# *Water temperature dynamics downstream of reservoirs*

**Research Report #1347**

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# 1.0 INTRODUCTION

Fisheries and Oceans' Center of Expertise on the Effects of Hydropower on Fish and Fish Habitat (CHIF) is conducting research in partnership with the HYDRONET NSERC (Natural Science and Engineering Research Council) network. As part of this partnership, researchers from the Gulf Region (D. Caissie) and INRS-ETE (A. St-Hilaire, A. Daigle, A. Maheu and L. Beaupré) are involved in investigating the potential impact of dams on the thermal regime of rivers. A large part of this research deals with water temperature modelling and is being conducted as a sub component of HYDRONET project dealing with the thermal regime of rivers. In addition, the present project, which is funded by CHIF, deals with the characterization of the thermal regime on impounded and natural rivers.

The specific objectives of this project are complementary to those of HYDRONET subcomponent 6.3.2 (Effects of dams on the thermal regime of rivers). These objectives include: 1) to monitor both regulated and unregulated (control) HYDRONET sites for comparison purposes and assess the degree of thermal modifications, with an emphasis on winter thermal conditions and summer extremes, 2) to study the spatial variability of thermal conditions immediately downstream of reservoirs and to define thermal indices that characterize this variability. Additional specific objectives identified in the proposal have not been addressed in the present study, but will be components of the theses of the two graduate students involved in the project (L. Beaupré and A. Maheu).

# 2.0 METHODS

## *2.1 Study sites and temperature monitoring*

Within the research framework of HYDRONET, study sites include paired rivers (one impounded, one natural) located in the provinces of Newfoundland and Labrador, Québec, Ontario, Manitoba, Alberta and British Columbia. Water temperature monitoring was initiated in 2011 in a subset of those rivers in Ontario, Québec and Newfoundland (Table 1). In some cases, the initial selection of HYDRONET pairs was respected. However, other rivers were also added due to close proximity and field logistics. The Fourchue River was monitored both upstream and downstream of its dam. The upstream reach of the Fourchue was selected in addition to its original paired river (Du Loup), because the Du Loup River is located mostly in the agricultural portion of the watershed, whereas the reach of the Fourchue river located downstream of the dam is mostly draining a forested region. The Etchemin River, a regulated river, was monitored, but no nearby natural river was monitored. To compensate, the Ste-Marguerite River was added to the list. Water temperature was recorded in a total of 13 rivers. A Microsoft Access database was constructed and is made available to all CHIF and HYDRONET researchers.

**Table 1. List of Rivers and their locations.**

| | River | Dam | Province | Latitude | Longitude |
|---|---|---|---|---|---|
| 1a | Etchemin | Yes | Qc | 46,649 | -71,069 |
| 1b | Ste-Marguerite | No | Qc | 48,268 | -69,899 |
| 2a | Du Loup | No | Qc | 47,604 | -69,654 |
| 2b | Fourchue Upstream | No | Qc | 47,599 | -69,529 |
| 2c | Fourchue Downstream | Yes | Qc | 47,677 | -69,520 |
| 4a | StJean | Yes | Qc | 48,208 | -70,230 |
| 4b | Petite Saguenay | No | Qc | 48,201 | -70,059 |
| 5a | Aubinadong | No | Ont | 46,954 | -83,421 |
| 5b | Mississagi | Yes | Ont | 46,896 | -83,283 |
| 6a | Batchawana | No | Ont | 46,998 | -84,523 |

| | River | Dam | Province | Latitude | Longitude |
|---|---|---|---|---|---|
| 6b | Magpie | Yes | Ont | 48,035 | -84,827 |
| 7a | West Salmon | Yes | NFL | 48,171 | -56,228 |
| 7b | Twilick Brook | No | NFL | 48,117 | -55,577 |

Thermographs were deployed during the ice-free period on all rivers listed in Table 1. Given the large spatial dispersion of the selected sites, the deployment was conducted in collaboration with local HYDRONET research partners. This explains in part the variability of the onset of the monitoring period across the country. On all rivers except the Fourchue and Du Loup, water temperature was recorded using Onset Hobo Pendant temperature logger (precision of 0.5 °C). On the three aforementioned river reaches, Hobo Pro V2 (precision of 0.2 °C) were used. Ten thermographs were deployed on each river, except for the Fourchue River, where 20 loggers were deployed per reach.

In addition to water temperature monitoring during the ice-free season, an attempt was made to monitor the thermal regime of the Fourchue River during the winter of 2011-2012. Six thermographs were deployed (three upstream and three downstream of the dam) on 21 November 2011. Of the six deployed, four (two upstream and two downstream of the dam) were recovered on 16 March 2012 (Figure 1).

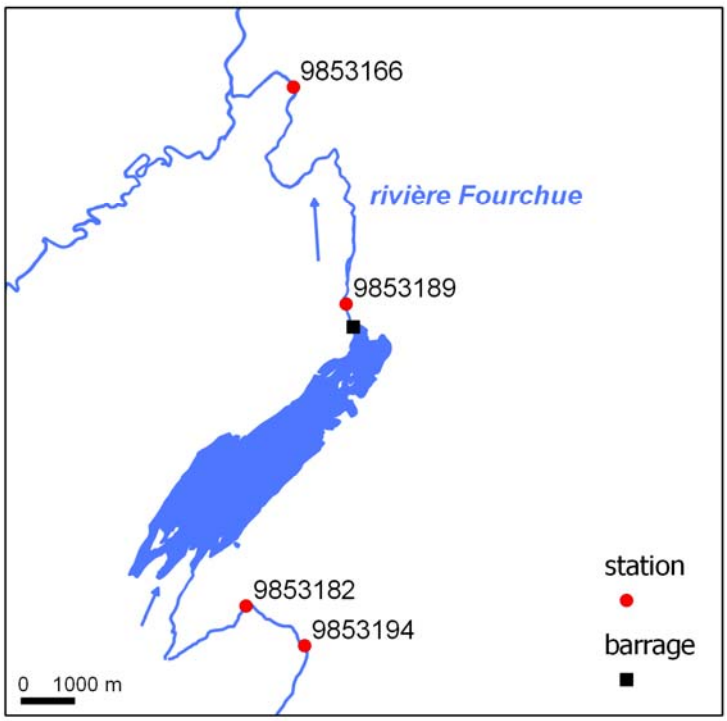


**Figure 1. Location of the recovered thermographs deployed during the 2011-2012 winter in the Fourchue River.**

## *2.2 Thermal Indices*

The comparison of the thermal regimes of different rivers can be partly achieved by calculating thermal indices from the recorded time series. Thermal indices are descriptive statistics of the magnitude (e.g. monthly minimum, mean or maximum), timing (e.g. date of occurrence of the monthly maximum) or variability (e.g. standard deviation) of the water temperature time series. The indices that were calculated on the recorded time series are listed in Table 2.

