.0068		5	0.65	0.0064		6	1.26	0.011		6	1.07	0.0091		5	1.57	0.0127		6	0.36	0.0273		5	0.002
Metals (mg/L except as noted)																																	
Aluminum-D	0.0762	0.0014		7	0.0526	<0.001	1	5	0.091	0.0016		5	0.69	0.0025		6	0.0519	0.0082		6	0.202	0.0029		5	0.104	<0.001	1	6	0.0593	<0.001	2	5	0.001
Aluminum-T	10.7	0.0364		7	7.74	0.231		5	7.99	0.0631		5	5.65	0.0344		6	9	0.122		6	6.25	0.0697		5	10.6	0.0055		6	3.37	0.148		5	0.001
Antimony-D	<0.0001	<0.0001	7	7	<0.0001	<0.0001	5	5	0.00017	0.00013		5	0.00018	0.00013		6	0.00022	<0.0001	3	6	0.0002	<0.0001	1	5	0.00026	<0.0001	4	6	0.00018	<0.0001	4	5	0.0001
Antimony-T	0.00047	<0.0001	6	7	0.00045	<0.0001	2	5	0.00046	0.00015		5	0.0003	0.00012		6	0.00073	0.00015		6	0.00051	0.0001		5	0.00054	<0.0001	4	6	0.00029	<0.0001	3	5	0.0001
Arsenic-D	0.0005	0.00017		7	0.00036	0.00019		5	0.00094	0.00016		5	0.0006	0.00013		6	0.00125	0.00022		6	0.00059	0.00039		5	0.00074	0.0005		6	0.00096	0.00044		5	0.0001
Arsenic-T	0.00559	0.00018		7	0.00506	0.00037		5	0.00555	0.00021		5	0.00341	0.00015		6	0.00662	0.00044		6	0.00518	0.00047		5	0.00676	0.00066		6	0.0032	0.00112		5	0.0001
Barium-D	0.132	0.104		7	0.116	0.0999		5	0.115	0.0498		5	0.0852	0.0598		6	0.1	0.0622		6	0.115	0.0492		5	0.0762	0.026		6	0.0839	0.0503		5	0.00005
Barium-T	0.611	0.106		7	0.321	0.126		5	0.371	0.0797		5	0.308	0.0792		6	0.394	0.0761		6	0.36	0.0809		5	0.374	0.0273		6	0.158	0.057		5	0.00005
Beryllium-D	<0.0005	<0.0005	7	7	<0.0005	<0.0005	5	5	<0.0005	<0.0005	5	5	<0.0005	<0.0005	6	6	<0.0005	<0.0005	6	6	<0.0005	<0.0005	5	5	<0.0005	<0.0005	6	6	<0.0005	<0.0005	5	5	0.0005
Beryllium-T	<0.0005	<0.0005	7	7	0.00062	<0.0005	4	5	0.0006	<0.0005	4	5	<0.0005	<0.0005	6	6	<0.0005	<0.0005	6	6	<0.0005	<0.0005	5	5	<0.0005	<0.0005	6	6	<0.0005	<0.0005	5	5	0.0005
Bismuth D	<0.0005	<0.0005	7	7	<0.0005	<0.0005	5	5	<0.0005	<0.0005	5	5	<0.0005	<0.0005	6	6	<0.0005	<0.0005	6	6	<0.0005	<0.0005	5	5	<0.0005	<0.0005	6	6	<0.0005	<0.0005	5	5	0.0005
Bismuth T	<0.0005	<0.0005	7	7	<0.0005	<0.0005	5	5	<0.0005	<0.0005	5	5	<0.0005	<0.0005	6	6	<0.0005	<0.0005	6	6	<0.0005	<0.0005	5	5	<0.0005	<0.0005	6	6	<0.0005	<0.0005	5	5	0.0005
Boron-D	<0.01	<0.01	7	7	<0.01	<0.01	5	5	0.023	0.01		5	0.013	<0.01	2	6	0.047	<0.01	2	6	0.034	0.014		5	0.107	0.023		6	0.045	<0.01	1	5	0.01
Boron-T	0.024	<0.01	6	7	0.026	<0.01	4	5	0.025	0.011		5	0.018	<0.01	1	6	0.049	0.011		6	0.035	0.02		5	0.107	0.036		6	0.047	0.018		5	0.01
Cadmium-D	<0.00005	<0.00005	7	7	<0.00005	<0.00005	5	5	0.000083	<0.00005	4	5	0.000109	<0.00005	5	6	<0.00005	<0.00005	6	6	0.000077	<0.00005	4	5	<0.00005	<0.00005	6	6	0.00013	<0.00005	3	5	0.00005
Cadmium-T	0.00067	<0.00005	5	7	0.00108	<0.00005	2	5	0.000863	<0.00005	1	5	0.000316	<0.00005	2	6	0.00199	<0.00005	1	6	0.00155	<0.00005	2	5	0.00157	<0.00005	4	6	0.00071	<0.00005	1	5	0.00005
Calcium-D	35.1	23.7		7	41	26.3		5	71.1	32.2		5	72	30.5		6	97.9	43.6		6	82.8	25.8		5	192	28.7		6	151	33		5	0.05
Calcium-T	37	24.1		7	41.9	28.4		5	75.1	44.4		5	73	38.4		6	111	52.8		6	82.7	46		5	189	63.4		6	150	39.1		5	0.05
Chromium-D	<0.0005	<0.0005	7	7	<0.0005	<0.0005	5	5	0.00063	<0.0005	4	5	0.00135	<0.0005	4	6	0.0016	<0.0005	5	6	0.00065	<0.0005	3	5	0.0013	<0.0005	4	6	0.0014	<0.0005	4	5	0.0005
Chromium-T	0.0205	<0.0005	5	7	0.0152	<0.0005	1	5	0.0151	<0.0005	1	5	0.0101	<0.0005	2	6	0.0179	<0.0005	1	6	0.0124	<0.0005	1	5	0.0181	<0.0005	3	6	0.0055	<0.0005	1	5	0.0005
Cobalt-D	<0.0001	<0.0001	7	7	0.00013	<0.0001	4	5	0.00047	<0.0001	3	5	0.00069	<0.0001	5	6	0.00045	<0.0001	1	6	0.00047	<0.0001	4	5	0.00427	0.00059		6	0.00235	0.00054		5	0.0001
Cobalt-T	0.00799	<0.0001	3	7	0.00597	0.00022		5	0.00687	<0.0001	1	5	0.00371	<0.0001	2	6	0.00792	0.00029		6	0.00755	<0.0001	1	5	0.0123	0.00114		6	0.00736	0.00166		5	0.0001
Copper-D	0.00215	0.00067		7	0.00187	0.00061		5	0.00315	0.00035		5	0.00386	0.00036		6	0.00325	0.00065		6	0.00365	0.00103		5	0.00517	<0.0001	1	6	0.00407	0.00041		5	0.0001
Copper-T	0.0214	<0.0001	3	7	0.0181	0.0011		5	0.0199	<0.0001	1	5	0.0114	0.00047		6	0.0296	0.00129		6	0.0227	0.0011		5	0.0377	0.00025		6	0.0104	0.00101		5	0.0001
Iron-D	0.154	<0.03	3	7	0.076	<0.03	3	5	0.249	<0.03	2	5	0.806	<0.03	4	6	0.086	<0.03	5	6	0.318	<0.03	2	5	0.406	<0.03	4	6	0.238	<0.03	3	5	0.03
Iron-T	18.4	0.072		7	12.5	0.324		5	13.6	0.144		5	8.56	0.049		6	14.5	0.186		6	12.1	0.122		5	17.4	0.509		6	7.45	0.734		5	0.03
Lead-D	0.00017	<0.00005	6	7	0.000078	<0.00005	4	5	0.000125	<0.00005	4	5	0.000488	<0.00005	5	6	<0.00005	<0.00005	6	6	0.000479	<0.00005	2	5	0.00081	<0.00005	4	6	0.000117	<0.00005	4	5	0.00005
Lead-T	0.0113	<0.00005	1	7	0.0075	0.000189		5	0.00798	0.00006		5	0.00519	<0.00005	1	6	0.0098	0.000097		6	0.00924	0.000053		5	0.0162	<0.00005	2	6	0.00284	0.00015		5	0.00005
Lithium-D	<0.005	<0.005	7	7	<0.005	<0.005	5	5	0.0131	<0.005	1	5	0.007	<0.005	2	6	0.028	<0.005	2	6	0.0173	<0.005	1	5	0.052	<0.005	1	6	0.027	<0.005	2	5	0.005
Lithium-T	0.016	<0.005	5	7	0.013	<0.005	4	5	0.0146	0.0061		5	0.0098	0.0061		6	0.029	0.0055		6	0.0177	0.0091		5	0.051	0.014		6	0.029	0.0064		5	0.005
Magnesium-D	9.82	6.93		7	11.1	7.22		5	30.6	7.53		5	19.2	7.12		6	64.2	13.9		6	25	6.28		5	66.9	8.26		6	36.7	9.09		5	0.1
Magnesium-T	11.4	7.01		7	11.3	7.84		5	32.2	11.8		5	19.2	10.4		6	65.3	14.2		6	25.1	12.9		5	66.9	17.3		6	36.4	10.4		5	0.1
Manganese-D	0.0168	0.000704		7	0.0123	0.000508		5	0.0386	0.00348		5	0.0443	0.00198		6	0.0319	0.00488		6	0.0308	0.0013		5	1.47	0.0684		6	1.2	0.0243		5	0.00005
Manganese-T	0.295	0.00399		7	0.2	0.0156		5	0.237	0.00695		5	0.155	0.00311		6	0.443	0.0123		6	0.433	0.0163		5	1.65	0.477		6	1.45	0.104		5	0.00005
Mercury-D	<0.00005	<0.00005	7	7	<0.00005	<0.00005	5	5	<0.00005	<0.00005	5	5	<0.00005	<0.00005	6	6	<0.00005	<0.00005	6	6	<0.00005	<0.00005	5	5	<0.00005	<0.00005	6	6	<0.00005	<0.00005	5	5	0.00005
Mercury-T	<0.00005	<0.00005	7	7	<0.00005	<0.00005	5	5	<0.00005	<0.00005	5	5	<0.00005	<0.00005	6	6	<0.00005	<0.00005	6	6	<0.00005	<0.00005	5	5	<0.00005	<0.00005	6	6	<0.00005	<0.00005	5	5	0.00005
Molybdenum-D	0.00043	0.000323		7	0.00052	0.000348		5	0.004	0.00127		5	0.00401	0.00109		6	0.00558	0.00148		6	0.00172	0.000679		5	0.00266	0.00102		6	0.00274	0.00094		5	0.00005
Molybdenum-T	0.00083	0.000301		7	0.00203	0.000454		5	0.004	0.00218		5	0.00394	0.000874		6	0.00547	0.00249		6	0.00156	0.000884		5	0.00256	0.00164		6	0.0029	0.0011		5	0.00005
Nickel-D	0.0041	0.00079		7	0.00266	0.00087		5	0.00438	0.00133		5	0.00529	0.00101		6	0.0046	0.0011		6	0.00493	0.00194		5	0.0141	0.0054		6	0.0153	0.0037		5	0.0005
Nickel-T	0.0273	<0.0005	2	7	0.0227	0.00145		5	0.0241	0.00142		5	0.0135	0.00098		6	0.028	0.00205		6	0.0248	0.00211		5	0.0374	0.0053		6	0.0266	0.0045		5	0.0005
Phosphorus-D	<0.03	<0.03	7	7	<0.03	<0.03	5	5	<0.03	<0.03	5	5	<0.03	<0.03	6	6	<0.03	<0.03	6	6	<0.03	<0.03	5	5	<0.03	<0.03	6	6	<0.03	<0.03	5	5	0.3
Phosphorus-T	0.73	<0.03	6	7	0.59	<0.03	4	5	0.67	<0.03	4	5	0.36	<0.03	5	6	0.89	<0.03	5	6	0.89	<0.03	4	5	1.02	<0.03	5	6	0.42	<0.03	4	5	0.3
Potassium-D	<2.0	<2.0	7	7	<2.0	<2.0	5	5	2.4	<2.0	4	5	2.2	<2.0	5	6	3.2	<2.0	1	6	2.5	<2.0	2	5	8.6	4.1		6	7.1	4.2		5	2.0
Potassium-T	5.5	<2.0	6	7	4.6	<2.0	4	5	4.5	<2.0	3	5	3.4	<2.0	5	6	6.4	<2.0	1	6	4.2	<2.0	3	5	9.6	5.7		6	7.8	4.3		5	2.0
Selenium-D	<0.001	<0.001	7	7	<0.001	<0.001	5	5	0.0019	<0.001	2	5	0.0021	<0.001	1	6	0.0014	<0.001	5	6	<0.001	<0.001	5	5	<0.001	<0.001	6	6	<0.001	<0.001	5	5	0.001

Table 14: **Water quality analysis results summary showing maximum and minimum values and the number of samples within the data set below method detection limits (MDLs) from sample sites in the Peace River tributaries, 2008.**

Parameter	Moberly 6				Moberly 7				Halfway 8				Halfway 9				Lynx 10				Farrell 11				Cache 12				Boudreau 13				MDL
	Max	Min	No. < D.L.	n	Max	Min	No. < D.L.	n	Max	Min	No. < D.L.	n	Max	Min	No. < D.L.	n	Max	Min	No. < D.L.	n	Max	Min	No. < D.L.	n	Max	Min	No. < D.L.	n	Max	Min	No. < D.L.	n	
Selenium-T	<0.001	<0.001	7	7	0.0015	<0.001	4	5	0.0019	<0.001	1	5	0.0022	<0.001	1	6	0.0012	<0.001	5	6	0.0011	<0.001	4	5	<0.001	<0.001	6	6	<0.001	<0.001	5	5	0.001
Silicon-D	1.8	0.995		7	1.45	1.13		5	4.08	1.65		5	4.26	1.65		6	6.9	1.59		6	2.54	0.658		5	3.44	1.34		6	6.04	1.5		5	0.05
Silicon-T	25.9	1.11		7	18.8	1.54		5	17.7	1.8		5	12.4	1.95		6	24.5	3		6	12.8	1.05		5	30	2.45		6	10.9	5.6		5	0.05
Silver-D	<0.00001	<0.00001	7	7	<0.00001	<0.00001	5	5	<0.00001	<0.00001	5	5	0.000016	<0.00001	5	6	<0.00001	<0.00001	6	6	0.000012	<0.00001	4	5	<0.00001	<0.00001	6	6	<0.00001	<0.00001	5	5	0.00001
Silver-T	0.00026	<0.00001	6	7	0.000178	<0.00001	1	5	0.000182	<0.00001	2	5	0.000117	<0.00001	3	6	0.000178	<0.00001	2	6	0.000127	<0.00001	3	5	0.00016	<0.00001	3	6	0.000083	<0.00001	3	5	0.00001
Sodium-D	2.4	<2.0	5	7	2.8	<2.0	2	5	8.7	2		5	4	2.2		6	18.6	2		6	15.3	3		5	222	11.2		6	10.5	2.3		5	2.0
Sodium-T	2.3	<2.0	4	7	3.6	<2.0	2	5	8.9	<2.0	1	5	3.9	2.1		6	18.7	2.1		6	15	3.3		5	248	11.3		6	10.4	2.3		5	2.0
Strontium-D	0.0714	0.0496		7	0.0788	0.056		5	0.272	0.107		5	0.309	0.1		6	0.536	0.117		6	0.191	0.0604		5	0.584	0.0991		6	0.355	0.0884		5	0.0001
Strontium-T	0.0975	0.0542		7	0.137	0.0633		5	0.277	0.154		5	0.306	0.0948		6	0.579	0.21		6	0.192	0.096		5	0.639	0.201		6	0.359	0.109		5	0.0001
Thallium-D	<0.0001	<0.0001	7	7	<0.0001	<0.0001	5	5	<0.0001	<0.0001	5	5	<0.0001	<0.0001	6	6	<0.0001	<0.0001	6	6	<0.0001	<0.0001	5	5	<0.0001	<0.0001	6	6	<0.0001	<0.0001	5	5	0.0001
Thallium-T	0.00027	<0.0001	6	7	0.00023	<0.0001	4	5	0.00024	<0.0001	4	5	0.00015	<0.0001	5	6	0.00026	<0.0001	4	6	0.00019	<0.0001	4	5	0.00022	<0.0001	5	6	<0.0001	<0.0001	5	5	0.0001
Tin-D	<0.0001	<0.0001	7	7	<0.0001	<0.0001	5	5	<0.0001	<0.0001	5	5	<0.0001	<0.0001	6	6	<0.0001	<0.0001	6	6	<0.0001	<0.0001	5	5	<0.0001	<0.0001	6	6	<0.0001	<0.0001	5	5	0.0001
Tin-T	<0.0001	<0.0001	7	7	0.00011	<0.0001	4	5	0.00016	<0.0001	4	5	0.0001	<0.0001	5	6	0.00016	<0.0001	5	6	<0.0001	<0.0001	5	5	<0.0001	<0.0001	6	6	0.00046	<0.0001	3	5	0.0001
Titanium-D	<0.01	<0.01	7	7	<0.01	<0.01	5	5	<0.01	<0.01	5	5	0.044	<0.01	5	6	<0.01	<0.01	6	6	0.011	<0.01	4	5	<0.01	<0.01	6	6	<0.01	<0.01	5	5	0.01
Titanium-T	0.267	<0.01	5	7	0.208	<0.01	2	5	0.183	<0.01	1	5	0.118	<0.01	1	6	0.322	<0.01	1	6	0.133	0.01		5	0.416	<0.01	3	6	0.119	<0.01	1	5	0.01
Uranium-D	0.000325	0.000124		7	0.00032	0.000157		5	0.00169	0.000463		5	0.000879	0.000494		6	0.00411	0.000656		6	0.00122	0.000442		5	0.00334	0.000868		6	0.003	0.00069		5	0.00001
Uranium-T	0.000966	0.000136		7	0.00117	0.000192		5	0.00186	0.000691		5	0.000872	0.000648		6	0.00442	0.000746		6	0.00135	0.000626		5	0.00363	0.0021		6	0.00347	0.000964		5	0.00001
Vanadium-D	<0.001	<0.001	7	7	<0.001	<0.001	5	5	<0.001	<0.001	5	5	0.0031	<0.001	5	6	<0.001	<0.001	6	6	0.0013	<0.001	4	5	<0.001	<0.001	6	6	<0.001	<0.001	5	5	0.001
Vanadium-T	0.0409	<0.001	5	7	0.0346	<0.001	1	5	0.0361	<0.001	1	5	0.0221	<0.001	2	6	0.0465	<0.001	1	6	0.0337	<0.001	2	5	0.0439	<0.001	3	6	0.0132	<0.001	1	5	0.001
Zinc-D	0.0297	<0.001	4	7	0.0029	<0.001	3	5	0.0446	<0.001	2	5	0.0055	<0.001	2	6	0.0041	<0.001	3	6	0.0041	<0.001	1	5	0.0489	<0.001	1	6	0.0099	0.0023		5	0.001
Zinc-T	0.0995	<0.001	5	7	0.0723	<0.001	1	5	0.0806	0.0023		5	0.0431	0.0013		6	0.0992	<0.001	1	6	0.0784	<0.001	2	5	0.114	<0.001	1	6	0.0847	0.004		5	0.001
Organic Parameters (mg/L except as noted)																																	
Chlorophyll *a* (µg/L)	1.32	0.278		7	9.24	0.422		5	0.749	0.164		5	0.606	0.029		6	2.95	0.156		6	1.72	0.209		5	4.68	0.0647		6	81	0.565		5	0.0006
Diss. Organic Carbon	11	5.19		7	16.6	3.65		5	22.7	1.86		5	23.6	1.27		6	16.8	2.29		6	22.4	5.39		5	30.1	5.79		6	30.8	10.8		5	0.5
Tot. Inorg. Carbon	27.7	14.5		7	48.9	16.2		5	64	17.5		5	46	13.8		6	113	33.7		6	62.3	25.3		5	76.9	16.6		6	73.2	20.4		5	0.5
Total Organic Carbon	27	5.49		7	17.9	4.2		5	34.1	2.12		5	34.3	1.4		6	31.7	4.03		6	40.2	5.75		5	53.9	6.84		6	32.6	11.5		5	0.5

Notes: Min. >MDL = Minimum value within sample set for site above detection limit (MDL).

No.< MDL=No. of samples in a sample set for a site below the MDL (if No.< MDL=6 when n=8, 6 of 8 samples were below the MDL & presented data is from two samples).

Table 15: The number of instances specific parameters for either CCME and BCWQ guidelines were exceeded for specific parameters in surface water grab samples between November 2006 and August 2008.

Total Individual Sample Periods/Site	**2007**																										**2008**																										**Total by Parameter**			
	6		**5**		**6**		**7**		**7**		**5**		**4**		**5**		**5**		**6**		**6**		**6**		**4**		**9**		**6**		**6**		**6**		**7**		**7**		**5**		**5**		**6**		**6**		**5**		**6**		**5**					
Parameter (units in mg/L except as noted)	**Peace 1**		**Peace 2**		**Peace 3**		**Peace 4**		**Peace 5**		**Moberly 6**		**Moberly 7**		**Halfway 8**		**Halfway 9**		**Lynx 10**		**Farrell 11**		**Cache 12**		**Boudreau 13**		**Peace 1**		**Peace 2**		**Peace 3**		**Peace 4**		**Peace 5**		**Moberly 6**		**Moberly 7**		**Halfway 8**		**Halfway 9**		**Lynx 10**		**Farrell 11**		**Cache 12**		**Boudreau 13**		**2007**		**2008**	
Anions and Nutrients																																																								
Absorbable Organic Halogen (µg/L)																																																								
Ammonia as N																																																								
Acidity (as CaCO3)																																																								
Alkalinity, Total (as CaCO3)																																																								
Bromide (Br)																																																								
Chloride (Cl)																																																								
Fluoride (F)																			3		1		4		3				1		1						1		1						4				1		4		11		13	
Sulphate (SO4)																					1		5		3				1		1						1		1										1		4		9		9	
Sulphide as S																																																								
Nitrate and Nitrite as N																																																								
Nitrate (as N)																																																								
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Total Nitrogen																																																								
Ortho Phosphate as P																																																								
Total Dissolved Phosphate As P																																																								
Total Phosphate as P																																																								
Metals - Total (T) or Dissolved (D)	**T**	**D**	**T**	**D**	**T**	**D**	**T**	**D**	**T**	**D**	**T**	**D**	**T**	**D**	**T**	**D**	**T**	**D**	**T**	**D**	**T**	**D**	**T**	**D**	**T**	**D**	**T**	**D**	**T**	**D**	**T**	**D**	**T**	**D**	**T**	**D**	**T**	**D**	**T**	**D**	**T**	**D**	**T**	**D**	**T**	**D**	**T**	**D**	**T**	**D**	**T**	**D**	**T**	**D**	**T**	**D**
Aluminum (Al)			3		4		4		5	2	3		3	1	4		4		5	1	4		4	2	2	1			4		4		5		7	2	5		5		4	1	5	1	6		4	1	4		5		45	7	58	5
Antimony (Sb)							1																																														1			
Arsenic (As)									1										1				1												2		1		1				1		1		1		1				3		8	
Barium (Ba)																																																								
Beryllium (Be)																																																								
Bismuth (Bi)																																																								
Boron (B)																																																								
Cadmium (Cd)			2		2		2		5		4		3		5		4		4		4	1	2		2	2	1	1	2		4		3		4		2		3		4	1	4		5		3	1	2	1	4	2	39	3	41	6
Calcium (Ca)																																																								
Chromium (Cr)																																																								
Cobalt (Co)																																																								
Copper (Cu)					2		1		4		1		2		1		2		3		3		3	1	2	2			3		1		1		2	1	2	1	2		1	1	2	1	3		1	1	2		2	2	24	3	22	7
Iron (Fe)			2		4		4		5	1	3		3		4		4		5		3		5		4	1					4		3		5	2	4		5		4	1	4	1	5		3	1	4		5		46	2	46	5
Lead (Pb)																																																								
Lithium (Li)																																																								
Magnesium (Mg)																																																								
Manganese (Mn)																			1				2		3	2					1	1					1	1					1							1	4	3	6	2	7	6
Mercury (Hg)																																																								
Molybdenum (Mo)																																																								
Nickel (Ni)																																																								
Phosphorus (P)																																																								
Potassium (K)																																																								
Selenium (Se)															4	4	5	5	1		1	1	2																1		4	4	4	4	1	1	1		1				13	10	12	9
Silicon (Si)																																																								
Silver (Ag)					1		1		2				1		1		1		1				1												2		1		1		1		1		1		1		1				9		9	
Sodium (Na)																																																								
Strontium (Sr)																																																								
Thallium (Tl)					1		1																1												2																		3		2	
Tin (Sn)																																																								
Titanium (Ti)																																																								
Uranium (U)																																																								
Vanadium (V)					1		2		5		1		2		2		3		3		2		2										1		2		2		2		1		2		4		1		2		2		23		19	
Zinc (Zn)					1		1		4		1		2		1		3		3		2		2		2	2							1		2		2	2	2		1		2		3		1		2	1	4		22	2	20	3

Table 16: **The number of times water analysis results from Peace River and tributary sites were under method detection limits (MDL) for dissolved metals during the 2006-7 and 2008 sample years.**

Site	2006-07			2008			Pooled		
	< MDL	n	%	< MDL	n	%	< MDL	n	%
Peace 1	86	230	37%	108	396	27%	**194**	**626**	**31%**
Peace 2	72	198	36%	76	198	38%	**148**	**396**	**37%**
Peace 3	102	264	39%	76	198	38%	**178**	**462**	**39%**
Peace 4	95	297	32%	70	198	35%	**165**	**495**	**33%**
Peace 5	95	264	36%	84	231	36%	**179**	**495**	**36%**
Moberly 6	69	165	42%	94	231	41%	**163**	**396**	**41%**
Moberly 7	55	132	42%	66	165	40%	**121**	**297**	**41%**
Halfway 8	74	165	45%	97	165	59%	**171**	**330**	**52%**
Halfway 9	93	165	56%	110	198	56%	**203**	**363**	**56%**
Lynx 10	107	198	54%	104	198	53%	**211**	**396**	**53%**
Farrell 11	111	198	56%	115	165	70%	**226**	**363**	**62%**
Cache 12	113	198	57%	117	198	59%	**230**	**396**	**58%**
Boudreau 13	75	132	57%	90	165	55%	**165**	**297**	**56%**
Peace River	**450**	**1253**	**36%**	**414**	**1221**	**34%**	**864**	**2474**	**35%**
Tributaries	**697**	**1353**	**52%**	**793**	**1485**	**53%**	**1490**	**2838**	**53%**
Pooled	**1147**	**2606**	**44%**	**1207**	**2706**	**45%**	**2354**	**5312**	**44%**

Table 17: A summary of observed exceedences of BCWQ and CCME water quality guidelines for metals at individual sites and mean number of exceedences based upon total water samples taken over the course of surface water grab sampling between November 2006 and October 2008.

Sample Site	Samples Taken per Site		Total Metal Exceedences		Dissolved Metal Exceedences		Count of Individual Total Metals Exceeded		Count of Individual Dissolved Metals Exceeded		Mean Total Metal Exceedences		Mean of Dissolved Metal Exceedences		Mean Individual Total Metals Exceeded		Mean Individual Dissolved Metals Exceeded	
	06-07	**08**	**06-07**	**08**	**06-07**	**08**	**06-07**	**08**	**06-07**	**08**	**06-07**	**08**	**06-07**	**08**	**06-07**	**08**	**06-07**	**08**
Peace 1	6	9	0	1	0	1	0	1	0	1	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1
Peace 2	5	6	7	9	0	0	3	3	0	0	1.4	1.5	0.0	0.0	0.6	0.5	0.0	0.0
Peace 3	6	6	16	14	0	1	8	5	0	1	2.7	2.3	0.0	0.2	1.3	0.8	0.0	0.2
Peace 4	7	6	17	14	0	0	9	6	0	0	2.4	2.3	0.0	0.0	1.3	1.0	0.0	0.0
Peace 5	7	7	31	28	3	5	8	9	2	3	4.4	4.0	0.4	0.7	1.1	1.3	0.3	0.4
Moberly 6	5	7	13	20	0	4	6	9	0	3	2.6	2.9	0.0	0.6	1.2	1.3	0.0	0.4
Moberly 7	4	5	16	22	1	0	7	9	1	0	4.0	4.4	0.3	0.0	1.8	1.8	0.3	0.0
Halfway 8	5	5	22	20	4	8	8	8	1	5	4.4	4.0	0.8	1.6	1.6	1.6	0.2	1.0
Halfway 9	5	6	26	26	5	7	8	10	1	4	5.2	4.3	1.0	1.2	1.6	1.7	0.2	0.7
Lynx 10	6	6	27	29	1	1	10	9	1	1	4.5	4.8	0.2	0.2	1.7	1.5	0.2	0.2
Farrell 11	6	5	19	16	2	4	7	9	2	4	3.2	3.2	0.3	0.8	1.2	1.8	0.3	0.8
Cache 12	6	6	25	19	3	3	11	9	2	3	4.2	3.2	0.5	0.5	1.8	1.5	0.3	0.5
Boudreau 13	4	5	15	26	10	7	6	7	6	3	3.8	5.2	2.5	1.4	1.5	1.4	1.5	0.6
Sum/Mean-All Sites	72	79	234	244	29	41	91	94	16	28	3.25	3.09	0.40	0.52	1.26	1.19	0.22	0.35
Sum/Mean-Peace R.	31	34	71	66	3	7	28	24	2	5	2.29	1.94	0.10	0.21	0.90	0.71	0.06	0.15
Sum/Mean-Tributaries	41	45	163	178	26	34	63	70	14	23	3.98	3.96	0.63	0.76	1.54	1.56	0.34	0.51

Table 18: Summary of adsorbable organic halogen (AOX) concentrations from the Peace River and selected tributaries above the minimum detection the limit (4.0 µg/L) in 2007 and 2008.

Sample Site	2006-07			2008			TOTAL		
	Count	**n**	%	Count	n	%	**Count**	**n**	**%**
Peace 1	5	7	71%	4	9	44%	9	16	56%
Peace 2	5	6	83%	1	6	17%	6	12	50%
Peace 3	5	7	71%	2	6	33%	7	13	54%
Peace 4	4	9	44%	2	6	33%	6	15	40%
Peace 5	5	7	71%	3	7	43%	8	14	57%
Moberly 6	4	5	80%	5	7	71%	9	12	75%
Moberly 7	4	4	100%	2	5	40%	6	9	67%
Halfway 8	3	5	60%	2	5	40%	5	10	50%
Halfway 9	4	5	80%	2	6	33%	6	11	55%
Lynx 10	5	6	83%	4	6	67%	9	12	75%
Farrell 11	4	6	67%	5	6	83%	9	12	75%
Cache 12	5	6	83%	3	6	50%	8	12	67%
Boudreau 13	4	4	100%	3	5	60%	7	9	78%
Sum-All Sites	57	77	74%	38	80	48%	48	157	30%
Sum-Peace R.	24	36	67%	12	34	35%	18	70	26%
Sum-Tributaries	33	41	80%	26	46	57%	30	87	34%

Table 19: **Examples of observed large variations in analysis results of sampled parameters between original and duplicate samples taken from the Peace River and Moberly River in 2008.**

Site	**PEACE 1**		**PEACE 1**		**PEACE 1**		**PEACE 3**		**PEACE 5**		**MOBERLY 6**	
Sample Period	10-Jun-08		26-Aug-08		28-Oct-08		08-Jul-07		08-May-08		27-Feb-08	
Physical Tests (mg/L except as noted)												
TSS	<3.0	<3.0	<3.0	<3.0			51.5	35.5	1640	1440		
Turbidity (NTU)							51.5	35.5	1110	738		
Anions and Nutrients (mg/L except as noted)												
Total Phosphate							0.0712	0.044				
Metals (mg/L except as noted)												
Aluminum-D	0.0039	0.0064										
Manganese-D			0.000664	0.000855								
Organic Parameters (mg/L except as noted)												
Chlorophyll *a* (µg/L)									0.0929	0.418		
Total No. of Large Variations (1)	1		1		0		2		2		0	

Notes:

(1) "large variations" are interpreted as near double or more between parameters.

Variation in Peace 1 duplicates for June and August do not appear to be associcatted with variation in TSS for the same dates.

Table 20: **A summary of the total number of observed exceedences of method detection limits within a travel blank taken in 2008.**

Sample Period	09-May-08
ALS Sample ID	L628019-5
No. >MDL.	1
Total Parameters Tested	39
% > MDL.	3%

Table 21: **Comparisons in discharge measurements from Lynx, Farrell, Cache and Boudreau creeks between 2007 and 2008.**

	MEASUREMENT DATES											
Sample Site	16-Apr-07	April - 08 (5)	17-May-07	5-May-08	6-Jun-07	12-Jun-08	8-Jul-07	10-Jul-08	16-Aug-07	26-Aug-08	Oct. - 07 (6)	28-Oct-08
Lynx 10	n/a (1)	n/a	1.324	1.383	0.929	0.421	2.020	0.143	0.152	0.152	n/a	0.177
Farrell 11	n/a (1)	n/a	4.102	n/a (1)	2.750	1.720	0.310	0.240	0.210	0.410	n/a	0.050
Cache 12 (4)	n/a (1)	n/a	0.885	n/a (7)	0.152	0.127	0.480	n/a (7)	n/a (3)	n/a (3)	n/a	0.001
Boudreau 13 (4)	n/a (2)	n/a	0.004	0.02	n/a (3)	n/a (3)	n/a (3)	n/a (3)	n/a (3)	n/a (3)	n/a	n/a (3)

(1) Streams too high to wade.

(2) Site not established yet.

(3) No discernable water velocity by flow meter.

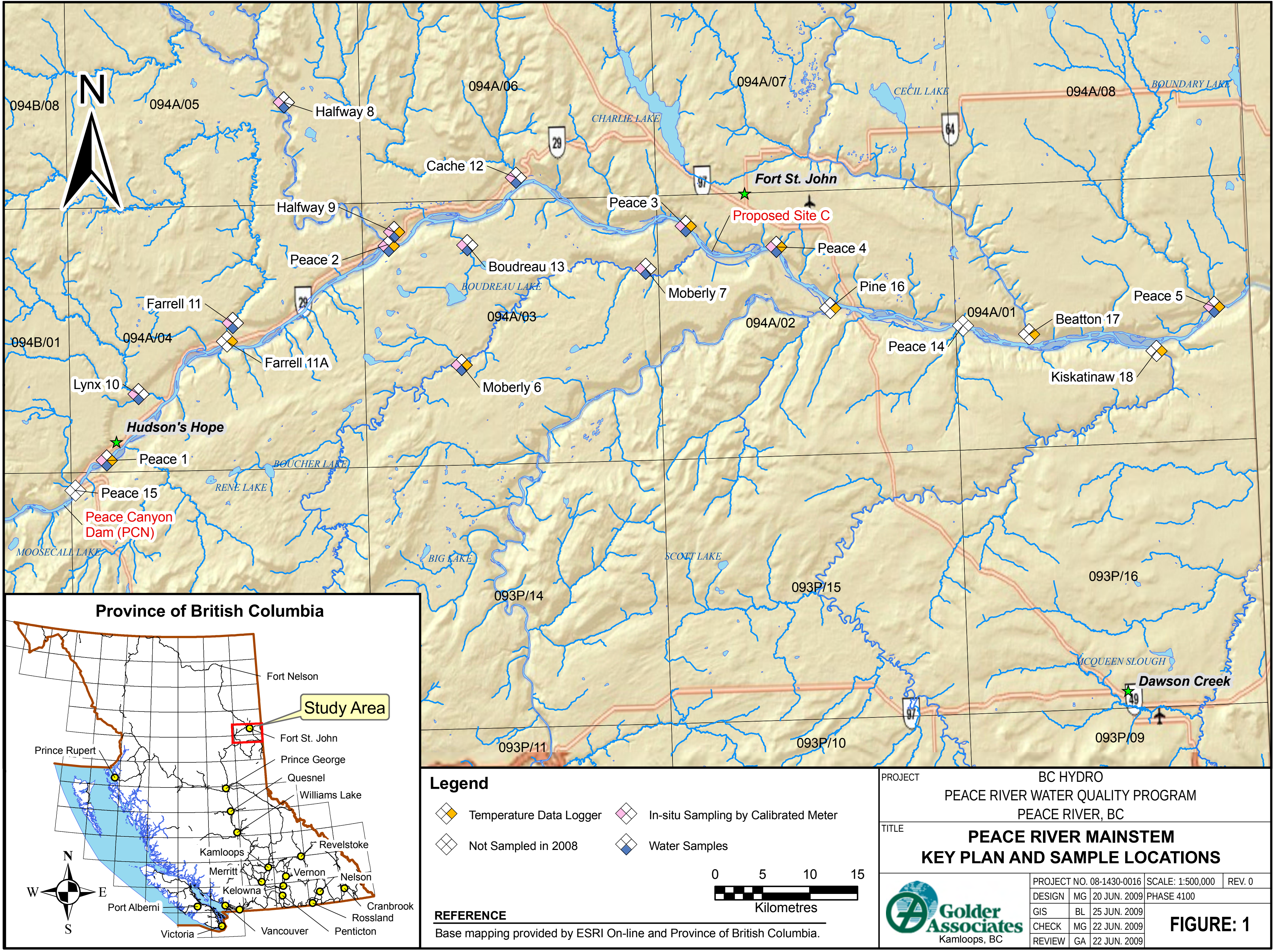
(4) Boudreau and Cache Creek measuring dates within one day of those of other tributaries.

(5) No sampling in April 2008.

(6) No sampling in October 2007.

(7) Site inaccessible due to bridge replacement work.

N:\Graphics\2008\1430 Kamloops\08-1430-0016 BC Hydro Peace River Water Quality Extension\GIS\2009\Figure 1.mxd



Legend

◈ Temperature Data Logger

◈ In-situ Sampling by Calibrated Meter

◇ Not Sampled in 2008

◈ Water Samples

0 5 10 15
Kilometres

REFERENCE

Base mapping provided by ESRI On-line and Province of British Columbia.

PROJECT
BC HYDRO
PEACE RIVER WATER QUALITY PROGRAM
PEACE RIVER, BC

TITLE
PEACE RIVER MAINSTEM KEY PLAN AND SAMPLE LOCATIONS

Golder Associates
Kamloops, BC

PROJECT NO. 08-1430-0016		SCALE: 1:500,000	REV. 0
DESIGN	MG	20 JUN. 2009	PHASE 4100
GIS	BL	25 JUN. 2009	
CHECK	MG	22 JUN. 2009	FIGURE: 1
REVIEW	GA	22 JUN. 2009	

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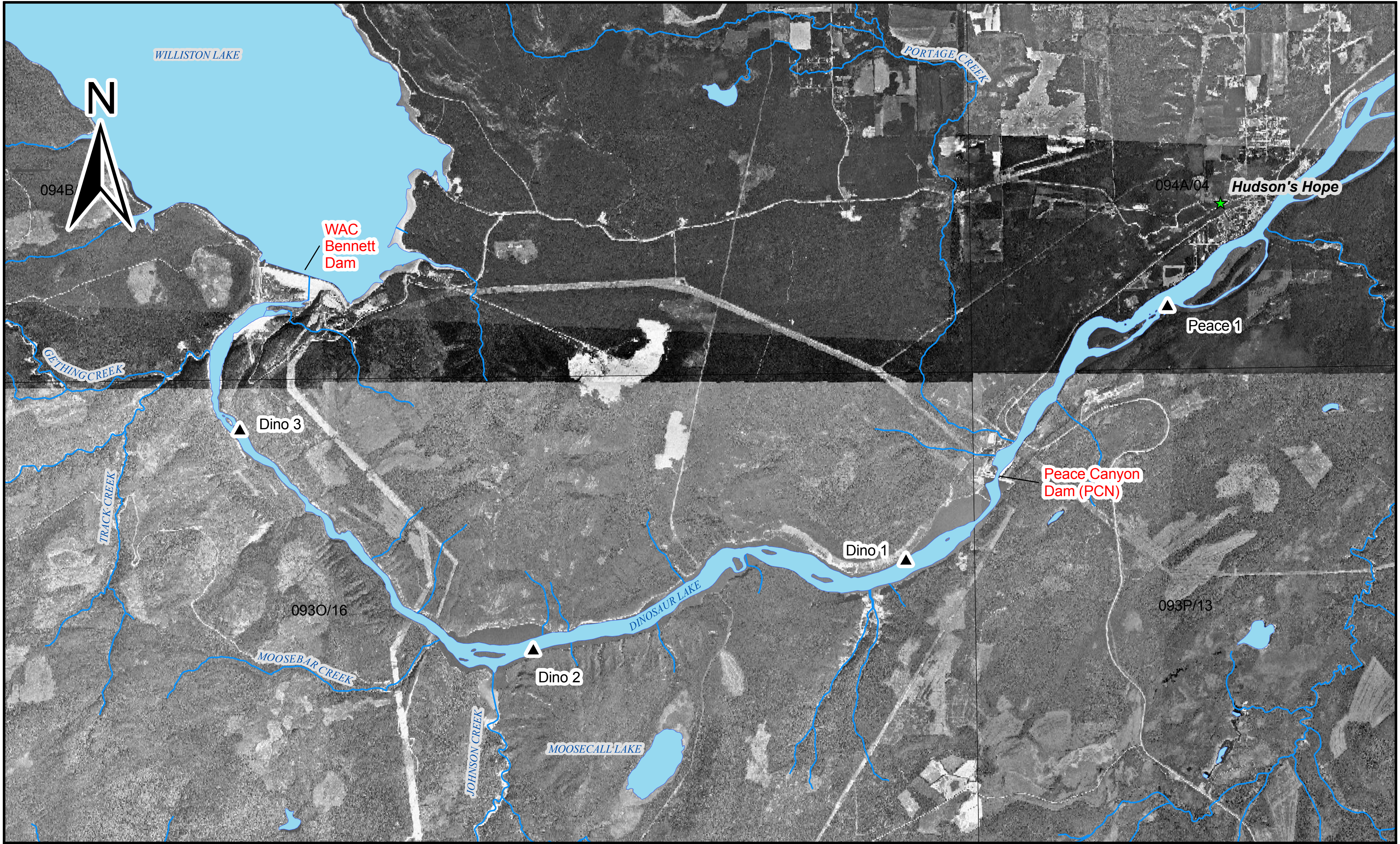


Legend

▲ Sample Sites

★ Place Names

0 1 2 3 4

Kilometres

REFERENCE

Base mapping provided by ESRI On-line and Province of British Columbia.