**Table 2. Definition of thermal indices.**

| | |
|---|---|
| Mean | Monthly mean (°C) for the stated month (7=July, 8=August, 9=September). Means are only calculated on complete monthly time series |
| Max | Maximum water temperature for the stated period (e.g. max 07-09 means the maximum value recorded between July and September). |

| | |
|---|---|
| Julian day of max | Date of occurrence of the maximum temperature |
| SD | Standard deviation of monthly temperature (°C). |
| Max_Dailyrange | Maximum observed daily temperature range for the stated period (°C). |
| Julian day of max range | Date of occurrence of the Maximum observed daily temperature range. |
| Degreedays | Sum of daily mean temperature of the stated period (°C-days). |

# 3.0 RESULTS

## *3.1 Thermal indices on HYDRONET Rivers*

Figures 2-5 show boxplots of some of the thermal indices for four pairs of HYDRONET rivers. Tables of indices are in Appendix. Each boxplot represents the empirical distribution of the thermal index, calculated individually for all thermographs deployed in the river. The red line is the median, the limits of the rectangle represent the $25^{th}$ and $75^{th}$ percentiles, while the whiskers represent the $10^{th}$ and $90^{th}$ percentiles. Outliers are shown as asterisks. On each plot, the natural river is represented by the left-hand side box, and the impounded river by the right-hand side box.

All river pairs show contrasts in the median values of most magnitude indices. Three of the four pairs show higher median mean monthly temperatures for natural rivers than regulated rivers. Monthly means (July, August and September) show median differences varying 0.6 °C and 3.14 °C (difference in medians of monthly means of July between the Magpie and Batchwana rivers). The Abinadong River, which is unregulated, had lower monthly means than its regulated counterpart, the Mississagi River, for the months of August and September.

Thermal variability was quantified at each station by calculating monthly standard deviations. Unsurprisingly, unregulated (natural) rivers had median standard deviations larger than regulated rivers. The difference in median standard deviation between natural rivers and their impounded counterpart varied between 0.14°C (St-Jean vs. Petit Saguenay in August) to 1.5 °C (Abinadong vs. Mississagi in August).

The date of occurrence of the maximum temperature did not show a systematic difference between regulated and unregulated rivers. Both the Magpie and Mississagi rivers, which are regulated, reached their maximum temperature at a later date than their unregulated counterpart. However, the occurrence of maximum temperature was only separated by one day in the case of Twilick Brook and West Salmon Rivers and maximum occurred on the same day for the St-Jean and Petit Saguenay rivers.

The date of occurrence of maximum daily range showed high variability and no consistent differences between regulated and natural rivers.

Degree-days were summed up for the monitoring period on each river to approximate heat accumulation over the summer. Again, results showed a marked difference between pairs of rivers, with three pairs showing higher degree-days in the impounded river than in the unregulated river and two pairs showing lower degree-days for the regulated system than for the unregulated river.