PROJECT
BC HYDRO
PEACE RIVER WATER QUALITY PROGRAM
PEACE RIVER, BC

TITLE
DINOSAUR LAKE
LIMNOLOGY SAMPLE STATIONS

Golder Associates
Kamloops, BC

PROJECT No. 08-1430-0016		SCALE: 1:100,000	REV. 0
DESIGN	MG	20 JUN. 2009	
GIS	BL	25 JUN. 2009	
CHECK	MG	22 JUN. 2009	
REVIEW	GA	22 JUN. 2009	

FIGURE 2

Figure 3: Daily mean, maximum, and minimum water temperatures recorded by temperature data loggers plotted with discharge in the Peace River from November 2006 to October 2008.

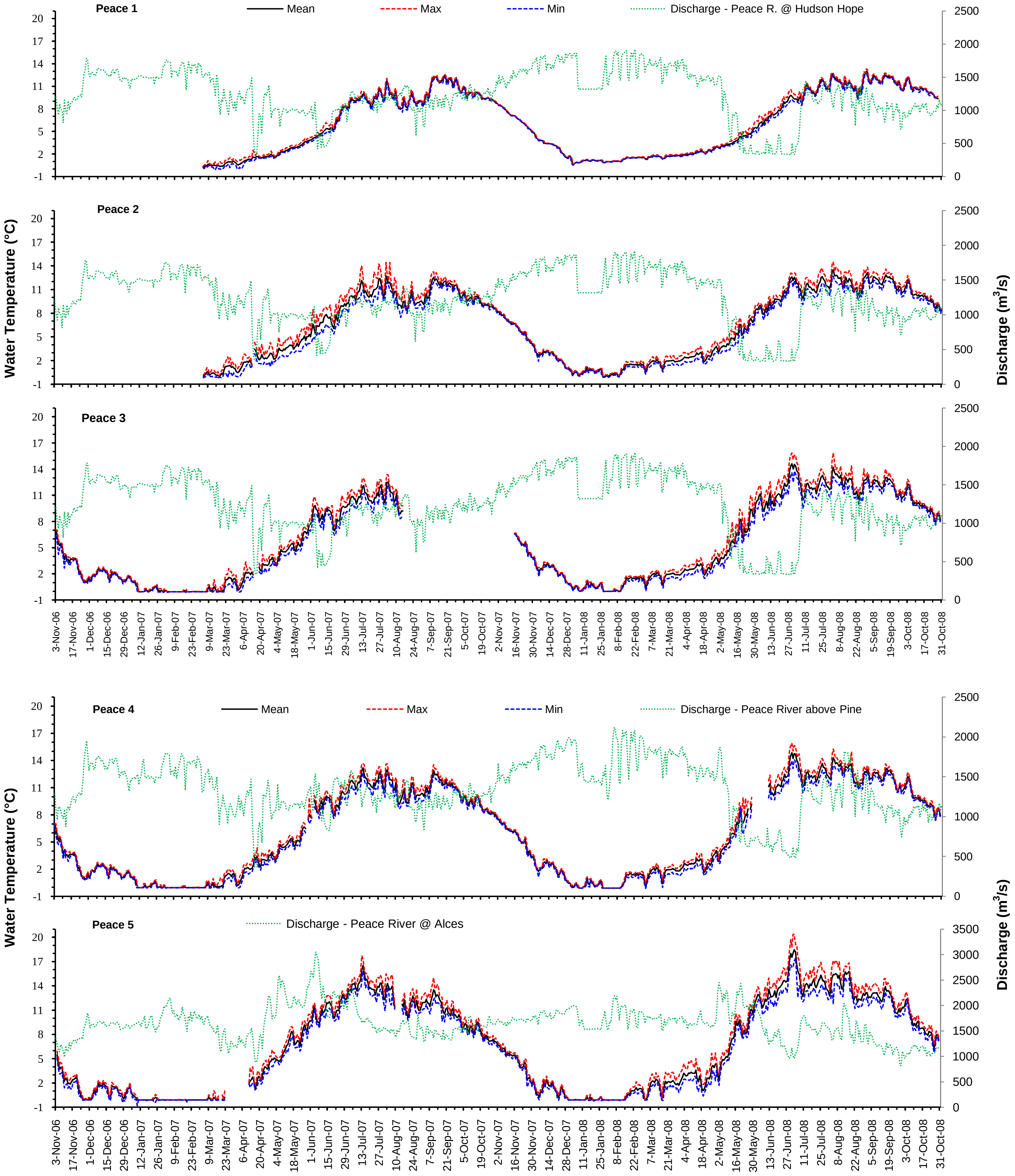


Figure 4: Daily mean, maximum, and minimum water temperatures recorded by temperature data loggers plotted against discharge in Peace River tributaries from November 2006 to October 2008. 2008 WSC discharge data are preliminary and subject to change.

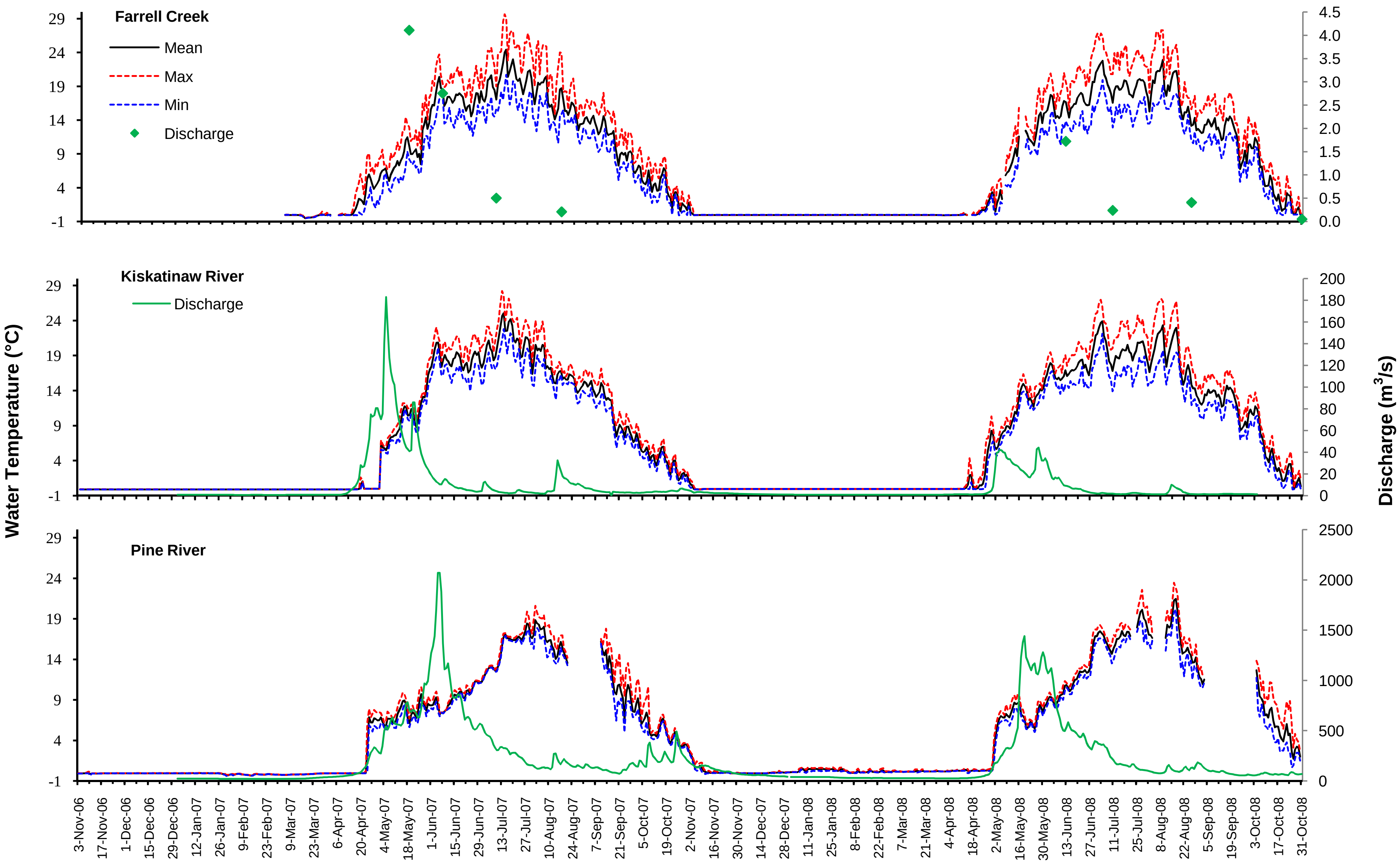


Figure 4: Daily mean, maximum, and minimum water temperatures recorded by temperature data loggers plotted against discharge in Peace River tributaries from November 2006 to October 2008. 2008 WSC discharge data are preliminary and subject to change.

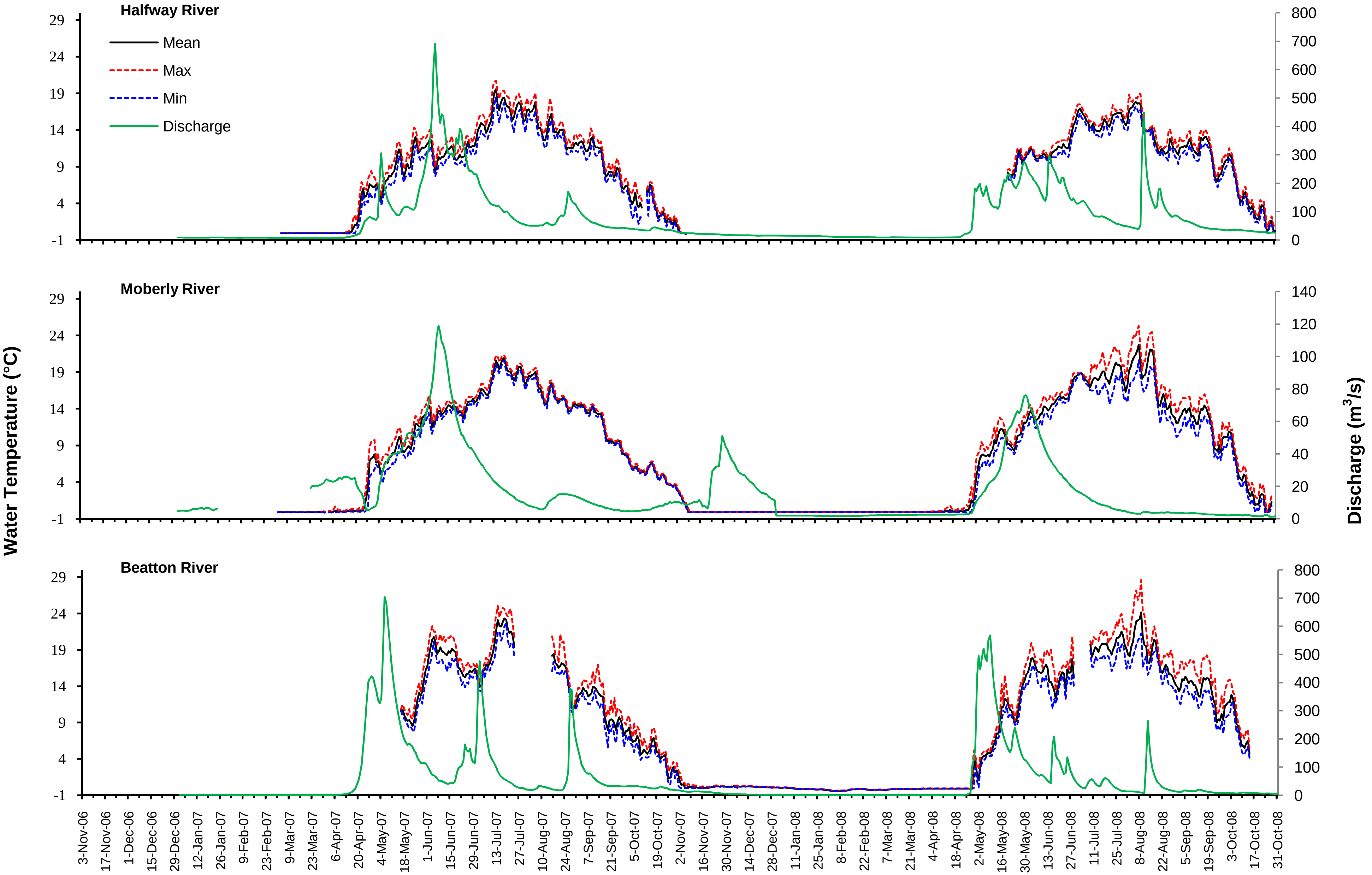


Figure 5: A comparison of mean water temperatures in the Peace River between 2007 and 2008.

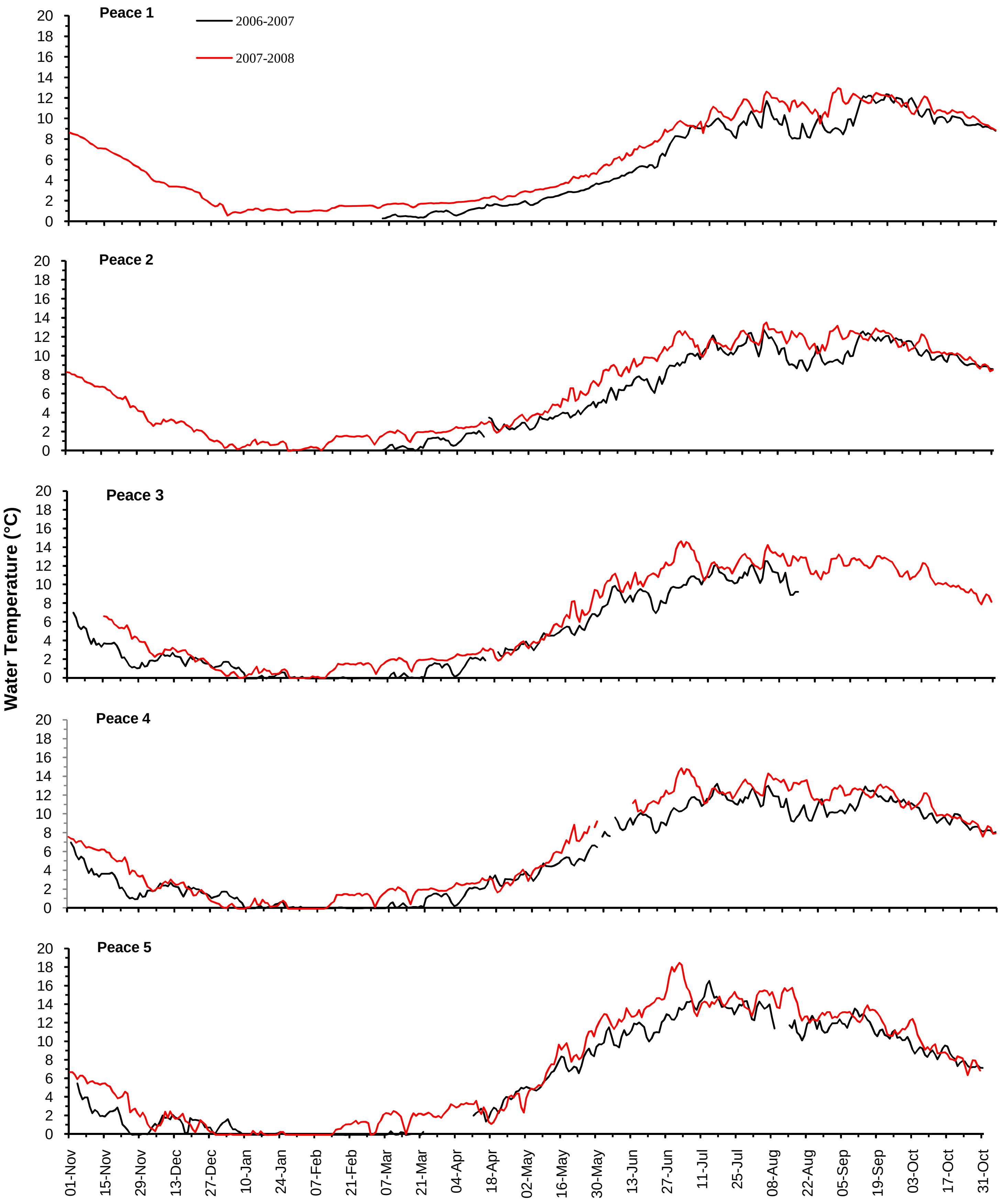


Figure 6: A comparison of mean water temperatures in Peace tributaries between 2007 and 2008.

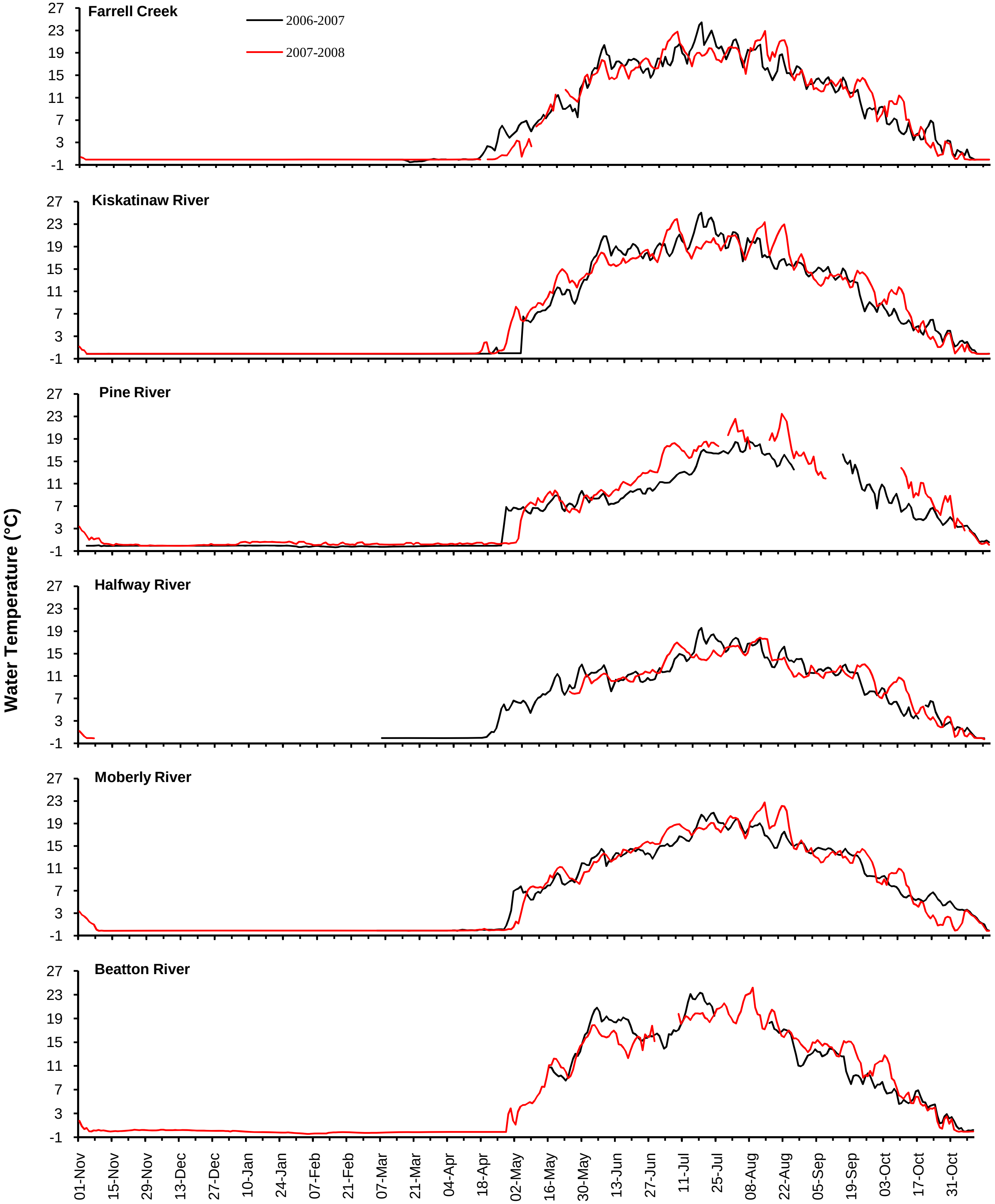


Figure 7: A comparison of mean monthly water temperatures in the Peace River between November 2006 and October 2008. Markers with solid colour represent a complete month of temperature data, and therefore an actual mean.

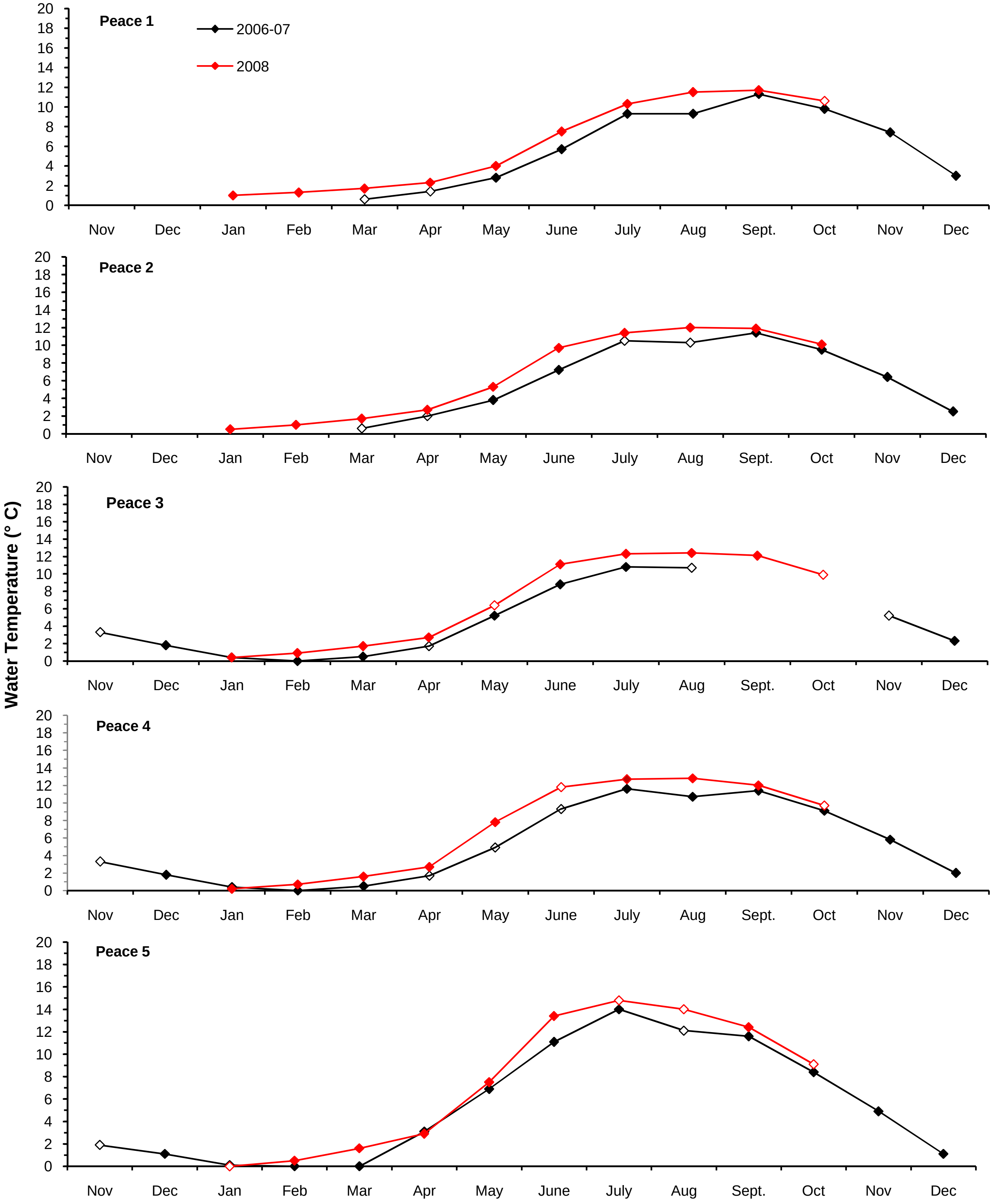


Figure 8: A comparison of mean monthly water temperatures in Peace tributaries between November 2006 and October 2008. Markers with solid colour represent a complete month of temperature data,

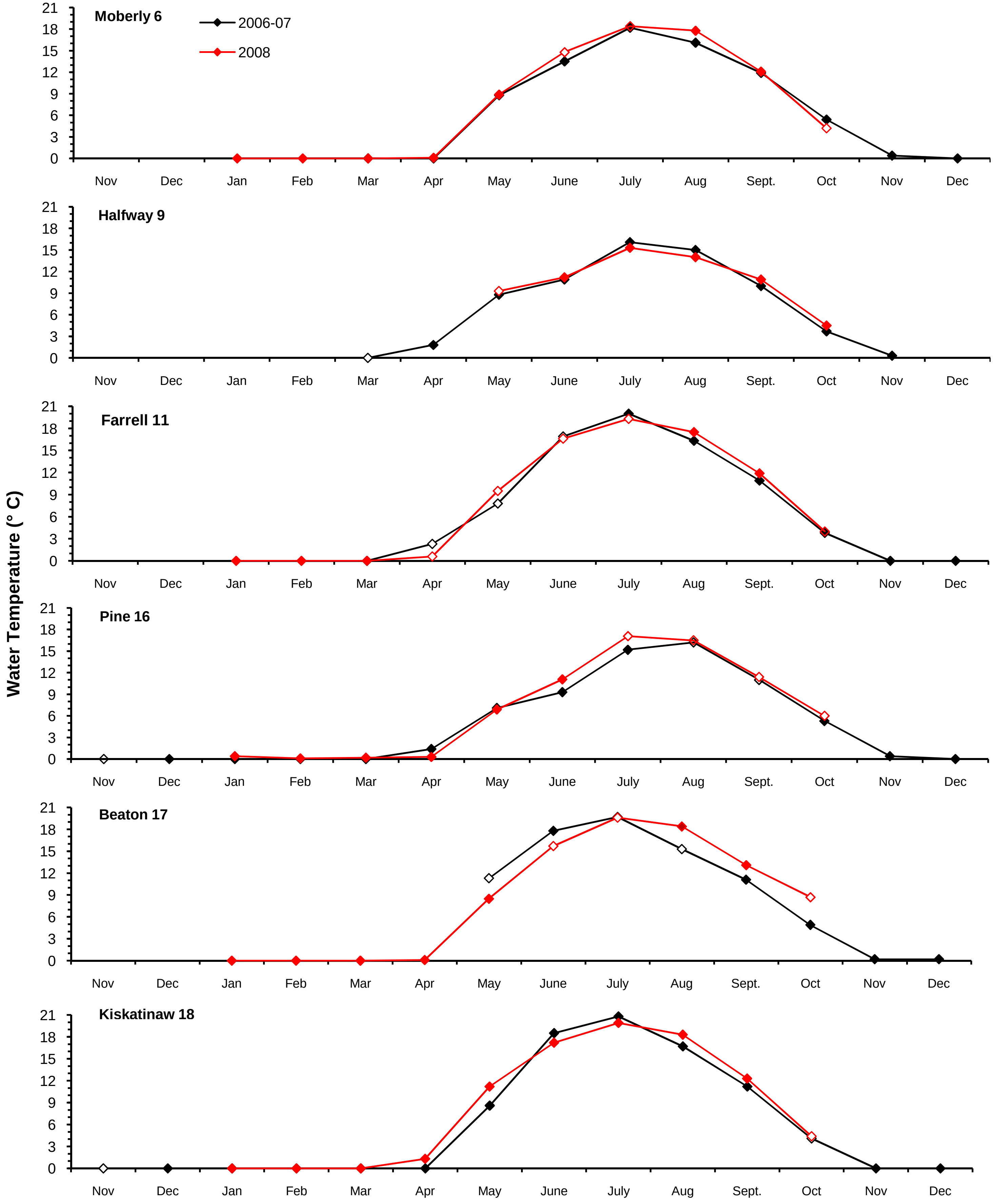


Figure 9: Mean monthly air temperatures recorded by Environment Canada at the Fort St. John weather office from November 2006 to December 2008.

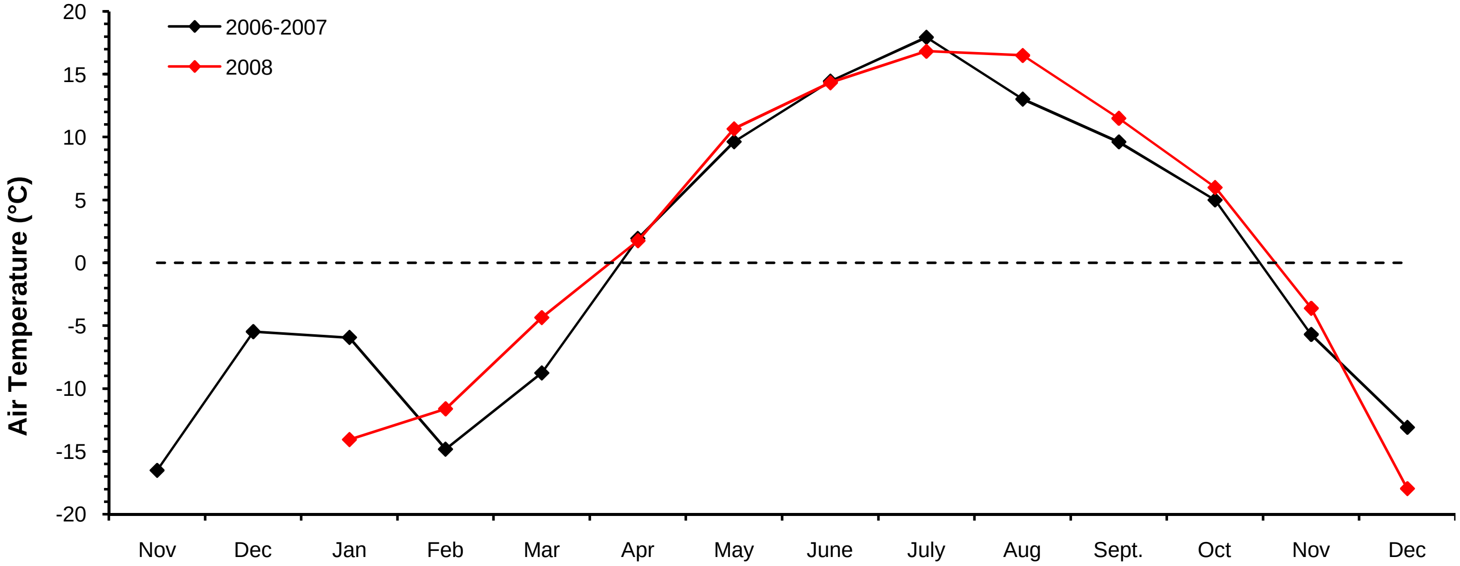


Figure 10: Daily means of water temperature recorded by temperature data loggers at each sample location in Dinosaur Lake during 2008.

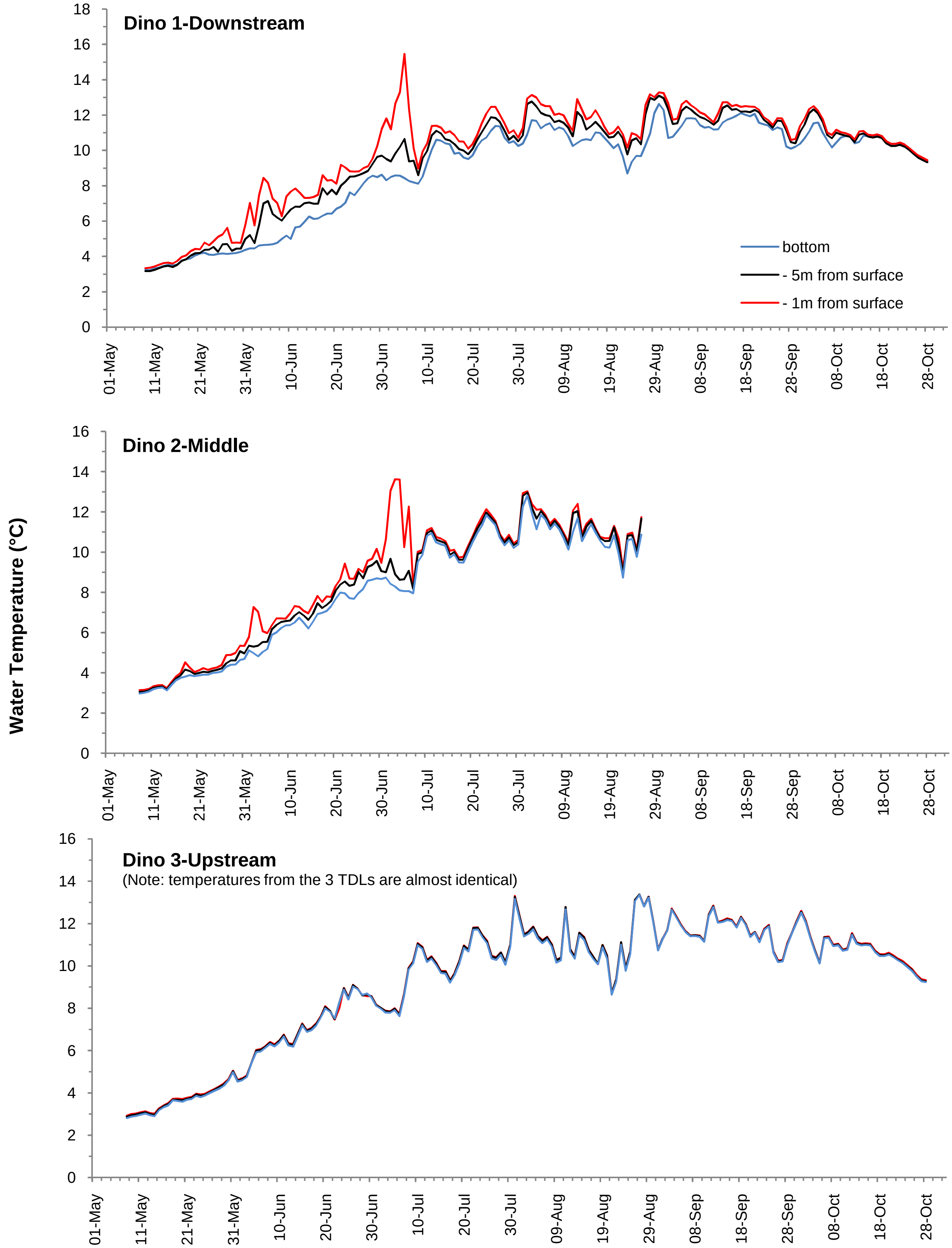


Figure 11: Comparisons between combined means of the daily water temperatures recorded by temperature data loggers from all depths for each sample location in Dinosaur Lake during 2008.

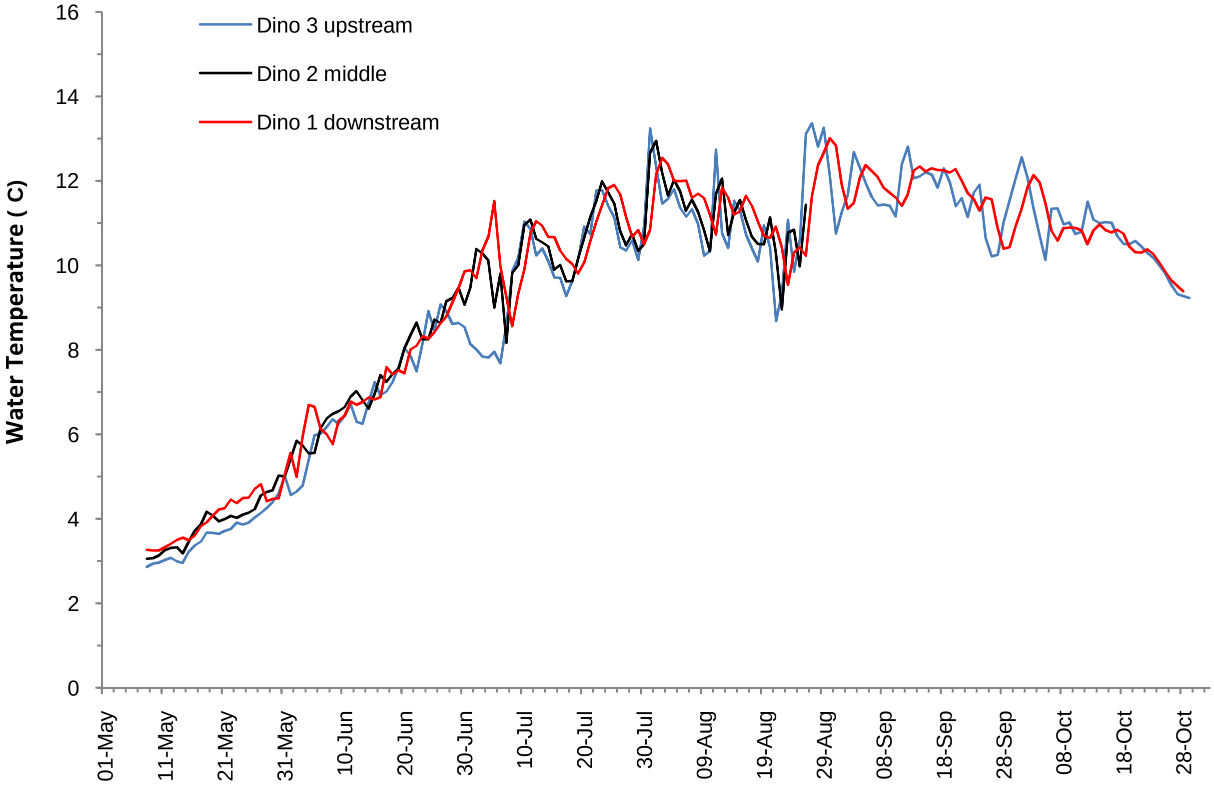


Figure 12: Water temperature profiles observed in Dinosaur Lake in 2008.

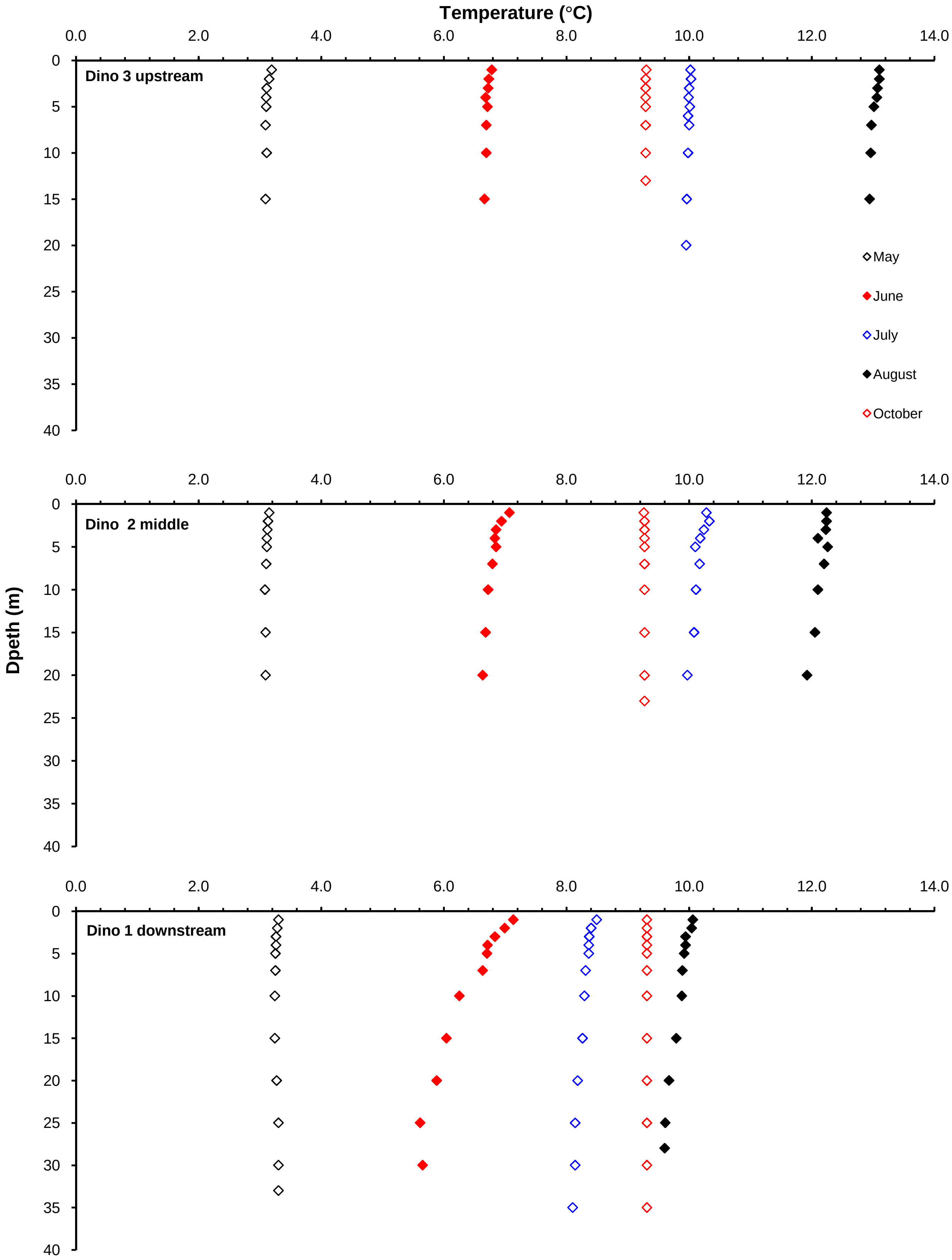


Figure 13: Dissolved oxygen profiles observed in Dinosaur Lake in 2008.