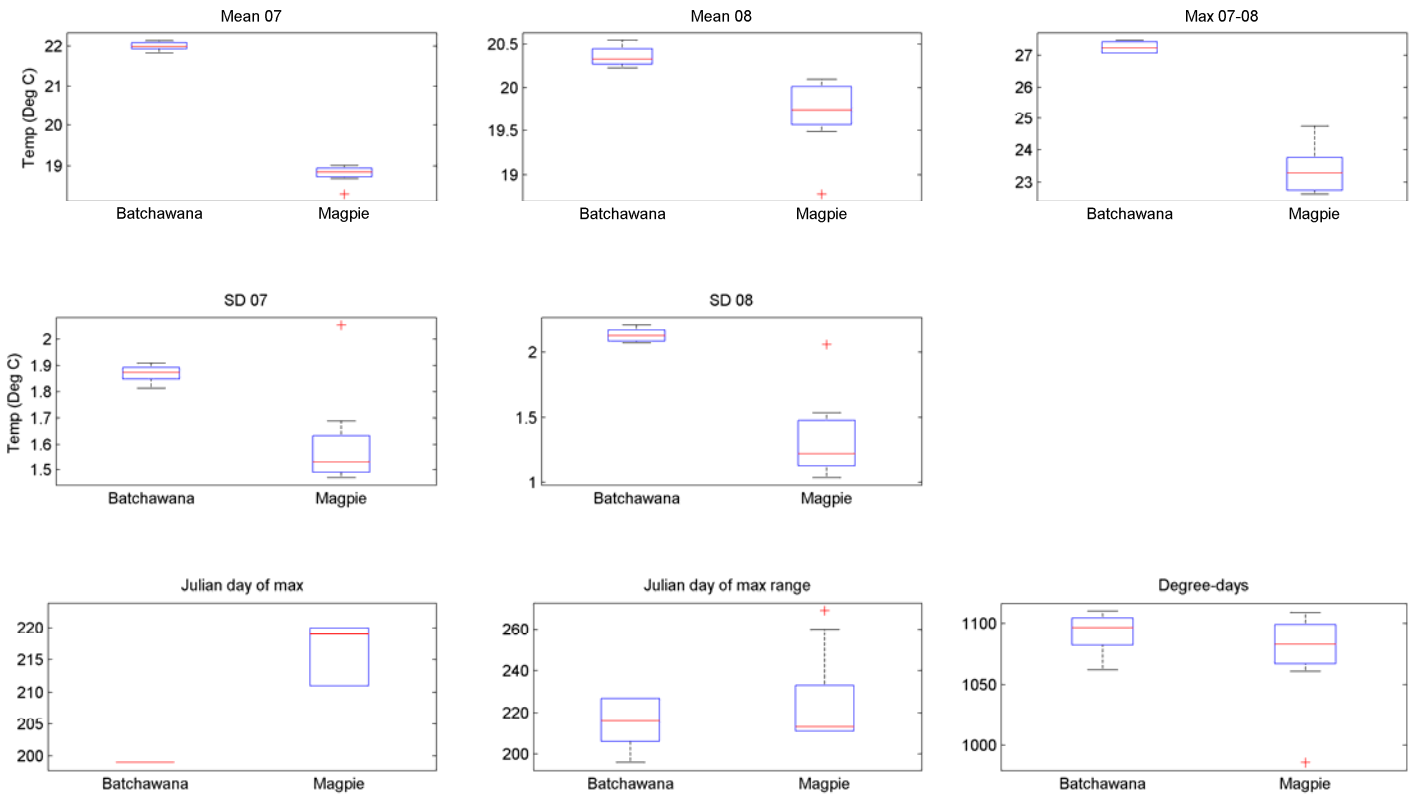


**Figure 2. Box plots of a subsample of thermal indices of the Batchawna (natural) and Magpie (regulated) rivers.**

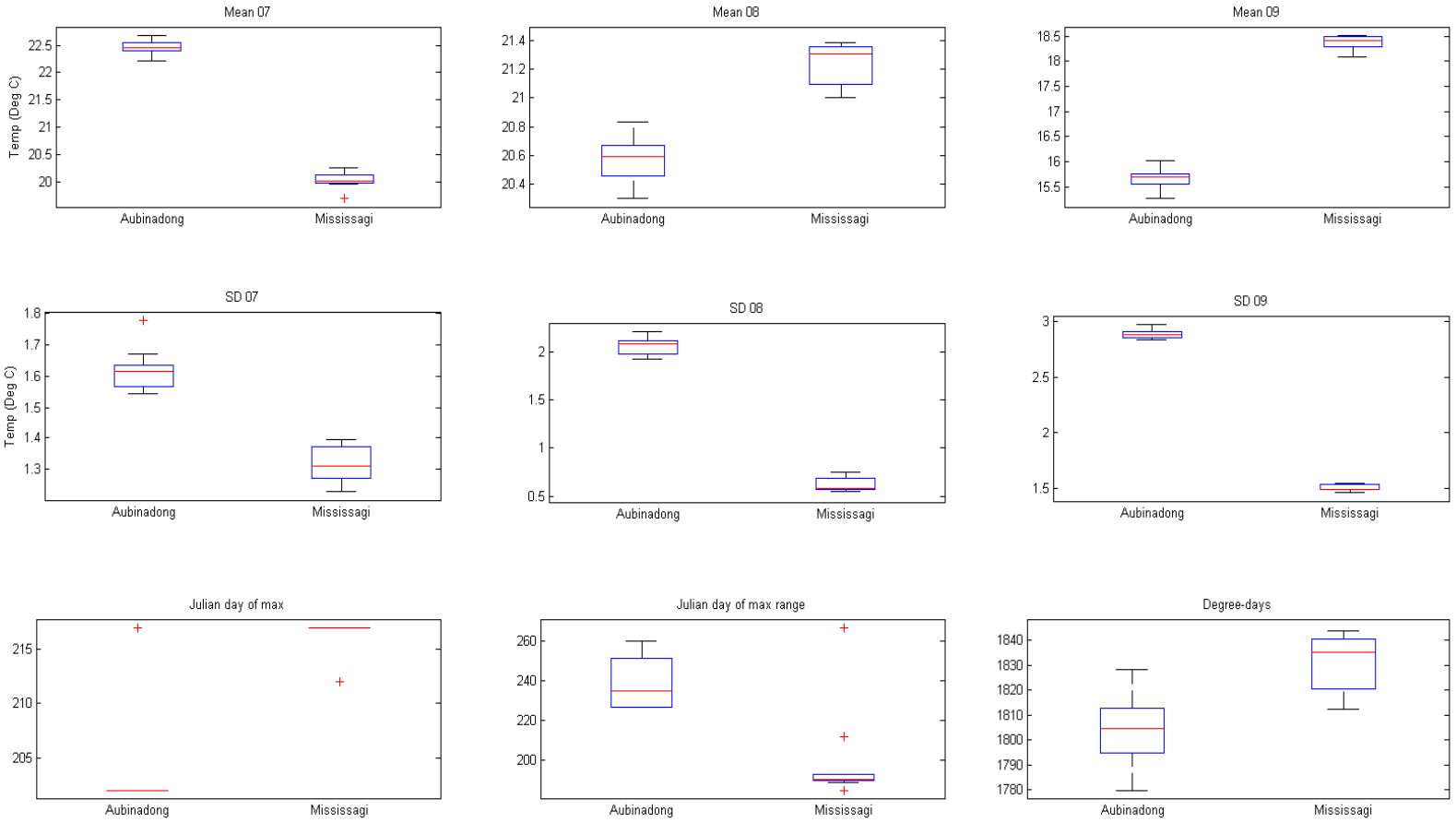


**Figure 3. Box plots of a subsample of thermal indices of the Aubinadong (natural) and Missasigi (regulated) rivers.**

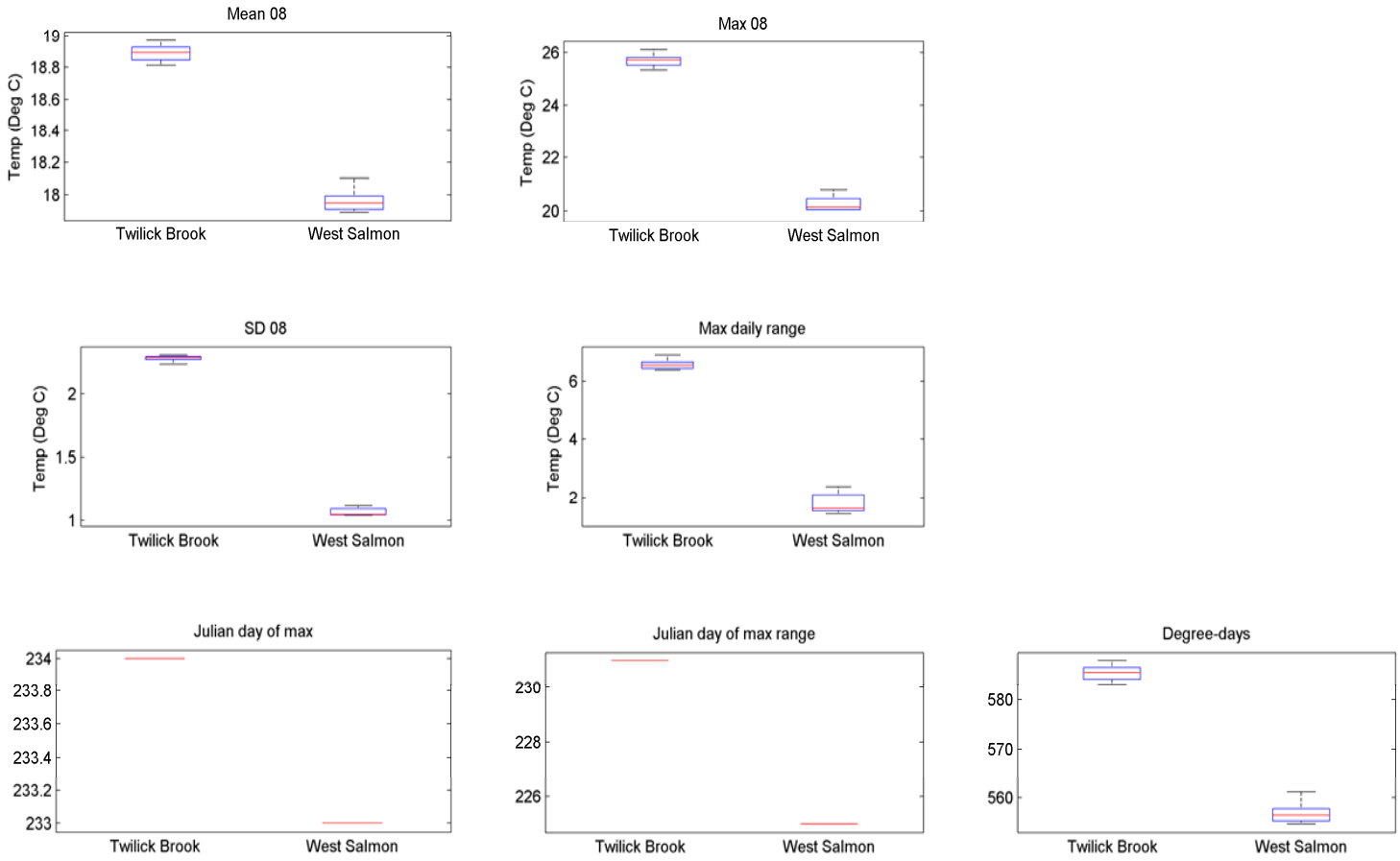


**Figure 4. Box plots of a subsample of thermal indices of Twilick Brook (natural) and West Salmon River (regulated).**

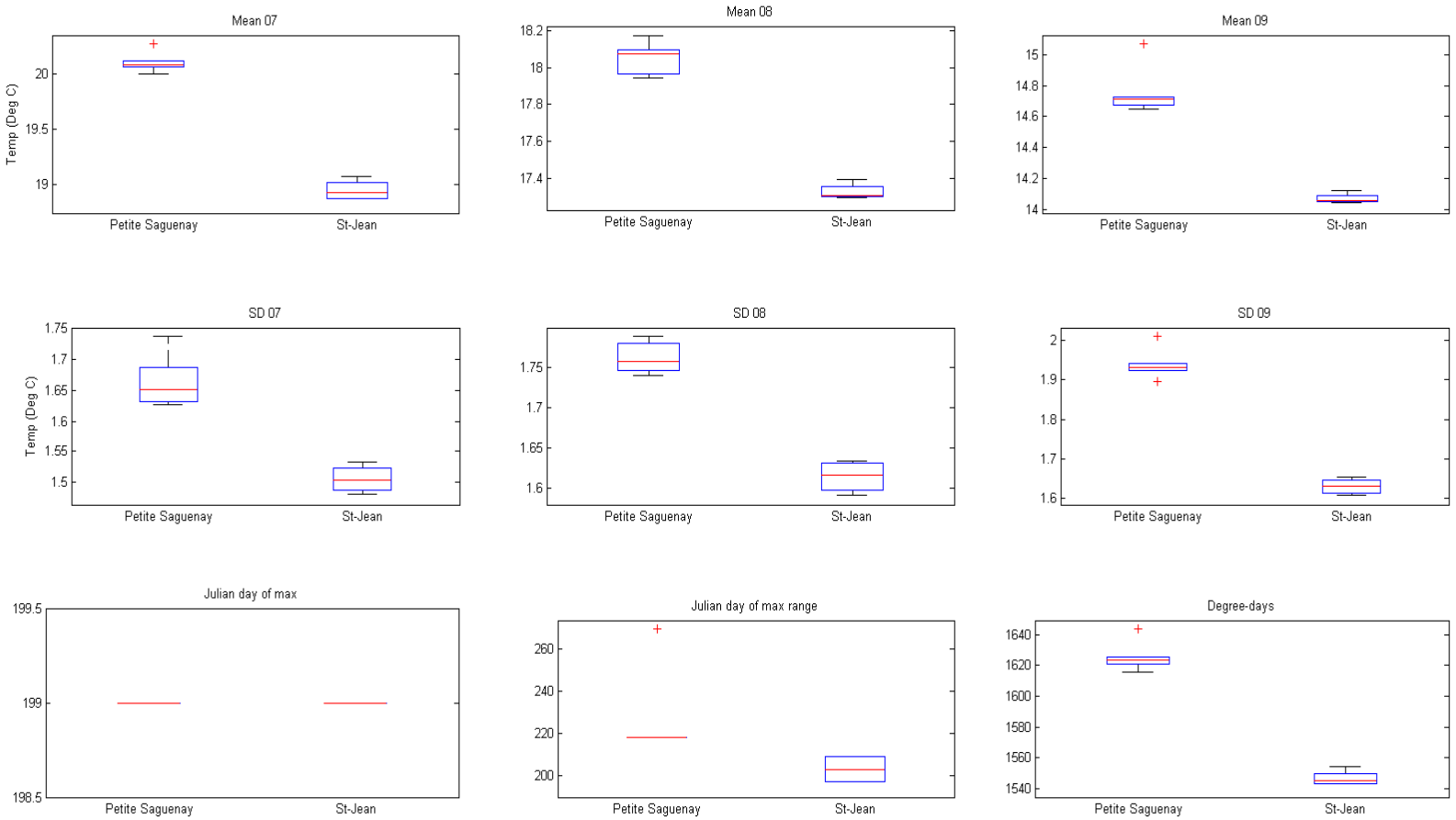


**Figure 5. Box plots of a subsample of thermal indices of Petit-Saguenay (natural) and St-Jean (regulated) rivers.**

## *3.2 Monitoring of winter temperature on the Fourchue River.*

Figure 6 shows the time series of water temperature measured at four sites on the Fourchue River (two below the dam and two upstream of the reservoir, see Figure 1). As expected, the two thermographs that were deployed downstream of the dam show more variability than the thermographs located in the unregulated reach of the river, upstream of the reservoir during winter. Thermograph 9853189, located 100 m downstream of the dam, recorded positive temperatures throughout the winter, with an average of 1.7 °C and a maximum of 3.8 °C in 2011 and 2.4 °C in 2012. Thermograph 9853166, located approximately five km downstream of the dam and 10 