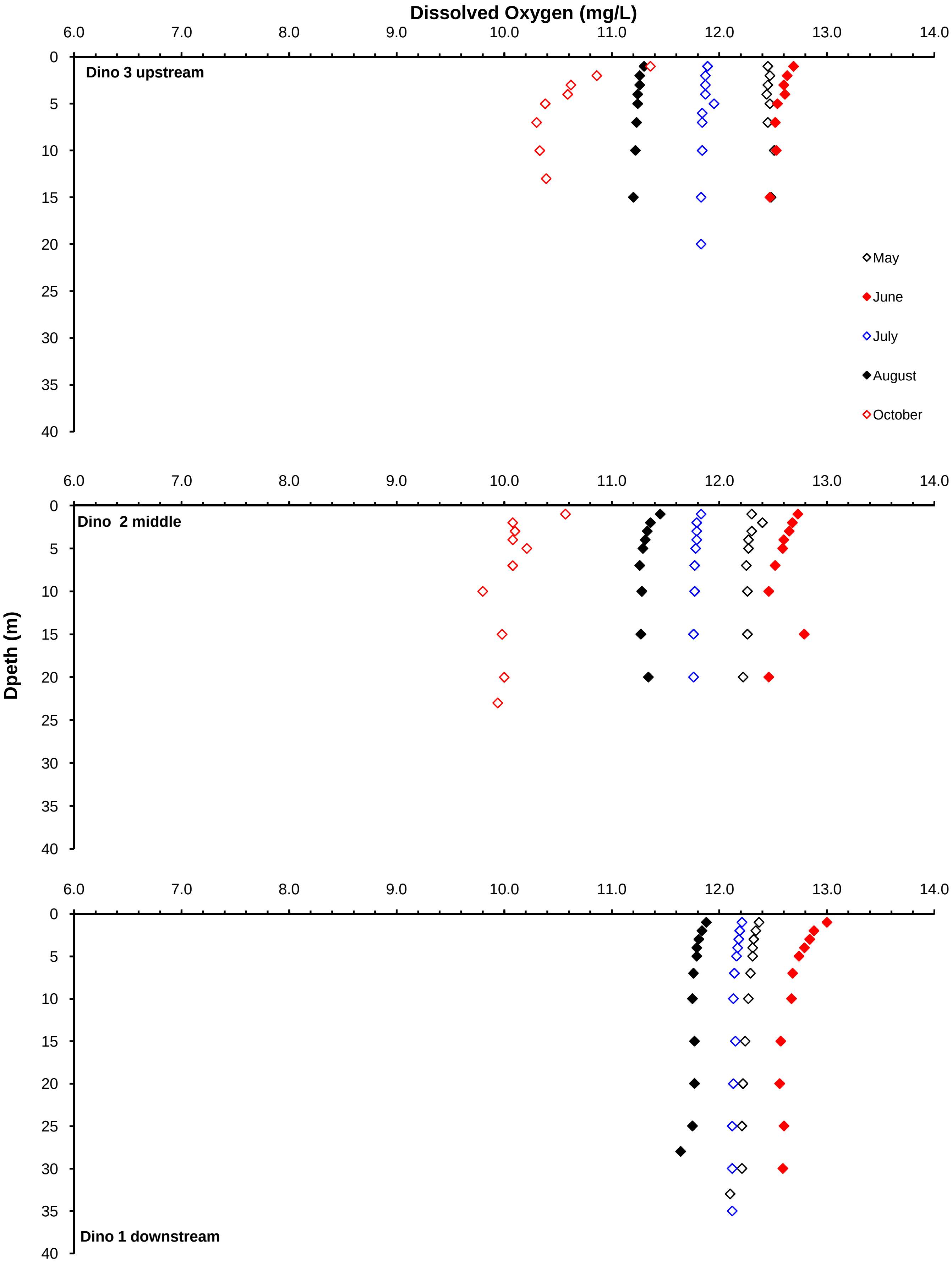


Figure 14: Profiles of pH observed in Dinosaur Lake in 2008.

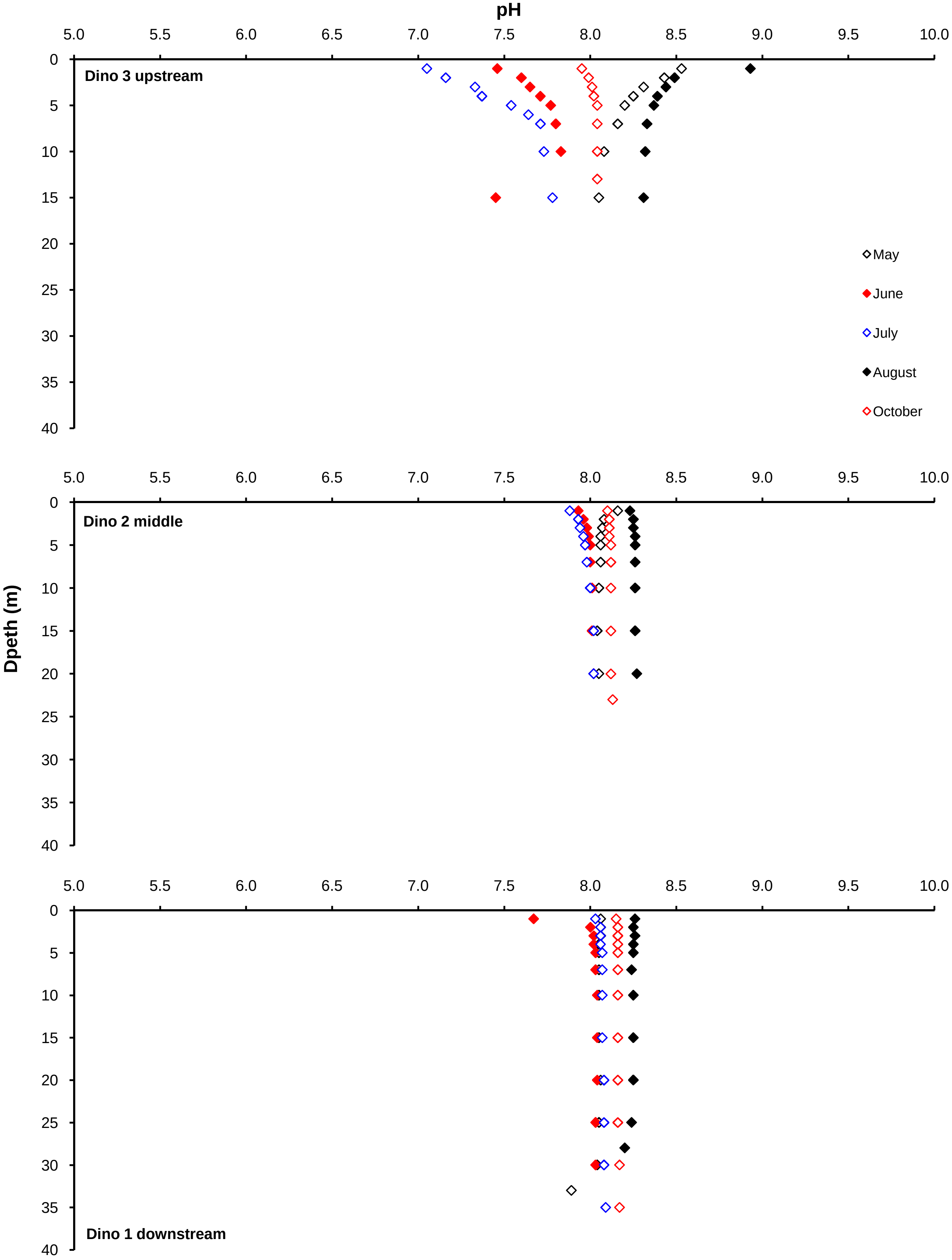


Figure 15: Conductivity profiles observed in Dinosaur Lake in 2008.

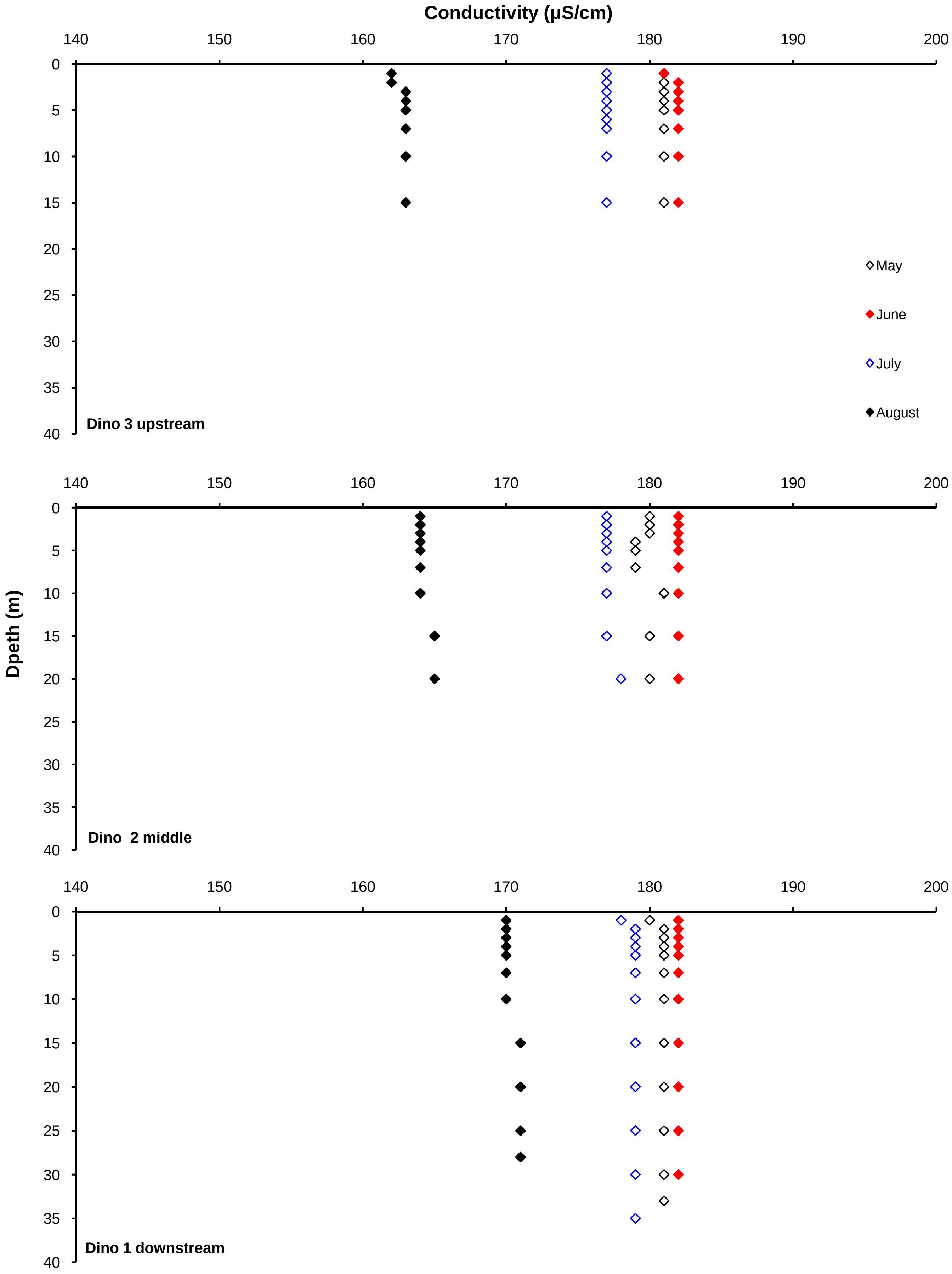


Figure 16: **Total Gas Pressure measured at Peace River sites in 2008.**

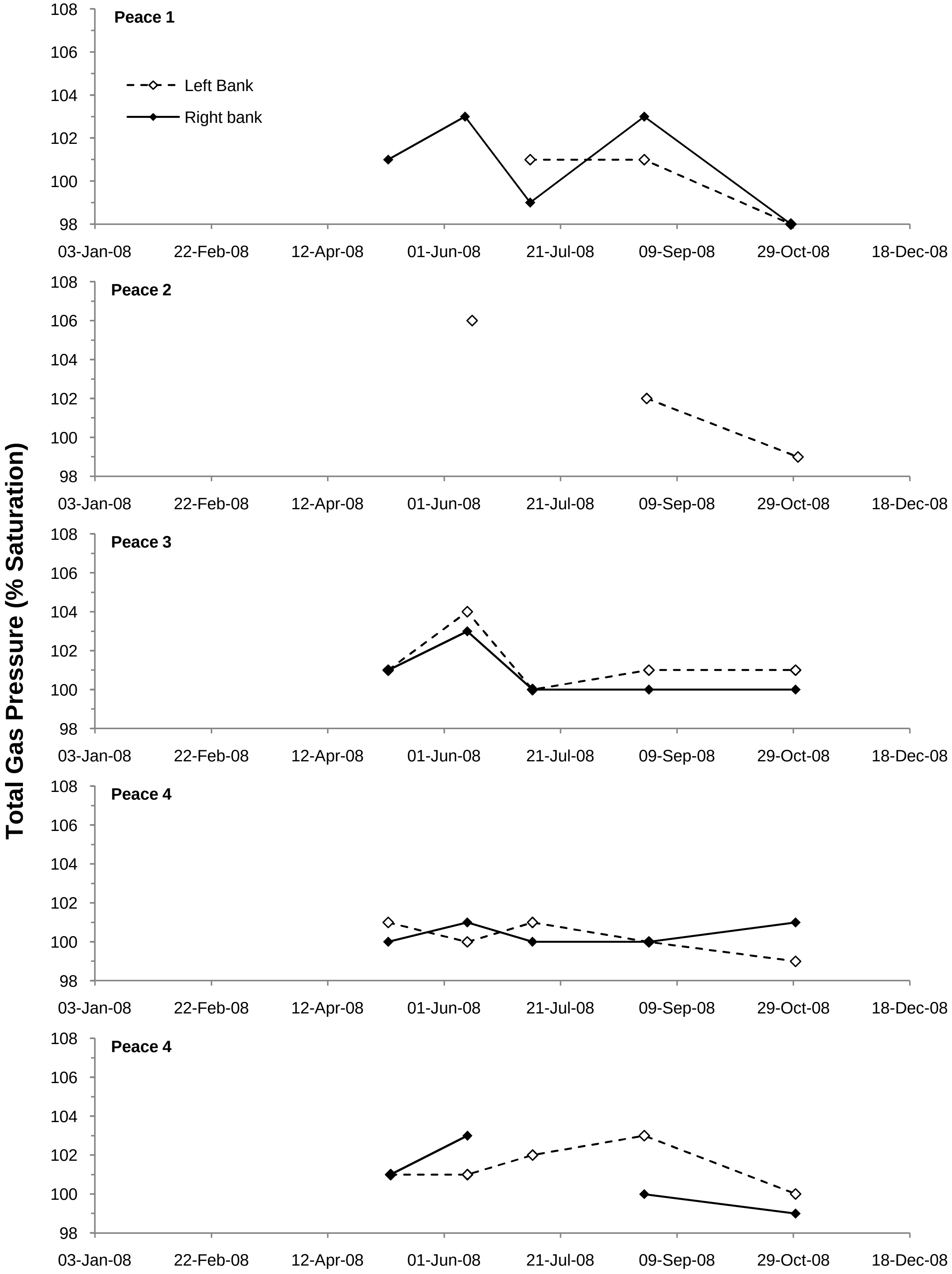


Figure 17: Total Gas Pressure profiles observed in Dinosaur Lake in 2008.

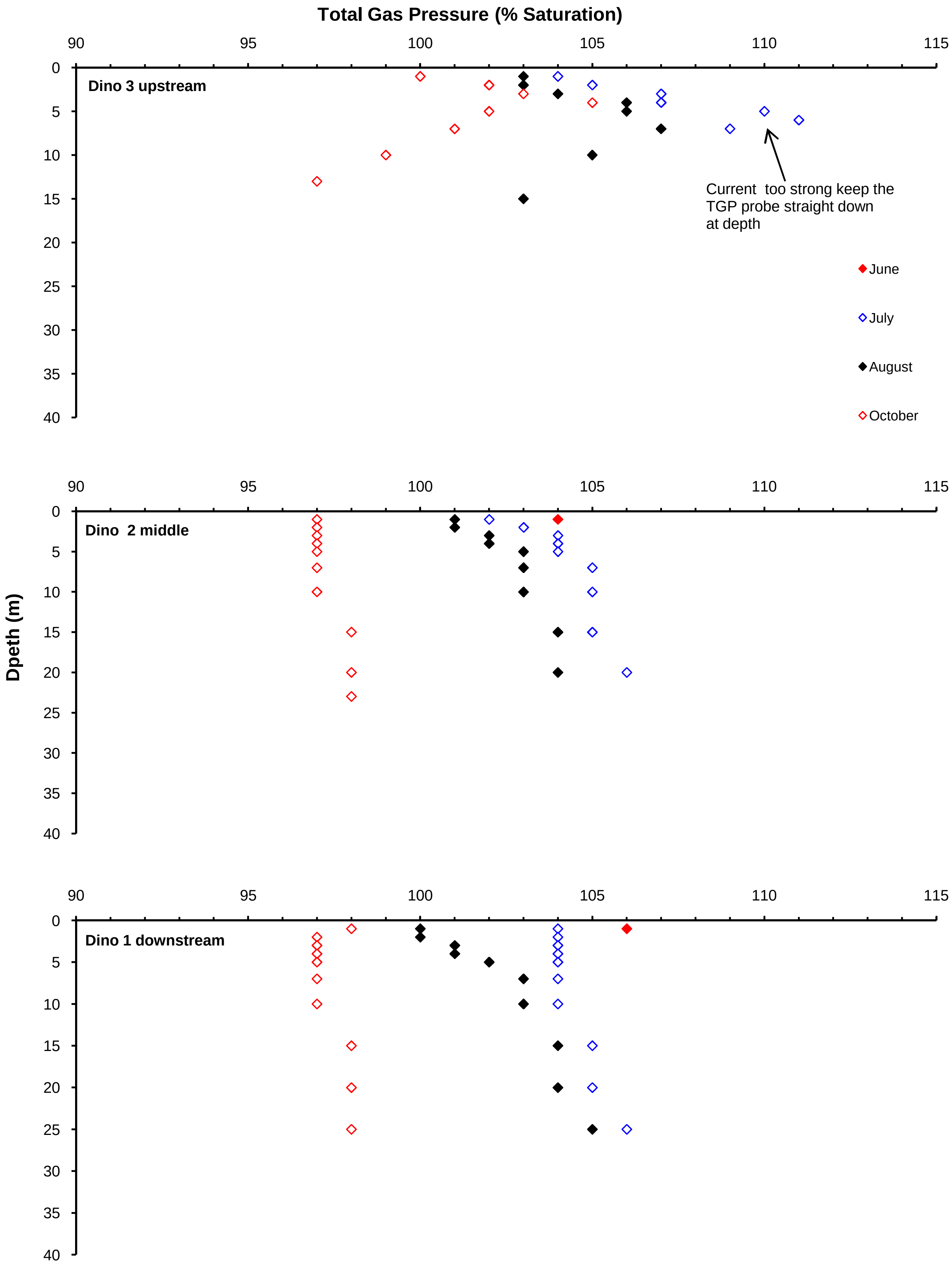


Figure 18: Turbidity and TSS from water sample results compared to discharge measured at WSC stations at the Halfway and Moberly Rivers in 2007 and 2008.