m below a breached weir showed high variability, with temperatures ranging from 0°C to 4.1 °C. In the unregulated reach, temperatures varied for the first few weeks, but stabilize to near-zero values in mid-January and showed little variability for the rest of the sampling period.

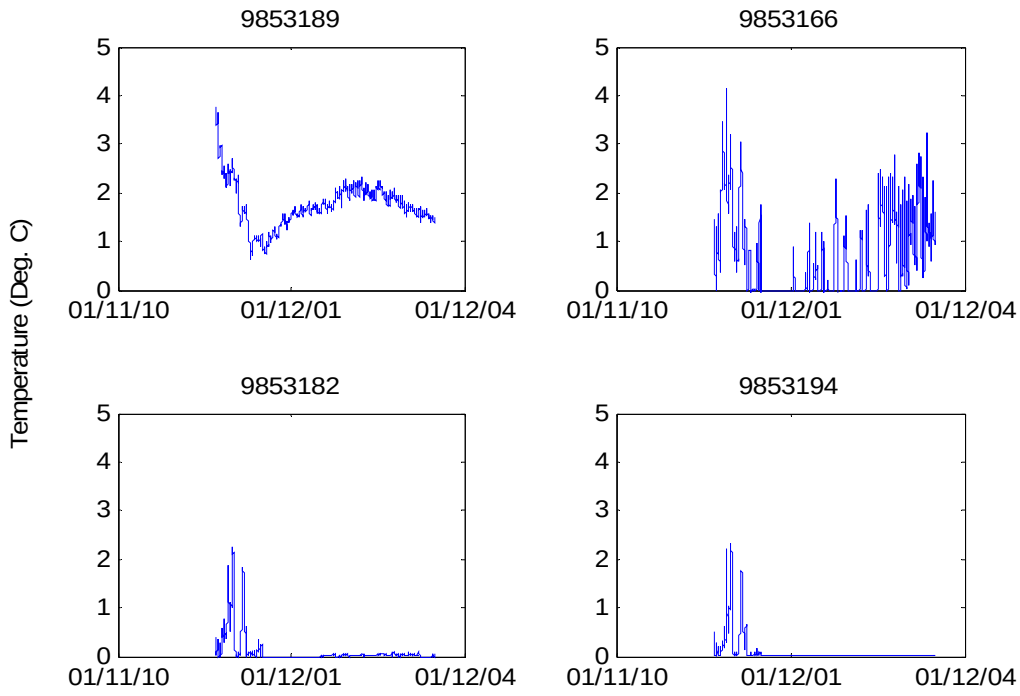


**Figure 6. Time series of water temperature in the Fourchue River during the winter period. Downstream = 9853189 and 9853166. Upstream = 9853182 and 9853194.**

# 4.0 CONCLUSION AND FUTURE WORK

This report highlights the recent and ongoing activities of our CHIF project.

In summary:

- Water temperature monitoring was initiated in 2011 and will continue in the forthcoming years. The number of rivers to be monitored will be increased during the summer of 2012.
- A water temperature database was created and is available in a Microsoft Access format. This database will be expanded in 2012-2013.
- Thermal indices were calculated for a limited number of pairs of rivers to characterize the thermal regime. These indices clearly show that the approach will allow contrasting the water temperature magnitude, variability and timing of events on regulated and natural rivers.
- Our first attempt at monitoring water temperature during the winter was successful. The winter time series clearly show striking differences in the thermal regime of the regulated vs. unregulated reaches of the Fourchue River.

It is anticipated that an additional four rivers will be monitored during the ice-free season of 2012. Thermal indices during the spring will be calculated on the Fourchue River to complete summertime indices. In addition to the Fourchue River, water temperature on a second pair of rivers will be monitored during the winter of 2012-2011. Thermal indices will be calculated on all time series. Prior to making a final selection on a limited number of indices to be used to compare impounded and natural rivers, the initial list of indices will be expanded to include a characterization of event frequency and duration (e.g. number of consecutive days above biologically relevant thresholds). The choice of indices will be completed using a combination of multivariate approaches (e.g. Daigle et al., 2011) and enthropy measures (Yoo et al., 2011)

# 5.0 REFERENCES

DAIGLE, A., A. ST-HILAIRE, D. BEVERIDGE, D. CAISSIE, L. BENYAHYA. 2011. Multivariate analysis of low flow regimes in eastern Canadian rivers. *Hydrological Sciences Journal* 56(1):51-67.

YOO, CHULSANG; KU HYEJIN, K. KEEWOOK. 2011. Use of a Distance Measure for the Comparison of Unit Hydrographs: Application to the Stream Gauge Network Optimization. *Journal of Hydrologic Engineering*, 198.73.162.9: 880-890.