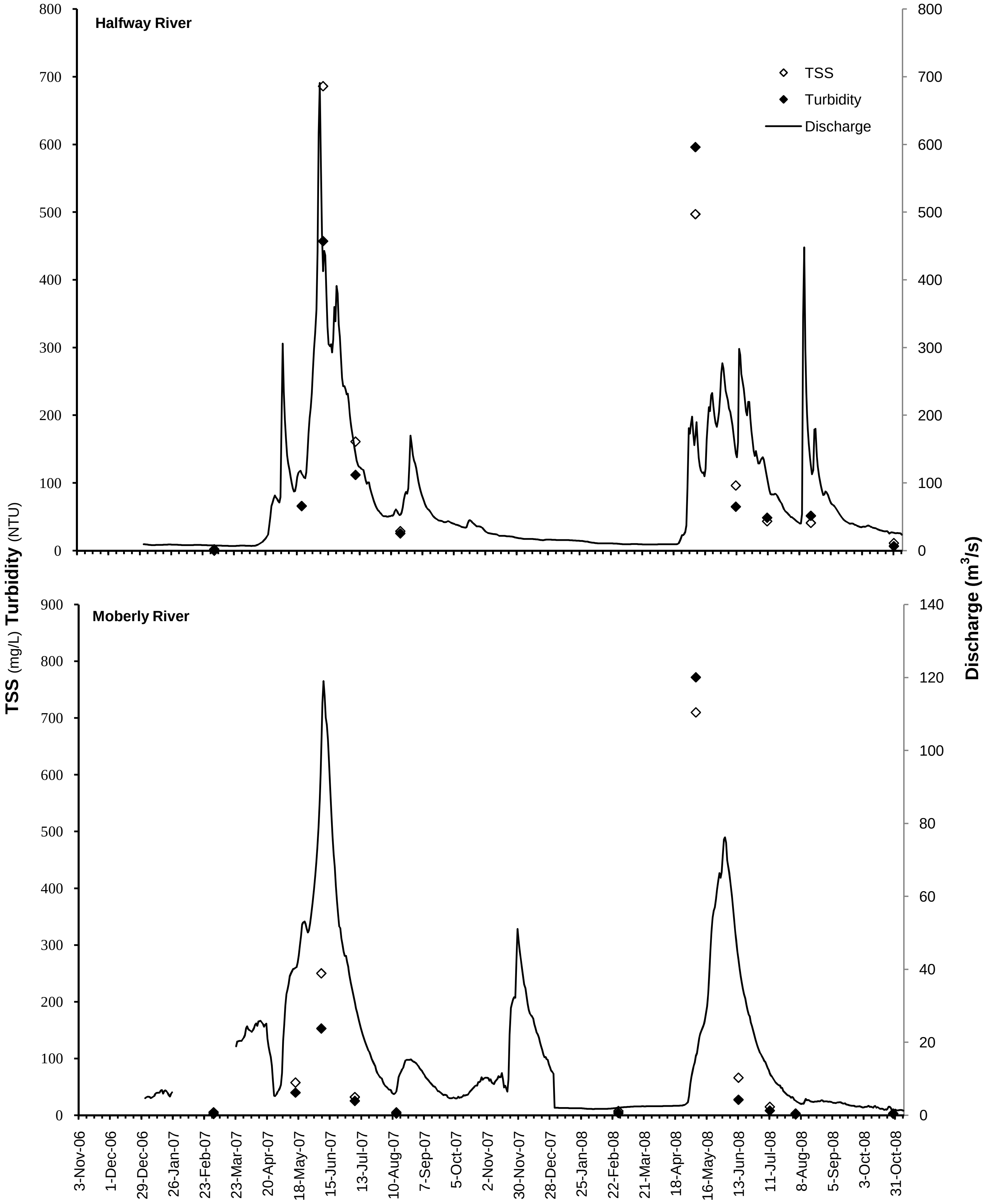


Figure 19: Turbidity and TSS from water sample results plotted against measured discharge for Cache, Lynx, Farrell and Boudreau creeks in 2007 and 2008.

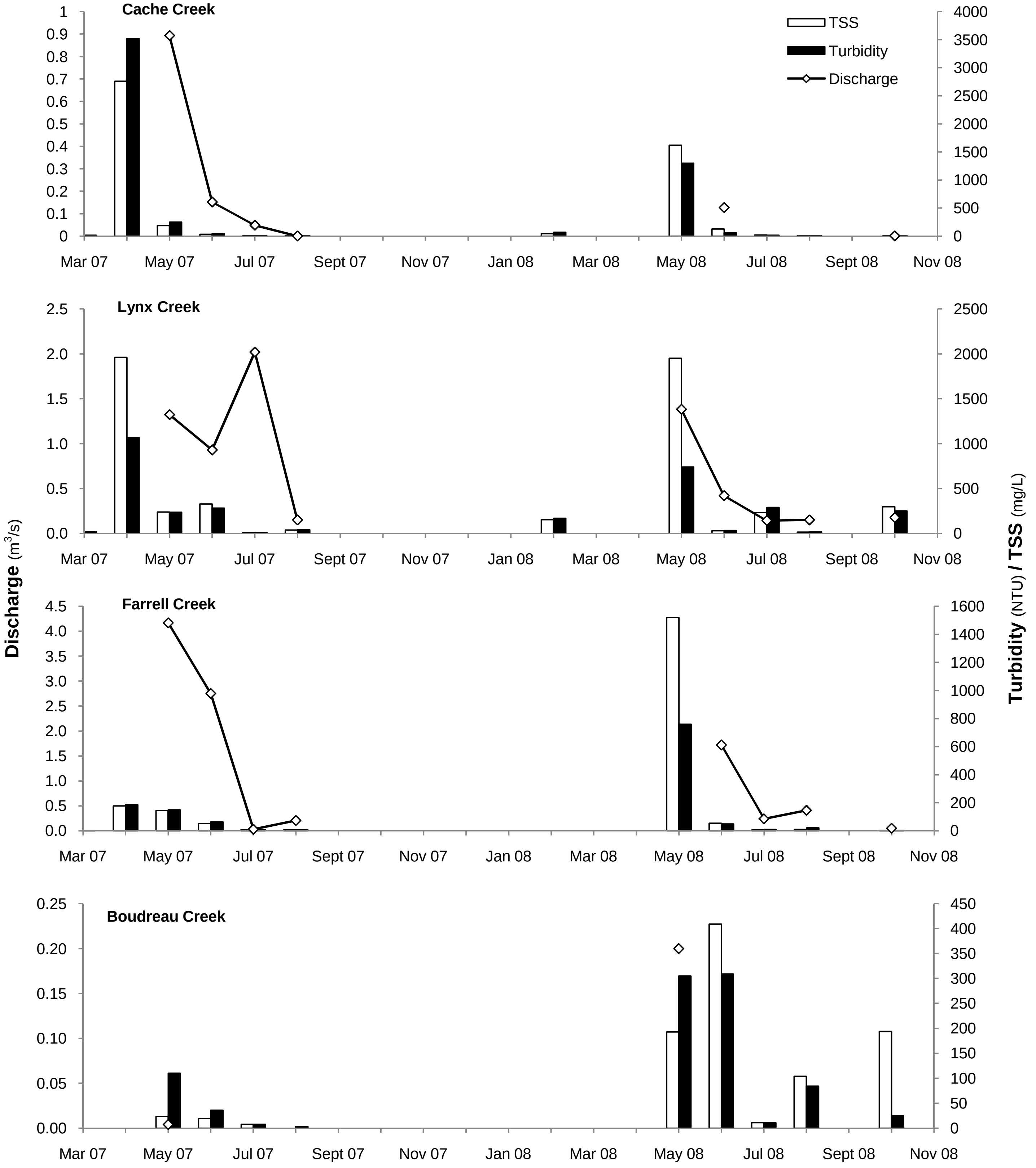


Figure 20: **Discharge recorded at Peace River WSC stations between PCN Dam and the Alberta Border compared to TSS and turbidity results from Peace River water quality monitoring sites.**

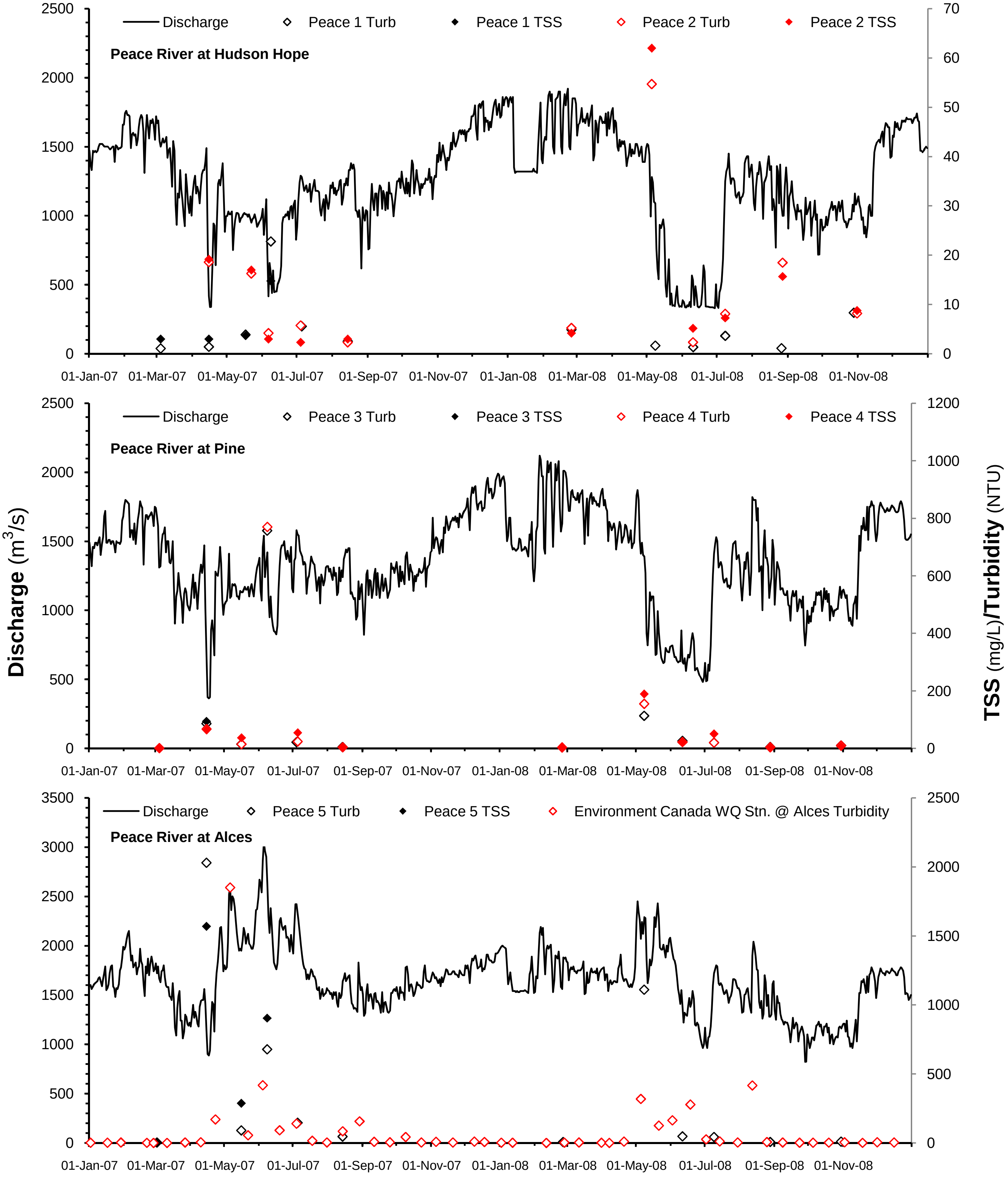


Figure 21: The log-linear relationship between TSS and turbidity derived from 2006-2008 surface water grab samples taken from the Peace River and selected tributaries (lab analysis results).

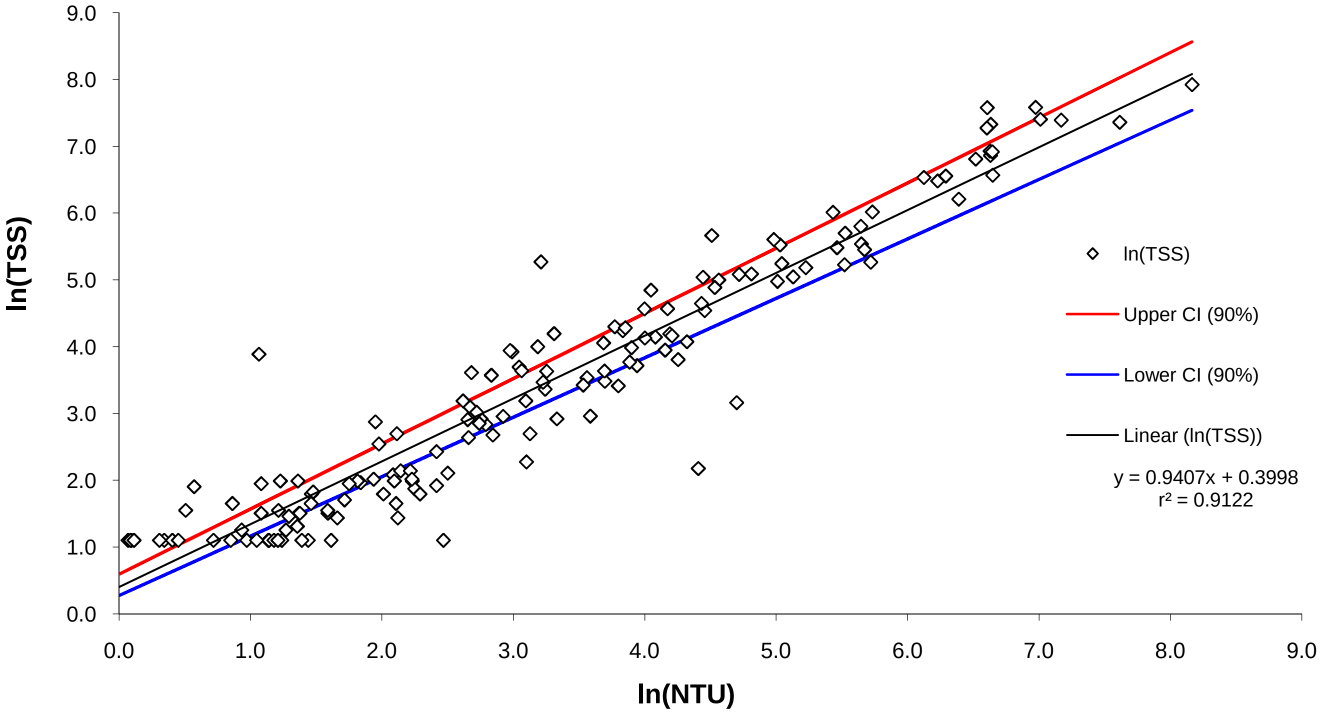


Figure 22: The mean number of individual total metals exceeding BCWQ and/or CCME water quality guidelines for aquatic life per water sample compared to the mean frequency of exceedences per water sample observed at Peace River sample sites for 2007 and 2008.

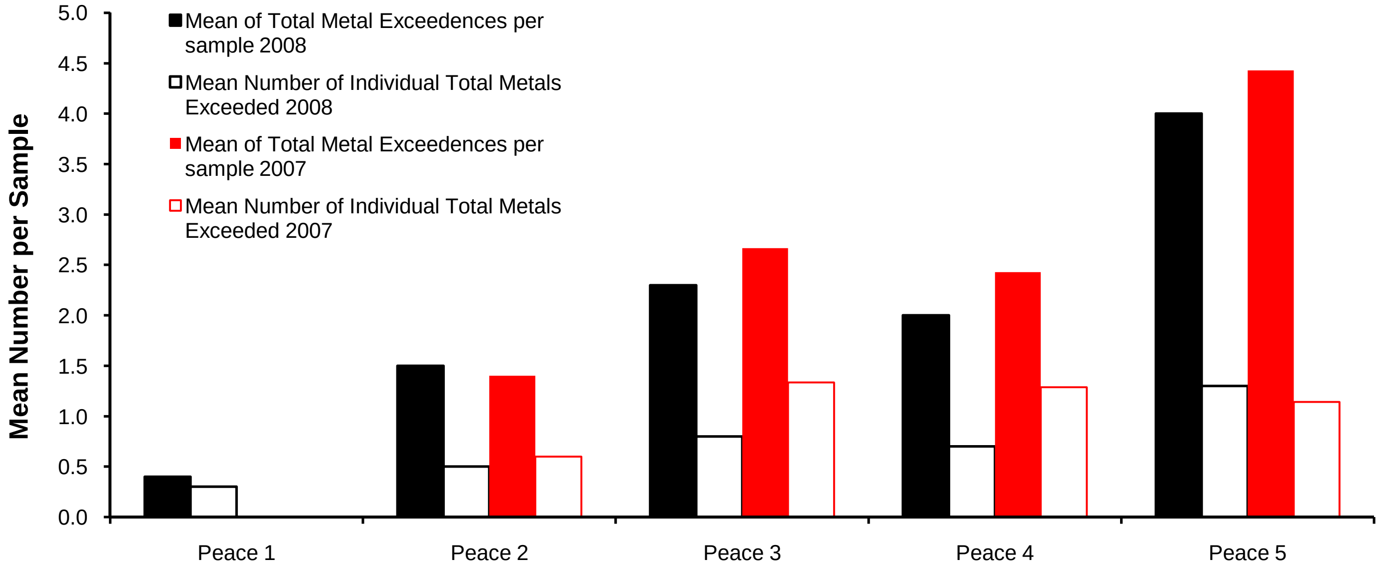


Figure 23: Plots of selected total metals commonly exceeding BCWQ and/or CCME guidelines for aquatic life in the Halfway River over the course of the 2006-2008 sample period. Exceedences are indicated by Open red symbol = BCWQ, solid blue = CCME; solid red = both. Similar plots for other sample sites are provided in Appendix H.

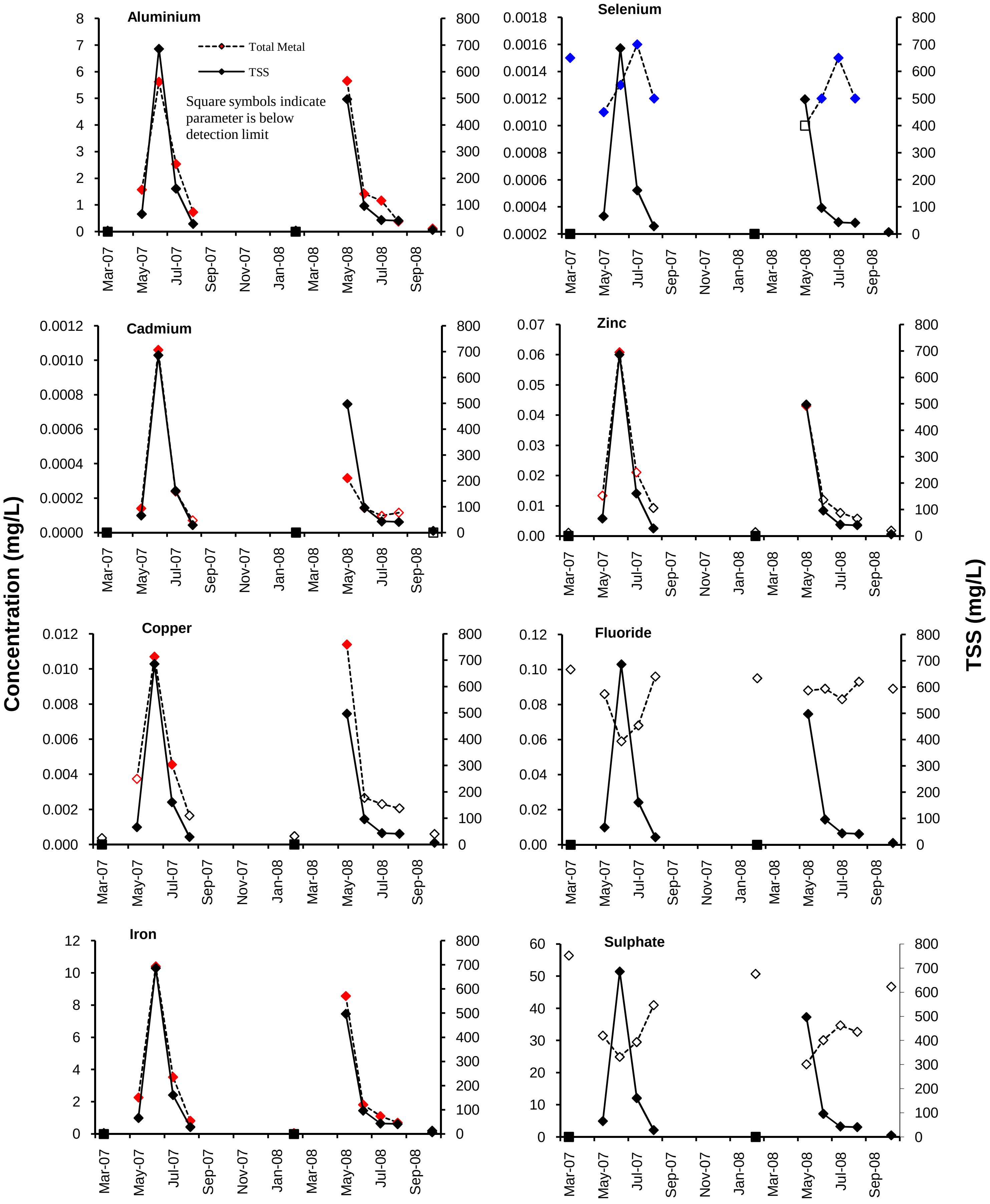


Figure 24: **The mean number of individual dissolved metals exceeding CCME/BCWQ water quality guidelines per sample compared to the frequency of exceedences per sample observed at tributary sample sites in 2007 and 2008.**