# 6.0 APPENDIX: THERMAL INDICES

## Batchawana-Magpie

| River | FlowRegime | SerialNum | Mean 07 | Mean 08 | Mean 09 | Max07-08 | Date_max07-08 | SD07 | SD08 | SD09 | Max_range07-08 | Date_max_rangen07-08 | Degr-days07-08 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Batchawana | NR | 2368437 | 21.82 | 20.22 | -- | 27.08 | 2011-07-18 17:30 | 1.89 | 2.18 | -- | 5.72 | 2011-08-15 | 1061.40 |
| Batchawana | NR | 2368441 | 22.11 | 20.48 | 15.71 | 27.47 | 2011-07-18 19:00 | 1.88 | 2.09 | 2.65 | 5.48 | 2011-08-04 | 1105.65 |
| Batchawana | NR | 2368444 | 21.98 | 20.33 | 15.60 | 27.08 | 2011-07-18 18:30 | 1.87 | 2.07 | 2.67 | 5.54 | 2011-07-15 | 1097.77 |
| Batchawana | NR | 2368447 | 22.10 | 20.50 | 15.73 | 27.47 | 2011-07-18 18:15 | 1.90 | 2.13 | 2.73 | 5.67 | 2011-08-04 | 1106.82 |
| Batchawana | NR | 2368450 | 21.95 | 20.30 | 15.55 | 27.27 | 2011-07-18 18:30 | 1.87 | 2.10 | 2.64 | 5.47 | 2911-08-04 | 1095.24 |
| Batchawana | NR | 2368464 | 21.92 | 20.24 | nan | 27.17 | 2011-07-18 18:00 | 1.83 | 2.17 | nan | 5.91 | 2011-08-15 | 1079.71 |
| Batchawana | NR | 2368466 | 22.06 | 20.42 | 15.68 | 27.17 | 2011-07-18 18:30 | 1.87 | 2.08 | 2.66 | 5.55 | 2011-07-15 | 1102.68 |
| Batchawana | NR | 9742670 | 21.97 | 20.31 | 15.57 | 27.08 | 2011-07-18 18:30 | 1.87 | 2.08 | 2.66 | 5.45 | 2011-07-15 | 1100.42 |
| Batchawana | NR | 9742675 | 22.13 | 20.54 | 15.79 | 27.47 | 2011-07-18 18:00 | 1.91 | 2.12 | 2.71 | 5.58 | 2011-08-04 | 1109.83 |
| Batchawana | NR | 9742682 | 21.98 | 20.30 | nan | 27.27 | 2011-07-18 18:00 | 1.83 | 2.16 | nan | 5.91 | 2011-08-15 | 1083.66 |
| Batchawana | NR | 9742683 | 22.07 | 20.42 | nan | 27.37 | 2011-07-18 17:00 | 1.89 | 2.20 | nan | 6.10 | 2011-08-15 | 1091.12 |
| Batchawana | NR | 9742708 | 21.91 | 20.23 | nan | 27.08 | 2011-07-18 17:30 | 1.81 | 2.15 | nan | 5.82 | 2011-08-15 | 1080.15 |
| Magpie | R | 2368430 | 18.95 | 20.09 | nan | 22.81 | 2011-08-08 17:30 | 1.47 | 1.05 | nan | 3.81 | 2011-08-01 | 1105.50 |
| Magpie | R | 2368433 | 18.76 | 19.74 | nan | 22.72 | 2011-08-08 17:30 | 1.47 | 1.13 | nan | 4.09 | 2011-08-01 | 1082.35 |
| Magpie | R | 2368434 | 18.85 | 19.49 | nan | 23.68 | 2011-07-30 17:15 | 1.63 | 1.48 | nan | 5.92 | 2011-07-30 | 1060.34 |
| Magpie | R | 2368436 | 18.30 | 18.78 | nan | 23.77 | 2011-08-07 20:00 | 2.05 | 2.06 | nan | 8.40 | 2011-08-28 | 986.08 |
| Magpie | R | 2368440 | 19.01 | 19.64 | nan | 24.74 | 2011-07-30 15:30 | 1.69 | 1.54 | nan | 6.88 | 2011-07-30 | 1068.42 |
| Magpie | R | 2368442 | 18.92 | 20.07 | nan | 24.26 | 2011-08-08 18:00 | 1.54 | 1.22 | nan | 5.81 | 2011-09-26 | 1108.70 |
| Magpie | R | 2368449 | 18.73 | 19.86 | nan | 22.91 | 2011-08-07 17:45 | 1.48 | 1.12 | nan | 4.47 | 2011-08-01 | 1092.11 |
| Magpie | R | 9742677 | 18.68 | 19.65 | nan | 22.72 | 2011-08-08 17:30 | 1.52 | 1.15 | nan | 6.50 | 2911-09-17 | 1072.26 |
| Magpie | R | 9742678 | 18.72 | 19.75 | nan | 22.62 | 2011-08-08 17:30 | 1.49 | 1.11 | nan | 4.00 | 2011-08-01 | 1084.51 |
| Magpie | R | 9742680 | 18.83 | 20.10 | nan | 22.62 | 2011-08-07 18:15 | 1.49 | 1.04 | nan | 3.71 | 2011-08-01 | 1108.34 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Magpie | R | 9742688 | 18.89 | 19.55 | nan | 23.68 | 2011-07-30 17:30 | 1.64 | 1.49 | nan | 5.92 | 2011-07-30 | 1066.02 |
| Magpie | R | 9742696 | 19.00 | 19.99 | nan | 23.29 | 2011-08-08 18:00 | 1.53 | 1.28 | nan | 4.68 | 2011-09-17 | 1090.85 |
| Magpie | R | 9742701 | 18.85 | 19.49 | nan | 23.68 | 2011-07-30 17:30 | 1.62 | 1.48 | nan | 5.92 | 2011-07-30 | 1060.71 |
| Magpie | R | 9742706 | 18.94 | 20.02 | nan | 22.91 | 2011-08-08 17:15 | 1.52 | 1.18 | nan | 4.00 | 2011-08-01 | 1101.24 |
| Magpie | R | 9742711 | 18.71 | 19.63 | nan | 24.45 | 2011-07-30 16:00 | 1.64 | 1.29 | nan | 6.31 | 2011-07-30 | 1078.62 |