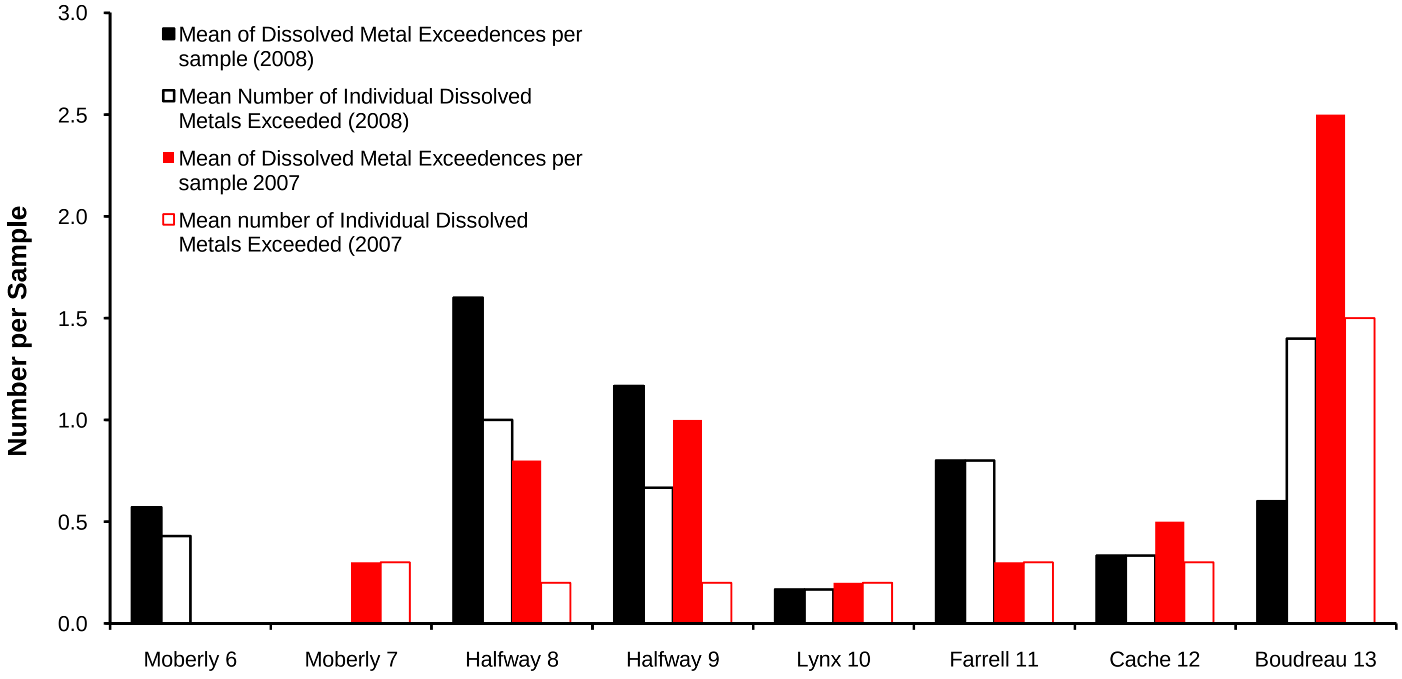


Figure 25: Fluoride concentrations in Lynx and Boudreau creeks in 2007 and 2008. Open red symbols indicate an exceedance of BCWQ guidelines for fresh water aquatic life whereas solid red symbols indicate an exceedence of both CCME/BCWQ guidelines for fresh water aquatic life.

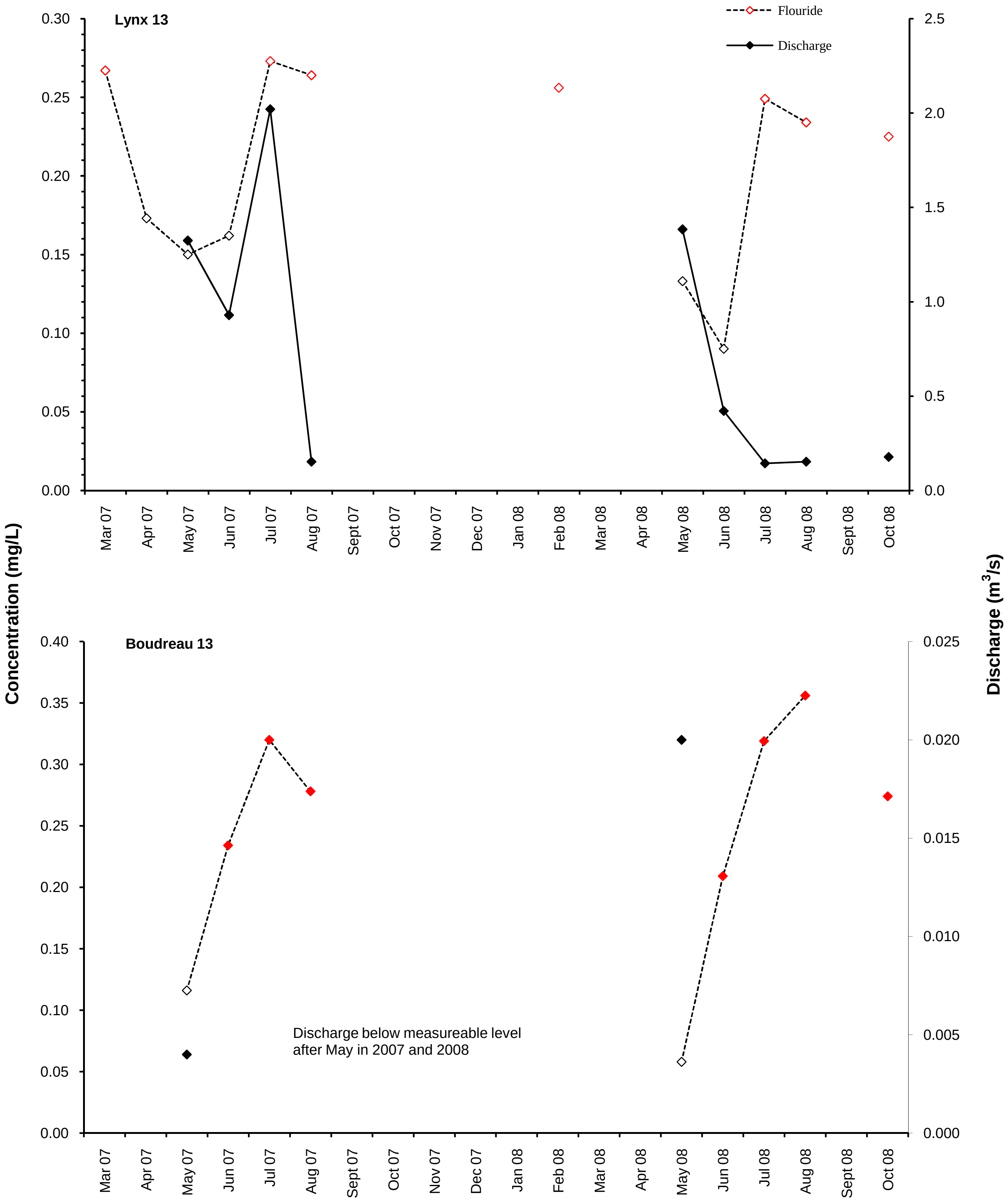


Figure 26: Sulphate concentrations in Lynx and Boudreau creeks in 2007 and 2008. There are no established CCME guidelines for sulphate.

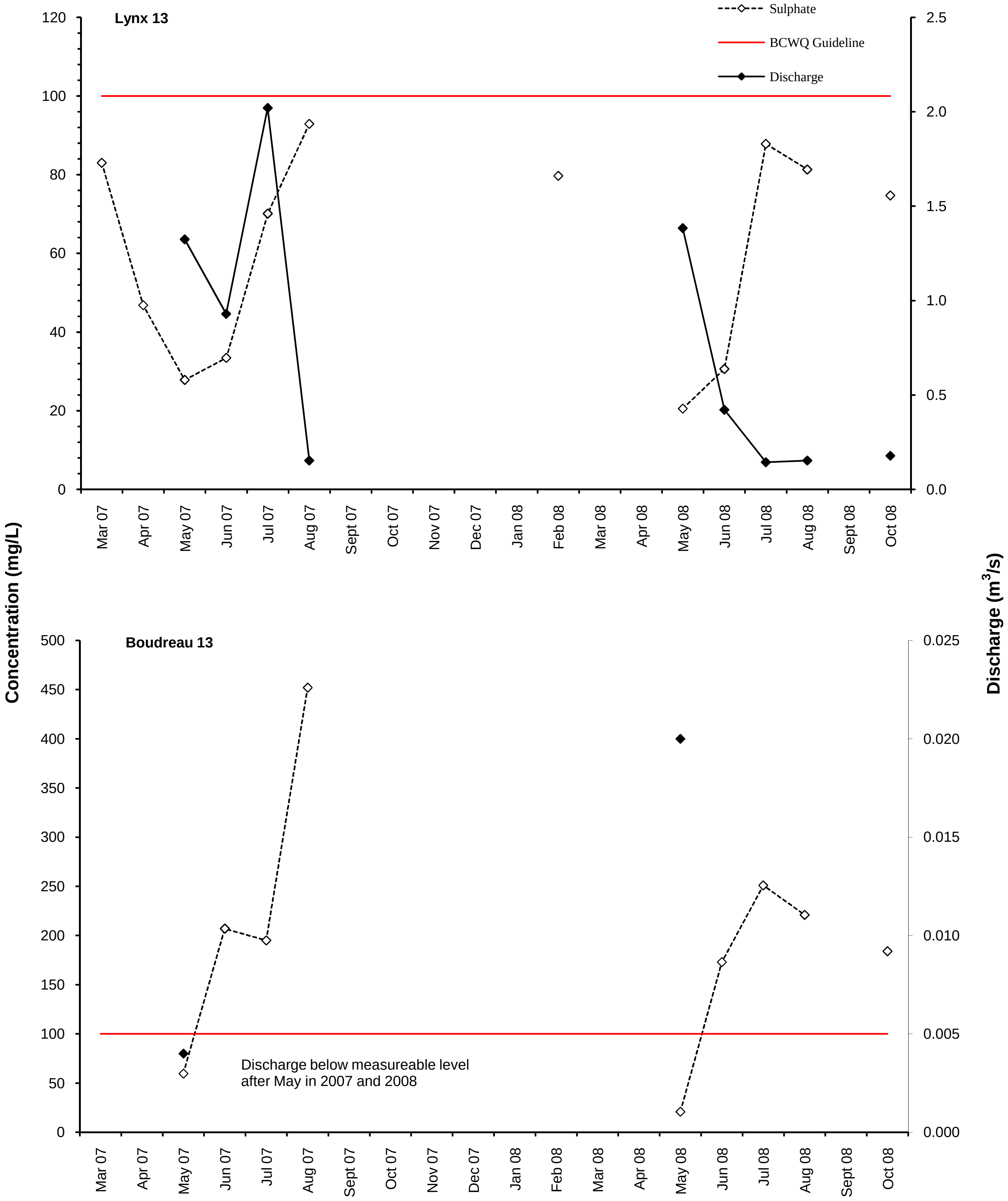


Figure 27: Total Adsorbable Organic Halogen concentrations at Peace River and Peace tributary sites between November 2006 and October 2008. Values below detection limits are shown as at the MDL.

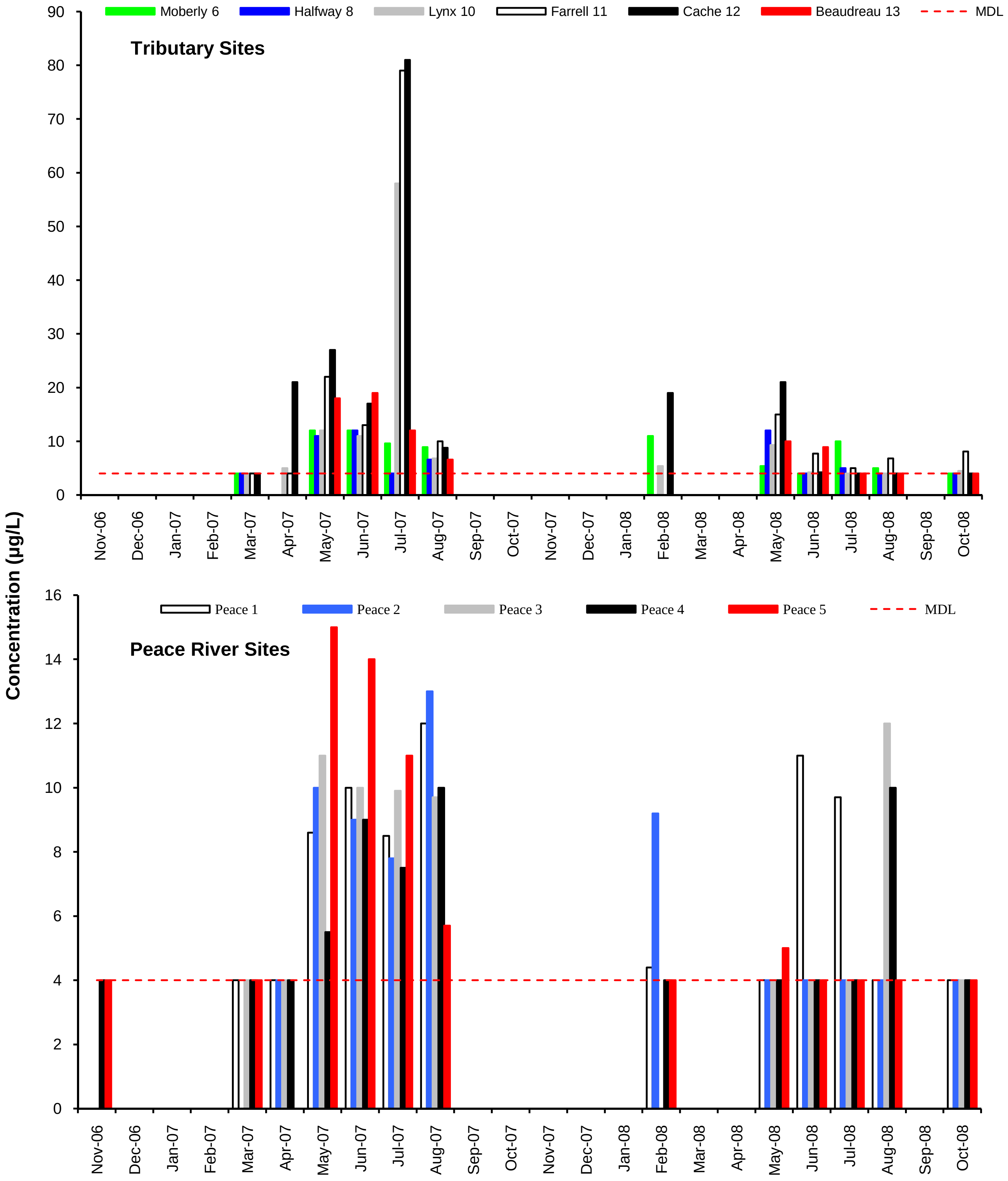


Figure 28: **Chlorophyll *a* concentrations at Peace River mainstem sites and accompanying orthophosphate concentrations in 2007 and 2008.**

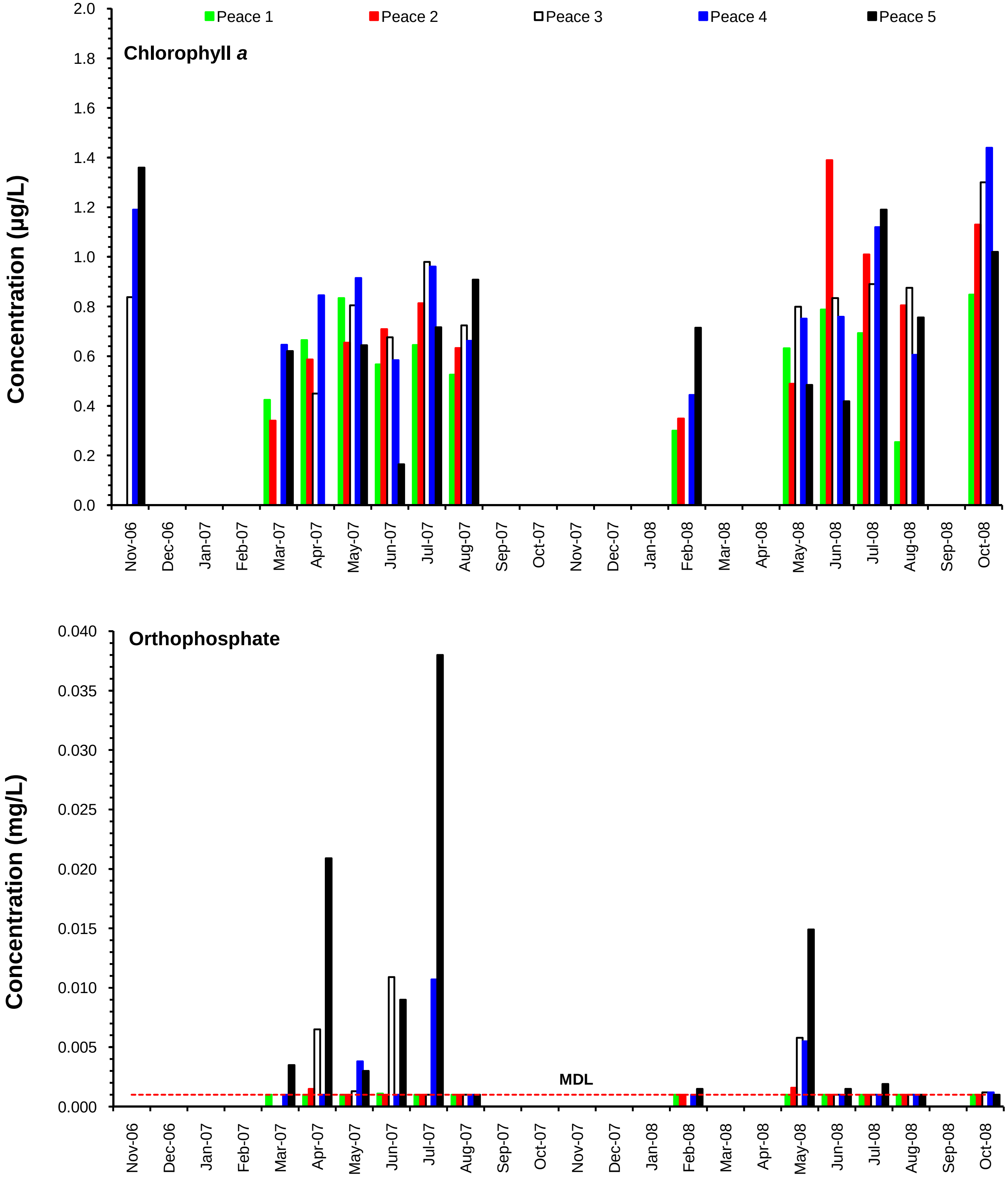
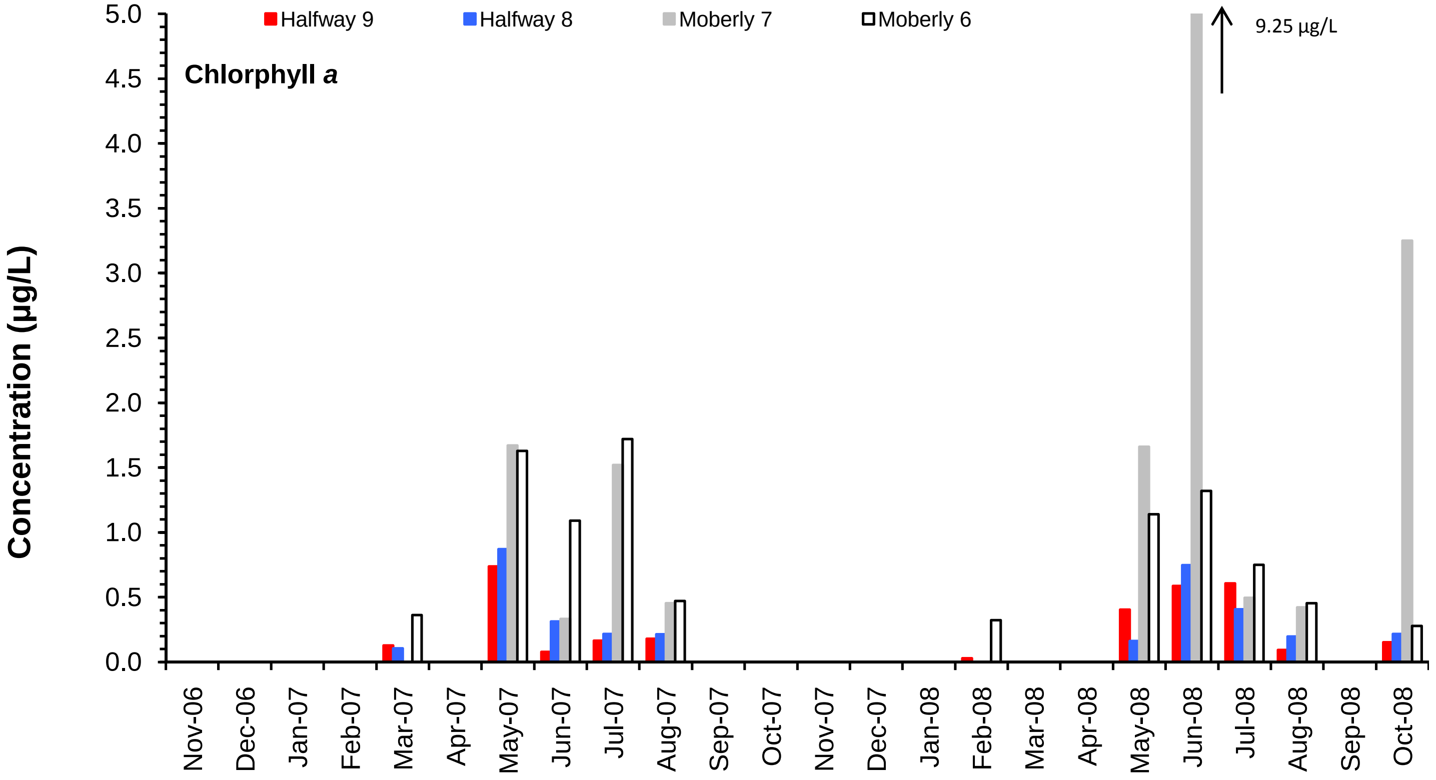


Figure 29: Chlorophyll *a* concentrations at large tributary sites and accompanying orthphosphate concentrations in 2007 and 2008.



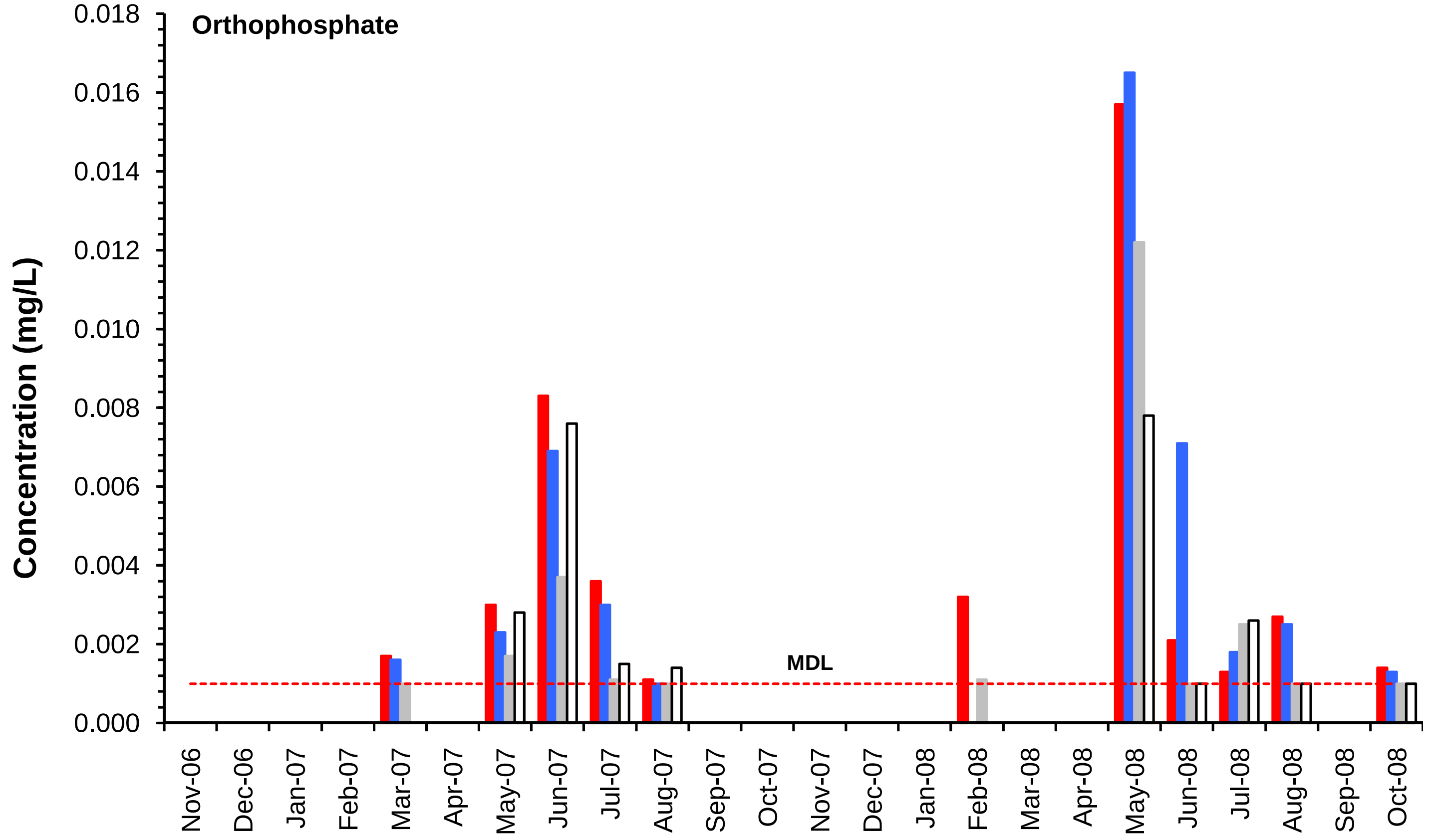


Figure 30: Chlorophyll *a* concentrations at small tributary sites and accompanying orthophosphate concentrations in 2007 and 2008.

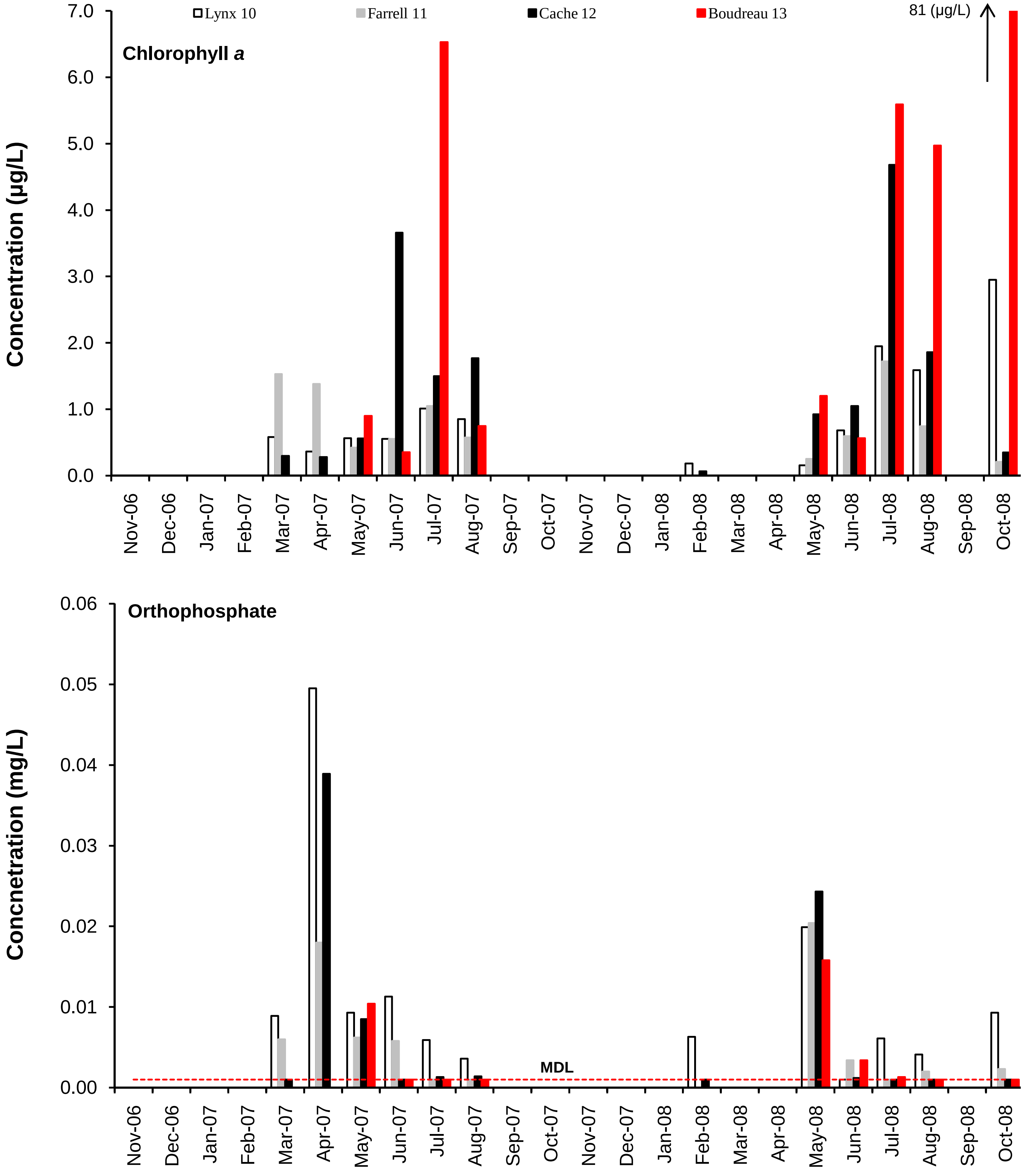


Figure 31: Plots of dissolved organic carbon (DOC) from selected sample sites in the Peace River and tributaries from 2007 and 2008 sample years.

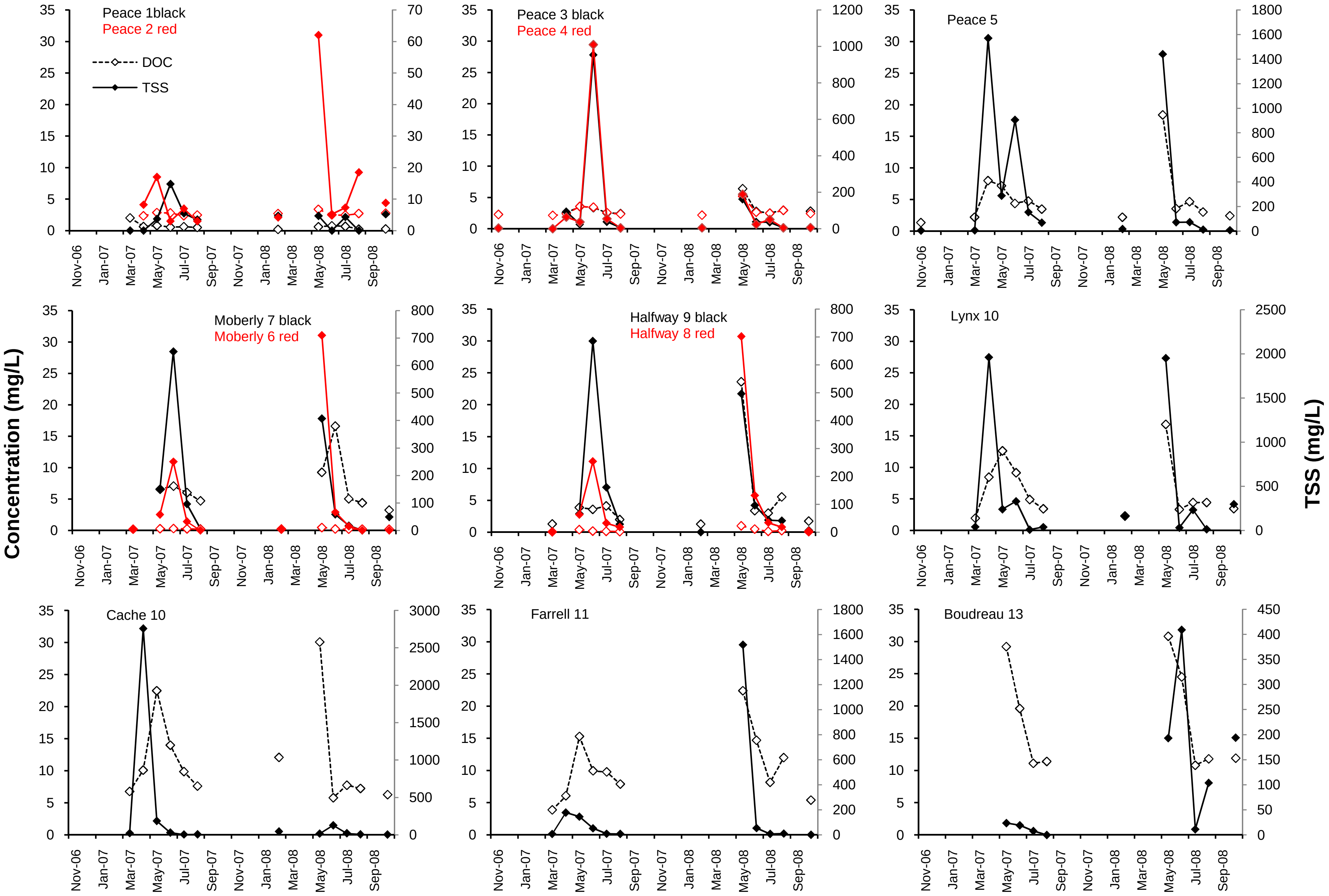


Figure 32: Plots of Nitrate (NO_3) from selected sample sites in the Peace River and tributaries in 2007 and 2008 sample years. Detection Limit (MDL) for Nitrate is 0.005 mg/L.

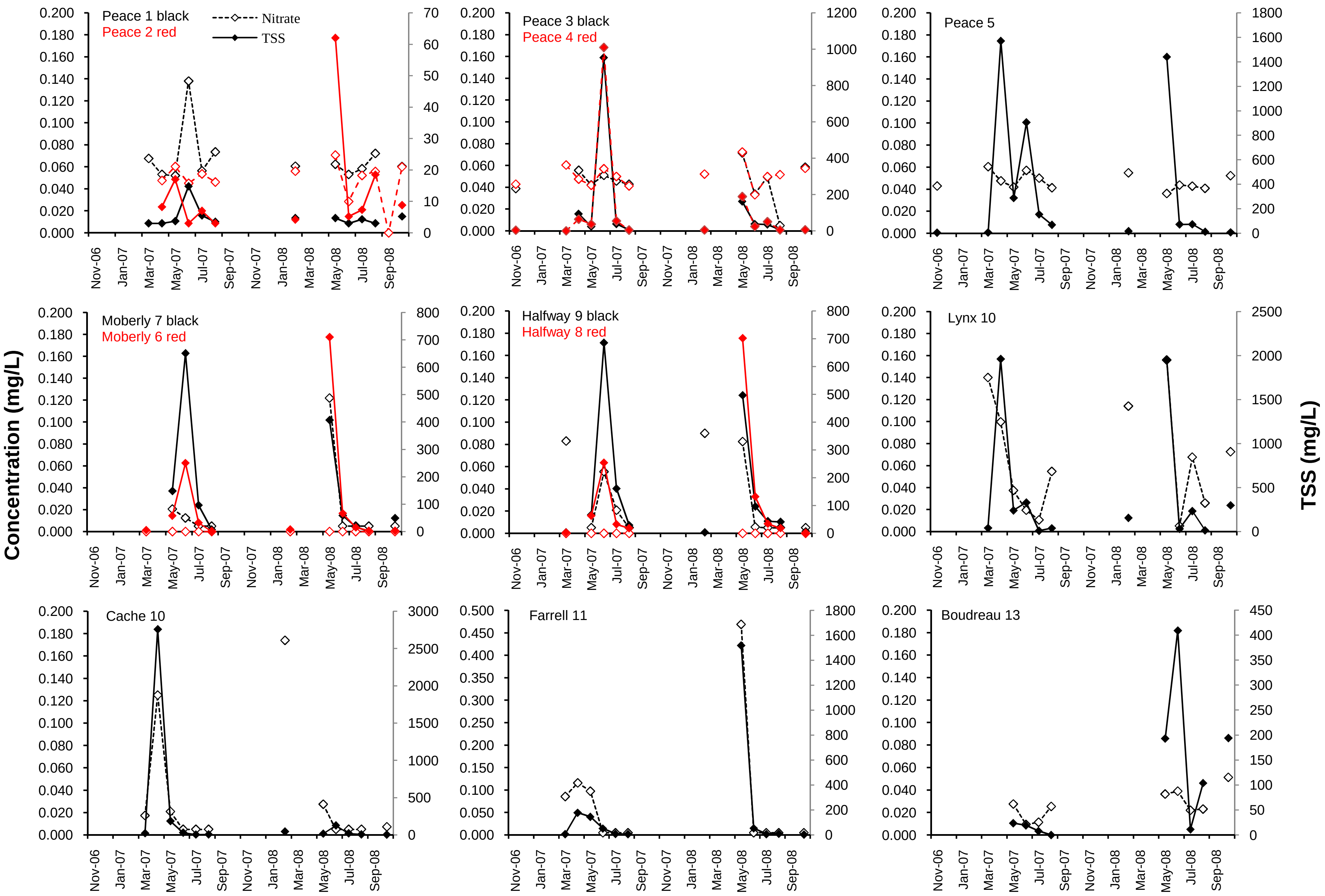


Figure 33: Water level readings compared to measured discharges for Lynx, Farrell and Cache creeks. Water level readings are not standardized between years.

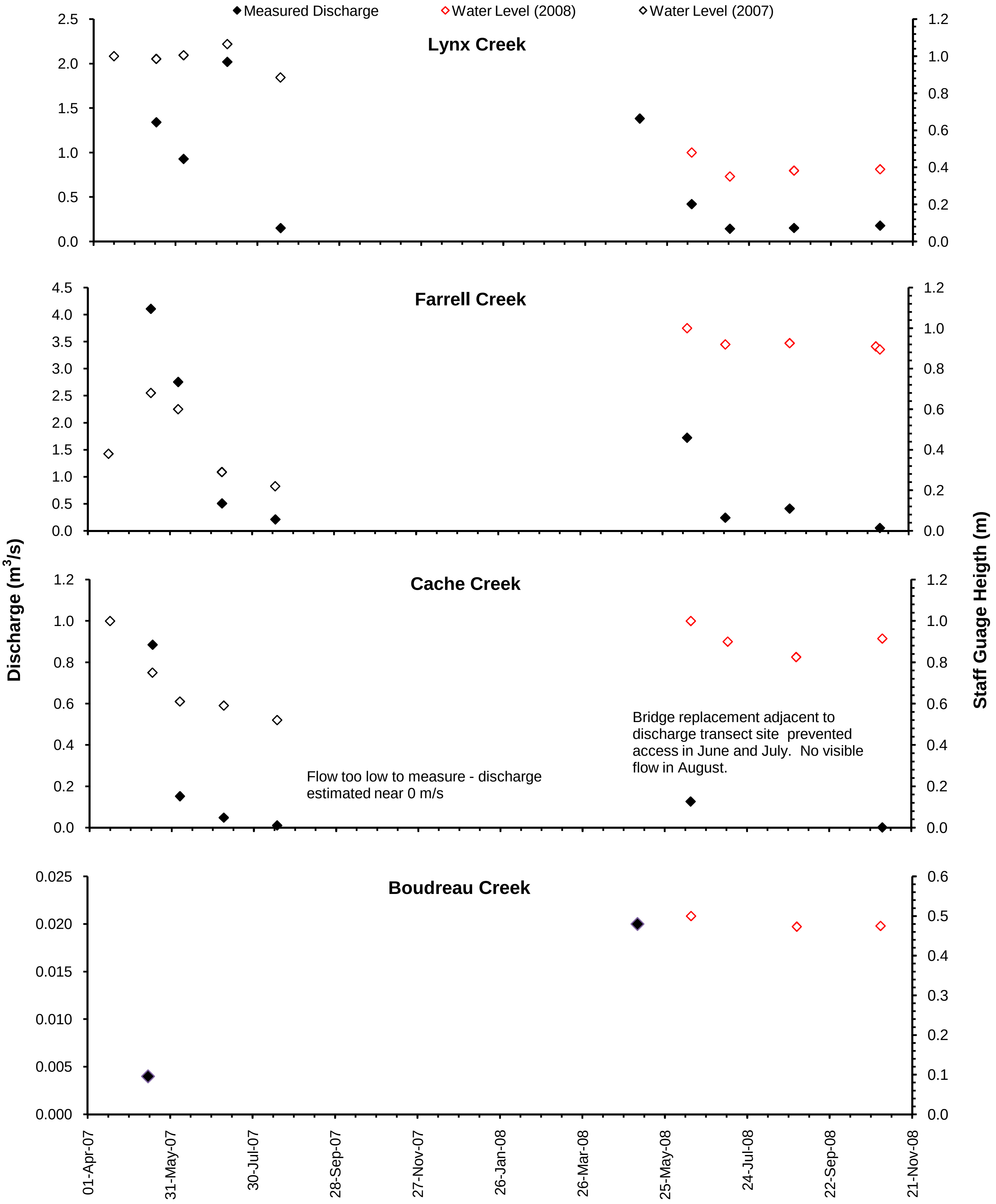


Figure 34: A comparison between 2007 and 2008 discharge curves measured at WSC stations on the Pine, Halfway and Moberly rivers. 2008 data were not finalized by WSC at time of report preparation.