**Note : R = Regulated, NR = Unregulated.**

## Aubinadong-Nississagi

| River | FlowRegime | SerialNum | Mean07 | Mean08 | Mean09 | Max07-09 | Date_max07-09 | SD07 | SD08 | SD09 | Max_range07-09 | Date_max_range07-09 | Degays07-09 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Aubinadong | NR | 2368453 | 22.35 | 20.41 | 15.51 | 26.88 | 2011-07-21 | 1.64 | 2.11 | 2.85 | 5.713 | 2011-08-23 | 1790.63 |
| Aubinadong | NR | 2368427 | 22.41 | 20.49 | 15.54 | 27.37 | 2011-08-05 | 1.67 | 2.21 | 2.86 | 6.496 | 2011-08-15 | 1795.84 |
| Aubinadong | NR | 2368448 | 22.39 | 20.56 | 15.66 | 26.39 | 2011-07-21 | 1.56 | 1.97 | 2.92 | 5.714 | 2011-09-09 | 1801.02 |
| Aubinadong | NR | 2368462 | 22.42 | 20.46 | 15.26 | 26.68 | 2011-07-21 | 1.61 | 2.13 | 2.88 | 8.584 | 2011-09-17 | 1786.84 |
| Aubinadong | NR | 2368465 | 22.40 | 20.42 | 15.55 | 27.08 | 2011-07-21 | 1.66 | 2.11 | 2.90 | 6.108 | 2011-08-15 | 1793.52 |
| Aubinadong | NR | 2368473 | 22.21 | 20.30 | 15.42 | 26.68 | 2011-07-21 | 1.63 | 2.07 | 2.86 | 5.723 | 2011-08-15 | 1779.79 |
| Aubinadong | NR | 2405508 | 22.50 | 20.62 | 15.72 | 26.59 | 2011-08-05 | 1.58 | 2.09 | 2.88 | 5.81 | 2011-08-23 | 1808.03 |
| Aubinadong | NR | 2405513 | 22.46 | 20.64 | 15.73 | 26.59 | 2011-07-21 | 1.56 | 1.94 | 2.89 | 5.522 | 2011-09-09 | 1807.71 |
| Aubinadong | NR | 9742671 | 22.44 | 20.45 | 15.56 | 26.98 | 2011-07-21 | 1.62 | 2.11 | 2.84 | 5.713 | 2011-08-23 | 1796.10 |
| Aubinadong | NR | 9742672 | 22.48 | 20.68 | 15.78 | 26.39 | 2011-07-21 | 1.55 | 1.94 | 2.89 | 5.525 | 2011-09-08 | 1810.85 |
| Aubinadong | NR | 9742674 | 22.55 | 20.67 | 15.76 | 26.49 | 2011-07-21 | 1.57 | 2.06 | 2.88 | 5.618 | 2011-08-23 | 1812.17 |
| Aubinadong | NR | 9742676 | 22.64 | 20.83 | 16.03 | 26.98 | 2011-07-21 | 1.61 | 1.99 | 2.98 | 6.192 | 2011-09-08 | 1828.17 |
| Aubinadong | NR | 9742681 | 22.41 | 20.49 | 15.59 | 26.78 | 2011-07-21 | 1.61 | 2.05 | 2.86 | 5.629 | 2011-08-15 | 1797.47 |
| Aubinadong | NR | 9742685 | -- | 20.69 | 15.79 | -- | -- | -- | 1.94 | 2.88 | -- | -- | -- |
| Aubinadong | NR | 9742686 | 22.60 | 20.81 | 15.89 | 26.59 | 2011-07-21 | 1.55 | 1.92 | 2.88 | 5.522 | 2011-09-09 | 1822.31 |
| Aubinadong | NR | 9742692 | 22.55 | 20.69 | 15.76 | 26.88 | 2011-08-05 | 1.62 | 2.12 | 2.92 | 6.192 | 2011-08-23 | 1813.00 |
| Aubinadong | NR | 9742699 | 22.69 | 20.67 | 15.84 | 28.06 | 2011-07-21 | 1.78 | 2.16 | 2.97 | 6.398 | 2011-08-15 | 1818.93 |
| Mississagi | R | 2368432 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Mississagi | R | 2368445 | 19.96 | 21.00 | 18.08 | 23.00 | 2011-08-05 | 1.27 | 0.75 | 1.55 | 3.521 | 2011-07-04 | 1812.34 |
| Mississagi | R | 2368446 | 19.69 | 21.07 | 18.33 | 22.53 | 2011-08-0 | 1.39 | 0.54 | 1.46 | 2.951 | 2011-07-10 | 1813.36 |
| Mississagi | R | 2368451 | 20.02 | 21.34 | 18.49 | 22.81 | 2011-08-05 | 1.37 | 0.57 | 1.49 | 2.854 | 2011-07-09 | 1836.76 |
| Mississagi | R | 2368460 | -- | 20.69 | 15.79 | -- | -- | -- | 1.94 | 2.88 | -- | -- | -- |
| Mississagi | R | 2368474 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mississagi | R | 2358476 | -- | -- | -- | -- | -- | -- | -- | -- | -- | | -- | -- |
| Mississagi | R | 9742668 | 19.97 | 21.25 | 18.39 | 22.91 | 2011-08-05 | 1.36 | 0.59 | 1.49 | | 2.854 | 2011-07-09 | 1829.20 |
| Mississagi | R | 9742673 | 20.26 | 21.33 | 18.30 | 24.93 | 2011-07-31 | 1.27 | 0.69 | 1.55 | | 3.84 | 2011-07-31 | 1838.00 |
| Mississagi | R | 9742679 | 20.09 | 21.36 | 18.52 | 23.39 | 2011-08-05 | 1.30 | 0.56 | 1.49 | | 3.72 | 2011-07-10 | 1840.77 |
| Mississagi | R | 9742687 | 20.25 | 21.39 | 18.45 | 23.68 | 2011-08-05 | 1.23 | 0.60 | 1.52 | | 3.998 | 2011-09-24 | 1844.05 |
| Mississagi | R | 9742693 | 19.97 | 21.29 | 18.49 | 23.10 | 2011-08-05 | 1.37 | 0.57 | 1.47 | | 2.854 | 2011-07-09 | 1833.70 |
| Mississagi | R | 9742703 | -- | -- | -- | -- | -- | -- | -- | -- | -- | | -- | -- |
| Mississagi | R | 9742704 | 20.12 | 21.36 | 18.52 | 23.58 | 2011-08-05 | 1.32 | 0.57 | 1.49 | | 4.576 | 2011-07-08 | 1841.39 |
| Mississagi | R | 9742705 | -- | -- | -- | -- | -- | -- | -- | -- | -- | | -- | -- |
| Mississagi | R | 9742707 | -- | -- | -- | -- | -- | -- | -- | -- | -- | | -- | -- |
| Mississagi | R | 9742710 | 20.02 | 21.10 | 18.20 | 23.29 | 2011-08-05 | 1.26 | 0.71 | 1.53 | | 3.336 | 2011-07-12 | 1820.46 |

## Twilick-West Salmon

| River | FlowRegime | SerialNum | Mean08 | Max08 | Date_max08 | SD08 | Max_range08 | Date_max_range08 | Degdays08 |
|---|---|---|---|---|---|---|---|---|---|
| Twilick Brook | NR | 9916681 | 18,97 | 26,097 | 2011-08-22 | 2,296 | 6,868 | 2011-08-19 | 588,1318 |
| Twilick Brook | NR | 9916682 | 18,86 | 25,513 | 2011-08-22 | 2,258 | 6,387 | 2011-08-19 | 584,7828 |
| Twilick Brook | NR | 9916694 | 18,83 | 25,513 | 2011-08-22 | 2,265 | 6,482 | 2011-08-19 | 583,7251 |
| Twilick Brook | NR | 9916695 | 18,94 | 25,805 | 2011-08-22 | 2,282 | 6,675 | 2011-08-19 | 587,2512 |
| Twilick Brook | NR | 9916708 | 18,88 | 25,708 | 2011-08-22 | 2,276 | 6,483 | 2011-08-19 | 585,3491 |
| Twilick Brook | NR | 9916709 | 18,81 | 25,319 | 2011-08-22 | 2,230 | 6,386 | 2011-08-19 | 583,2269 |
| Twilick Brook | NR | 9916710 | 18,91 | 25,708 | 2011-08-22 | 2,278 | 6,579 | 2011-08-19 | 586,2434 |
| Twilick Brook | NR | 9916720 | 18,91 | 25,805 | 2011-08-22 | 2,288 | 6,579 | 2011-08-19 | 586,0638 |
| West Salmon | R | 9916668 | 17,89 | 20,043 | 2011-08-21 | 1,039 | 1,523 | 2011-08-13 | 554,6787 |
| West Salmon | R | 9916669 | 17,95 | 20,043 | 2011-08-21 | 1,039 | 1,427 | 2011-08-13 | 556,3941 |
| West Salmon | R | 9916683 | 17,90 | 20,043 | 2011-08-21 | 1,041 | 1,523 | 2011-08-13 | 555,0099 |
| West Salmon | R | 9916684 | 18,00 | 20,329 | 2011-08-21 | 1,060 | 1,809 | 2011-08-13 | 557,8826 |
| West Salmon | R | 9916697 | 18,10 | 20,805 | 2011-08-21 | 1,111 | 2,379 | 2011-08-13 | 561,1935 |
| West Salmon | R | 9916707 | 17,93 | 20,138 | 2011-08-21 | 1,045 | 1,618 | 2011-08-13 | 555,8992 |
| West Salmon | R | 9916719 | 17,98 | 20,519 | 2011-08-21 | 1,098 | 2,189 | 2011-08-13 | 557,4866 |

## Petit-Saguenay-St-Jean

| River | FlowRegime | SerialNum | Mean07 | Mean08 | Mean09 | Max07-09 | Date_max | SD07 | SD08 | SD09 | Max_range07-09 | Date_max_range07-09 | Deg-days07-09 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Petite Saguenay | NR | 2368456 | 20.11 | 17.97 | 14.67 | 24.35 | 2011-07-18 | 1.74 | 1.79 | 1.94 | 4.292 | 2011-08-06 | 1620.58 |
| Petite Saguenay | NR | 2368637 | 20.06 | 18.07 | 14.70 | 24.16 | 2011-07-18 | 1.64 | 1.76 | 1.93 | 3.913 | 2011-08-06 | 1623.01 |
| Petite Saguenay | NR | 9742691 | 19.99 | 17.95 | 14.65 | 24.06 | 2011-07-18 | 1.66 | 1.75 | 1.93 | 4.101 | 2011-08-06 | 1615.48 |
| Petite Saguenay | NR | 9916677 | 20.07 | 18.08 | 14.72 | 24.06 | 2011-07-18 | 1.63 | 1.74 | 1.90 | 3.912 | 2011-08-06 | 1624.38 |
| Petite Saguenay | NR | 9916689 | 20.27 | 18.17 | 15.07 | 24.55 | 2011-07-18 | 1.69 | 1.78 | 2.01 | 4.576 | 2011-09-27 | 1643.97 |
| Petite Saguenay | NR | 9916690 | 15.61 | 15.80 | -- | -- | -- | 1.33 | 0.94 | -- | -- | -- | -- |
| Petite Saguenay | NR | 9916705 | 20.09 | 18.09 | 14.73 | 24.16 | 2011-07-18 | 1.63 | 1.75 | 1.92 | 4.008 | 2011-08-06 | 1625.5206 |
| St-Jean | R | 9742694 | 18.98 | 17.72 | -- | -- | -- | 1.52 | 1.26 | -- | -- | -- | -- |
| St-Jean | R | 9916675 | 18.87 | 17.30 | 14.06 | 22.91 | 2011-07-18 | 1.48 | 1.59 | 1.64 | 4.006 | 2011-07-16 | 1543.04 |
| St-Jean | R | 9916678 | 18.89 | 17.30 | 14.06 | 23.10 | 2011-07-18 | 1.50 | 1.60 | 1.65 | 4.197 | 2011-07-16 | 1543.57 |
| St-Jean | R | 9916702 | 18.96 | 17.31 | 14.04 | 22.53 | 2011-07-18 | 1.53 | 1.63 | 1.62 | 3.713 | 2011-07-28 | 1545.96 |
| St-Jean | R | 9916704 | 19.07 | 17.39 | 14.12 | 22.62 | 2011-07-18 | 1.51 | 1.63 | 1.61 | 3.617 | 2011-07-28 | 1553.98 |